Estimating the Willingness-to-Pay for Agri-Environmental BMP Adoption in Alberta's South Saskatchewan Region

By

Zhaochao Lin

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Department of Resource Economics and Environmental Sociology

University of Alberta

Abstract

The overall objective of this study was to determine the economic benefits associated with wildlife habitat and water quality enhancement in Alberta's South Saskatchewan Region as results of agri-environmental BMP adoptions. Stated preference questionnaires were designed to elicit the associated non-market values by using water quality ladders and numbers of at-risk species as the survey attributes for water quality and wildlife habitat questionnaire respectively.

Parametric results from logit models showed that Alberta South Saskatchewan Residents valued wildlife habitat or water quality improvements. The estimated mean annual household WTP for wildlife BMP programs ranged from $71 - $206 for one-unit improvement in the numbers of net not-at-risk species. The wildlife habitat survey results showed that urban, female as well as higher household income respondents were more willing to pay for BMP programs. In addition, awareness on farming practices and the period of the programs also could impact the values of WTP. On the other hand, the estimated mean annual household WTP ranged from $100 - $113 for changing Bow River Basin or Oldman River Basin water quality from fishable to swimmable, while only gender impacted the values of WTP. The survey data also indicated that there was a consensus between rural and urban individual regarding future government spending on water quality improvements, but no consensus on future wildlife habitat investments.

The estimated aggregated welfare measure was approximately $655 - $818 million for wildlife habitat programs, and $338-$381 million for one-level water quality improvement in Bow River Basin and Oldman River Basin. Overall, the results support *Growing Forward*, however, the funding amount provided to agricultural producers are much less than our estimated aggregated welfare measures. To improve future BMP adoptions as well as to enhance wildlife and water

quality in SSR, government authorities need to relax the requirement of Environmental Farm Plan (EFP) and to take actions to improvement BMP and GF awareness.

Preface

This thesis is an original work by Zhaochao Lin, under Dr. Peter Boxall and Dr. Marian Weber's supervision. The research project received research ethics approval from the University of Alberta Research Ethics Board, Project Name "Managing Environmental Impacts from Livestock Operations in Alberta", Study Number "Pro00067830".

Dedication

I would like to dedicate this thesis to you who value the environment, and, our mother Earth.

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Chapter 1 Alberta Beef Industry and the Beneficial Management Practices

This chapter discusses literature that is relevant to this study, and describes how farming practices in the Alberta beef industry and beef operations can lead to potential environmental impacts and benefits to water resources and wildlife habitats. In addition to introducing the concepts of beneficial management practices (BMPs), this chapter will also outline current agri-environmental policies, regulations, and programs provided by governments and non-governmental organizations (NGOs) in Canada.

1.1 Introduction

The beef industry is economically significant for Alberta. It contributed $16 billion to national GDP (Canadian Beef 2017) and accounted for 22.4% of the total Canadian farm cash receipt in 2016 (Statistics Canada 2017a). In addition to economic benefits, there are also prospective environmental benefits from cattle grazing if grazing practices are implemented with caution. For example, livestock grazing is an effective measure to control non-native annual herbaceous plants and sustain essential wildlife habitat (Carlson 2011; Bartolome et al., 2014; Barry 2015). It is also recognized for its benefits in natural land preservation and native biodiversity enhancement (Bartolome et al., 2014; Gennet et al., 2017; McAllister 2018). There are also studies showed that livestock grazing could enhance vegetation quality through old forage removal (Georgiadis et al., 1989).

However, there are also potential negative consequences from intensive grazing and other management practices in the beef industry. Potential environmental concerns resulting from livestock grazing are mainly attributed to impacts on the aquatic and the terrestrial environments (Clearwater et al., 2016). Water quality concerns focus on nutrient discharge from livestock manure, as well as pathogen and antibiotic contamination (Powers 2009). On the terrestrial side, intensive livestock grazing has also been known to lead to soil compaction, impairment of vegetative growth as well as physical damage to stream banks (Kauffman and Krueger 1984). Cattle grazing and beef production may also generate more greenhouse gas emissions (GHG) than other livestock. Not only does cattle grazing produce additional GHG (from their manure), but to manage the farm one needs to utilize additional fossil fuels (McAllister 2017).

There has been increasing environmental awareness within government agencies about environmental impacts from agricultural practices. Together Canada's agri- environmental programs *Growing Forward 1&*2, legislation such as Alberta's Agricultural Operation Practice Act; and, other regulations and policies jointly aim to facilitate the adoption of agricultural BMPs needed to generate environmental and human benefits. By improving ecosystem outcomes through cattle management, society can reap benefits such as improved human health and better recreational experiences. While there are concerted efforts across Canada's three levels of government to improve the management of livestock grazing to minimize agricultural impacts, the effectiveness of these programs to date is limited. Over the past decades, there is increasing concern over issues of water quantity and quality as agricultural water uses and fertilizer inputs increase due to agricultural expansion (Council of Canadian Academies 2013). However, despite significant investment by the federal and provincial governments in increasing the adoption of beneficial management practices (BMPs), by 2011, only about 15% and 5% of the total Canadian farms and Alberta farms implemented recommended BMPs respectively (Statistics Canada 2013).

1.1.1 Economic Significance of the Beef Industry

Cattle farming is an essential and an important part of Canada's agriculture and economy. In 2016, there were about 193,000 farms in Canada, generating $60.3 billion total farm cash receipts, as shown in Table 1.1. Of this total number of farms, there are 46,538 cattle farms reported in Canada. Of the 46,538 cattle farms, about 36,013 (77.4%) of them are beef cattle ranching and farming operations, producing a total of 12 million cattle and calves. The remaining cattle farms are dairy farms. Based on the 2016 Census of Agriculture, total farm cash receipts generated by agricultural farms were $60.3 billion (Statistics Canada, 2017b). Of this total, $23.9 billion (40%) came from overall livestock and livestock products, with cattle and calves contributing about $9 billion. In the same year, there were about 12.5 million cattle and calves; within this total, 4.7 million were cows, with beef cows contributing 3.7 million (Statistics Canada, 2017b).

Relative to all other provinces, Alberta is the largest cattle producing province. Based on the 2016 Census of Agriculture, Alberta represented 21% of total number of agricultural farms in Canada. Of the 46,538 cattle farms in Canada in 2016, there were approximately 12,693 (27.3%) in Alberta. Further, within the 36,013 farms categorized as beef cattle ranching and farming in Canada, Alberta farms accounted for 34.1%. In the same year, 41.6% of the national total cattle and calves

were reported in Alberta. Within the total cattle and calves in Alberta, 1.65 million were categorized as cows, which accounted for 35.3% of the national total. Of these 1.65 million cows, 1.57 million of them were then categorized as beef cows, which accounted for 42.1% of the national total (Statistics Canada, 2017b). Additionally, the farm cash receipts for Alberta's major agricultural products totaled $13.5 billion, representing 22.4% of the total Canadian farm cash receipts in 2016 (Statistics Canada, 2017b). In the same year, livestock and livestock-related products generated $6.1 billion farm cash receipt in Alberta, accounting for 25.5% in national total. With a high level of cattle-related farms and operations, along with high contributions to GDP, it is noticeable that beef industry is economically significant to Alberta.

Table 1.1 Number of farms, number of cattle and calves and total farm cash receipts in Canada and Alberta in 2016

	Total amount in Canada	Total amount in Alberta	Alberta Percentage in Canada (%)
Numbers of Farms			
Total Number of Farm	193492	40638	21.0
Cattle Ranching and farming	46538	12693	27.3
Beef Cattle Ranching and Farming, include Feedlots	36013	12282	34.1
Dairy Cattle and milk production	10525	411	3.9
Number of Cattle and Calves			
Total cattle and calves (Million)	12.50	5.20	41.6
Total Cows (Million)	4.67	1.65	35.3
Total Beef Cows (Million)	3.73	1.57	42.1
Farm Cash Receipt			
Total Farm Cash Receipt (Billion $)	60.30	13.50	22.4
Total farm Cash Receipt from livestock and livestock product (Billion $)	23.90	6.10	25.5
Total Farm Cash Receipt from Cattle and Calves (Billion $)	8.70	4.58	52.6

Data Source: Statistics Canada 2017b

1.1.2 Alberta's Beef Industry

Alberta's beef operations consist of three main stages: Cow/Calf Operations, Backgrounding Operations, and Feedlot Operations (Koeckhoven 2008; King n.d). A typical beef production sequence is illustrated in Figure 1.1 (King n.d).

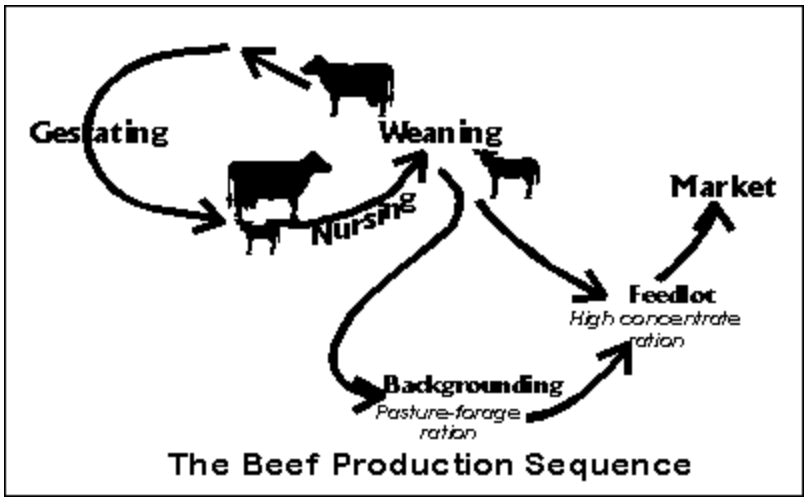


Figure 1.1 The Beef Production Sequence. Source: King (n.d), University of Guelph

Beef production usually begins with cow/calf operations which involve raising calves in pastures until they are ready to be weaned (Koeckhoven 2008; King n.d). According to the Canadian Cattlemen's Association (CCA) (2017a), beef calves are normally born in the spring to match the sprouting period of spring grasses. To ensure the calving period for cows occurs roughly at the same time, the time cows spend with bulls is limited. If cows do not get pregnant during the calving period, they would normally be sold to lower feeding costs (CCA 2017a). After calves are born, they stay with their mothers until they are ready for weaning (CCA 2017a). Based on 2016 Statistics Canada about 2.87 million (or 42%) of the 6.91 million cows in cow-calf operations in Canada, were managed by Alberta cow-calf operators (Table 1.2).

After weaning, calves are sold to backgrounding producers where they are maintained on a high forage diet to ensure sufficient weight gain before they are sold to feedlot operations (Koeckhoven 2008). By the time cattle reach 9 to 11 months, they generally gain sufficient weight, about 900 pounds, to be sent to a feedlot operation. In January and July of 2016 respectively, about 1.66 million and 2.45 million cows were handled in backgrounding operations in Canada. In the same year, there were respectively 0.99 million and 1.41 million cows in Alberta backgrounding operations during the months of January and July (Statistics Canada, 2017b).

Cattle are sold to feedlot operators after they reach 900 pounds. The feedlot is the last step of the beef production cycle which involves feeding the cattle until they reach the desired weight for slaughter (Koeckhoven 2008). Cattle are fed with a high-energy diet for about 60 to 200 days until

they reach this desired weight (CCA 2017b). Their diet is mostly composed of grain to aid in the formation of tender and marbled meat. Table 1.2 shows that the total number of cows managed in Canadian feeding or feedlot operations were 1.39 million in January 2016; this figure increased to 1.55 million in July. In comparison, cows fed in Alberta feeding operations rose from 0.87 million in January to 0.96 million in July (Statistics Canada, 2017b).

Table 1.2 Numbers of cows in three main different operations in Canada and Alberta in January and July 2016

	Canada (million head)		Alberta (million head)	
	January	July	January	July
Cow calf operations	6.91	7.07	2.87	2.86
Backgrounding operations	1.66	2.45	0.99	1.41
Feeding operations	1.39	1.55	0.87	0.96

Data Source: Statistics Canada, 2017b

1.1.3 Potential Environmental Impacts from the Beef Industry

1.1.3.1 Impacts on water quality

While grazing is important to the Alberta economy, cattle grazing could lead to detrimental impacts on the environment in numerous ways. Kauffman et al. (1983) investigated the influences of cattle grazing on streambank erosion in Catherine Creek, Oregon. They found that there was much a higher rate of streambank loss and soil disturbance in grazed agricultural areas compared to non-agricultural land. Similar results were found by Tufekcioglu et al.(2013) in which they tried to explore the degree of streambank erosion and phosphorus runoff as the result of riparian cattle grazing. They conducted their study in three grazed riparian areas in Iowa and compared the changes in soil bulk density, as well as losses in suspended sediment and total phosphorus. They found that higher stocking rates corresponded with higher contributions of: suspended sediment, total phosphorus, and soil compaction in associated water courses. They also suggested that riparian disturbance could be avoided or minimized by applying fencing, or off-stream watering systems.

Lorenz et al. (2011) investigated the impact of livestock manure application on groundwater quality in Alberta. This field project initiated by Alberta Agricultural and Rural Development in 2008, aimed to investigate the effect of 1) manure spreading, and 2) earthen manure storage (EMSs) and CFOs on groundwater in Alberta. In order to capture different regional geological and hydrological conditions in Alberta, these two components were examined in two study sites: the Battersea area in Picture Butte, and, the Lacombe-Ponoka area in central Alberta. Their results

indicated extensive irrigation activities and high density of CFOs have led to increases in concentration of Nitrate N and Chloride in ground water.

1.1.3.2 Impacts on wildlife animals and habitat

Cattle grazing can impact terrestrial and aquatic habitats for birds and animals. For example, intense cattle grazing has been found to negatively affect waterfowl pairs and broods (Harrison et al. 2017). A number of studies investigating the relationship between the intensity of livestock grazing and the abundance of Sage Grouse (*Centrocercus urophasianus*) have shown that intense grazing had a negative impact on the Sage Grouse habitat by directly altering the composition, productivity, and structure of the herbaceous plants in sagebrush plant communities, (Adams et al., 2004; Cagney et al., 2010; Boyd et al., 2014). As grazing intensity increased, *big sagebrush* (*Aetemisia tridentata* subspecies *tridentate)* became more dominant but was not an adequate plant species to support the Sage Grouse foraging needs (Adams et al., 2004). Intense grazing also has also been found to negatively affect the presence of plant residues or litter which protects Sage-Grouse nests and their young from predators (Van Poollen and Lacey 1979; Boyd et al., 2014).

Golding and Dreitz (2017) conducted a study in the Golden Valley and Musselshell Counties in Montana where livestock grazing was the dominant anthropological disturbance. Their study compared the abundance of eight songbird species over a two-year period in fields using rest-rotational grazing systems and traditional season-long continuous grazing systems. Results of the study indicated that season-long grazing management affected abundance of McCown's longspur negatively.

Burrowing Owls (*Athene cunicularia*) and Swift Foxes (*Vulpes velox*) are examples of endangered species that have been detrimentally affected by intense grazing practices. Although Burrowing Owls prefer grasslands grazed by cattle or prairie dogs, the use of pesticides on grazed lands is harmful (Dechant et al. 2002). In addition, the use of insecticides and rodenticides in grassland regions diminishes the owl's food source and imposes additional risks of poisoning (COSEWIC 2017). Similarly, in their examination of population decline amongst closely-related kit foxes (*Vulpes macrotis*), O'Farrell (1983) showed that factors of reduced habitat quality and prey abundance as a result of overgrazing were of concern.

1.1.3.3 Other impacts

Cattle grazing is also known to be a contributor to air quality concerns. Rafique et al. (2012) examined the impacts of grazing on the N_2O[1] dynamics in grasslands in South West Ireland and found that grazing events and grass cutting coincided with higher N_2O emissions. Cattle also produce more GHGs relative to other livestock from their manure and fossil fuel uses on-farm management (McAllister 2017).

Livestock waste also imposes health risks to both animals and humans from associated pathogens. Common pathogens from livestock include *Esherichia coli, Salmonella, Campylobacter* and Yersinia, which cause fever, diarrhea, vomiting, nausea and abdominal pain (Spiehs and Goyal 2007). Improperly managed livestock waste may also give rise to disease from waterborne protozoa (i.e. *Giardia* and *Crytosporidia*) which cannot be easily removed (Spiehs and Goyals (2007).

1.1.4 Research questions and objectives

Agricultural BMP adoption is essential for minimizing environmental impacts from agricultural practices, and for generating additional ecosystem services and social benefits; however, it usually involves financial investment which comes as additional costs for agricultural producers (e.g. Curtis and Robertson, 2003; Lambert et al. 2007; Tilman et al. 2002; Afari-sefa et al. 2008). The purpose of this study is to determine the economic value, or willingness to pay (WTP), for ecosystem services generated by the adoption of BMPs in livestock operations. This study will focus on improvement in water quality associated with the Bow River, the Oldman River, the South Saskatchewan River, and the Milk River, as well as on the maintenance and enhancement of grassland wildlife habitats in southern Alberta, both of which lead to environmental benefits enjoyed by the public. This study will use stated preference methods, which involves the use of focus groups, to assist in the design of questionnaires needed for the collection of valuation information.

The specific objectives of this study are:

[1] N_2O, or Nitrous oxide, is one of greenhouse gases which could results in Ozone destruction as the concentration reaches a certain level (Rafique et al., 2012)

i) to understand the benefits associated with livestock producers changing the way they raise livestock, and the further impact on water quality and wildlife habitat;

ii) to understand the general public's concerns regarding beef production and environmental impacts surrounding water quality and/or wildlife habitat in Alberta;

iii) to generate knowledge that can be used to inform further development of incentive policies in the agriculture sector; and

iv) to generate information that can be used in government reports, such as Bow River Phosphorus Management Plan and the South Saskatchewan Regional Plan.

1.1.5 Organization of the study

Six chapters are included in this thesis. Chapter 1 provides introduction to the Alberta Cattle Industry in terms of potential benefits and impacts. The remaining of the chapter 1 will discuss agricultural BMPs and current environmental programs and regulation to overcome agricultural impacts on environments. Chapter 2 delivers geological characteristics of the study area, the South Saskatchewan Region, as well it discusses the agricultural and the beef cattle industry specific to this region. This chapter also provides an overview of stated preferences, methods, and theory. Chapter 3 presents the development of the survey and the process of data collection. Chapter 4 provides descriptions for the survey data. Chapter 5 discusses the empirical results on public WTP. Chapter 6 ends this study with conclusions, discussions, limitations and suggestions for further study.

1.2 Beneficial Management Practices

1.2.1 BMPs in relation to the cattle industry

Beneficial Management Practices (BMPs) are defined as "any practices that reduce or eliminate environmental impacts" (Alberta Agriculture and Forestry 2010). A few commonly used agricultural BMPs and some of the ecological goods and services that could increase after BMP adoption are shown in Table 1.3. These BMPs include: 1) fencing and off-stream watering; 2) buffers; 3) time and density of stocking; 4) rotational grazing; 5) crop residue management; 6) addition of legumes to fields; 7) habitat conservation and sustainable use of natural areas; and 8) manure management. Potential ecological goods and services after adopting BMPs are also listed in Table 1.3.

1.2.1.1 Fencing and Off-stream Watering

Fencing, excludes cattle from accessing surface water or riparian areas by constructing an exclusion fence. The potential ecological benefits from constructing fencing and/or off-stream watering system are shown in Table 1.3. Miller et al. (2010) investigated the effect of streambank fencing on the environmental quality of cattle-excluded pastures in the Lower Little Bow River in southern Alberta. Their results showed that cattle exclusion fencing successfully reduced the surface runoff and total nitrogen loss through increased vegetation cover, more standing litter, less bare soil, and reduced soil compaction.

Moreover, pathogens and other health risk pollutants from fecal contamination could also be reduced by preventing direct access to water bodies using exclusionary fencing (Collins et al., 2007). A more recent study by Bragina et al. (2017) found that the concentration of *E. coli* was significantly higher in streams without exclusion fencing, and that fencing was effective for mitigating fecal contamination from cattle.

Off-stream watering is a complementary practice that controls animal access to river and stream banks and is usually implemented with streambank exclusionary fencing. Miller et al (2011) investigated changes in water quality in the Low Little Bow River in southern Alberta where three off-stream watering systems were installed from 290m to more than 730m away from river banks. They found significant improvements in riparian health, water quality, canopy cover, and total basal and soil properties after off-stream watering systems were installed. Their findings coincided with the results of earlier studies which attempted to prove the effectiveness of off-stream watering systems both on reducing the time cattle spend at a stream, and on minimizing impacts on riparian and water quality (Sheffield et al., 1997; Clawson 1993; Miner et al., 1992; Godwin and Miner 1996; Platts and Wagstaff 1984). Off-stream watering can also have positive benefits for farmers. For example, Dickard et al. (1998) stated that the weight of cows increased by 25.2 lbs if they were given access to off-stream water sources over a 42-day period;, calves gained 0.31lb/day within the same time-frame. Such result is as well supported by Porath et al (1998) in which that they proved that there could be a possible gain in cattle and calf weight by providing off-stream water sources.

1.2.1.2 Buffer strips

Riparian buffer strips are vegetative areas along water sources designed to prevent the loss or removal of excess amounts of sediment, organic matter, nutrients, chemicals and other pollutants (Hadrich 2012). Maintaining riparian buffers along a river bank help prevent deposition of fecal material into nearby water streams and thus reduce surface runoff (Collins et al., 2007). Young et al.(1980) tested the effectiveness of vegetation buffer strips in regulating contamination from cattle grazing which they concluded that a buffer could successfully results in a reduction in runoff and total solids as well as a reduction in total nitrogen and total phosphorus. Similar results were found by Webber et al. (2010) where they found that reduction in runoff, total solids and NO_3-N increases as the buffer area increases. Wang et al. (2012) studied the effectiveness of utilizing tree and pasture buffers in removing NO_3-N [2] from cattle feedlot in Armadale, Australia using a buffer strip experiment. The targeted buffer strip, at an average slope of 3%, was established below the liquid waste disposal region, and 15 experimental plots were constructed. Their results from water sampling indicated NO_3-N concentrations were reduced by approximately 8.5%, 14.7% and 14.4% for surface runoff, shallow and deep groundwater respectively by tree and pasture buffer strips. These results coincide with results from previous studies which show buffer strips remove runoff from cultivated land leading to improved water quality (Dillaha 1989; Lee et al.,1999; Borin et al.,2005). Buffer strips also reduce microbes and pathogens from fecal deposits of cattle and other animals entering waterbodies (Collins et al., 2007).

Wildlife species also benefit from the utilization of buffer strips. Chapman and Ribic (2002) illustrated the positive relationship between riparian buffer strips and small mammal abundance in southwestern Wisconsin. Cole et al. (2012) tested the impact of riparian buffer strips on biodiversity in livestock grazed grasslands in Scotland. They examined the density of 15 key invertebrates (e.g. spiders, beetles, insects) at 69 riparian sites over a 4-year period and found improvements in invertebrate population, representing more potential preys for bird species, by maintaining riparian buffer strips. Similarly, Westbury et al. (2017) demonstrated the importance of buffer strips in enhancing plant resource abundance for farmland birds.

[2] NO_3-N (Nitrate Nitrogen) may lead to water contamination such as eutrophication and fish poisoning (Wang et al., 2012)

1.2.1.3 Time and Density of Stocking

The timing of grazing and the stocking rate of cattle are critical for minimizing environmental impacts. Stocking density is the relationship between the number of animals and the amount of land being grazed within a specific time period, this is usually expressed as animal units or units of grazed land at a specific time (Allen et al., 2011). McInnis and Mciver (2009) conducted a two-year study in northeastern Oregon to test the impacts of timing on stream banks. Three grazing treatments: non-grazed, early summer grazing and late summer grazing, were compared with stream bank vegetation cover and stability measured prior and after each grazing treatment. They found early summer grazing (around mid-June to mid-July) imposed less damage to streams in comparison to late summer grazing

Van Poollen and Lacey (1979) reviewed the literature on grazing systems and grazing intensity and found a 13% mean annual increase in herbage production when moderate stocking intensity was implemented. If continuous livestock use was reduced from heavy to moderate, and from moderate to light, there were 35% and 27% increases in herbage production respectively. Increases in plant residues and litter also has positive impacts for wildlife. Evans (1986) revealed substantial growth in Sage Grouse populations as grazing intensity was reduced from heavy to moderate and from moderate to light. Waterfowl populations can also be improved by lowering livestock grazing intensity and by grazing cattle later in the season (Harrison et al., 2017).

1.2.1.4 Rotational Grazing

Rotational grazing, which is related to the management of time and density of stocking, is a method of dividing pastures into three or four sections; each section is utilized for a relatively short period of time and then rested until vegetation is fully recovered (Allen et al.,2011). By implementing rotational grazing instead of continuous grazing, fecal coliform counts and turbidity in streams can be reduced (Sovell et al.,2000). Walton et al (1981) compared the impacts of continuous and rotational grazing on animal weight gain for a brome-alfalfa-creeping red fescue pasture at the University of Alberta Range. They found that weight gain from rotationally grazed pasture doubled compared to continuous grazing. Lyons et al. (2000) studied the influences of rotational grazing in Southwestern Wisconsin and found rotational grazing was useful in reducing bank erosion and improving fish populations and water quality. Mundinger (1975) examined the impact of rest-rotation grazing on waterfowl populations in Phillips County, Montana and found a 42% increase

in breeding pairs and a 50% increase in brood production. The positive response of waterfowl to rotational grazing coincides with findings from other studies (e.g. Gjersing 1971; Mundinger 1975).

1.2.1.5 Crop Residue Management

Crop residue management involves incorporating, retaining, removing by burning, baling or using residues as feed or bedding materials for livestock (Kumar and Goh 1999). The management of crop residue is connected with tillage systems. Conventional tillage usually involves residue removal, while conservation tillage (reduced or zero tillage) is associated with residue retention (Turmel et al., 2015). When crop residues are retained on the soil surface the physical, chemical and biological characteristics of soil are enhanced (Wilhelm et al.,2007; Turmel et al.,2015). Fuentes et al. (2009) examined the effects of residue management, tillage systems, and crop rotation on soil quality and crop production in Mexico over a 14-year period. Their results showed that zero-tillage applied with residue retention with either monoculture or crop rotation produced the highest wheat and maize yields, and the best soil quality and soil organic matter. Other studies also found increased crop yields after residue retention (Shafi et al., 2007; Iqbal et al., 2011). In addition, Govaerts et al. (2007) demonstrated that overall biomass and catabolic diversity can be enhanced by implementing a combination of: zero-tillage, crop rotation, and crop residue retention. Retaining crop residue on the soil surface can lead to a decrease in daytime soil temperature (Verhulst et al., 2011). Last but not least, proper crop residue management contributes to improved water quality by reducing water erosion. The implementation of conservation tillage could effectively reduce 90% of wind and water erosion from rainfall as crop residues provide a protective shield over the soil surface (Dickey et al.1981). Residues also lower the rate of water runoff and soil particle loss by forming complex diversion dams (Dickey et al., 1981).

1.2.1.6 Addition of legumes to fields

Addition of legumes to tame pastures, incorporated with crop residue management and rotational grazing, also provides ecological benefits to human and the ecosystem. The most significant benefits from the introduction of legumes toward higher crop yield is the improvement in soil nitrogen content due to nitrogen fixation (Putnam et al., 2001). In their Pakistan study, Shafi et al. (2007) studied the effect of residue management, fertilizer N, and legumes in crop rotation on yields and soil quality. They concluded that legume treatments experienced a 112% and 133%

increase in maize and stover yields respectively, along with 64.6% increases in soil N fertility In addition, researchers concluded that legume species could reduce both wind and water erosion by stabilizing the soil structure (Putnam et al., 2001), and positively assist wildlife animal species by: improving water quality, lowering soil erosion and providing extra food source cover (Jacobs and Siddoway 2007). Legume species can also indirectly improve water quality by lowering the utilization of pesticides and herbicides (Putnam et al., 2001).

1.2.1.7 Habitat Conservation and Sustainable Use of Natural Areas

In the context of agricultural beef production, *habitat conservation* could include protection and restoration of native grasslands and wetlands (McAllister 2017). In their investigation of the correlation between the abundance of songbirds relative to the type of grassland (native and planted) in southern Saskatchewan and Alberta, Davis et al. (2013) found that fluctuations in the populations of songbirds were influenced by the amount and type of grassland. This research showed that the abundance of bird species, such as Sprague's pipit (*Abthus* spragueii) and Baird's sparrow (*Ammodramus bairdii*), increased with the amount of native grassland present. Lower habitat quality in planted grassland was also suggested to be a potential reason for lower songbird abundance. In support of Davis et al.'s claims, a more recent study conducted by Davis et al. (2016) also emphasized the importance of native grassland preservation. This latter research studied the different impact of native pastures and planted grasslands on songbird's and waterfowl's reproductive success rates in southern Saskatchewan, Canada. Their results indicated a positive relationship between native grassland and reproductive success or nest survival for songbirds and waterfowl. For instance, they found that Sprague's Pipit only nested in native grasslands, and that Baird's Sparrow had a 1.4 – 4.5 higher reproduction rate in native pastures. Similarly, AAFC (2015b) proved benefits in biological diversity and reduced fragmentation from wetland conservation.

Hebb et al. (2017) studied the benefits of soil properties from native grassland conservation in Canadian prairies. They compared the soil properties in: native grassland, introduced pasture, and, annual cropland in southern and central parts of Alberta, Canada. Their results indicated that almost all soil properties examined were better in native grasslands and were the poorest in cropland; with the exception of potassium levels which were poorer in native grasslands. Moreover, habitat conservation is also known to bring positive impacts to water quality. Shrestha

et al. (2017) examined the effects of wetland conservation on the nearby stream and water quality in an agricultural watershed in the Mississippi River Basin in southeastern Arkansas, USA. Based on their results, they found improved water quality measures (such as turbidity, total suspended solids, and nutrients) and that overall better stream habitats were found in wetland associated streams, in comparison to cropland associated streams. Likewise, Yang et al. (2008) studied the water quality benefits from wetland conversation and restoration in the Broughton's Creek watershed in Manitoba using the Soil and Water Assessment Tool (SWAT) modeling. Their results demonstrated a progressive reduction in total phosphorus and total nitrogen levels in water streams as the level of wetland conservation and restoration increased.

1.2.1.8 Manure Management

Manure management mainly involves managing the storage and application of manure, controlling manure run-on/run-off, and odor, and reducing manure nutrient content (Beaulieu 2004). By adopting a carefully designed manure management plan, manure-borne phosphorus runoff can be reduced (Sharpley et al., 2004) thereby improving water quality. Manure management can also lead to better surface and groundwater quality by reducing nutrient and other particular runoff from manure (Beaulieu 2004). With precise management, manure application on farm fields would benefit the soil. Moshia et al. (2015) tested the influence of variable-rate application of cattle manure on soil quality from an experiment strip located in northeastern Colorado, USA. Their results suggested a significant increase in soil organic matter, surface soil water-holding capacity, as well as soil electrical conductivity. Hence, soil quality can be enhanced by implementing precise manure application methods. Moreover, pathogens and bacteria from cattle excrement are easier to control if manure management is implemented (Walker et al., 1990). Using Monte Carlo simulation models incorporating rainfall and temperature variations, Walker et al. (1990) concluded that both long-term manure storage, and incorporation of manure were effective in lowering the livestock-induced bacterial level in streams.

Holly et al. (2017) investigated the effect of anaerobic digestion (AD), solid-liquid separation (SLS) and the combination of AD+SLS on GHG and NH_3 (ammonia) emission. When analyzed alone, the application of AD significantly lowered 25% of the total CH_4 for storage, and the implementation of SLS significantly reduced 46% of CH_4 (methane) from storage. If SLS was applied after digestion, there would be an additional 43% reduction in CH_4. Similarly, Cambareri

et al. (2017) tested the impact of timing and method of manure application on annual nitrous oxide emissions in Elora, Ontario, Canada. The three manure application methods studied were: surface broadcasting, incorporation, and, injection; the application time was controlled to spring and fall. Their results suggested that manure application methods influenced the N_2O released into the air and that incorporating manure was the best practice among the three practices tested.

Table 1.3 Commonly used agricultural beneficial management practices (BMPs) and the corresponding ecological goods and services provided by their implementation

BMPs	Ecological goods and services after adopting BMPs
Fencing and off-stream watering	1. Improved water quality (Sheffield et al., 1997; Miner et al., 1992; Clawson 1993, Godwin and Miner 1996; Miller et al., 2010; Bragina et al., 2017) 2.Improved riparian habitats and fish population within and around waterways (Platts and Wagstaff, 1984; Collins, 2007; Miller et al., 2010; Miller et al., 2011) 3. Improved cow and calf weight (Porath et al., 1997; Dickard et al., 1998) 4. Controlled pathogen in water bodies (Collins, 2007)
Buffers	1. Improved water and soil quality (Collins, 2007; Young et al., 1980; Dillaha 1989; Lee et al.,1999; Borin et al.,2005; Webber et al.,2010; Wang et al.,2012) 2. Additional wildlife habitat (Cole et al., 2012; Westbury et al.,2017) 3. Controlled pathogen in water bodies (Collins, 2007)
time and density of stocking	1. Improved vegetative cover (Van Pollen and Lacey, 1979) 2. population growth for animal species (Harrison et al., 2017; Evans, 1986) 3. Reduced soil erosion (McInnis and McIver, 2009)
Rotational Grazing	1. Improve riparian health and water quality (Olson et al., 2011; Sovell et al.,2000) 2. Improve Soil quality (Lyons et al., 2000) 3. Improved fish population (Lyons el al., 2000) 4. Improved waterfowl population (Mundinger 1976; Gjersing 1971)) 5. Improved animal weight (Walton et al., 1981)
Crop residue management	1. Improved water quality due to minimized risk of erosion (Dickey et al., 1981) 2. Improved crop yield (Fuentes et al.,2009; Iqbal et al., 2011; Shafi et al., 2007) 3. Enhanced Soil quality (Fuentes et al., 2009; Wilhelm et al.,2007; Turmel et al.,2015; Govaerts et al. 2007)
Addition of legumes	1. Protect water from by lowering the use of pesticides and herbicides (Putnam et al., 2001) as well as reduced erosion ((Jacobs and Siddoway 2007)) 2. Improved crop yields (Shafi et al., 2007) 3. Improved soil quality (Putnam et al., 2001) 4. Benefits to wildlife animals ((Jacobs and Siddoway 2007))
Habitat conservation and sustainable use of natural areas	1. Increased soil properties (Hebb et al., 2017) 2. Improved wildlife habitat for animals such as songbird and waterfowl abundance and population (Davis et al. 2013; Davis et al.,2016) 3. Better water quality and stream habitat (Shrestha et al.,2017) 4. Reduced fragmentation and improved biodiversity (AAFC 2004) 5. Improved wetland and grassland (McAlister 2017)
Manure management	1. Preventing runoff and protect surface and ground water (Beaulieu 2004) 2. Improve soil quality (Moshia et al., 2015; Walker et al., 1990) 3. Reduced GHG and NH_4 emission (Cambareri et al., 2017; Holly et al., 2017)

1.2.2 Challenges with BMP adoption

Despite the environmental benefits from adopting BMPs, and in some cases private economic benefits, the adoption rate is not particularly high in the beef industry. Gillespie et al. (2007) surveyed beef producers in Louisiana to identify reasons for non-adoption of BMPs. They examined 16 commonly used BMPs including: erosion and sediment control; grazing management; mortality, nutrient and pesticide management. The potential reasons for non-adoption included: "unfamiliarity"; "high cost"; "non-applicability to the operation"; "still considering adoption", and, "prefer not to adopt". The found "non-applicability" and "unfamiliarity" were the main reasons BMPs were not adopted. However, Gillespie et al. (2007) found that in some case producers thought a BMP was not applicable because they did not have the knowledge to understand the benefits of its adoption. The second most chosen reason for non-adoption was unfamiliarity with BMP, which suggests need for education and extension.

Costs incurred by producers during the design, implementation, and management of BMPs are impediments to implementation (Curtis and Robertson 2003; Lambert et al., 2007; Tilman et al., 2002; Afari-sefa et al., 2008). Afari-sefa et al. (2008) investigated the adoption cost associated with two structural BMPs (livestock exclusion fencing and storm water diversion drainage system), and one non-structural BMP (nutrient management planning), in Thomas Brook Watershed, Nova Scotia. The authors accounted for implementation costs, labor costs, technical consultancy fees, maintenance costs as well as opportunity costs. They found that the total cost to establish a 75-meter-long exclusion fence, with an approximately 20-year lifespan, would be $3136. Of this cost, about 47% was for fence construction (including material cost), and 32% was attributed to labor and consultancy costs. The remaining cost covered maintenance and opportunity cost factors. In comparison, the total cost of adopting a storm water diversion drainage system was more than double, at $6755. More than half (60%) of the total cost of storm water diversion drainage system was spent on professional and technical consultancy fees prior to construction as well as labor costs.

Yang et al. (2012) estimated the costs associated with adopting vegetative buffer zones in the Lower Little Bow Watershed in Alberta, Canada. Based on a baseline cow-calf operating farm in the study area, a dynamic Monte Carlo simulation was used to simulate 4 different BMP scenarios: vegetative buffer without and with fencing, and, permanent cover with vegetative buffer without

and with fencing. The simulated annual net cost for BMP scenario 1, where cattle were allowed to graze within the buffer zone, was $57 - $100 per acre. When the cattle were excluded from the vegetative buffer (BMP 2), the annual cost increased to $215 - $620, depending on the buffer width. While additional permanent vegetative cover, converted from crop production land, was introduced the annual net cost increased to $80 - $315, and $153 - $666 for BMP 3 and BMP 4 respectively.

A more recent study conducted by Bruce (2017) also investigated the cost of BMP adoption in Southern Alberta using the dynamic Monte Carlo cash flow simulation analysis. A representative southern Alberta farm was used for raising a 160 cow beef herd on roughly 656 acres of tame pasture and 2130 acres of native pasture; while producing crops such as spring wheat, barley, canola, alfalfa/grass mix hay on 2000 acres of cultivated land. Simulations of a baseline model and BMP adoption scenarios were analyzed based on historical crop, beef prices, and crop yields. The baseline scenario, where none of the BMPs were assumed to be adopted by the producer, was used in comparison with BMP adoption scenarios to indicate changes in net present values from adoption. The targeted BMPs in this study included: 1) manure management, 2) crop residue management, 3) rotational grazing, 4) conservation of natural areas, and 5) enhancing tame pasture productivity through the incorporation of legumes. The results indicated small positive net benefits, about $1.50 - $2.00 per acre annually over the entire cropped region for only manure management and crop residue management BMPs, while other BMPs generally brought mixed or negative financial impacts to producers.

Based on the examples above, one can conclude that a profit-maximizing producer would be unlikely to implement a BMP without government support even if they understood the possible environmental benefits from adopting the BMP.

1.2.3 Ecosystem services and Linkage between BMPs, Ecosystem services and human benefits

Ecosystem service (ES) is defined as the "component of natural, directly enjoyed, consumed, or used to yield human well-being" (Boyd and Banzhaf 2007). In their definition, ES is not the benefit directly obtained by humanity from nature, but rather the ecological components which *directly* generate human well-being. The first critical aspect of this definition is the concept of intermediate and final goods. By indicating that a service must be "directly enjoyed, consumed, or used" in order to be considered as an ecosystem service, solves the issue of double-counting. The

example illustrated by Boyd and Banzhaf (2007) was clean water drinking. Clean water would be directly consumed by humans; hence, it would be considered as the end-product, or the act of clean water drinking itself is the ecosystem service provided by the ecosystem. However, before the final ES is utilized by humans, there will be many intermediate ecological goods introduced into the system (such as lowered phosphorus and nitrogen levels) after adopting nutrient management as a BMP. The lowered phosphorus and nitrogen content, although ultimately leading to clean drinking water, would be considered as intermediate ecological goods since there will be no direct human consumption involved. Besides the distinction between intermediate and final ecosystem services, Boyd and Banzhaf (2007) also emphasized the difference between benefits and final ecosystem services. Using clean water as an example, human health and safety will be considered as the benefits to humans from drinking clean water while the clean water itself is considered as one of the potential ecosystem services from water quality management.

BMP adoption will generate ES as well as benefits to human. Figure 1.2, which is adapted from the study conducted by Jeffrey et al. (2012), illustrates examples of BMPs and associated ES plus human benefits based on Boyd and Banzhaf's definition of ES. For instance, the establishment of buffer strips could improve wildlife habitats around water banks, and the resulting ES would be increased wildlife populations which provide recreational benefits to society. Similarly, a reduction in water contamination, as a result of manure management, would lead to water quality improvement and thus an enhancement of human safety.

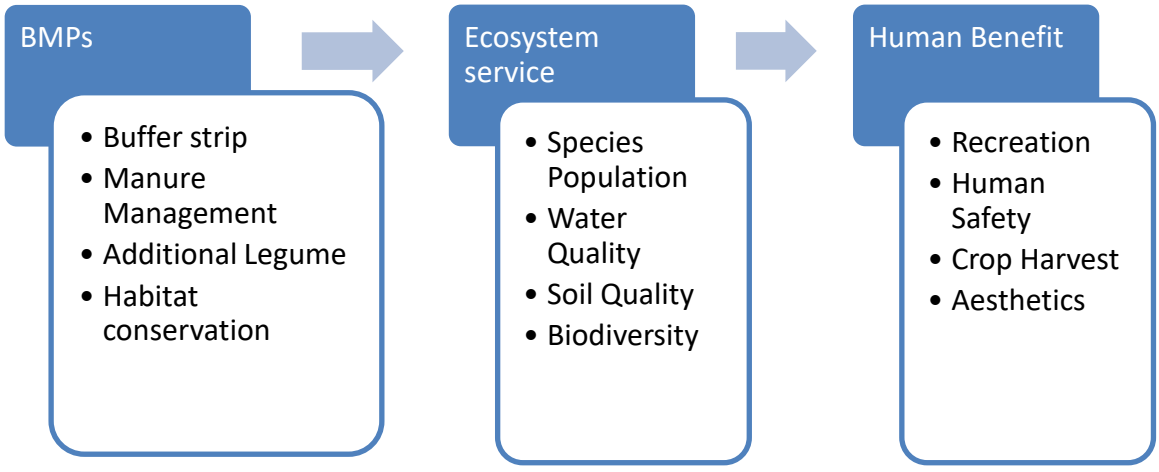


Figure 1.2 Agricultural BMPs, Ecosystem services and Human Benefits

Table 1.4 BMPs and associated Ecosystem services and Benefits

BMPs	Ecosystem service(s)	Human Benefit(s)
Fencing and off-stream watering	Clean Water Healthy Soil Species Population Biodiversity	Human safety Recreation Aesthetic Passive and existence value Livestock production Lower environmental damage recovery cost
Buffers	Clean Water Species Population Biodiversity Healthy Soil	Human safety and Health Recreation Farming safety Higher income for producers Passive and existence value Lower environmental damage recovery cost
Time and Density of Stocking	Species Population Healthy Soil Biodiversity	Passive and existence value Higher income Livestock production Aesthetic Passive and existence value
Rotational Grazing	Healthy Soil Species Population Clean Water Biodiversity	Human Safety and Health Recreation Crop harvest Aesthetic Higher income for producers Passive and existence value
Crop residue management	Healthy Soil Species Population Clean Water Biodiversity	Crop Harvest Recreation Human safety Aesthetic Passive and existence value Crop harvest
Addition of legumes	Healthy Soil Clean Air	Crop harvest Human safety Higher income for producers Crop harvest
Habitat conservation and sustainable use of natural area	Biodiversity Habitat conservation Clean Water Species Population Healthy Soil	Aesthetic Passive and existence value Recreation Human Health
Manure and fertilizer management	Clean Water Air Quality Healthy Soil	Human Safety Crop harvest

Based on the ecological goods and services from the BMPs summarized in Table 1.3, and incorporated with Boyd and Banzhaf's definition of ES, the ES and human benefits from adopting agricultural BMPs are summarized and listed below in Table 1.4. Not surprisingly, there are typically several ecosystem services associated with adoption of a single BMP. For example, as discussed in the previous section, the adoption of fencing and an off-stream watering system could prevent water contamination, improve riparian and soil health, and advance fish populations. Therefore, the ecosystem services we can obtain from adopting fencing includes clean water and healthy soil. The human benefit of clean water acquired from implementing fencing and off-stream watering systems could include: human safety and health, recreational benefits. It is noteworthy that different ecosystem services can contribute to the same human benefit. For example, clean water and increases in species populations and biodiversity can lead to improvements in recreational experiences.

Additionally, one ES could bring several human benefits. In the example of clean water, which is an ES, additional benefits include improved recreation experiences specifically in the areas of angling or boating. Other human safety contributions from utilizing clean water include lower pathogens and nutrient runoff. Moreover, clean water also could contribute to aesthetic, passive or existence values. Similarly, the same logic was applied for the remaining BMPs, and the resulting ecosystem services and human benefits are summarized in Table 1.4.

1.3 Environmental programs, regulations and policies

1.3.1 Agricultural Policy Framework and Growing Forward Framework

The most widespread agricultural program in Canada is the Agricultural Policy Framework (APF). It started as a five-year agricultural agreement framed and signed by the federal, provincial and territorial governments in 2003. Components of framework aim to achieve environmentally friendly and responsible agricultural production (AAFC 2005; Finnigan, 2017). The first APF running from 2003 to 2008 consisted of 5 major components: 1) Business Risk Management (BRM) Programs; 2) Environment Program; 3) Food Safety and Quality Programs; 4) Science and Innovation programs, and 5) Renewal and International Programs.

The environmental programs provided under the APF were further divided into Environmental Farm Planning (EFP), National Land and Water Information Service (NLWIS), National Agri-Health Analysis and Reporting Program (NAHARP), and, National Farm Stewardship Program

(NFSP). There were also environmental programs provided in provincial and territorial levels such as the Canada-Alberta Farm Water Program and the Canada-Alberta Irrigation Rehabilitation Program Agreement.

The EFP is a national initiative that "encourages producers to develop farm plans, implement beneficial management practices and continuously evaluate their environmental performance" (AAFC 2005). Agricultural producers who have participated in the EFP would take the voluntary and confidential actions to evaluate the potential environmental benefits and risks from their operations, and, to develop an action plan to alleviate the threats. All agricultural producers are eligible for applying to and joining the EFP program; further, accepted participants would get financial assistance through NFSP or other government programs to implement BMPs identified in their action plans. The purpose of the NFSP was to stimulate BMP adoption in Canada by providing a cost-share incentive (AAFC 2005). After producers signed into the EFP or an equivalent agri-environmental plan (EAEP), they would be eligible to apply for financial support to alleviate the costs in adopting BMPs.

The NLWIS provides assistance in land-use decision making by providing easy access to comprehensive geospatial information and interpretive models (AAFC 2005). By increasing the accessibility of information on land, soil, water, air, climate and biodiversity to the land users, the agricultural sectors and government as well as the general public, better land-use decisions could be made to ensure economic benefits while protecting the environment. The NAHARP is an internal AAFC program that develops and reports on a detailed set of agri-environmental indicators to track changes in environmental impacts from agricultural production. Overall, those national environmental programs worked together to reach the goal of minimizing on-farm environmental risks.

By 2008, the APF evolved into the *Growing Forward Framework* (Finnigan 2017). The framework immediately following the APF was called Growing Forward 1 (GF1). GF1 was effective from 2008 to 2013. This was succeeded by the current, or the third, agricultural policy framework, Growing Forward 2 (GF2). In Alberta three main stewardship programs were included in GF1, namely: integrated crop management, grazing and winter-feeding management, and manure management. Similarly, there were three major stewardship programs provided under GF2 in Alberta: on-farm stewardship program, confined feeding operation program and agricultural

watershed enhancement (Boxall 2018). On-farm stewardship programs, which include grazing management, manure and livestock facilities management, pesticide management, as well as fuel and used oil storage management, aim to mitigate and lower the agricultural impact on water quality and promote inorganic agricultural wastes (AAFC 2005). Confined feeding operation stewardship programs include BMP programs to help livestock producers and confined feeding operators minimize potential water quality risks from manure application (AAFC 2005). Agricultural watershed enhancement program (AWEP), which involved riparian and wetland enhancements, and other watershed management projects, was implemented with the intention to improve water quality (AAFC 2005). Unlike on-farm stewardship program, and confined feeding operation, AWEP does not requires applications to hold an EFP.

Table 1.5, adapted from Boxall (2018), illustrates the BMPs, cost share, and funding maximum for the Alberta Growing Forward 2 Environmental Stewardship Programs. Under the on-farm stewardship programs, the cost share was highest at 70% for BMP projects related to riparian area fencing, wetland restoration, and agricultural plastic waste management. While the cost share was 50% for all other projects under on-farm stewardship program. The funding maximum under on-farm stewardship programs ranged at the highest at $50,000 for BMP projects on riparian fencing and management, wetland restoration, livestock facility runoff control, and wintering site relocation. It was lowest for projects on used oil storage management, where the funding maximum was only $2,000. In the case of the confined feeding operation stewardship program, the highest funding maximum ($100,000) would be approved if the program involved relocation of confined feeding operations (feedlots). The funding herein was lowest ($10,000) for projects related to surface water management system construction or for upgrading and construction for the purpose of meeting *Agricultural Operation Practice Act* standards. The government cost-share scheme for most of the confined feeding operation stewardship projects was 50% and could have increased to 70% for confined feeding operation relocation projects or engineering investigations and/or feasibility assessment projects.

Table 1.5 Beneficial Management Practices, government Cost Share, and the maximum funding amount in the Alberta Growing Forward 2 (2013-18) Environmental Stewardship Programs

BMPs in Growing Forward 2	Government Cost Share (%)	Category Maximum
On-Farm Stewardship Program		
Category A: Grazing Management		
Riparian Area Fencing and Management	70	$50,000
Year-Round/Summer Watering Systems	50	$30,000
Wetland Restoration	70	$50,000
Shelterbelt Establishment	50	$10,000
Category B: Manure and Livestock Faculties Management		
Livestock Facility Runoff Control	50	$50,000
Livestock Facility and Permanent Wintering Site Relocation	50	$50,000
Category C: Crop Input Management		
Improved Pesticide Management	50	$10,000
Improved Nutrient Management	50	$15,000
Category D: Agricultural Waste Management		
Used Oil Storage	50	$2,000
Agricultural Plastic Waste Management	70	$5,000
Confined Feeding Operation Stewardship Program		
Engineering Investigation and/or feasibility assessment	70	$15,000
Construction or upgrade of a surface water management system	50	$10,000
Livestock facility reconstruction to meet current AOPA standards for liners	50	$10,000
Improved Manure Storage Facility	50	$50,000
Relocation of a Confined Feeding Operation	70	$100,000
Manure Treatment - Solid/liquid Separation System	50	$50,000
Manure Treatment - Composting	50	$30,000
Improved Land Application of Manure	50	$70,000

1.3.1.1 BMP adoption and the Environmental Farm Plan (EFP)

To collect information about EFP enrolments and environmental management on Canadian farms, a voluntary telephone survey, the *Farm Environmental Management (FEM) Survey*[3], was conducted. Partial results of the 2011 FEM were shown in Table 1.6. By 2011, 35% of the Canadian farms had a formal EFP. Of the total Canadian farms that had an EFP, approximately 43% full implemented the BMP recommended in EFP. However, there were 57% of the farm did

[3] the *Farm Environmental Management Survey is conducted every 5 years; however, the FEM 2016 data is still unavailable*

not or only partially implemented BMPs. Almost four out of ten farms in Canada had received financial assistance to implement the beneficial management practices included in their EFP.

In comparison, roughly one fourth of the Alberta farms had an EFP in 2011. Within those farms with an EFP, only one fifth fully implemented BMPs, while the remaining farms either only partially (73%) or did not (6%) implement the recommended BMPs. Additionally, only 66% of Alberta farms with an EFP had obtained financial assistance for BMP adoption.

The potential reasons for not adopting BMPs were also captured by the 2011 FEM, and are summarized in Figure 1.3. There were 3 main reasons identified: lack of time, lack of information or don't accept recommendations, and, economic pressures. Overall, the main reason that stopped agricultural producers from implementing BMPs was economic pressures (55%).

The overall 2011 FEM Alberta results indicated a low participation rate for the EFP, full BMP implementation, and financial assistance; however, there is room for improvement in the future if economic pressures can be overcome.

Table 1.6 Percentage of EFP participation, BMP adoption, and Financial assistance in CANADA and Alberta, in 2011

Categories		Canada (%)	Alberta (%)
Percentage of farms with an EFP	Yes	35	23
	Under development/review	3	1
	No	60	73
BMPs on Canadian/Alberta farms[1] with an EFP	Full implemented	43	20
	Partially implemented	52	73
	Not implemented	5	6
Financial assistance for implementing BMPs on Canadian/ Alberta farms[1]	Yes	39	34
	No	60	66

Data source: Statistics Canada, 2011 FEM

Note 1: Excludes farms that do not have either an established environmental farm plan, or an environmental farm plan that is under review

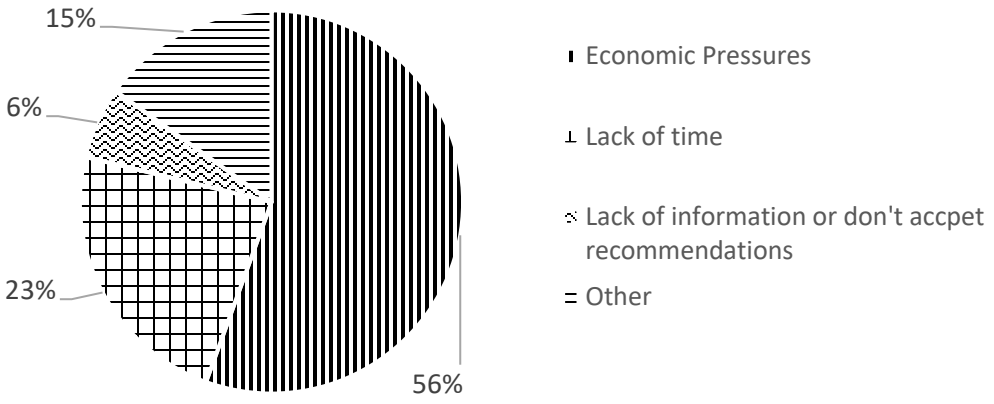


Figure 1.3 Reasons for not adopting BMPs, 2011 Canada

1.3.1.2 Adoption of Beneficial Management Practices under the Growing Forward Framework

Many producers voluntarily implemented BMPs in order to manage the impacts of their operations on the environment. Government and non-government programs provide information and funding to producers to encourage additional BMP adoption. Within the South Saskatchewan Region in Alberta, there were around 3130 livestock operations reported over the period of GF1 and GF2. The top six adopted livestock BMP projects in the South Saskatchewan Region from 2010 to present are listed in Table 1.7. Similar BMP projects in GF1 and GF2 are lumped together. The most adopted BMP from 2010 to present were portable shelters and windbreaks (which move cattle around pastures), and enhanced grazing management. Watering systems were the second most adopted BMPs, which moved cattle away from natural water bodies. Other BMPs such as riparian area fencing and management, fencing to enhance grazing, manure application management, and nutrients management were also well adopted.

Table 1.7 Six most adopted beneficial management practice in Alberta South Saskatchewan Region from 2010 to present

Project	Counts
Portable Shelters and wind breaks	175
Watering systems	156
Riparian area fencing and management	60
Fencing to enhance grazing	35
Improved application of manure	35
Improved management of nutrients from manure	21

Data Source: AAFC GF1 and GF2 Data and Dollars, from Scott McKie

The Federal and Provincial governments provide financial support to producers who adopt BMPs through the *Growing Forward Stewardship Programs*. Through these *Growing Forward*

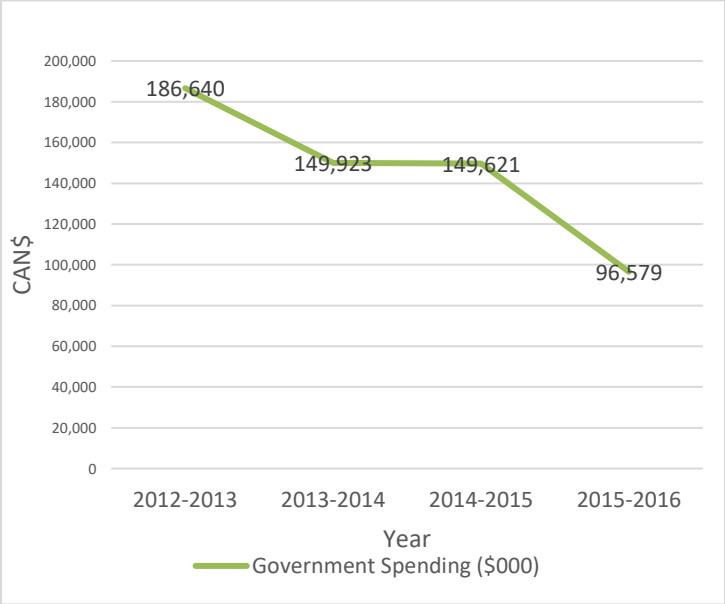
Programs, the Government of Alberta spent $4 million on 380 livestock BMPs from 2013 to present, and $3.1 million on subsidizing 256 livestock BMPs between 2010 and 2013 (Table 1.8).

Table 1.8 BMP numbers and government spending in Alberta South Saskatchewan Region, 2010 to present

South Saskatchewan Region	Number of livestock operations in SSR	Number of livestock-related BMP projects	Percentage of all BMP projects funded	Total $ spent on livestock BMPs
2010 – 2013	3130	256	62%	$3.10 million
2013 - present	3130	380	75%	$4.00 million
Total	3130	636	69%	$7.10 million

Data source: AAFC GF1 and GF2 Data and Dollars, from Scott McKie

The federal, provincial and territorial governments provide support to producers so they can improve farming and operational practices needed to mitigate negative environmental impacts. However, the annual amounts invested from 2012 to 2016 have declined. The total governmental spending related to environment in support of the agri-food sector is shown in Figure 1.4(left). Nationally, federal government spending on agri-environmental programs dropped from $186.64 million in 2012 to $96 million in 2016. Within the same timeframe, Alberta levels of investment also declined, dropping from $39 million in 2012 to about $25 million in 2016 (Figure 1.4(right)).



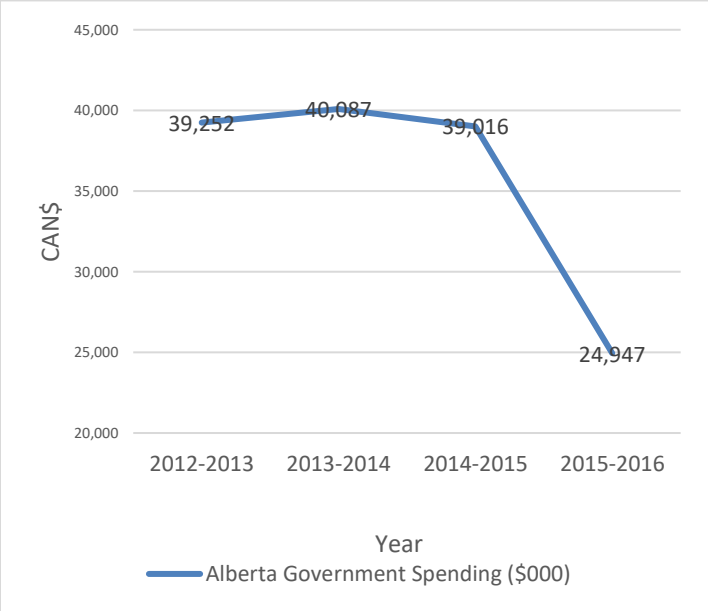


Figure 1.4 (left) Total Canadian government spending related to environment in support of the Agri-food sector from 2012 to 2016; (right) Total Alberta government spending related to environment in support of the Agri-food sector from 2012 to 2016

1.3.2 Agricultural Operation Practice Act Legislation

The Agricultural Operation Practice Act (AOPA) is provincial legislation which sets out manure application standards for Alberta's agricultural producers (AAF n.d). It applies to anyone who produces, transports, receives or applies livestock manure, such as livestock and crop producers (AAF n.d). AOPA is maintained by Alberta Agriculture and Forestry (AF) and enforced by the Natural Resource Conservation Board (NRCB). After producers apply for AOPA permits, NRCB approval officers will process the applications and issue permits once approved. Three different permits can be issued by the NRCB: *Registrations* are permits for smaller CFOs, *Approvals* are permits for larger CFO, and, *Authorizations* are permits for construction of manure storage facilities or manure collection areas. AOPA also sets out a series of standards for manure application, which are shown in Table 1.9.

Table 1.9 A list of Manure application rules under Agricultural Operation Practice Act (AOPA) legislation

Manure Application Rules	Details
Incorporation requirement	Solid and liquid manure applied to land under traditional cultivation must be incorporated within 48hrs to reduce odors. Exception if the manure is applied to forage, direct-seeded crops, frozen or snow-covered land or the permits set out different requirements
Minimum Setback Distance for Manure that is applied and incorporated	Manure cannot be applied within 30 meters of a water well, 10 meters of a common body of water in the case of subsurface injection, or within 30 meters of a common body of water if manure is surface-applied and incorporated within 48 hrs.
Minimum Setback Distance for manure applied on forage, direct-seeded corps, and frozen or snow-covered land	30 m for 4% or less average slope within 90 meters of a common body of water; 60m for greater than 4% but less than 6% average slope within 90 meters of a common body of water; 90m for greater than 6% but less than 12% slope within 90 meters of a common body of water. If the slope is greater than 12%, manure cannot be applied.
Nitrate-nitrogen limits	Nitrate-nitrogen limits are determined based on different soils type, soil texture and depth to water table, which range from 80 kg/ha for coarse textured brown soils to 270 kg/ha for medium and fine textured irrigated soils
Salinity constraints	Manure cannot be applied at rate that would result in a one Deci-siemens/meter (dS/m) increases in EC in the top of 6 in of soil, and cannot be applied when the EC of the soil in the top 6 in in larger than 4 dS/m
Nutrient management plan	Not mandatory unless the applicants wish to exceed the nitrate-nitrogen or salinity limits
Manure handling plans	Applicants who apply for CFO permit can submit a manure handling plans to reduce or eliminate the need to meet the manure application and storage requirement under AOPA

Source: Alberta Agriculture and Forestry, n.d

1.3.3 The Water Act and the Water for Life Strategy

There are also strategies and legislation focusing on water resource management which concerns Alberta cattle producers. The Alberta *Water Act* is provincial legislation that came into force in 1991 and involves the efficient use and allocation of water resources. It not only provides a standard for provincial water use allocations among different water users and water-related activities, but also encourages water quality management by demanding a provincial water management plan (AEP 2018). Built upon the general directions from the *Water Act,* the Alberta provincial strategy, *Water for Life* provides goals and direction for effective water resources management (AEP 2003). It was released in 2003, renewed in 2008, and has been providing water management policy support ever since.

Three goals are emphasized under the *Water for Life* Strategy. The first goal is to protect drinking water safety by implementing actions such as improving current drinking water systems, and developing further waterborne disease research. The second goal is to maintain and improve Alberta's aquatic ecosystems, such as rivers, lakes and wetlands. This is to be achieved by adopting measures including protecting critical aquatic ecosystems and by implementing new wetland conservation policies. Lastly, *Water for Life* strategies also strives to ensure a long-term reliable and quality supply of water. In addition to the abovementioned goals, there are also three key directions established under the *Water for Life.* These directions include: 1) ensure Alberta residents have required knowledge to achieve the goals of safe drinking water and healthy aquatic ecosystem; 2) to make sure *Water for Life* partners are actively involved in the watershed stewardship; and 3) to improve Albertans' awareness regarding water-related impacts from their actions, and to encourage water conservation (AEP 2009).

To review the progress of the actions set by out *Water for Life*, the Alberta Water Council (AWC) was established. Results from AWC's *Review of Implementation Progress of Water for Life, 2012-2015* on the total numbers of actions for each goals and direction, as well as their progress by 2015, are listed in Table 1.10. Overall, four actions, or 13% of the total number of actions, set out by the *Water for Life* strategy have been completed by 2015, 10 actions were progressing on track, and 13 actions were making considerable of progress. The direction with the best progress is *safe secure drinking water*, where one of the actions had been completed and six additional actions were progressing successfully.

Table 1.10 Progress on Water for Life actions and key directions

Progress of the Actions / Goals or Key Direction	Being re-evaluated	Actions making limited progress	Actions making some progress	Actions progressing on track	Action completed	Total Number of actions for each goal and key direction
Safe secure drinking water	0	0	2	6	1	9
Healthy aquatic ecosystems	0	2	1	0	2	5
Reliable quality water supplies	0	0	3	1	0	4
knowledge and research	0	0	3	1	0	4
Partnerships	0	1	4	0	1	6
Water conservation	1	0	0	2	0	3
Total number (percentage) of actions	1 (3%)	3 (10%)	13 (42%)	10 (32%)	4 (13%)	31

Note: Adapted from *Review of Implementation Progress of Water for Life, 2012-2015, Alberta Water Council*

1.3.4 Non-governmental Organization Programs

1.3.4.1 Alternative Land Use Services

In addition to government programs and legislation, there are some non-government organizations (NGOs) that have policy and program initiatives dedicated to improving environmental conditions associated with agricultural production. One such NGO is Alternative Land Use Services (ALUS) which is a "community-developed, farmer-delivered" organization, active in Alberta, Saskatchewan, Manitoba, Ontario, P.E.I, and Quebec. It involves a voluntary program that provides financial and technical support to farmers, ranchers and producers, aiming to maintain and improve the sustainability of agriculture, wildlife and natural areas (ALUS Canada 2018b). After over a decade of collaboration with agricultural producers, governments and other environmental groups, there are currently 21 ALUS communities; 575 farmers and ranchers participating in ALUS programs, and contributions of 15 thousand acres of wetland ecosystems, 13 thousand acres of pollinator habitat, and 3,637 acres of land reforested with native trees and shrubs by March 31, 2018(ALUS Canada 2018a). ALUS programs involve agricultural producers and local stakeholders forming a Partnership Advisory Committee (PAC), along with a local ALUS Coordinator to develop program details. After producers express interest in ALUS projects and complete interest forms, ALUS coordinators would visit the operations and provide potential project opportunities. The ALUS Coordinator would then create a project proposal and present it

to the PAC for review and approval. Once the proposal is approved, a flexible 5 to 10-year term agreement will be provided to the producers with the option to renew or to opt out (ALUS Canada 2018b).

In general, ALUS provides a cost-share incentive scheme for farmers to take part in the programs. The philosophy involves producers finding other ways to generate income from marginal farmland they may hold, and in doing so maintain sustainability and generate ecosystem services. In addition, there are annual payments for conserved land. Table 1.11 illustrates the cost-shares and annual payments for a representative 5-year exclusion fencing project in Brazeau County, Alberta, adopted from the 2017 Brazeau County ALUS PAC meeting report (ALUS Canada 2017).

Table 1.11 Cost-share and Annual payment for a 5-year exclusion fencing ALUS in Brazeau County, Alberta

Project	Details	Cost Estimates	ALUS Portion	Annual Payment
Exclusion Fencing	Materials and Labour	$6,029.68	$3,014.84	N/A
Riparian Area Enhancement	16.3 acres	N/A	N/A	16.3acres * $37.5 = $611.25
Wetland Enhancement	0.79 acres	N/A	N/A	0.79 acres *$20 = $15.80
Total	17.09 acres	$6,029.68	$3,014.84	($611.15+$15.8)* 5 year = $3.135.25

Source: ALUS, 2017

Typically, ALUS projects would provide a 50/50 cost share for construction of exclusion fencing. In the case above, ALUS could help to cover $3 thousand, or 50%, of the material and labour cost for building exclusion fencing on the targeted areas. Additionally, ALUS also provides an annual payment for every acre of land conserved, namely $37.5/acre for riparian areas and $20/acre of wetland for this 5-year project.

1.3.4.2 Ducks Unlimited Canada (DUC)

Ducks Unlimited (DU) is a non-profit, non-government organization committed to “conserve, restore and manage wetland and associated habitats for North America’s waterfowl” (Duck Unlimited, 2018). As in 2018, habitat conservation programs delivered through close cooperation between DU, landowners and agencies conserved about 6.5 million acres in Canada, and approximately 14 million acres of land in North America. In Canada, conservation programs are carried out by the sister organization, Ducks Unlimited Canada (DUC). Ever since 1938, when the

first DUC project took place, DUC has completed over 10 thousand projects and has imposed positive influences on more than 166 million acres of habitats (DUC 2018). In Alberta, there are over 2,000 DUC habitat conservation or restoration projects, covering a total of 2.3 million acres of Alberta land. In Table 1.12, an overview of a list of DUC programs is illustrated. Those programs facilitate the wildlife habitat conservations and restorations which bring benefits to not only waterfowls but also to wetland, grassland, water, wildlife.

Table 1.12 A list of environmental programs offered by Duck Unlimited Canada

DUC Programs	Region (s)	Details
Wetland Restoration	AB, BC, MB, NB, NL, NS, ON, PEI, SAS	Combined with other programs such as conservation easement to reach the goal of restoring wetlands. DUC provides technical supports and, in some regions, project funding and compensation.
Hay/Grazing Tender Program	AB, MB, SAS	DUC provides lands for haying and/or grazing with annual tenders. Producers who are interested provide bidding on AUM basis. All revenue generated from the tendering is reinvested into conservation programs
FlexFarm	SAS	Producers are paid for taking out marginal land that are less productive out of production to restore as grassland and sloughs. Payments are based on natural commodities that the land provides like flood retention, carbon sequestration
Revolving Land Conservation Program	AB, MB, ON, SAS	DUC purchases land from land owners and restore wetland and habitat within the property, and then place a conservation easement on the land title and ready for purchase to the public
Conservation Easements	AB, MB, ON, SAS	Legal agreement that a land owner makes to limit the type and amount of development on his or her property
Winter Wheat Extension	AB, MB, SAS	Building awareness for winter wheat
Crop Cover Program	BC	Financial incentives provided for winter cove crops of grasses, legumes or grains
2018 Forage Program	AB, MB, SAS	Offsets the cost when producers covert cultivated land to hay of pasture. In AB or SAS, produces received $100 per 50 lb of forage seed while producers in MB received $50 for every new forage acre

Source: Ducks Unlimited Canada, 2018

DUC also offers numerous resources for industry, such as *Resource Roads and Wetland Guide*, and, *Enhanced Wetland Classification: Inferred Producers User Guide* and *Field Guide of Boreal Wetland Classes in the Boreal Plains Ecozone of Canada.* These resources help decision-makers in relevant industries to minimize environmental impacts from construction and development by identifying potential wetlands and other valued resources in the field. In addition, DUC also invests in youth education by offering various award-winning education programs, such as *Project Webfoot*, to teach youth about wetlands and waterfowls.

1.3.5 Environmental Policies and supports in other developed countries

Environmental impacts from agricultural practices have always been of international concern. Here I will briefly describe environmental policies and regulations in other developed countries, and will further contrast them with Canadian policy.

In the European Union, cross-compliance and agri-environmental payment methods are used to provide incentives to generate ecological goods and services (Schmidt et al., 2012). Cross-compliance is a mandatory program which involves producers meeting minimum requirements to maintain their land in an environmentally friendly way, in order for them to receive government payments (Schmidt et al., 2012). In comparison, agri-environmental measures are a voluntary method for producers to gain additional payments if specific environmental requirements are met (Schmidt et al., 2012).

In the United States the production of ecological goods and services are facilitated through 11 mandatory programs such as: 1) the Conservation Reserve Program (CRP), 2) the Environmental Quality Incentive Program (EQIP), 3) the Agricultural Water Enhancement Program, 4) Farm and Ranch Lands Protection Program, 5) Conservation Stewardship Program, 6) Wildlife Habitat Incentive Programs, 7) Grassland Reserve Program, 8) Chesapeake Bay Watershed Program, and 9) Agricultural Management Assistance (Schmidt et al., 2012). The CRP and the EQIP programs have the highest rates of producer participation, which in combination accounted for about 50% of the US total conservation budget in 2016 (USDA, 2016). The CRP is an auction-based environmental program which aims to determine the value of farmland removal by asking farmers to bid on willingness to accept (Schmidt et al., 2012). On the other hand, the EQIP provides financial supports to producers who implement practices to reduce the environmental impacts of their operations (Schmidt et al., 2012).

There are also a variety of environmental measures in place in Australia. One such Australian program would be conservation covenants, which are the agreements made between landowners and an authorized body, like a non-profit organization, to set out rules for land usage. Other programs, such as the National Landcare Program and the Reef Trust, also effectively promote environmental protection.

In comparing Canada to other developed countries, the approximate annual investment on agri-environmental issues as well as the annual environmental investment levels per farm from 2015 to 2016 are summarized and compared in Table 1.13; all the monetary values have been adjusted to 2015 Canadian dollars. Inspection of Table 1.13 suggests that Canadian (federal and provincial) investments on addressing environmental impacts in agriculture are relatively low in comparison to other developed countries. From 2015 to 2016, the US spent the highest amount, at about CAN$8.4 billion per year on environmental issues in agriculture. In the same year, the European Union and Australia spent roughly CAN$6 billion and CAN$326 million respectively, while Canada spent the lowest in Canada among the four countries at only CAN$96.5 million.

Table 1.13 Approximate annual investment on environmental issues in agriculture and annual environmental expenditure per farms from 2015 to 2016 in United States, European Union, Australia and Canada, price adjusted

Countries	Approximate annual investment on environmental issues in agriculture in 2015-2016 (in 2015 CAN$)	Annual environmental investment per farm in 2015-2016 (in 2015 CAN$)
United States	$8.4 billion/year	$3817/farm
European Union	$6.0 billion/year	$4989/farm
Australia	$326.0 million/year	$2397/farm
Canada	$96.5 million/year	$469/farm

Data Source, USDA, 2016; Department of Environment and Energy of Australia, 2017; AAFC 2015;

However, it is important to note that the expenditure levels above could be related to the size of the sector in terms of the number of farm operations. Accordingly, in order to take the total number of farms into account, the annual investment levels were converted into annual expenditures per farm by dividing the total expenditure by the numbers of farms in each country in that year. Results indicated that the highest per farm annual environmental investment occurred in EU, at about $4989/farm, followed by $3817/farm in the US, and $2397/farm in Australia (Table 1.13). The investment per farm in Canada was only about 469 dollars per farm. The US and EU continued to

show the highest level of investment in agri-environmental issues, especially in EU which was about 4 times higher compared to the level in Canada. Among the four developed countries, Canada showed the lowest total annual agri-environmental program investment and the lowest per farm investment.

1.3.6 Policy Mechanism

For a rational profit-maximizing producer, it is reasonable to assume that he or she would not choose to adopt BMP when there will be additional expenses, hence, financial incentives may be essential in generating adoption of BMPs. There are many different forms of government interventions such as technology transfer, regulation, education, taxes or subsidies. However, it is not an easy task to choose between different policy mechanisms (Pannell 2008). To ensure the effectiveness of environmental policies, (Pannell 2008) suggested that the decision on a policy mechanism for enhancing environmental improvements should be determined by the relative level of associated private and public net benefits.

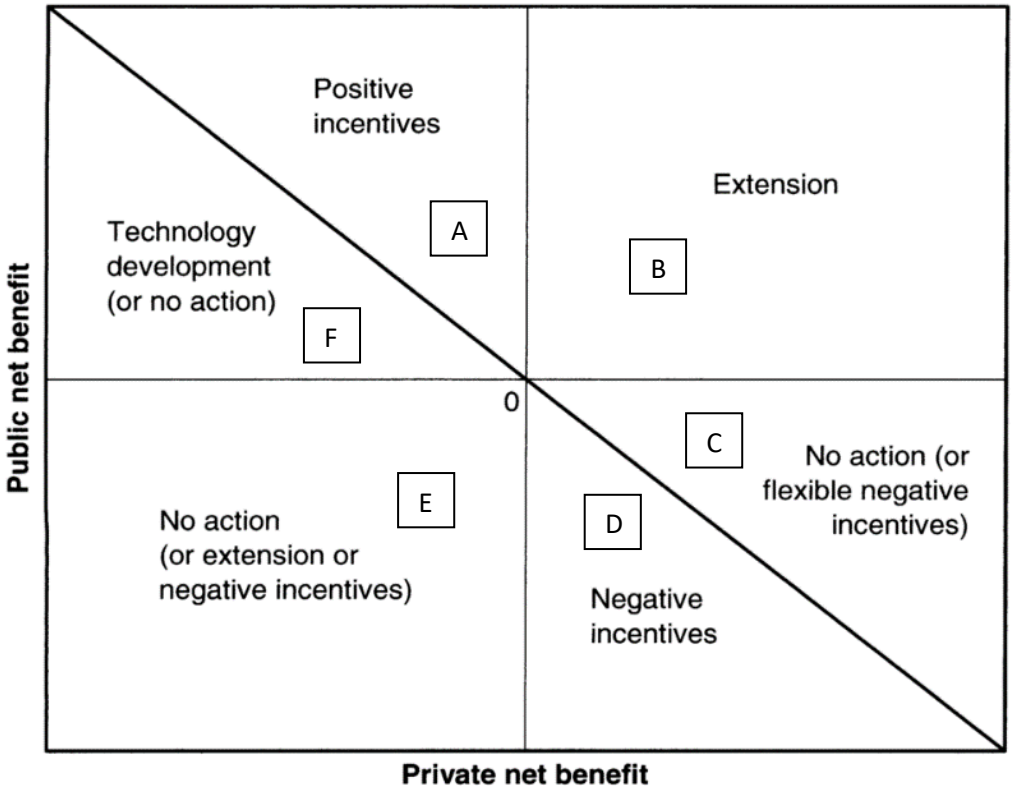


Figure 1.5 Suggested Classes of Policy Tools for Different Levels of Public and Private Benefits. Source: Pannell (2008).

Pannell (2008) demonstrated different classes of policy tools under different levels of public and private benefits, as shown in Figure 1.5. In the case of high positive public benefits, and negative or close to zero private net benefits, positive incentives such as financial support are ideal. When public benefits are negative, while private benefits are positive, negative incentives or implementing a polluter-pays policy should be applied. If public net benefits and private net benefits are both positive, an extension program including technology transfer, education or communication could be a potential mechanism. For scenarios where private net costs are similar or higher than public net benefits, the government should invest in technology development. Last but not least, there should be no action taken when both public and private net benefits are negative or private net benefits outweigh the public net benefit.

As discussed in the previous section, BMP adoption generates social and environmental benefits to the public; however, it is not always the case that they generate private benefits for livestock and crop producers. To ensure the effectiveness of the policy mechanism, it is important to take both public net benefits and private net benefits into consideration. For example, with BMPs such as exclusion fencing, which involves a considerable amount of additional construction costs to producers, it is reasonable to provide positive incentives in promoting adoption.

Chapter Summary

The beef industry in Alberta is significant economically for it provides jobs and food sources, as well generates significant GDP plus total farm cash receipts. However, this industry has the potential to provide non-negligible environmental concerns such as water pollution and wildlife habitat loss. Hence, the policy response has been to encourage livestock producers to adopt agricultural BMPs. To facilitate this adoption, the government environmental program, *Growing Forward,* along with programs provided by non-government organizations like DUC and ALUS, has provided financial support to producers needed to implement BMPs. In addition, provincial legislation such as AOPA has developed regulations, such as manure handling standards, for producers to follow. However, the current levels of environmental investment in the agriculture sector in Canada, are lower than those in other developed countries like the US, EU, and Australia.

Chapter 2 Study Area and Methods

This chapter provides an overview of the study area encompassing the Alberta South Saskatchewan Region. The cattle industry and the agricultural land use in the South Saskatchewan Region are also discussed in this chapter. Relevant land use plans and regional plans that apply to this region will also be introduced. This chapter then delivers a short discussion of stated preference methods, including contingent valuation and its advantages and limitations. It further provides a brief review of relevant past studies using stated preference methods to estimate values associated with either improvement in water quality or wildlife conservation. Following this, it uses past studies as a foundation to further discuss the selection of attributes and levels for this study. Lastly, it outlines the econometric methods used in this study.

2.1 The Alberta South Saskatchewan Region

2.1.1 Overview

The South Saskatchewan Region (SSR) is a large and densely populated area located in the southern part of Alberta (Figure 2.1), comprising about 12.6% of that area. There are 15 municipal districts, 1 specialized municipality, 2 improvement districts, 5 cities, 29 towns, 23 villages, 2 summer villages, and 7 First Nations in the SSR. Contained therein are also four major river basins: the Bow River Basin, the Oldman River Basin, the South Saskatchewan River Basin, and the Milk River Basin, as illustrated in Figure 2.1. The landscapes and wildlife animal species in SSR are also diverse. There are four Natural Regions in SSR namely: Grassland, Parkland, Foothills and Rocky Mountains (Government of Alberta (GOA) 2014). In the SSR, there are approximately 17 sport fish species, 700 vascular plant species, and an abundance of bird, mammal and plant species. Of the total number of species at risk of extinction in Alberta, about 80% of them can be found in the SSR; this total is listed under the species at Risk Act and the wildlife Act.

According to the 2016 Census of Population (Statistics Canada, 2016), about 1.8 million people live in SSR, and about 4 in 5 people live in one of the urban municipalities, shown in Table 2.1. Census subdivisions consisting of more than 50,000 people are defined as the urban region in this study. The gender ratio in SSR was about 50/50, and remains at this ratio for both urban and rural populations. In the same year, the average pre-tax annual household income in the region was about $98,000. The rural average pre-tax household income was slightly below this overall average, at about $97,000, while the urban average pre-tax household income was higher at about

$112,000. The average household size in SSR was about 2.64 people, with urban households tending to be smaller (2.53) than rural households (2.65).

Age distribution and education levels in the SSR are illustrated in Table 2.1. In 2016, about 29% of the SSR population fell into the *35-54* year category, and about 25% into the *under 18* year category, this accounts for the two largest age segments. Other age categories, *25-34, 55-64,* and, *65 and older*, accounted for around 12%-16%, and the lowest proportion was found in the *18-24* category. There are also rural-urban differences within different age categories. The percentage of *under 18*, *54-64* and, *65 and above* were relatively lower in urban SSR compared to the rural region, while the remaining age categories were opposite. In terms of educational level, the elementary (grade school), and secondary (high school) levels in the SSR were roughly 12% and 21% respectively. The percentage of higher education degrees such as: college diploma, university diploma, or Master degree were about 15%, 18% and 5% of the total SSR population respectively. In general, urban residents tend to have a higher education level, as shown by the higher percentages of university diplomas and Masters' degrees, and a lower proportion of residents in urban settings who have only grade school or high school education.

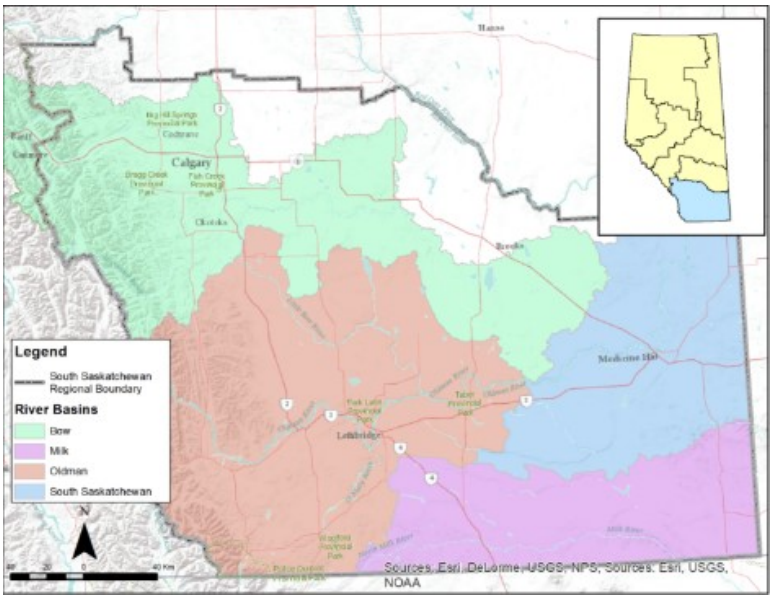


Figure 2.1 The South Saskatchewan Region in Alberta; Source: Esri, USGS, NOAA

Table 2.1 Demographic information from Census 2016, by total SSR, rural SSR, and Urban SSR

	Total	Rural	Urban
Population Size	1813229	356583	1456790
Population in percentage		19.67%	80.34%
Average before-tax household income	98405	97536	112310
Average Family Size	2.64	2.65	2.53
Percent Male	49.89%	50.29%	49.79%
Age Distribution**:**			
Under 18	24.97%	28.33%	24.15%
18-24	6.20%	5.42%	6.39%
25-34	15.67%	11.39%	16.72%
35-54	28.83%	27.23%	29.22%
55-64	12.28%	13.74%	11.93%
65 and older	12.05%	13.89%	11.60%
Education:			
Grade school	11.9%	14.7%	11.2%
High School	21.3%	21.6%	21.3%
Technical school	6.0%	7.3%	5.7%
Some college or university	2.4%	2.0%	2.4%
College diploma	14.8%	15.3%	14.7%
University diploma	17.6%	11.0%	19.3%
Master and above	4.9%	2.4%	5.5%

Source: Statistics Canada, 2016 Canadian Census.

2.1.2 The Cattle Industry and Agricultural Land Use in the South Saskatchewan Region

As discussed in Chapter 1, the beef industry is an important component of the Alberta economy. As of 2011, the SSR is the second largest cattle farming region in Alberta, and contains about one-quarter of Alberta's cattle farms as shown in Figure 2.2 (Statistics Canada, 2017b). The major land uses in SSR are agricultural production and grasslands. In the SSR, most of the land is used for agricultural purposes, and these lands are concentrated in the Bow River and the Oldman River Basins as shown in orange in Figure 2.3. There are also agricultural activities in the Milk River Basin and the South Saskatchewan River Basin regions, but are at relatively lower levels. The second largest land cover in the SSR is grassland, shown in light yellow in Figure 2.3. Most of the grassland is located in the Milk River Basin and the South Saskatchewan River Basin, although the Bow River and the Oldman River Basins also contain small percentages of grassland.

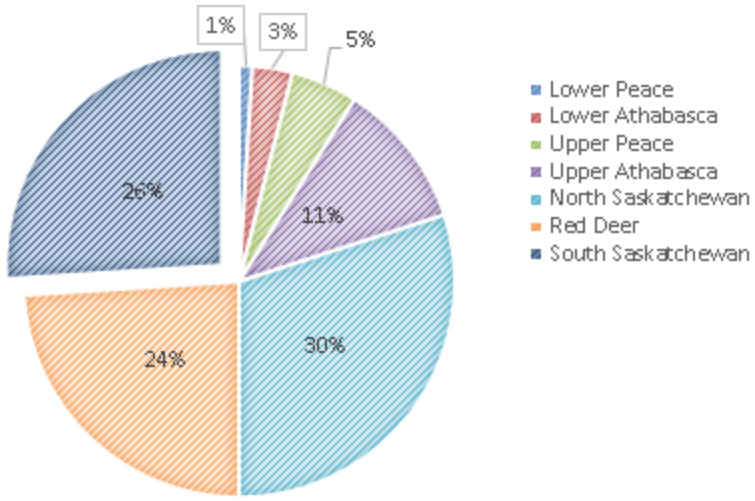


Figure 2.2 Distribution of cattle farms in Alberta; Date Source: Statistics Canada

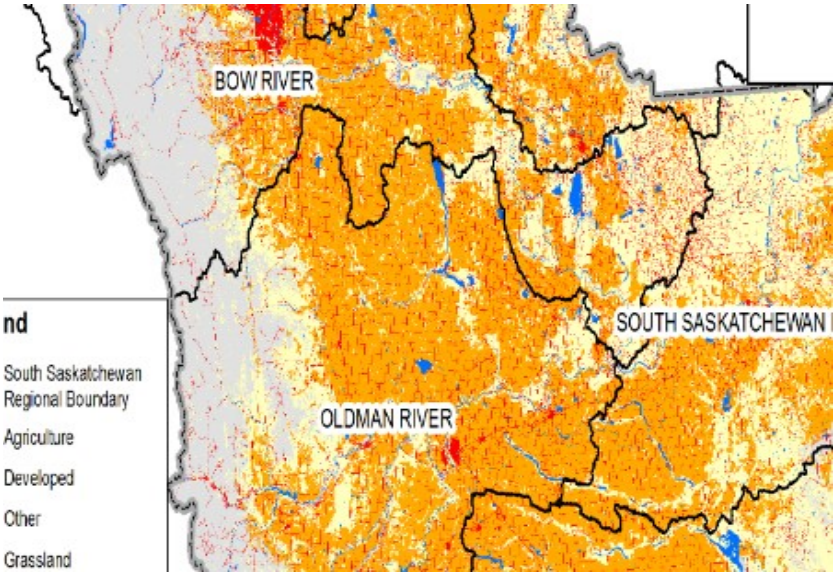


Figure 2.3 Land Cover in the South Saskatchewan Region; Source: Christopher Mallon, 2017

Information on trajectories of major land use changes from1990 to 2010, were obtained from the AAFC land use report (AAFC 2015a), and are listed in the Table 2.2. Based on AAFC land use reports, "managed" grassland is defined as natural grass and shrubs used for grazing; and cropland is defined as land used to cultivate annual and perennial crops.

In general, the two largest land uses in SSR were cropland and grassland, with the former showing an increasing trend over time and the latter showing a slight decreasing trend. In 1990, there were

about 8.54 million acres of cropland, or 41.3% of the total area. This land use increased to 8.85 million acres in 2000, and further rose to 9 million acres in 2010. However, the managed grassland for livestock grazing, which includes native grassland and tame pasture, showed a decreasing trend.

In 2010, there were about 6.91 million acres of managed grassland, or 33.4% of the total area in the SSR. This 2010 acreage was lower than in 2000 and in 1990, which were 7.10 million acres and 7.41 million acres respectively. On the other hand, unmanaged grassland has remained constant at about 0.2% of the total SSR area. Other than the changes in cropland and grassland use, there were also changes in wetland and woodland areas which have declined over the past few decades. These land cover types changed from 3.78 million acres in 1990 to 3.76 million acres in 2000 and further dropped to 3.75 million acres in 2010. For all other land uses, which includes roads and settlements from 1990 to 2010, there was an increasing trend indicating increasing human development.

Table 2.2 Land use changes in South Saskatchewan Region from 1990 to 2010, by amounts and percentages

	1990		2000		2010	
	Amount (million acres)	Percent of total area	Amount (million acres)	Percent of total area	Amount (million acres)	Percent of total area
Cropland	8.54	41.3	8.85	42.7	9.01	43.5
Grassland managed	7.41	35.8	7.10	34.3	6.91	33.4
Grassland unmanaged	0.04	0.2	0.04	0.2	0.04	0.2
Wetland and woodland	3.78	18.2	3.76	18.2	3.75	18.1
All other land use	0.93	4.5	0.96	4.6	0.99	4.8
Total areas	20.70		20.70		20.70	

Source: AAFC 2015a

2.2 Land use planning and strategic plans in SSR

Rapid economic and population growth in Alberta has led to increasing demands for both public and private land uses, and also has increased conflicts between land users (GOA 2008). To effectively manage land and natural resources in Alberta, Alberta's Land Use Framework (LUF), supported by the Alberta Land Stewardship Act, established seven land use planning regions. The province requires the development of a specific plan for each region (GOA 2014). These regions include: lower Athabasca region, lower Peace Region, North Saskatchewan Region, Red Deer

Region, South Saskatchewan Region, Upper Athabasca Region, and, Upper Peach Region. The purpose of regional planning is to facilitate the decision-making process by setting out regional-specific and long-term directions, as well as providing policy integration. Up to now, only the regional plans for the South Saskatchewan Region and the Lower Athabasca Region have been approved; the regional plan for the North Saskatchewan Region is still in progress. Regional plans for other regions have not started yet. Other than the SSRP, there are also other strategic plans and frameworks that are either independent from or are integrated with the SSRP, such as the South Saskatchewan Region Surface Water Quality Management Framework, the Biodiversity Management Framework, and, the Species Recovery Plan. These documents provide guidelines and management responses to improve land use management and to enhance environmental quality.

2.2.1 The South Saskatchewan Regional Plans (SSRP)

The South Saskatchewan Regional Plan (SSRP), is one of the Alberta regional plans developed to set a long-term vision for the region over the next 10 years; it is to be updated every 5 years if necessary (GOA 2014). It aims to balance Alberta's economic, environmental and social goals, and, align them with existing laws and regulations. The SSRP is also integrated with other frameworks such as the *Surface Water Quality Management Framework* and the *Air Quality Management Framework*, which were developed by Alberta Environment and Sustainable Resource Development (ESRD) to contribute to long-term management of air, land, and water.

The SSRP provides strategic plans, implementation plans, and regulatory details for the region. The plan provides overall guidance including specific vision, outcomes and strategic directions. The vision indicates the desired future state for the SSR aligning with the principles in the LUF. The regional outcomes and strategic directions were established to facilitate the accomplishment of the regional vision (GOA 2014). Table 2.3 illustrates examples of the vision, outcomes and strategic directions with respect to biodiversity and watersheds in the SSR, provided in the SSRP. To achieve the vision of sustainable and healthy functioning wildlife, biodiversity and ecosystem functions should be sustained through shared stewardship to conserve and maintain the benefits from biodiversity. Similarly, improved watershed management will be achieved through shared stewardship to accomplish the goal of a healthy watershed ecosystem (GOA 2014b). Other than watershed and biodiversity, strategic planning in the SSRP also covers other aspects including:

economic sectors (such as agriculture, energy and forestry); other environmental components (such as air), and, social components (such as community development).

Table 2.3 An example of strategic plan in respect to biodiversity and watershed

Vision	**Outcome**	**Strategic Direction**
"[…], water, […] and biodiversity are sustained with healthy functioning ecosystems."	Biodiversity and ecosystem function are sustained through shared stewardship	Conserving and maintaining the benefits of biodiversity
	Watersheds are managed to support healthy ecosystem and human needs through shard stewardship	Advancing watershed management

The *Implementation plan* consists of regional objectives, strategies, and actions that will be used to accomplish the regional vision and outcomes. Table 2.4 shows the regional objectives and selective strategies established in the SSRP in respect to agriculture, biodiversity and surface water. For instance, the regional objective for surface water quality is to manage water quality in the Bow, Oldman, South Saskatchewan, and Milk River to ensure current and future water uses. To achieve the regional water quality objectives, the *South Saskatchewan Region Surface Water Quality Management Framework* should be carried out. Finally, *regulatory details plan* provides detailed information on regulated actions, provided by the Alberta Land Stewardship Act that concern decision makers (GOA 2014).

Table 2.4 A list of implementation objectives and strategies established by South Saskatchewan Regional Plan, in respect to agriculture, biodiversity, and surface water

Aspect	Regional objective(s)	Selective Regional Strategy (ies)
Agriculture	1) The region's agricultural industry is maintained and diversified	1) To lower the fragmentation and conversion of agricultural land; 2) To support a innovative irrigated agriculture. 3) To improve opportunities for value-added agricultural products 4) To recognize the contribution of local production 5) To support the next generation of agri-related entrepreneurs

		6) To encourage the use of voluntary market-based instrument
Biodiversity & Ecosystem (Regional, apply to both public and private lands)	1) Terrestrial and aquatic biodiversity are maintained 2) Long-term ecosystem health and resiliency are maintained 3) Species at risk are recovered and no new species at risk are designated 4) Biodiversity and health, functioning ecosystems continue to provide various benefits to communities in the region and all Albertans	See below
Biodiversity & Ecosystem (Crown Lands)	1) The regional network of areas that support biodiversity conservation is enhanced through additional conservation area	1) To finish the development of the *South Saskatchewan Region Biodiversity Management Framework* 2) To generate a linear footprint management plan 3) To review integrated Resource Plans 4) To expand public land use zones and more
Biodiversity & Ecosystem (Private Lands)	1) The contributions of landowners for their stewardship and conservation efforts on private lands are recognized 2) The contribution and value of private land in supplying ecosystem services is recognized and opportunities to support ecosystem services on private land are identified	1) To facilitate the continued stewardship of Alberta's private lands 2) To finish development and evaluation of the Southeast Alberta Conservation offset Pilot 3) To improve the adoption of beneficial management practices 4)To consider native grassland intactness as the highest priority under the Land Trust Grant
Surface Water Quality	1) Surface water quality in the Bow, Oldman, South Saskatchewan and Milk Rivers is managed so current and future water uses are protected	1) To implement the *South Saskatchewan Region Surface Water Quality Management Framework*

Source: Government of Alberta, South Saskatchewan Region Plan

2.2.2 The South Saskatchewan Region Surface Water Quality Management Framework

The *South Saskatchewan Region Surface Water Quality Management Framework* (SWQMF) is a proactive regional water management measure developed by Alberta Environment and Sustainable Resource Development (ESRD), and integrated with the South Saskatchewan Regional Plans. The purpose is to provide water quality standards for managing cumulative effects from anthropological activities in rivers within the SSR. This framework aligns with existing provincial legislation and policies on water quality, wastewater and the aquatic environment, and provides a

mechanism to monitor and manage ambient water quality (ESRD 2014b). A detailed list of key legislation and policy for managing surface water quality in the SSR is found in Table 2.5.

Table 2.5 Key legislation and policy for managing surface water quality in the SSR

Governance	Jurisdiction
Acts	
Alberta Land Stewardship Act (ALSA)	Provincial/Regional
Agricultural Operation Practice Act (AOPA)	Alberta
Environmental Protection and Enhancement Act (EPEA)	Alberta
Municipal Government Act (MGA)	Municipalities
Public Lands Act (PLA)	Alberta
Water Act (WA)	Alberta
Approvals, monitoring requirements, reporting requirements	Alberta (AOPA, EPEA, PLA, WA)
Compliance and enforcement	Alberta (AOPA, EPEA, PLA, WA)
Guidelines	
Environmental Quality Guidelines for Alberta Surface Waters	Alberta
Canadian Environmental Quality Guidelines	Canadian Council of Ministers of the Environment (CCME)
Guidelines for Canadian Drinking Water Quality	Health Canada
Guidelines for Canadian Recreational Water Quality	Health Canada
Policies	
Framework for Water Management Planning	Alberta
Industrial Release Limits Policy	Alberta
Municipal Policies and Procedures Manual	Alberta
Water Quality Based Effluent Limits Procedures Manual	Alberta
Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems	Alberta
Approved Water Management Plan for the South Saskatchewan River Basin	Alberta
Strategies	
Strategy for the Protection of the Aquatic Environment	Alberta
Water for Life: Alberta's Strategy for Sustainability	Alberta
Land-use Framework	Provincial/Regional
Agreements	
Prairie Provinces Master Agreement on Apportionment- Schedule E Water Quality Agreement	Inter-Provincial
Boundary Waters Treaty	International
Federal Acts	
Canadian Environmental Protection Act	Canada
Fisheries Act	Canada

Source: ESRD 2014b, South Saskatchewan Region Surface Water Quality Management Framework

The Goal of the SWQMF is to identify ambient surface water indicators, triggers, and limits to enhance the water quality; this is accomplished through monitoring, evaluation and protection.

Indicators established in this framework based on historical datasets and overall relevance in all four rivers (ESRD 2014b) include: total Ammonia (NH_{3+4}-N), Chloride (Cl), Nitrate (NO_3-N), total Nitrogen (TN), total dissolved Phosphorus (TDP), total Phosphorus (TP), sulphate (SO_4^-), Sodium adsorption ratio, specific conductivity, total dissolved solids, total organic carbon, total suspended solids, turbidity, pH, and E.coli. *Triggers* are values calculated from historical monthly data from each monitoring station which signal a need to take management actions to lower water pollutants before the limits are hit. *Limits* are the maximum amounts of the substance concentrations that outlined by water quality guidelines (ESRD 2014b). The surface water quality triggers, and surface water quality limits differ by river basin and by monitoring stations.

There are nine water quality monitoring stations in the SSR. Four of the monitoring stations capture water quality changes in the Bow River. A relatively higher number of monitoring stations were placed in the Bow River region as a result of: higher development levels, denser population, more intense agricultural uses, and the presence of wastewater treatment facilities. The ambient water quality changes in the Oldman River are monitored by three monitoring stations due to intense agricultural activities. There is only one monitoring station for each of the South Saskatchewan River and the Milk River due to the relatively less dense human population and lower development levels within the SSR (ESRD 2014b).

2.2.3 The Bow River Phosphorus Management Plan (BRPMP)

The Phosphorus Management Plan (BRPMP), implemented in 2014, was a strategy aimed to meet the SWQMF objectives by identifying both non-point and point pollutions sources and managing phosphorus input levels in Bow River waterbodies (ESRD 2014a). It was a proactive management method that was introduced in response to the rapid economic and population growth in Bow River region, and was intended to maintain and mitigate water quality conditions in Bow River by controlling potential phosphorus inputs (ESRD 2014a). In addition, the stewardship responsibilities outlined in the BRPMP are shared among contributing parties which manage current water quality conditions, and these responsibilities align with the trigger thresholds developed under the SWQMF in the SSRP (ESRD 2014a).

There are five secondary objectives, and corresponding strategies, set in the BRMPM to fulfill the primary goal of Bow River water quality management. To begin with, the understanding of potential impacts from excessive phosphorus in the waterbodies can be potentially improved or

changed by providing more accessible public education opportunities. Secondly, the overall knowledge regarding the phosphorus sources, the planning area, and phosphorus management practices can be enhanced by specific measures including: continuous water quality monitoring, improved landscape mapping, regulatory policy reviews, and, further researches on potential phosphorus management options. These achieve the third objective of reductions in phosphorus additions, livestock manure BMPs and urban-source phosphorus management are suggested as potential strategies. Additionally, the movement of phosphorus to the river can be lowered by maintaining and improving wetland and riparian quality, and by, reducing and minimizing sediment loading and erosion. The final objective is to reduce excess phosphorus from water before it reaches the Bow River, which can be achieved by practices such as setting regional phosphorus loading targets (ESRD 2014a).

The most up-to-date BRPMP program status is shown in Figure 2.4. By 2017, there was a total of 51 programs implemented in the management plan area with 8% considered as completed. Another 29% was considered as in sustainable progress which were expected to reach completion in the following years. Approximately three fifth of the BRPMP programs still require additional inputs (GOA 2017).

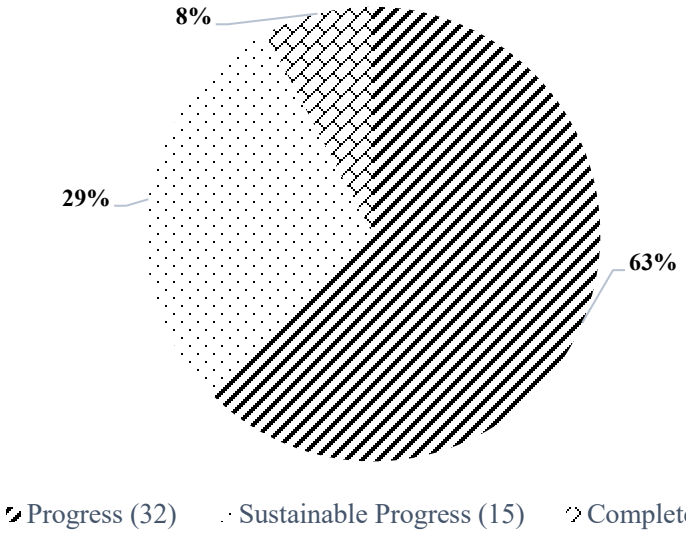


Figure 2.4 Bow River Phosphorus Management Plan, Status of Action 2017, adopted from AEP

2.2.4 The Biodiversity Management Framework (BMF)

There is also a Biodiversity Management Framework (BMF), which focuses on maintaining species and habitat intactness for every Alberta land use planning region. Currently, only the Lower Athabasca BMF is close to completion, while the BMFs for the other land use regions are still under development. Similar to the *Surface Water Quality Management Framework*, the BMF provides biodiversity indicators and triggers for monitoring changes over time, and provides proactive measures if the limits are reached (White 2015).

In the Lower Athabasca BMF indicators (a similar concept to those part of the air and water framework) are measurable variables that represent valued components of biodiversity health such as key species, habitats and landscapes. The purpose of these indicators is to provide information on overall regional biodiversity conditions. There are four types of indicators: terrestrial species, aquatic species, terrestrial habitat and aquatic habitat. The habitat indicators, which are consistent across Alberta's land use planning regions, consist of terrestrial biodiversity intactness, wetland biodiversity intactness, terrestrial native cover, and, aquatic native cover. The species indicators normally include typical terrestrial, aquatic, and plant species specific to different regions. Triggers are set based on current levels of the indicators relative to undisturbed or historical conditions (White 2015).

Similar but more region-specific BMF indicators are expected to be developed for South Saskatchewan Region in the near future.

2.2.5 Species Recovery Plans

There will be a recovery plan developed for species once they are designated as either endangered or threatened. The aim is to restore or maintain the target species to "viable, naturally self-sustaining population" (ESRD 2013). It consists of an overall recovery goal, specific objectives, and, strategies and actions to achieve the goal and its objectives for the target threatened or endangered species. An example of the Species Recovery Plans which could apply to SSR is the *Alberta Greater Sage-grouse Recovery Plan 2013-2018*.

The Greater Sage-Grouse (*Centrocencus urophasianus urophasianus)* is a species listed as endangered in Alberta. Based on historical and current data, Alberta Sage Grouse populations can only be found in the SSR. Goals of the Sage Grouse Recovery Plan are twofold. Firstly, it aims to

enhance and maintain Sage Grouse habitat for meeting life-cycle requirements in support of a viable population. Secondly, it tries to recover the Sage Grouse population to a level that provides recreation (viewing) and hunting opportunities. Based on these two goals, several objectives were established such as protecting and restoring critical breeding, nesting and wintering habitats, providing incentives for land conversion from cropland to native grassland, as well as enhancing the speed of population recovery through translocation of birds from the U.S. Finally, strategies for achieving the recovery goals were set, and each strategy has specific associated action plans.

2.3 Methods

2.3.1 Non-market Valuation and Stated Preference Methods

Although there are numerous ecosystem services and benefits associated with BMP adoption, the valuation of those benefits is not an easy task. Unlike most of the commodities consumers can purchase from the marketplace, not all ecosystem goods and services provided by improvements in water and wildlife conservation have market prices (Adamowicz et al., 1991; Adamowicz et al., 1998; Boxall et al., 1996; He et al., 2017). There are two major methods for valuing non-market goods and services: stated preference (SP) and revealed preference (RP). SP approaches, such as choice experiments or contingent valuation, elicit non-market values by asking respondents to state their willingness to pay or to choose among a series of hypothetical environmental policy alternatives (e.g. Boxall et al., 1996). The approach evolved from conjoint analysis, which is commonly used in marketing, geography and economic research (Louviere 1988; Batsell and Louviere 1991; Mark and Swait 2004). On the other hand, RP approaches estimate values for environmental amenities based on actual decisions made by consumers. RP approaches include travel cost methods and hedonic property value methods that use the travel cost or the monetary value spent to purchase a house as proxies for willingness to pay for the environmental service (Adamowicz et al., 1994a). In contrast to the RP approach where actual decision data is required, the SP approach allows researchers to examine the value of hypothetical changes in the provision of goods and services (Adamowicz et al., 1994b; Mark and Swait 2004).

Contingent valuation (CV) is a commonly used SP valuation method which involves designing binary choice scenarios and asking respondents to make tradeoffs between money and changes in the targeted non-market goods utilizing a referendum (Grafton et al., 2004). It has been well documented that binary choice referendum format provides advantages in ensuring incentive

compatibility in the provision of a public good with a tax payment (Carson and Groves 2007; Vossler et al., 2012; Vossler and Watson 2013; Carson, et al., 2014). In this study, a hybrid CV method, one of the SP approaches, is adopted to elicit the non-market values associated with water quality and wildlife habitat improvements.

2.3.2 Concerns with Stated Preference Methods

Even though stated preference methods are well- established, there are a number of design challenges which influence the accuracy of the results. Hypothetical bias, which occurs when respondents indicate a higher value in a hypothetical survey than they would actually pay in a real referendum (Loomis 2014). It can occur due to either strategic behavior or social desirability bias. Strategic behavior occurs when participants answer survey question strategically when they do not think the survey is credible and the survey results will be consequential (Grafton et al. 2004). Social desirability bias occurs when participants give a value they think society or others would pay instead of their true value (Leggett et al., 2003). Yea-saying is another common hypothetical bias in the SP approach, which could also influence the accuracy of survey results. Yea saying occurs when respondents choose the proposed program regardless of the cost or the survey contents (Blamey et al., 1999; Adamowicz et al.,1994b). It is a phenomenon when individuals overstate their true values to avoid voting against measures that could be socially and/or environmentally beneficial (Mitchell and Carson 1989; Boxall et al., 1996). WTP values with hypothetical bias are generally greater than the true WTP values (Loomis 2014; Carson and Groves 2007; Blamey et al., 1999).

To minimize the impacts of hypothetical bias, a few measures can be taken. Carson and Groves (2007) suggested two conditions that hypothetical survey questions must meet in order to be consequential The first condition is that respondents answering the questions need to believe that their choices in the survey have an actual impact on future policy. Secondly, respondents need to care about the environmental changes resulting from the proposed programs (Carson and Groves 2007). One method to achieve these two conditions is to provide a *consequentiality question* after the choice scenario which asks respondents if they believe the results of the survey will have an actual impact in policy decisions (Vossler and Evans 2009; Poe and Vossler 2011; Broadbent 2012). By including the consequentiality question, it is possible for researchers to focus their

analyses only on those respondents who believe their decisions in the survey instrument will be consequential (Broadbent 2012).

Uncertainty questions can also be used to reduce hypothetical biases in the survey responses (Champ et al., 1997; Ready et al., 2010). After respondents are asked to vote "yes" or "no" to a proposed program, they can be asked to complete follow-up questions about how certain they are that they would make the same choice if they were asked the same question in a real referendum. The more respondents are certain about their hypothetical votes, the less it will deviate from the true value in a real referendum, all else being equal (Champ et al., 1997; Blumenschein et al., 1998; Pattison et al., 2011). In other words, if respondents are not certain about their choices, it is possible that their choice decisions will have hypothetical bias. Uncertainty questions mitigate the problem of hypothetical bias by converting the "yes" responses to "no" if the respondents were not confident about their choice (Champ et al., 1997; Ready et al., 2010). *Inferred valuation questions,* which involve asking respondents how much they think other people would pay, can be used to reduce hypothetical bias caused by social desirability bias (Norwood and Lusk 2011; Loomis 2014). To identify yea-sayers in the sample of respondents, a follow-up question after the choice scenarios can be applied where respondents are asked if they would choose the proposed program regardless of the cost or the tax payment (e.g. Pattison et al., 2011).

2.3.3 Guidelines for Conducting Reliable Stated Preference Studies

To accurately elicit the non-market values of environmental improvements from BMP adoption in the SSR, it is essential to ensure the reliability of the SP survey. Johnston et al. (2017) provided recommendations for ensuring reliability when designing SP studies.

2.3.1.1 Survey Development and Implementation

Stated Preference questionnaires should present the status quo scenarios, the proposed changes to the current condition as well as other components, such as bid design, of the survey clearly and accurately for easy understanding (Johnston et al., 2017). After constructing the survey instrument, it is necessary to test its effectiveness by conducting pre-test such as focus groups, interviews, and/or pilot studies depending on the survey context and budget (Johnston et al., 2017). Testing the draft survey instrument with random respondents allows researchers to understand whether the information and the choice scenarios in the draft questionnaire are credible and easy to understand for individuals with different socio-economic backgrounds (Mitchell and Carson 1989; Johnston

et al., 2017). Moreover, the accuracy of data generated using an SP approach also relies on the use of precise valuation methods. Johnston et al. (2017) suggest choosing between CVM and CE based on the study objectives, how normally the goods and services are being perceived, and what information is required for later analysis.

Experimental design is another important aspect of the design of the SP tool employed and plays a significant role in determining bid or attribute assignment to SP questions. To develop efficient experimental designs, researchers should gather information from past studies and derive statistical design properties, like D-efficiency or C-efficiency, based on statistical models or using statistical software such as Ngene or SAS (Johnston et al., 2017). In addition, researchers must follow the ethics for conducting research involving human subjects and materials such as informed consent as well as the final survey instrument must be reviewed by university or research ethics boards (Johnston et al., 2017).

The final consideration of the survey instrument development is to decide the sampling frame, mode of administration and how to deal with nonresponse bias (Johnston et al., 2017). Common sampling modes include in-person or telephone interview, mailings, and internet. Every survey mode has its advantages and disadvantages, but the most suitable survey mode should be chosen based on the research context and budget constraint (Johnston et al., 2017). In terms of the sampling frame, it should be determined depending on the study objectives while the potential respondents are randomly selected from the sampling frame (Johnston et al., 2017). As for nonresponse bias, Johnston et al. (2017) suggest adopting methods such as participation incentives to encourage appropriate response rates which could help to minimize the presence of nonresponse bias.

2.3.1.2 Value Elicitation

Reliable value elicitation begins with the decision between WTP and willingness to accept (WTA) based on the study context and objectives (Johnston et al., 2017). Determining the valuation question response format is another important aspect for value elicitation. For CVM, a single, binary choice is the most preferred question formation since it does not violate incentive-compatibility (Carson and Groves 2007; Carson et al., 2014; Johnston et al., 2017). Additionally, a no-answer option encourages respondents to avoid providing their preferences (Krosnick et al., 2002; Johnston et al., 2017). Moreover, determining what indicator to be used as the payment

vehicle is also an important consideration. Johnston et al. (2017) suggest that a feasible payment vehicle should be "realistic, credible, familiar and binding for all respondents to as great an extent as possible, and that researchers should try to ensure that payments are viewed as fixed and nonmalleable". To meet this condition, taxes are usually used as the payment vehicle.

Finally, it is essential to include supporting questions in the survey to facilitate the value elicitation process (Krupnick and Adamowicz 2006; Johnston et al., 2017). By utilizing supporting question in the survey, researchers can not only obtain valuable information regarding preference variation and decision strategy but also select useful subsets of the dataset for analysis (Krupnick and Adamowicz 2006; Vossler and Evans 2009; Poe and Vossler 2009; Broadbent 2012). Commonly used supporting question includes introductory, warm-up and attitudinal questions, debriefing question as well as basic demographic and personal characteristics questions (Krupnick and Adamowicz 2006). The last step of value elicitation is to improve consequentiality and incentive compatibility and reduce the probability of overestimation through ex-ante procedures such as cheap talk (Johnston et al., 2017).

2.5 Past valuation studies [4]

There are numerous valuation studies estimating values associated with increased provision of environmental goods and services, a list of selective literature on relevant past studies were reviewed and shown in Table 2.6.

Willingness to pay for Wildlife improvement

Adamowicz et al. (1991) examined the total economic values of wildlife in Alberta by estimating both use and non-use values of Alberta wildlife, the non-use values, or the preservation values, were determined by using CVM asking Alberta residents how much they were willing to pay for a trust fund to preserve wildlife. The use values, both consumptive and non-consumptive, were obtained using the National Survey on the value of wildlife to Canadians. The resulting annual preservation value for wildlife was $125.37 and the total consumption and non-consumption values were about $257 and $253 respectively for an Albertan residence every year. A study by Boxall et al. (2012) utilized a hybrid CVM to investigate the WTP to improve the population of Belugas Whales, Harbour Seals and Atlantic Blue Whales found in St. Lawrence, Canada.

[4] Dollar values are converted to 2016 CAD level

Questionnaire participants were asked to choose between programs which varies in species status, size of marine protected areas, and, shipping and whale watching industry regulations. If respondents chose recovery programs over status quo condition, they would have to pay additional household's annual taxes. Their results indicated they respondents showed a positive WTP for species population recovery programs, ranged from $82 to $243 per year per household depending on the species, and the level of improvements.

A more recent study by Forbes et al. (2015) examined the economic values associated with recovering Canadian pacific rockfish species at-risk of extinction using a referendum-style stated preference method. In the survey, respondents were asked to choose between a current management option in which case the interested fish species would become endangered in 40 years with no management actions and additional costs, and a proposed management option where the status of fish species, or future fish population, would be improved using various management measures with additional annual household taxes. The attributes of a representative pacific rockfish population were determined in collaboration with biologists and fisheries experts, and the final attributes in the survey included the status of the targeted species in 40 years, the probability of extinction, and the level of impacts on jobs and income. By using a binary probit model to analyze votes and generate WTP values, they found that respondents were willing to pay more to obtain a higher degree of fish population improvements, where the annual WTP values ranged between $49 and $182 per household. Other than aforementioned studies, there are an increasing number of valuation researches supported the idea that people generally have a positive WTP toward species or wildlife protections (Bandara and Tisdell 2005; Christie et al., 2006; Wilson et al., 2010; Morse-Jones et al., 2012; Wallmo and Lew 2012; Wallmo and Lew 2016).

Willingness to pay for Water quality improvement

There is also a growing literature investigating the economic values associated with water quality improvements (e.g. Brouwer et al., 2015; Brox et al., 2003; Dupont 2003; He et al., 2017; Hime et al., 2009; Loomis and Santiago 2013). To estimate the national benefits from water quality improvement in US, Carson and Mitchell (1993) conducted an interview-based CVM to solicit individual's WTP. Water quality ladder was used to indicate the current and future water quality scenarios, and annual taxes and higher product prices were utilized as the payment vehicle. Based on their estimation, they found that people were willing to pay $206.8 to improvement water

quality from non-boatable to boatable, $155.6 to change from boatable to fishable, and another $173 to achieve swimmable water quality conditions. The effectiveness of water quality ladder in estimating WTP was further tested by Alvarez et al. (2016) which they examined the potential benefits from potential water quality improvements as a result of urban and agricultural BMP adoption in Florida, US. Two main types of BMPs were defined, which were structural BMPs, such as buffer strips and fencings, and management BMPs including nutriment management and conservation tillage. They used water quality ladder as the common mean to account for water quality improvements across studies. Their results suggested that individuals from counties in Florida would be willing to pay 5 cents to $1088 per person per year for a water quality improvement from fishable to swimmable water quality.

Pattison et al. (2011) examined how much Manitoba residents were willing to pay for wetland retention and restoration to the level of 1968 using a stated preference approach. Six wetland choice scenarios were determined (one current situation, one retention scenario, and four restoration scenarios) and the attributes were future wetland areas, nutrients reduction, erosion control, wildlife habitat measured as the number of breeding duck pairs, and CO_2 capture and storage in 2020. A series of binary logit models were used to estimate the WTP, and the results indicated that Manitobans were willing to pay $318 to $350 per year per household depending on the level of wetland improvement. Similarly, Lantz et al. (2013) utilized same method to investigate the social benefits associated with wetland conservation programs in the Credit River Watershed, Ontario, Canada. Attributes used in this study included wetland area, water quality, wildlife habitat, carbon storage, and flood, drought, erosion control. The resulting annual WTP for wetland retention programs ranged from $36.12 to $1110.68 per respondent while the annual WTP for wetland retention and restoration were between $37.46 and $1086.45 per respondent.

Willingness to pay for BMP adoption – Canadian studies

Relative to valuation studies on water or wildlife improvements, there is a limited number of studies estimating the willingness to pay for agricultural BMP adoption in Canada (e.g. Larue et al., 2017). Belcher et al. (2007) used conjoint analysis to determine the preferences and values associated with environmentally friendly beef products in the south Saskatchewan Wood River watershed in Canada. The attributes considered in the study included the production method, the purchasing method, the environmental impacts and the price premium required by producers to

adopt beneficial management practices. The results indicated that environmental group members were willing to pay a higher price premium for food products with environmental attributes relative to the general population. The mean amounts (in %) the general population and environmental group members were willing to pay over regular prices beef food products produced using BMPs were 13.84% and 30% respectively.

A thesis by Mingle (2016) used CVM to evaluate the economic values of environmental improvements after the adoption of agricultural beneficial management practices in the South Tobacco Creek watershed, Manitoba, and the Ag-Day Farm in Brandon, Manitoba. The targeted BMPs included land conversion, riparian buffer strips, limited livestock access, and, nutrient management. Respondents were given a series of environmental attributes, including water clarity, water odor, water quantity, recreation and fish habitat, which could be influenced by beneficial management practice adoption. The iterative bidding, ranging from zero annual tax payment to greater than $100 every year, was adopted to elicit values for environmental attributes. Their results indicated that respondents generally valued flood reduction the most and the odor reduction the least, and the mean annual household WTP ranged from $$22.68 to $44.41 depending on years and specific improvements.

A recent study by Dupras et al. (2018) used both CVM and CE to value the impacts of agri-environmental practices on landscapes aesthetics in upper Ruisseau Vacher watershed, Quebec. The implemented BMPs included erosion controls, output controls for drain, ditches and furrows, as well as bird and fish species monitoring. For the CVM study respondents were given realistic photo images of the landscaped, which were simulated based on historical vegetation pattern, to indicate the changes in landscape after BMP adoption. If the respondents were willing to pay for the landscape improvement, they were then given an open-ended question to state their annual WTP for the following 5 years. In the CE, 4 environmental attributes were considered: water quality, fish diversity, bird diversity and landscape diversity. The mean annual household WTP calculated using CV data ranged from $31.57 to $76.91 as the level of landscape improvement increases. On the other hand, the WTP estimates were calculated using a conditional logistic model where the respondents were more willing to pay for water quality improvement and less willing to pay for the increase in bird diversity.

Table 2.6 A selective of relevant past valuation studies

Author(S)	Purpose(s)	Methods	Adjusted WTP [1]
Willingness to pay for Wildlife improvement			
Adamowicz et al. 1991	To examine the total economic values of wildlife in Alberta	CVM; estimating both use and non-use values of Alberta wildlife, the non-use values, or the preservation values	Wildlife preservation value was $125.37 /household/year; consumption and non-consumption values were $257 and $253 / household/year
Admowicz et al.2013	To provide a potential costs and benefits associated with South of the Divide Multiple Species at risk (Multi-SAR) action plan that implemented in Saskatchewan	SP, hybrid CV; Species status and income tax were used as attributes	WTP ranged between $81 and $197/ household/year
Bandara and Tisdell 2005	To explore the WTP for wild Asian elephant conservation in Sri Lanka	CVM with iterative bidding	Mean WTP of 1.10/month/ household
Boxall et al.2012	To examine the WTP to recover the population of Belugas Whales, Harbour Seals and Atlantic Blue Whales found in St. Lawrence, Canada	SP, and hybrid CVM; Attributes includes: species status, size of marine protected area; and restrictions on shipping and whale watching industry regulation	$82 to $243 /year/ household; $1021 to $3024 million nationally; Willing to pay more if there are greater increases in populations
Christie et al. 2006	To estimate the value associated with biodiversity, in England	CE with attributes of familiarity of species, species rarity, habitat, and ecosystem process, and CVM for a biodiversity enhancements policy	Ranged from $83.26 to $336.89/household/year
Forbes et al.2015	To estimate economic values associated with recovering Canadian pacific rockfish species at-risk of extinction	referendum-style SP; Attributed used: species status, probability of extinction, levels of incomes on jobs and income	WTP values ranged between $49 and $1820 / household/year
Morse-Jones et al. 2012	To understand what factors determine the WTP for the non-use values from tropical wildlife conservations in the Eastern Arc Mountains, UK.	CE; Survey attributes were the number and type of species saved or lost with or without the conservation program. Annual household donation as payment vehicle.	Annual household WTP ranged from 7.14 to 25.58, depending on the species type
Wallmo and Lew 2012	To estimate the U.S public WTP for recovering the population of: 1) loggerhead sea turtle, 2) leatherback sea turtle, 3) North Atlantic right whale, 4)North Pacific right whale, 5)upper Willamette River Chinook salmon, 6)Puget Sound Chinook salmon, 7)Hawaiian monk seals, 8)smalltouth sawfish	CE; Species' ESA status for eight targeted species and annual household cost	$58.44 to $106.76 /household /year
Wallmo and Lew 2016	To estimate the WTP for recovering the population of 1) Hawsbill sea turtle, 2) Southern resident killer whale, 3) Humpback whale, 4) Johnson's seagrass, 5) Central California coast coho salmon, 6) Southern California steelhead, 7)Elkhorn coral, and 8)Black abalone, that were listed under Endangered Species Act (ESA), in US	CE; Species' ESA status for eight targeted species and annual household cost	$59.34 to $134.77 /household /year
Wilson et al 2010	To assess the benefits and costs associated with establishing protected natural areas in New Brunswick, Canada	CVM; Information provided includes: current protected area, opportunity costs, and potential ecological improvement and recreational opportunities with additional protected areas	$64.70/household/year for establishing additional 143,000ha of protected natural areas.

Author(S)	Purpose(s)	Methods	Adjusted WTP [1]
Willingness to pay for Water quality improvement			
Alvarez et al.2016	to value the potential benefits from water quality improvements from BMP adoption in 67 Florida counties	meta-analysis; RFF's Water Quality Ladder	5 cents to $1088 per person per year for an improvement in water quality from fishable to swimmable
Brouwer et al. 2015	To explore the WTP for improved drinking water quality in rural and urban Kenya	CE with attributes of flow rate, storage capacity, diarrhea prevalence, and price, and CVM for a gravity-driven membrane water disinfection filter	Mean WTP ranges from $0.08 to $92.5 per litre
Brox, Kumar, and Stollery 2003	To estimate WTP for improved water quality in the Grand River watershed, Ontario	CVM and payment-card method	An average WTP of between $10.42 per household per month, and aggregated WTP of $27.01 million per year
Carson and Mitchell 1993	To estimate national benefits from freshwater quality improvement	interview-based CVM; RFF's Water Quality ladder Payment vehicle was annual taxes and higher product prices	$206.8/household/year to change from non-boatable to boatable, $155.6/household/year to change from boatable to fishable, and $173/household/year to change from fishable to swimmable
Dupont 2003	To obtain WTP among active, potentially active, and, passive users, for improvements in swimming, fishing, and recreational boating in Hamilton Harbor, Ontario.	CVM, discrete choice.	$9.21 to $84.42 increases in water bill, depending on the user types
He et al.2017	To value wetland ecosystem services in southern Quebec	CVM and CE: Attributes include: the numbers of endangered species, flood protection, water quality, climate regulation and municipal taxes on water and sanitation	Annual household WTP varied from about $447 to $465 depending on the stated preference method employed
Hime et al 2009	To estimate the economic values from open-water quality improvements in UK	SP; RFF's water quality ladder	Annual household WTP were approximately $22 - $110
Lantz et al 2013	To investigate the social benefits as results of wetland conservation in the Credit River Watershed, Ontario, Canada	SP with attributes of wetland area, water quality, wildlife habitat, carbon storage, as well as flood, drought, erosion control. Annual property tax used as payment vehicle	Annual WTP for wetland retention ranged from $36.12 to $1110.68 per respondent; annual WTP for wetland retention and restoration range from $37.46 to $1086.45 per respondent
Loomis and Santiago 2013	To examine the economic values of beach water quality improvement in Puerto Rico.	CE and CVM with attributes of wave eight, absence of trash, crowding, and water clarity; Additional travel cost used as payment vehicle	Additional travel cost ranged from $47.5 - $182.9, in 2011 level
Pattison et al.2011	To estimate Manitoba residences' WTP for wetland retention and restoration to the level of 1968	SP; attributes were future wetland areas, nutrients reduction, erosion control, wildlife habitat measured as the number of breeding duck pairs, and CO2 capture and storage in 2020	$318 to $350 per year per household depending on the level of wetland improvement

Author(S)	Purpose(s)	Methods	Adjusted WTP [1]
Willingness to pay for BMP adoption – Canadian studies			
Belcher et al. 2007	To determine the preferences and values associated with environmentally friendly beef products, as results of BMP adoption, in the south Saskatchewan Wood River watershed in Canada	conjoint analysis to compare environmental group participants and general population; attributes: production method, purchasing method, environmental impacts, and price premium required by producers to adopt BMPs	13.84% price premium for the general population, and 29.60% price premium for environmental group participants
Dupras et al.2018	determine the value of agri-environmental practices on landscapes aesthetics in Quebec; Targeted BMPs: erosion controls, output controls for drain, ditches and furrows, as well as bird and fish species monitoring	CVM and CE; Attributes were Water Quality, Fish Diversity; Bird Diversity, landscape diversity, and municipal taxes	$31.57 to $76.91 per year per household based on CVM,
Larue et al. 2017	To investigate the economic valuations of rural residents for water quality improvements from BMP adoption	CE; reductions in phosphorus, coliforms	$0.68 to $8.32 per taxpayers per year for coliform and phosphorus reductions.
Mingle 2016	Estimate the social values of environmental improvements casued by BMP adoption in Manitoba; Targeted BMPs: conversion from cropland to grassland, riparian buffer strips, limited livestock access to water streams and nutrient management.	CVM; Attributes: water clarity, water odor, water quantity, recreation and fish habitat, which could be influenced by beneficial management practice adoption	$22.68 to $44.41 per year per household, varied based on years and specific improvements. Respondents valued the flood reduction the most and valued the odour reduction the least

Note 1: Dollar values were adjusted to 2016 CAD level.

2.4 Selection of Attributes and Levels

As discussed in Chapters 1 and 2, there will be different ecological benefits and ES associated with improvements in water quality and wildlife habitat; however, not every ecological benefit or ES would be easy for the public to understand. To indicate the environmental changes in a way that is understandable to the general public, attributes and levels were determined based on past research and expert opinions. Since this study consists of two surveys, a different set of attributes and levels are used for each of the surveys.

2.4.1 The Wildlife Habitat Survey: Species at Risk and Agricultural Land Use

Options for depicting wildlife habitat improvements from BMP adoption ere developed through discussions with experts from Alberta Agriculture Forestry (AAF) and the Alberta Biodiversity Monitoring Institute (ABMI) in spring 2017. After conducting a series of public focus groups, the changes in species extinction status, and amount of cropland were chosen as the most appropriate indicators of wildlife habitat improvement survey.

The current number of SSR wildlife animal species listed under the *Species at Risk Act* was obtained from the *profile of the South Saskatchewan Region*, and modified after consulting with experts from the Alberta government. In total, there are 39 different at-risk species found in the SSR; 13 of them were endangered, 11 of them were threatened, and 15 of them were of special concerns. Nevertheless, it is rather problematic to determine the exact changes in wildlife populations after adopting BMPs due to uncertainties in how wildlife species would respond to these management practices and possible resulting habitat changes. Through consultation with experts from the AAF and ABMI, possible changes in the number of species in each status category after adopting agricultural BMPs were estimated; these are shown in Table 2.7.

Since the number of species in each at-risk category moves simultaneously, those numbers will be correlated which will lead to statistical errors if used directly. For analytical purposes, the net not-at-risk species were included to capture the changes in at-risk status. These potential changes in the number of at-risk species were determined based on levels of habitat improvement and land uses following BMP adoption. The lowest improvement was a result of retention of existing habitats and the improvement increased after habitat enhancement and biodiversity management practices would be put into practice. The highest level of improvement in wildlife species status

was achieved through enhancement of existing habitats as well as restoration of disturbed land back to native habitat.

The specific changes in the amount of cropland and managed grassland were also used as attributes in the wildlife survey. Data on the current areas of cropland and grassland were obtained and predicted based on Agricultural and Agri-Food Canada (AAFC): Alberta Land Accounts 1990 – 2010 (AAFC 2015a). Land uses are categorized into 15 classes based on specific land uses and land characteristics. For this study, two of these land use classes, managed grassland and cropland, were used. Based on AAFC land use reports, managed grassland is defined as natural grass and shrubs used for grazing; and cropland is land used to cultivate annual and perennial crops.

Table 2.7 Attributes and levels used in the construction of scenarios for wildlife habitat questionnaires

Attributes	**Levels**	**Definition**
Species at risk	Endangered; 5, 7, 9, 11, 13	Number of species listed as endangered. It ranged from 5 to 13.
	Threaten; 7, 8, 9, 11	Number of species listed as threaten. It ranged from 7 to 11.
	Special concerns; 11, 12, 13, 15	Number of species listed as species concerns. It ranged from 11 to 15.
	Net not at risk; 0, 6, 8, 10, 12, 14	The NET number of species that is listed not at risk. It ranged from 0 to 14, and the NET current level is 0.
Managed grassland	5.8, 6.9, 7.4, 7.6, 7.9, 8.1	The amount of managed grassland, in million acres.
Cropland	7.8, 8.3, 8.5, 8.7, 9.0, 9.8	The amount of cropland, in million acres
Tax payment	$50, $150, $300, $500 and $750	Increases in the annual household income tax
Period	5 years or 10 years	The time period for the proposed programs

Using AAFC estimates for managed grassland and cropland in 1990, 2000 and 2010 level, we predicted the approximate current and historical (1970 and 1980) amount of grassland and cropland is SSR using a linear regression model assuming a constant land conversion rate. Bringing land use back to historical levels was treated as a result of BMP adoption in this survey. The resulting acreages of grassland and cropland are displayed in the Table 2.7 where the managed

grassland and cropland were ranged from 5.8 to 8.1 million acres and 7.8 to 9.8 million acres respectively. Lastly, the increase in annual household income tax was used as payment vehicle with the lowest amount of $50 and the highest amount of $750. In addition, the proposed wildlife improvement programs could be either 5 years or 10 years which was used to identify the impact of program length on individual's WTP.

2.4.2 The Water Quality Survey: Water Quality Ladder

To indicate the changes in the water quality after adopting agricultural BMPs in the water quality improvement questionnaire, the concept of the water quality ladder was adopted. The water quality ladder, shown in Figure 2.5, is an index which maps a collection of water quality variables to human use. The variables include nitrogen, phosphorus, and turbidity that range from poor, or non-boatable, to excellent, or drinkable, water quality (Mitchell and Carson 1981; Mitchell and Carson 1989; Carson and Mitchell 1993; Russell et al. 2001). The ladder associates different levels of water quality with changes in how water at that quality level can be used by people. Movements along the ladder represent either potential increases in human benefits from higher water quality, or potential increases in costs from lower water quality levels. These are shown in Figure 2.7 and Table 2.8. When the water quality ladder value is 2.5, the quality of the water being tested is only boatable. If the water quality ladder values increase from 2.5 to 5, water becomes not only boatable but also fishable. When water quality ladder values increase to 7, the water being tested is also swimmable, and also fishable and boatable. Water quality ladder values of 9.5 indicate that the water becomes drinkable. Hence, the water quality ladder can capture human benefits of quality changes in the type of beneficial uses supported by water bodies.

Table 2.8 Attributes and levels used in the construction of scenarios for water quality questionnaire

Attributes	**Levels**	Definition
Water Quality	Drinkable	The water quality ladder value is equal or greater than 9.5, and the water is suitable for drinking, swimming, fishing and boating.
	Swimmable	The water quality ladder value is between 7 and 9.5, and the water is suitable for swimming, fishing and boating
	Fishable	The water quality ladder value is between 5 and 7, and the water is suitable for fishing and boating only

	Boatable	The water quality ladder value is between 2.5 and 5, and the water is suitable for boating only
Tax payment	\$50, \$150, \$300, \$500 and \$750	Increases in the annual household income tax for the following 5 years

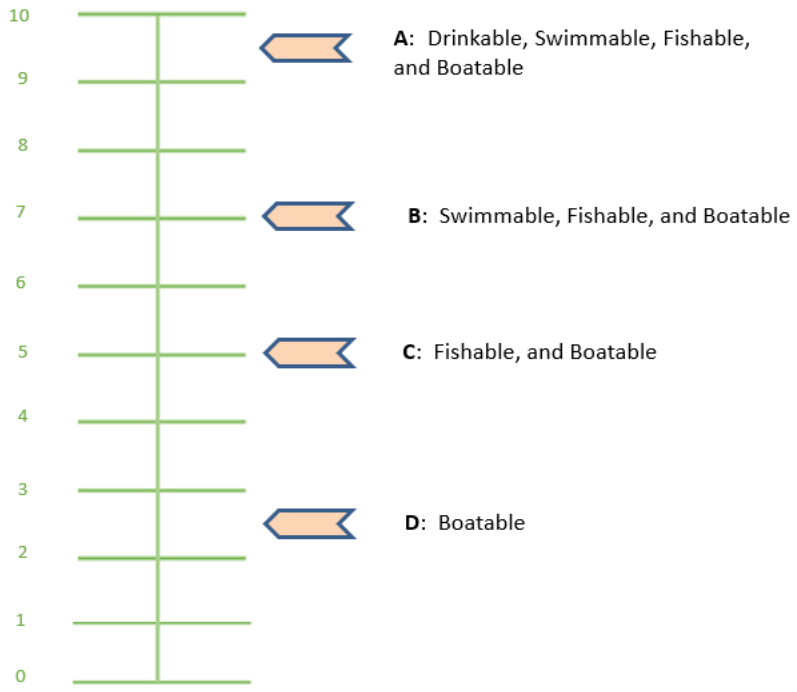


Figure 2.5 A representation of water quality ladder used in the water quality improvement survey

The equation used for calculating water quality ladder estimates is illustrated below:

$$WQL = \left(\prod_{i=1}^{n} q_i^{w_i}\right)/10$$

where WQL is the resulting water quality ladder estimate, q_i is the quality estimate for the i^{th} parameter, w_i is the unit weight of the i^{th} parameter, and n is the number of parameters (McClelland 1974). The sum of the unit weights equal 1. There is a total of nine parameters in the original parameter list used by McClelland (1974), as demonstrated in Table 2.9. However, data for the 5-day biochemical oxygen demand was not regularly collected on the mainstream river locations by Alberta Environment and Parks. Thus, this parameter was omitted from the calculations in this present study and the weights for the remaining parameters were adjusted, as shown in Table 2.10.

The 2015 water quality ladder estimates in the South Saskatchewan Sub-Basins were calculated based on the surface water quality data obtained from Alberta Environment and Parks (AEP), shown in Figure 2.2. The 2015 ladder values for Bow River, Oldman River, and South Saskatchewan River showed a similar trend. Water quality was typically better during spring and winter, decreases during summer and fall. The lowest ladder estimates for Bow, Oldman and Saskatchewan River occurred in June or July and reached the maximum in November, December, and January. Water quality in these three river streams was suitable for fishing, boating, and swimming for most time of year, but became only fishable and boatable during summer months. Although there was also a similar trend for the Milk River water quality ladder estimates, relatively lower and more dramatic changes were observed for the Milk River, as demonstrated by the blue line. The ladder estimate got as low as 5.0 during the summer months when there is considerable runoff. At that time of year, the Milk River became only fishable and boatable.

Table 2.9 Original parameters, units and weights used by McClelland for calculating Water Quality Ladder Estimates

Parameters	Units	Weights
Dissolved Oxygen	Expressed as percent saturation	0.17
Fecal coliform density	no./100 ml	0.16
pH		0.11
Nitrates (NO3)	mg/L NO3-N	0.11
Phosphates (PO4)	mg/L PO4-P	0.10
5-day biochemical oxygen demand	mg/L	0.11
Temperature	Departure from equilibrium	0.10
Total solids	Mg/L	0.07
Turbidity	JTU (Jackson turbidity units)	0.08

Table 2.10 Parameters, units and re-weighted weights for calculating Water Quality Ladder Estimates in this study

Parameters	Units	Weights
Dissolved Oxygen	Expressed as percent saturation	0.1825
Fecal coliform density	no./100 ml	0.1725
pH		0.1225
Nitrates (NO3)	mg/L NO3-N	0.1225
Phosphates (PO4)	mg/L PO4-P	0.1125
Temperature	Departure from equilibrium	0.1125
Total solids	Mg/L	0.0825
Turbidity	JTU (Jackson turbidity units)	0.0925

In addition to ladder value estimates the increases in the annual household income tax levels for the following 5 years was used as the payment vehicle, and ranged from $50/year/household to $750/year/household over the 5-year period.

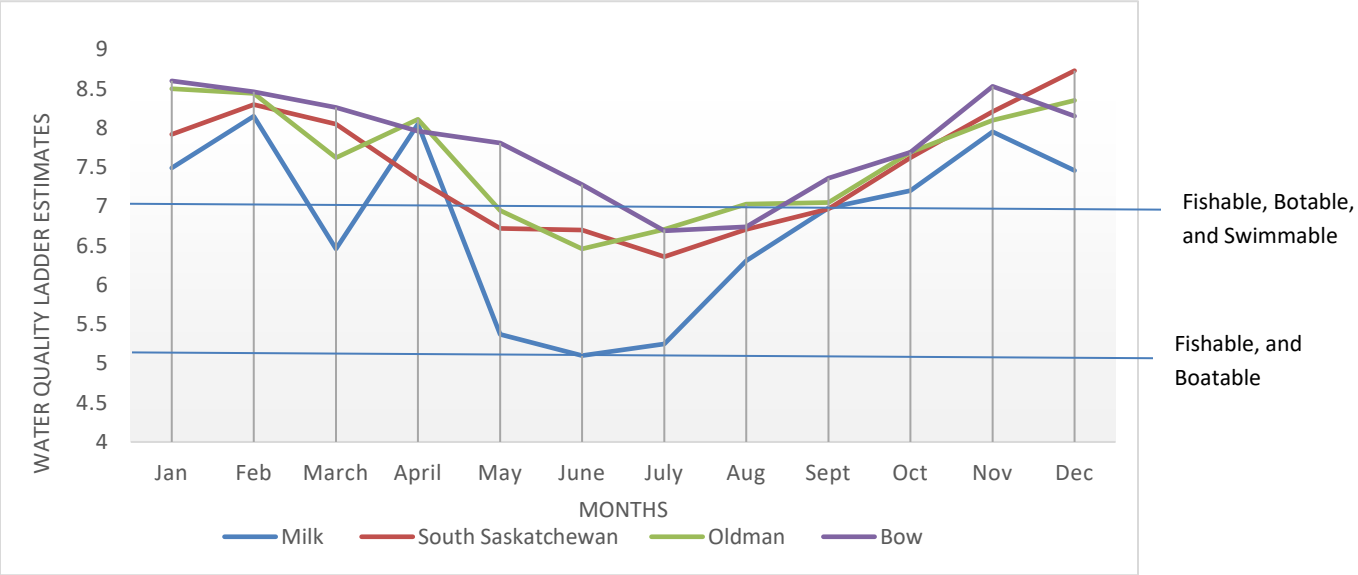


Figure 2.6 Water Quality Ladder Estimates for Monitoring Stations in the South Saskatchewan Sub-Basins in 2015

2.5 Econometric Model

2.5.1 Random Utility Theory

Maximum likelihood estimation of a logit model was adopted in this study where the dependent variable is the probability the survey participants answering "yes" to the proposed agricultural BMP programs for water quality or wildlife habitat improvement. This study utilized random utility model (RUM) where consumers are assumed to be rational, hence they would choose the alternative that results in the highest utility among all other alternatives (Haab and McConnell, 2002; Grafton et al., 2004; Pattison 2011; Boxall et al., 2012; Harper 2012).

The underpinning theory used to support econometric estimation of the binary decisions (votes) made by respondents in both the water quality and wildlife habitat voting data was random utility theory (RUM). In this theoretical approach the utility function is composed of a systematic component (V) and a random component (ε) where the subscript i indicates the program alternatives and j represents the j^{th} individual (see equation 1).

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad [1]$$

The systematic component is usually a function of various factors such as income, age and other individual-specific demographic characteristics. This model assumes that consumers know their preferences and that the researchers, who do not have full knowledge, can only observe the systematic portion. In the case of our hybrid contingent valuation approach, the respondent chooses between yes or no to a repeated referendum, question repeatedly. Hence, the subscript *i* in equation 1 represents whether the respondent chooses "yes" or "no" to the proposed BMP program. If the respondent chose the proposed program to improve water or wildlife habitat conditions in the SSR, their household annual income (M) would be reduced by the amount of annual tax *t*. If the respondent chooses not to pay additional taxes and stay in the current water or wildlife conditions, there will be no change in income as shown in equations 2 and 3. Equation 2 represents the indirect utility of choosing the proposed program for individual j where V_{1j} is the indirect utility, Z_j is a vector of individual-specific household characteristics for individual j, M is the individual's pre-tax household income, t is the additional tax payment for the proposed program and ε_{1j} is the random component unknown to the researcher. On the other hand, equation 3 represents the indirect utility of choosing stay in the current situation of individual j, where V_{0j} is the indirect utility for choosing the status quo, Z_j represents the characteristics of individual j, M is the household income before tax and ε_{0j} is the random component.

$$V_{1j} = V_{1j}(Z_j, M_j - t_j) + \varepsilon_{1j} \quad [2]$$

$$V_{0j} = V_{0j}(Z_j, M_j) + \varepsilon_{0j} \quad [3]$$

The equations indicating the probability for individual j to choose the proposed program given a specific cost are represented by equations 4.1 to 4.3. Equation 4.1 shows the probability respondents to say yes to a proposed program is equivalent to the probability that respondents obtain higher utility from the proposed program than the status quo (Haab and McConnell 2002). Equation [4.2] is obtained by substituting equation [2] and [3] into equation [4.1], and it can be re-arranged into equation [4.3]. It intuitively implies that the probability of individual j saying "yes" to a proposed program is equal to the probability that the individual j's utility from choosing the proposed programs is greater than the utility from staying at the status quo condition, taking individual j's personal characteristics into considerations.

$$\Pr(yes_j) = \Pr(V_{1j} > V_{0j}) \quad [4.1]$$

$$\Pr(yes_j) = \Pr(V_{1j}(Z_j, M_j - t_j) + \varepsilon_{1j} > V_{0j}(Z_j, M_j) + \varepsilon_{0j}) \quad [4.2]$$

$$\Pr(yes_j) = \Pr(V_{1j}(Z_j, M_j - t_j) - V_{0j}(Z_j, M_j) > \varepsilon_{0j} - \varepsilon_{1j}) \quad [4.3]$$

According to Haab and McConnell (2002), the systematic components, or the indirect utility, can be expressed as equation [5] and [6] in the case of linear relationship where α is a vector of parameters for each management strategy, β_0 and β_1 are the marginal utility of income before and after adopting the proposed program.

$$V_{1j} = \alpha_1 Z_j + \beta_1(M_j - t_j) + \varepsilon_{1j} \quad [5]$$

$$V_{0j} = \alpha_0 Z_j + \beta_0(M_j) + \varepsilon_{0j} \quad [6]$$

The difference in utility can be expressed using equation [7]. Following the assumption made by Haab and McConnell (2002) that the marginal utility of income is constant between two binary policy scenarios. It implies that the value of β_1 and β_0 in equation [7] would equal to the value. Therefore, the difference in utility can be further simplified into equation [8], assuming $\alpha = \alpha_1 - \alpha_0$ and $\varepsilon_j = \varepsilon_{1j} - \varepsilon_{0j}$.

$$V_{1j} - V_{0j} = (\alpha_1 - \alpha_0)Z_j + \beta_1(M_j - t_j) - \beta_0(M_j) + \varepsilon_{1j} - \varepsilon_{0j} \quad [7]$$

$$V_{1j} - V_{0j} = \alpha Z_j - \beta t_j + \varepsilon_j \quad [8]$$

In order to estimate the parameters of the systematic component of the utility function, it is necessary to determine how the error term is distributed. In this study, the logit model is used assuming the error term is distributed logistic. The basic assumption about the error terms is that ε_j are independently and identically distributed with means equal to zero. When ε_j is logistically distributed, the associated mean and variance will be zero and $\frac{\pi^2 \sigma_L^2}{3}$ respectively. To generate a logistic variable with mean zero and variance of $\pi^2/3$, we normalized the data by σ_L (Haab and McConnell (2002). The resulting probability equation of the logit model, or the cumulative distribution function, for individual j to choose the proposed program can be represented by equation [9] which can be estimated by STATA software:

$$\Pr(yes_j) = \frac{1}{1 + exp\left(-\left({}^{\alpha Z_j}/_{\sigma_L} - {}^{\beta t_j}/_{\sigma_L}\right)\right)} \quad [9]$$

2.5.2 Willingness to Pay Estimation

WTP is the monetary amount that will make individuals indifferent before and after choosing the proposed environmental improvement program (Habb and McConnel, 2002). The WTP for changes in environmental quality (i.e. water quality, wildlife habitat) that result in a gain in utility for individual j can be derived from the following formula:

$$V_{1j}\,(q_1,\ M_j - WTP\,) = V_{0j}\,(q_0, M_j) \quad [10]$$

Following the previous section, let V_{1j} and V_{0j} indicate the indirect utility from choosing the proposed program and choosing the status quo respectively; q_0 and q_1 represent the environmental quality levels before and after the introduction of the BMP adoption policy, and M represents individual j's annual household income. Assuming a linear relationship, equation [10] can be expressed as equation [11] and can be re-arranged to yield the WTP as shown in equation [12]. Under the assumption that the parameter values of $\alpha, \beta$and Z_j are known, the expected WTP can be written as equation [13] [5]where $\bar{Z}$ is the mean of the covariates, α and $\bar{Z}$ are both vectors of parameters, and β is the marginal utility of income.

$$\alpha_1 Z_j + \beta\left(M_j - WTP_j\right) + \varepsilon_{1j} = \alpha_0 Z_j + \beta M_j + \varepsilon_{0j} \quad [11]$$

$$WTP_j = \alpha Z_j/\beta + \varepsilon_j/\beta \quad [12]$$

$$E_\varepsilon\left(WTP_j \middle| \alpha, \beta, Z_j\right) = \frac{\alpha\bar{Z}}{\beta} \quad [13]$$

Chapter Summary

The SSR is a large, population-dense region within Alberta with an economic focus on agriculture and livestock grazing. Recently, increasing amounts of grassland have been transformed into cropland for agricultural purposes. To promote more environmentally-friendly and sustainable land uses in the SSR, there are a series of land use planning frameworks and strategic plans

[5] Other than the parametric valuation method mentioned above, WTP values can also be estimated using a non-parametric method. Detailed procedures for the non-parametric estimation methods and results for both water quality and wildlife habitat improvement are shown in Appendix I.

implemented such as the South Saskatchewan Regional Plan and the South Saskatchewan Region Surface Water Management Framework.

Stated preference methods were used in this study to conduct non-market valuation for water quality and wildlife habitat improvement after implementing an agricultural beneficial management practices adoption policy. Although there are advantages for conducting a stated preference study, concerns such as hypothetical bias are also not negligible. To ensure the effectiveness and accuracy of our valuation approach, relevant guidelines for constructing and employing stated preference methods were reviewed. The attributes and levels used in this present study to communicate water or wildlife quality improvements to respondents based on the hypothetical BMP adoption policy were determined based on past literatures and consultations with experts. For the water quality survey, the water quality ladder was employed; for the wildlife habitat survey, the status of at-risk species and agricultural land uses were used. For both surveys, tax increases were used as a payment vehicle and the wildlife survey had an additional program period variable to capture the effect of variable program lengths on WTP. This latter feature was introduced to accommodate concerns regarding the temporal dimensions thought to be important in wildlife species conservation efforts. Random utility models were introduced and will be utilized to value the amount respondents were willing to pay for the projected water quality and wildlife habitat environmental improvements resulting from the new BMP policy.

Chapter 3 Survey Design and Data Collection

This chapter discusses the process followed to design and administer the survey instruments used to develop estimates of the WTP for policy change. This is followed by an overview of the four major sections of the final questionnaires.

3.1 Questionnaire Design Steps

3.1.1 Initial Questionnaire Development and Ethics Approval

Before the initial questionnaire development, relevant literature was reviewed as discussed in previous chapters. Based on relevant past studies, draft questionnaires for wildlife habitat and water quality conditions were constructed. The next step was to test the draft surveys by holding focus groups discussions and test the understandability of the employed concepts and readability of the draft survey instruments.

In addition, ethics approval was essential to hold focus group discussions and pilot tests. There are several major components for the research ethics management, including study staff members and funding, study objectives and methods, risks and benefits assessments, participant recruitment and informed consent, and as well as data collection procedures and storage. The information sheet and informed consent forms, which were required for conducting focus groups, also needed to be approved by the Research Ethics Board. The information sheet and consent forms used in the focus groups are presented in the Appendix. After the survey design was complete, the final surveys were also uploaded and examined by the Research Ethics Board and final ethics approval was provided by the University of Alberta Research Ethics Office on Nov 4th,2016 and amended on December 1st, 2017.

3.1.2 Focus Groups

Before finalizing and implementing surveys to obtain data from Alberta citizens, the questionnaires were designed and pre-tested through focus group discussions with experts and randomly selected members of the public. The aims of conducting focus groups were to obtain suggestions and comments on survey structure and to determine whether the questionnaire content is unambiguous and understandable for a general public audience.

The expert focus group took place on Oct.11th, 2016, in the Legislative ANNEX building in downtown Edmonton and involved 5 experts from academia and the Alberta government. The

main purpose of the expert focus group was to set up a general direction for the structure of the questionnaire and to facilitate its development. Several critical aspects of the survey design were discussed, which included: the choice between examining issues in the whole of Alberta or to simply focus on Southern Alberta as the study focus, information on current wildlife habitat conditions and water quality were examined, along with options for choice of a payment vehicle. In this regard, the feasibility and credibility of using the *Water Quality Ladder* and *Species at Risk* categories to represent the changes in water quality and wildlife habitat conditions after increased adoption of agricultural BMPs was discussed.

After the initial development of the questionnaires, three preliminary public focus group discussions were held to testify the readability and understandability of the survey. The first public focus group was held on Feb 21st, 2017, in the Trend Research Center in downtown Edmonton. There were 6 individuals, randomly selected by a recruiting company from the entire city population based on phone number, who participated in the first focus group. The second public focus group took place on Feb 27th, 2017, in the eStyle Marketing Research Service from in downtown Calgary, where 12 randomly selected participants participated. The third public focus group took place on March 9th, 2017, in the Lethbridge Lodge Hotel in Lethbridge. Three females and 7 males were randomly selected and joined in the discussion. These three public focus groups were used to obtain feedback on readability of the draft survey content and the valuation questioning approach. One major common concern, the complexity of the survey background information, arose from all three focus groups. A copy of the Information Sheet and Consent Form used in the public focus groups are shown in Appendix A and Appendix B.

3.1.3 Survey Video Testing

To present survey background information effectively and efficiently, information content in the questionnaires were condensed and made into four videos. These videos illustrated the importance and impact of the beef industry in the SSR, the benefits and current adoption of BMPs in the region, current water quality conditions, and current wildlife habitat conditions in the SSR. The videos were then tested by holding survey video testing sessions. The initial survey video testing was conducted on May 9th, 2017, with professors and graduate students from the Department of Resource Economics and Environmental Sociology at University of Alberta, and the second video testing was conducted on May 19th, 2017 with experts from the beef industry and the Alberta

government. Similar to the previous public focus groups, survey video tests aimed to improve the understandability of the information provided in the survey.

3.1.4 Final Focus Groups and Pre-test

After finalizing the survey video based on the comments received, the complete online surveys, one for wildlife habitat improvement and one for water quality improvement, were constructed by the market research firm *Advanis.* The complete online surveys were composed of a short instruction to the study, survey videos, valuation scenarios, and a demographic component. The complete online surveys were further tested using two further focus group discussions. The wildlife survey focus group discussion was held on Oct 18th, 2017 at Trend Research Inc. in Edmonton. Nine randomly-selected participants contributed to survey testing and discussion. The water survey focus group was conducted at the same place on Oct 26th, 2017, and 8 randomly-selected individuals participated. Feedback from these two focus groups provided valuable information on survey structure, video flow, confusing wording and other minor concerns participants experienced such as mismatching colors, interrupted video sound etc.

The pre-test was launched by *Advanis* on December 4th, 2017, and was targeted at the population of Alberta's South Saskatchewan area. Telephone recruitment was chosen as the recruitment method, and postal codes were used to constrain the population to the target area. A total of 52 individuals participated in a pre-test of the survey instrument: 26 of them completed the water quality survey and the remainder completed the wildlife habitat questionnaires. Both wildlife and water questionnaires were revised and finalized after obtaining feedback from the final focus groups and pre-tests. Preliminary tests were run for both datasets to understand the respondents' sensitivity to tax levels and the results indicated that most respondents were willing to choose the improved programs even with the highest tax levels in the valuation questions. Therefore, the range of taxes, or the cost, were increased to ensure that respondents were responding to higher "prices" in accordance with economic theory.

3.1.5 Survey Participation Incentives

To encourage potential participants to complete the survey, an official random price draw was provided for those who participated. After respondents completed the survey, they had the option to enter the random draw by providing information including their telephone number and email address. The winners were determined by a random draw from all eligible respondents received

by December 31, 2017, and the draw process was conducted by *Advanis*. A total of 8 winners were selected from the eligible survey participants and they each received a $100 CDN gift card.

3.1.6 Survey Administration

There are three common modes of administration: mail, face-to-face, and internet. In this study, internet survey administration was used. Compared to mail-based surveys and face-to-face, or interview-based surveys which are more time-consuming, an Internet-based survey is quick and more convenient (Wright, 2005). It also saves money since there will be no paper or interviewers involved. However, there are also drawbacks associated with the internet-based survey approach. For instance, it might be more difficult for elderly people to participate since they might not know how to use computers or smartphones. Another disadvantage of internet survey is the issue of sampling to generate respondents. Unlike mail or interview surveys, in which participants can be chosen randomly, it is possible that internet surveys could only be accessed by a certain group of individuals in the population of interest (Wright, 2005).

Survey respondents were restricted to southern Alberta residents since the major focus of this study was to determine the WTP for BMP adoption in the SSR region to increase provision of ecosystem services from water and wildlife resources. Residents who did not live in the SSR might not be directly impacted by the potential agricultural BMP adoption policy change, hence the inclusion of non-SSR residents would influence the applicability of the final results. The sampling strategy was determined based on the population distribution in SSR to ensure the samples being selected represent the target population fairly. The targeted total number of participants for each survey instrument was 500, with an urban/rural ratio of 3:1. In addition, the targeted percentages of respondents live in the Bow, Oldman, and, all other river basin regions were determined to be 60%, 20%, and 20% respectively. Similar to the pre-test, potential survey participants were chosen by random telephone recruitment based on eligible postal codes. When an individual agreed to participate in the survey, they received a web-link of the survey on their electric device. They then completed the questionnaire either on their smartphone, laptop or other device.

The response rates for the final survey instruments are displayed in Table 3.1. A total of 1594 people were contacted via telephone to participate into the wildlife habitat improvement survey, only 532 of them completed the web survey. Within the 532 respondents, 26 of them resided outside of the study area, leaving a total of 506 adequate survey completions. The survey response

rate was thus 33.40% and 31.70% respectively for web survey completions with or without outside area completion. For the water quality improvement survey, a total of 2046 people were contact using random telephone dialing; a total of 542 of participants completed the web survey. After removing 24 outside-of-area completions, 518 adequate survey completions were obtained with a response rate of 25.30%. The complete wildlife and water quality survey instruments are in Appendix C and Appendix D.

Table 3.1 Response statistics for the final survey instruments

Categories	Wildlife habitat improvement survey	Water quality improvement survey
Telephone Recruits	1594	2046
Web Survey Completions	506	518
Incompletes	95	128
Outside area complete, not included in final dataset	26	24
Response rate (includes outside area completes)	33.4%	26.5%
Response rate (excludes outside area completes)	31.7%	25.3%

3.2 An Overview of the Final Questionnaire

3.2.1 Introduction Section

The introductory section of the survey began with a short explanation of the random draw after successful completion of the questionnaire and was followed by a series of "warm-up" questions. As discussed in Chapter 2, these question can help to obtain valuable information regarding preference variation and decision strategy and to select useful subsets of the sample of respondents. The warm-up questions began with the respondents providing their postal code and answering which part of the SSR region they resided in. Those two questions narrowed down the sample population to the targeted study area. Other warm-up questions involved solicitation of the frequency of household food purchases, the frequency of household meat purchases, and the frequency of household beef purchases. There were four levels of frequencies where the highest level was "Regularly", and the lowest level was "Never". This section also included questions asking if respondents currently, or at any time during their early years growing up, lived on a farm and also question regarding typical annual farm visits. These questions were provided to allow us to determine whether the participant was familiar with farming. Other important aspects such as food preferences were also solicited in this section.

In addition, respondents' knowledge regarding a series of agricultural and environmental related topics were also determined in the introductory section. Respondents were given a list of topics for which they had to provide their levels of understanding which was recorded as "A great deal" and the lowest level of understanding was recorded as "Nothing". A complete list of topics included in the section is shown in Table 3.2 and an example of these questions was demonstrated below:

Table 3.2 List of environmental and agricultural issues

Topics
1. Growth hormone use in livestock
2. Antibiotic use in livestock
3. Genetically modified food
4. Mad Cow Disease
5. Battery Cage for chicken
6. Abuse of farm animals
7. Greenhouse gas emission from livestock
8. Water Pollution from livestock grazing
9. Salmonella food poisoning
10. Soil erosion from livestock grazing
11. Land Conversion for livestock grazing
12. Bovine spongiform encephalopathy (BSE)
13. Threats to wildlife from intensified livestock grazing

How much have you heard or read about each of the following topics in the past year?

Growth hormone use in livestock

- *A great deal*
- *Quite a bit*
- *A moderate amount*
- *A little*
- *Nothing*

3.2.2 Survey Video Section

After the warm-up questions, each participant viewed three survey videos (shown in paper form in Appendices E-H). Every respondent in both the wildlife and water quality surveys watched the Alberta South Saskatchewan Region introduction video, and the Beneficial Management Practice video. Following viewing these, each respondent viewed a video about either species at risk or water quality depending on which sample they were recruited to. After each video, there were de-briefing questions to minimize bias in the CVM questions, as discussed in Chapter 2. For example,

after the Alberta SSR introduction video, participants were asked whether they aware of the economic importance of the beef sector to the SSR, and whether they aware of the potential environmental impacts from the beef sector before they watched the first video. After the second video, participants were asked whether they had heard of BMPs, and the Growing Forward Stewardship Program.

Respondents were also asked to provide their opinion on future government funding investment on the environmental impacts of agricultural production. Respondents could choose among "increase investment", "decrease investment" and "do nothing". The question used in the questionnaires:

> *What do you think the Canadian and Alberta Government should do regarding future levels of funding specifically on the environmental impacts of agricultural production?*
>
> 1. ***Increase investments*** in protecting the environment from impacts resulting from agricultural production
> 2. ***Decrease investment*** in protecting the environment from impacts resulting from agricultural production
> 3. ***Do Nothing***: Current government spending on environmental protection is sufficient

There were also questions included to measure concerns about environmental impacts, concerns regarding agricultural jobs and production, and concerns about BMP adoption. These questions were provided after the third video. In the water quality survey, the environmental concern question was framed as "how important is it to you personally that every possible effort be made to improve water quality in Canadian rivers and lakes". Similarly, the environmental concern question in the wildlife habitat survey was framed as "how important is it to you personally that every possible effort be made to protect all species that are currently at risk". The environmental concern variable in each case was a Likert scale variable that ranged from 1 to 6 with increasing importance level. After the environmental question, respondents were asked whether they had concerns about the potential impacts of BMP adoption on agricultural jobs and food production. Like the environmental questions, agricultural job and production concern question was also a rating scale variable and ranged from 1 to 6 with increasing concerns.

3.2.3 Valuation Scenarios

Following the introductory sections and concern/awareness questions both questionnaires transitioned to the stated preference or CVM sections Examples of valuation questions for each survey are provided below. The format used for the wildlife habitat choice scenarios involved a binary choice referendum question for choosing between enhanced or status quo wildlife habitat conditions (see Fig 3.1). The species status was expressed as the number of species listed under different species-at-risk risk categories used in the current Species at Risk Act, while the agricultural land uses were represented by the amount of cropland and grassland in the SSR. The tax levels employed one of were $50/year, $150/year, $300/year, $500/year and $750/year respectively. Additionally, the program period for the wildlife habitat survey could be either 5 years or 10 years. This was used to provide a more accurate interpretation of the programs action on wildlife populations based upon expert opinion. To effectively capture the influences of program on WTP, wildlife survey respondents have to answer five choice scenarios.

Figure 3.2 displays an example choice scenario used in the water quality survey where respondents were faced with a binary choice referendum question for the future water quality. One option was to stay at the current level of water quality, expressed as water uses (determined by water quality ladder estimates), with no additional annual taxes; the other choice was to improve water quality at an increase in additional household costs through paying higher taxes. The first column indicates the four different river basins included in the study. The second and third columns provide assessments of the water quality status in each river basin for the proposed and current programs, as well as associated tax payments. There were five levels of tax increases associated with proposed programs: $50/year, $150/year, $300/year, $500/year and $750/year. The period of the program was fixed at 5 years in this survey. Currently, the water quality in the Bow, Oldman and South Saskatchewan Rivers is fishable and boatable. The water quality in these rivers can have a 1-level improvement which would increase to swimmable water quality, or a 2-level increase which would move to drinkable water quality. However, the current water quality in the Milk River

is only boatable, hence, it is possible to have a 1-level, a 2-level, or a 3-level improvement for Milk River. For water quality, each respondent was required to answer four choice scenarios.

The Next five sets of questions will ask you to consider five potential scenarios of new government programs. These enhance programs provide financial inventives to Alberta livestock producers to incoporate BMPs in their operations, which would help to improve Wildlife habitat conditions in the South Saskatchewan Region.

In each set, you will be asked to compare the enhanced program with the option to make no additional investment and vote for the option you prefer.The scenarios are similar but will vary by one or two different attributes. We will give you an example of scenarios, and then you will complete 5 scenarios yourself. Each scenario should be treated as an indepent decision that is unrelated to your answers on the previous option

It is very important that you **Vote as if this were a real vote.** You need to image that you actuallyhave to **dig into your household budget and pay the additional cost.** Please carefully conisder the wildlife habitat condition differences betwee the current situation and the new enhanced program scenarios and the increeased tax level option before voting.

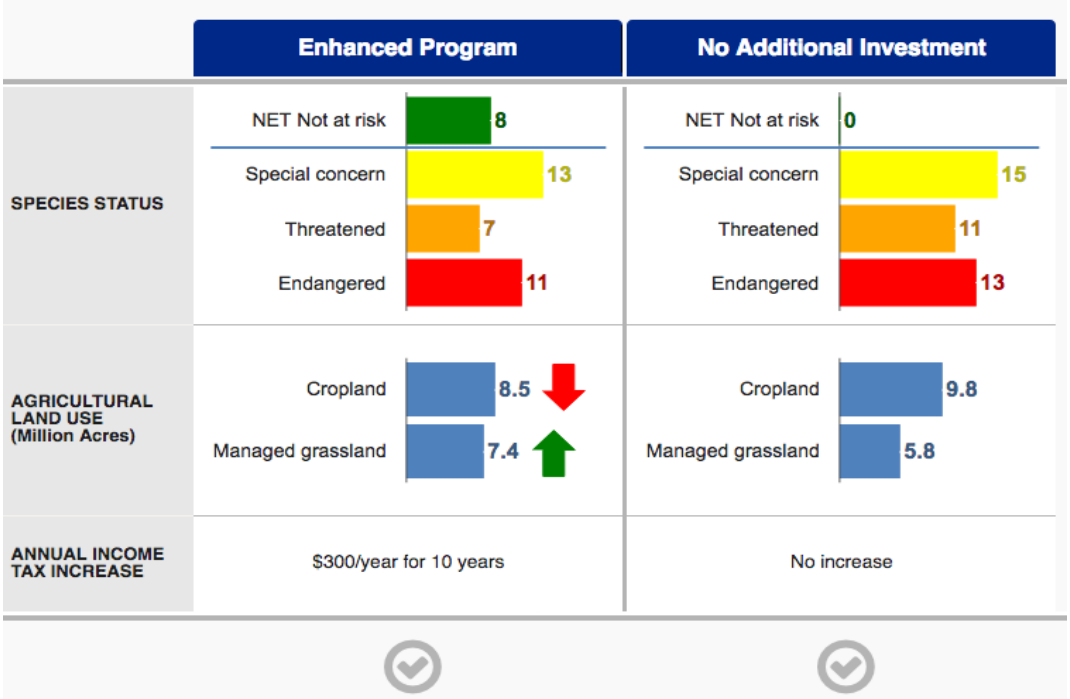


Figure 3.1 An example of the valuation question for the wildlife habitat survey

.

The Next four sets of questions will ask you to consider five potential scenarios of new government programs. These enhance programs provide financial inventives to Alberta livestock producers to incoporate BMPs in their operations, which would help to improve surface water quality in the four main rivers in the South Saskatchewan River Basins.

In each set, you will be asked to compare the enhanced program with the option to make no additional investment and vote for the option you prefer.The scenarios are similar but will vary by one or two different attributes. We will give you an example of scenarios, and then you will complete 4 scenarios yourself. Each scenario should be treated as an indepent decision that is unrelated to your answers on the previous option

It is very important that you **Vote as if this were a real vote.** You need to image that you actuallyhave to **dig into your household budget and pay the additional cost.** Please carefully conisder the wildlife habitat condition differences betwee the current situation and the new enhanced program scenarios and the increeased tax level option before voting.

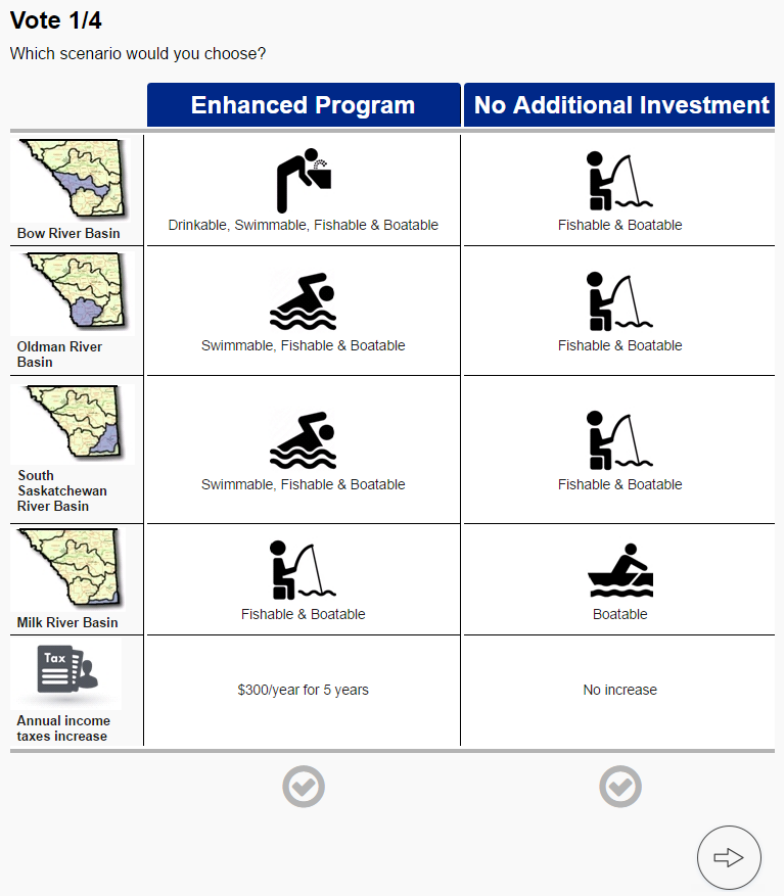


Figure 3.2 An example of the valuation question for the water quality survey

After every choice scenario, respondents were provided with a certainty question asking how certain they felt about their choice if it was a real referendum. The purpose of this certainty question is to determine whether the respondents were confident about their choices. It is possible for respondents to vote differently in a real referendum when they were uncertain about the choices they made in a hypothetical scenario (Grafton et al, 2004). There will be cases where respondents

chose a proposed program, however, they were not certain about their choice. To ensure accuracy and to reduce hypothetical bias for later data analysis, as discussed in Chapter 2, "yes" responses were changed to "no" responses if the respondents were not "very certain" about their choices (Champ et al, 1997; Ready et al, 2010).

In both wildlife habitat and water quality survey, the certainty question was:

> *How certain are you that this is the choice you would make if this was a real referendum?*
>
> - *Very Uncertain*
> - *Somewhat uncertain*
> - *Somewhat certain*
> - *Very certain*

Inferred valuation questions followed after the certainty questions. This procedure was used as a measure to minimize the influences of hypothetical bias and to examine the degree of social desirability bias by asking the respondent to predict how much other individuals would pay for any environmental programs (Lusk and Norwood 2009). An example of the inferred valuation question, although not used in this study, is shown below:

> *Considering the **enhanced program option** outlined previously, what percentage of South Saskatchewan residents do you believe would vote in favour of this in a **real referendum** ?*

In addition, consequentiality questions were provided after the choice scenarios. As discussed in chapter 4, survey participants might answer the questions strategically since they may not feel the survey results would have a real consequence. In the first consequentiality question, respondents were asked to choose how likely they thought the survey results would be used by government policy makers. This is thought to identify respondents behaving strategically if they believed that it was very unlikely. The second consequentiality question emphasized the likelihood of tax increases in the future, which also aimed to reduce hypothetical bias, as discussed in Chapter 2.

1) In your opinion, how likely do you think it is that policy makers will consider the results from this survey to make decisions about beneficial management practice?

- Very unlikely
- Somewhat unlikely
- An even chance
- Somewhat likely
- Very likely
- No opinion

2) *Do you understand that your tax payment would increases for the foreseeable future if any of these programs were put in place?*

There were additional follow-up questions which facilitated understanding why respondents chose or not chose the proposed program. When the respondents chose to stay with the current situation (i.e. vote "no" in the referendum), they were asked for the reasons that led to their choice. There were a number of potential reasons provided for not choosing a proposed program. For example, it could be that the respondents did not believe the effectiveness of the proposed program, or they simply do not want to pay additional taxes, or the tax amount proposed were too high. Similarly, respondents were also asked to choose the reasons they selected a proposed program. Those reasons included: 1) good use of public funding, 2) the benefits obtained from watershed or wildlife habitat protection are worth the increases in taxes, 3) watershed or wildlife habitat should be protected at any price, 4) protecting watershed is important to me, and 5) other.

More importantly, respondents were identified as potential yea-sayers if they chose the third option above as the reason for voting for a proposed program. Yea-saying is defined as the tendency of saying "yes" no matter what contents are provided to them (e.g. Blamey et al, 1999). Including data from yea-saying respondents could lead to bias in data analysis as discussed in chapter 2. In this case, the proposed programs would be chosen regardless of the design variables (tax levels, improvement in water quality ladder, improvement in the species at risk etc.) and other demographic characteristics, which meet the condition for a yea-sayer. However, yea-sayers in this study were not determined solely based on this question. Two conditions have to be met in order to be considered as a yea-sayer: 1) they must have chosen the third option as one of the reasons for choosing a proposed program, as discussed above; and 2) the respondent must actually

choose “yes” to proposed programs for every choice scenario provided to them. If the respondents did not select the proposed program in every choice scenario but third option is one of the reasons for choosing the proposed program, they were not considered as yea-sayers and vice versa.

3.2.4 Demographic Information Section

After the valuation scenario section, a series of simple demographic information questions were provided. These demographic questions required respondents to provide their gender, age, pre-tax household annual income, highest level of education, family size, and whether they are members of an environmental organization. To examine how well the survey data represented the Southern Alberta population, the percentage of rural and urban residents and the percentage of males and females from the survey data were compared with 2016 census data.

Chapter Summary

This chapter introduced the design of the binary choice stated preference tools employed in the two surveys. The discussion started with literature reviews and descriptions of ethics approvals, followed by discussion of preliminary design focus groups, video testing sessions, final focus groups and questionnaire pre-tests to improve the overall survey quality. After revision, the final survey was implemented via phone recruitment and internet method, conducted by a market research firm. The final survey instruments consisted of four major parts: an introductory section, a survey video section, a valuation scenario section and the demographic information section. To minimize common biases in the valuation assessments, measures such as certainty and consequentiality questions were also employed in the final survey instruments.

Chapter 4 Survey Data Description

This chapter provides a description of the data from the water and wildlife habitat surveys. First, socio-demographic characteristics of the sample respondents are presented and compared with 2016 Canadian Census information for Alberta South Saskatchewan region. The frequencies of food and meat purchases and beef consumption are also examined as well as respondents' familiarity and awareness with a series of topics related to the agriculture and beef sectors. This chapter also provides descriptions about respondents' membership in environmental groups, their attitudes toward environmental protection and future government investments in environmental stewardship, as well as their levels of concern for potential impacts of environmental stewardship on employment and food production.

4.1 Socio-demographic characteristics

Socio-demographic data from the wildlife and water quality surveys are summarized in Table 4.1. To examine how well the survey data represents the Southern Alberta population, socio-demographic data are compared with relevant information from the 2016 census data from the SSR.

Wildlife Habitat Questionnaire:

For the wildlife habitat questionnaire, the proportion of male respondents was 56%, which was higher than the Census average of 50%. Average age of the wildlife habitat survey respondents was 46, with most respondents (about 45%) falling between the ages of 35 and 54. This average age is slightly higher than the Census average age of 40 because no respondents under 18 were selected into the survey. Almost three-quarters of the wildlife questionnaire respondents lived in an urban region, and most of the urban residents lived within the Bow River Basin region. For the remaining one quarter of respondents who lived in a rural region, a higher percentage of them lived in either rural Bow River (10%) or rural Oldman River Basin regions (11%). This coincides with Census percentage on regional distribution where the urban Bow population accounted for the largest proportion in SSR.

The percentage of wildlife habitat questionnaire respondents who had a university undergraduate degree or higher was approximately 30%, which is higher than the Census average of 23%. A higher percentage of college-degree respondents (20%) was also observed in wildlife habitat

dataset compared to the Census average (15%). However, Census data from the SSR demonstrated a higher percentage of individuals who had education levels of high school or less compared to the wildlife habitat dataset (33% in Census vs 17% in the wildlife dataset). Median household pre-tax annual income for wildlife questionnaire respondents was between $100,000 and $119,999 while a lower median pre-tax annual income ($80,000 to $99,999) was observed in Census data from the SSR. Moreover, approximately 59% and 11% of the wildlife habitat questionnaire respondents claimed they were employed full time and part-time respectively. Actual full-time and part-time employed residents in the SSR were approximately 37% respectively. Although there are differences between socio-demographic characteristic of wildlife questionnaire respondents with actual values from Census 2016, wildlife habitat respondent sample is a fair representation of the SSR population.

Water Quality Questionnaire:

The basic demographic characteristics of the water quality questionnaire respondents are shown in Table 4.1. Within a total 518 participants, 47% of male and 51% of female were observed. It was quite similar comparing to the Census average gender distribution in SSR where men and women were equally distributed. The majority of the water questionnaire respondents (47%) were located in the 35-54 age category, and the average age of this sample was 46. It coincided with Census data of SSR where the percentage was highest in the middle age categories and the relatively lower in both tails. Similar to wildlife habitat questionnaires, the omission of the 0-18 age category might be one of the reasons which lead to difference in average age. The percentage of water quality questionnaire respondents who lived in the urban region was roughly 78%, and the majority of the urban residents lived in the Bow River Basin Region. Similarly, the amount of residents who lived in rural Bow River Basin region (10%) was also relatively larger than other rural regions (8% in rural Oldman Region, and 4% in rural Other regions). Similar trend was observed in Census of SSR where approximately 80% and 12% of SSR population lived in urban SSR and rural Bow River Basin region respectively.

In terms of education level, a higher percentage of individuals with a university undergraduate degree or higher was observed in water quality datasets in comparison with Census SSR (40% v.s 30%). The number of respondents who had a high school education level or less was roughly 18%, which was much lower comparing to the Census of SSR (33%). The median income for water

quality questionnaire respondents was also between $100,000 and $119,999 while the Census of SSR demonstrated a lower pre-tax median income between $80,000 and $99,999. Lastly, approximately 54% and 12% of the water questionnaire respondents had a full-time and part-time job respectively while the full-time and part-time employments found in Census of SSR were about 37% of the total working force. Overall, the water quality questionnaire dataset is fairly representative of the Southern Alberta population although differences exist.

Table 4.1 Comparison of the demographic Statistics between questionnaires and Census data

Demographic	Statistic	wildlife habitat questionnaire (n=506)		Water quality questionnaire (n=518)		Census 2016
		Frequency	Percentage (%)	Frequency	Percentage (%)	Percentage (%)
Gender	Male	282	55.7	242	46.7	49.9
	Female	214	42.3	266	51.4	50.1
	Prefer not to answer	10	2	10	1.9	-
Age	18 to 24	46	9.1	35	6.8	6.2
	25 to 34	91	18	98	18.9	15.7
	35 to 54	225	44.5	241	46.5	28.8
	55 to 64	101	20	104	20.1	12.3
	65 or older	43	8.5	40	7.7	12.1
Average age		**46**		**46**		**40**
Region	Rural Bow River Basin Region	50	9.9	54	10.4	11.8
	Rural Oldman River Basin Region	53	10.5	42	8.1	6.2
	Rural Other River Basin Region	28	5.5	19	3.7	3.5
	Urban Bow River Basin Region	236	46.6	270	52.1	71.7
	Urban Oldman River Basin Region	57	11.3	57	11	5.1
	Urban Other River Basin Region	82	16.2	76	14.7	3.5
Education	Grade school or some high school	25	4.9	11	2.1	11.9
	High School diploma	65	12.8	52	10	21.3
	Post-secondary technical school	71	14	64	12.4	6.0
	Some college or university	74	14.6	74	14.3	2.4
	College degree or diploma	102	20.2	104	20.1	14.8
	University undergraduate degree	107	21.1	138	26.6	17.6
	University graduate degree (Masters or PhD)	50	9.9	64	12.4	4.9
	Prefer not to answer	12	2.4	11	2.1	-
Pre-tax household income	Less than $20,000	27	5.3	20	3.9	5.5
	$20,000 to $39,999	34	6.7	38	7.3	11.2
	$40,000 to $59,999	56	11.1	56	10.8	12.3
	$60,000 to $79,999	60	11.9	55	10.6	12.3
	$80,000 to $99,999	63	12.5	54	10.4	11.5
	$100,000 to $119,999	50	9.9	65	12.5	12.0
	$120,000 to $139,999	35	6.9	32	6.2	9.1
	$140,000 to $159,999	23	4.5	30	5.8	11.5
	Greater than $160,000	76	15	77	14.9	14.5
	Prefer not to answer	82	16.2	91	17.6	-
Employment Status	Employed full time	298	58.9	280	54.1	37.2
	Employed part time	53	10.5	64	12.4	37.6

Data Source: Census 2016 Statistics Canada

4.2 Frequency of food and meat purchase and beef consumption

Respondents' frequency of food and meat purchases and their frequency of beef consumption are shown in Table 4.2 and Table 4.3 respectively.

Table 4.2 Respondents 'frequency of food and meat purchases

		Percentage of Sample (%)					
		wildlife habitat improvement survey (n=506)			Water Quality Improvement Survey (n=518)		
		Regularly	Occasionally or rarely	Never	Regularly	Occasionally or rarely	Never
Household Food Purchase	Rural Bow	72.0	28.0	0.0	90.7	9.3	0.0
	Rural Oldman	88.7	11.3	0.0	81.0	19.0	0.0
	Rural Other	64.3	32.1	3.6	73.7	26.3	0.0
	Urban Bow	78.8	19.9	1.3	87.0	13.0	0.0
	Urban Oldman	87.7	12.3	0.0	86.0	14.0	0.0
	Urban Other	82.9	15.9	1.2	89.5	10.5	0.0
	Overall	**80.0**	**19.0**	**1.0**	**86.7**	**13.3**	**0.0**
Household Meat Purchase	Rural Bow	56.0	40.0	4.0	77.8	22.2	0.0
	Rural Oldman	67.9	30.2	1.9	52.4	47.6	0.0
	Rural Other	46.4	50.0	3.6	73.7	21.2	5.3
	Urban Bow	64.8	30.9	4.2	70.0	28.1	1.9
	Urban Oldman	71.9	26.3	1.8	68.4	28.1	3.5
	Urban Other	72.0	26.8	1.2	75.0	25.0	0.0
	Overall	**65.2**	**31.6**	**3.2**	**70.1**	**28.4**	**1.5**

Note 1: Values may not add up to 100% due to rounding

Note 2: Rural other and Urban other indicated respondents who live in Milk River Basin Region or South Saskatchewan River Basin Region

Wildlife Habitat Questionnaire:

For the overall wildlife questionnaire respondents, 80% were regular food purchasers and approximately 19% were occasional or rare food purchasers for their households. Additional 1% of respondents indicated that their household never purchased food respectively. By breaking down the wildlife questionnaire respondents by region, it can be observed that respondents from rural and urban areas in the Oldman River Basin Region hold the highest percentage of regular food purchasers, which was 89% and 88% respectively. Respondents from rural areas in the Milk River Basin region and South Saskatchewan River Basin region (represented by Rural Other) showed the lowest percentage of regular good purchasers and highest percentage of respondents who never purchase food, which were 64% and 4% respectively.

In terms of the overall household meat purchases, 65% and 32% of wildlife questionnaire respondents stated they purchased meat regularly or occasionally respectively for their households; the remaining 3% of the respondents never made meat purchases. Wildlife Questionnaire respondents from urban regions purchased meat more regularly than respondents who lived in rural regions. Respondents from urban Oldman and urban other regions showed the highest frequency of meat purchase at 72% respectively; respondents from rural other regions showed the lowest frequency at 46%.

Overall, 9% of wildlife questionnaire respondents indicated that they consumed beef once per month or less, and 24% of the respondents consumed beef a few times per month. The remaining 67% stated they consumed beef at least once per week (Table 4.4). Within the wildlife questionnaire respondents, residents who lived in the Bow River Basin region showed relatively lower frequency of beef consumption compared to other demographic regions. 15% and 10% of the rural and urban Bow residents claimed they only consumed beef once per month or even less, and 72% and 59% of the rural and urban residents respectively indicated they consumed beef products at least per week.

Water Quality Questionnaire:

Water quality respondents showed similar trends, where roughly 87% respondents indicated they would purchase food regularly; the remaining 13% indicated they purchase food occasionally, or rarely for their household. The highest percentage of regular food purchasers within the water quality dataset was observed within the rural Bow River sample (91%) while the lowest was observed within the rural Milk and rural South Saskatchewan River samples (74%).

Moreover, about 70% of respondents stated they regularly purchased meat for their household, but roughly 28% rarely purchased meat occasionally or rarely, and the remaining 1.5% never purchased meat for their households. Over 70% of respondents, either lived in rural or urban region, from Bow, Milk or South Saskatchewan River Basin region claimed they purchased meat regularly. Rural Bow respondents showed relatively lower meat purchase frequency where only 52% of regular meat purchasers was observed.

In terms of the overall beef consumption frequency, approximately 13% of the respondents indicated that they consumed beef once per month or less, 26% of the respondents indicated they

consumed beef a few times per month. Percentages of respondents who consumed beef at least once per week was approximately 61%. Regionally, respondents from the rural Oldman River Basin region showed the lowest beef consumption frequency where 13% of them claimed they only consume beef once per month or less. In contrast, rural or urban respondents from the Milk or South Saskatchewan River Basin demonstrated the highest beef consumption frequency where over 70% of them stated they consumed beef at least once per week.

Table 4.3 Respondents' frequency of beef consumption

		Percentage of Sample (%)					
		wildlife habitat improvement survey (n=506)			water quality improvement survey (n=518)		
		Once per month or less	A few times per month	At least once per week	Once per month or less	A few times per month	At least once per week
Beef Consumption	Rural Bow	15.2	13.0	71.7	15.1	22.6	62.3
	Rural Oldman	8.2	18.4	73.5	22.0	22.0	56.1
	Rural Other	7.1	21.4	71.4	0.0	21.1	78.9
	Urban Bow	10.3	30.9	58.7	14.7	28.7	56.6
	Urban Oldman	3.5	32.1	64.2	5.7	28.3	66.0
	Urban Other	5.0	12.5	82.5	6.8	20.5	72.6
	Overall	**8.8**	**24.4**	**66.8**	**12.7**	**26.0**	**61.4**

Note 1: Values may not add up to 100% due to rounding
Note 2: Rural Other and Urban Other indicated respondents who live in Milk River Basin Region or South Saskatchewan River Region

4.3 Familiarity and Awareness

4.3.1 Familiarity with agri-environmental issues

Respondents were asked about their familiarity with agri-environmental issues related to livestock grazing. The resulting responses are displayed in Table 4.4. The results demonstrate that wildlife questionnaire respondents were relatively more familiar with issues regarding the use of growth hormones, antibiotic use, genetically modified foods, and salmonella food poisoning. Over 30% of the wildlife questionnaire respondents claimed they knew at least quite bit about those subjects before answering the questionnaire.

Topic that respondents were relatively less familiar with included: the use of battery cages for chickens, water pollution from livestock grazing, land conversion for livestock grazing, soil erosion from livestock grazing, Bovine spongiform encephalopathy, and, threats to wildlife from intensified livestock grazing. where at least 60% of respondents indicated they knew a little or less

about those topics. Similar results were found for water quality survey respondents. Overall, these results suggest that respondents from both questionnaire samples are more familiar with issues related to human health, but less familiar with potential negative impacts on the environment in general.

Table 4.4 Respondents' familiarity with agri-environmental issues in Alberta South Saskatchewan Region

Agricultural-Environmental Issue	Percentage of Sample (%)					
	wildlife habitat survey (N=506)			water quality survey (N=518)		
	at least quite a bit	a moderate amount	a little or less	at least quite a bit	a moderate amount	a little or less
Growth hormone use in livestock	33	36	31	38.2	29.9	31.8
Antibiotic use in livestock	37.4	28.5	34.2	35.4	31.9	32.8
Genetically modified food	44.1	33	23	40.7	31.5	27.8
Mad Cow Disease	27.5	28.1	44.4	23.6	32	44.4
Battery Cage for chicken	11.8	16	72.2	12.9	19.3	67.8
Abuse of farm animals	28.5	26.1	45.4	25.1	29.7	45.1
Greenhouse gas emission from livestock	26.1	29.6	44.3	28.8	24.9	46.3
Water Pollution from livestock grazing	18.8	20.2	61.1	16	18.7	65.2
Salmonella food poisoning	30.6	35.4	34	25.6	35.3	39
Soil erosion from livestock grazing	13.7	16.4	69.9	10.4	16.4	73.2
Land Conversion for livestock grazing	14.4	13.4	72.2	11.2	16.2	72.6
Bovine spongiform encephalopathy (BSE)	17	20	63	13.9	17	69.1
Threats to wildlife from intensified livestock grazing	13.8	14.6	71.5	11	16.2	72.8

Note 1: Values may not add up to 100% due to rounding
Note 2: Rural Other and Urban Other indicated respondents who live in Milk River Basin Region or South Saskatchewan River Basin Region

4.3.2 Familiarity with farming practices in the South Saskatchewan Region

To identify socio-demographic characteristics that could be linked to attitudes towards farming, respondents were asked whether they currently live or at some time in the past lived on a farm, and/or they regularly visited a farm. As discussed in chapter 4, this information was collected to provide insight about how familiar those respondents were toward farming practices in Alberta South Saskatchewan Region. The results are shown in Table 4.5.

Wildlife Habitat questionnaire:

For wildlife questionnaire respondents, 7% of them stated they currently lived on a farm in the South Saskatchewan Region and 35% lived on a farm while growing up. Thirty-nine percent of respondents stated that they visited a farm at least once every year. After breaking overall percentage down into regions, rural Oldman and rural other regions showed a higher concentration

of residents who currently or used to live on a farm. In terms of farm visit, there was a relatively higher chance for rural respondents to visit a farm comparing to urban samples, with an exception for respondents from other regions. Overall, wildlife questionnaire respondents that reside in rural regions are more familiar with farming practices in the Alberta SSR as expected.

Water Quality Questionnaire:

For the water questionnaire respondents, the overall percentages of respondents who currently or used to live on a farm were 5% and 28% respectively. Additionally, the percentage who visited a farm at least once a year was 35%. Regionally, respondents from the rural areas in the Oldman River Basin showed the highest proportion of both current and past farm residents (24%, and 62% respectively). Moreover, more rural respondents indicated they would visit a farm at least once a year, in comparison with urban samples. Hence, a higher level of farming practice familiarity was observed within rural samples.

Table 4.5 Respondents' familiarity with farming practices in Alberta South Saskatchewan Region

		Percentage of sample (%)	
		wildlife habitat improvement survey (N=506)	water quality improvement survey (N=518)
Currently living on a farm	Rural Bow	14	9.3
	Rural Oldman	20.8	23.8
	Rural Other	35.7	21.1
	Urban Bow	2.1	1.1
	Urban Oldman	0	3.5
	Urban Other	2.4	3.9
	Overall	**6.9**	**5.2**
Lived on a farm at any time when growing up	Rural Bow	38	33.3
	Rural Oldman	43.4	61.9
	Rural Other	53.6	47.4
	Urban Bow	27.5	18.5
	Urban Oldman	36.8	31.6
	Urban Other	39	30.3
	Overall	**34.6**	**27.8**
Typically visit a farm at least once a year	Rural Bow	48	37
	Rural Oldman	45.3	52.4
	Rural Other	28.6	68.4
	Urban Bow	30.5	26.7
	Urban Oldman	40.4	40.4
	Urban Other	56.1	42.5
	Overall	**38.9**	**34.9**

Note 1: Values may not add up to 100% due to rounding
Note 2: Rural Other and Urban Other indicated respondents who live in Milk River Basin Region or

4.3.3 Awareness of Issues Concerning Alberta's Beef Industry

Respondents' awareness of issues related to the Alberta beef industry were presented in Table 4.6.

Wildlife Habitat questionnaire:

The overall percentage of the wildlife questionnaire participants claiming they were aware of the economic significance of the beef sector to the Alberta SSR ("cattle benefit awareness" or "cattle benefits" thereafter) before answering the questionnaires was 63%. By looking across the regional samples, it is evident that relative higher percentages of respondents who were aware of the benefits of the cattle resided in rural regions, with an exception for urban other regions (60%, 72%, and 68% for the rural Bow, Oldman and other respectively, v.s, 56%, 63%, and 78% respectively). However, only 59% of the total respondents know about the potential environmental risks arising from beef sector activities ("cattle risk awareness" or "cattle risks" thereafter) and approximately 36% claimed an opposing opinion. The lowest probability of cattle risk awareness was found within the rural Oldman respondents (53%) followed by urban Bow Basin respondents (54%), and, urban other samples (62%).

In general, the level of cattle benefit awareness was relatively higher in rural regions where most of SSR farms are located; and the highest cattle benefit awareness region (rural Oldman) was associated with the second lowest cattle risk awareness. Additionally, respondents from the urban Bow River Basin region has the lowest percentages for both cattle risk awareness and cattle benefits awareness.

Water Quality Questionnaire:

With respect to the water quality questionnaire participants, over 60% claimed they were aware of the benefits provided by the cattle sector. Regionally, respondents from rural regions generally had a higher percentage of cattle sector benefit awareness for each River Basin region, in comparison with urban respondents. Within the rural samples, the highest level of cattle benefit awareness was observed within respondents who lived in the Milk or South Saskatchewan River Basin regions (90%) followed by Oldman residents (74%).

However, 55% of total water questionnaire respondents stated they were not aware of environmental risks from the cattle sector. The two largest percentages of respondents who were aware of these risks were found within the rural Milk or South Saskatchewan Regions (68%), and within the urban Oldman region (67%).

In general, rural participants from each River Basin region had a relatively higher percentage being aware of the cattle benefits and risks, relative to urban samples. Similar to wildlife habitat questionnaire participants, water quality questionnaire respondents who were from urban Bow regions also showed relatively lower percentages for both cattle risk awareness and cattle benefit awareness.

Table 4.6 Respondents' awareness regarding the economic importance and the potential environmental risk of the beef sector in Alberta South Saskatchewan Region before answering the questionnaire

		Percentage of Sample (%)					
		wildlife habitat improvement survey (n=506)			water quality improvement survey (n=518)		
Categories		yes	no	not sure	yes	no	not sure
Awareness of the economic importance of beef sector to Alberta SSR before the questionnaire	Rural Bow	60	36	4	68.5	27.8	3.7
	Rural Oldman	71.7	22.6	5.7	73.8	21.4	4.8
	Rural Other	67.9	25	7.1	89.5	5.3	5.3
	Urban Bow	55.9	35.2	8.9	54.4	38.1	7.4
	Urban Oldman	63.2	29.8	7	71.9	24.6	3.5
	Urban Other	78	19.5	2.4	71.1	18.4	10.5
	Overall	**63**	**30.2**	**6.7**	**63.1**	**30.1**	**6.8**
Awareness of the potential environmental risk of the beef sector before the questionnaire	Rural Bow	68	26	6	61.1	33.3	5.6
	Rural Oldman	52.8	37.7	9.4	54.8	28.6	16.7
	Rural Other	64.3	28.6	7.1	68.4	31.6	0
	Urban Bow	53.8	39.4	6.8	51.9	43	5.2
	Urban Oldman	66.7	31.6	1.8	66.7	28.1	5.3
	Urban Other	62.2	37.8	0	47.4	39.5	13.2
	Overall	**58.5**	**36.2**	**5.3**	**54.6**	**38.2**	**7.1**

Note 1: Values may not add up to 100% due to rounding
Note 2: Rural Other and Urban Other indicated respondents who live in Milk River Basin Region or South Saskatchewan River Basin Region

4.3.4 Awareness regarding Beneficial Management Practices and Growing Forward program

Table 4.7 shows the level of awareness questionnaire respondents had about BMPs and GF prior to participating in the questionnaire.

Wildlife Habitat questionnaire:

The term BMP was not a well-known concept to wildlife questionnaire participants. The majority of the wildlife survey respondents, approximately 73%, stated that they had never heard of BMPs. The highest percentages of low-awareness were observed within the Bow residents, where 76% of rural residents and 78% of urban residents were not aware of it. Respondents from the Milk or South Saskatchewan River Basin regions presented relatively higher levels of awareness about this subject (54% in rural samples, and 66% in urban samples respectively).

Most of the wildlife questionnaire respondents were also not familiar the GF program provided by the government. Overall, only 13% of the total respondents claimed they were aware of GF before the survey was conducted. A relatively higher level of GF awareness was shown by individuals from the Milk and South Saskatchewan River Basin regions where 39% of the rural sample and 15% of the urban sample indicated they were familiar with GF. In comparison, the Bow residents showed relatively lower GF awareness where 88% of the rural Bow residents and 89% of the urban Bow residents

To sum up, not only urban residents but also rural residents generally do not have a high level of awareness about BMPs and GF; however, respondents were even less aware of GF relative to BMP. More importantly, Bow River Basin residents showed the lowest levels of awareness for both BMPs and GF, relative to respondents from other regions.

Water Quality Questionnaire:

As for water quality questionnaire respondents, unfamiliarity toward BMPs was reported for approximately 77% of the questionnaire participants. The highest level of BMP awareness was observed within the respondents (37%) who lived in either the Milk or South Saskatchewan River Basin regions. In contrast, Bow River Basin residents showed the lowest BMP awareness level where 69% of rural respondents and 81% of the urban respondents indicated they had never heard of BMPs. In addition, the rural sample tended be more familiar with BMPs in comparison with the urban sample.

In addition, an overall low level of GF awareness was also illustrated. Within the total water questionnaire sample, 87% of the respondents stated they did not know about BMPs. Regionally,

rural samples generally had a higher level of GF awareness relative to their urban counterparts. Within rural regions, respondents who lived in the Milk or South Saskatchewan River Basin had the highest level of GF awareness; within urban regions, respondents who lived in the Oldman River Basin had the highest level of GF awareness.

In general, most of the water questionnaire respondents were not aware of BMPs and GF. Relatively, more respondents did not know about GF in comparison to BMPs. Rural residents tend to have a relatively higher BMP and/or GF awareness, in comparison with urban residents.

Table 4.7 Awareness of Beneficial Management Practices and Growing Forward Programs in Alberta South Saskatchewan Region before answering the questionnaire

Categories		Percentage of sample (%)					
		wildlife habitat improvement survey (n=506)			water quality improvement survey (n=518)		
		yes	no	not sure	yes	no	not sure
BMP awareness	Rural Bow	18.0	76.0	6.0	22.2	68.5	9.3
	Rural Oldman	26.4	67.9	5.7	28.6	66.7	4.8
	Rural Other	39.3	53.6	7.1	36.8	57.9	5.3
	Urban Bow	16.9	78.0	5.1	15.2	80.7	4.1
	Urban Oldman	26.3	70.2	3.5	17.5	75.4	7.0
	Urban Other	25.6	65.9	8.5	14.5	78.9	6.6
	Overall	**21.7**	**72.5**	**5.7**	**18.0**	**76.6**	**5.4**
GF awareness	Rural Bow	12.0	88.0	0.0	16.7	77.8	5.6
	Rural Oldman	17.0	81.1	1.9	14.3	81.0	4.8
	Rural Other	39.3	53.6	7.1	26.3	73.7	0.0
	Urban Bow	8.1	88.6	3.4	5.2	92.2	2.6
	Urban Oldman	12.3	80.7	7.0	14	82.5	3.5
	Urban Other	14.6	84.1	1.2	10.5	86.8	2.6
	Overall	**12.6**	**84.2**	**3.2**	**9.7**	**87.3**	**3.1**

Note 1: Values may not add up to 100% due to rounding
Note 2: Rural Other and Urban Other indicated respondents who live in Milk River Basin Region or South Saskatchewan River Basin Region

4.3.5 Awareness regarding at-risk species and water quality concerns

Respondents' awareness of species at-risk or water quality issues in Alberta SSR was summarized in Table 4.8.

Wildlife Habitat questionnaire:

Overall, 52% of wildlife questionnaire respondents knew about the presence of at-risk species in Alberta's SSR; only about 5% of them stated they were not certain if they were aware of this issue. Regionally, rural residents showed relatively higher awareness in all river basin regions compared

to urban residents. Within the rural regional samples, residents who lived in the rural areas of the Oldman River Basin region demonstrated the highest level of awareness at 68%. Urban Milk River or South Saskatchewan River Basin residents showed the highest awareness of at-risk species within urban regional samples at 59%.

Water Quality Questionnaire:

Approximately 41% of the respondents who participated in the water quality improvement questionnaire indicated they knew about the issues of water quality concerns in river basins in Alberta's SSR. About 6% of them were not sure about their awareness. After breaking this information down by regions, relatively lower awareness was observed for urban residents compared to rural residents. Respondents from the Bow River Basin region, both rural and urban residents, demonstrated relatively lowest awareness of water quality concerns (46% for rural and 32% for urban) compared to residents from other regions.

Overall, rural residents were generally more aware of at-risk species or water quality concerns in the SSR compared to urban residents. Moreover, residents from the Bow River Basin region showed relative lower awareness of at-risk species or water quality concerns compared to residents from other regions.

Table 4.8 Awareness of at-risk species and water quality concerns in Alberta South Saskatchewan Region before answering the questionnaire

	Percentage of Sample (%)					
	wildlife habitat improvement survey (n=506)			water quality improvement survey (n=518)		
	yes	no	not sure	yes	no	not sure
Rural Bow	52	44	4	46.3	44.4	9.3
Rural Oldman	67.9	30.2	1.9	59.5	35.7	4.8
Rural Other	60.7	28.6	10.7	63.2	31.6	5.3
Urban Bow	44.9	48.7	6.8	31.5	62.2	6.3
Urban Oldman	56.1	38.6	5.3	45.6	47.4	7
Urban Other	58.5	37.8	3.7	50	48.7	1.3
Overall	**52.4**	**42.3**	**5.3**	**40.7**	**53.5**	**5.8**

Note 1: Values may not add up to 100% due to rounding
Note 2: Rural Other and Urban Other indicated respondents who live in Milk River Basin Region or South Saskatchewan River Basin Region

4.4 Membership in Environmental Groups

Information regarding respondents' membership in environmental organizations is displayed in Table 4.9.

Wildlife habitat Questionnaire:

A majority (81%) of wildlife questionnaire respondents did not belong to any of the environmental groups provided in the questionnaires. Roughly 10% of the respondents belonged to outdoor recreation clubs or fishing/hunting clubs respectively, and about 6% belonged to an environmental or a conservation organization. Only about 1% of respondents belonged to natural history or bird watching clubs.

Regionally, the highest percentage (11%) of environmental or conservation members were observed in rural respondents who lived in either the Milk or South Saskatchewan River Basin regions. Over 10% of the rural respondents claimed they participated in fishing or hunting clubs, compared to urban respondents where only urban other region residents showed over 10% participation in these organizations. Memberships in natural history or bird watching clubs were less than 2% for all regions, and the highest participant levels (2%) were observed within rural Oldman residents. In terms of outdoor recreation club members, the percentage was highest within the rural Oldman sample (13%) and lowest within rural other regions (4%).

The wildlife survey results indicated overall low participation in environmental groups, while the participation in fishing/hunting clubs or outdoor/recreational clubs were relatively higher than those in environmental groups. The results also suggest that rural individuals are more likely to participate in environmental or conservation organizations, fishing or hunting clubs in comparison to urban responders.

Water Quality questionnaire:

Similarly, a large portion (83%) of the water questionnaire respondents did not belong to any of the named environmental groups. Outdoor recreation clubs accounted for the highest percentage of membership, at about 8%. Approximately 7% of the wildlife questionnaire respondents belonged to environmental or conservation organizations, and 6% of the respondents belonged to

fishing or hunting clubs. The percentage of respondents belonging to natural history or bird watching clubs was the lowest compared to other environmental groups, at only about 2%.

Table 4.9 Percentage of respondents who have a membership in environmental groups

Membership in Environmental groups		Percentage of total sample %	
		Wildlife habitat improvement survey (n=506)	Water quality improvement survey (n=518)
Environmental or conservation organization	Rural Bow	4	7.4
	Rural Oldman	5.7	9.5
	Rural Other	10.7	10.5
	Urban Bow	5.9	6.7
	Urban Oldman	7	10.5
	Urban Other	3.7	5.3
	Overall	**5.7**	**7.3**
Fishing or hunting club	Rural Bow	12	14.8
	Rural Oldman	13.2	14.3
	Rural Other	10.7	5.3
	Urban Bow	8.9	3.3
	Urban Oldman	3.5	5.3
	Urban Other	11	7.9
	Overall	**9.5**	**6.4**
Natural history or bird watching club	Rural Bow	0	5.6
	Rural Oldman	1.9	4.8
	Rural Other	0	0
	Urban Bow	0.4	0.7
	Urban Oldman	0	3.5
	Urban Other	1.2	0
	Overall	**0.6**	**1.7**
Outdoor recreation club	Rural Bow	8	9.3
	Rural Oldman	13.2	11.9
	Rural Other	3.6	10.5
	Urban Bow	9.3	7
	Urban Oldman	10.5	8.8
	Urban Other	12.2	7.9
	Overall	**9.9**	**8.1**
None of above	Rural Bow	80	75.9
	Rural Oldman	73.6	81
	Rural Other	82.1	84.2
	Urban Bow	81.8	84.8
	Urban Oldman	86	80.7
	Urban Other	80.5	85.5
	Overall	**81**	**83.2**

Note 1: Values may not add up to 100 because a respondent can belong to multiple environmental group
Note 2: Rural Other and Urban other indicated respondents who live in Milk River Basin Region or South Saskatchewan River Basin Region

Regionally, water questionnaire respondents from rural Milk or South Saskatchewan River Basin regions, and respondents from the urban/rural Oldman River Basin region showed relatively higher percentages of participation in environmental or conservation organizations at about 10-11% respectively. Fishing or hunting club members were more common in the rural Bow or rural Oldman River Basin regions (15% and 14%). Higher percentages of natural history or bird watching club members were observed within rural samples, where respondents from rural Bow and rural Oldman River Basin regions showed relatively higher percentages (6% and 5%). Percentages of outdoor recreation club members were relatively similar among all regions with the lowest participation of 7% in the urban Bow River Basin region and the highest at 12% in the rural Oldman River Basin region.

Water quality questionnaire data indicate similar participation rates (6-8%) in all targeted environmental groups and natural history or bird watching clubs (2%). In addition, rural participants were more likely to have a membership in fishing/hunting clubs in comparison to urban samples.

4.5 Importance of Environment, Food production and Job Concerns

Respondents' attitudes toward either water quality or wildlife habitat protection ("environmental concern" thereafter), and concerns toward potential agricultural-related jobs loss and reductions in food production ("economic concern" thereafter) are shown in Table 4.10-11.

Wildlife Habitat Questionnaire:

About 54% of wildlife habitat questionnaire respondents stated that the protection of at-risk species in the SSR was either very or extremely important to them. Roughly 27% showed a moderate level of concern. The remaining 19% of the respondents claimed that it was only somewhat or not at all important if measures to protect at-risk species in Alberta SSR were undertaken. More specifically, the highest level of concern was found within rural Oldman respondents where 62% showed a higher levels of concern.

As for economic concerns following adoption of environmental measures, rough 32% of all respondents presented a high level of concern. Regionally, residents who lived in rural Oldman or urban Milk/South Saskatchewan River Basin regions showed relatively higher level of concerns

for the potential job loss and food production reduction (45% and 40% respectively); respondents who lived in the urban Bow River Basin region showed the lowest level of economic concerns.

On the whole, it is noteworthy that respondents generally had a relatively lower level of economic concern in comparison with environmental concerns. Additionally, both the highest level of environment concern and the highest level of economic concerns were observed within rural Oldman residents relative to other regions.

Water Quality Questionnaire:

About 69% of the water quality questionnaire sample claimed that it was extremely important or very important to improve water quality in Alberta SSR. Approximately 18% stated moderate levels of concern for water quality in the SSR. The remaining 13% of the sample indicated that protecting water quality was not or only somewhat important. All regions showed a relatively higher level of environmental concern (about 70%), with an exception for the rural respondents in the Oldman region (50%).

On the other hand, high level of economic concerns accounted for approximately 37% of the total water quality questionnaire respondents. Regionally, respondents from rural and urban Milk/South Saskatchewan River Basin respondents demonstrated the highest and the lowest proportion of high economic concerns (26% and 45% respectively). In general, respondents were not as concerned about economic impacts in comparison to environmental concerns.

Table 4.10 Environmental Attitude for environmental protection

		Percentage of Sample (%)					
		wildlife habitat improvement survey (n=506)			water quality improvement survey (n=518)		
Level of Importance		Not or Somewhat	Moderate	Very or Extremely	Not or Somewhat	Moderate	Very or Extremely
Attitude toward environment protection (Wildlife habitat or water quality)	Rural Bow	24.00	22.00	54.00	14.80	13.00	72.20
	Rural Oldman	15.10	22.60	62.30	26.20	23.80	50.00
	Rural Other	21.40	28.60	50.00	21.10	5.30	73.70
	Urban Bow	19.10	26.70	54.20	10.00	19.30	70.70
	Urban Oldman	14.00	33.30	52.60	7.00	22.80	70.20
	Urban Other	23.20	26.80	50.00	15.80	14.50	69.70
	Overall	**19.40**	**26.70**	**54.00**	**12.70**	**18.10**	**69.10**

Note 1: Values may not add up to 100 because a respondent can belong to multiple environmental group
Note 2: Rural Other and Urban other indicated respondents who live in Milk River Basin Region or South Saskatchewan River Basin Region

Table 4.11 Job and food production Concerns

Level of Concern		Percentage of Sample (%)					
		wildlife habitat improvement survey (n=506)			water quality improvement survey (n=518)		
		Not or Somewhat	Moderate	Very or Extremely	Not or Somewhat	Moderate	Very or Extremely
Job and Food production concern	Rural Bow	36.00	34.00	30.00	29.60	33.30	37.00
	Rural Oldman	32.10	22.60	45.30	35.70	28.60	35.70
	Rural Other	21.40	42.90	35.70	31.60	42.10	26.30
	Urban Bow	38.60	35.20	26.30	33.30	31.50	35.20
	Urban Oldman	42.10	29.80	28.10	31.60	31.60	36.80
	Urban Other	32.90	26.80	40.20	18.40	36.80	44.70
	Overall	**36.20**	**32.20**	**31.60**	**30.70**	**32.60**	**36.70**

Note 1: Values may not add up to 100 because a respondent can belong to multiple environmental group
Note 2: Rural Other and Urban other indicated respondents who live in Milk River Basin Region or South Saskatchewan River Basin Region

4.6 Attitudes toward future government funding on reducing environmental impacts

As discussed in the previous chapter, respondents' attitudes toward future government investments on mitigating environmental impacts from agricultural production were identified by asking questionnaire respondents to provide their opinions on whether the Canadian and provincial governments should increase, decrease or make no further changes to levels of expenditures on such measures. The resulting responses are shown in Table 4.12.

Wildlife habitat survey:

After providing background information about the potential environmental impacts from livestock grazing, approximately 57% of the wildlife habitat questionnaire respondents believed governments should increase investments in protecting the environment from impacts resulting from agricultural production; about 7% of respondents had an opposing opinion, 17 % of the respondents were satisfied with the current investment levels, and the remaining 19% were not certain about their choices. Regionally, respondents from the urban Bow River Basin and rural Milk/South Saskatchewan River Basin regions demonstrated the highest percentage of being in favor of government funding increases (61% and 64%). In comparison, respondents from the rural Bow River Basin and urban Oldman River Basin regions showed relatively lower percentages of voting in favor of funding increases.

In general, rural wildlife questionnaire respondents were more likely to vote against the government funding increases for wildlife habitat improvements compared to urban respondents

since the percentages of voting for "doing nothing" and "decrease funding" were generally higher for rural residents.

Water Quality Questionnaire:

As for water quality questionnaire respondents, 61% of them voted for increasing future investments on environmental impact mitigation, 5% supported decreasing the current levels of investment, and about 14% believed the current levels of government funding were sufficient. Regionally, respondents (either rural or urban) from the Milk or South Saskatchewan River Basin regions demonstrated relatively lower percentages of voting for investment increases. In addition, relatively higher percentages of voting for maintaining the current investment levels were found within rural other regions.

Generally, rural water questionnaire respondents were less likely to vote for investment increases compared to urban respondents (56%, 50%, and 37% for rural, and 63%, 72% and 59% for urban). In addition, rural respondents were also more likely to vote for staying at the current investment level (26%, 12%, and 26% for rural, and 11%, 12%, and 12% for urban).

Table 4.12 Attitude for future government funding investment on environmental impact mitigation

Categories	Percentage of sample (%)							
	Wildlife habitat improvement survey (n=506)				Water quality improvement survey (n=518)			
	Increase Investment	Decrease Investment	Do nothing	No sure	Increase Investment	Decrease Investment	Do nothing	No sure
Rural Bow	46.0	10.0	28.0	16.0	55.6	3.7	25.9	14.8
Rural Oldman	54.7	7.5	20.8	17.0	50.0	4.8	11.9	33.3
Rural Other	64.3	10.7	21.4	3.6	36.8	5.3	26.3	31.6
Urban Bow	61.4	4.7	14.0	19.9	63.7	5.9	11.1	19.3
Urban Oldman	50.9	7.0	15.8	26.3	71.9	1.8	12.3	14.0
Urban Other	52.4	7.3	18.3	22.0	59.2	6.6	11.8	22.4
Overall	**56.7**	**6.5**	**17.4**	**19.4**	**61.0**	**5.2**	**13.5**	**20.3**

Note 1: Values may not add up to 100% due to rounding
Note 2: Rural Other and Urban Other indicated respondents who live in Milk River Basin Region or South Saskatchewan River Basin Region

Information summarizing the main findings from the results described above can be found in Table 4.13. Overall, although rural respondents were generally more familiar with potential benefits and drawbacks from the Alberta cattle industry as well as government measures to reduce associated environmental impacts (e.g. GF, BMP), they appeared to be less supportive for government funding increases to mitigate environmental impacts from agricultural production. This

information aligns with the fact stated in earlier chapters that producers are not likely to adopt BMP measures where they have to bear additional costs associated with their adoption. It also emphasizes the importance of providing government support to incent higher adoption levels.

Table 4.13 Summary tables for respondents' familiarity, awareness and attitude

	Wildlife habitat survey	Water quality survey
Regular Household Food Purchaser	highest in rural and urban Oldman regions; lowest in rural Milk/SS	High in all region other than residents from rural Milk/SS
Regular Household Meat Purchaser	highest in Oldman regions, and urban Milk/SS	high in Bow; and Milk/SS regions
Regular Beef Consumers	lowest in urban Bow and urban Oldman	lowest in urban Bow; also low in rural Bow and Oldman
Familiarity with agri-environmental issues	more familiar with human health related issues but not environment-related issues	more familiar with human health related issues but not environment-related issues
Higher farming practices familiarity	generally higher in rural regions	generally higher in rural regions
Higher cattle benefit awareness	high in rural areas, expect for urban other; Urban bow is the lowest	high in rural areas; urban bow is the lowest
Higher cattle risk awareness	relatively higher in rural areas; lowest in urban bow	relatively higher in rural areas; lowest in urban bow
Higher BMP awareness	low for all regions but relatively higher in rural regions ; lowest in urban bow	low for all regions but relatively higher in rural regions ; lowest in urban bow
Higher GF awareness	low for all regions but relatively higher in rural regions ; lowest in urban bow	low for all regions but relatively higher in rural regions ; lowest in urban bow
Higher At-risk species/water quality risk awareness	high in rural areas; lowest in urban bow	high in rural areas; lowest in urban bow
Environmental group Membership	more likely to participate in fishing or hunting club, or outdoor recreation club	more likely to participate in fishing or hunting club, or outdoor recreation club
Higher Environmental concerns	highest in rural Oldman; lowest in rural Milk or South Saskatchewan	relatively high in all regions expect rural Oldman
Higher Economic concerns	highest in rural oldman, lowest in urban bow	highest in urban Milk/South Saskatchewan
Attitude for future government funding	higher rural percentages voted for do nothing or decreasing funding	higher urban percentages voted for funding increase

Note 1: Oldman, Bow, Milk/.SS mentioned above are referring to river basin regions in Alberta South Saskatchewan Region

Note 2: If a region is not disguised between rural and urban, it means both rural and urban meet the condition

Chapter Summary

This chapter provided information about the respondents. It first demonstrated that both water and wildlife questionnaire data were a reasonable representation of the Alberta South Saskatchewan region population by comparing questionnaire dataset with 2016 Canadian Census data. It then discussed respondents' frequencies of food and meat purchases as well as beef consumption. The results indicated that most of the respondents made regular food or meat purchases, and more than half of the respondents consumed beef at least once per week. Additionally, most of the respondents were more familiar with health related agri-environmental issues, but not issues that concern degradation of environmental quality. Nevertheless, a fairly high proportion of the respondents knew about current at-risk species or water quality risks in the South Saskatchewan region, and relatively higher awareness was observed within rural samples.

Higher levels of farming practice familiarity were observed in rural samples for both questionnaires. Rural respondents from both questionnaires showed a higher level of awareness of GF, BMPs, economic benefits and risks from cattle farming, relative to urban respondents. In addition, respondents who lived in the urban Bow River Basin region showed the lowest levels for abovementioned awareness. Nevertheless, rural respondents in general demonstrated a higher level of awareness in the presence of potential at-risk species and water quality risks.

Low participation by respondents in environmental groups was observed in both questionnaires; however, memberships in outdoor recreation clubs, fishing and hunting clubs were relatively higher. Furthermore, respondents were found to be more concerned about environmental protection relative to jobs or food production concerns. Lastly, this chapter also described respondents' attitude toward future government investment in environmental impact mitigation where urban respondents were found to be more likely to vote in favor of.

In conclusion, rural respondents were found to be less supportive for government funding increases even though they generally held higher levels of awareness of various associated issues.

Chapter 5 Valuation Question Results and Discussion

This chapter gives out the reasons for respondents' choice on valuation scenarios. In addition to identifying yea-sayers and addressing potential hypothetical bias, this chapter will also briefly discuss the effectiveness of the bid design. Lastly, parametric econometric analysis will be conducted to estimate WTPs and overall welfare measures.

5.1 Reasons for responses 'choices

The reasons for respondents to choose either the proposed environmental improvement programs or status quo were obtained using debriefing questions, and the results were demonstrated in Table 5.1 and Table 5.2 respectively. Respondents were able to choose multiple reasons for voting for and against the proposed programs from a given list, hence, the aggregated percentage would be over 100%. For wildlife habitat improvement questionnaire (n=506), most of the respondents (40%) who voted for the programs because they believed that the benefits from adopting wildlife improvement programs were worth the tax increases. 29% of the respondents believed these programs were a good use of public fund and another 35% suggested that the protecting wildlife habitat was important to them. Additionally, there were 14.4% of the respondents who claimed that the wildlife habitat should be protected at any price, which indicating potential yea-saying behaviors as discussed in Chapter 2 and 3.

For water quality improvement questionnaire (n=518), almost half of the respondents claimed that the increases in taxes for exchange of benefits from watershed protection was worthy. 37.6% of the respondents voted for the proposed programs because protecting watersheds were important to them, and another 31.3% chose the programs as they believed these programs would be a good use of public funds. Moreover, there were 17.4% of potential yea-sayers as they believed that the watershed should be protected at any cost.

The reasons for staying at the status quo conditions were demonstrated in Table 5.2. For wildlife habitat improvement questionnaire, 32 % of the respondents, who voted against the program, indicated that the cost for implementing the enhance programs was too high. Another 30% claimed they did not believe the government can effectively use public funds to achieve the improvement goals. A quarter of the respondents who voted against stated they were unwilling to pay additional taxes. Another quarter of the respondents claimed they required more information before they

made a decision. In addition, 21% of respondents indicated that they were not able to afford the potential tax increases.

Table 5.1 Reasons for voting for the proposed program, for wildlife questionnaire and water quality questionnaire data

	Percentage of sample (%)	
Reasons contributes to the choice	Wildlife habitat improvement survey (n=506)	Water quality improvement survey (n=518)
1.These programs are a good use of public funds	29.2	31.3
2.The benefits of wildlife habitat (or watershed) protection are worth the increases in taxes	40.1	46.1
3.Wildlife habitat (or Watersheds) should be protected at any price	14.4	17.4
4.Protecting wildlife habitat (or watersheds) are important to me	35	37.6
5.Other	7.3	7.1

Note 1: for wildlife habitat improvement questionnaire, 113 respondents, or 22.3%, did not provide answers to this question; for water quality improvement questionnaire, 84 respondents, or 16.2%, did not answer to this question.
Note 2: The percentages do not add up to 100% since a respondent can choose multiple reasons

Table 5.2 Reasons for voting against the proposed programs, for wildlife questionnaire and water quality questionnaire data

	Percentage of sample (%)	
Reasons contributes to the choice	Wildlife habitat improvement survey (n=506)	Water quality improvement survey (n=518)
1.The cost of the enhanced programs was too high	32.2	25.1
2.I do not believe that the enhanced program would work	10.1	8.7
3.I do not feel it is my responsibility to pay to protect wildlife habitat (or watershed) within this region	8.1	5
4. I do not believe that the impacts would be as specified	11.9	7.9
Protecting wildlife habitat (or watershed) are not a priority for me	2.8	1.9
5.I do not want to pay additional taxes	24.9	17.2
5.I do not trust the government to run the enhanced program effectively	29.8	19.3
6.I need more information before I can decide	24.5	21.8
7.I cannot afford to pay the specified amount associated with the enhanced program	20.8	13.3
8.Other	5.5	6.8

Note 1: for wildlife habitat improvement questionnaire, 134 respondents, or 26.5%, did not provide answers to this question; for water quality improvement questionnaire, 224 respondents, or 43.2%, did not answer to this question
Note 2: The percentages do not add up to 100% since a respondent can choose multiple reasons

For water quality questionnaire, 25% of the respondents indicated that the program costs were too high. 22% claimed they feel the questionnaire did not provide sufficient information to make a decision. 19% of the respondents voted to stay at status quo condition because they did not believe the governments were able to use the public funds effectively to achieve the proposed environmental goals. 17% of respondents simply did not want to pay additional tax expense and 13% of respondents claimed that they were able to afford the implementing cost. Overall, both wildlife habitat and water quality questionnaire showed similar trends in terms of the reasons for voting for or against the proposed programs.

5.2 Addressing hypothetical bias

5.2.1 Yea-sayers

As discussed in Chapter 3, respondents have to meet two conditions in order to be identified as yea-sayers. The first condition is that the respondents must have indicated that the watershed, or wildlife habitat, should be protected at any price as one of the reasons for choosing the proposed program in the debriefing question after the choice scenarios. The second condition is that respondent have to actually choose the proposed program for every single choice scenario throughout the entire questionnaire. The results showed that there were 51 yea-sayers in wildlife habitat improvement questionnaire, and 72 yea-sayers. To minimize the hypothetical bias due to yea-saying behavior, yea-sayers were removed when conducting parametric analyses.

5.2.2 Uncertainty

Respondents were asked to provide their certainty level about their choices after every choice scenario in order to minimize the hypothetical bias, as discussed in Chapter 2 and 3. The resulting percentages of certainty level at different tax level for wildlife habitat and water quality questionnaire were summarized in Table 5.3. For wildlife habitat questionnaire, every respondent answered 5 choice scenarios which resulted in a total of 2530 in sample size. At $50 annual tax level, 40.3% of the respondents were certain about their choices. At the same tax level, 41.3% of respondents were somewhat certain about their choices, and the remaining 11% and 7.4% respondents were somewhat uncertain and very uncertain about their choices respectively. As the annual tax level increased, there was a general decreasing trend in percentage of respondents who were certain about their choices.

For water quality questionnaire, every respondent answered 4 choice scenarios which resulted in a total of 2072 in sample size. At the lowest annual tax level, 55.2% of respondents were confident about their choices while 6.5% of the respondents were very uncertain. The percentage of respondents who were very confident about their choices decreased to 39%, 34%, 32% and 31% as the annual tax level increased to $150, $300, $500, and $750 respectively. Overall, there was a general decreasing trend in the percentage of respondents who were certain about their choice as the tax level increases. To minimize the potential risk of hypothetical bias in statistical analysis, the yes-responses provided by respondents, who were very uncertain about their choices, were converted to no-responses as suggest by literature discussed in Chapter 3.

Table 5.3 Percentage of certainty level at different tax level, for both Wildlife habitat questionnaire (n=2530) and water quality questionnaire (n=2072)

Survey	Tax ($/year)	Number of samples	Percent (%) of sample within each tax category			
			Very Uncertain	Somewhat Uncertain	Somewhat Certain	Very Certain
Wildlife habitat survey	50	501	7.4	11	41.3	40.3
	150	515	5.8	14.6	42.5	37.1
	300	488	4.5	11.3	45.5	38.7
	500	510	5.5	13.9	46.1	34.5
	750	516	7.4	17.4	39.9	35.3
Water quality survey	50	446	6.5	7.2	31.2	55.2
	150	386	7.3	12.2	41.5	39.1
	300	387	7.2	11.6	46.8	34.4
	500	424	6.1	13.2	48.3	32.3
	750	429	6.5	18.4	44.1	31.0

Note 1: the total sample size for wildlife habitat questionnaire is 2530 because every wildlife questionnaire respondent answer 5 choice scenarios (506*5); the total sample size for water quality questionnaire is 2072 because every water questionnaire respondent answered 4 choice scenarios (518*4).
Note 2: Both "yes" and "no" responses to the choice scenarios were included

5.2.3 Consequentiality question

Respondents were given two consequentiality questions at the end of the last choice scenario. The first question asked the respondents if they understood that the tax payment would increases for the foreseeable future when any of the proposed programs were put in place; the results were shown in Table 5.4. For wildlife improvement questionnaire participants, 71.5% of them indicated

they were aware of the potential annual tax increase, and 2.6% and 3.6% of the respondents were not aware of or not sure about this subject. The remaining 22.3% of the respondents did not provide answers. If the missing data was not taken into consideration, there was 92.1% of the respondent who claimed they understood the future tax increase in the proposed programs were implemented. For water quality questionnaire participants, 75.7% of the respondents indicated they were aware of the potential future household tax increases, while 3.1% of the respondents indicated the opposite. 5% of respondents claimed they were not sure if they have to pay additional tax, and the remaining 16.2% did not provide answers. Similarly, the percentage of respondents, who understood the potential tax increases, became 90.3% if missing data was not taken into consideration.

The second consequentiality question asked respondents' opinion about how likely they believed policy makers would actually use the results from this questionnaire to make decisions about BMP adoption in SSR, results were shown in Table 5.5. For wildlife habitat questionnaire respondents, only 5% believed it was very likely the questionnaire results would actually be used in decision making. 25% of the respondents believed it was somewhat likely and quite a few (21%) claimed that they believed it was very unlikely their inputs would be consequential. As for water quality questionnaire respondents, only less than 5% of them claimed they believed it was very likely that the government would use the questionnaire results to aid decision making. 27% of respondents claimed they believed it was only somewhat likely their inputs would be used in decision making. The remaining respondents who believed it was very unlikely or somewhat unlikely that the questionnaire results were consequential were 15% and 25%, respectively.

Table 5.4 Respondent's awareness of potential tax increases after BMP adoption, for wildlife habitat questionnaire and water quality questionnaire

Category	Percentage of sample (%)			
	Wildlife habitat improvement survey (n=506)		Water quality improvement survey (n=518)	
	With missing data	Without missing data	With missing data	Without missing data
Yes	71.5	92.1	75.7	90.3
No	2.6	3.3	3.1	3.7
Not sure	3.6	4.6	5	6
Missing	22.3		16.2	

Table 5.5 Respondents' opinion regarding the likelihood of the questionnaire result being used

	Percentage of sample (%)	
Category	Wildlife habitat improvement survey (n=506)	Water quality improvement survey (n=518)
Very unlikely	20.6	14.3
Somewhat unlikely	25.7	24.5
An even chance	21.5	26.3
Somewhat likely	24.5	27.2
Very likely	5.1	4.4
No opinion	2.6	3.3

5.3 Bid design

Figure 5.1 demonstrated the respondents' sensitivity regarding tax levels before and after yea-sayer removal and certainty adjustment. The percentages of full-sample voted for the proposed program at various tax levels were represented by black bars in Figure 6.1. At annual tax level of $50, about 70% of the wildlife habitat questionnaire respondents voted in favor of the proposed programs. As the tax level increased, the percentage of yes responses decreased, and it reached the lowest level as the tax level was $750 per year. Similarly, the highest percentage of yes responses was highest at $50/year for water quality questionnaires, and decreased as annual tax payment increased.

To reduce risks of hypothetical bias, yea-sayers were removed, and uncertainty responses were adjusted as discussed in previous Chapters. The percentage of reduced sample voted for the proposed programs was represented by grey bars in Figure 5.1. There were slight decreases in percentages of respondents who vote in favor of the proposed program when yea-sayers were removed, and very uncertain yes-responses were recoded as no-responses, however, the general decreasing trend in the percentage of yes responses as the level of annual tax amount increases remained the same.

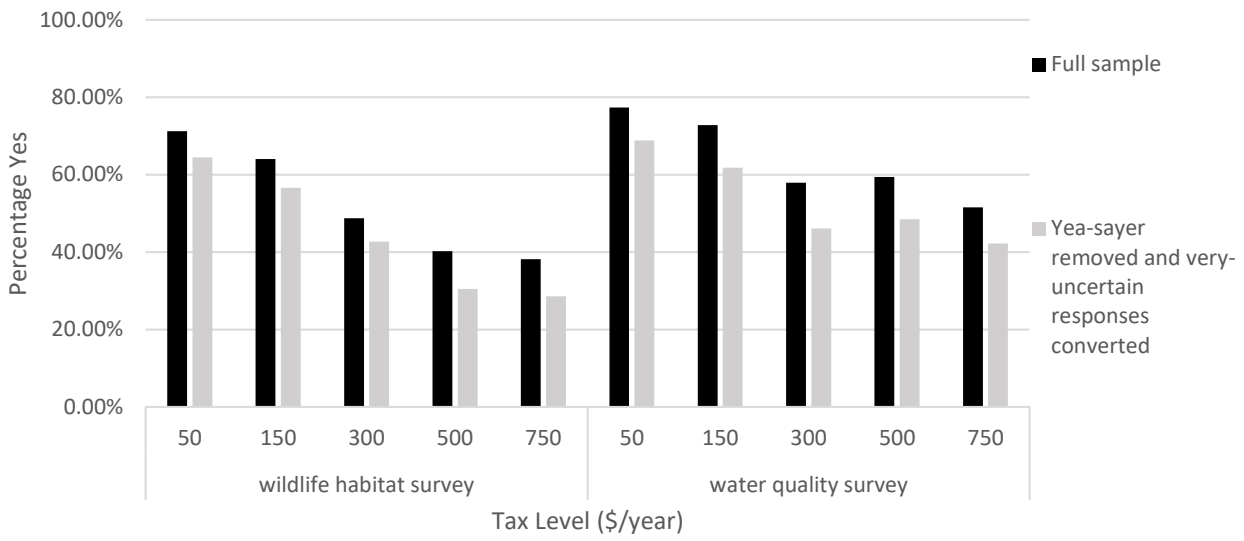


Figure 5.1 Percentage of questionnaire respondents voted for the proposed programs by annual tax level, yea-sayer removed, and very uncertain responses converted, for wildlife habitat questionnaire and water quality questionnaire

5.4 Parametric analysis

5.4.1 Variable description

Binary logit model specifications were implemented to estimate the parameters using the equation discussed in Chapter 2. For both questionnaires, the dependent variables were the responses provided by respondents indicating whether they would vote against or vote in favor for the proposed environmental programs (either improvement in water quality or wildlife habitat depending on the questionnaire). Table 5.6 presented descriptions and descriptive statistics of a list of variables used in econometric analyses. In Wildlife questionnaire, the design variables were *Tax, Period*, and *NAR*. *Tax* was the amount of tax payment each household had to pay to receive the benefits from agricultural BMP programs. It ranged from CAD$0, where respondent voted against the proposed program, to CAD$750. *Period* was the time variable to indicate the length of the programs which could be either 5 years or 10 years. *NAR* is used to capture the improvements in wildlife habitat after BMP adoption. It represented the net changes in the number of not-at-risk species after BMP programs. Although there was other wildlife improvement information, such as net changes in endangered species, threatened species, and amount of grassland and cropland, captured in the questionnaire, they were not included in the analyses due to high correlations.

In water quality improvement questionnaire, the design variables were *Tax*, *Bi*, *Oi*, *Si*, and *Mi*. Same as wildlife data analysis, *Tax* was used to indicate the amount of income each household had to give up if they voted in favor of the programs. *Bi*, *Oi*, *Si*, and *Mi* represented the level of water quality improvements in Bow River, Oldman River, South Saskatchewan River and Milk River, respectively. Water quality improvement in first three rivers could have two possible levels (fishable to swimmable, fishable to drinkable), while water quality improvements in Milk River could 3 possible levels (boatable to fishable, boatable to swimmable, boatable to drinkable).

Location variables indicating the region of respondent's residence were also included in both questionnaire data analyses to determine whether locations influenced respondents' willingness to pay. Demographic variables employed in both questionnaire data analyses included gender, employment status, education levels, age, and household income level. Finally, there were also additional dummy variables to indicate whether the respondents currently live in a farm or belong to any environmental organizations.

Table 5.6 Descriptive statistics and description of variables used in the econometric analysis, for wildlife habitat questionnaire and water quality questionnaire

Variable	Type	Mean	S.D	Min	Max	Description
Wildlife habitat improvement questionnaire						
Tax	Continuous	352.05	252.26	0	750	Five tax levels ($50, $150, $300, $500, and $750) and it equals to $0 if status quo was chosen
YS	Dummy	0.101	0.301	0	1	YS=1 if the respondent is a Yea-sayer
Period	Continuous	7.496	2.5	0	10	Two period levels (5 years and 10 years) and equal to 0 if status quo was chosen
NAR	Continuous	10	2.829	6	14	Net not-at-risk species after adopting proposed BMP programs
rbow	Dummy	0.099	0.298	0	1	rbow=1 if the respondent lives in rural Bow river basin region
rold	Dummy	0.105	0.306	0	1	rold=1 if the respondent lives in rural Oldman river basin region
rother	Dummy	0.055	0.229	0	1	rother=1 if the respondent lives in rural Milk river basin region or rural South Saskatchewan river basin region
ubow	Dummy	0.466	0.498	0	1	ubow=1 if the respondent lives in urban Bow river basin region
uold	Dummy	0.112	0.316	0	1	uold=1 if the respondent lives in urban Oldman river basin region
uother	Dummy	0.162	0.368	0	1	uother=1 if the respondent lives in urban Milk river basin or urban South Saskatchewan river basin region
Rural	Dummy	0.259	0.438	0	1	Rural =1 if the respondent live in a rural area
Rural_NAR	Continuous	2.589	4.612	0	14	Interaction term between NAR and Rural
EO	Dummy	0.19	0.392	0	1	EO=1 if the respondent belongs to any environmental organization
FC	Dummy	0.6917	0.254	0	1	FC=1 if the respondent currently lives on a farm
Male	Dummy	0.569	0.495	0	1	Male =1 if the respondent is a male
Employed	Dummy	0.812	0.391	0	1	Employed=1 if the respondent is employed and has a job
HighEdu	Dummy	0.559	0.497	0	1	HighEdu=1 if the respondent has an education level higher than high school
Age1	Dummy	0.271	0.444	0	1	Age1=1 if the respondent is 35 years old or less
Age2	Dummy	0.285	0.451	0	1	Age2=1 if the respondent is 55 years old or above
lincome	Dummy	0.231	0.422	0	1	lincome=1 if the respondent's household annual income is lower than the average level within the region
aincome	Dummy	0.342	0.474	0	1	aincome=1 if the respondent's household annual income is at average level or higher within the region
hincome	Dummy	0.265	0.441	0	1	hincome=1 if the respondent's household annual income is high than the average level within the region
Water quality improvement questionnaire						
Tax	Continuous	352.34	255.05	0	750	Five tax levels ($50, $150, $300, $500, and $750) and it equals to $0 if status quo was chosen
YS	Dummy	0.139	0.346	0	1	YS=1 if the respondent is a Yea-sayer
Bi	Continuous	1.034	0.802	0	2	Level of improvement in Bow river basin after adopting proposed BMP programs
Oi	Continuous	1.024	0.82	0	2	Level of improvement in Oldman river basin after adopting proposed BMP programs
Si	Continuous	1	0.832	0	2	Level of improvement in South Saskatchewan river basin after adopting proposed BMP programs
Mi	Continuous	1.487	1.14	0	3	Level of improvement in Milk river basin
rbow	Dummy	0.104	0.306	0	1	rbow=1 if the respondent lives in rural Bow river basin region
rold	Dummy	0.081	0.273	0	1	rold=1 if the respondent lives in rural Oldman river basin region
rother	Dummy	0.037	0.188	0	1	rother=1 if the respondent lives in rural Milk river basin region or rural South Saskatchewan river basin region
ubow	Dummy	0.521	0.5	0	1	ubow=1 if the respondent lives in urban Bow river basin region
uold	Dummy	0.11	0.313	0	1	uold=1 if the respondent lives in urban Oldman river basin region
uother	Dummy	0.147	0.354	0	1	uother=1 if the respondent lives in urban Milk river basin or urban South Saskatchewan river basin region
Rural	Dummy	0.222	0.416	0	1	Rural =1 if the respondent lives in a rural area
Rural_bi	Continuous	0.236	0.578	0	2	Interaction term between Bi and rural
Rural_oi	Continuous	0.236	0.588	0	2	Interaction term between Oi and rural
Rural_si	Continuous	0.216	0.57	0	2	Interaction term between Si and rural
Rural_mi	Continuous	0.333	0.821	0	3	Interaction term between Mi and rural
EO	Dummy	0.168	0.374	0	1	EO=1 if the respondent belongs to any environmental organization
FC	Dummy	0.052	0.222	0	1	FC=1 if the respondent currently lives on a farm
Male	Dummy	0.476	0.5	0	1	Male =1 if the respondent is a male
Employed	Dummy	0.764	0.424	0	1	Employed=1 if the respondent is employed and has a job
HighEdu	Dummy	0.61	0.488	0	1	HighEdu=1 if the respondent has an education level higher than high school
Age1	Dummy	0.257	0.437	0	1	Age1=1 if the respondent is 35 years old or less
Age2	Dummy	0.278	0.448	0	1	Age2=1 if the respondent is 55 years old or above
lincome	Dummy	0.22	0.414	0	1	lincome=1 if the respondent's household annual income is lower than the average level within the region
aincome	Dummy	0.336	0.472	0	1	aincome=1 if the respondent's household annual income is at average level or higher within the region
hincome	Dummy	0.268	0.443	0	1	hincome=1 if the respondent's household annual income is high than the average level within the region

5.4.2 Choice of the functional form

The econometric analysis was done in STATA in the binary logit model framework. To determine the best fitting functional forms, basic models were tested using three functional specifications (linear, quadratic and logarithmic). To improve accuracy in data analyses, yea-sayers were removed, and uncertainty was adjusted. Parameter estimates from basic binary logit models using three specifications for wildlife habitat questionnaire data were presented in Table 5.7. Design variables were significant in all three functional forms, however, the Pseudo R^2 value was slightly higher when either linear or logarithmic functional form was used. Either linear and logarithmic specifications could be used to estimate WTP as the R^2 values were quite similar (0.0665 vs. 0.0666 respectively), linear functional specification was selected as final functional forms due to its simplicity.

Parameter estimates for basic binary logit models for water questionnaire data were presented in Table 5.8. Results from all three functional forms showed significances in same set of design variables, and the values of R^2 were also quite similar. Since the linear functional specification showed a slightly higher Pseudo R^2 value compared to quadratic or logarithmic functional form, it was selected for further econometric analyses.

Table 5.7 Wildlife habitat questionnaire Parameter estimates for basic binary logit models with clustered standard error using three specifications, yea-sayers removed

Variable	Linear Specification	Quadratic Specification	Logarithmic Specification
Tax	-0.0023***	-0.0023***	-0.0023***
Nar	0.0351***		
rural_nar	-0.0557***		
period	-0.0340**	-0.0338**	-0.0341**
Nar2		0.0022***	
rural_Nar2		-0.0045***	
lognar			0.2665**
rural_lognar			-0.2555***
N	2275	2275	2275
log-likelihood	-1459.7542	-1461.2085	-1459.5783
P-value > Chi-square	0.0000	0.0000	0.0000
Pseudo R^2	0.0665	0.0655	0.0666

Note 1: * p<.1; ** p<.05; *** p<.01
Note 2: yea-sayers removed and uncertainty adjusted
Note 3: clustered standard error applied

Table 5.8 Water quality questionnaire Parameter estimates for basic binary logit models with clustered standard error using three specifications, yea-sayers removed

Variable	Linear Specification	Quadratic Specification	Logarithmic Specification
Tax	-0.0015***	-0.0015***	-0.0015***
Bi	0.1541***		
Oi	0.1739***		
Si	0.0782		
Mi	0.0648		
Bi2		0.0659**	
Oi2		0.0773***	
Si2		0.0426	
Mi2		0.0260*	
Logbi			0.2754*
Logoi			0.3486**
Logsi			0.2279
Logmi			0.2253**
N	1784	1784	1784
log-likelihood	-1193.8864	-1194.3189	-1195.468
P-value > Chi-square	0.0000	0.0000	0.0000
Pseudo R^2	0.0309	0.0306	0.0296

Note 1: * p<.1; ** p<.05; *** p<.01
Note 2: yea-sayers removed and uncertainty adjusted
Note 3: clustered standard error applied

5.4.3 Logit model results

Binary logit regression estimates for wildlife habitat improvement questionnaire data were demonstrated in Table 5.9. Model 1 included design variables *Tax*, *NAR* and *Period* as well as interaction variable *Rural_nar*. The coefficient on *Tax*, or the marginal utility of money, was negative and statistically significant at 1%. It indicated that respondents' probability of voting in favors for the proposed agricultural BMP programs decreases as the annual tax amount increases. The level of wildlife habitat improvement, captured by *NAR*, was positive and significant at 1%, indicating respondents were more likely to vote for the proposed programs as the wildlife habitat improvements increase. The coefficient associated with time variable was negative and statistically significant at 5% level. That is, as the program period for the proposed programs increased respondents were less likely to vote in favor of the proposed program. In another word, the longer time period respondents have to pay additional taxes, the lower the probability for them to vote for the proposed programs. The coefficient for the interaction term between Rural and NAR is negative and statistically significant, which suggested that rural residents were more likely to vote

against the proposed BMP programs. There were 2275 observations in this model and the Pseudo R square is 0.0665.

Table 5.9 Binary logit model parameter estimates, for wildlife habitat questionnaire

Variable	Model1	Model2
Tax	-0.0023***	-0.0024***
	(0.000)	(0.000)
NAR	0.0351***	0.0270**
	(0.013)	(0.013)
Rural_nar	-0.0557***	-0.0430**
	(0.016)	(0.017)
period	-0.0340**	-0.0284*
	(0.014)	(0.014)
fc		-0.7145**
		(0.347)
male		-0.5136***
		(0.151)
aincome		0.3100**
		(0.153)
Constant	0.6152***	0.8136***
	(0.180)	(0.221)
N	2275	2225
log-likelihood	-1459.7542	-1404.27
P-value > Chi-square	0.0000	0.0000
Pseudo R2	0.0665	0.0831

Note 1: * p<.1; ** p<.05; *** p<.01
Note 2: yea-sayers removed and uncertainty adjusted
Note 3: clustered standard error applied
Note 4: Values in the parenthesis are the standard errors

The second model for wildlife habitat questionnaire data included same design and location variables as the first model, but have additional demographic variables. The signs for design variables and location variables stayed the same, while the significance levels for *NAR* and *Period* decreased. *FC,* which indicated whether respondents currently lived on a farm, was found to be negative and statistically significant at 5% level. It indicated that the probability of voting in favor of the proposed BMP programs decreased if respondents lived on a farm. In another word, as respondents' familiarity towards farming practices increase, the less likely they would vote for the BMP programs. *Male* was found to be negative and statistically significant at 1% level, indicating female residents were more willing to pay for agricultural BMPs to improve wildlife habitat conditions in SSR. The coefficient for *Aincome* (average or higher income) was positive and statistically significant at 5%, indicating average income and high income household were more

likely to choose the proposed management strategy. There were 2225 observations in the model and the Pseudo R square is 0.0831. Additional models for wildlife habitat questionnaire data were presented in Appendix J. More demographic variables were examined but no significance was found.

Binary logit regression results for water quality improvement questionnaire data were shown in Table 5.10. Model 1 included only design variables *Tax*, *Bi*, *Oi*, *Si, Mi*. The marginal utility of money, or the coefficient associated with *Tax*, was negative and statistically significant at 1% level, indicating likelihood of respondents voting in favor of the proposed BMP programs decrease as the additional annual tax payment increases. Water quality improvement in Bow River Basin, captured by *Bi*, was positive and significant at 1% level. It indicated that respondents' possibility of voting against the proposed BMP programs decreased as the level of water quality improvement in Bow River Basin increased. Similarly, the coefficient estimate associated with the level of water quality improvement in Oldman River Basin was found to be positive and significant at 1% level, indicating respondents were more willing to choose the proposed programs if there were higher water quality improvement in Oldman River Basin. The coefficient estimates for the remaining two design variables showed no significance, suggesting that the level of water quality improvement in South Saskatchewan River Basin or Milk River Basin did not play a significant role in determining respondents' WTP.

The parameter estimates for the second models, which had additional demographic variable, were demonstrated third column. Same signs and significance were observed for all design variables, with an expectation for *Bi* variable where the parameter estimate was only significant at 5% level. The coefficient for *Male* was negative and significant, suggesting men were less likely to pay additional tax for agricultural BMP programs. There were also additional models, presented in Appendix H, had been adopted to test other demographic variables for water quality data sets, however, no significances were found.

Table 5.10 Binary logit model parameter estimates, for water quality improvement questionnaire

Variable	Model1	Model2
Tax	-0.0015***	-0.0016***
	(0.000)	(0.000)
Bi	0.1541***	0.1484**
	(0.057)	(0.057)
Oi	0.1739***	0.1856***
	(0.057)	(0.058)
Si	0.0782	0.0873
	(0.060)	(0.062)
Mi	0.0648	0.0644
	(0.065)	(0.047)
male		-0.3589**
		(0.154)
Constant	0.1842	0.3726**
	(0.160)	(0.1750)
N	1,784	1,748
log-likelihood	-1193.886	-1160.5986
P-value > Chi-square	0.0000	0.0000
Pseudo R2	0.0309	0.0383

Note 1: * p<.1; ** p<.05; *** p<.01
Note 2: yea-sayers removed and uncertainty adjusted
Note 3: clustered standard error applied
Note 4: Values in the parenthesis are the standard errors

5.4.4 WTP estimates and aggregated welfare measures

Willingness to pay measure for one-unit wildlife habitat improvement, captured by the net number of not at risk species, were presented in Table 5.11. For a 5-year program, an urban resident was willing to pay $206 per household per year while a rural resident was willing to pay $144 per household per year. For a 10-year program, the annual household WTP decreased to $133 and $71 for urban residents and rural residents respectively.

Parametric WTP estimate for water quality improvements were provided in Table 5.12. Individual's willingness to pay for one-level water quality improvement in Bow River Basin was about $100 per household per year for a five-year agricultural BMP program. The WTP estimates for one-level water quality improvement in Oldman River Basin was about $113 per household per year for a five-year period.

Table 5.11 WTP estimates for one level improvement in NAR over a 5-year wildlife habitat improvement program, yea-sayers removed and certainty adjusted

WTP for one unit improvement in NAR	WTP for a 5-year program ($/household/year)	WTP for a 10-year program ($/household/year)
Urban residents	206.232	133.200
	(35.004)	(62.127)
Rural residents	144.284	71.232
	(35.970)	(63.089)

Note 1: Values in the parenthesis under the WTP estimates are the standard errors

Note 2: yea-sayers removed and uncertainty adjusted

Table 5.12 WTP estimates for one level water quality improvement in Bow River Basin or Oldman River Basin in South Saskatchewan Region, yea-sayers removed and certainty adjusted

WTP for one level improvement in water quality	WTP ($/household/year)
One-level improvement in Bow River Basin	99.952
	(39.262)
One-level improvement in	112.800
Old man River Basin	(37.665)

Note 1: Values in the parenthesis under the WTP estimates are the standard errors

Note 2: yea-sayers removed and uncertainty adjusted

To obtain economic values for improvement water quality or wildlife habitat conditions after adopting BMP programs, the household level WTP were aggregated over the total number of household in SSR. According to Census 2016, the aggregated household numbers in SSR is 675,475 (Statistics Canada, 2016). The aggregated welfare measures for wildlife BMP programs were presented in Table 5.13. The estimated aggregated annual WTP for a 5-year wildlife BMP programs was about $131 million, and the aggregated welfare measure for the overall 5-year programs was about $655 million. For a 10-year program, the aggregated annual WTP was about $82 million, resulting in $818 million in total.

The aggregated welfare measure for a 5-year BMP programs to improve water quality in SSR was demonstrated in Table 5.14. The estimated aggregated annual WTP for one-level water quality improvement in Bow River Basin was $67.5 million, and the overall aggregated WTP for the 5-year programs was $338 million. The estimated aggregated WTP for one-level water quality

improvement in Oldman River Basin was $76.2 million per year. The total aggregated WTP for one-level improvement in Oldman River Basin over the 5-year periods was $381 million.

Table 5.13 Aggregated WTP for BMP programs to improve wildlife habitat conditions in South Saskatchewan Region

	Aggregated WTP for BMP programs (million CAD$/year)	Aggregated WTP for BMP programs (million CAD$)
5-year BMP programs	131.1	655.4
10-year BMP programs	81.7	817.5

Note: yea-sayers removed and uncertainty adjusted

Table 5.14 Aggregated WTP for a 5-year BMP programs to improve water quality in South Saskatchewan Region

	Aggregated WTP for a 5-year BMP programs (million CAD$/year)	Aggregated WTP for a 5-year BMP programs (million CAD$)
One-level water quality improvement in Bow River Basin	67.5	337.6
One-level water quality improvement in Oldman River Basin	76.2	380.9

Note: yea-sayers removed and uncertainty adjusted

Chapter Summary

This chapter first presented respondent's reasons for their choices. Most of respondents who voted in favor for the programs believe the benefits of wildlife habitat (or watershed) protection are worth the increases in taxes. On the other hand, most of respondents who voted against the proposed BMP programs claimed either they have financial constraints, or they did not trust government would put their taxes into a good use.

After minimizing potential hypothetical bias through removing yea-sayers and adjusting certainty, linear binary logit models were conducted for both wildlife habitat dataset and water quality dataset. The parametric analysis for the wildlife habitat data showed that men and rural residents were less likely to pay for proposed BMP programs. In addition, lower income respondents tended to be less likely to pay for BMP wildlife BMP programs compares to average and higher income respondents. As residents' awareness of farming practices increases, they were also willing to pay less. Moreover, the longer the program period was, the less the respondents were willing to pay.

On average, a rural respondent was willing to pay $144 and $71 per household per year for a 5-year and a 10-year wildlife BMP program respectively. In comparison, an urban respondent was willing to pay $206 and $133 per household per year for a 5-year and a 10-year program. Aggregated welfare for 5-year and 10-year wildlife BMP programs were $655 million and $817 million respectively.

The parametric analysis for the water questionnaire data showed that respondents were only willing to pay for water quality improvement in Bow River Basin and Oldman River Basin. Additional, the results showed that only gender played a role in determining respondents' WTP for water quality BMP programs. On average, respondents were willing to pay $100 per household per year for one-level improvement (fishable to swimmable) in Bow River Basin. WTP for one-level water quality improvement in Oldman River Basin were slightly higher, which was about $112 per household per year. Aggregated welfare measures for 5-year water quality improvements programs in Bow River Basin and Oldman River Basins, which improved water quality from fishable to swimmable, were $338 million and $381 million respectively.

Chapter 6 Conclusion, Policy Implication and Limitations

6.1 Summary and Conclusion

The main objective of this study was to obtain benefit estimates of agri-environmental BMP projects in the Alberta South Saskatchewan region. To do this we developed an internet questionnaire containing a stated preference tool that utilized a hybrid CVM approach to estimate the non-market values associated with the potential improvements in water or wildlife habitat qualities after adopting BMP programs. The initial survey was constructed based on past studies and was further polished and modified through expert and public focus groups, as well as a pre-test of 52 participants on December 2017. To indicate the potential improvements in water quality and wildlife habitat after BMP adoption, the concept of the water quality ladder and the status of at-risk species were used in the choice scenarios. Experts determined various improvement levels of water quality and wildlife habitat conditions. To improve overall understandability, a set of videos on background information was provided to respondents in the final administration of the questionnaires.

The final questionnaire was administrated through internet on December of 2017. A total of 1594 people were randomly recruited into the wildlife habitat improvement questionnaire, only 506 adequate survey completions were obtained with a response rate of 31.7%. For the water quality questionnaire, 2046 people were recruited, and 518 adequate survey completions were collected with a response rate of 25.3%. Resulting demographic characteristics demonstrated that both questionnaire datasets were reasonable representations of the Alberta South Saskatchewan region population.

Information on respondents' attitudes toward, and awareness of industrial and environmentally related issues, were gathered. Results indicated that most of the respondents were regular food/meat purchasers and regular beef consumers. Most of the respondents were generally more familiar with health related agri-environmental issues but not issues related to environmental quality degradation. In addition, a higher awareness of Growing Forward, BMPs, farming practices, economic benefits and risks from cattle farming, presence of at-risk species or water quality risks, was observed within rural respondents; while the urban residents of the Bow River basin showed the lowest levels of awareness in the aforementioned subjects. Low rates of membership in environmental groups was shown among respondents in both datasets, while

relatively higher participation rates in outdoor recreation clubs, and fishing and hunting clubs were observed. Furthermore, respondents were more concerned about environmental protection than job or food reductions, and urban respondents were more likely to vote in favor of environmental-related funding increases. Overall, this collective body of information suggested that rural respondents were less supportive of government funding increases, although they generally had higher levels of understanding about the industry in most aspects.

Other than gathering information on respondents' background knowledge and awareness towards topics about the beef industry and existing government mitigation measures, the final survey instruments also collected respondents' choices on various BMP scenarios for econometric analyses. Parametric results from the stated preference choice questions indicated that Alberta South Saskatchewan Region residents valued wildlife habitat or water quality and were willing to pay for increased levels of BMP adoption by agricultural producers to improve wildlife or water quality conditions. The estimated mean annual household WTP for 5-year wildlife BMP programs was $206 and $144 for urban and rural residents respectively. As the program period increased to 10 years, WTP estimates dropped to $133 and $71 per year for urban residents and rural residents respectively. On the other hand, respondents were willing to pay $100/household/year and $113/household/year for water quality improvements from fishable to swimmable in the Bow River and Oldman River Basins over a five-year period respectively. The estimated aggregated welfare measure was approximately $655 million for a 5-year wildlife habitat program, and $818 for a 10-year wildlife habitat program. The estimated aggregated welfare measure for a 5-year water quality program was $338 million and $381 million for one-level water quality improvement in the Bow River Basin and the Oldman River Basin respectively.

Results from the parametric welfare analysis support previous research that suggests that the public is willing to pay positive economic values for water quality or wildlife habitat improvements. However, different factors contributed to respondents' decisions on their levels of willingness-to-pay. The differences between the wildlife habitat and water quality results are captured by rural/urban status, and income levels. From the wildlife habitat survey results, we can conclude that urban respondents and female respondents were more willing to pay for BMP funding programs. In addition, respondents with higher household incomes and lower awareness of SSR farming practices were more likely to pay for improvements in wildlife BMP programs. However,

respondents were generally willing to pay less as the program funding period increased. In contrast, rural/urban status and income condition did not play significant roles, as suggested by the parametric results, in determining the values of WTP for water quality questionnaire respondents. The results indicated that respondents were only willing to pay for quality improvements in the Bow River Basin and the Oldman River Basin. Values associated with water quality improvements in the Oldman River Basin were generally higher than those for the Bow River Basin. Additionally, female individuals more likely to vote for water quality improvement programs and were willing to pay more.

Other than the econometric differences, graphic representations of the data also provide insights regarding respondents' choices. Urban respondents were more likely to vote in favor of the proposed BMP or NSQ, wildlife habitat programs (52%), in contrast to rural respondents (42%). As for the water quality questionnaire, the percentage of urban residents who chose the proposed program was about the same as the percentage of rural residents who voted in favor of NSQ situations, as shown in Figure 6.1. Within the rural samples (Figure 6.2), respondents who currently live on a farm were more likely to choose to stay at the status quo condition. In other words, farm residents were less supportive regarding the tax increases for water quality or wildlife habitat improvements measures. Nevertheless, parametric and graphic representation results from both questionnaires suggested that rural individuals are willing to pay less for either water quality or wildlife habitat improvements. A possible explanation is that rural residents are more familiar and/or involved with farming operations, and while they agree that funding should be provided to producers to enhance environmental benefits from farming operations, they expect urban residents to provide most of the funding for incentive programs to generate those environmental benefits.

The reasons for the observed level of consensus on water quality questionnaire results between rural and urban residents might be multifold. Firstly, there is a closer relationship between water and human life and activity. As one of the most vital substances to human and other living forms, water is consumed everyday. In contrast, although wildlife habitat is also an essential part of nature and brings environmental benefits to humans (e.g. potential water and air quality improvements), improvements in wildlife habitat may not directly influence every individual. To be more specific, it might be easier for a respondent to understand the importance and necessity to enhance water quality since human life depends on clean water sources. However, the importance of a wildlife

habitat improvement to a particular respondent could depend on if the respondent understands the potential benefits from retaining and restoring wildlife habitat, and whether that respondent would ever directly enjoy the benefits from the wildlife habitat improvement.

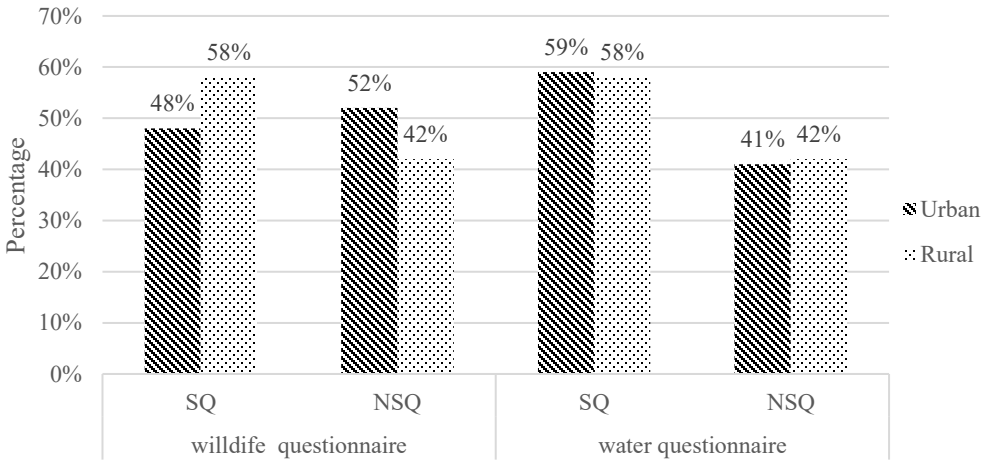


Figure 6.1 Percentage of respondents who voted to stay in Status quo (SQ) conditions, and percentage of respondents who voted for Non-status quo (NSQ) conditions, by urban and rural

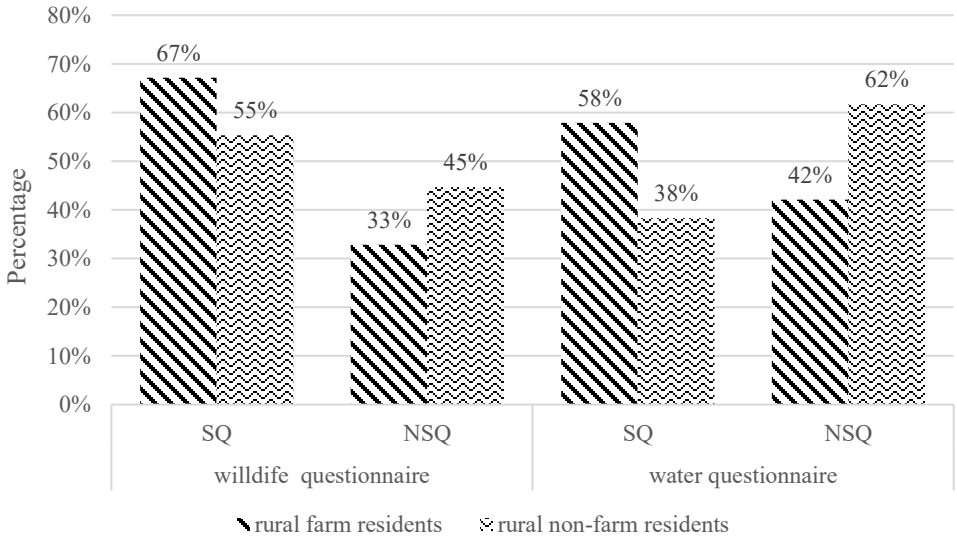


Figure 6.2 Percentage of respondents who voted to stay in Status quo (SQ) conditions, and percentage of respondents who voted for Non-status quo (NSQ) conditions, by rural farm residents, and rural non-farm residents

There are also more on-farm benefits and health-related benefits from water quality improvements. For instance, water quality improvement projects bring benefits to agricultural producers since freshwater is required for most agricultural activities. However, wildlife projects, such as wetland restoration, provide more direct benefits to urban residents as the future recreational opportunities could increase for example. As rural and farm residents already have more opportunities to enjoy the benefits from wildlife relative to urban residents, the benefits from restoring wildlife habitat for rural and farm residents might be not as high as the benefits to urban residents. Other than the costs to undergo the wildlife habitat protection, restoring natural regions could lead to possible reductions of the total lands that can be used for agricultural activities. All these reasons could possibly explain consensus between urban and rural respondents on water quality improvement projects, but not on wildlife habitat improvement projects.

However, the estimated WTP values for wildlife habitat protection, whether for rural or urban individuals, were much higher than water quality improvement projects even though there was no consensus between rural and urban residents regarding future government investments on wildlife habitat protection. This suggests that although not everyone values the importance of wildlife habitat improvements, for those that do, they were willing to sacrifice a higher level of their household income to obtain the potential future benefits. The higher level of WTP for wildlife habitat improvement could be a result of the existence, or intrinsic values associated with endangered species.

The results from this study support the actions carried out by *Growing Forward* by indicating that SSR residents are willing to pay for water quality and wildlife habitat improvements. However, these results suggest that the total funding amounts provided to SSR farmers via the *Growing Forward* Environmental Stewardship Programs were much lower than our estimated economic values. The estimated aggregated welfare measure was approximately $655 million for a 5-year wildlife habitat program, and $818 for a 10-year wildlife habitat program. The estimated aggregated welfare measure for a 5-year water quality program was $338 million and $381 million for one-level water quality improvement in the Bow River Basin and the Oldman River Basin respectively. Yet, the total government spending on livestock-related BMP programs in Alberta SSR to support *Growing Forward* Stewardship programs from 2010 to present was only $7.1 million, as described in Chapter 1.

One possible solution to encourage increased adoption of BMPs and environmental improvements is to relax the eligibility requirement for access to the *Growing Forward* programs. As discussed in Chapter 1, an agricultural producer needs to hold an Environmental Farm Plan (EFP) in order to be considered as eligible for applying for government financial support to implement BMP projects. However, only a small number of Alberta farmers actually do possess an EFP. As Boxall (2018) pointed out, the requirement of holding an EFP limits the number of eligible applicants who are willing to apply for government support to implement agri-environmental BMPs. Once the funding requirement is removed or relaxed, there will be additional producers able to access the Stewardship funding programs to promote higher levels of BMP adoption.

Other than that, Government authorities can also promote environmental improvements by enhancing education and public awareness about BMPs and *Growing Forward* (which now called CAP), especially for rural and farm residents. Our data showed that most of the respondents, whether they lived in rural or urban regions, were not aware of existence of BMPs and/or *Growing Forward*. Once individuals such as beef producers know more about what the benefits agri-environmental BMPs could bring to the environment, and what financial support governments could offer for them to cover the implementation costs, there could be higher levels of BMP adoption in the future. Similarly, there is also a need for government authorities to improve public awareness of the potential detrimental impacts of livestock operations on water quality and wildlife habitat.

6.2 Policy implications

There are several policy implications of the survey results. Firstly, this study provides information on Alberta South Saskatchewan Region residents' familiarity with current agri-environmental issues, farming practices and beef industry in South Saskatchewan Region, as well as awareness regarding potential concerns from beef industry and existing government mitigation measures. This information can be used by policy makers to understand the general public's concerns regarding beef production and environmental impacts surrounding water quality and/or wildlife habitat in Alberta prior any further development or implementation of incentive policies. It can also be used to tailor communication programs to improve awareness. Secondly, expected average household annual WTP values, and aggregated welfare measures, associated with potential

improvements in agri-environmental BMP adoption were estimated in this study. Those measures can be used to develop more effective incentive policies in the agriculture sector in the future.

Last but not the least, in the sense of the model proposed by Pannell (2008) our results can help policy makers understand which form of government intervention would result in effective environmental outcomes. The positive public net benefits toward environmental enhancement, as suggested by positive WTP estimates, and the negative private net benefits based on an assumption that producers require financial inducement, demonstrates that the positive financial incentives would be suitable to foster environmental improvements. It also suggests that the current Growing Forward stewardship program, with sufficient funding, could be a feasible measure to alleviate agricultural impacts on the environment.

6.3 Limitations and further research

One potential limitation of this current study is that we failed to identify differences between respondents who believed their inputs were consequential and those who did not in the econometric analyses of the stated preference information. When respondents did not feel that their time and inputs on the survey were consequential, the choices respondents made in the survey might not reflect their true values for the designed agri-environmental programs. Although the final survey instruments collected related consequentiality information, no further consequentiality tests were performed in the econometric analyses. For future research, one could consider this information when conducing econometric analysis to improve the estimation accuracy.

Complexity in the survey context and valuation tasks might also influence the overall accuracy of the econometric estimates. There was a massive amount of information provided to survey respondents before they answered the choice scenarios. Although efforts were made to improve overall levels of knowledge and understanding (e.g. use of videos instead of traditional texts) it might still be difficult respondents to understand information provided and the choice tasks.

Sample representativeness is another aspect that can be further improved in the future study. Even though both wildlife questionnaire and water questionnaire datasets were fair representations of the SSR population, some of the demographic characteristics collected could not fully reflect the true demographic conditions in the SSR (e.g. employment and education levels). A

misrepresentation of the population could lead to miscalculation of the final WTP and the final aggregated welfare measures.

Another potential shortcoming of this study are uncertainties with respect to the actual water quality or wildlife habitat improvements generated after agri-environmental BMP adoption. For example, all the levels of environmental enhancements used in the questionnaire were based on previous research and expert opinion. Yet the exact environmental enhancement measures after BMP adoption are difficult to quantify due to the complex nature of the natural systems involved. In this study, we assumed that water or wildlife habitat quality in SSR would increase to levels suggested by experts as long as a series of BMPs would be adopted to lower agricultural impacts. This certainty was implied to respondents, some of whom may not agree or believe in this degree of certainty. We are not able to consider this degree of respondent uncertainty in our WTP estimates, except to suggest that this could be inherent in the questions that examined the degree of confidence in the voting choices made by each respondent in the questionnaire. Without taking into account that there could be other human managerial and natural factors that contribute to overall water and wildlife habitat quality, the estimated WTP values and the social welfare measures might not be accurate enough to be used in programs that could leads to targeted environmental enhancements. To improve the accuracy of the welfare estimation in the future, researchers should attempt to come up with more accurate estimation models in which other factors contributing to uncertainty in WTP estimates can be taken into account.

Finally, this study did not account for the possibility that agricultural producers might also have positive values toward environmental improvements regardless of financial supports. We reached our conclusion based on the assumption that producers are rational and are not willing to undergo BMP adoption measures unless financial incentives are provided to compensate for their adoption cost. The corresponding results demonstrated that government programs may need to provide increased positive incentive levels since there are positive public net benefits, but possibly negative private net benefits (as demonstrated in the Pannell diagram in Chapter 1). However, we neglected the fact that it is possible that producers, even though they suffer from additional financial costs, are still willing to sacrifice income or profit to obtain and enjoy higher environmental benefits. In this case, an extension program (e.g. education, communication) could also be implemented in addition to positive financial incentives since both public and private net benefits are gained. When

producers not only gain public but also private benefits from BMP adoption, their willingness to accept values could be smaller than the costs they bear in adopting BMPs (see Norton et al. 1994). Future research could try to delve further into the differences in levels of support of government agri-environmental incentive programs that generate environmental improvements from changes in farm management systems.

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Appendix A Focus Group Information Sheet

Participant Information Sheet

Managing Environmental Impacts from Livestock Operations in Alberta

Purpose: The purpose of this project is to determine how much the public values the environmental improvements generated by beneficial management practice adoption in livestock operations

Methods: We will be using stated preference method, which involves developing a questionnaire, in order to collect information about how respondents make trade-offs between ecosystem services and financial payments from the government to livestock producers. We would like your inputs about the questions and any ideas or concepts we plan to apply in the study. We would like you to read a draft of the scenarios and to comment on the content, the questions, and other things that may come up when completing it. Please be advised of that the focus group will be audio-recorded and every participant will be reimbursed and paid for their time.

Confidentiality: You can be assured that your answers are confidential and will only be released in an anonymous form. Because other people in the focus group will be hearing your ideas, confidentially from them cannot be assured but we ask that all participants do not talk about anything brought up during discussion outside the focus group

Risks: There are no foreseeable risks to the individuals. The only potential risk is that individuals in the focus group will hear each other's comments and confidentiality regarding these comments cannot be guaranteed. We will request every participant to keep everything in the group confidential even though we cannot stop them to discuss comments or activities from the focus group outside the group setting.

Benefits: Participants will acquire a better understanding of the beef industry and ecosystem services generated by adopting beneficial management practices. They may also learn more about environmental impacts and how these impacts can be mitigated through changes in production practices.

Withdrawal from the study: Your participation in this study is completely voluntary and you may refuse to participate or leave the study at any time. If you decide to not participate in the study or leave the study it will be without any consequences to you. After the focus group is finished, focus group data cannot be withdrawn as we need the answers to develop and to test the survey.

Use of your information: This study is conducted for research purposes only. The information you provided will help the researchers to improve the development of the survey for identifying people's willingness to pay for ecosystem services generated by BMP adoption in livestock operations in Alberta.

In the case of any concerns. Complaints or consequences contact:

Research Ethics Office

University of Alberta

Edmonton, Alberta, Canada T6G 2H1

Phone: 780-492-2615

Appendix B Focus Group Consent Form

Consent Form

Managing Environmental Impacts from Livestock Operations in Alberta

Investigators:

Peter Boxall
515 General Services Building
Tel: (780) 492-5604
peter.boxall@ualberta.ca

Marian Weber
250 Karl Clark Road
Tel: (780) 450-5193
marian.weber@albertainnovates.ca

Zhaochao Lin
515 General Services Building
Tel: (780) 803-9995
zhaochao@ualberta.ca

Please circle your answers.

Do you consent to participating in a discussion about the questionnaire "Managing Environmental Impacts from Livestock Operations in Alberta"?

Yes *No*

Do you understand that you have been asked to be part of a focus group?

Yes *No*

Have you received and read of the Information Sheet?

Yes *No*

Do you understand the benefits and risks involved in taking part in this focus group as outlined in the Information Sheet?

Yes *No*

Do you understand that you can quit taking part in this study at any time? You do not have to say why and it will not affect any payments you receive for participating.

Yes *No*

Do you understand who will be able to see or hear what you said?

Yes *No*

Do you know what the information you say will be used for?

Yes *No*

Do you give us permission to use your data for the purposes specified?

Yes *No*

I agree to take part in the focus group.

_____ _____

Signature Date

Appendix C Wildlife survey instrument

Wildlife Habitat Conditions in Alberta
Click on the next arrow at the bottom right corner of the page to continue.

Introduction

Your answers will remain confidential. Answers will be compiled and released in anonymous form in project reports and research publications. The study is conducted for research purposes only and researchers will store the data until March 31, 2020.

For completing the survey, you will be entered into a draw to win 1 of 4 $100 e-gift cards. Please click **here** for complete draw rules.

Links to: https://surveys.advanis.ca/media/ wildlife /ENVIRONMENT_SURVEYS_OFFICIAL_RANDOM_PRIZE_DRAW_RULES.htm

Click on the next arrow at the bottom right corner of the page to continue.

A1

To begin, you will be asked some general questions about yourself. Please answer based on your own experience.

How often do you purchase food for your household?

- ❍1 Regularly
- ❍2 Occasionally
- ❍3 Rarely
- ❍4 Never

A2

How often do you buy meat for your household?

- ❍1 Regularly
- ❍2 Occasionally
- ❍3 Rarely
- ❍4 Never

A3

Are you currently living on a farm?

- ❍1 Yes
- ❍2 No

A4

Did you live on a farm at any time when you were growing up?

- ❍1 Yes
- ❍2 No

A5 *Show If Does_not_currently_live_on_a_farm*

Do you typically visit a farm at least once a year?

- ❍1 Yes
- ❍2 No

A6

Which of the following describes your food preferences?

- ❍1 I eat meat and fish
- ❍2 I eat fish but not meat
- ❍3 I eat meat but not fish
- ❍4 I am a vegetarian or vegan

A7 *Show If Eats_meat*

How often do you eat beef?

- ❍1 Less than once per month
- ❍2 Once per month
- ❍3 A few times per month
- ❍4 Once per week
- ❍5 More than once per week

A8

How much have you heard or read about each of the following topics in the past few years?
Programming note: Row items are randomized.

		Nothing	A little	A moderate amount	Quite a bit	A great deal
a.	Growth hormone use in livestock	❍1	❍2	❍3	❍4	❍5
b.	Antibiotic use in livestock	❍1	❍2	❍3	❍4	❍5
c.	Genetically modified foods	❍1	❍2	❍3	❍4	❍5
d.	Mad cow disease	❍1	❍2	❍3	❍4	❍5
e.	Battery cages for chickens	❍1	❍2	❍3	❍4	❍5
f.	Abuse of farm animals – animal welfare	❍1	❍2	❍3	❍4	❍5
g.	Greenhouse gas emissions from livestock	❍1	❍2	❍3	❍4	❍5
h.	Water pollution from livestock grazing	❍1	❍2	❍3	❍4	❍5
i.	Salmonella food poisoning	❍1	❍2	❍3	❍4	❍5
j.	Soil erosion from livestock grazing	❍1	❍2	❍3	❍4	❍5
k.	Land conversion for livestock grazing	❍1	❍2	❍3	❍4	❍5
l.	Bovine spongiform encephalopathy (BSE)	❍1	❍2	❍3	❍4	❍5
m.	Threats to wildlife from intensified livestock grazing	❍1	❍2	❍3	❍4	❍5

Video1

To answer the next few questions, you will need to watch the video about the economy and the beef cattle sector in the South Saskatchewan Region. When you are done, click on the next arrow at the bottom right corner of the page to continue.

Please watch the video in full screen mode. If you prefer, you can review it in PDF format **here**
Programming note: links to –
https://surveys.advanis.ca/media/wildlife/Introduction.pdf

Programming note: **Video displays here**
(https://surveys.advanis.ca/media/wildlife/4401_introduction.mp4)

V1

Before watching the video, were you already aware of the economic importance of the cattle sector to the South Saskatchewan Region?

- ❍1 Yes
- ❍2 No
- ❍3 Not sure

V2

Before watching the video, were you already aware of the potential environmental risks from the beef sector?

- ❍1 Yes
- ❍2 No
- ❍3 Not sure

Video2

In order to answer the next set of questions, please watch this video about the adoption of **beneficial management practices (BMP)** by livestock producers and investments by government on supporting changes in livestock management practices. When you are done, click on the next arrow at the bottom right corner of the page to continue.

Please watch the video in full screen mode. If you prefer, you can review it in PDF format **here**
Programming note, (links to) –
https://surveys.advanis.ca/media/wildlife/Sept26_BMP_V2.pdf

Programming note: **Video displays here**
(https://surveys.advanis.ca/media/wildlife/4401_bmp_v3.mp4)

V3

Before you started this survey, had you ever heard of **Beneficial management practices (or BMPs)**?

- ❍1 Yes
- ❍2 No
- ❍3 Not sure

V4

Before you started this survey, had you ever heard of **The Growing Forward Program**?

- ❍1 Yes
- ❍2 No
- ❍3 Not sure

V5

What do you think the Canadian and Alberta Governments should do regarding future levels of funding specifically on the environmental impacts of agricultural production?

- ❍1 Increase investments in protecting the environment from impacts resulting from agricultural production; Current government spending on environmental protection is not enough, it is important to prevent potential environmental damages
- ❍2 Decrease investments in protecting the environment from impacts resulting from agricultural production; Current government spending on environmental protection is too much, the environment is still in good condition
- ❍3 Do nothing; Current government spending on environmental protection is sufficient
- ❍4 Not sure

Video3txt

Now we would like to focus on some specific environmental impacts in agriculture.

This next and final video will highlight issues relating to species at risk of extinction in the South Saskatchewan Region of Alberta.
Click on the next arrow at the bottom right corner of the page to continue.

Video3

The video will outline the potential damages to wildlife habitat and animal species within the South Saskatchewan Region from the beef cattle sector, and how we will be accounting for the potential improvements in our survey. When you are done, click on the next arrow at the bottom right corner of the page to continue.

Please watch the video in full screen mode. If you prefer, you can review it in PDF format **here**
Programming note, (links to): https://surveys.advanis.ca/media/wildlife/WildlifeHabitat.pdf

Programming note: **Video display here**
(https://surveys.advanis.ca/media/wildlife/4401_wildlife_habitat.mp4

V6

How important is it to you personally that every possible effort be made to protect all species that are currently at risk?

- ❍1 Not at all important
- ❍2 Somewhat important
- ❍3 Moderately important
- ❍4 Very important
- ❍5 Extremely important
- ❍6 Not sure

V7

How concerned are you that efforts to protect species at risk will reduce food production and jobs in the agriculture sector?

- ❍1 Not at all concerned
- ❍2 Somewhat concerned
- ❍3 Moderately concerned
- ❍4 Very concerned
- ❍5 Extremely concerned
- ❍6 Not sure

V8

Before participating in this survey, were you already aware that several species present in the South Saskatchewan Region of Alberta are at risk?

- ❍1 Yes
- ❍2 No
- ❍3 Not sure

Choice scenario Introduction A

The next sets of questions will ask you to consider five potential scenarios of new government programs.

These enhanced programs provide financial incentive to Alberta livestock producers to incorporate BMPs in their operations, which would help to improve **wildlife habitat conditions** in the South Saskatchewan Region.

In each set, you will be asked to compare the enhanced program with the option to make no additional investment, and vote for the option you prefer.

The scenarios are similar but will vary by one or two different attributes. We will give you an

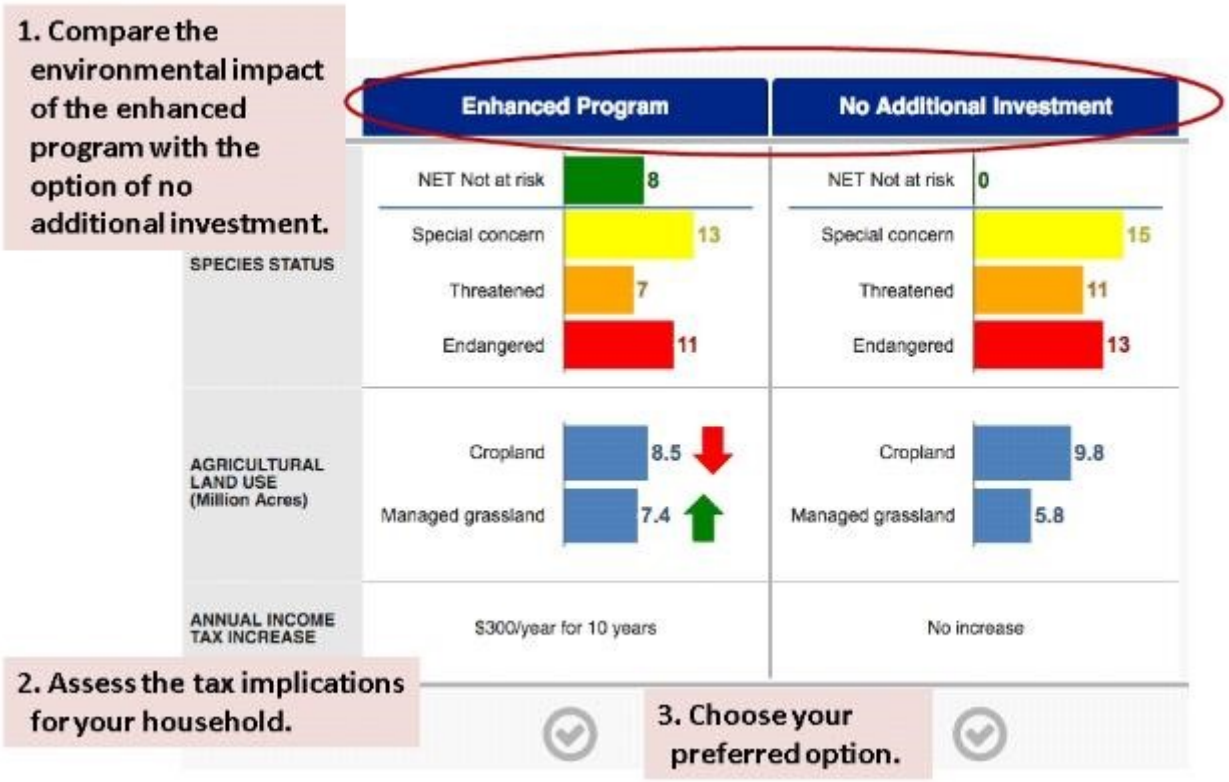
example of a scenario, and then you will complete 5 scenarios yourself. Each scenario should be treated as an independent decision that is unrelated to your answers on the previous option.

Click on the next arrow at the bottom right corner of the page to continue.

Choice scenario Example

An example of the tasks you will see is presented below. You will be asked to vote on various funding options for putting this enhanced program into action.

In each scenario:



When reviewing each scenario, please expand your screen as much as possible to ensure you can view all of the information including the checkboxes at the bottom of each column.

Click on the next arrow at the bottom right corner of the page to continue.

Choice scenario Introduction B

It is very important that you **vote as if this were a real vote**. You need to imagine that you actually have to **dig into your household budget and pay the additional cost**.

Please carefully consider the wildlife habitat condition differences between the current situation and the new enhanced program scenario and the increased tax level option before voting.

Click on the next arrow at the bottom right corner of the page to continue.

Choice 1 Displays

QchsA2

How certain are you that this is the choice you would make if this was a real referendum?

- ❍1 Very uncertain
- ❍2 Somewhat uncertain
- ❍3 Somewhat certain
- ❍4 Very certain

QchsA3

Considering the **enhanced program option** outlined previously, what percentage of South Saskatchewan residents do you believe would vote in favour of this in a **real referendum**?

Click on the next arrow at the bottom right corner of the page to continue. _____%

Choice 2 Displays

QchsB2

How certain are you that this is the choice you would make if this was a real referendum?

- ❍1 Very uncertain
- ❍2 Somewhat uncertain
- ❍3 Somewhat certain
- ❍4 Very certain

QchsB3

Considering the **enhanced program option** outlined previously, what percentage of South Saskatchewan residents do you believe would vote in favour of this in a **real referendum**?

Click on the next arrow at the bottom right corner of the page to continue. _____%

Choice 3 Displays

QchsC2

How certain are you that this is the choice you would make if this was a real referendum?

- ❍1 Very uncertain
- ❍2 Somewhat uncertain
- ❍3 Somewhat certain
- ❍4 Very certain

QchsC3

Considering the **enhanced program option** outlined previously, what percentage of South Saskatchewan residents do you believe would vote in favour of this in a **real referendum**?

Click on the next arrow at the bottom right corner of the page to continue._____%

Choice 4 Displays

QchsD2

How certain are you that this is the choice you would make if this was a real referendum?

- ❍1 Very uncertain
- ❍2 Somewhat uncertain
- ❍3 Somewhat certain
- ❍4 Very certain

QchsD3

Considering the **enhanced program option** outlined previously, what percentage of South Saskatchewan residents do you believe would vote in favour of this in a **real referendum**?

Click on the next arrow at the bottom right corner of the page to continue. _____%

Choice 5 Displays

QchsE2

How certain are you that this is the choice you would make if this was a real referendum?

- ❍1 Very uncertain
- ❍2 Somewhat uncertain
- ❍3 Somewhat certain
- ❍4 Very certain

QchsE3

Considering the **enhanced program option** outlined previously, what percentage of South Saskatchewan residents do you believe would vote in favour of this in a **real referendum**?

Click on the next arrow at the bottom right corner of the page to continue. _____%

QchsE4

In your opinion, how likely do you think it is that policy makers will consider the results from this survey to make decisions about beneficial management practice adoption in the South Saskatchewan Region?

- ❍1 Very unlikely
- ❍2 Somewhat unlikely
- ❍3 An even chance
- ❍4 Somewhat likely
- ❍5 Very likely
- ❍6 No opinion

C1 *Show If Enhanced_any_choice_custom*

Please indicate which of the factors below contributed to your decision to vote for the enhanced program in some of the scenarios presented.

(Select all that apply then click on the next arrow at the bottom right corner of the page to continue.)

- ☐1 These programs are a good use of public funds
- ☐2 The benefits of watershed protection are worth the increases in taxes
- ☐3 Watersheds should be protected at any price
- ☐4 Protecting watersheds are important to me
- ☐5 Other (specify):

C2 *Show If C1_Multiple_items_selected*

Which factor listed was the **most** important to you?

- ❍1 These programs are a good use of public funds. *[Show If C1_1_These_programs_]*
- ❍2 The benefits of watershed protections are worth the increases in taxes. *[Show If C1_2_The_benefits_of]*
- ❍3 Watersheds should be protected at any price. *[Show If C1_3_Watersheds_shou]*
- ❍4 Protecting watersheds are important to me. *[Show If C1_4_Protecting_wate]*
- ❍5 <<Specify from C1>> *[Show If C1_5_<<C1.specify(5)]*

C3 *Show If Enhanced_any_choice_custom*

Do you understand that your tax payment would increase for the foreseeable future if any of these programs were put in place?

- ❍1 Yes
- ❍2 No
- ❍3 Not sure

C4 *Show If Current_any_choice_custom*

Please indicate which of the factors below contributed to your decision to vote for the current program in some of the scenarios above.

(Select all that apply then click on the next arrow at the bottom right corner of the page to continue.)

- ☐1 The cost of the enhanced program was too high
- ☐2 I do not believe that the enhanced program would work
- ☐3 I do not feel it is my responsibility to pay to protect watersheds within this region
- ☐4 I do not believe that the impacts would be as specified
- ☐5 Protecting watersheds are not a priority for me
- ☐6 I do not want to pay additional taxes
- ☐7 I do not trust the government to run the enhanced program effectively

☐8 I need more information before I can decide
☐9 I cannot afford to pay the specified amount associated with the enhanced program
☐10 Other (specify):

C5 *Show If C4_Multiple_items_selected*

Which factor listed was the **most** important to you?

❍1 The cost of the enhanced program was too high *[Show If C4_1_The_cost_of_the]*
❍2 I do not believe that the enhanced program would work *[Show If C4_2_I_do_not_believ]*
❍3 I do not feel it is my responsibility to pay to protect watersheds within this region. *[Show If C4_3_I_do_not_feel_i]*
❍4 I do not believe that the impacts would be as specified. *[Show If C4_4_I_do_not_believ]*
❍5 Protecting watersheds are not a priority for me. *[Show If C4_5_Protecting_wate]*
❍6 I do not want to pay additional taxes. *[Show If C4_6_I_do_not_want_t]*
❍7 I do not trust the government to run the enhanced program effectively. *[Show If C4_7_I_do_not_trust_]*
❍8 I need more information before I can decide. *[Show If C4_8_I_need_more_inf]*
❍9 I cannot afford to pay the specified amount associated with the enhanced program. *[Show If C4_9_I_cannot_afford]*
❍10 <<Specify from C4>>*[Show If C4_10_<<C4.specify(10]*

Demographic Question

Finally, we would like to ask you a few questions about you and your household. Responses to these questions will be used only for statistical purposes and to compare respondents to this survey with the Canadian population as a whole. Your answers will not be saved or stored in a way that can be associated with you.

Click on the next arrow at the bottom right corner of the page to continue.

D1

Do you belong to any of the following organizations?

(Select all that apply then click on the next arrow at the bottom right corner of the page to continue.)

☐1 Environmental or conservation organization
☐2 Fishing or hunting club
☐3 Natural history or bird-watching club
☐4 Outdoor recreation club
☐5 None of the above

D2

Are you male or female?

- ❍1 Male
- ❍2 Female
- ❍3 Prefer not to answer

D3

What is your age?

Click on the next arrow at the bottom right corner of the page to continue.

_____years old

- ☐-8 Prefer not to answer

D4

Including yourself, how many members of your household are in the following age groups? Please specify the number of people in each age group, then click on the next arrow at the bottom right corner of the page to continue.

Under 5 years old	_____
5 to 19 years old	_____
20 to 64 years old	_____
65 years old or older	_____

D5

What is the highest level of education you have completed?

- ❍1 Grade school or some high school
- ❍2 High School diploma
- ❍3 Post-secondary technical school
- ❍4 Some college or university
- ❍5 College degree or diploma
- ❍6 University undergraduate degree
- ❍7 University graduate degree (Masters or PhD)
- ❍8 Prefer not to answer

D6

What was your total pre-tax household income, including all earners in your household, in 2016?

- ❍1 Less than $20,000
- ❍2 $20,000 to $39,999
- ❍3 $40,000 to $59,999
- ❍4 $60,000 to $79,999
- ❍5 $80,000 to $99,999
- ❍6 $100,000 to $119,999
- ❍7 $120,000 to $139,999

❍8 $140,000 to $159,999
❍9 Greater than $160,000
❍10 Prefer not to answer

D7a

Which of the following categories best describes your employment status?

❍1 Employed full time
❍2 Employed part time
❍3 Retired
❍4 Student
❍5 Full-time homemaker
❍6 Unemployed
❍7 Other (specify):
❍8 Prefer not to answer

D7c *Show If Your_employment_status_is_other*

How would you describe your employment status?

Click on the next arrow at the bottom right corner of the page to continue.

_____
_____
_____
_____
_____

☐-8 Prefer not to answer

D8

What is your postal code?

Your postal code is required to group responses by region in Alberta._____

D9

Would you be willing to be contacted in the future concerning further research conducted by Advanis?

❍1 Yes
❍2 No
❍3 Prefer not to say

End

Those are all the questions we have for you today. Thank you very much for your cooperation. You will be contacted by January 12, 2018 if you are a draw winner. If you wish to be excluded from the draw, please email Sue Day, Project Manager at InnotechAB@advanis.ne

Appendix D Water Survey instrument

Water Quality in Alberta

Click on the next arrow at the bottom right corner of the page to continue.

Introduction

Your answers will remain confidential. Answers will be compiled and released in anonymous form in project reports and research publications. The study is conducted for research purposes only and researchers will store the data until March 31, 2020.

For completing the survey, you will be entered into a draw to win 1 of 4 $100 e-gift cards. Please click **here** for complete draw rules.
Links to:
https://surveys.advanis.ca/media/waterquality/ENVIRONMENT_SURVEYS_OFFICIAL_RANDOM_PRIZE_DRAW_RULES.htm

Click on the next arrow at the bottom right corner of the page to continue.

A1

To begin, you will be asked some general questions about yourself. Please answer based on your own experience.

How often do you purchase food for your household?

- ❍1 Regularly
- ❍2 Occasionally
- ❍3 Rarely
- ❍4 Never

A2

How often do you buy meat for your household?

- ❍1 Regularly
- ❍2 Occasionally
- ❍3 Rarely
- ❍4 Never

A3

Are you currently living on a farm?

- ❍1 Yes
- ❍2 No

A4

Did you live on a farm at any time when you were growing up?

- ❍1 Yes
- ❍2 No

A5 *Show If Does_not_currently_live_on_a_farm*

Do you typically visit a farm at least once a year?

- ❍1 Yes
- ❍2 No

A6

Which of the following describes your food preferences?

- ❍1 I eat meat and fish
- ❍2 I eat fish but not meat
- ❍3 I eat meat but not fish
- ❍4 I am a vegetarian or vegan

A7 *Show If Eats_meat*

How often do you eat beef?

- ❍1 Less than once per month
- ❍2 Once per month
- ❍3 A few times per month
- ❍4 Once per week
- ❍5 More than once per week

A8

How much have you heard or read about each of the following topics in the past few years?

Programming note: Row items are randomized.

		Nothing	A little	A moderate amount	Quite a bit	A great deal
n.	Growth hormone use in livestock	❍1	❍2	❍3	❍4	❍5
o.	Antibiotic use in livestock	❍1	❍2	❍3	❍4	❍5
p.	Genetically modified foods	❍1	❍2	❍3	❍4	❍5
q.	Mad cow disease	❍1	❍2	❍3	❍4	❍5
r.	Battery cages for chickens	❍1	❍2	❍3	❍4	❍5
s.	Abuse of farm animals – animal welfare	❍1	❍2	❍3	❍4	❍5
t.	Greenhouse gas emissions from livestock	❍1	❍2	❍3	❍4	❍5
u.	Water pollution from livestock grazing	❍1	❍2	❍3	❍4	❍5
v.	Salmonella food poisoning	❍1	❍2	❍3	❍4	❍5
w.	Soil erosion from livestock grazing	❍1	❍2	❍3	❍4	❍5
x.	Land conversion for livestock grazing	❍1	❍2	❍3	❍4	❍5
y.	Bovine spongiform encephalopathy (BSE)	❍1	❍2	❍3	❍4	❍5
z.	Threats to wildlife from intensified livestock grazing	❍1	❍2	❍3	❍4	❍5

Video1 – Introduction Video

To answer the next few questions, you will need to watch the video about the economy and the beef cattle sector in the South Saskatchewan Region. When you are done, click on the next arrow at the bottom right corner of the page to continue.

Please watch the video in full screen mode. If you prefer, you can review it in PDF format **here**
Programming note: links to - https://surveys.advanis.ca/media/waterquality/Introduction.pdf

Programming note: **Video displays here**
(https://surveys.advanis.ca/media/waterquality/4401_introduction.mp4)

V1

Before watching the video, were you already aware of the economic importance of the cattle sector to the South Saskatchewan Region?

- ❍1 Yes
- ❍2 No
- ❍3 Not sure

V2

Before watching the video, were you already aware of the potential environmental risks from the beef sector?

- ❍1 Yes
- ❍2 No
- ❍3 Not sure

Video2

In order to answer the next set of questions, please watch this video about the adoption of **beneficial management practices (BMP)** by livestock producers and investments by government on supporting changes in livestock management practices. When you are done, click on the next arrow at the bottom right corner of the page to continue.

Please watch the video in full screen mode. If you prefer, you can review it in PDF format **here**
Programming note, (links to) –
https://surveys.advanis.ca/media/wildlife/Sept26_BMP_V2.pdf

Programming note: **Video displays here**
(https://surveys.advanis.ca/media/wildlife/4401_bmp_v3.mp4)

V3

Before you started this survey, had you ever heard of **Beneficial management practices (or BMPs)**?

- ❍1 Yes
- ❍2 No
- ❍3 Not sure

V4

Before you started this survey, had you ever heard of **The Growing Forward Program**?

- ❍1 Yes
- ❍2 No
- ❍3 Not sure

V5

What do you think the Canadian and Alberta Governments should do regarding future levels of funding specifically on the environmental impacts of agricultural production?

- ❍1 Increase investments in protecting the environment from impacts resulting from agricultural production; Current government spending on environmental protection is not enough, it is important to prevent potential environmental damages
- ❍2 Decrease investments in protecting the environment from impacts resulting from agricultural production; Current government spending on environmental protection is too much, the environment is still in good condition
- ❍3 Do nothing; Current government spending on environmental protection is sufficient
- ❍4 Not sure

Now we would like to focus on some specific environmental impacts in agriculture.

This next and final video will highlight issues relating to surface water quality in the South Saskatchewan Region of Alberta.
Click on the next arrow at the bottom right corner of the page to continue.

Video3

The video will outline the potential impacts to water quality of the four major river basins within the South Saskatchewan Region from the beef cattle sector, and how we will be accounting for the potential improvements in our survey. When you are done, click on the next arrow at the bottom right corner of the page to continue.

Please watch the video in full screen mode. If you prefer, you can review it in PDF format **here**
Programming note: links to - https://surveys.advanis.ca/media/waterquality/WaterQuality.pdf

Programming note: **Video displays here**
(https://surveys.advanis.ca/media/waterquality/4401_water_quality.mp4)

V6

How important is it to you personally that every possible effort be made to improve water quality in Canadian rivers and lakes?

- ❍1 Not at all important
- ❍2 Somewhat important
- ❍3 Moderately important
- ❍4 Very important
- ❍5 Extremely important
- ❍6 Not sure

V7

How concerned are you that efforts to address water quality issues will reduce food production and jobs in the agriculture sector?

- ❍1 Not at all concerned
- ❍2 Somewhat concerned
- ❍3 Moderately concerned
- ❍4 Very concerned
- ❍5 Extremely concerned
- ❍6 Not sure

V8

Before participating in this survey, were you already aware that water quality in the major rivers in the South Saskatchewan Region of Alberta is a concern?

- ❍1 Yes
- ❍2 No
- ❍3 Not sure

Choice scenario introduction A

The next four sets of questions will ask you to consider four potential scenarios of new government programs.

These enhanced programs provide financial incentive to Alberta livestock producers to incorporate BMPs in their operations, which would help to improve surface water quality in the four main rivers in the South Saskatchewan River Basin.

In each set, you will be asked to compare the enhanced program with the option to make no additional investment, and vote for the option you prefer.

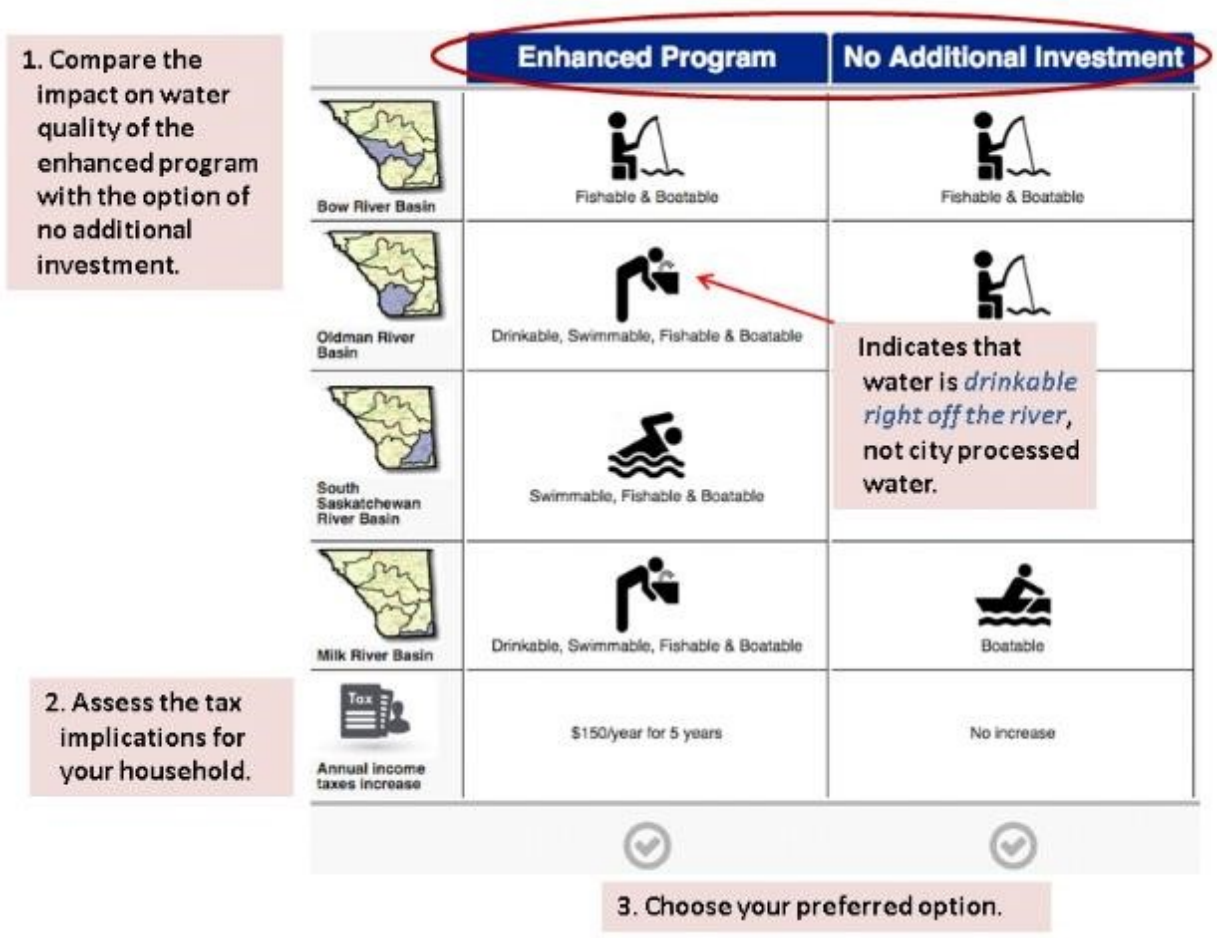
The scenarios are similar but will vary by one or two different attributes. We will give you an example of a scenario, and then you will complete 4 scenarios yourself. Each scenario should be treated as an independent decision that is unrelated to your answers on the previous option.

Click on the next arrow at the bottom right corner of the page to continue.

Choice scenario Example

An example of the tasks you will see is presented below. You will be asked to vote on various funding options for putting this enhanced program into action.

In each scenario:



When reviewing each scenario, please expand your screen as much as possible to ensure you can view all of the information including the checkboxes at the bottom of each column

Click on the next arrow at the bottom right corner of the page to continue.

Choice scenario introduction B

It is very important that you vote as if this were a real vote. You need to imagine that you actually have to dig into your household budget and pay the additional cost.

Please carefully consider the water quality differences between the current situation and the new enhanced program scenario and the increased tax level option before voting.

Click on the next arrow at the bottom right corner of the page to continue.

Choice 1 Displays

QchsA2

How certain are you that this is the choice you would make if this was a real referendum?

- ❍1 Very uncertain
- ❍2 Somewhat uncertain
- ❍3 Somewhat certain
- ❍4 Very certain

QchsA3

Considering the **enhanced program option** outlined previously, what percentage of South Saskatchewan residents do you believe would vote in favour of this in a **real referendum**?

Click on the next arrow at the bottom right corner of the page to continue. _____%

Choice 2 Displays

QchsB2

How certain are you that this is the choice you would make if this was a real referendum?

- ❍1 Very uncertain
- ❍2 Somewhat uncertain
- ❍3 Somewhat certain
- ❍4 Very certain

QchsB3

Considering the **enhanced program option** outlined previously, what percentage of South Saskatchewan residents do you believe would vote in favour of this in a **real referendum**?

Click on the next arrow at the bottom right corner of the page to continue. _____%

Choice 3 Displays

QchsC2

How certain are you that this is the choice you would make if this was a real referendum?

- ❍1 Very uncertain
- ❍2 Somewhat uncertain
- ❍3 Somewhat certain
- ❍4 Very certain

QchsC3

Considering the **enhanced program option** outlined previously, what percentage of South Saskatchewan residents do you believe would vote in favour of this in a **real referendum**?

Click on the next arrow at the bottom right corner of the page to continue. _____%

Choice 4 Displays

QchsD2

How certain are you that this is the choice you would make if this was a real referendum?

- ❍1 Very uncertain
- ❍2 Somewhat uncertain
- ❍3 Somewhat certain
- ❍4 Very certain

QchsD3

Considering the **enhanced program option** outlined previously, what percentage of South Saskatchewan residents do you believe would vote in favour of this in a **real referendum**?

Click on the next arrow at the bottom right corner of the page to continue. _____%

QchsD4

In your opinion, how likely do you think it is that policy makers will consider the results from this survey to make decisions about beneficial management practice adoption in the South Saskatchewan Region?

- ❍1 Very unlikely
- ❍2 Somewhat unlikely
- ❍3 An even chance
- ❍4 Somewhat likely
- ❍5 Very likely
- ❍6 No opinion

C1 *Show If Enhanced_any_choice_custom*

Please indicate which of the factors below contributed to your decision to vote for the enhanced program in some of the scenarios presented.

(Select all that apply then click on the next arrow at the bottom right corner of the page to continue.)

- ☐1 These programs are a good use of public funds
- ☐2 The benefits of watershed protection are worth the increases in taxes

☐3 Watersheds should be protected at any price
☐4 Protecting watersheds are important to me
☐5 Other (specify):

C2 *Show If C1_Multiple_items_selected*

Which factor listed was the **most** important to you?

❍1 These programs are a good use of public funds. *[Show If C1_1_These_programs_]*
❍2 The benefits of watershed protections are worth the increases in taxes. *[Show If C1_2_The_benefits_of]*
❍3 Watersheds should be protected at any price. *[Show If C1_3_Watersheds_shou]*
❍4 Protecting watersheds are important to me. *[Show If C1_4_Protecting_wate]*
❍5 <<Specify from C1)>> *[Show If C1_5_<<C1.specify(5)]*

C3 *Show If Enhanced_any_choice_custom*

Do you understand that your tax payment would increase for the foreseeable future if any of these programs were put in place?

❍1 Yes
❍2 No
❍3 Not sure

C4 *Show If Current_any_choice_custom*

Please indicate which of the factors below contributed to your decision to vote for the current program in some of the scenarios above.
(Select all that apply then click on the next arrow at the bottom right corner of the page to continue.)

☐1 The cost of the enhanced program was too high
☐2 I do not believe that the enhanced program would work
☐3 I do not feel it is my responsibility to pay to protect watersheds within this region
☐4 I do not believe that the impacts would be as specified
☐5 Protecting watersheds are not a priority for me
☐6 I do not want to pay additional taxes
☐7 I do not trust the government to run the enhanced program effectively
☐8 I need more information before I can decide
☐9 I cannot afford to pay the specified amount associated with the enhanced program
☐10 Other (specify):

C5 *Show If C4_Multiple_items_selected*

Which factor listed was the **most** important to you?

❍1 The cost of the enhanced program was too high *[Show If C4_1_The_cost_of_the]*
❍2 I do not believe that the enhanced program would work *[Show If*

C4_2_I_do_not_believ]

❍3 I do not feel it is my responsibility to pay to protect watersheds within this region. *[Show If C4_3_I_do_not_feel_i]*

❍4 I do not believe that the impacts would be as specified. *[Show If C4_4_I_do_not_believ]*

❍5 Protecting watersheds are not a priority for me. *[Show If C4_5_Protecting_wate]*

❍6 I do not want to pay additional taxes. *[Show If C4_6_I_do_not_want_t]*

❍7 I do not trust the government to run the enhanced program effectively. *[Show If C4_7_I_do_not_trust_]*

❍8 I need more information before I can decide. *[Show If C4_8_I_need_more_inf]*

❍9 I cannot afford to pay the specified amount associated with the enhanced program. *[Show If C4_9_I_cannot_afford]*

❍10 <<Specify from C4)>> *[Show If C4_10_<<C4.specify(10]*

Demographic Question

Finally, we would like to ask you a few questions about you and your household. Responses to these questions will be used only for statistical purposes and to compare respondents to this survey with the Canadian population as a whole. Your answers will not be saved or stored in a way that can be associated with you.

Click on the next arrow at the bottom right corner of the page to continue.

D1

Do you belong to any of the following organizations?

(Select all that apply then click on the next arrow at the bottom right corner of the page to continue.)

☐1 Environmental or conservation organization
☐2 Fishing or hunting club
☐3 Natural history or bird-watching club
☐4 Outdoor recreation club
☐5 None of the above

D2

Are you male or female?

❍1 Male
❍2 Female
❍3 Prefer not to answer

D3

What is your age?

Click on the next arrow at the bottom right corner of the page to continue.

_____years old

☐-8 Prefer not to answer

D4

Including yourself, how many members of your household are in the following age groups? Please specify the number of people in each age group, and click on the next arrow at the bottom right corner of the page to continue.

Under 5 years old	_____
5 to 19 years old	_____
20 to 64 years old	_____
65 years old or older	_____

D5

What is the highest level of education you have completed?

❍1 Grade school or some high school
❍2 High School diploma
❍3 Post-secondary technical school
❍4 Some college or university
❍5 College degree or diploma
❍6 University undergraduate degree
❍7 University graduate degree (Masters or PhD)
❍8 Prefer not to answer

D6

What was your total pre-tax household income, including all earners in your household, in 2016?

❍1 Less than $20,000
❍2 $20,000 to $39,999
❍3 $40,000 to $59,999
❍4 $60,000 to $79,999
❍5 $80,000 to $99,999
❍6 $100,000 to $119,999
❍7 $120,000 to $139,999
❍8 $140,000 to $159,999
❍9 Greater than $160,000
❍10 Prefer not to answer

D7a

Which of the following categories best describes your employment status?

❍1 Employed full time
❍2 Employed part time

❍3 Retired
❍4 Student
❍5 Full-time homemaker
❍6 Unemployed
❍7 Other (specify):
❍8 Prefer not to answer

D7c *Show If Your_employment_status_is_other*

How would you describe your employment status?

Click on the next arrow at the bottom right corner of the page to continue.

_____
_____
_____
_____
_____

☐-8 Prefer not to answer

D8

What is your postal code?

Your postal code is required to group responses by region in Alberta._____

D9

Would you be willing to be contacted in the future concerning further research conducted by Advanis?

❍1 Yes
❍2 No
❍3 Prefer not to say

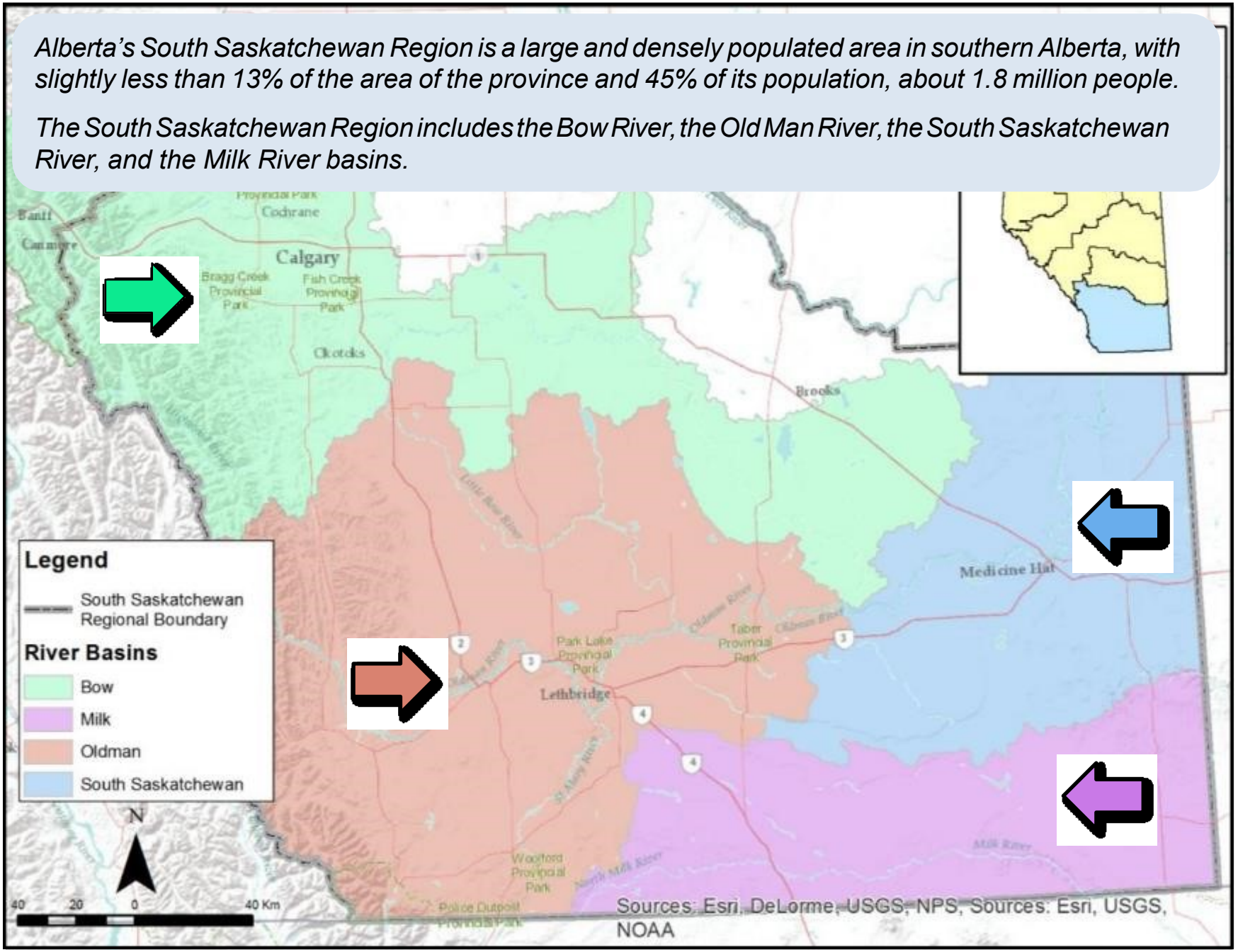
End

Those are all the questions we have for you today. Thank you very much for your cooperation. You will be contacted by January 12, 2018 if you are a draw winner. If you wish to be excluded from the draw, please email Sue Day, Project Manager at InnotechAB@advanis.net

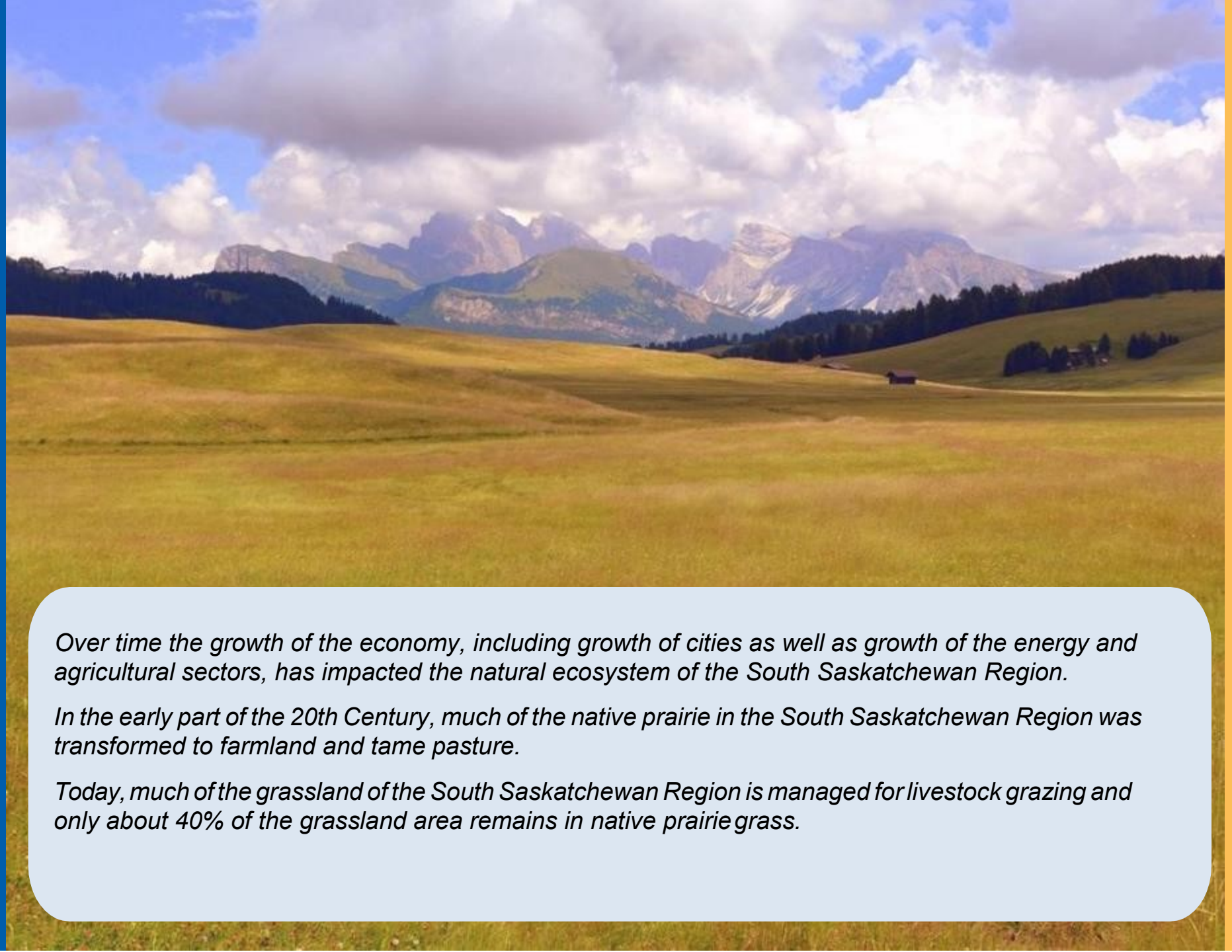
Appendix E Survey Video 1: Introduction

Alberta's South Saskatchewan Region is a large and densely populated area in southern Alberta, with slightly less than 13% of the area of the province and 45% of its population, about 1.8 million people.

The South Saskatchewan Region includes the Bow River, the Old Man River, the South Saskatchewan River, and the Milk River basins.



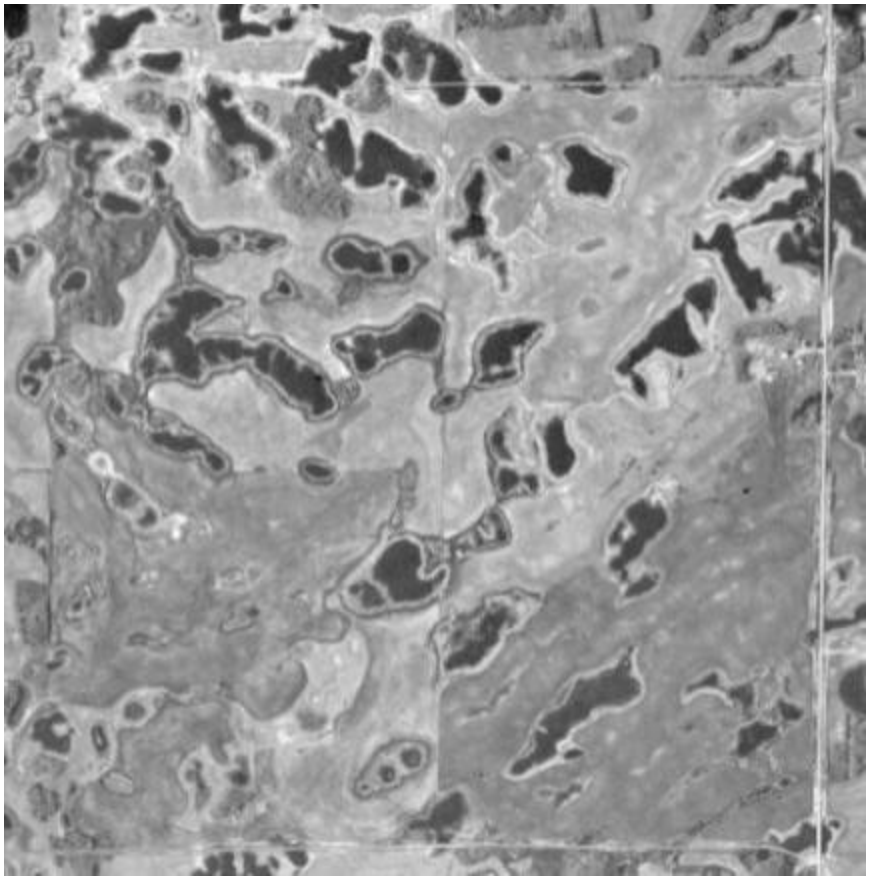
The economy of Alberta's South Saskatchewan Region is diverse – nearly $28 billion of revenue is generated by the energy industry, followed by, $6 billion from foods and beverages, $4.5 billion from agriculture, and $2.4 billion from tourism.

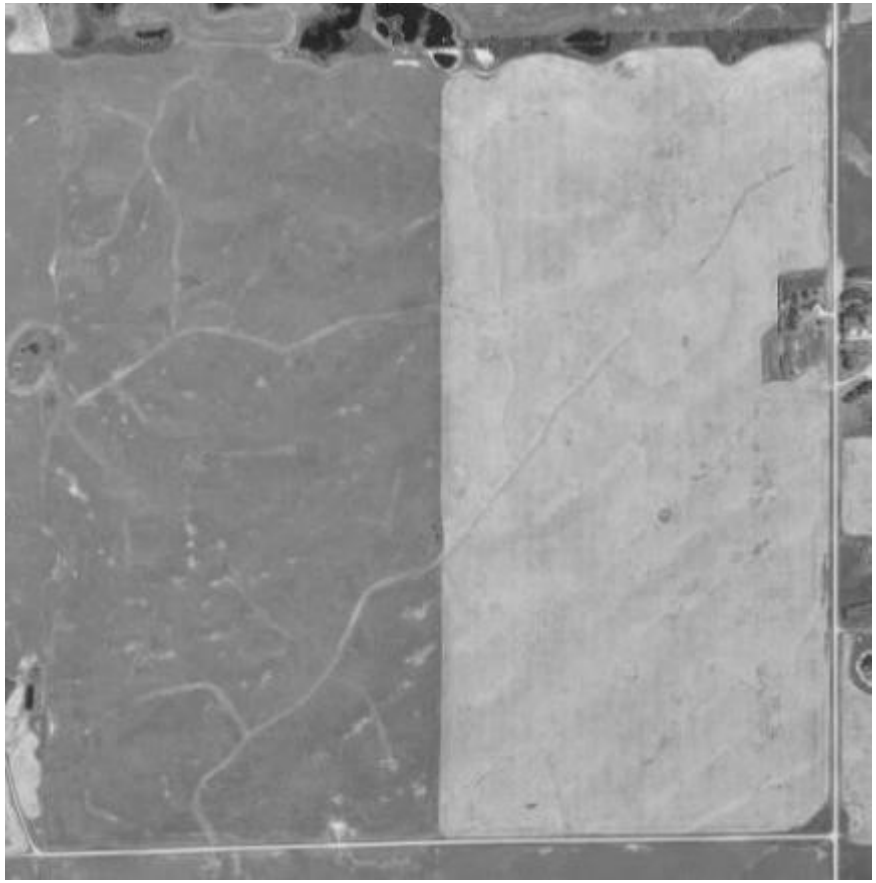


Over time the growth of the economy, including growth of cities as well as growth of the energy and agricultural sectors, has impacted the natural ecosystem of the South Saskatchewan Region.

In the early part of the 20th Century, much of the native prairie in the South Saskatchewan Region was transformed to farmland and tame pasture.

Today, much of the grassland of the South Saskatchewan Region is managed for livestock grazing and only about 40% of the grassland area remains in native prairie grass.

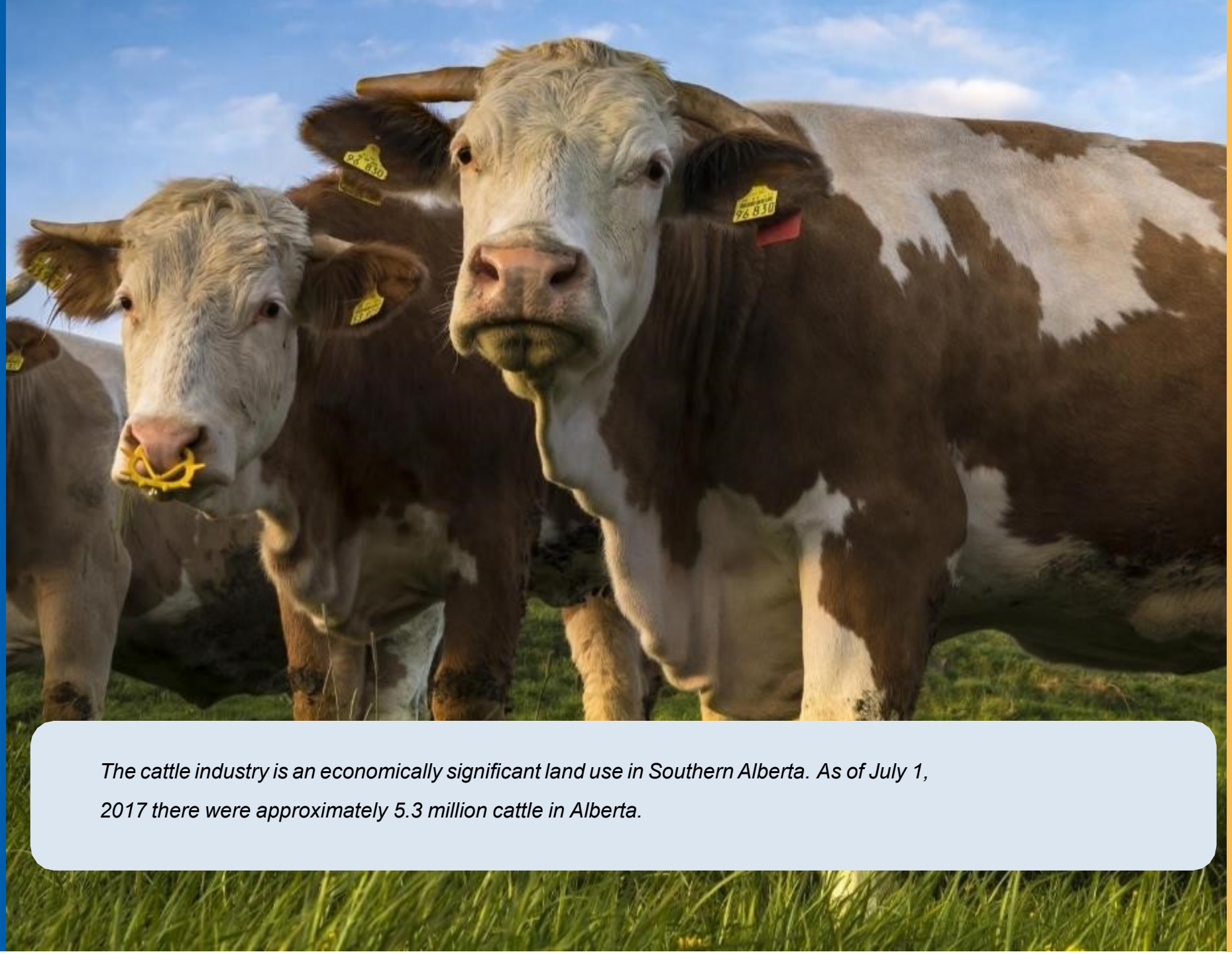




1948 **1995**

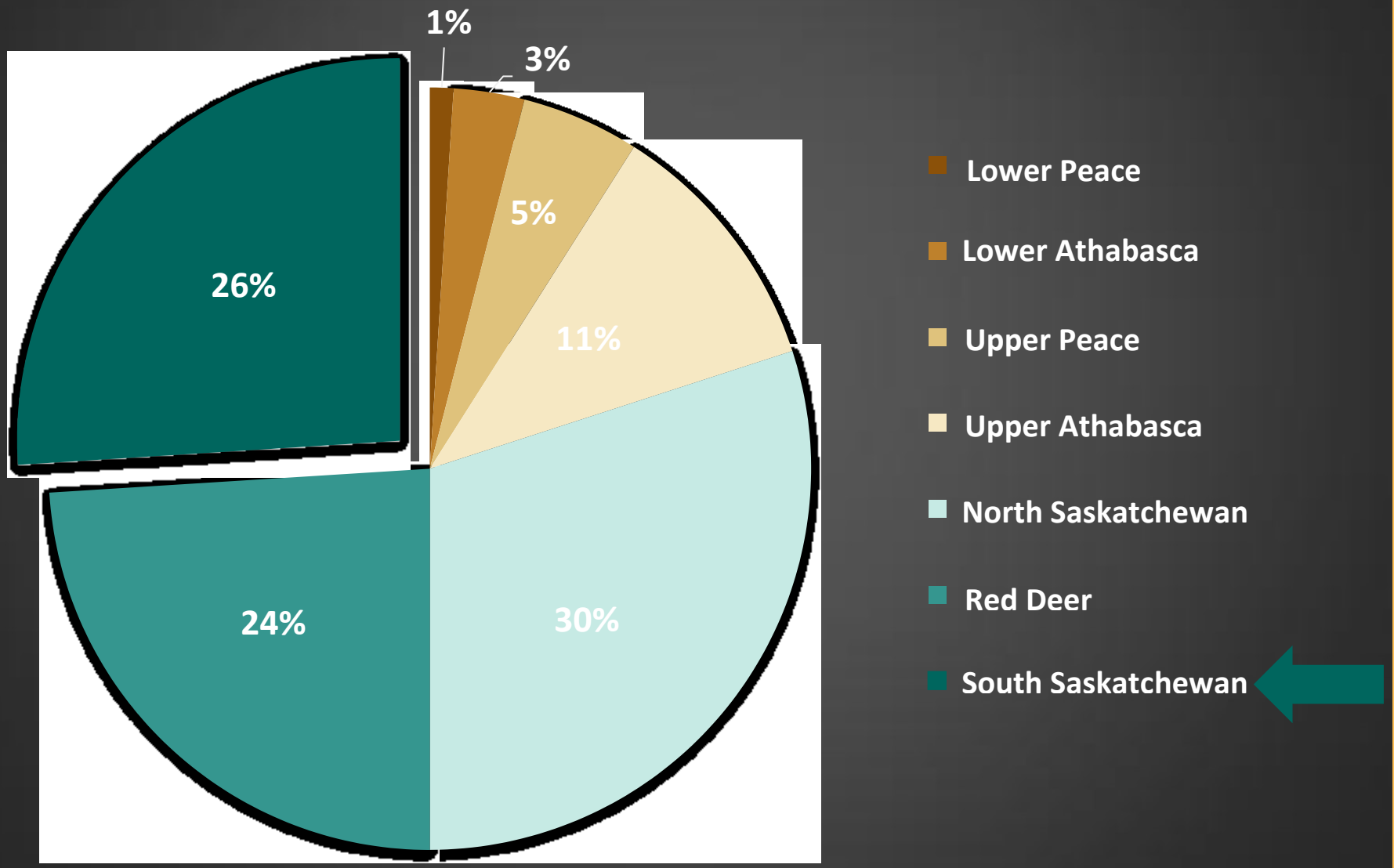
Economic development has also impacted wetlands. Over one million hectares of prairie-parkland wetlands have been drained and converted for municipal and industrial development and agricultural uses.

This represents a loss of about 60% to 70% of original wetland area. Wetland loss has been shown to reduce wildlife habitat as well as water quality, flood protection, and drought mitigation.



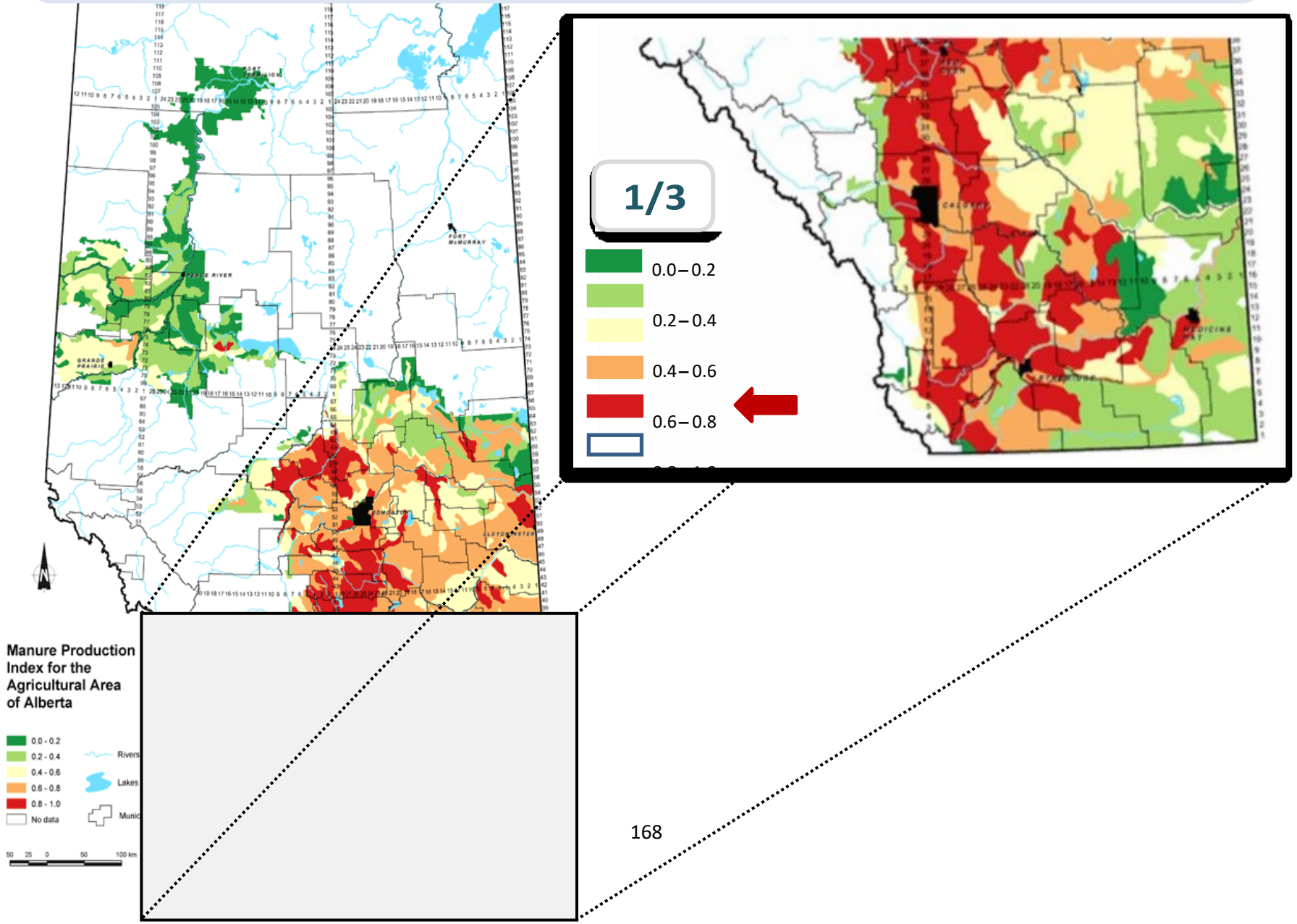
The cattle industry is an economically significant land use in Southern Alberta. As of July 1, 2017 there were approximately 5.3 million cattle in Alberta.

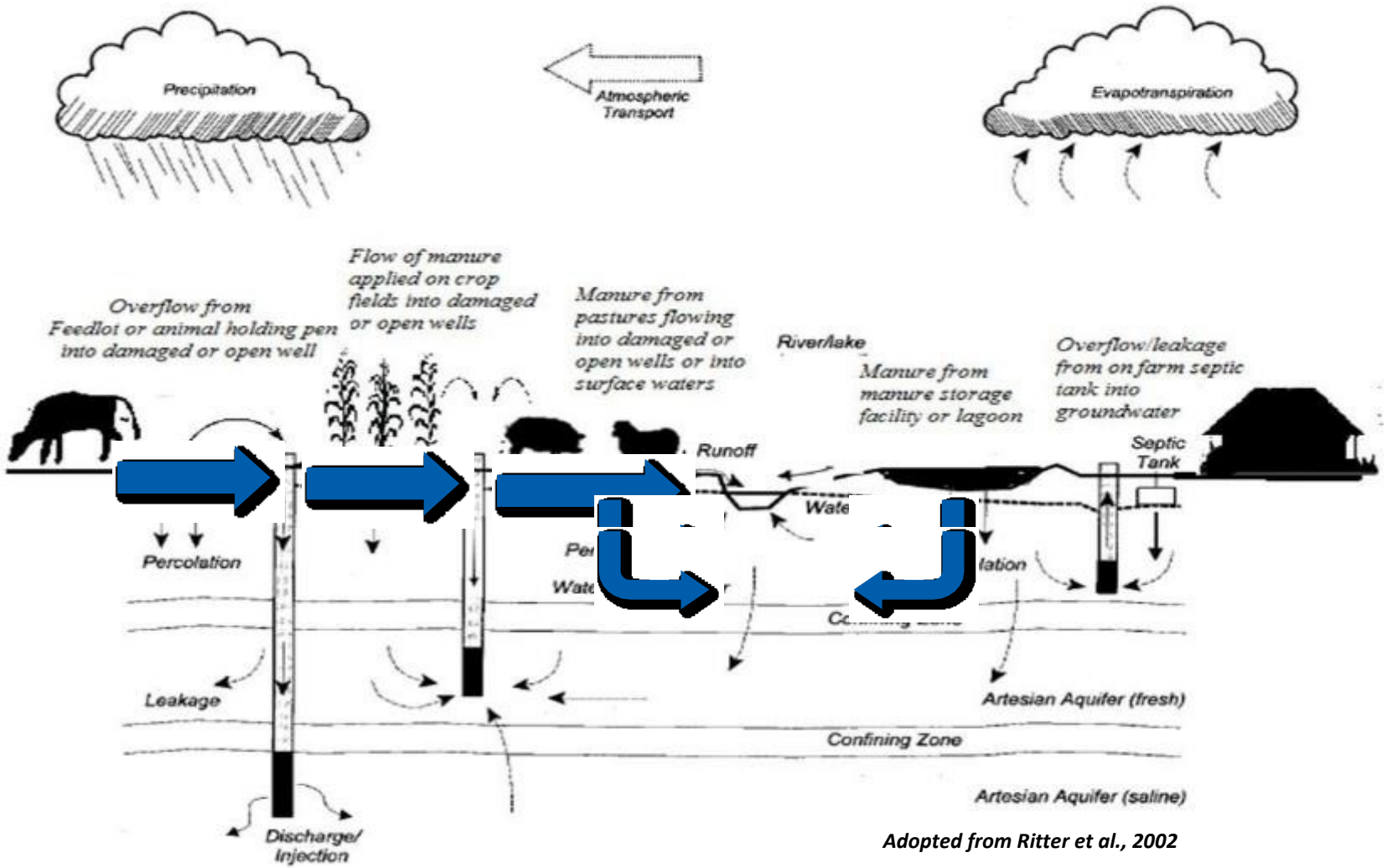
About one quarter of Alberta's cattle farms and approximately 37% of Alberta's total cattle herd is located in the South Saskatchewan Region



Beef production practices that affect wildlife habitat and water quality include (1) stocking rates and the number of cattle in pasture, (2) the amount of tame compared to native pasture; and (3) the location of feeding and watering sites for cattle. Beef producers also protect water and riparian areas from the chemicals and pathogens found in manure through vegetative buffers and fencing.

This map shows the concentration of Alberta's manure production, with red indicating areas of high concentration. About 1/3rd of the total agricultural area contributes high levels of manure production.

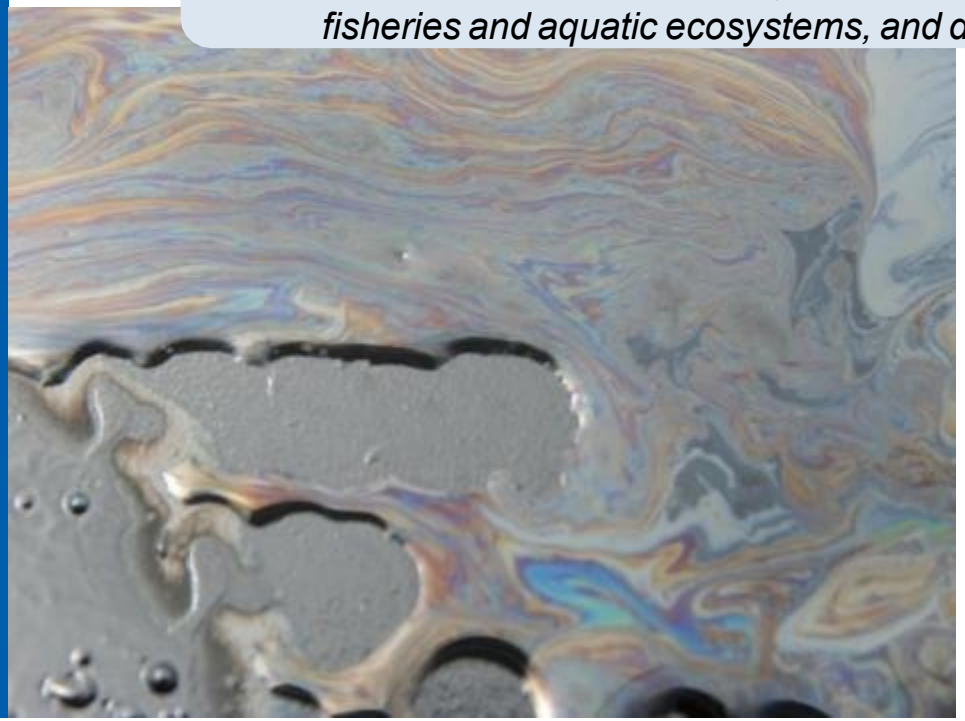




Adopted from Ritter et al., 2002

While Alberta regulates the storage and handling of manure, excessive application of manure on fields for fertilizer can lead to high levels of phosphorus and nitrogen in surface water caused by precipitation and runoff, as well as seepage into ground water. There is also potential for contamination from pathogens such as E. Coli and other bacteria.

High concentrations of phosphorous can increase algal growth, which can lead to increased wastewater treatment costs, increased drinking water treatment costs, increased risks to fisheries and aquatic ecosystems, and decreased aesthetic and recreational benefits.



Appendix F Survey Video 2: BMP

Many beef producers voluntarily undertake Beneficial Management Practices (or BMPs) to reduce environmental impacts. These are agricultural management changes that have been developed by scientists to reduce potential water pollution issues as well as protect fish and wildlife habitats. The following are a few examples of BMPs.

These practices provide public benefits by reducing sediment, nitrogen and phosphorus in nearby rivers and lakes, and maintaining habitat for fish and wildlife. However most are costly to implement.

Management of manure and fertilizers involves a variety of practices that alter the placement, amount, and timing of application to reduce nitrogen and phosphorus in runoff.

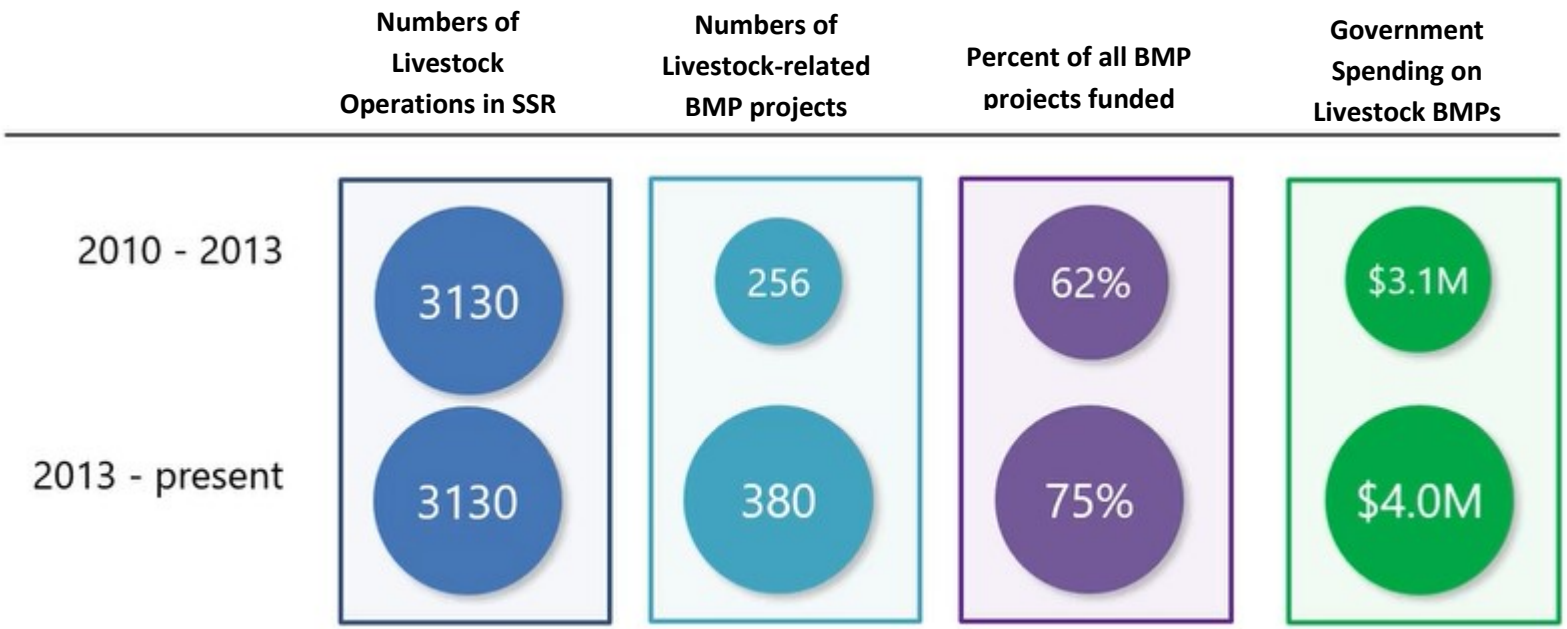
Surface water quality management refers to practices that reduce impacts of livestock production on water quality in lakes, rivers and streams. Surface water quality management involves the use of grassed waterways, treed areas, & hayland to dilute and slow runoff, and absorb nitrogen and phosphorus in soils.

Wintering site management is the use of in-field grazing and feeding strategies that reduce the buildup of manure in fields and confined feeding areas over the winter months.

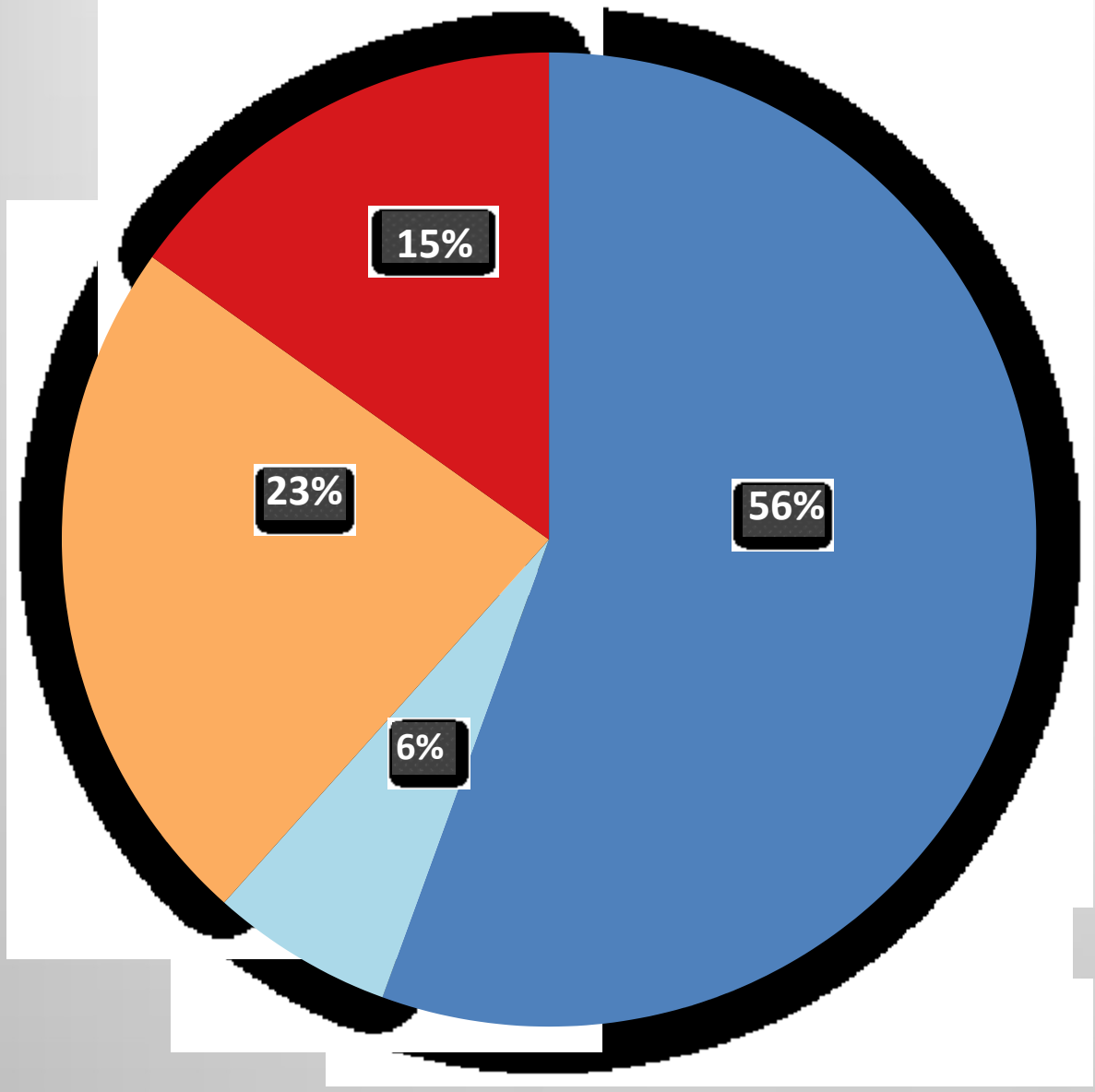
Pasture management is the care and use of pasture to feed cattle without endangering forage plants, soil and water resources, and fish and wildlife habitat conditions.

While many producers voluntarily undertake BMPs to manage the impacts of their operations on the environment there are a number of government and non-government programs which provide information and funding to encourage additional BMP adoption.

The largest programs in Canada, called Growing Forward Stewardship Programs, are jointly funded by federal and provincial governments to provide financial support to producers who adopt BMPs. From 2010 to present Alberta's Growing Forward Program spent 7 million dollars to support adoption of 636 livestock BMPs.



However, Growing Forward Programs only provide a share of the cost of BMP adoption, typically ranging from 30-70% of the cost of the practice change. The pie chart shows that "economic pressures" are the main reason farmers do note adopt BMPs.

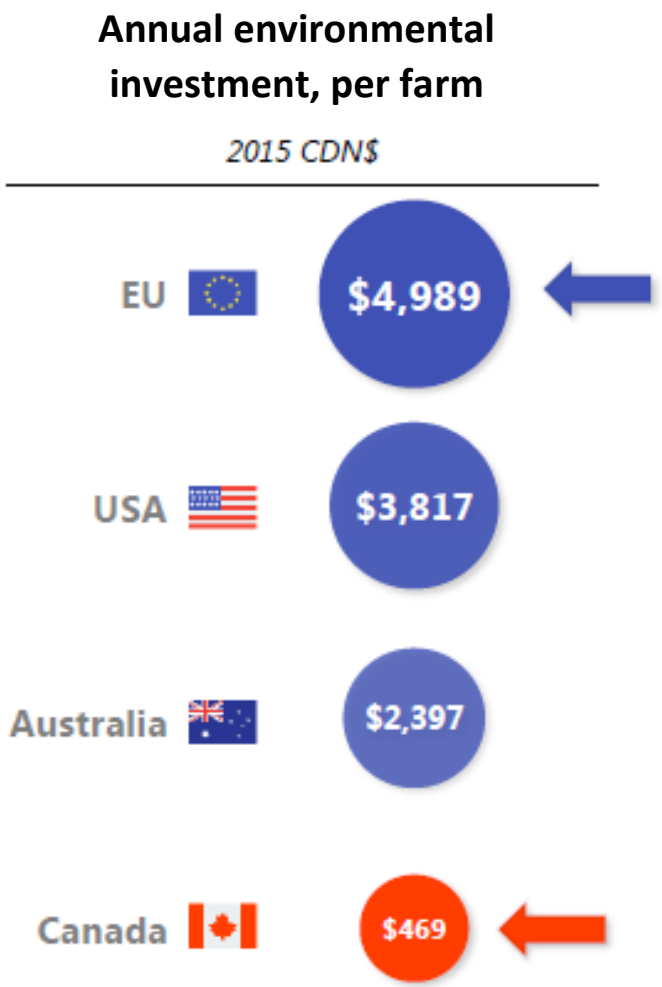


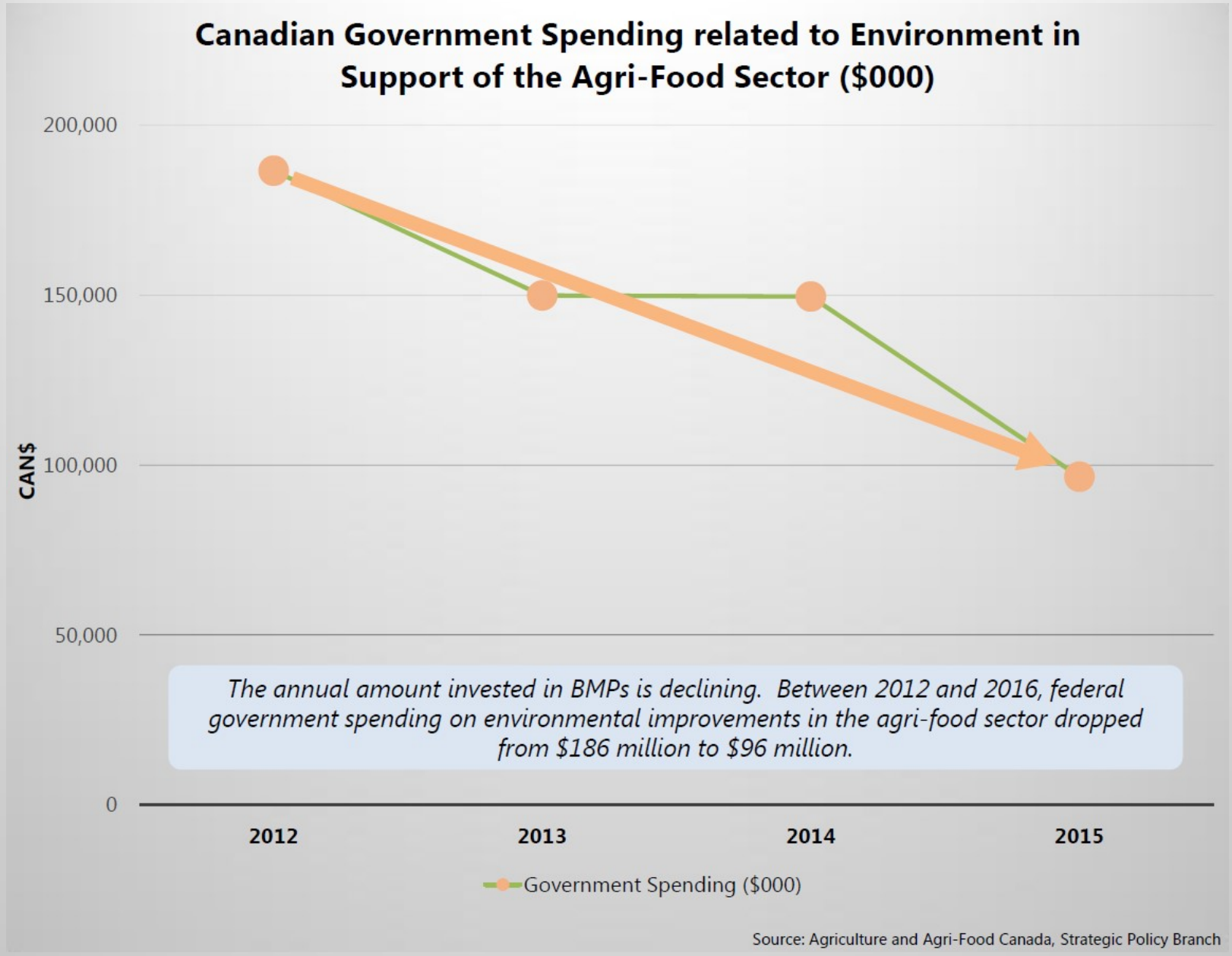
Note: Percentages may not add up to 100 due to rounding.
Source: Statistic Canada, 2013. Environment Accounts and Statistic Division. 2011 Farm Environmental Management Survey (Survey number 5044)

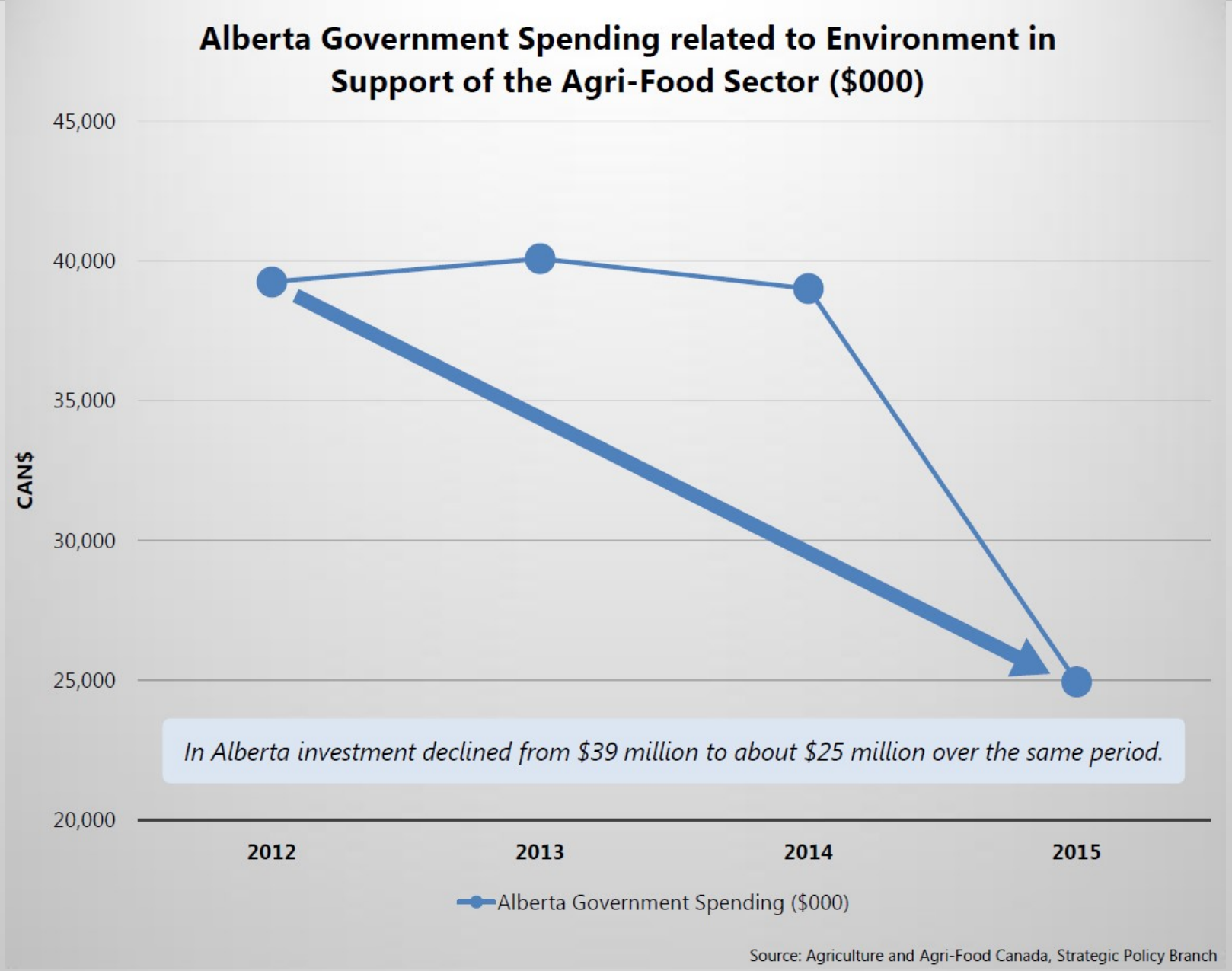
Since BMPs often increase costs to producers, the number and type of BMPs adopted depend on government financial support.

A comparison of the annual environmental investment per farm between countries shows that, in 2015, Canada invested about $469 per farm.

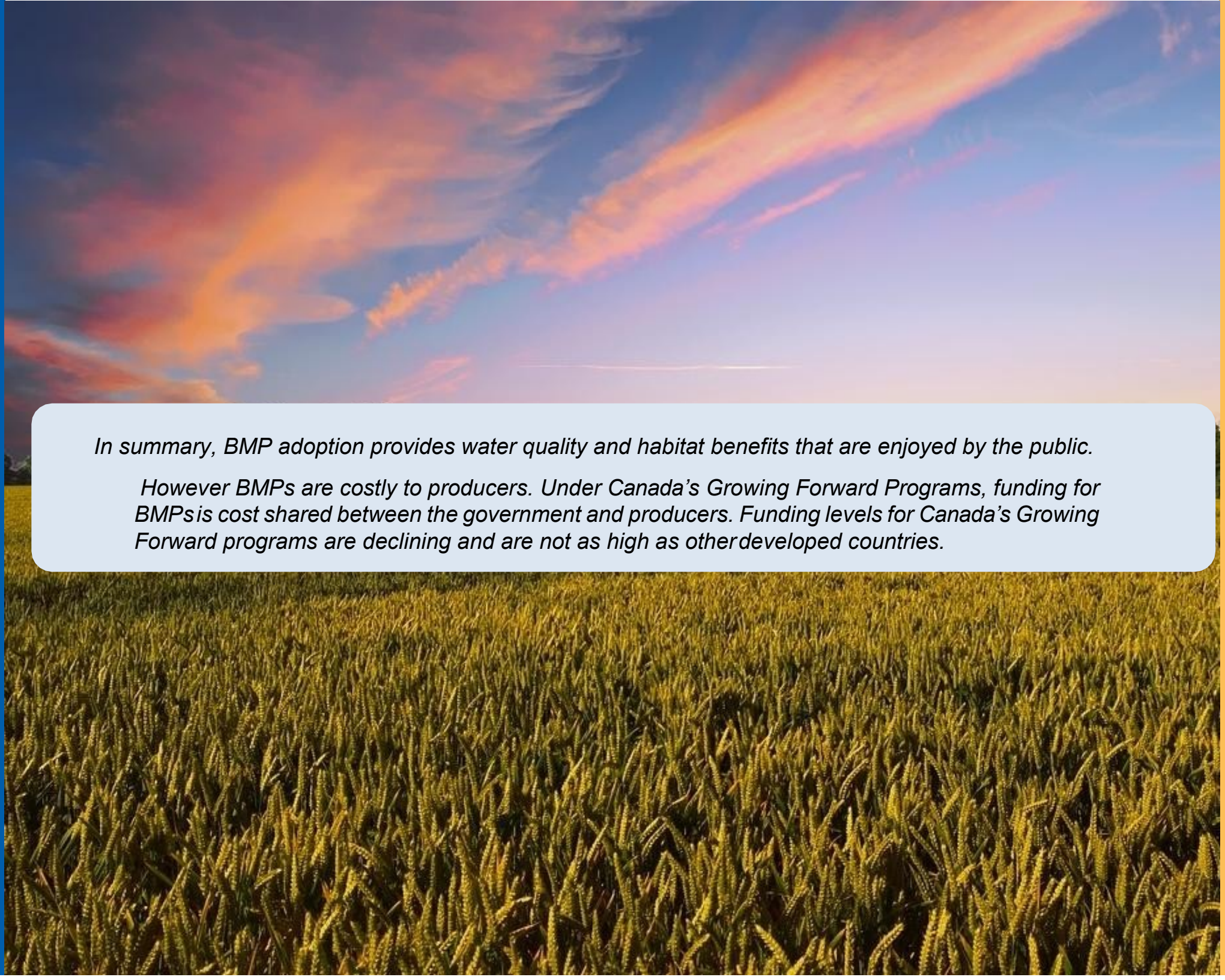
In contrast, the European Union invested nearly $5,000 per farm, over 10x more than Canada.




Canadian Government Spending related to Environment in Support of the Agri-Food Sector ($000)
200,000
150,000
100,000
50,000
0
CAN$
2012
2013
2014
2015
Government Spending ($000)
The annual amount invested in BMPs is declining. Between 2012 and 2016, federal government spending on environmental improvements in the agri-food sector dropped from $186 million to $96 million.
Source: Agriculture and Agri-Food Canada, Strategic Policy Branch


Alberta Government Spending related to Environment in Support of the Agri-Food Sector ($000)
45,000
40,000
35,000
30,000
25,000
20,000
CAN$
In Alberta investment declined from $39 million to about $25 million over the same period.
2012
2013
2014
2015
Alberta Government Spending ($000)
Source: Agriculture and Agri-Food Canada, Strategic Policy Branch

To provide more financial incentives for Alberta Livestock producers to adopt agricultural Beneficial Management Practices, increased government funding is necessary. This could be funded through provincial or federal tax increases.



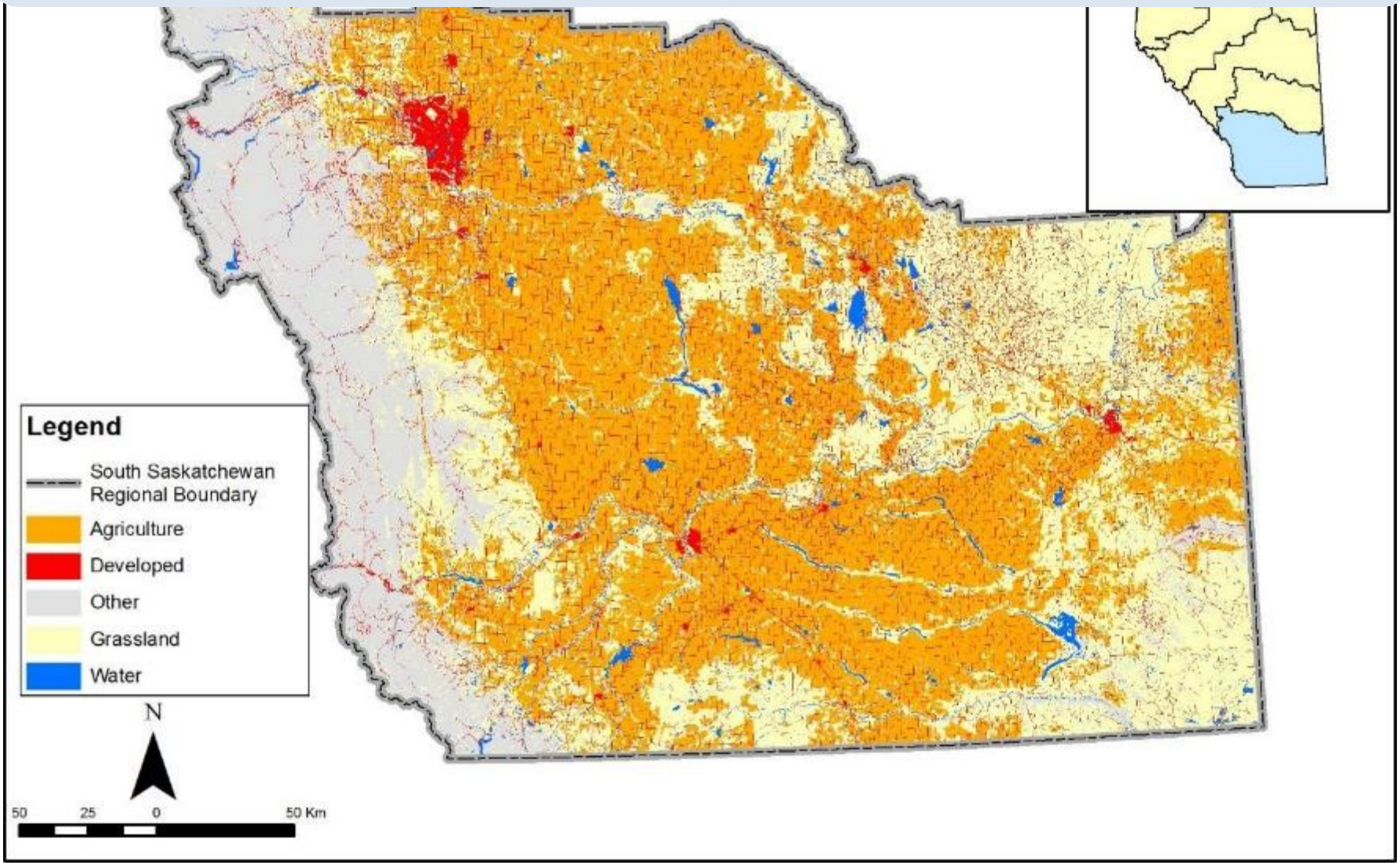
In summary, BMP adoption provides water quality and habitat benefits that are enjoyed by the public.

However BMPs are costly to producers. Under Canada's Growing Forward Programs, funding for BMPs is cost shared between the government and producers. Funding levels for Canada's Growing Forward programs are declining and are not as high as other developed countries.

Appendix G Survey Video 3: Wildlife Habitat

Native prairie grasslands originally covered about 9 million hectares in Alberta. Much of that native grassland has been converted to cropland, tame pasture, and other uses. Today about 42 percent of the area of the South Saskatchewan Region is used for crops, shown as orange on the map. 31 percent is considered grassland, shown as yellow on the map, and is used primarily for livestock grazing.

Only about 40 per cent of the grassland area is in native grasses the rest is in tame pasture. Some prairie grasslands such as native fescue are particularly endangered, with only about 16 per cent remaining.



3.7M acres
Wetland & Woodland

9.0M acres
Cropland

6.8M acres
Grassland
(Managed)

0.0M acres
Grassland
(Unmanaged)

1.0M acres
All other uses

The two largest agricultural land uses in South Saskatchewan Regions are cropland and grassland, where managed grassland are natural grasses and tame pasture used for cattle grazing, and unmanaged grassland, on the other hand, are natural grass and shrubs with no apparent use.

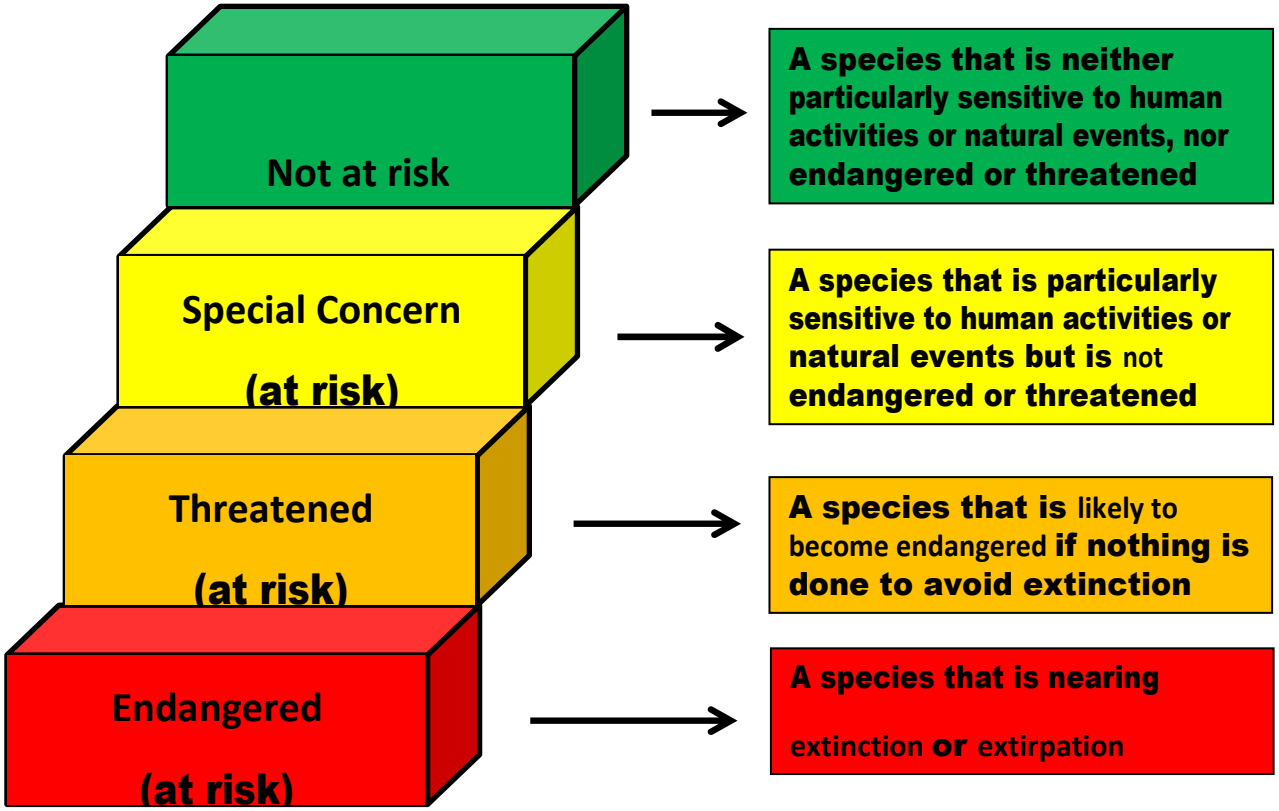
Currently, there are about 6.8 million acres of grassland managed for livestock grazing, which includes native grasses and tame pasture. On the other hand, there are 9 million acres of cropland.

In addition to grassland loss, over a million hectares of prairie-parkland wetlands have also been lost due to municipal and industrial development, agricultural drainage, and climate change.

Wetlands represent the transition between upland and freshwater ecosystems and are disproportionately important for biodiversity.

The loss of both wetland and grassland habitats have increased risks for some species however the precise relationship between habitat and species risk is unknown.

A number of factors contribute to species at risk, including habitat loss and degradation, overharvesting, persecution, isolation, and disease. In Canada, a species in danger of extirpation (or removal) from an area is referred to as "at risk". Based on the level of extirpation and extinction risk, species are assigned to the following categories:



A species is extirpated when it is no longer found in the wild in Canada but is found in the wild elsewhere in the world.

A species is considered to be "recovering" if its risk of extinction or extirpation decreases. As a species recovers, it moves from a higher risk category such as threatened or endangered to a lower risk category such as special concern, or not at risk.

In the South Saskatchewan Region there are several species at risk. For example, the Swift Fox and the Burrowing Owl are endangered, Sprague's Pipit is threatened, and the Northern Leopard Frog is of special concern.

Overall, of the species that inhabit the South Saskatchewan Region, ten species are endangered, ten species are threatened, and thirteen are of special concern.

Endangered

Burrowing Owl

Swift Fox

Threatened

Sprague's Pipit

Special Concern

Northern Leopard Frog

Burrowing Owl

Short Horned Lizard

Greater Sage Grouse

Tiny Cryptantha

Western Spiderwort

Endangered

Ord's Kangaroo Rat

Piping Plover

Mountain Plover

Swift Fox

Trumpeter Swan

Eastslope Sculpin

Sprague's Pipit

Threatened

Ferruginous Hawk

Small-flowered Sand-verbena

Loggerhead Shrike

Lake Sturgeon

Stonecat

Western Silvery Minnow

Harlequin Duck

Northern Leopard Frog

Western Small-Footed Bat

Weideneyers' Admiral

Special Concern

Bull Trout

Western Grebe

Grizzly Bear

Long-toed Salamander

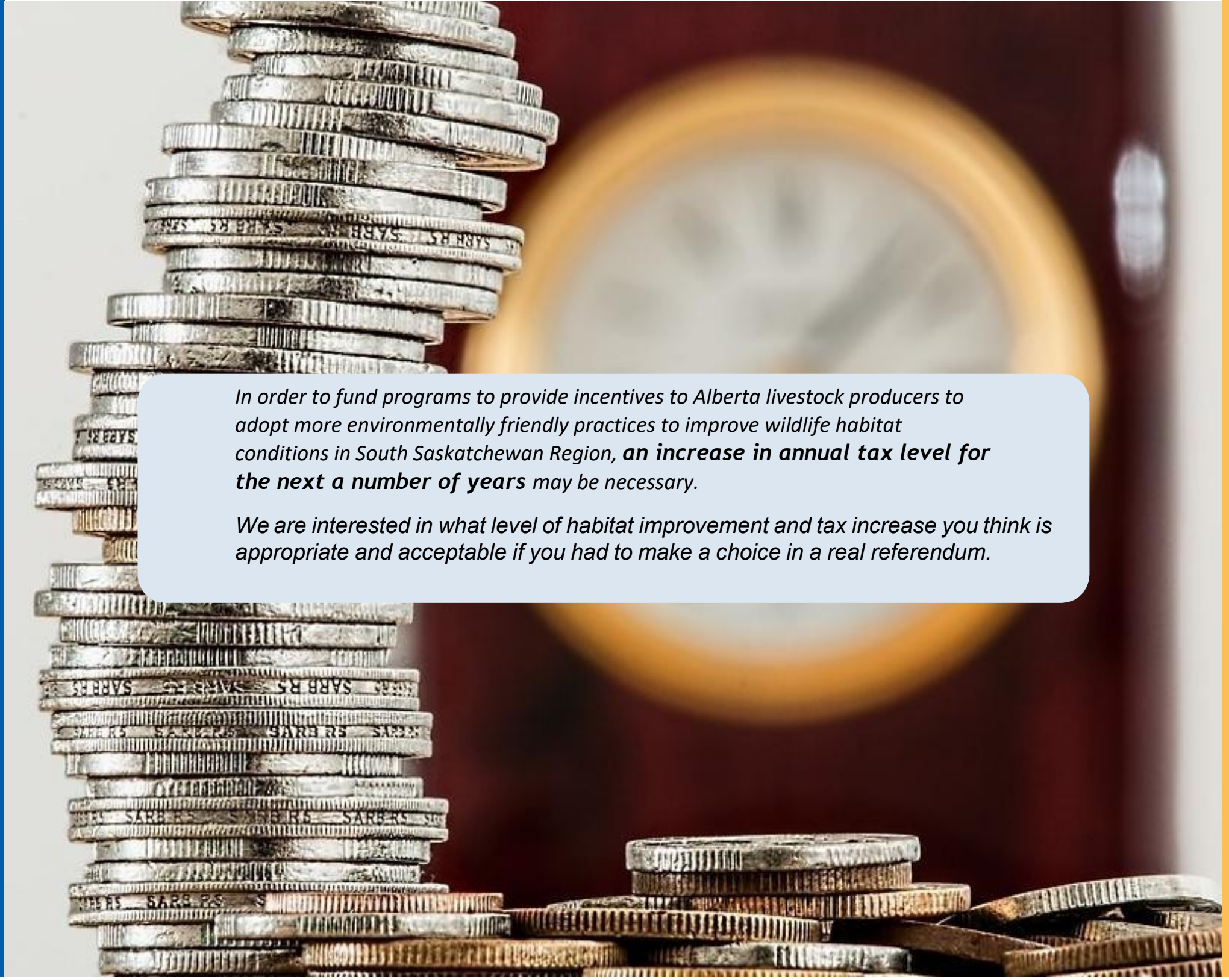
Long billed Curlew

Barred Owl

Western Blue Flag

Prairie Falcon

Peregrine Falcon



In order to fund programs to provide incentives to Alberta livestock producers to adopt more environmentally friendly practices to improve wildlife habitat conditions in South Saskatchewan Region, ***an increase in annual tax level for the next a number of years*** *may be necessary.*

We are interested in what level of habitat improvement and tax increase you think is appropriate and acceptable if you had to make a choice in a real referendum.

Appendix H Survey video 4: Water Quality

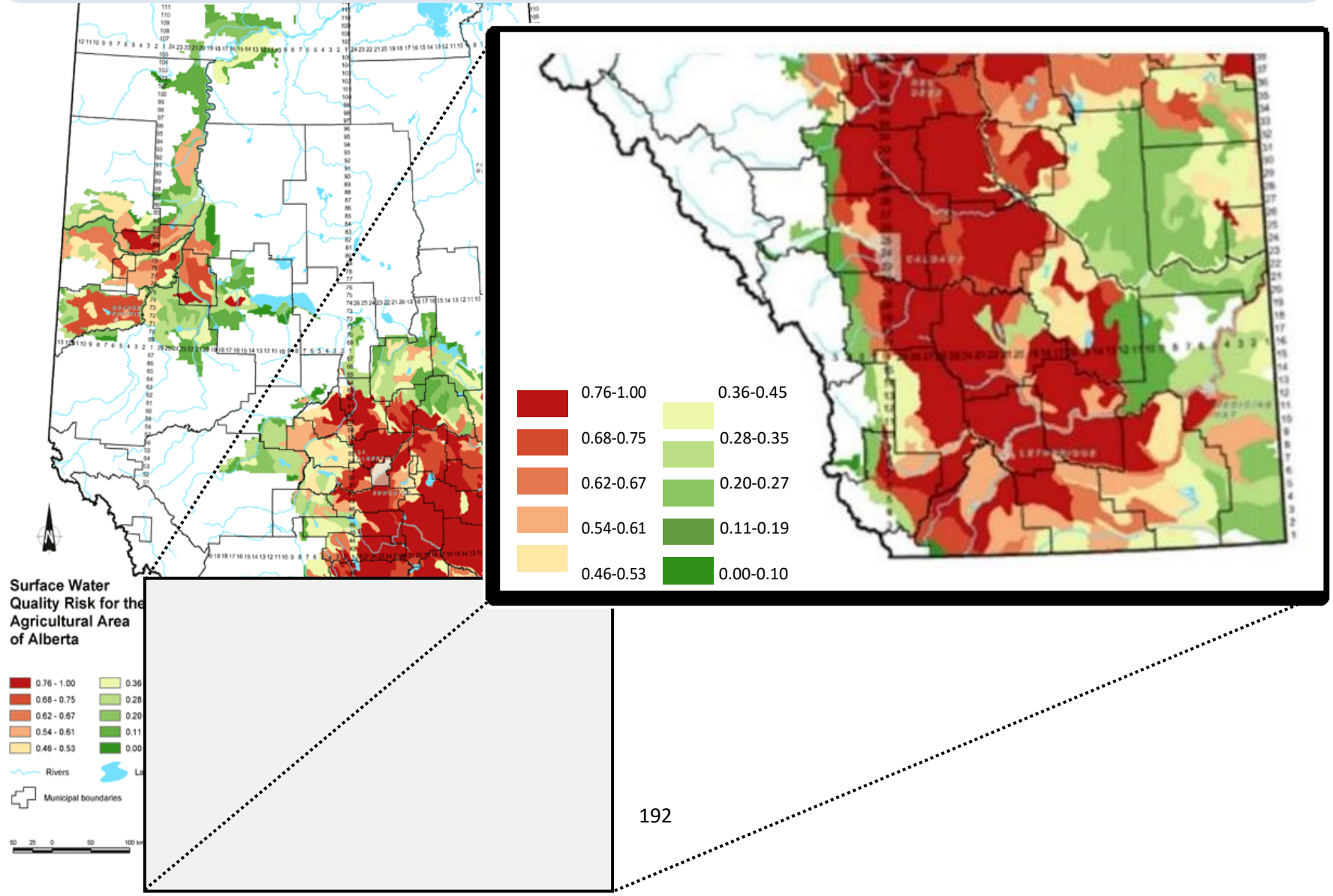

Kenneth Allen

Water quality is a continued risk for the South Saskatchewan River, and affects agricultural, drinking water, and recreational uses.

Risks include nutrients and pathogens contributed from agricultural runoff as well as nutrients and contaminants such as fecal coliforms and elevated concentrations of mercury, salt and sulfides contributed from municipal and industrial effluents and urban stormwater runoff.

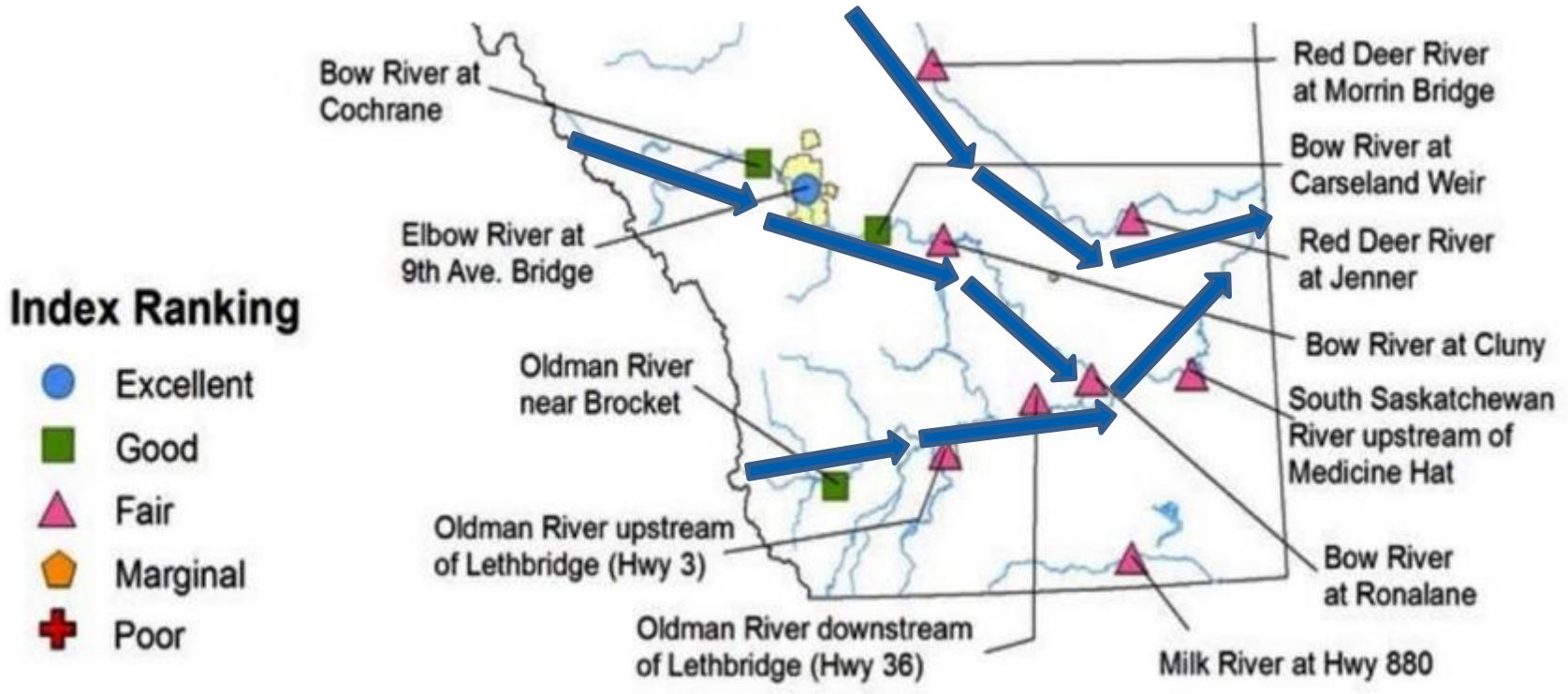

Robert Lawton

In Alberta, the areas facing the highest surface water quality risks are concentrated in the southern half of the province. This corresponds to areas with high levels of sewage and storm water runoff from urban areas like the city of Calgary, and as well as areas with high concentrations of cropland and livestock.



Nutrients such as Phosphorous and Nitrogen contribute to reduced water quality. Nutrient loads come from municipal sewage and runoff, as well as agricultural runoff. In agriculture, nutrients come from the application of mineral and manure fertilizers to crops.

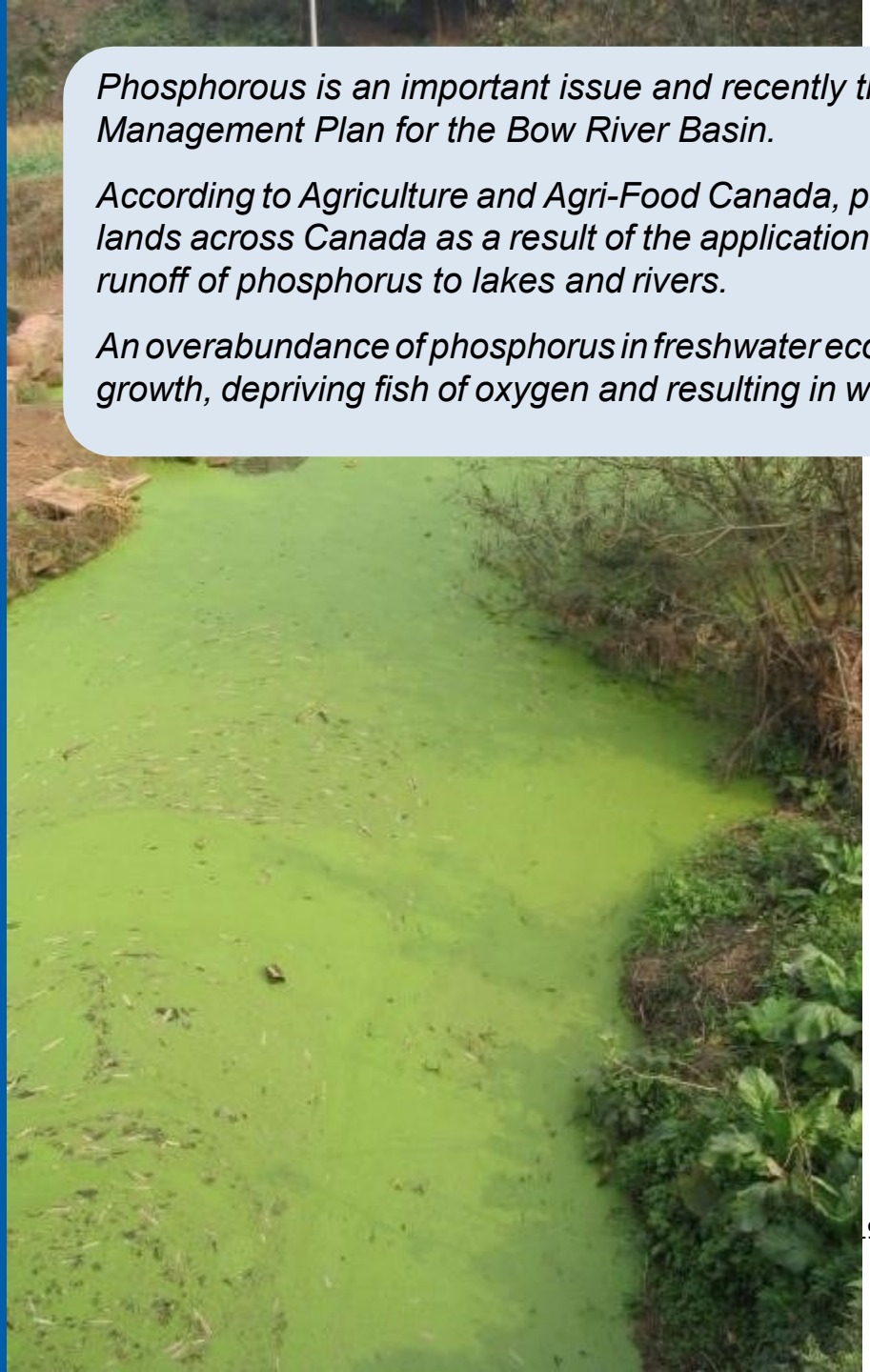
The Alberta river quality nutrient index in the South Saskatchewan River shows that as we move from the headwaters of the Bow river at Cochrane, through the city of Calgary and industrial areas, then through agricultural areas towards the Saskatchewan border, water quality deteriorates.

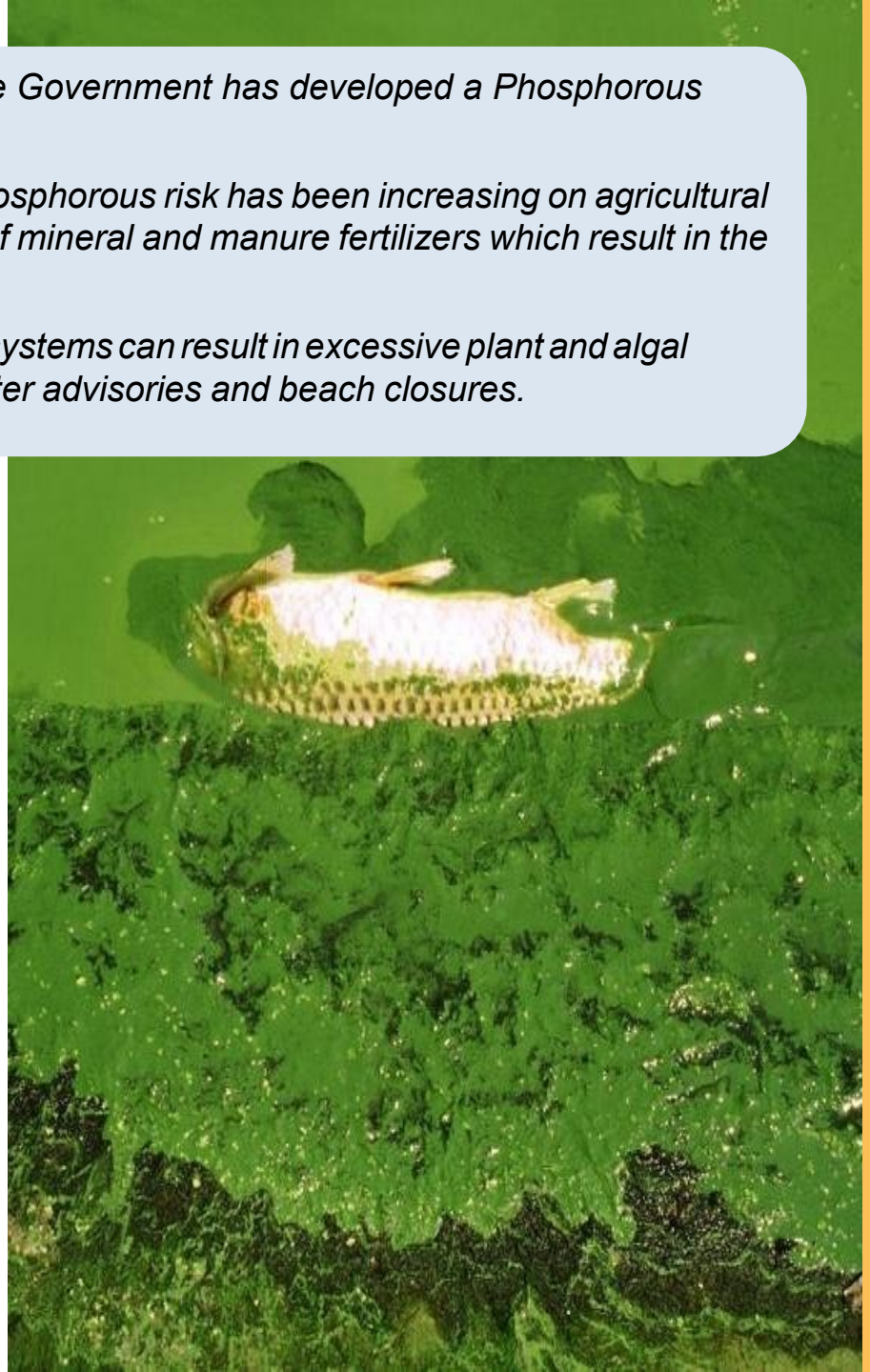


Phosphorous is an important issue and recently the Government has developed a Phosphorous Management Plan for the Bow River Basin.

According to Agriculture and Agri-Food Canada, phosphorous risk has been increasing on agricultural lands across Canada as a result of the application of mineral and manure fertilizers which result in the runoff of phosphorus to lakes and rivers.

An overabundance of phosphorus in freshwater ecosystems can result in excessive plant and algal growth, depriving fish of oxygen and resulting in water advisories and beach closures.





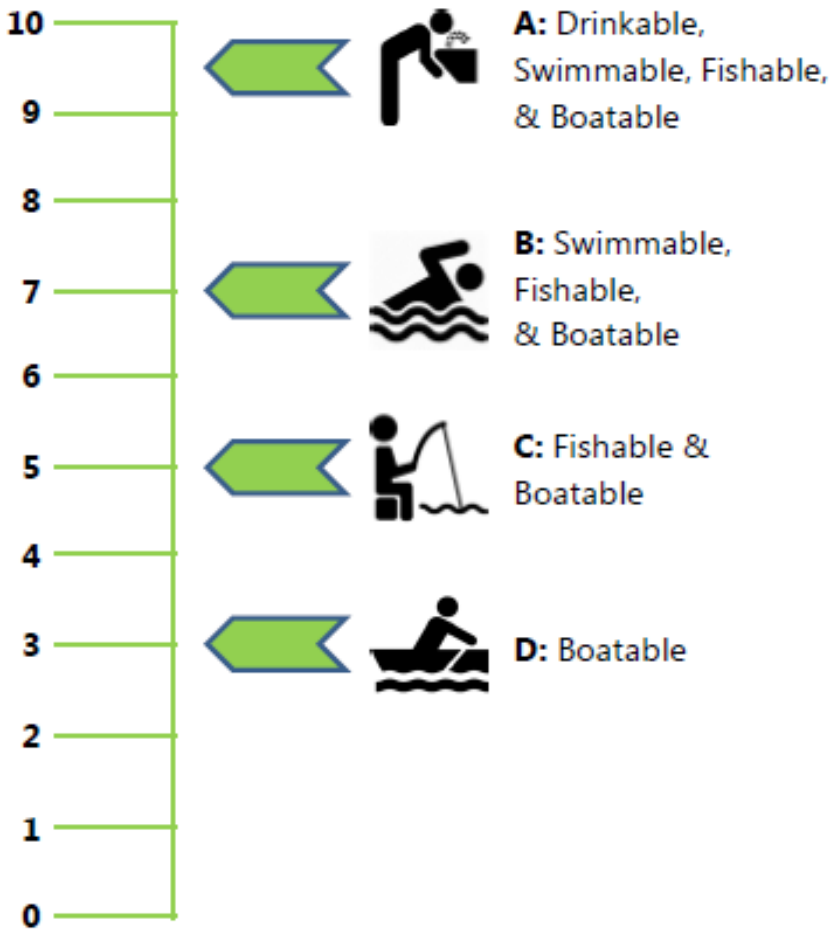
The water quality ladder is a standardized ten-point index that has been used by the many scientists to measure changes in water quality.

At levels greater than 9, water is drinkable, swimmable, fishable, and boatable.

At a value of 7 water is suitable for just swimming, fishing and boating.

At a level of 5 water is suitable for fishing and boating.

Finally, at levels below 3, water is only suitable for boating.



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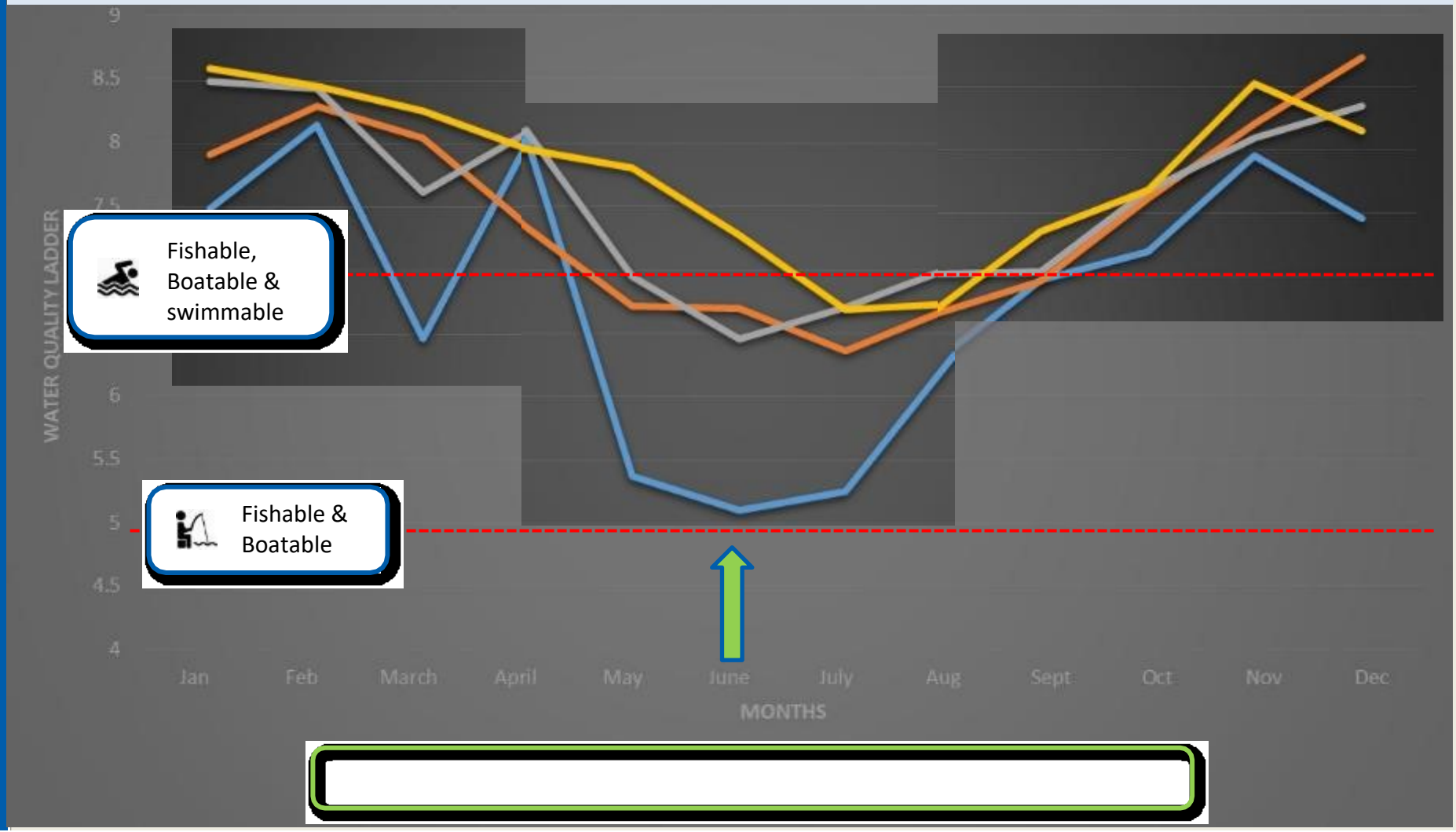
*The water quality ladder values from monitoring stations in the south Saskatchewan subbasins show different levels of water quality throughout the year (2015) for each of the four major rivers: the Milk River in **blue**, the South Saskatchewan in **orange**, the Oldman in **grey**, and the Bow in **yellow**.*

For the Milk River, the water quality ladder value gets as low as five during the summer months, when there are low flows and lots of runoff. At that time of year, it is only fishable and boatable. For the rest, water quality is typically high during winter until spring runoff, at which time nutrients are flushed into the system. Water quality then falls during the summer, and increases again in the fall. For the other river basins besides the Milk River, water quality hovers just below fishable, boatable, and swimmable levels throughout the summer months.



In order to fund programs to provide incentives to Alberta livestock producers to adopt beneficial management practices to improve water quality conditions in South Saskatchewan Region, ***an increase in annual ax level for the next 5 years*** *maybe necessary*

We are interested in what level of water quality improvement and what tax increases you think is appropriate and acceptable if you had to make a choice in a real referendum

Appendix I Non-Parametric Analysis

Non-parametric Analysis

Table 1 and Table 2 demonstrate the percentage of participants who chosen proposed program at different annual household income tax level for water and wildlife survey respectively.

Table 1. Bid Design for water survey

Tax level	total	yes	%yes
50	446	319	72%
150	386	258	67%
300	387	206	53%
500	424	233	55%
750	429	212	49%

Table 2. Bid Design for wildlife survey

Tax Level	total	yes	%yes
50	501	336	67%
150	515	308	60%
300	488	231	47%
500	510	195	38%
750	516	182	35%

For water survey data, there were approximately 72% of the respondent chosen the proposed BMP programs at the lowest tax level, shown in Table 1. As the annual household income tax increased to $150, the percentage of respondent saying YES increased to 67%. The percentage of saying yes further decreased to 53% when the tax increased to $300 annually. The probability of saying yes was lowest, 49%, as the tax level increased to $750.

The bid design for wildlife survey data was shown in Table 2. The highest probability of saying yes to the proposed program occurred at the lowest tax level. It dropped to 60% when the tax level increased to 150. As the annual tax amount rose to $300, $500, and $750, the chances of respondents saying yes decreased to 47%, 38% and 35% respectively.

The non-parametric method used to calculate the expected WTP and welfare measure is the Turnbull Lower Bound Estimator. The Turnbull lower bound estimator, defined by Habb and McConnell (2003), is:

$$f_j^* = F_{j+1}^* - F_j^*$$

Where f_j^* is the Turnbull lower bound estimator, F_j^* is the percentage of respondent saying no to the j[th] tax category and F_{j+1}^* is the percentage of respondent saying no the (j+1) [th] tax category. The expected Turnbull lower bound WTP estimate is calculated as:

$$E_{LB}(WTP) = \sum_{j=0}^{M} t_j(F_{j+1}^* - F_j^*)$$

The Turnbull lower bound estimates for water survey data and wildlife data are shown in Table 3, Table 4 and Table 5. and the tj is the tax amount, Nj is the number of respondent who choose "no" to the proposed program, Tj is the number of people who are asked in that question category, Fj is the percentage of people who answered "no" to the proposed program in that tax level, and f_j^* is the Turnbull lower bound estimator. When the value of Fj is not monotonic, values are pooled and recorded in F*j.

Respondents are willing to pay $406.12 per household per year for 5 years for improvement in water quality, and they are willing to pay $344.85 and $228.61 per household per year for 5 years and 10 years for improvement in wildlife habitat.

Table 3. Non-parametric Method for water survey data

t_i	N_j	Tj	Fj	F*j	f*j
50	127	446	0.285	0.285	0.285
150	128	386	0.332	0.332	0.047
300	181	387	0.468	0.459	0.127
500	191	424	0.450	Pooled	Pooled
750	217	429	0.506	0.506	0.047
750+	-	-	1	1	0.494

Expected WTP Value:

Turnbull Lower-bound Estimates = 0*0.285 + 50*0.047 + 150*0.127 + 300*0.047 + 750*0.494

= $406.12/household/year

Welfare measure = $406.12 * Household Number in SSR = $406.12 * 675310 = $274254490.2

= $274.25 million

Table 4. Non-Parametric Method (5-year program) for wildlife survey data

t_i	N_j	Tj	Fj	f*j
50	67	240	0.279	0.279
150	109	267	0.408	0.129
300	133	253	0.526	0.117
500	166	290	0.572	0.047
750	136	217	0.627	0.054
750+	-	-	1	0.373

Expected WTP Value for a 5-year NAR improvement program

- Turnbull Lower-bound Estimate = 0*0.279 + 50*0.129 + 150*0.117 + 300*0.047 + 500*0.054+ 750*0.373
  = **344.85/year/household**
- Welfare Measure = $344.85 * Household Number in SSR

  = $344.85 * 675310

  = $ 232880653.5

  = $232.881 million

Table 5. Non-Parametric Method (10-year program) for wildlife survey data

t_i	N_j	Tj	Fj	F*j	f*j
50	98	261	0.375	0.375	0.375
150	98	248	0.395	0.395	0.020
300	124	235	0.528	0.528	0.132
500	149	220	0.677	0.670	0.142
750	198	299	0.662	pooled	pooled
750+	-	-	1	1	0.330

Expected WTP Value for a 10-year NAR improvement program

- Turnbull Lower-bound Estimate = 0*0.375 + 50*0.020 + 150*0.132 + 300*0.142 + 500*0.373
  = **228.61/year/household**
- Welfare Measure = $344.85 * Household Number in SSR

  = $228.61 * 675310

  = $ 15438463135

  = $154.385 million

Appendix J Selective additional models

Table 6. A selective binary logit model parameter estimates, for wildlife habitat survey

Variable	Model1	Model2	Model3	Model4
Tax	-0.0023***	-0.0024***	-0.0024***	-0.0024***
	(0.000)	(0.000)	(0.000)	(0.000)
NAR	0.0351***	0.0270**	0.0271**	0.0268**
	(0.013)	(0.013)	(0.013)	(0.013)
Rural_nar	-0.0557***	-0.0430***	-0.0440***	-0.0427***
	(0.016)	(0.017)	(0.017)	(0.017)
Period	-0.0340**	-0.0284*	-0.0300**	-0.0280*
	(0.014)	(0.014)	(0.015)	(0.015)
fc		-0.7145**	-0.7217**	-0.689*
		(0.347)	(0.356)	(0.349)
male		-0.5136***	-0.4861***	-0.498***
		(0.151)	(0.151)	(0.152)
aincome		0.3100**		0.3149*
		(0.153)		(0.160)
lincome			-0.1552	
			(0.182)	
hincome			-0.0643	
			(0.189)	
EO				-0.159
				(0.210)
Constant	0.6152***	0.8136***	1.0493***	0.8306***
	(0.180)	(0.221)	(0.222)	(0.221)
N	2275	2275	2275	2275
log-likelihood	-1459.7542	-1404.27	-1408.8	-1403.03
P-value > Chi-square	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.0665	0.0831	0.0801	0.0839

Note 1: * p<.1; ** p<.05; *** p<.01
Note 2: yea-sayer removed and uncertainty adjusted
Note 3: clustered standard error applied

Table 7. A selective binary logit model parameter estimates, for water quality survey

Variable	Model1	Model2	Model3	Model4
Tax	-0.0015***	-0.0016***	-0.0016***	-0.0016***
	(0.000)	(0.000)	(0.000)	(0.000)
Bi	0.1541***	0.1481**	0.1520**	0.1507**
	(0.0570	(0.064)	(0.064)	(0.064)
Oi	0.1739***	0.1913***	0.1929***	0.1911***
	(0.057)	(0.058)	(0.058)	(0.058)
Si	0.0782	0.0841	0.0826	0.0862
	(0.060)	(0.062)	(0.052)	(0.062)
Mi	0.0648	0.0675	0.0664	0.0705
	(0.065)	(0.047)	(0.047)	(0.047)
Rural_bi		0.0199	0.0193	0.0094
		(0.130)	(0.131)	(0.128)
male		-0.3282**	-0.3382**	-0.3638**
		(0.157)	(0.157)	(0.163)
fc		-0.3525	-0.3555	-0.3799
		(0.326)	(0.322)	(0.317)
aincome		-0.1394		-0.1315
		(0.158)		(0.163)
lincome			0.2737	
			(0.201)	
hincome			0.0742	
			(0.181)	
EO				-0.1787
				(0.210)
highedu				-0.2012
				(0.163)
Age1				-0.2216
				(0.182)
Age2				-0.0287
				(0.202)
Constant	0.1842	0.4500**	0.2908	0.6768***
	(0.160)	(0.200)	(0.193)	(0.249)
N	1,784	1,748	1,748	1,748
log-likelihood	-1193.886	-1158.28	-1156.94	-1153.05
P-value > Chi-square	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.0309	0.0402	0.0413	0.0445

Note 1: * p<.1; ** p<.05; *** p<.01
Note 2: yea-sayer removed and uncertainty adjusted
Note 3: clustered standard error applied