University of Alberta

Producer Stated Preference for Hypothetical New Winter Wheat Varieties on the Canadian Prairies

By

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Abstract

This research project gauges producer demand on the Canadian Prairies for the attributes of new hypothetical varieties of winter wheat. Data collected from a survey of producers in Western Canada is used to determine the values and attitudes of producers regarding new winter wheat variety traits with a focus on increased winter survival rates and increased waterfowl nesting habitat. Increased nesting habitat was found to have a small negative but significant impact on the decision to adopt hypothetical winter wheat varieties; however winter kill rates and gross profit had a large positive effect on its adoption and expansion. Other important drivers of the decision to adopt hypothetical winter wheat varieties are also analyzed. Policy implications include potential guidance of incentives for environmentally friendly farming practices, and the provision of information to winter wheat breeding programs about the needs of producers.

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Chapter 1: Introduction and Background

1.1 Preface

This study is the result of a collaborative effort to improve cereal varieties in Western Canada with a focus on cold tolerance in winter wheat. Institutions involved include the Crop Development Center (CDC) in Saskatoon at the University of Saskatchewan with technical expertise on breeding, and the University of Alberta department of Rural Economy analyzing socio economic impacts of improved varieties and their traits.

The research seeks to determine the value placed by producers on the winter wheat traits of cold tolerance and duck nesting habitat in hypothetical new varieties. The focus of the thesis will be on the decision to adopt or expand acres of the new varieties of winter wheat while taking into account the farm manager's financial, environmental, attitudinal, and demographic factors affecting the decision. The results may be used to aid in the improvement of new winter wheat varieties in accordance with future demands by producers. An extension to this research evaluates how incentives can be devised to provide benefits to producers as well as society in the fulfillment of future environmental targets, specifically with respect to wetland and upland habitat conservation.

Historical research on the adoption of new farm technologies has focused mainly on profitability and other economic related drivers (e.g. Griliches, 1957; Batte, Jones and Schnitkey, 1990; Nijkamp, Rodenburg, and Verhoef, 2001). There have also been studies that include an environmental element as well such as Lynne, Shonkwiler, and Rola (1988) which include attitudes about conservation, and a study from Mayberry, Crase and Gullifer (2005) that found conservation as a motivator of adoption. The environmental element in farm level technology adoption is hard to ignore and is becoming a focus in farm level adoption studies.

A gap in the literature exists for farm level adoption of winter wheat in Western Canada. A study by McCorkle (2007) looked at demographic influences on the willingness to pay (WTP) for a more cold tolerant spring wheat variety but did not include environmental concerns. Presently, there have been no studies undertaken that ascertain the value to Western Canadian producers of environmental or other traits in winter wheat.

In a climate of increasing environmental awareness and concern, winter wheat may be a good fit for producers. Not only does it provide superior nesting habitat for waterfowl compared to spring wheat (Devries *et al.*, 2008) but may present some advantages to producers as well. Dr. Brian Fowler, a winter wheat breeder at the University of Saskatchewan CDC in Saskatoon, lists his top ten reasons to grow winter wheat in Western Canada:

1. "Good fit with conservation farming systems."
2. "More efficient water utilization than spring seeded crops."
3. "Avoids wheat midge damage due to early heading – no need for insecticides."
4. "Good weed competitor so wild oat herbicide not usually required – saves up to "$15.00 per acre in input costs."
5. "No spraying for wild oat reduces selection pressure for herbicide resistance."
6. "Reduced risk of Fusarium head blight due to early development and maturity."
7. "Avoids seeding problems on late, wet springs. Earlier harvest than spring wheat."
8. "Lower energy requirements due to reduced tillage and pesticide use."
9. "Less disturbance to wildlife, especially waterfowl and upland game birds."
10. "High yield potential and reduced pesticide costs mean greater potential for increased returns per acre."

(Source: Fowler, 2002a)

Salmon and McLelland (2008) list some advantages of winter wheat to producers as:

- "Provides soil cover during the fall and winter, reducing the potential for soil loss due to water and wind"
- "Spring moisture is not lost from a seeding operation"
- "Uses early spring moisture in dry areas more efficiently than spring cereals"
- "When spring weather conditions make seeding difficult, winter wheat is already established in the field"
- "May yield 10 to 15 per cent higher than Canadian western Red Spring wheat"
- "Matures earlier than spring cereals, spreading out harvest operations and reducing the potential for grade losses due to early frost"
- "Provides another tool for weed management since the crop is seeded and growing when weeds in a spring cropping situation have had little crop competition (fall and early spring)"

(Salmon and McLelland, 2008)

1.2 Goals of the Study

The main goal of this study is to determine if producers value the cold tolerance trait of winter wheat and the increase in waterfowl nesting success when adopting hypothetical new varieties of winter wheat. The study assesses the willingness of producers to make a tradeoff between profits and increased duck nesting capacity when adopting or expanding winter wheat acres. This study will compliment contemporary studies in determining what segment of society (if any) should pay for future targets for increases in waterfowl populations, and which policy vehicle should be used to give appropriate incentives to producers to reach these targets.

There are two secondary objectives. The first, being the determination of existing drivers and barriers to winter wheat adoption on the prairies. This information will help provide background that can reveal the strengths and weaknesses of current varieties. It will also provide focus for the last objective of providing a ranking by producers of possible attributes in new varieties that can be presented to those involved in developing these varieties.

In order to achieve these goals a survey was developed and administered to wheat producers in Western Canada. Data for the evaluation goal are gathered through questions with a contingent valuation structure. The secondary objectives are ascertained through data arising from questions concerning attitudes and preferences regarding current usage of winter wheat and possible new varieties in the future. The survey is conducted at farm shows and meetings in the Prairie Provinces of Alberta, Saskatchewan and Manitoba. It should be noted that the survey used bushels and acres for measurements of yield, current wheat acreages, etc… so imperial notation will be used throughout the thesis.

1.3 Winter Wheat

1.3.1 Description of Winter Wheat

Winter wheat[1] are varieties (*Triticum aestivum. L*) that require vernalization, a physiological requirement of growth under cool temperatures before flowering (Encyclopedia Britannica, 2009). Vernalization allows winter wheat to be planted in the fall and harvested the following year, in most cases earlier than spring seeded wheat crops. Although winter varieties are very similar to spring varieties, there are differences in yield, quality, and other attributes that cause winter wheat to be classified differently than spring wheat in the World Wheat Market Classes, and by the Canadian Wheat Board (Fowler, 2002b).

The Canadian Wheat Board currently has only one class for winter wheat; the Canada Western Red Winter class (CWRW) (Canadian Wheat Board, 2009a). The CWRW class is currently the only type of winter wheat registered on the Canadian Prairies (Fowler, 2002b), although soft white and soft red winter wheat varieties also

[1] For further information on the winter survival of winter wheat see Struthers and Greer (2003)

exist (Sikkema *et al.*, 2007). Different varieties of winter wheat grown on the Prairie Provinces can be seen in Table 1.1.

Table 1.1 2008 Winter Wheat Variety Composition on the Prairies by Percentage of Total Winter Wheat Acres

Variety	Prairie Average	MB	SK	AB
CDC Falcon	29.6%	73.2%	2.3%	2.0%
CDC Buteo	26.3%	14.2%	58.4%	4.2%
Radiant	18.9%	0.0%	7.0%	59.5%
AC Bellatrix	9.0%	0.0%	8.0%	22.9%
CDC Raptor	4.1%	1.9%	10.2%	0.0%
CDC Clair	3.4%	2.0%	4.8%	3.7%
McClintock	3.0%	6.5%	1.7%	0.0%
CDC Osprey	3.0%	0.0%	5.4%	4.2%
AC Readymade	0.8%	0.0%	0.0%	2.9%
CDC Harrier	0.7%	1.2%	0.7%	0.0%
CDC Kestrel	0.5%	0.7%	0.5%	0.3%
Other	0.3%	0.3%	0.6%	0.0%
Norstar	0.2%	0.0%	0.5%	0.0%
AC Tempest	0.1%	0.0%	0.0%	0.5%

(Source: Canadian Wheat Board, 2009a)

CWRW wheat has excellent milling yield and dough strength. Markets for current varieties include hearth breads, crackers, oriental noodles, livestock feed, and ethanol. Canadian Prairie Spring (CPS) wheat classes exhibit the closest marketing characteristics to winter wheat grown on the prairies but there is also significant overlap in the range of applications with Hard Red Spring wheat varieties (HRS). The Canadian Wheat Board labels HRS wheat varieties as the Canadian Western Red Spring (CWRS) class. For the purposes of this study this class of wheat will be referred to by its common HRS designation. HRS varieties are considered better quality wheat because of higher protein levels and superior gluten properties useful in baking high volume breads. (Canadian Wheat Board, 2008)

1.3.2 Winter Kill

Winterkill has historically been an issue with winter wheat production. Struthers and Greer (2003) provide a synopsis of the different schools of thought surrounding winter survival issues. They mention that farmers who have less experience with the crop, especially with current agronomy practices regarding the crop, perceive a high level of risk due to winterkill. The other viewpoint comes from producers who currently grow the crop and experience a low rate of winter kill loss. These producers perceive that winter wheat lowers their production risk in general which is attributed to reduced losses in quality in other crops, fewer pest problems and gains in harvest timing (Struthers and Greer, 2003). It should be noted that winterkill generally includes a wide range of loss from cold weather. A field with a low level of winter kill may not necessarily be replanted in the spring if the damage is low enough to produce a crop that the producer feels is adequate. A 50% rate of winter kill results in just a %10 decrease in yield potential (Salmon and Mclelland. 2008).

Ideal planting dates for winter wheat in Alberta vary from region to region. For example, the ideal seeding date in Lethbridge, AB is September 9th, compared to the ideal date in Saskatoon, SK, August 30th (Fowler, 2002b). Planting close to the ideal date produces the lowest probability of winter kill but can be shifted as much as two weeks with few consequences (Fowler, 2002b). Winter wheat requires anywhere from 8 to 12 weeks of growth (3 leaf plus tiller stage) to become as winter hardy as possible (Struthers and Greer, 2003). When temperatures dip below +9 degrees Celsius winter wheat begins the process of acclimatization preparing for the winter months (Struthers and Greer, 2003).

1.3.3 The History of Winter Wheat in Western Canada

The history of winter wheat in Western Canada can be traced back to the fall of 1812 when a group of 22 Selkirk settlers planted a crop of winter wheat seed they had brought from Scotland (Fedak, 1999). This crop and the one in the following year failed due to lack of agronomic experience with the crop in Western Canadian conditions however, the crop that was planted in the fall of 1814 was successfully harvested the following year. Due to political, agronomic and weather problems this line of seed came to an end. (Fedak, 2007)

The Selkirk settlers made further attempts to source winter wheat varieties that would grow well in the conditions they faced but a successful variety of wheat was not present until 1842 when David Fyfe, a farmer from Otonabee, Ontario sourced seed for a spring wheat variety called “Halychanka” from the Ukraine. This variety resisted the rust problems associated with an imported winter variety called “Siberian” which suffered from high rates of winter kill and damage. This new Halychanka variety of spring wheat, commonly known as “Red Fyfe”, took a leading role in Western Canadian wheat production in the years to come. Red Fyfe spring wheat and the invention of the steel roller mill in 1870, which reduced the demand for the higher milling quality of winter wheat at the time, caused spring varieties to dominate wheat production on the Prairies. (Fedak, 2007)

Earlier varieties of winter wheat such as “Turkey Red” also known as “Kharkiv” were introduced to North America by Russian Mennonites from what is now the Steppe region of the Ukraine around 1874 (Kansas State Historical Society, 2000). The Kharkiv variety was very successful in the state of Kansas because of favorable winters but was not a large part of Western Canadian wheat production in the early twentieth century

(Table 1.2). Canada presented challenges to winter wheat production such as very cold winters, a lack of insulating snow cover in some areas, and a damaging freeze-thaw cycle in the spring (Fedak, 2007).

Table 1.2. Winter and Spring Wheat Acres in the Prairie Provinces in 1918

	Spring Wheat acres	Winter Wheat acres	Winter Wheat as a % of Total Wheat
Alberta	3,187,000	58,000	1.79%
Saskatchewan	9,101,000	0	0.00%
Manitoba	2,616,000	2,000	0.08%
Total	14,904,000	60,000	0.40%

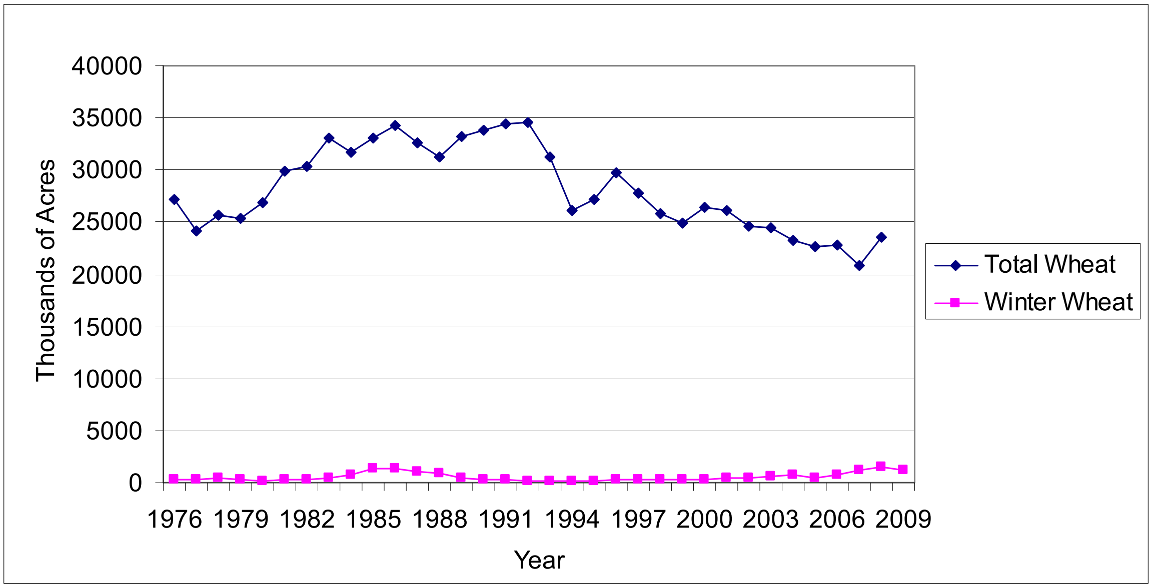
(Adapted from Fedak, 2007)

Despite the challenges Canada presented to production, winter wheat development proceeded with the inception of breeding programs such as the early program at the Lethbridge Experimental Farm (Fedak, 2007). From the late 1970's to early 1980's Southern Alberta produced most of the winter wheat in the Prairie Provinces. It was shortly after this period that improvements to the grain handling system allowed winter wheat to be delivered closer to the time of harvest. This aided in the spread of winter varieties to Saskatchewan and Manitoba. (Fowler, 2002b)

In recent history, the acres of winter wheat seeded have seen two sharp increases (Figure 1.1 and 1.2). The first increase started around 1983 and continued until 1986 where a sharp decrease in acres was seen across the prairies, mainly due to problems with rust (*Puccinia graminis)* and other diseases (McCallum and Depauw, 2008) although drought and winter survival were also issues that producers in general remember as causal to its decline. Manitoba farmers reported yield losses between 20 and 50% due to rust problems in 1986 (Martens and McFadden, 1988). McCallum and Depauw (2008) attribute the rise in acres seeded post 2004 to improved varieties, ethanol demand, and the inception of a Canadian Wheat Board (CWB) program for identity preserved contracts that pay a premium for varieties with high end use qualities. Ducks Unlimited, the largest waterfowl conservation organization, has also played a role in promoting winter wheat acres as upland migratory waterfowl habitat through awareness programs, moral suasion, and payments for upland habitat provision (van Kooten and Schmitz, 1992; Ducks Unlimited, 2009e).

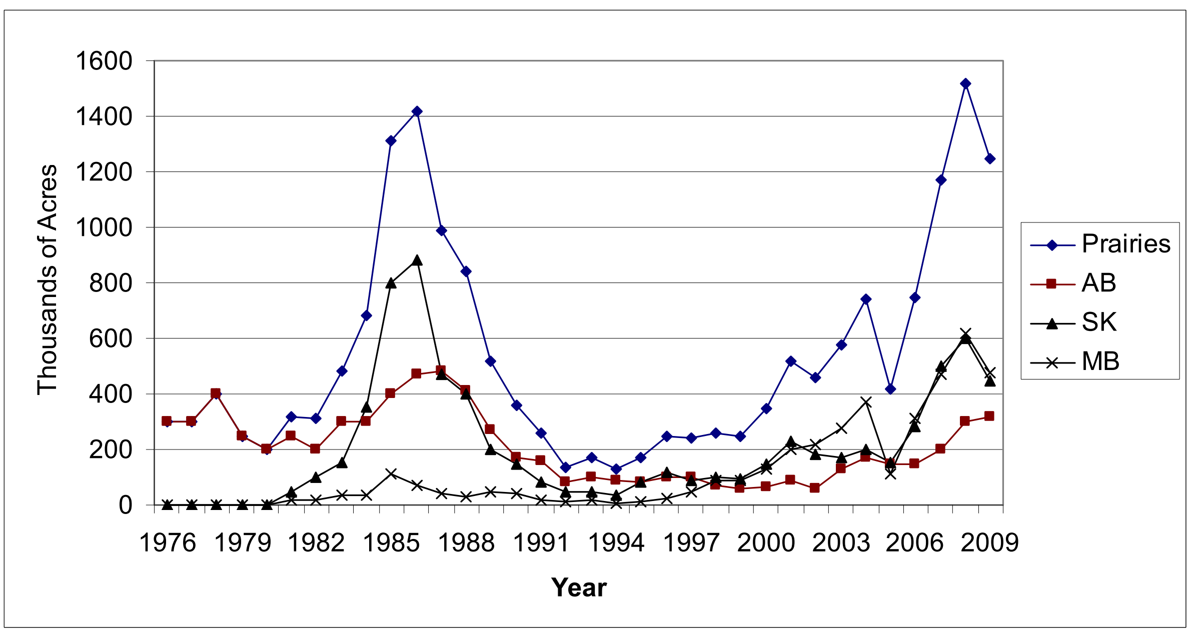
The private sector has recently increased its role in promoting winter wheat on the Prairies. In January of 2009, Ducks Unlimited, and Bayer Crop Science announced a program designed to increase winter cereal acreage called "*Winter Cereals: Sustainability in Action*" (Ducks Unlimited, 2009a). Bayer Crop Science made a 20 million dollar commitment over five years to the project in Canada and the United States which aims to develop new winter wheat varieties, agronomic practices, and conduct research on sustainable waterfowl habitat and production systems (Ducks Unlimited, 2009a). Viterra, an input supply and grain handling company, has also pledged to support the initiative with in-kind, and marketing assistance for the program. The Canadian portion of the project has targeted an increase of 100,000 acres for winter wheat in the 2009 seeding year (Viterra, 2009).

Figure 1.1 Comparison of Total Wheat and Winter Wheat Acres Seeded in the Prairie Provinces (AB, SK, and MB combined)



(Source: Statistics Canada, 2009b)

Figure 1.2 Historical Winter Wheat Acres Seeded in the Prairie Provinces from 1976 to 2009



(Source: Statistics Canada, 2009b)

1.3.4 Winter Wheat Breeding Programs

Wheat breeding programs have been instrumental to the development of agricultural production on the Canadian Prairies providing a significant social return on investment (Zenter and Peterson, 1982). Although spring wheat breeding has received more attention than winter wheat in Canadian agricultural development, there have been a number of new winter wheat varieties released, especially from 1990 to present (Alberta Agriculture and Rural Development, 2006). The varieties are noted in Table 1.3. in chronological order of release in Canada. The main areas of focus in winter wheat breeding have historically been disease resistance, quality, yield (McCallum and Depauw, 2008) and cold tolerance (Fowler and Gusta, 1979; Fowler and Limin,1997; Limin and Fowler, 1993).

Table 1.3 Hard Red Winter Wheat Varieties Released in Canada

Release Year In Canada	Variety	Development Location
1912	Karkov 22mc	Macdonald College
1961	Winalta	Agriculture Canada, Lethbridge
1971	Sundance	Agriculture Canada, Lethbridge
1977	Norstar	Agriculture Canada, Lethbridge
1986	Norwin	Montana State University
1990	CDC Kestrel	Crop Development Centre, Saskatoon
1991	AC Readymade	Agriculture Canada ,Lethbridge
1995	CDC Osprey	Crop Development Centre, Saskatoon
1995	CDC Clair	Crop Development Centre, Saskatoon
1996	AC Tempest	Agriculture Canada, Lethbridge
1997	CDC Harrier	Crop Development Centre, Saskatoon
1998	AC Bellatrix	Agriculture Canada, Lethbridge
1998	CDC Falcon	Crop Development Centre, Saskatoon
1999	CDC Raptor	Crop Development Centre, Saskatoon
2001	AC Radiant	Agriculture Canada, Lethbridge
2001	CDC Buteo	Crop Development Centre, Saskatoon
2001	McClintock	University of Manitoba, Winnipeg

(Adapted from: Alberta Agriculture and Rural Development, 2006)

1.3.5 Winter Wheat and Avian Habitat

It has been documented that farming activities are not helpful to the nesting success of birds (Goelitz, 1918). Improvements that have been suggested to provide better nesting success for birds in cropping systems include using minimum till systems (Cowan, 1982), and winter seeded crops (Duebbert and Kantrud, 1987; Devries *et al.*, 2008). The timeframe of bird nesting and the spring seeding of crops generally overlap meaning that the nests are at risk of being destroyed by seeding equipment.

Winter wheat is seeded in the fall so there is no risk of destruction to the nests from seeding activity in the spring (if the crop succeeds). In a recent study, Devries *et al.* (2008) found that winter wheat provided a 38% survival rate for Mallard duck nests compared to 12% in spring seeded crops. Devries (2002) also found that Mallard ducks exhibit a strong preference for winter wheat over spring wheat for nesting. This thesis will henceforth refer primarily to duck nesting habitat as an environmental benefit of planting winter wheat. It should be noted that the upland habitat potential winter wheat provides has other environmental benefits such as habitat for bird species other than ducks.

1.4 The Prairie Pothole Region of Western Canada

The Prairie Pothole Region (PPR) of North America is responsible for about 50% of the production of common duck species (Batt *et al.*, 1989; Smith, Stoudt and Gollop, 1964). The Canadian portion encompasses more than half of the 715,000km^2 area of the PPR (United States Geological Survey, 2006b) and includes Alberta, Saskatchewan, and Manitoba in its territory. Agricultural activities, especially crop production, occupy a majority of the land in the PPR which has created a land use conflict between nesting habitat and farming (Goldstein, 1971).

Upland habitat in the PPR has changed considerably since settlement (Archibold and Wilson, 1980). The changes in upland habitat and a decrease of wetland habitat of up to 70% in some areas due mostly to drainage projects (Ducks Unlimited, 2009d) have lead to low duck nesting success rates in the region and concerns that the population is not self sustaining (Cowardin, Gilmer and Shaiffer, 1985; Klett, Shaffer and Johnson, 1988).

1.5 The Importance of Upland Habitat

Uplands are defined as "The land and habitat located around a wetland" (Ducks Unlimited, 2009c). Upland habitat plays a vital role in maintaining wetland species (Gibbons, 2003; Attum *et al.*, 2007). For every acre of wetland habitat three acres of upland habitat are optimal to support the functions of wildlife (Switzer and Olson, 2005). Ducks for instance, nest in the cover of upland habitat and may travel up to a mile to the wetland after the young are old enough to make the trip (Ducks Unlimited, 2009b).

1.6 Economic Problem

Traditional economic profit maximization frameworks suggest that producers will choose activities that maximize the profit function subject to the constraints faced by the individual farm operation. This approach has shortcomings when attempting to include hard to value environmental outcomes in the decision making process, especially if the benefits do not accrue directly to the decision maker. Goldstein (1971) implies that decisions may be biased if all the benefits and costs of the environmental outcomes are not accounted for. Etzioni (1986) points out that a pure profit maximizing framework is too parsimonious and Chouinard *et al.* (2008, pg.79) goes further to say it is "a bit insulting to farmers".

Chouinard *et al.* (2008) has also suggested that there may be producers willing to sacrifice profits for environmental stewardship. They suggest that on their farm environmentally friendly practices could be adopted out of the utility farmers derive for their own desires for environmental goods and services, or from a sense of obligation requiring personal sacrifice (Chouinard *et al.*, 2008). It has also been suggested that producers will need more than moral suasion to preserve upland waterfowl habitat (van Kooten and Schmitz, 1992). It appears that the environment is an important factor but less important than profits.

Producers face the complex decision of allocating acres to certain crops based on what benefits the crop will provide in terms of profits, personally satisfying environmental outcomes, and any other positive results, as well as the costs including inputs, personally dissatisfying environmental outcomes, etc…. In 2008 only 6.4% of total wheat acres seeded in Western Canada were winter varieties (Statistics Canada, 2009b). This fact coupled with the potential for greater returns per acre than spring varieties (Fowler, 2002b), points to factors other than profit in the acreage allocation decision between winter and spring wheat. This study evaluates the different factors that influence the decision to grow winter wheat and provide future input on programs encouraging winter wheat adoption. The relative importance of many factors affecting the producer's decision to produce winter wheat is unknown.

In order to answer the main questions asked in this study, some hypothesis that can be tested through quantifiable means were developed. These hypotheses are:

1. Wheat Producers place a positive value on the cold tolerance attribute of winter wheat.

2. Wheat Producers are willing to trade at least some profits for an increase in duck nesting success when adopting new winter wheat varieties or expanding current winter wheat acreage with new varieties.

3. A straight cash subsidy is not as effective as some other incentive method to encourage new winter wheat variety adoption

Producer valuation of new winter wheat varieties may be important to efficiently allocate public resources spent on their development. Furthermore, an accurate measure of the benefit to producers of duck nesting success could be compared with values that society in general places on duck habitat in the form of wetlands or possible future upland habitat valuation. The question of whether or not an environmental improvement can be made that benefits producers and society in general may be important to the future of agricultural crop development.

1.7 Organization of the Study

Following the introductory chapter in order of appearance is a literature review chapter, a chapter pertaining to the methodology of the study, a results and discussion chapter and a chapter discussing the conclusions and implications of this study. The literature review provides a basic overview of the neoclassical economic theory of producer decision making before presenting environmental conservation adoption studies and literature on the tradeoffs between profit and environmental stewardship.

The methodology chapter outlines how the survey was devised, revised, conducted, and to whom it was administered. Data collection methods and target population are described and discussed before an explanation of the factor analysis method. Lastly, the econometric model is explained before the results chapter.

A chapter on results starts with a comparison of the survey sample to the entire target population of wheat producers in the prairies before presenting the summary results from individual and sets of survey questions. Drivers and barriers to winter wheat adoption are identified to gain an understanding of what producers like and dislike about current winter wheat varieties. A factor analysis on the rating of potential winter wheat attributes is discussed before the econometric model results are presented in the last section of this chapter.

The final conclusions and implications chapter includes discussion on what was learned from the study and how it applies to future research and policymaking regarding winter wheat. A discussion of the original goals of the study and how they are addressed is also included. The final section includes recommendations for winter wheat breeding programs, and other stakeholders involved in the development of the crop.

Chapter 2: Review of the Literature

The literature concerning the topic of profit and environmental conservation tradeoff decisions is broken down into two distinct categories for this review. The first category deals with the adoption and diffusion of conservation technologies, and the second with the tradeoff between profits and environmental stewardship that producers face when adopting these innovations. The adoption of innovations and the tradeoff between profit and waterfowl nesting success are hard to separate when the technology adopted increases nesting success. The division between technology adoption and profit-environmental tradeoffs is not mutually exclusive in this case.

The majority of studies in conservation adoption can be split into those dealing with developed nations, and those with undeveloped ones. This study has a developed world context so that will be the focus of this review. Further division among these subgroups lies within the factors used to explain adoption behavior such as demographics, social factors and attitudes toward the technology.

Although utility is implied in most adoption literature, it is studied more explicitly in the tradeoff literature to separate the different components that it comprises. In the second section dealing with profit-stewardship tradeoffs, studies dealing with the overt tradeoff being made by producers will be examined first. Willingness to pay for conservation technologies and willingness to accept transfer payments as incentives will then be examined followed by the discrepancy between intentions and actions regarding the tradeoff.

2.1 Neoclassical Production Theory

Underlying the discussion about technology adoption and tradeoffs between the environment and profit is the decision producer's face of which crops to plant. This decision can be complicated and involve a large number of influencers such as profits, attitudes, and other motivators discussed later in this chapter. Beattie and Taylor (1985) provide a simplified representation of this decision using a profit maximization framework for multiproduct production. For simplicity and to fit the scope of this study, the choice of crops will be limited to spring wheat and winter wheat. Beattie and Taylor (1985, p.203-205) outline the process as follows:

The implicit production function for multiple outputs (spring wheat and winter wheat) is:

$F(x, y) = 0$ Equation (2.1)

x = A vector of inputs

y = A vector of outputs (winter and spring wheat)

The profit function for multi-output production:

$\pi = \text{TR} - VC - FC = \sum_{j=1}^{2}(p_j y_j - \tilde{c}(r_i, y_j))$ - FC Equation (2.2)

TR = $\sum_{j=1}^{2} p_j y_j$ = Total Revenue

p_j = price of output j

y_j = output level for j

VC = $\tilde{c}(r_i, y_j)$ = variable costs

r_i = input price for the *i*th input

FC = fixed costs

First Order Conditions:

$\frac{\partial \pi}{\partial y_j} = p_j - \frac{\partial \tilde{c}}{\partial y_j} = 0$ For all j Equation (2.3)

$p_j = \frac{\partial \tilde{c}}{\partial y_j}$ Equation (2.4)

Marginal revenue (MR) and marginal cost (MC) are defined as:

$$\text{MR} = \frac{d\text{TR}}{dy_j}$$, the first derivative of total revenue Equation (2.5)

$$\text{MC} = \frac{d\text{VC}}{dy_j}$$, the first derivative of variable costs Equation (2.6)

(Beattie and Taylor, 1985, p.155-156)

The requirement for profit maximization in equation (2.4) can now be represented as:

$MR_j = MC_j$ Equation (2.7)

or $MR_1 = MC_1$ (winter wheat) and $MR_2 = MC_2$ (spring wheat)

$MR_1 - MC_1 = MR_2 - MC_2$ is the profit maximizing mix of winter wheat and spring wheat.

If $MR_1 - MC_1 > MR_2 - MC_{2,}$ then winter wheat is planted

If $MR_1 - MC_1 < MR_2 - MC_{2,}$ then spring wheat is planted

Essentially, if the marginal profit is higher from any given crop, then it will be planted until another crop becomes marginally more profitable. In this case the practical units of spring wheat and winter wheat would be a quarter section or field. The marginal profit would be considered at the individual field level.

Theoretically the producer will plant an optimal mix of spring wheat and winter wheat where the marginal profit (MR-MC) is equal for spring and winter wheat. An example could be of a producer who raises hogs and grows wheat. Producing winter wheat for hog feed may have a higher marginal profit than spring wheat because of lower costs of production or high outside feed prices etc.... There may be a point after enough food is produced for the hogs where spring wheat starts to have a marginal profit advantage over winter wheat. At this point spring wheat is planted unless another point is reached where winter wheat regains the marginal profit advantage and so on until the maximum amount of land allocated to wheat production is reached. If no land constraint exists then theoretically, $MR_i - MC_i$ will go to zero where the producer makes no additional profit for producing an extra unit of winter or spring wheat.

Adding values for waterfowl habitat into the neoclassical profit maximizing framework is conceptually possible. In order to account for duck production it may be added as an extension to profitability. If the revenue and costs of duck production are added to equation 2.2 it might look something like the following:

$$\pi = \text{TR} - VC = \sum_{j=1}^{2} (p_j y_j - \tilde{c}(r_i, y_j) - \alpha \cdot g(s)_j) \qquad \text{Equation (2.8)}$$

Where:

$g(s)_j$ is the duck production function vector for winter and spring wheat dependant on a vector of inputs (s) including winter wheat acres, spring wheat acres, surrounding wetlands and any other factors in duck production.

$\alpha = R^d - C^d$ = Revenue from one duck – Cost of one duck

Assuming that the revenue from an extra duck is zero and crop losses exist as a cost to the producer, then $\alpha < 0$. This assumption means that the revenue of duck production will be negative for any positive production level, $g(s)_j > 0$. A production level of zero where no cost is incurred from duck production could be experienced under summer/chemical fallow conditions, however the cost of extra ducks is presumably less than the profit gained from planting even the least profitable crop. As long as the profit from planting a crop is higher than the cost of the extra ducks and the opportunity cost of summer/chemical fallow, the crop will be planted. Since winter wheat produces more ducks per acre than spring wheat (Devries *et al.*, 2008) it will be a negative aspect of planting winter wheat compared with spring wheat in the profit maximizing framework.

For simplicity assume that duck nesting success increases with crop acres as compared to the existing land use (i.e. no crops and in land in continuous summerfallow).
Equation 2.7 can be expanded to include the marginal revenue of duck production for each crop, $(\alpha \frac{\partial g}{\partial y_j}) < 0$:

$$MR_j + \alpha \frac{\partial g}{\partial y_j} = MC_j \qquad \text{Equation (2.9)}$$

Assuming that winter wheat provides more potential successful duck nests then the marginal duck production of winter wheat will be greater than that of spring wheat :

$$\alpha \frac{\partial g}{\partial y_w} > \alpha \frac{\partial g}{\partial y_s}$$

This representation of the production function includes ducks as a product of crop production and the surrounding environmental capacity for ducks and not as a competing production decision. The neoclassical model does not account for any underlying utility gains or losses from duck production which means that in order for a profit maximizing producer to demand winter wheat habitat for ducks the combination of profit from winter wheat production and duck provision must be marginally larger than the same from spring wheat production. In the case that α is negative, winter wheat will have a disadvantage when compared to spring wheat which produces fewer successful duck nests (Devries *et al.*, 2008).

The neoclassical approach provides an understanding of producer decision making based solely on profit. The following literature expands on the decision making process regarding the adoption of new technologies as well as tradeoffs between environmental outcomes and profit. The list of motivators is also explored beyond the traditional profit motive and includes factors such as social pressure, intrinsic value for the environment, and altruistic motives.

2.2 Conservation Adoption Literature

2.2.1 Behavior Surrounding the Adoption Process

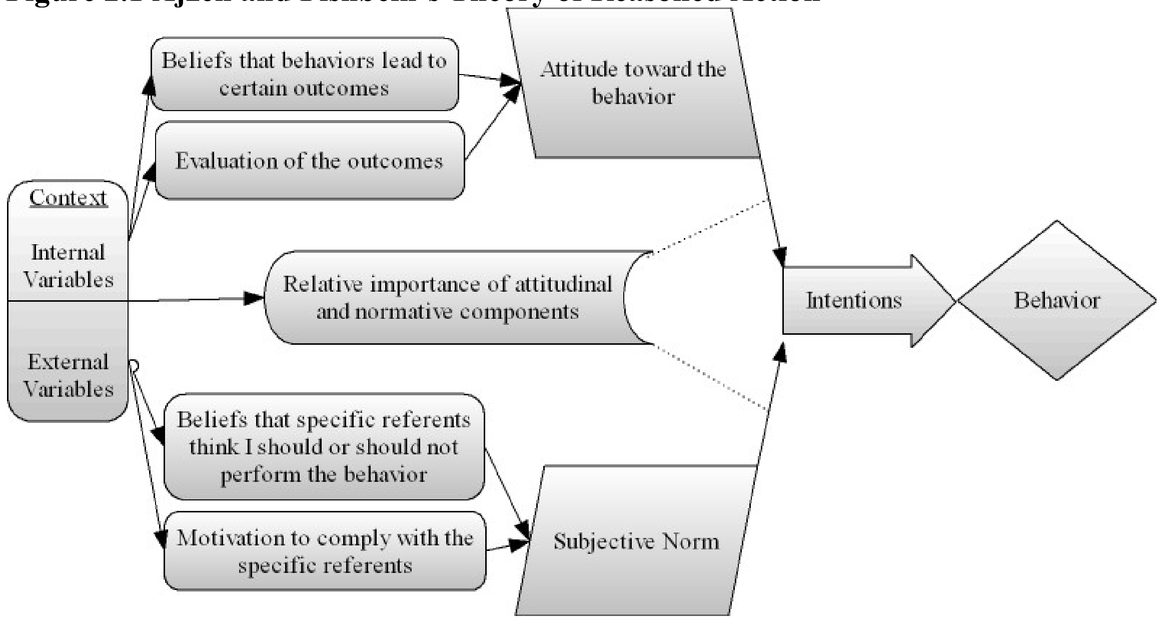
Pannell (1999) provides a general overview of complex farming system development asserting that more complex innovations have a more difficult adoption process. He augments this argument by indicating some necessary conditions to aid the adoption process which are: the awareness of the technology/innovation, a perception that the innovation is feasible to test and is worth testing, and that the technology is in line with the producer's goals and objectives. The potential adopter will evaluate the technology for economic and social worthiness for trialing/testing. If it passes the evaluation, it is trialed on a small scale and if successful, larger trials and eventually full scale production are implemented.

Pannell (1999) also gives insight on the history of agricultural technology adoption by arguing that in the past, agricultural production has been changed in large ways by equally large problems or challenges such as the green revolution. Pannell indicates that farm production systems are becoming more complex and even mimic natural ecosystems to a degree foreshadowing the future of crop production. This observation points to a need for increased study in the area of conservation adoption to understand how to make crops and production systems environmentally sustainable as well as profitable for the producer.

Sen (1977) provides a critique and discussion of economic theory pertaining to technology adoption and utility estimation. He criticizes the single dimensional approach of using egoism, or purely selfish motives, for examining rational decision making and coins the single minded individual who makes these one dimensional calculations as the "social moron" or "rational fool" (Sen, 1977). Sen believes that the traditional formal definition of rationality still has merit but needs to be augmented by social motives that may not fit with economic theory. The merging of social and economic factors into a single utility element is deemed irresponsible because of their heterogeneity and redundant due to the convoluted nature of utility where all motives lead to a single, generic perception of utility maximization (Sen, 1977). Sen's discussion leads nicely into current studies that incorporate a social element.

The social element is most prominently introduced by Ajzen and Fishbein (1980) with formalization of their "Theory of Reasoned Action" (TORA) (Figure 2.1). In this sociological model there are two important inputs into the formulation of the adopter's intentions. The first comes from internal variables such as beliefs and perceptions of the outcome which make up an attitude about the technology. The second is an external input comprised of beliefs about the approval of others and a motivation to comply with this suasion resulting in a subjective normal element. The attitudes and subjective norms make up the potential adopter's intention which is separated from the actual behavior. Ajzen (1991) added perceived control over the decision to the TORA and called it the Theory of Planned Behavior (TOPB).

Figure 2.1 Ajzen and Fishbein's Theory of Reasoned Action



(Adapted From Rehman *et al*., 2007, p. 283)

A study by Rehman *et al.* (2006) applies the Theory of Reasoned Action to the uptake of estrous detection technologies. The study finds that both attitudes about the technology such as the efficacy of detection and social pressures such as the perception from neighbors that the adopter will not "know their cows" as well were significant predictors of adoption behavior.

Lynne *et al.* (1995) uses Ajzen's (1991) Theory of Planned Behavior to test whether perceived control is important in voluntary conservation adoption decisions. They found that Producers need to perceive that they have at least some degree of control over the action for adoption to take place and that external control is detrimental to the uptake of conservation technologies. A mix of moral suasion and economic incentives was found to be an effective method which is consistent with the TORA.

2.2.2 Barriers and Drivers of Technology Adoption

An early study by Griliches (1957) sets the stage for determining the factors of agriculture technology adoption. He found a positive relationship between profitability and hybrid corn adoption rates in several U.S. states and that the barriers and drivers of adoption are susceptible to economic analysis. His analysis sets the stage for future studies on the motives for adoption.

After Griliches' early work, there were a plethora of studies concerning the drivers of technology adoption. Maybery, Crase and Gullifer (2005) categorize the drivers into three groups: economic, conservation, and lifestyle and finds three distinct groups of respondents that match these values using principal component analysis. Lynne, Shonkwiler and Rola (1988) found a positive relationship with conservation technology adoption and farm ownership, positive attitudes about conservation, and an acknowledgement of an environmental problem. They also found that a negative relationship existed between adopting conservation technology and an increased technology level or capability of the farm, high current farm profitability, increased risk aversion levels of the potential adopter, and an increased effort per unit of income if the technology is adopted. Lichtenberg (2004) revealed that the cross price effects of different conservation adoption technologies had impacts on adoption indicating that conservation activities can act as substitutes and compliments. He also found that the natural geographical endowment of the land was an important factor when the technology in question is specific to certain physical geographies.

Warriner and Moul (1992) found that adoption of conservation tillage technologies were positively affected by the age of the potential adopter, education, and beliefs regarding future profits. Nijkamp, Rodenburg and Verhoef (2001) found that cost, lack of information, and the degree of institutional or structural change needed were barriers to conservation adoption by firms. A higher profit potential of the new technology and larger farm sizes were found to have a positive impact on adoption by Saltiel, Bauder, and Palakovich (1994). A household bargaining model was used by Zepeda and Castillo (1994) to determine that spousal influence had an effect on technology adoption (can be positive or negative in this case).

McCorkle (2007) found when producers are hypothetically adopting new wheat varieties that increased frost tolerance, decreased days to maturity, larger farm sizes, higher incomes, and increased previous experience with frost damage all had a positive impact on the hypothetical adoption of a more cold tolerant wheat variety in Alberta. McCorkle (2007) also found that higher educations, more Southerly regions in Alberta, and higher seed costs had a negative impact on adoption rates of the hypothetical new varieties. Larger farm sizes, younger ages of potential adopters, more education, grain farms (compared to other types) and increased total expenditure for information about the technology all had a positive impact on adoption rates in a study from Batte, Jones, and Schnitkey (1990). Table 2.1 organizes select adoption barriers and drivers by the year the study was undertaken and gives the direction of impact for each as found by the study.

Table 2.1 Barriers and Drivers of Agricultural Technology Adoption from Selected References and the Direction of Impact on Adoption

Author	Year	Adoption Drivers found	Direction of the Impact on Adoption
Griliches	1957	Profititability	+
Lynne, Shonkwiler and Rola	1988	Ownership of the Farm	+
		Technology level/capability	-
		High current level of profitability	-
		Increased risk aversion level of individual	-
		Increased effort per unit of income	-
		Positive attitudes about conservation	+
		Acknowledgement of the environmental problem	+
Batte, Jones And Schnitkey	1990	Total expenditure for information about the technology	+
		Larger farm sizes	+
		Increased age	-
		Higher education levels	+
		Farm type (grain farm =1, other=0)	+
Warriner and Moul	1992	Increased age	+
		Higher education levels	+
		Belief of higher future profit	+
Saltiel, Bauder and Palakovich	1994	Higher profit potential of the technology	+
		Larger farm sizes	+
Zepeda and Castillo	1994	Spousal influence	Dependent on technology
Lynne *et al.*	1995	High perceived level of control over the adoption decision	+
Lichtenberg	2004	Cross price effects of other conservation technologies	Dependent on technology
		Natural geographical endowments	Dependent on technology
Maybery, Crase and Gullifer	2005	Found three groups of drivers (PCA): Economic, Conservation, and Lifestyle	NA
McCorkle	2007	Higher frost tolerance	+
		Decreased days to maturity	+
		Larger farm sizes	+
		Higher education levels	-
		Higher income levels	+
		Region (Ascending South in Alberta, Canada)	-
		High frequency of previous experience with frost	+
		Social pressure from neighbors to adopt	+

A study by Cary and Wilkinson (1997) examining adoption of conservation technologies by Australian producers found that future expectations of the profitability from the technologies examined were an important factor in adoption. Further, they found that attitudes about the environment did not have a significant affect by themselves on adoption decisions. They quote:

> "The finding that environmental orientation or concern about an environmental problem had no observable effect on the decision to plant trees…suggests that pro-environmental attitudes will not translate into pro-environmental behaviour unless there are economic or other benefits associated with the behaviour."
>
> (pg. 19)

The Cary and Wilkinson (1997) study concerns Australian agriculture but provides insight into possible producer behavior when considering the adoption of new winter wheat varieties. The assertion that profitability is the most important factor in conservation technology adoption is consistent with other studies in this field (Griliches, 1957; Saltiel, Bauder, and Palakovich, 1994) but contradicts Lynne, Shonkwiler and Rola (1988). Cary and Wilkinson (1997) provide insight by implying that conservation technologies may be desirable to producers but also need to be profitable or have some other benefit.

The previous literature on conservation and general agricultural technology adoption reveals a wide range of motivations for adoption including economic, conservation attitudes, lifestyle, social, demographic, institutional, and attributes of the innovation. This range of factors is broad but can be focused toward the context of the technology in question. Conservation studies tend to focus on the economic, conservation attitudes and social factors more than the other drivers. Crop variety studies tend to focus on the variety attributes and economic factors. Keeping this insight in mind, it should be relatively straightforward to adapt these categories to the issue of a tradeoff between profit and stewardship in a new winter wheat variety adoption context.

2.3 Profit – Environmental Stewardship Tradeoff Literature

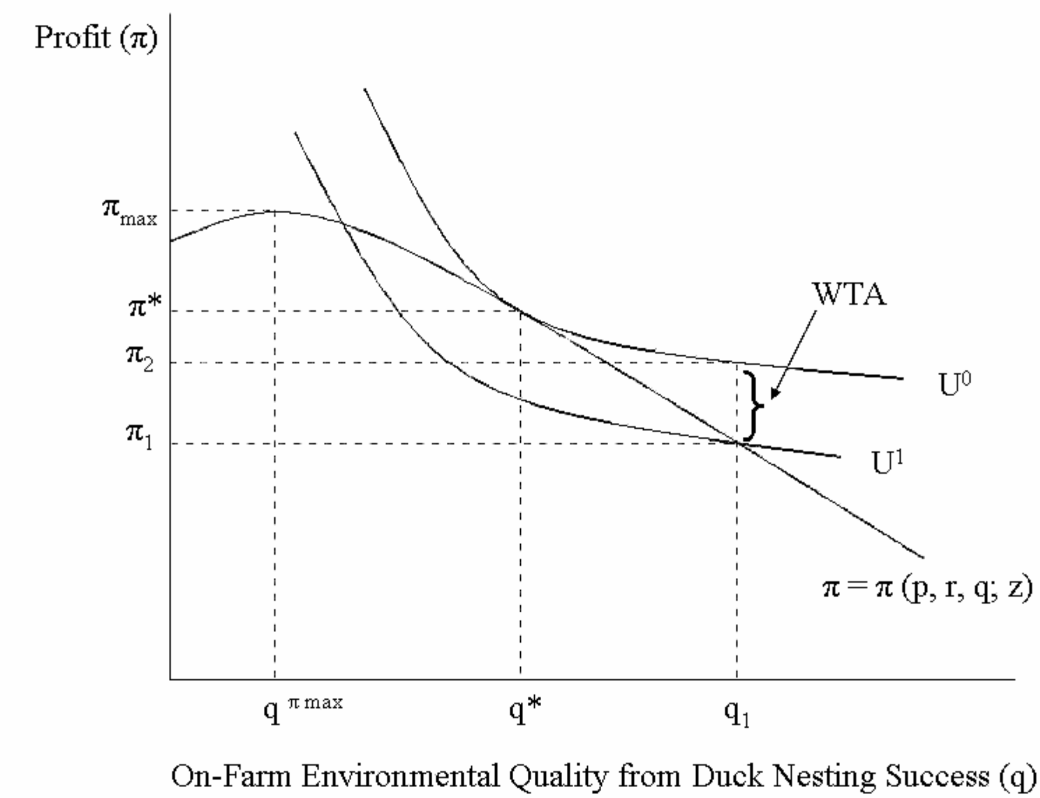
Amongst the literature concerning tradeoffs between environmentally positive outcomes and profits there is an inherent implication that profit, or some measure of welfare must be given up to be environmentally friendly (Chouinard *et al.*, 2008 and Van Kooten, Weisensel and Chinthammit, 1990). It has also been suggested that some producers will adopt environmentally friendly practices without payment (Cooper and Keim, 1996). These findings and implications suggest that some utility is gained from environmentally friendly farming practices, and hint at a convex utility function between profit and environmental quality. Norton, Phipps and Fletcher (1994) outline the decision between profit and environmental quality with regard to agricultural non point pollution reducing technologies. Figure 2.2 shows the process adapted to the context of winter wheat and duck nesting success improvements. The adapted process is as follows:

The producer maximizes a utility function that includes profit (π), environmental quality arising from duck nesting success (q), and a vector of socio-economic characteristics specific to the individual producer (S) subject to a profit function including output price (p), input price (r), duck nesting success (q), and a vector of farm specific factors such as weather and field type (Z) .

Maximize: $U = U(\pi, q; S)$

Subject To: $\pi = \pi(p, r, q; Z)$

Figure 2.2 Producer Willingness to Accept (WTA) for Duck Nesting Success Improvements



(Adapted from Norton, Phipps and Fletcher, 1994)

Figure 2.2 shows the optimal tradeoff between profit and duck nesting success at q* and π* where utility is maximized (U^0) along the profit curve that is decreasing in nesting success. In this case, the producer is willing to forgo profits equal to π_{max} - π* to increase nesting success from $q^{\pi max}$ to q*. q_1 represents a potential policy or societal target for duck nesting success. In this scenario the target is greater than the producer's optimal level for nesting success and a decrease in utility results from moving the isoutility line from U^0 to U^1. In order to bring the producer back to the original utility level a transfer equal to $\pi_2 - \pi_1$ needs to be made. This amount represents the producer's willingness to accept (WTA) payment for the loss in profit caused by an increase in duck nesting success. It is interesting to note that the WTA in this example ($\pi_2 - \pi_1$) is less than the profit lost from increasing the nesting success ($\pi^* - \pi_1$) indicating that the producer is still willing to trade some profit for duck nesting success to the right of the point q*. This may not always be the case if the profit function is shaped differently but this example from Norton, Phipps and Fletcher (1994) provides a nice background for understanding the tradeoff between profits and environmentally positive outcomes.

Etzioni (1986) augments Sen's (1977) earlier discussion about utility making a case for multiple utility. Etzioni spearheads the inclusion of a moral element of utility by arguing that traditional models are "too parsimonious" (p.159) in its omission. This is done through logical arguments and proof of its existence by citing studies that deal with altruism and moral behavior. For instance, Etzioni highlights a study from Hornstein, Fisch and Holmes (1968) that looks at cases of lost wallets where people act in a traditionally "irrational" fashion by returning the wallet at a loss with no apparent benefit to them. This action is explained through the existence of an intrinsic moral element where the person is enjoying doing the right thing or feeling some obligation to do the right thing. Etzioni makes the same argument about the irreducibility of moral behavior into a single utility component as Sen (1977) does with the social element.

Chouinard *et al.*, (2008) takes this idea of multiple utility and applies it to a profit-stewardship tradeoff decision. They use both self and social interests as utility components in the study. One is based on the Sen's (1977) self interested utility and labeled e-utility for ego. The other is a Sen (1977)-Etzioni (1986) hybrid based on social and moral interests and called the s-utility for social or steward. The Contingent Valuation Method (CVM) is employed (single bounded approach as in Bishop and Heberlein, (1979)) to measure the willingness to pay (WTP) for stewardship. They find a median WTP of $4.52 per acre for a given conservation technology indicating a positive willingness to forego profits for environmental stewardship. Moreover, three main types of producers are identified from the results. The first only considers profit when making a decision, the second considers profits but includes self benefiting environmental effects, and the third is one with both self and social interests in mind when considering a conservation technology. This study implies that profit is always a concern for the producer but the environment and social considerations are also important for a segment of producers.

Utility was also examined by Van Kooten (1990) to measure the tradeoff between net returns and soil quality. An underlying utility function comprised of monetary and soil quality attributes is used to obtain a marginal rate of substitution (MRS) between returns and soil conservation. The MRS is then equated to the marginal rate of transformation (MRT) of a soil conservation production function to obtain an equilibrium amount of soil conservation. He finds that tradeoffs for soil conservation are profit motivated when the soil is shallow and conservation motivated where the topsoil is deeper. The rationale is that with a decreasing return to soil quality, the impact on the quality of soil when topsoil is lost is less when it is deeper. The study finds that a large utility weighting on soil conservation is needed to induce change unless transfer payments are present and inducing conservation.

van Kooten (1992) examines the weighting of moral suasion and economic incentives with regards to participation in the North American Waterfowl Management Plan (NAWMP).   The Prairie Pothole Project (PPP) to conserve waterfowl habitat consisted of both a transfer payment and moral suasion element. It was found that the moral suasion element was useful but not as a substitute for economic incentives when preserving waterfowl habitat.

Cooper and Keim (1996) used the CVM method to determine the willingness to accept transfer payments to adopt several conservation practices including legume crediting (planting legumes in a crop rotation to add nitrogen to the soil) and integrated pest management (uses a wide range of complementary methods to control weeds and pests). Different levels of transfer payments were tested to obtain a supply curve for the conservation practices in question. A fairly linear relationship between payments and adoption percentages was found with an origin above zero, indicating a positive adoption rate without offering transfer payments. In fact, anywhere from 12 to 20% of producers would adopt these practices without payment, which means that they are either profitable or there is some other factor such as an intrinsic value for the environment driving their decision.

Cooper (1997) undertook another study that tests the CVM method by combining actual data with contingent behavior data to add information to the regression model of the adoption of water quality conservation practices. This study essentially tries to improve the methods used in his 1996 analysis and uses four of the five conservation practices used in the previous study. Adoption in the combined model was higher than with the CVM method alone suggesting overestimation of WTA and consequently higher than needed transfer payments using the CVM alone.

Cooper (2003) again improves upon his methodology in the aforementioned studies. This time ten choices are modeled simultaneously to predict the adoption of different bundles of conservation practices that may be adopted. He finds that bundles of best management practices (BMP) may lower the WTA transfer payments and in turn the costs of conservation programs and increase the efficiency of conservation in general.

Willingness to pay for wildlife conservation was examined by Philip and MacMillan (2005). A market stall CVM method is used where respondents are given time to think about their WTP answers and why they are willing to pay that amount. The method is used to uncover the underlying motivations for conservation decisions more effectively than a typical CVM analysis. A positive WTP for wildlife conservation projects by the general public was found.

Useche, Barham and Foltz (2005) also found WTP estimates for GM crop adoption using a multinomial logit model. A $0.60/acre WTP for higher input costs to reduce insecticide use and $0.11/acre for reduced herbicide usage on corn were the estimates found. These figures hardly counter the savings they offer on labor which was valued at $1.93/acre by the producer if one less worker can be hired. Even though the WTP for conservation practices in this case is rather low, it is positive and indicates that producers are willing to give up at least some profit for stewardship decisions.

Following Kahneman and Tversky's (1979) work on loss aversion where a higher value is placed on losses than gains by individuals, Boyce *et al.* (1992) conducted a study on the disparity between WTA and WTP measures. The study found that the WTA payment for a small pine tree was greater than the WTP. The higher value placed on the tree by the seller than the buyer was thought to indicate an intrinsic value held by the steward of the tree. If the respondents believed that the tree was going to be killed when sold or if not purchased, then the WTP and WTA were higher because of what the authors deemed a "moral" element or an intrinsic, non financial value.

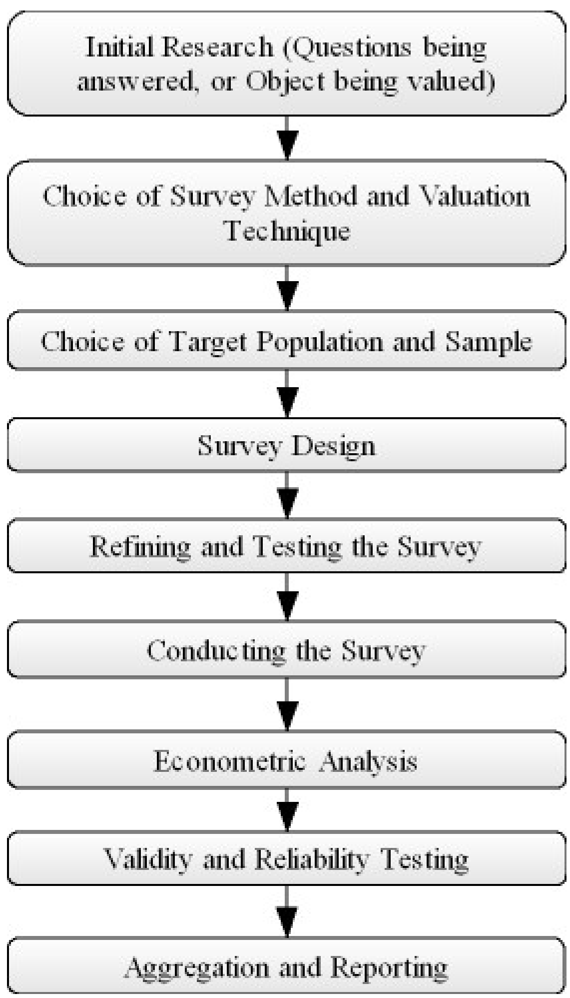
Another examination of the gap between WTA and WTP was done by Anderson, Vandjal, and Uhlin (2000) comparing eco friendly eggs to normal ones. For eco-friendly eggs the WTA was 1.5 times greater than WTP but for normal eggs the two measures were essentially the same. The difference seen in eco-friendly eggs was attributed to an intrinsic value for the welfare of the laying hens and the environment. The disparity between WTA and WTP seen in Anderson, Vandjal, and Uhlin (2000) and Boyce *et al.* (1992) points to a stewardship motive for making decisions based on Etzioni's (1986) moral element of utility.

The literature surrounding the profit-stewardship tradeoff reveals a complex process involving factors such as beliefs, attitudes, profits, social surroundings, and environmental endowments. Previous studies suggest that there is a willingness by segments of a target group to conserve environmental assets voluntarily because of an intrinsic utility element, overshadowed by a larger more prolific profit motive. A bigger picture of how conservation adoption can be motivated emerges where some producers may be willing to trade some profit for environmental conservation but may need another source of motivation such as transfer payments or technologies that not only increase conservation but profit as well.

Chapter 3: Methodology

Design of the data collection and ensuing analysis closely follows the general outline found in Pearce *et al.* (2002), a document prepared for the Department for Transport, Local Government and the Regions in London, England. It targets policymakers conducting stated preference (SP) studies with the goal of providing an up to date guide on how to conduct an SP study from start to finish. The document provided a structured guide for designing the study (Figure 3.1).

Figure 3.1 Flowchart of Suggested Steps to take when devising a stated preference survey from the Pearce *et al.* (2002) summary guide



(Adapted from: Pearce, 2002: pg. 28)

3.1 Revealed vs. Stated Choice Methods

Stated preference (SP) data were chosen for this study for a number of reasons that are highlighted by Hensher, Rose and Greene (2005). Revealed preference (RP) data is recovered from actual choices made in a market whereas SP data is gathered from hypothetical decisions that respondents make regarding possible choices. Both have benefits and drawbacks discussed in detail in Hensher, Rose and Greene (2005).

The first and most important factor for choosing SP methods is the lack of RP data due to the hypothetical nature of the study. This study focuses on future winter wheat varieties that have not currently been developed or marketed. SP is one approach to determine how much these hypothetical varieties will be demanded in the future. RP data concerning producer adoption of current hypothetical varieties may be available in the future only if the varieties are produced but at present, due to the limitations of RP, a SP approach is used for this study.

Another reason for employing SP over RP methods is the existence of farm level knowledge about the winter wheat attributes in question. The potential for realistic attribute level ranges in this study help to make the choices as close to reality as possible.

It has been shown that combining RP and SP data yields some benefits in analyzing choices (Adamowicz, Louviere and Williams, 1994). RP is possibly more accurate and less biased than SP because it is based on actual market decisions (Hensher, Rose and Greene 2005). Despite the benefits of RP it is not used in this case because the varieties in question do not currently exist.

3.2 Valuation Technique

The evaluation method and data requirements for this study were based on the objectives outlined in the introduction. The first being a determination of producer value for the cold tolerance and duck nesting success trait to assess whether willingness to trade profits for waterfowl habitat exists. The second is general drivers and barriers to winter wheat adoption and expansion and lastly, to rank possible crop attributes in order of desirability. The latter objective is less complex than the first and will be discussed in the survey design portion of this chapter.

The first objective required careful examination of which evaluation technique was most useful in this situation. To determine if a value exists for cold tolerance and duck nesting success in winter wheat a stated preference, contingent valuation method was chosen to elicit valuation responses. The contingent valuation (CV) method was chosen over the choice modeling (CM) method because it was the most parsimonious option.

Although CM has advantages for including a larger number of variables and reduces the "yea saying" effect where respondents give false positive answers (Pearce *et al.*, 2002), CV was ultimately chosen for a number of reasons. The first being a limited number of attributes in question which reduced the need for a more complex method. Another was that details of the possible new varieties and agronomics surrounding winter wheat were readily available or previously known. This made it possible to estimate the range of attribute levels with a high degree of accuracy so open ended questions were not as necessary in this case. A detailed discussion of the choice between CM and CV as elicitation techniques can be found in Pearce *et al.* (2002, p30-34).

3.3 Econometric Model

The choice of econometric model in this case depended on numerous factors concerning the structure of the study and the availability of data. Respondents were asked to choose between planting some of a new hypothetical winter wheat variety or keeping the spring wheat they already plant. If some of the winter wheat was chosen, they were then asked how many acres they thought they would plant. The result was a two stage process with a binary adoption/expansion decision in the first stage preceding a second stage intensity decision. A number of models exist which deal with a two stage decision making process.

The discrete dichotomous choice contingent valuation method used in the study is based on the utility of respondents in regards to new winter wheat varieties. Utility in this case is indirect because it is based on gross profit (I), a measure of income. As outlined in Grafton *et al.* (2004), utility (U) in this case consists of two components. The first (V) is a nonrandom component and the second (ε) is random. The random component means that utility can be only partially observed through survey questions. Grafton *et al.* (2004) represents the utility of the respondent as $U_i = V_i + \varepsilon_i$ where the subscript in V_i is conditional on the choice made (1=yes and 0=no). If the producer chooses to adopt the new variety, then $V_1 = V(I + \$B,1)$ where B is the increase or decrease in gross profit compared to spring wheat that increases or decreases income. If adoption or expansion is not chosen then utility is represented as $V_0 = V(I,0)$. (Grafton *et al.*, 2004)

A single stage binary choice model (Probit) was considered but lacks the ability to use the data from the second decision stage and may be considered inefficient in this case. The remaining possibilities all use the data available albeit in slightly different ways. The Tobit model (Tobin, 1958) uses all the available information, but employs a single stage approach which assumes the underlying factors in each stage are identical. In this research the adoption/expansion decision by producers was predicted to have different determinants than the acreage decision.

Cragg's double-hurdle model (Cragg, 1971) and Heckman's two stage selection model (Heckman, 1979) both use a two stage process that allows the set of independent variables to differ between stages. However, the Heckman model uses a corrected regression in the second stage to deal with possible selection bias in the sample. In this case a selection bias was suspected in the demographics of farm size due to convenience sampling but data for the entire target population that closely matched the survey sample data were unavailable and making the assumption of bias was considered too aggressive. These factors indicate that a Cragg model is the appropriate choice for the empirical needs of this study.

The Cragg model approach uses a Probit for the first stage and a truncated regression for the second. A general expression for Cragg's double-hurdle model as in Greene (2003, pp. 759-770), executed by Umberger, Boxall and Lacy (2009) follows:

The decision equation:

$\text{Prob}[\, y^* > 0\,] = \Phi(\gamma' z)$, Equation (3.3)

$\text{Prob}[\, y^* \leq 0\,] = 1 - \Phi(\gamma' z)$, Equation (3.4)

Where the standard normal distribution, $\Phi(\gamma' z)$, depends on

γ', a set of independent factors and z, a vector similar to the coefficients found in the tobit model (if $z = \beta / \sigma$ a tobit model results). This distribution determines the probability that the latent variable $y^* > 0$

If $y^* > 0$, then the regression in $\beta' x$ is truncated at 0

The latent variable is expressed as:

$y^* = x_i'\beta + \varepsilon_i$ where $\varepsilon_i \sim$ i.i.d. N(0, σ^2) Equation (3.5)

The observed data are represented as:

$y_i = y^*_i$ if $y^*_i > 0$ Equation (3.6)

$y_i = 0$ if $y^*_i \leq 0$ Equation (3.7)

The first stage probit, a decision to expand or adopt some winter wheat acres, can be represented by:

$D = \alpha_1 + \alpha_2 Z_1 + v$ Equation (3.8)

The second stage truncated regression, represented by the decision of how many acres of winter wheat to plant can be denoted by:

$W = \beta_1 + \beta_2 X_1 + \mu$ Equation (3.9)

Variable D is a zero-one variable set equal to one if the producer decides to switch some spring wheat acres to winter wheat. D=1 if y^*>0, otherwise D=0. W is the number of acres of winter wheat switched to. W is only observed if D=1, or y^*>0. The latent variable in the first stage is represented by y^*. Z and X are vectors of independent variables while v and μ are randomly distributed error terms. If Z = X and $v = \mu$, the Tobit model results, however if Z ≠ X and hence $v \neq \mu$, the Cragg model consisting of a Probit model in the first stage and and a truncated normal regression in the second is more appropriate. The model parameters are estimated in Limdep using Maximum Likelihood procedures.

3.4 Factor Analysis

When analyzing the possible future attributes of winter wheat varieties that producers rated on a scale of 1 to 5 (1 = Would not like to see at all, 5 = Would like to see very much), a method to determine if there were any latent factors behind the ratings that explained general demand patterns was desired. The existence of any clear patterns among attributes could point to the demand for certain groups of attributes or at least allow for greater generalization of attribute demand. Two options exist that would accomplish this goal. The first is principal component analysis (PCA) and the second is factor analysis. Although the two methods have been cited as interchangeable (Velicer and Jackson, 1990) a factor analysis was chosen due to Widaman's (1993) assertion that factor analysis is more useful than PCA for the interpretation of relationships between variables due to latent factors which is the goal in this case.

Essentially, factor analysis explains the variance in a set of variables through identifying a set of random underlying and unobserved common factors (Jobson, 1992). For each factor, loadings (weights) are placed on each variable in the set to determine a factor score for each individual respondent in the sample. The factor loadings determine the extent of the association of each variable to the underlying factor. Describing the underlying factors can be problematic if no clear pattern is evident in the factor loadings but can be useful in making generalizations about the demand for attributes and for reducing the amount of data. (Jobson, 1992). Jobson (1992 p.389,390) outlines common factor analysis as follows:

The common factor analysis model is given by the equation:

$$(R_i - \mu_i) = \alpha_{i1}F_1 + \alpha_{i2}F_2 + ... + \alpha_{ir}F_r + U_i \qquad \text{Equation (3.1)}$$

Where:

R_i = A vector (p * 1) of variables or questions to be analyzed with a mean vector μ

α_{ir} = Factor loadings for the i^{th} variable (X) and the r^{th} factor (F)

F_r = A set (r * 1) of latent variables called common factors

U_i = A set of unobservable error terms called unique factors

The variance in X_i is given by:

$$\sigma_i^2 = \sum_{j=1}^{r} \alpha_{ir}^2 + \sigma_{ui}^2 \qquad \text{Equation (3.2)}$$

Where $\sum_{j=1}^{r} \alpha_{ir}^2$ is the *communality,* or the variance in R_i explained by the common factors and σ_{ui}^2 is the *unique variance,* or the variance in R_i explained by the unobservable factors.

To determine the number of factors used in the analysis Jobson (1992, p.394) points out that the factor must be able to explain at least as much variance as a single variable. A factor is deemed more explanatory than a single variable if it's eigenvalue is greater than 1. An alternative to the eigenvalue criterion for which factors to include is the scree test where the eigenvalues are plotted against the factor number in ascending order. This graph normally takes the shape of an elbow. Factors up and to the left of the initial curve of the elbow are kept in the analysis. (Jobson, 1992)

3.5 Choice of Target Population and Sample

The target population was very straightforward to determine. Since the goal was determining producer attitudes and values on the Prairies regarding new winter wheat varieties, the target population was the entire population of wheat producers on the Prairies. From Canadian Agricultural Census data there were 43,435 farms that produced wheat on the prairies in 2006 (Table 3.1).

Table 3.1 Number of Wheat Producing Farms on the Prairies in 2006

	# of Wheat Farms
Alberta	11,791
Saskatchewan	24,488
Manitoba	7,156
Prairies	**43,435**

(Source: Statistics Canada, 2009a)

The sampling method was less straightforward to determine. Although a simple random sample may have produced higher quality data a tradeoff exists between quality and financial and time requirements. This tradeoff led to the choice of a convenience based sampling technique that provided the best possible data within the budget constraints. The convenience sample consisted of producers who attended farm shows and meetings from late November 2008 until mid February 2009. It should be noted that a bias due to the convenience sampling was expected before implementing the survey but was thought of as an acceptable consequence of lowering the costs of data collection.

It is difficult to determine a typical farm show attendee because a wide variety of producers attend these shows. However, at farm shows in general there may be attendance by larger producers with higher incomes. McCorkle (2007) found that respondents from a survey conducted at farm shows in Alberta had larger farms, higher incomes and higher levels of education than average. A possible explanation might be that farm shows attract producers who are searching for information and are more engaged in general than other producers. This category of producers may be more motivated to attend because of a possible economic advantage. A higher level of income might mean that they are in a position to purchase machinery that is often showcased at these types of events.

A drawback from the convenience sampling technique is the possibility that the geographic location of respondents is not evenly distributed. Some regions may not be represented according to their size and in some cases may not be represented at all. This drawback is important because of the regional variations in growing conditions and crop rotations in Western Canada. Some of this information may be missed with this sampling approach.

3.5.1 Sample Size

Pearce *et al.* (2002) provides a recommendation as to what the sample size should be for a stated preference study. Based on the target population size of about 44,000 and a 95% confidence interval for the accuracy of the sample compared to the target population they recommend that anywhere from 246 to 256 respondents be surveyed. This suggestion assumes that the respondent makes only one choice with regard to adoption of winter wheat. Pearce *et al.* (2002) also clarifies that if more choices are made per respondent, the sample size may be shrunk. In this study respondents will make four choices per survey so the sample may not need to be as high as the suggested range.

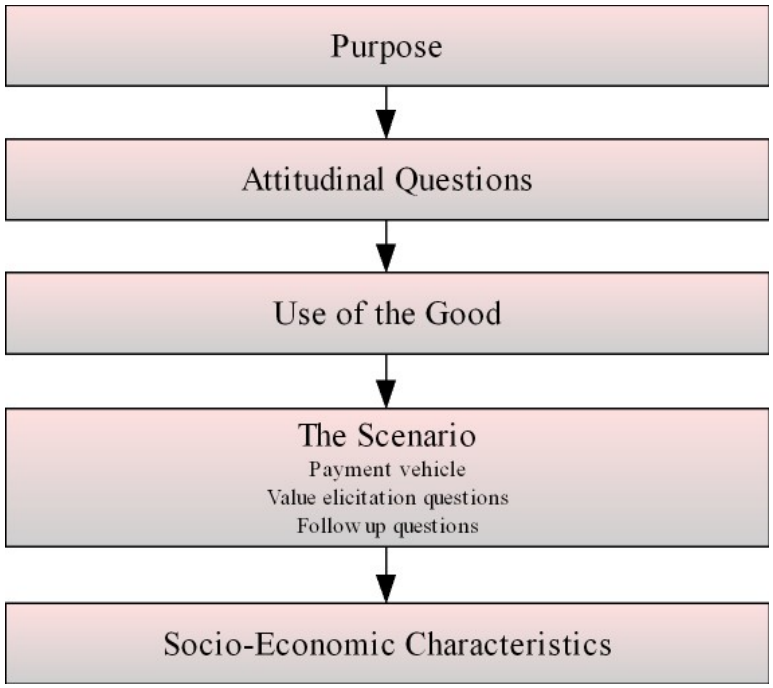
A range of sample sizes exists in the literature. Chouinard *et al.* (2008) surveyed 29 respondents out of a sample frame of 200. The survey from the Chouinard *et al.* (2008) study included 7 different choice questions per respondent. Cary and Wilkinson (1997) gathered 111 respondents for a study on conservation adoption decisions however the target population was only 329. 370 usable surveys were collected for a study by Smith and Baquet (1996) about the demand for multiple peril crop insurance in Montana. The Smith and Baquet (1996) study used a two stage model as well but the data were collected from questions incorporated into the Montana Farm and Ranch Annual Survey and cost of collection may not have been a significant concern.

The literature highlights a range of sample sizes for similar studies and models to this one. The approach toward sample size will be to survey producers until either enough are collected to run a usable econometric model or when the number recommended by Pearce *et al.* (2002) is reached. The target sample size to meet the Pearce et al. (2002) suggested guidelines would be in the range of 200 surveys. Also, a goal of the survey collection is to gain enough respondents from each Prairie province to estimate usable distinctions between the provincial respondents.

3.6 Survey Design

The survey format generally follows that found in Pearce *et al.* (2002, p47-53), an outline for CV survey design. The elements and their order that are suggested can be seen in Figure 3.2. A purpose for the study was put forward in the introduction to winter wheat and the prairie pothole region section of the survey. Attitudinal questions are seen with drivers and barriers to adoption and use of the good falls in line with the farm characteristics questions. The scenario was covered by the choice questions and lastly, the socio-economic characteristics were included in the demographics sections. The order followed was not exactly as suggested but followed the same general flow and structure.

Figure 3.2. Suggested Structure for a CV Survey



(Adapted from Pearce *et al.*, 2002)

3.6.1 Overview

There are a large combination of forms a stated preference questionnaire can take (Adamowicz, Louviere and Swait, 1998). An in-person paper and pencil survey was chosen for this study based on cost and quality concerns, and knowledge about the target population of producers. It was postulated that crop producers on the prairies generally receive a large number of survey requests (later backed up consistently by respondents who were concerned about this issue), and may not have internet access in rural areas. An in person survey was projected to have the best response rate and reception from producers because of personal contact. The presence of a surveyor allowed informal personal communication about the producer's experiences with winter wheat and issues that were possibly not captured by the survey which is helpful in putting the survey responses in context. A paper version also circumvented the lack of high speed internet connectivity on some parts of the Prairies. This method seemed to make the most sense when trying to make the connection with the target population and was relatively easy to build compared to an internet based survey.

The survey distribution method was tied to the "in person" aspect of the survey. It was assumed that mail outs, E-mail requests, and telephone surveys all had lower potential response rates compared to an in person method which led to the choice of surveying at farm shows and producer meetings. Another reason these venues were chosen was that a large number of potential respondents would be in the same place, sometimes for a number of days. This made travel easier for both respondents and the interviewer and lowered the costs of travel conduction relative to going door to door or meeting individually with producers in a central location.

Later in the survey collection process respondents were given the chance to take a survey home and mail it back via an included addressed and stamped envelope. This option was in response to the support of Carlene Van Brabant, a Member Coordinator with the Farm Leadership Council (FLC) in survey distribution and was not part of the original plan. The stamped and addressed envelopes allowed the FLC to distribute the survey in multiple provinces at farm shows and producer meetings without the need to collect them after completion.

3.6.2 Initial Consultation

Before the first version of the survey instrument was drafted, experts in the field of winter wheat and crop production in general were consulted about the specifics of winter wheat production. It was important to have comprehensive background knowledge about winter wheat in order to come up with a survey that had a good foundation to glean useful and accurate information. The first meeting was with Paul Thoroughgood, a Ducks Unlimited Agrologist, and wheat producer from southern Saskatchewan. He provided information on the benefits and costs of growing winter wheat both agronomically and environmentally.

Three wheat producers from Alberta were also interviewed about the challenges and successes of their experience with winter wheat (or lack thereof if they did not grow it). Large variations in culture, farm size, experience with winter wheat and location were targeted when talking to producers at the outset to try and get a good range of ideas. One was from the Grande Prairie area, another from Central Alberta, and the last from the Lethbridge area. Questions were asked about why they grew the crop (or not), what they liked or disliked about it, if they were concerned about waterfowl and what they would like to see in new varieties. In hindsight the answers given in these preliminary sessions foreshadowed the results from the survey data quite accurately.

The opportunity to visit Lethbridge for some initial consultation arose from an invitation from Bill McGregor, a weed scientist and head of the Alberta crop protection research with Dow Agrosciences, to do some winter wheat spraying as part of an industrial research program. Dr. McGregor travels throughout Alberta on a regular basis and keeps in touch with colleagues from other provinces about agronomic and environmental details regarding winter wheat which provided perspective about the differences between the provinces. While in Lethbridge another opportunity arose to consult with Dale Steele, a crop protection sales representative who has a rich background with winter wheat production in Southern Alberta. He provided information on what he thought were the main drivers and barriers to winter wheat production as well as provide introductions to a few producers in the area to briefly talk about their experiences with the crop.

3.6.3 Focus Groups

Three focus groups were undertaken to refine the survey. The first included ten students from the department of Rural Economy and the faculty of Agriculture Life and Environmental Sciences who had a basic knowledge of crop production and survey design. Pizza was provided for the hour and a half participation requirement. The purpose of this session was to roughly pare down the survey and focus on the main questions being asked. Many questions were taken out, some were added, and wording was greatly improved at this stage. The information section at the front of the survey was also revised for better flow.

The second group was held with eight graduate students but this time they were exclusively from crop producing farm backgrounds. A pizza lunch was provided for the hour and a half participation requirement as with the first focus group. This session provided valuable insight into what producers might think of the survey because of the close connection participants had with crop production. More technical details were discussed in this round such as drivers and barriers to production, and what attribute levels were appropriate for the contingent valuation choice questions. The possible attributes of new winter wheat varieties were also improved through the addition of ones that were not initially considered. Wording of the questions was improved as well with the intention of reducing leading effects and bias.

The first two focus groups prepared the survey for the third and final session with nine producers from the area around Camrose, Alberta. A breakfast meeting was arranged at a local restaurant in a private room which provided a meeting place and some compensation for the participant's time (roughly \$10-\$15 each). The session lasted roughly an hour and a half and provided insight into how to word questions, what was important in the adoption/expansion decision for winter wheat, and what issues they had with the crop in the past as well as successes. Despite the depth of information that was gained from this focus group, the changes that needed to be made to the survey were minimal at this point which indicated that the survey was nearly finalized (Pearce *et al.*, 2002). A final draft was checked for errors, and the attribute levels were finalized so the survey could be printed off as a final version.

3.6.4 Final Survey Version

The final survey version had five sections and can be seen in appendix A. An information section about winter wheat, the prairie pothole region and waterfowl nesting success in spring seeded vs. fall seeded crops preceded the survey questions. The information section provided a background that ensured each respondent had at least a minimum level of information to base their decisions on in the survey. Survey questions can be broken down into three main groups. One group of questions asked about drivers and barriers of winter wheat adoption, another had choice questions about the adoption of hypothetical new varieties, and a third contained demographics and farm characteristic questions.

The drivers and barriers questions were separated by grower type into two parts ("Section 2: For Non Winter Wheat Growers", and "Section 3: For Winter Wheat Growers"). The first was for those who did not grow winter wheat and the second for those who did. The growers were asked why they grew winter wheat and what would be important to them if they were considering expanding their winter wheat acres onto spring wheat acres. The non growers were asked why they didn't grow winter wheat and what would be important to them if they were considering adopting some acres of winter wheat which would replace spring wheat acres.

The choice questions ("Section 4: A New Winter Variety") asked the respondent to make a decision to either adopt/expand or not adopt/expand a hypothetical new winter wheat variety based on three attributes: winter kill rate, gross profit, and the duck nesting success rate. They were asked to compare these hypothetical varieties with the most common spring wheat variety they grew and make a decision to displace some of these acres with the new variety or not. If they answered yes to adopting/expanding the new variety they were then asked how many acres they thought they would displace.

A factorial design was used for the choice questions. Three attributes, each with three levels (low, medium, and high) produced twenty seven different combinations. The combinations each represented a single question and were split up into seven versions resulting in four choice questions per survey version. Twenty seven is not divisible by four and has a remainder of one so a randomly selected combination was chosen to fill this gap in the last version in order to keep all versions the same. The seven versions were identical to each other except for the attribute levels in the choice questions. An example of the choice question is seen in Figure 3.3 and the attribute levels used can be viewed in Table 3.2.

Figure 3.3 Choice Question Scenario #1 from Version #1 of the Survey

Scenario #1

	A New Winter Wheat Variety	My Current Spring Wheat Variety
Complete Winter Loss Rate (Have to reseed in the spring)	1 in 20 yrs	0
Gross Profit (revenue - costs) compared to Spring Wheat	10% more	-
Number of successful duck nests per quarter (160 acres)	5	1

My decision would be to: (please check one)	Switch some acres to the new winter variety	Stick with my current spring variety
	☐	☐

If applicable, How many acres would you switch to winter wheat? ____________________

Table 3.2 Attributes and levels used in the factorial design of the choice questions

	Attribute Levels		
Attribute	Low	Medium	High
Winter kill rate (must reseed in the spring)	2%	10%	20%
Gross profit compared to spring wheat*	5% less	10% more	20% more
# Of succesful duck nests per 160 acres*	5	10	15

*Note: Gross Profit and Duck nesting success were compared with the respondent's most abundant current spring wheat variety

It should be noted that a WTA measure may be difficult to estimate because the payment vehicle in the choice questions are expressed as a percentage. The gross profit compared to spring wheat attribute is given as a percentage to make the calculation easily transferable between farms and regions. A producer from Vegreville, AB may have very different profit levels for spring wheat than a farmer in Weyburn, SK. In the case of these differences, this attribute expressed as constant dollar amounts is not practical.

Producer's own actual profit levels are not solicited in the survey because of the possibility of bias due to the sensitive nature of the question and the use of a paper and pencil survey prevents easy transfer of individual specific costs into the choice questions. Hence specific WTA values are not estimated.

Following the choice questions in section 4, respondents were asked to rate attributes that might be possible in new winter wheat varieties according to how much they would like to see them in a new future variety. This question was designed to gauge the priority of individual characteristics and possible groups of characteristics. In hindsight, the range and comprehensiveness of the attributes was good, however an environmental characteristic(s) was not included in the list. An oversight that could have given some useful information about producer willingness to make a tradeoff between profits and agronomically related attributes.

Demographics and farm characteristics were split up into two groups of questions. The first, ("Section 1. Your Crops") were general questions about total acres seeded, acres of different wheat varieties, fallowed area, and rented land. This section provided a non controversial segway into the drivers and barriers section. The second group of questions was at the end of the survey ("Section 5: You and Your Farm") and included general demographics, and environmental characteristics of the farm and the respondent. The last demographics section was located at the end of the survey to avoid any bias caused from possible sensitivities to these questions, although much effort went into making these questions as non controversial as possible.

3.6.5 Conducting the Survey

3.6.5.1 Data Collection Sites

Surveys were administered at numerous farm shows and meetings in Alberta, Saskatchewan and Manitoba. A breakdown of the number of surveys collected at each site is shown in Table 3.3. The list of survey sites in chronological order by province is as follows:

Alberta

- Nisku - The Direct Seeding Advantage conference held by Reduced Tillage Linkages (conference on direct seeding practices)
- Red Deer - Rock the Farm hosted by Future Agriculture Business Builders (leadership conference for younger producers and agricultural professionals)
- Edmonton - Farm Tech 2009 (large agricultural trade show)
- Kingman – Kingman Marketing Club meeting (monthly meeting for a producer marketing club in Kingman)

Saskatchewan

- Regina – the Canadian Western Agribition (large agricultural trade show)
- Saskatoon – Crop Production Show and Crop Production Week (large agricultural trade show and commodity group meetings)

Manitoba

- Brandon – Manitoba Ag Days (large agricultural trade show)

Table 3.3 Number of surveys for each collection site

Survey Site	Date	# from site	% of total
Reduced Tillage Linkages	Nov. 22-23, 2008	17	9%
Rock The Farm	Feb. 13-14, 2009	14	7%
Farm Tech	Jan. 28-30, 2009	33	17%
Kingman	Feb. 17, 2009	10	5%
Canadian Western Agribition	Nov. 24-30, 2008	56	29%
Crop Production Show/Week	Jan. 12-15, 2009	32	16%
Manitoba Ag Days	Jan 20-24, 2009	29	15%
Unknown		5	3%
Total		196	100%

3.6.5.2 Recruitment of Respondents

Surveys were conducted in a parallel fashion at each event to maintain consistency in the results however some differences existed in how the respondents were approached or recruited for participation. At the agricultural trade show events a booth was generally used as a base of operation. At the Canadian Western Agribition a booth was set up representing the University of Alberta showcasing some past research and some current programs offered in Agricultural and environmentally related disciplines. Producers browsing the booth were asked if they grew wheat and would care to fill out the survey for a Tim Horton's gift certificate with a value of either $2 or $4. The value of the gift certificates was changed midway through the survey process and is discussed in the next section (3.5.5.3 Participant Compensation).

The remaining large trade shows were treated in the same manner however partner-hosts were available for these events providing the use of their booth to operate from. Ducks Unlimited hosted the survey in Edmonton at Farm Tech, and Winter Cereals Canada provided space in their booth at Manitoba at Ag Days. The Farm Leadership Council also hosted the survey from a booth at Manitoba Ag Days, Farm

Tech, and the Crop Production Show in Saskatoon. These surveys were handed out to interested producers with a stamped envelope for return.

At smaller events where no booth was available, introductions by the host organization were relied on to make the connection with producers attending the show. At these events potential respondents were invited to complete a survey on their own time and return it before the event concluded. In the case of all the events large or small, the host organization was contacted for permission to attend and given full disclosure of the recruitment methods and information about the study including a copy of the survey. All surveys done in person were conducted by the researcher (myself) and no other third party was known to have conducted any of the surveys that were returned by mail.

3.6.5.3 Participant Compensation

Compensation in the form of Tim Horton's gift certificates was given to all respondents to recognize the time it took to complete the survey. Participants completing a survey at the Direct Seeding Advantage conference and Canadian Western Agribition trade show received $2 for their survey completion while respondents from all other survey sites received $4. The amount was modified because of feedback from numerous participants that the former number was too low and felt that it was not much better than zero compensation.

3.6.6 Summary

A contingent valuation study was chosen to examine the attitudes toward and value placed on new winter wheat variety attributes by wheat producers. An in person survey was conceived, tested through focus groups, refined and then conducted at farm shows and meetings on the Prairies to collect data from the target population of wheat producers in Western Canada. A summary analysis of producer attitudes toward winter wheat and an econometric model examining if values are placed on duck nesting habitat and cold tolerance are the outcomes desired from the survey instrument. The Cragg double-hurdle model was chosen because it utilizes both the adoption/expansion decision regarding a new hypothetical winter wheat variety and the amount of acres the producer indicated they would be willing to plant if they chose to adopt or expand their current winter wheat acreage. Factor analysis will also be performed on the winter wheat variety trait ranking questions to determine if there is a demand from producers for certain packages of attributes.

Chapter 4: Results and Discussion

This chapter is divided into two main categories, the first consisting of summary analysis from sections not directly pertaining to the econometric choice model and the second section focuses on the econometric model. The demographic results are compared with population data for variables that data exist for. Summary results include demographics and farm characteristics, drivers and barriers to winter wheat production, producer attribute rankings and a factor analysis of the attributes. The econometric model section includes a test between a single and two stage model, the analytical model results, and predictions of the model vs. actual survey answer. It should be noted that explicit welfare estimates were excluded from this analysis to make the scope more manageable but may be included in future research.

4.1 Comparison of the Survey Sample to the Entire Population

There were 194 respondents that completed a survey from Alberta, Saskatchewan, and Manitoba. 40% (77) were from Alberta, 43% (84) from Saskatchewan and 17% (33) were from Manitoba. Representation from Alberta and Saskatchewan was greater than Manitoba due to time and budget constraints.

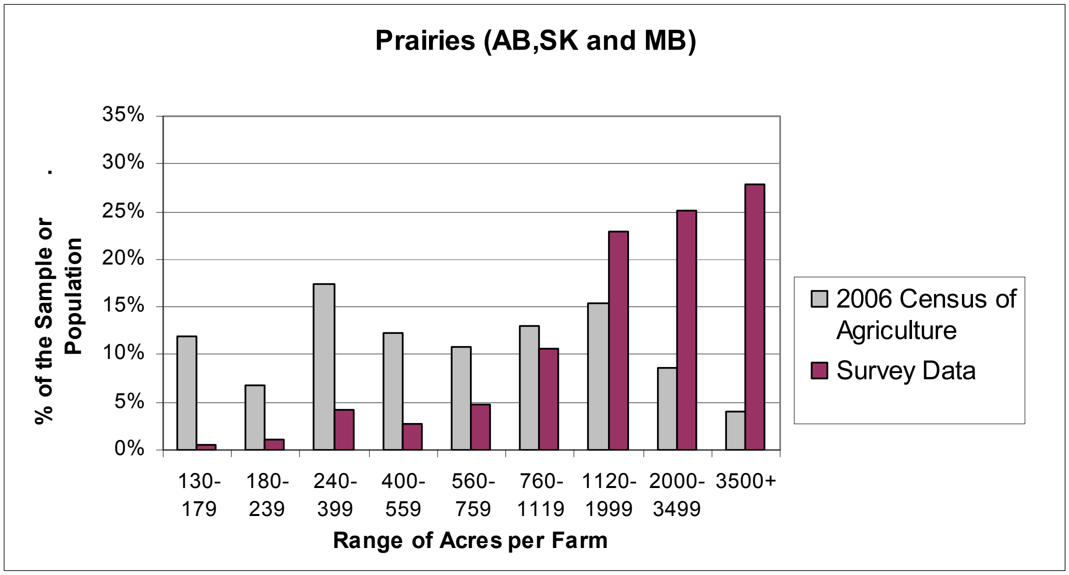
The convenience sampling technique used to collect data from the population held tradeoffs between levels of possible bias and ease of survey implementation. Comparing the survey data to data that represents the target population of all Prairie wheat growers should indicate potential biases in the Sample and ensuing results. The demographic parameters of importance to the adoption and expansion decision in the literature that the survey captures are: Attitudes about conservation (Lynne, Shonkwiler and Rola, 1988), farm size (Batte, Jones and Schnitkey, 1990; McCorkle, 2007; Saltiel, Bauder and Palakovich, 1994), and education (Batte, Jones and Schnitkey, 1990; McCorkle, 2007).

The relative differences in the data sets between these factors should indicate how representative the sample is of the target population.

It is also important that data from the population that closely matches the data from the survey sample be available. Of the aforementioned factors in the previous paragraph only farm size and wheat acre composition were readily available and similar enough to compare with the sample. Attitudes about conservation are hard to quantify and not included in the Census. Education levels are included in the Census however the scales used are different enough that an accurate comparison is not possible. Fortunately, the statistics on farm size including total seeded, fallowed, and wheat acres by type and province are readily available and easily compared with the survey data. Data from the 2006 census for wheat type and the CWB variety survey for 2008/09 are used to compare wheat acreages in the sample to the entire population.

Results of the comparison of population and sample data were in line with those expected from the convenience sampling technique. The sample from the survey has significantly higher average farm sizes than reported in the 2006 Census of Agriculture. Figure 4.1 shows the combined total crops seeded and fallowed acres for the acreage categories that are given in the census. Survey data from question 1 and 2 (Appendix A) are added and sorted according to the census categories for comparison. The most noticeable difference is seen between the modal scores. The mode of the census is the 240-399 acres range while the mode for the survey data is in the 3500+ acres category. The ranges used in the census may be responsible for the higher mode in the survey data as it treats everything above 3500 acres as one category. In either case the average seeded and fallowed acres are much higher in the sample than the entire population.

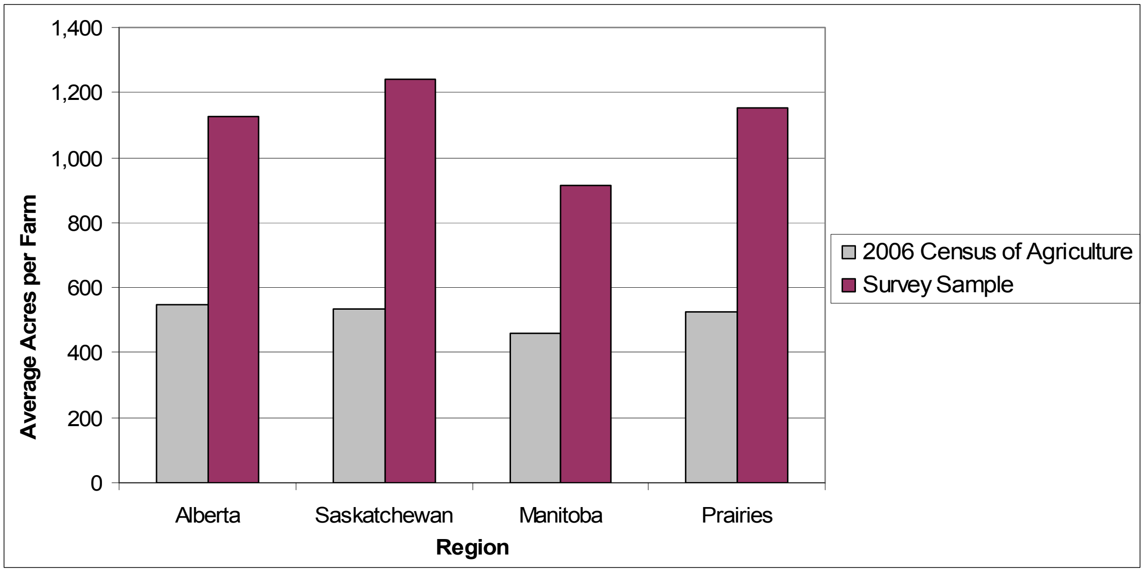
Figure 4.1 Histogram of Average Acres per Farm on the Prairies (2006 Census of Agriculture Compared with the Survey Sample)



(Data from: Statistics Canada, 2009a)

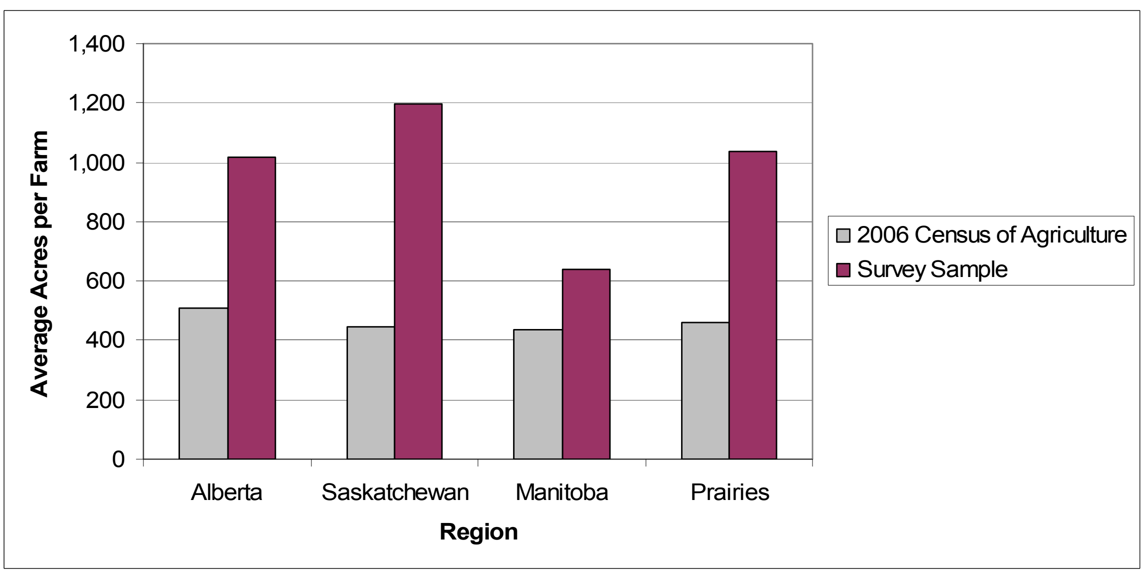
Figure 4.2 to 4.5 show differences between the sample and target population. 2006 Census data are used to compare the average acreage of wheat crops including total wheat seeded, spring wheat, winter wheat, and durum wheat. In order to maintain consistency between the sample and population data only data from producers who grew the specific crops are used because the same method is used in the census data tables. The census data is lower in every case except for durum wheat in Manitoba because none of the respondents surveyed in Manitoba grew durum. In many cases the average number of acres in the sample is at least twice as large as in the entire population.

Figure 4.2 Total Wheat Acres per Farm



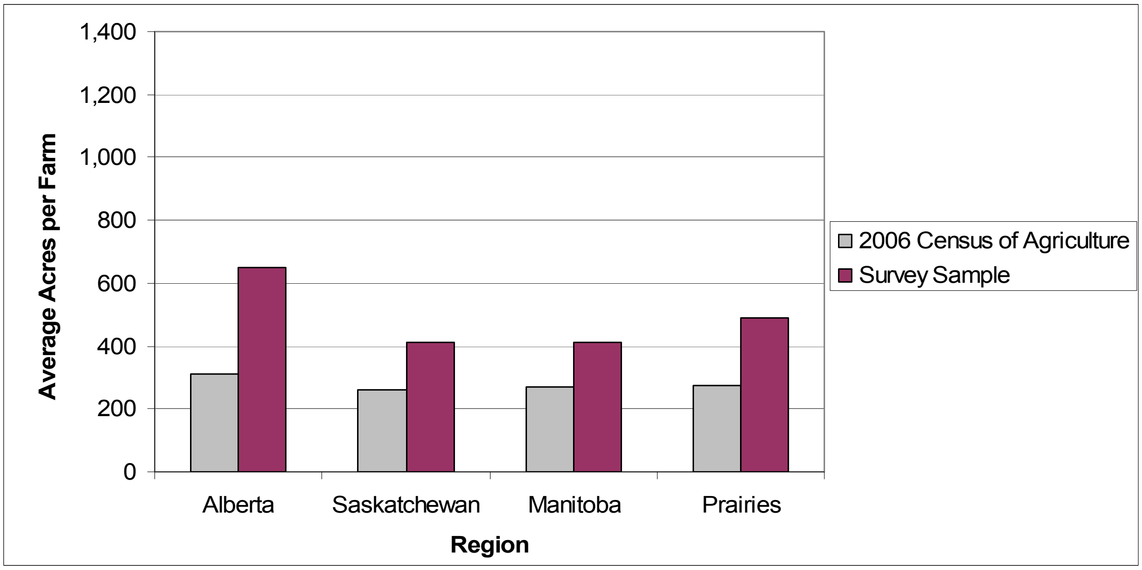
(Data from: Statistics Canada, 2009a)

Figure 4.3 All Spring Wheat Including Durum Acres per Farm (*includes only farms that grow spring wheat including durum*)



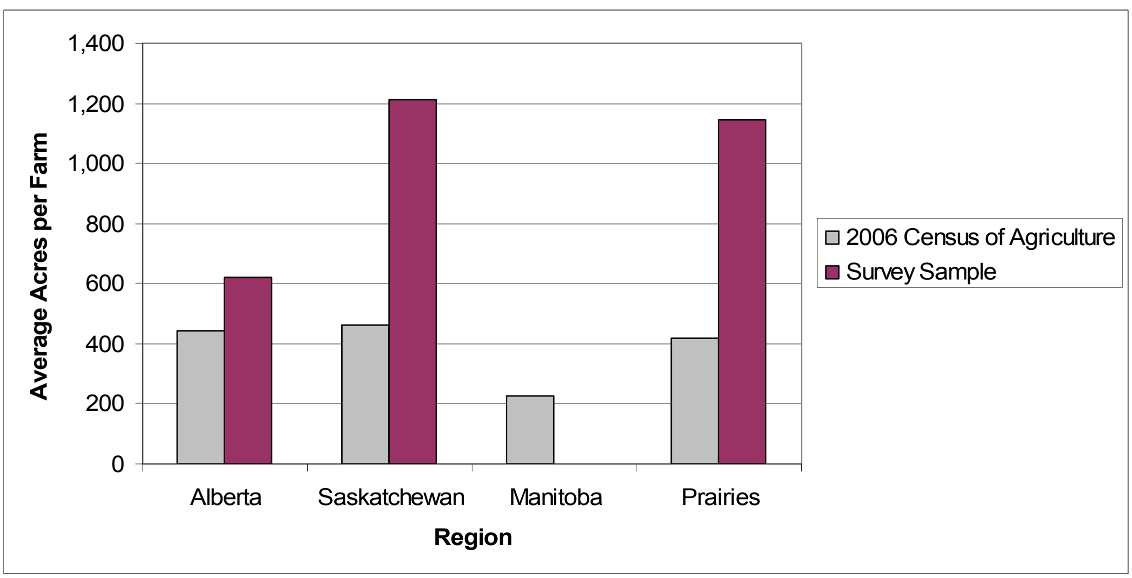
(Data from: Statistics Canada, 2009a)

Figure 4.4 Winter Wheat Acres per Farm (*includes only farms that grow winter wheat*)



(Data from: Statistics Canada, 2009a)

Figure 4.5 Durum Wheat Acres per Farm (*includes only farms that grow durum wheat*)



(Data from: Statistics Canada, 2009a)

A comparison between the relative composition of wheat types between the sample and entire population should separate the scale of farms from the wheat types. Differences here could point out bias in the types of wheat farms that were surveyed. Data from the 2006 Canadian census of agriculture as well as the 2008/2009 CWB variety survey were both used because both are readily available and match the survey data well. Tables 4.1 through 4.4 show the percentage composition of different wheat types on the prairies and by province from the three sources of comparison.

Table 4.1 Prairie Wheat Crop Composition by Type (Includes AB, SK, and MB)

Variety	Statistics Canada	CWB Variety Survey	Survey Sample
HRS	63.6%	61.9%	57.0%
Durum	27.0%	26.5%	22.6%
Winter Wheat	5.6%	6.6%	12.5%
CPS	3.8%	2.8%	7.8%
Other		2.3%	

(Data from: Statistics Canada, 2009a; Canadian Wheat Board, 2009a)

Table 4.2 Alberta Wheat Crop Composition by Type

Variety	Statistics Canada	CWB Variety Survey	Survey Sample
HRS	74.0%	70.5%	71.0%
Durum	13.9%	16.4%	3.6%
Winter Wheat	4.8%	5.9%	13.4%
CPS	7.3%	5.8%	12.1%
Other		1.4%	

(Data from: Statistics Canada, 2009a; Canadian Wheat Board, 2009a)

Table 4.3 Saksatchewan Wheat Crop Composition by Type

Variety	Statistics Canada	CWB Variety Survey	Survey Sample
HRS	53.4%	50.7%	42.5%
Durum	40.6%	40.7%	47.2%
Winter Wheat	3.6%	4.2%	4.5%
CPS	2.4%	1.6%	5.8%
Other		2.8%	

(Data from: Statistics Canada, 2009a; Canadian Wheat Board, 2009a)

Table 4.4 Manitoba Wheat Crop Composition by Type

Variety	Statistics Canada	CWB Variety Survey	Survey Sample
HRS	82.8%	81.0%	64.0%
Durum	0.0%	2.0%	0.0%
Winter Wheat	15.5%	15.4%	33.4%
CPS	1.6%	1.0%	2.5%
Other		2.4%	

(Data from: Statistics Canada, 2009a; Canadian Wheat Board, 2009a)

The survey sample was fairly representative of wheat composition however some differences exist. On the prairies in general winter wheat and CPS wheat are over represented when compared to the two population data sources. In Alberta durum is under represented while winter wheat and CPS are over represented. Saskatchewan was the most similar province when survey results were compared to the population data. Manitoba survey results have a lower percentage of HRS wheat, and a much higher rate of winter wheat. The Manitoba results for durum were quite accurate despite a previous concern that zero producers in the province reported that they were durum growers.

The comparison between the sample and target population reveal a possible sample bias toward producers with larger farm sizes. The total crops seeded as well as acreages of different types of wheat all indicated that producers who filled out the survey and/or attend the venues where surveys were conducted tended to have larger farms than average. This was also the case with the McCorkle (2007) study where an in person pen and paper survey was used with a convenience sampling technique at farm shows and meetings in Alberta. McCorkle (2007) also found a bias toward younger producers with higher incomes and more education.

Although the sample may have included larger farms than average some similarities exist in wheat type composition between the sample and the entire population of prairie wheat producers. HRS, and durum wheat were similar between the three sets of data however winter wheat was over represented in the sample population. A possible cause of this may be that winter wheat producers were more willing to fill out a survey dealing with winter wheat. These producers may also be predisposed to winter wheat and have more favourable opinions about the crop. Manitoba may have also played a role in attracting a disproportionate amount of winter wheat producers because of the surveyor being hosted by the Winter Cereal Canada booth in Brandon. A higher rate of winter wheat production in the sample than the target population may serve to more easily determine the traits that winter wheat producers demand to augment the demand of non growers for the same.

The bias found with this survey and many stated preference questionnaires should be carefully considered when interpreting results. The conclusions from analyzing the survey data may not necessarily apply to the whole target population but specifically producers with larger farms. The bias may be very useful considering that new product introductions should be targeted at larger operations with higher incomes (McCorkle, 2007).

The survey sample of 194 meets the initial goal of obtaining roughly 200 surveys suggested by the Pearce et al. (2002) guidelines. The amount of data collected is usable to conduct reliable and valid economic analysis.

4.2 Summary Results

4.2.1 Demographics and Farm Characteristics

A profile of the types of wheat and total seeded acres in 2008 was created using the questions in section 1: “Your Crops” also featured in the comparison with census data. Total seeded acres for the prairies (Figure 4.6) have a mean of 2779 acres with a distribution slightly skewed to the right. As expected there were a large number of small to medium sized farms up to around 3500 acres and fewer large farms with 3500 acres and above. Acreages and percentages of the total acres of different wheat types and activities by province can be seen in Table 4.5. Some points to note are that on average Alberta farmers planted more Hard Red Spring wheat (HRS) and Canadian Prairie Spring wheat (CPS) in 2008, Saskatchewan producers planted the most Durum wheat in 2008 and had more fallowed acres. Manitoba planted the most winter wheat acres per farm on average in 2008. These results were not out of the ordinary however the winter wheat acres in Manitoba are slightly higher than expected. This could be because the surveys in Manitoba were conducted from the Winter Cereals Canada booth which may have attracted a disproportionate amount of winter wheat producers and inflated this number. Rented acres were fairly high in the sample across provinces ranging from 33% of total seeded acres in Saskatchewan to 41% in Manitoba.

Figure 4.6 Histogram of Total Acres (all crops) Seeded in 2008 from Wheat Producing Farms on the Prairies

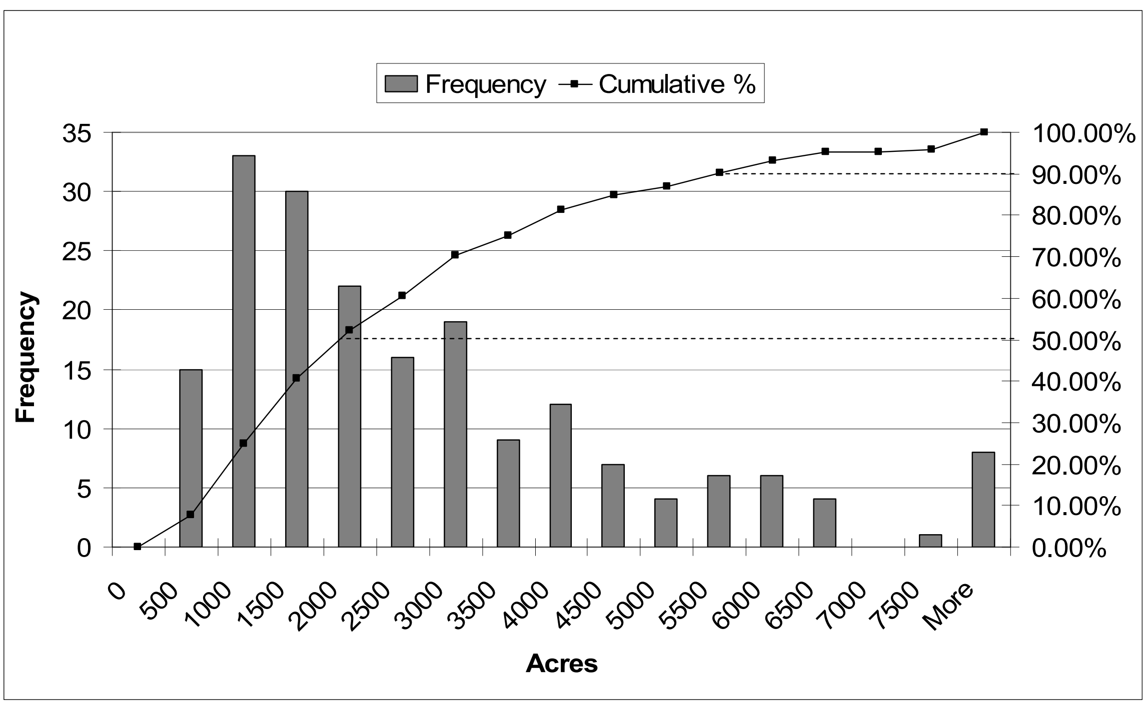


Table 4.5 Average Acres and Percentage of Total Acres Seeded for Wheat Types and Structural Farm Characteristics by Province (*Includes entire sample*)

	Average Acres				Percentage of Total Seeded Acres			
	Prairies	**AB**	**SK**	**MB**	**Prairies**	**AB**	**SK**	**MB**
Total Seeded	2,779	2,642	2,933	2,486	100%	100%	100%	100%
Sumer/Chemical Fallow	102	45	192	2	4%	2%	7%	0%
Rented	1,027	1,034	982	1,022	37%	39%	33%	41%
Hard Red Spring Wheat	618	780	470	579	22%	30%	16%	23%
Canadian Prairie Spring Wheat	85	133	65	23	3%	5%	2%	1%
Durum Wheat	245	39	522	0	9%	1%	18%	0%
Winter Wheat	135	147	50	302	5%	6%	2%	12%

A comparison of the four types of wheat represented in the survey is done between the whole sample and producers who grew the specific crop. Figure 4.7 can be interpreted as the average acres per farm of each crop for the whole survey sample and Figure 4.8 can be read as the average acres of each crop for farms that produce that particular crop. When the entire sample is included HRS wheat is the dominant wheat type on the prairies followed by durum, winter wheat and then CPS wheat. Saskatchewan as a whole however produces more durum than HRS and Manitoba produces none at all in this sample. Alberta produces some Durum but less than any other wheat type.

When looking exclusively at farms that grow each type of wheat a few key facts emerge. Alberta farms that grow winter and HRS wheat tend to grow more acres than farms in the other Prairie Provinces. Saskatchewan farms dominate durum production levels. This may be because durum producing regions in Southern Saskatchewan and Alberta tend to have larger farm sizes. If grown on a farm, durum wheat is planted on more acres than other wheat crops on average. Alberta winter wheat growers also plant more acres of the crop than their Manitoba or Saskatchewan counterparts. The results from Figure 4.9 featuring the frequency of different wheat producers in the sample show that even though durum is grown in large acreages, only 21% of Prairie wheat producers grow it. HRS is the most widely grown type of wheat with 77% of farms growing the crop. 30% of growers in the sample grew winter wheat and only 17% grew CPS in the three Prairie Provinces.

Figure 4.7 Average Acres per Farm of Different Wheat Types by Province (Entire Sample Included)

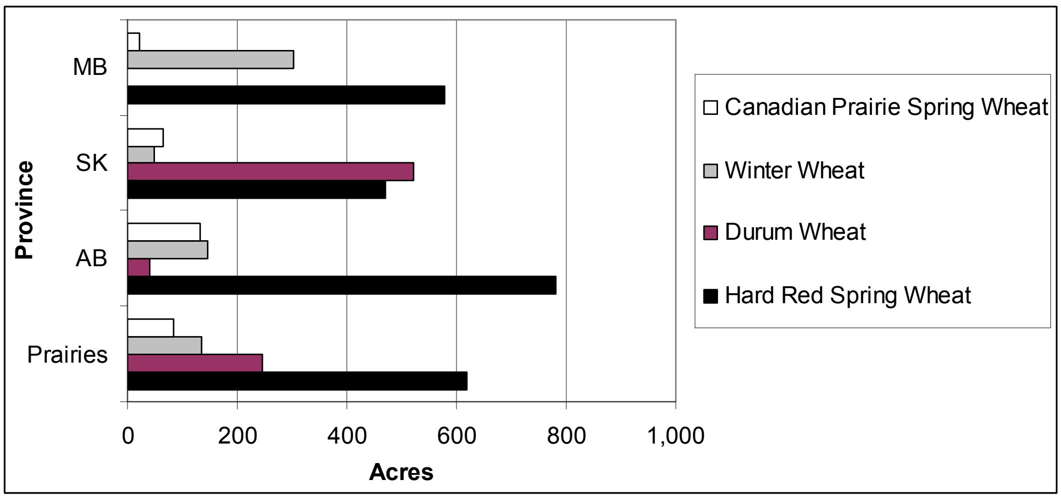


Figure 4.8 Average Acres per Farm of Different Wheat Types by Province (Only Producers Who Grew the Crop are Included for Each Type)

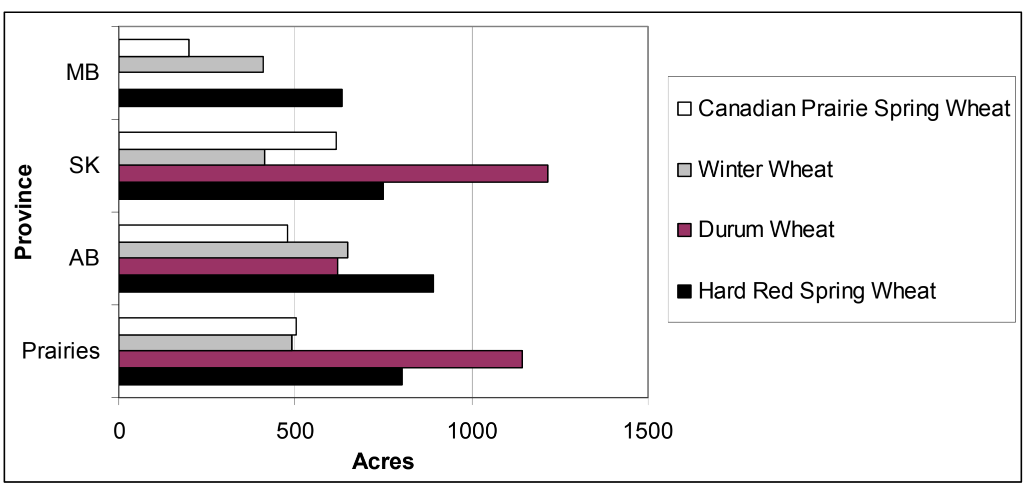
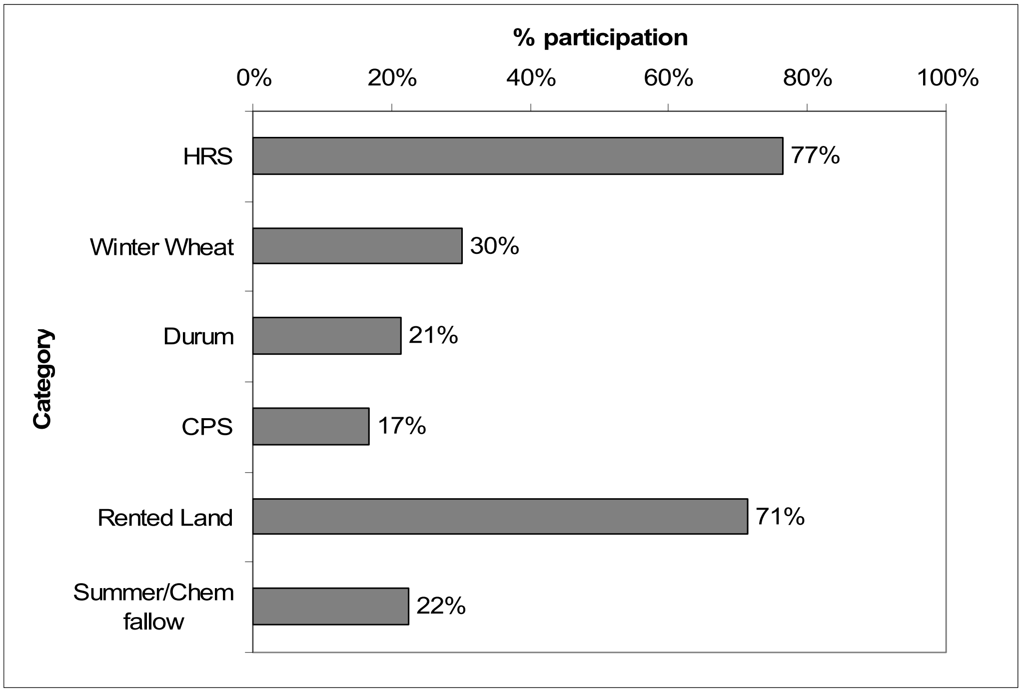
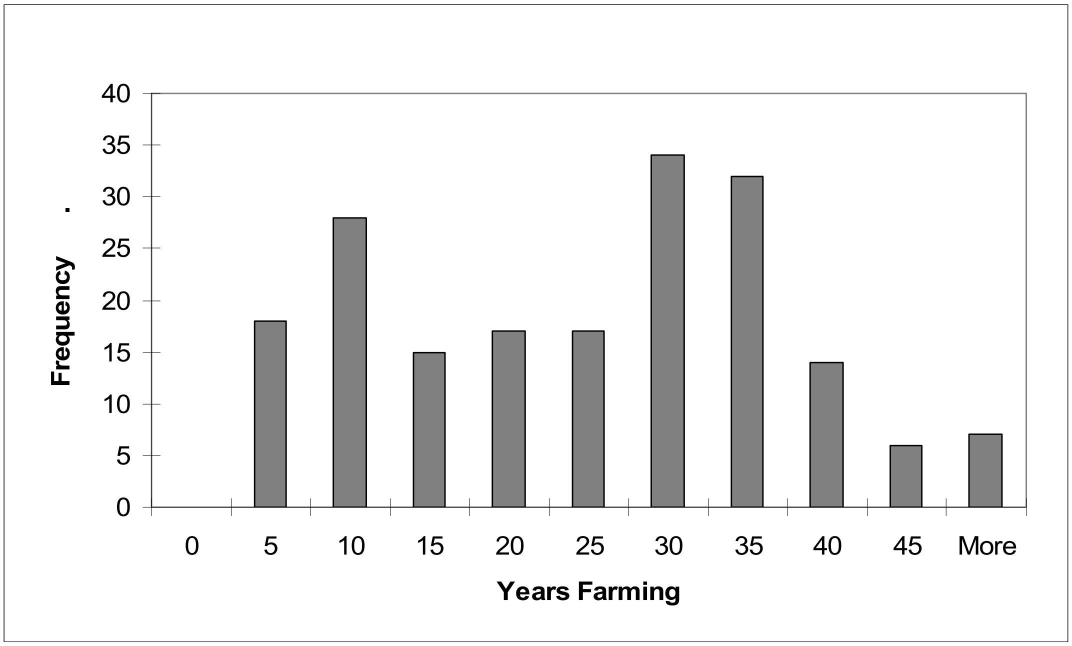


Figure 4.9 Frequency of Growers for Different Crops and Activities in the Prairie Provinces



The farming experience of producers in the sample is shown in Figure 4.10. A bimodal distribution is seen with peaks at around 10 years of experience and 30 to 35 years with the latter group including a larger number of producers than the former. This may be due to a combination of generational transfer and a structural change in farm size. There may also be fewer young or inexperienced farmers because of the increasing farm sizes. In any case, there are two distinct experience levels of producers in the sample with a 20 to 25 year gap, or roughly one generation.

Figure 4.10 Histogram of the Number of Years Farming



Demographics and environmental activities in which the farm participates are asked near the end of the survey in section 5: "You and Your Farm". As seen in Table 4.6, 95% of respondents are the principal decision maker on the farm. The other 5% were included in the sample because they may have some influence over the decision making process or will be the principal decision maker in the future. 59% indicated that they planned to expand their operation in the next five years which is an indication that the trend might continue toward larger farms in the future. Participation in the government run farm income stabilization program AgraStability/AgraInvest was 79% and 90% of the sample attended an agronomy seminar or similar event in the last three years.

The environmental characteristics shed some light on the attitudes and actions of producers in the sample concerning environmental activities. 74% indicated that they had an environmental farm plan. Other environmental questions included a 39% rate of intentional preservation of waterfowl habitat and a 55% rate of intentionally preserving other wildlife habitat. 79% of producers surveyed allow duck hunters on their land while 19% are duck hunters themselves. Concerning wetlands, 44% of the sample have drained wetlands on their farm while only 6% have restored wetlands with the help of payments or incentives. This reinforces the high economic value of draining wetlands to farmers (Cortus *et al.*, 2005). The environmental characteristic of the farm questions show that producers generally favor environmentally positive outcomes on their farms but there are conflicts when these outcomes impede more profitable farming activities.

Table 4.6 Demographics and Environmental Farm Characteristics by Province

	Prairies	AB	SK	MB
Is the Principal decision maker	95%	89%	98%	97%
Plans to Expand in the next 5 years	59%	65%	56%	54%
Has an Environmental Farm Plan	74%	76%	74%	74%
Participates in AgraStability/AgraInvest	79%	73%	80%	83%
Allow Duck Hunters on Their Land	79%	80%	77%	80%
Is a Duck Hunter	19%	19%	20%	26%
Has Drained Wetland(s)	44%	43%	37%	63%
Has Restored Wetlands With Payments	6%	1%	8%	9%
Intentionally Preserves Waterfowl Nesting Habitat	39%	38%	44%	37%
Intentionally Preserves Other Habitat	55%	58%	50%	60%
Attended a Seminar in the Last 3 Years	90%	97%	85%	89%

4.2.2 Drivers and Barriers to Adoption/Expansion of WW

In a series of questions covering sections 2 and 3 winter wheat growers and non growers filled out similar but separate questions about why they grew the crop or why they did not grow it, and what factors would be important when considering switching some spring wheat acres to winter wheat to either adopt or expand their winter wheat acres. Figures 4.11 and 4.12 show the responses to the first set of questions asking respondents to check off any reason listed why they did or did not grow winter wheat. For those that did not grow winter wheat on the Prairies seeding during harvest, risk of winter damage, and the "other" category are the top three barriers to adoption. The dominant reason in the "other" category was a late harvest in 2008 where winter wheat was hard to seed on time but other logistics issues surrounding seeding and a cited lack of interest in some cases are also reasons specified for not growing winter wheat.

The top three barriers in Alberta followed the order on the Prairies in general but there are some differences across the provinces. Saskatchewan and Alberta are the most similar in this comparison however in Saskatchewan not being familiar with the crop is more important. Manitoba producers seem to have different reasons than the other provinces for not growing winter wheat. The logistics of seeding did not seem to be as large of an issue, winter damage is a significantly lower concern, and no respondent checked the "not as profitable" option in Manitoba. The "other" category here is the largest barrier and included only late harvest and a dry fall as the reasons for not growing it. There are a small number of Manitoba producers in the sample who did not grow winter wheat so there may have simply been too few respondents in this category to gain an accurate picture of the barriers to production of winter wheat in Manitoba.

Barriers of less concern to non growers are Downy and Japanese Brome issues, a weed problem in Southern Alberta and Saskatchewan and perceived level of insurance coverage. Profitability, familiarity and rotational considerations were mid level concerns. Overall, non growers were most concerned with the difficulty of seeding and the cold tolerance of winter wheat.

Winter wheat growers revealed somewhat different drivers than the barriers of production that the non growers are concerned with. The drivers to winter wheat production are also more similar between provinces than the barriers. The top three drivers for growing winter wheat among growers in all provinces are time use and machinery efficiency, that it fit in their rotation, and that it is more profitable than spring wheat. Manitoba differed from the other two provinces with profit being more important than Alberta or Saskatchewan. This is not unexpected due to higher average yields in Manitoba for winter wheat compared to spring wheat relative to the other provinces. The fact that neighbors had previous success with the crop is also a more significant reason in Manitoba relative to the other provinces. Alternatively, increased waterfowl habitat is a greater driver in Alberta and Saskatchewan than Manitoba.

A more abrupt transition between the more important and less important drivers is exhibited with growers of winter wheat compared to non growers. Lower on the list was financial support, livestock feed purposes and recommendations from a third party. The success of neighbors and waterfowl habitat are the mid level drivers but did not score much higher than the least important reasons.

Figure 4.11 Current Barriers to Winter Wheat Adoption from Non Growers

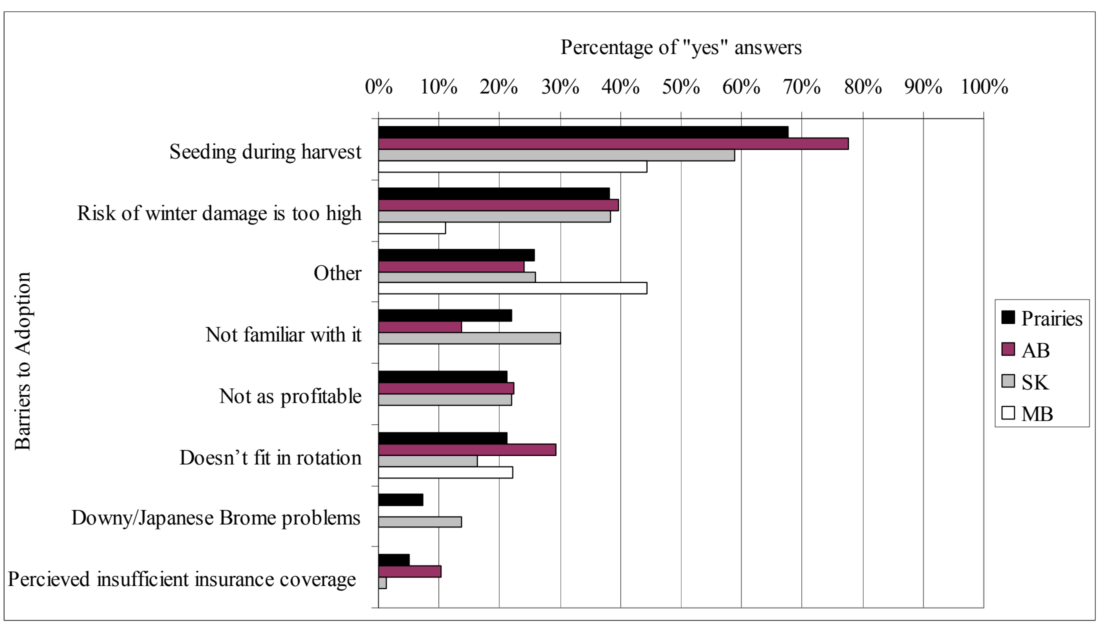
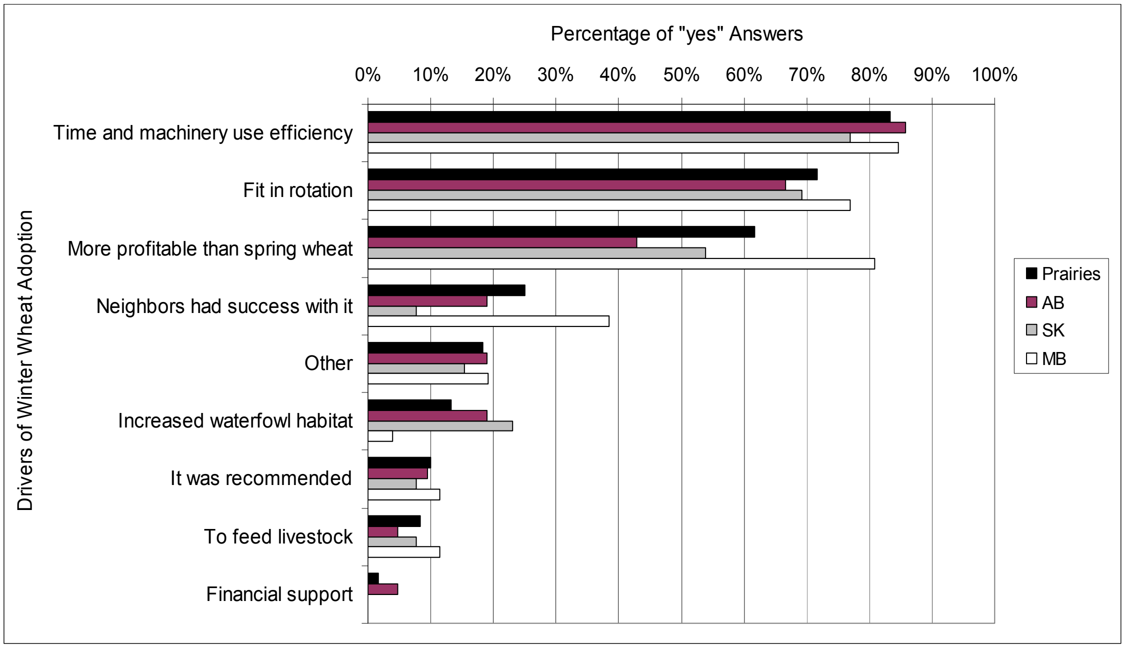


Figure 4.12 Current Drivers of Winter Wheat Adoption from Growers

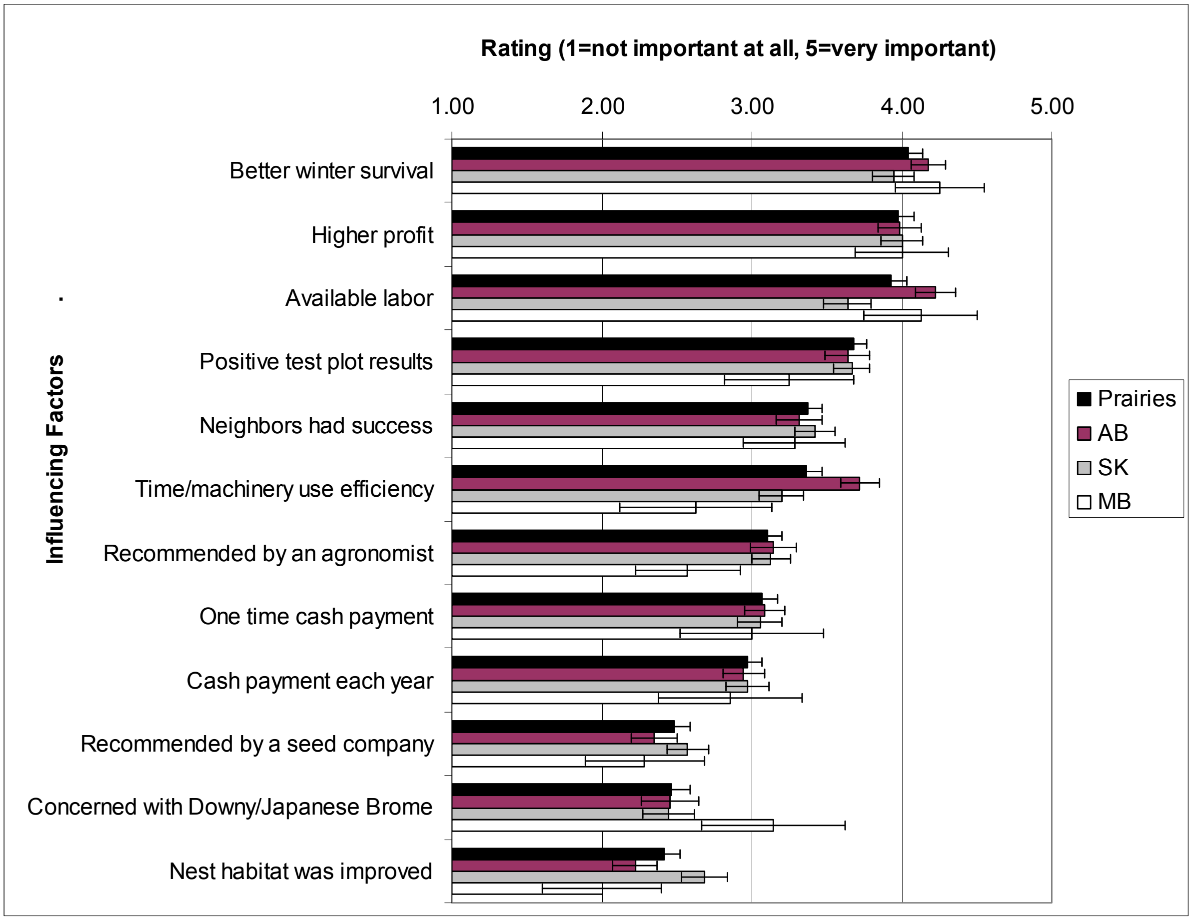


Figures 4.13 and 4.14 show the responses of both growers and non growers of winter wheat when asked what would be important to them when considering a switch from spring wheat to winter wheat. These questions are somewhat redundant considering that drivers and barriers are already asked but serve as a check for consistency in responses and act as a comparison between spring wheat, the substitute in this case, and winter wheat while the previous questions focused on winter wheat alone. On the Prairies in general non winter wheat growers thought better winter survival, higher profits and the availability of labor were most important. Growers of winter wheat also favored higher profits and better winter survival but time use and machinery efficiency edged out the available labor concern for a spot in the top three.

The bottom three concerns for both growers and non growers are an increase in waterfowl nesting habitat (last), concern with Downy and Japanese Brome and a recommendation by a seed company. A recommendation from an agronomist is rated slightly higher on the list by both parties than recommendation from a seed company. Cash payments for growing winter wheat including both one time payments and payments each year on a recurring basis offering less compensation each year than a one time payment would offer once are less important than the profit related attributes. Good test plot results are reasonably high on the list for both winter wheat growers and non growers. It should be noted that different responses related to growing winter wheat may be related to farm location that is more specific than the provincial level which is not included in the analysis.

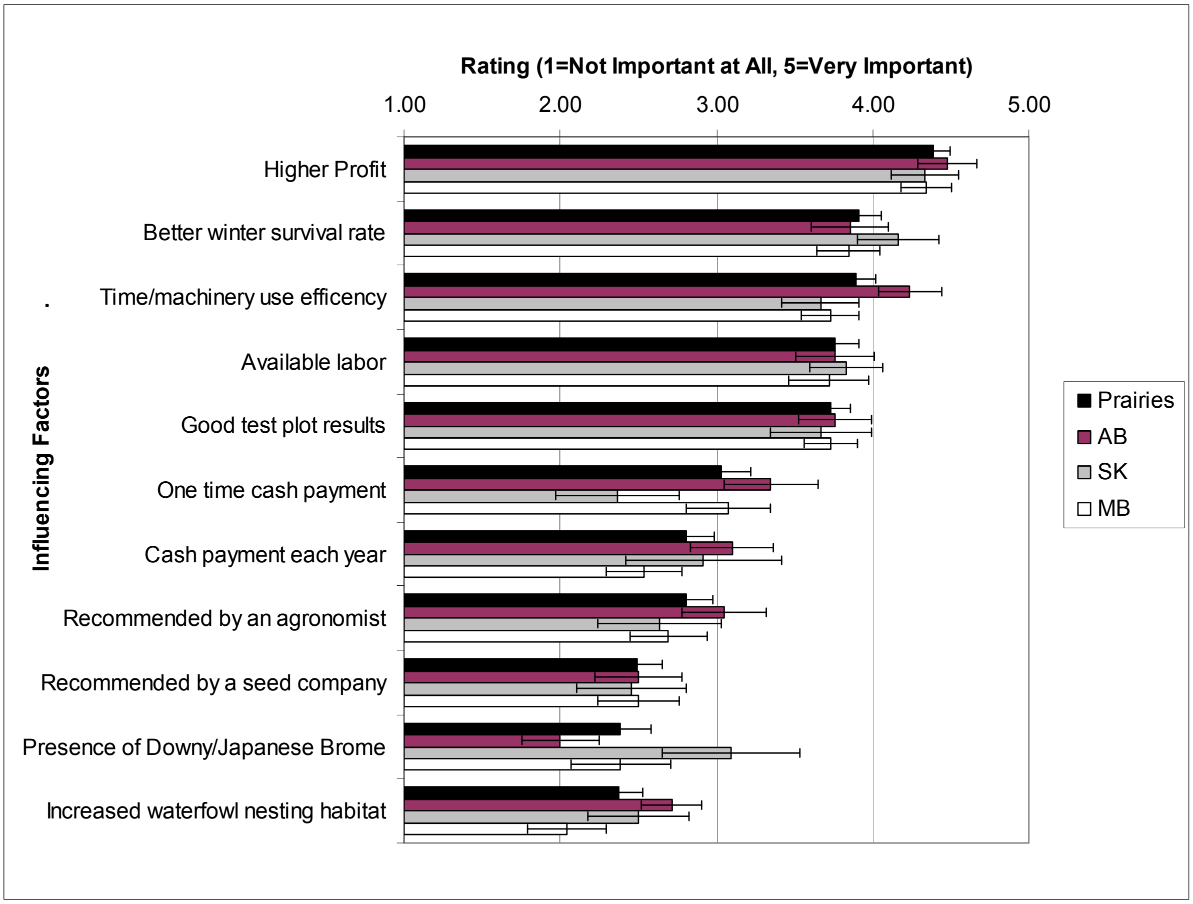
In summary there are two distinct groups of drivers for winter wheat adoption or expansion. The first and most heavily weighted when compared against spring wheat are the profit related factors which include cold tolerance and the more direct profit related questions. The second group consists of logistics, specifically during seeding for non growers and the time use and machinery efficiency advantages with growers. It appears that a hurdle to the initial production of winter wheat is the lack of ability to seed during harvest or in time for the crop to be successful. Once the initial crop is sown some logistic advantages are touted by growers including the ability to spread harvest over a longer period in the fall. Waterfowl nesting habitat holds little weight for either group when considering winter wheat as a viable crop on their farm compared to all other factors asked about in this section of the survey.

Figure 4.13 Mean Ratings of Influencing Factors for Non Winter Wheat Growers When Hypothetically Switching Some Spring Wheat Acres to Grow Winter Wheat



Note: The error bars depict one standard error on each side of the mean

Figure 4.14 Mean Ratings of Influencing Factors for Winter Wheat Growers When Hypothetically Switching Some Spring Wheat Acres to Expand Their Winter Wheat



Note: The error bars depict one standard error on each side of the mean

4.2.3 Attribute Ranking

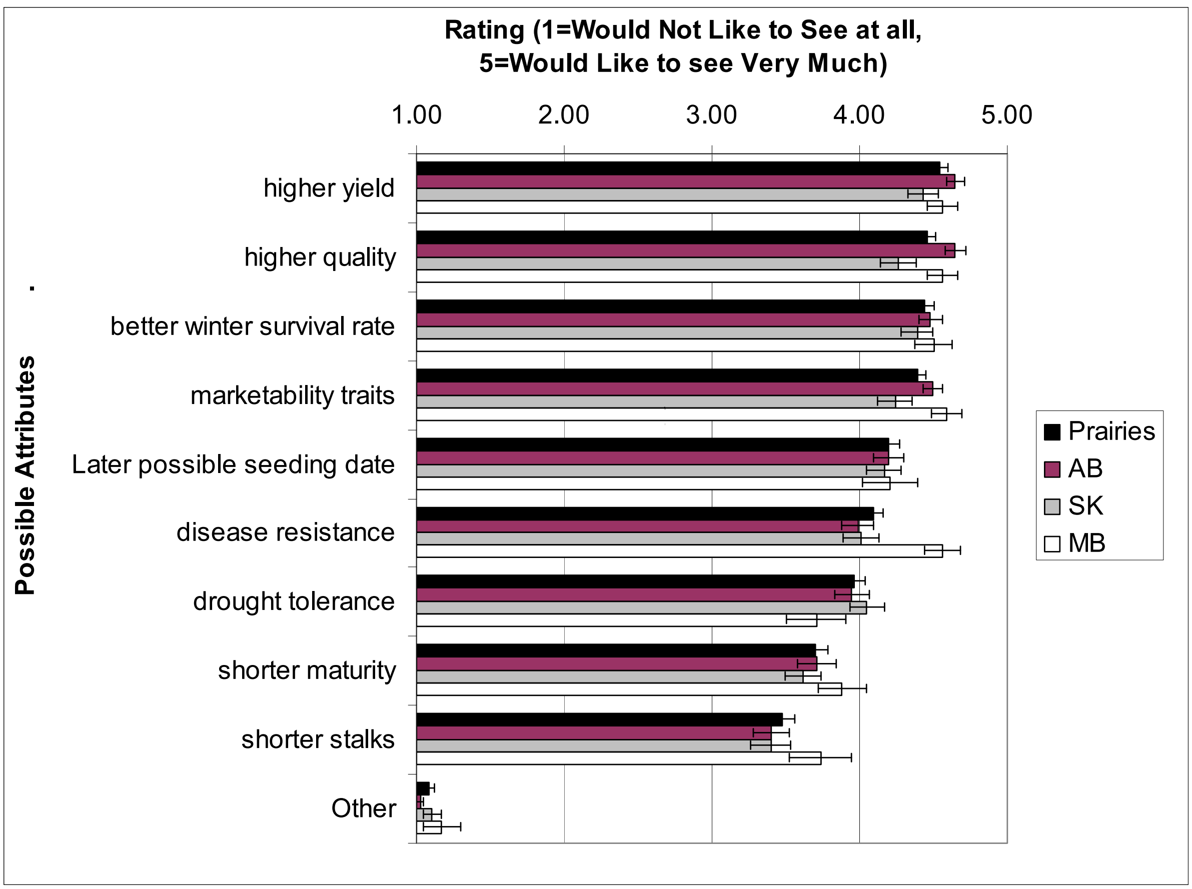
As part of section 4: "A New Winter Variety" directly following the hypothetical variety choice scenarios was a set of questions which asked for a rating from 1 to 5 to describe how much the producer would like to see the appearance of certain possible traits in new winter wheat varieties. Figure 4.15 highlights differences between the provinces and Figure 4.16 shows the differences between those who grow winter wheat and those who do not. As expected none of the attributes scored poorly (below 3 out of 5) on the scale because they are all traits that make the crop more profitable or easier to grow so the discussion will focus on relative differences between ratings of the different possible traits. On a Prairie wide basis there were no individual attributes that stood out very significantly from the rest but rather groups of attributes that can be identified as those pertaining to profitability and those concerned with logistics and agronomics.

Higher yield and quality are the top two attributes producers wish to see in new varieties on the prairies. They are followed closely by better winter survival and marketability traits. Among these first four, there is no significant difference if standard errors are considered. A later possible seeding date occupied the median position followed by disease and drought tolerance. Shorter maturity and stalks are the least desirable of the traits. Explicit profitability traits such as yield and quality scored the highest in this question followed by logistics and agronomic traits.

When the results are analyzed by province some interesting differences arise (Table 4.7). Most of the Saskatchewan and Alberta results were within 1 rank except for Saskatchewan farmers desiring cold tolerance noticeably more than those in Alberta. Manitoba exhibits the highest difference in rank between attributes. Producers in Manitoba want marketability traits more than any other and much more than in the other Provinces. Better winter survival rates are ranked much lower by Manitoba producers, most likely because more snow cover in the winter gives the province an advantage for winter survival. Disease resistance and drought tolerance are spread farther apart as well in Manitoba. Higher levels of precipitation in Manitoba may contribute to an increased risk of disease and decrease the possibility of drought which may contribute to making drought resistance a low priority and disease resistance a high priority relative to the other provinces.

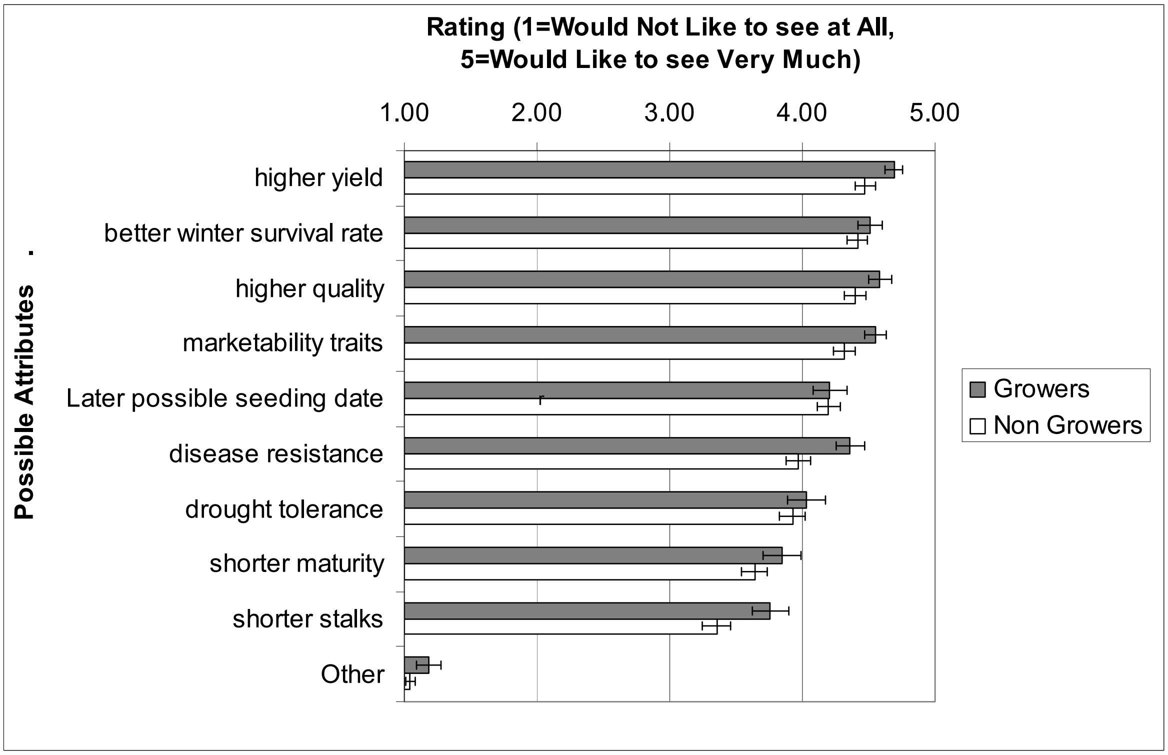
The sample is also divided into winter wheat growers and non growers and analyzed for this question (Figure 4.16). Some attributes exhibit no significant difference between the groups but differences exist in about half the traits. In all of these traits the growers rating was higher than the non growers for some reason. Growers had a greater desire for higher yield, more quality, marketability traits, disease resistance, and shorter stalks than non growers.

Figure 4.15 Mean Ratings of Hypothetical Attributes Available in New Winter Wheat Varieties by Province



Note: The error bars depict one standard error on each side of the mean

Figure 4.16 Mean Ratings of Hypothetical Attributes Available in New Winter Wheat Varieties by Winter Wheat Growers and non Growers



Note: The error bars depict one standard error on each side of the mean

Table 4.7 Ranking of Attributes Desired by Producers in New Winter Wheat Varieties by Province

Rank	AB	SK	MB
1	higher yield	higher yield	marketability traits
2	higher quality	better winter survival rate	higher yield
3	marketability traits	higher quality	higher quality
4	better winter survival rate	marketability traits	disease resistance
5	Later possible seeding date	Later possible seeding date	better winter survival rate
6	disease resistance	drought tolerance	Later possible seeding date
7	drought tolerance	disease resistance	shorter maturity
8	shorter maturity	shorter maturity	shorter stalks
9	shorter stalks	shorter stalks	drought tolerance
10	Other	Other	Other

4.3 Factor Analysis

A factor analysis using the principal component extraction method and a varimax rotation is performed on question 12 of the survey (Appendix A) in SPSS version 17.0. The question asked respondents to rate, on a scale of one to five, a list of possible attributes that they might prefert in a future new variety. The analysis reveals one strong factor that places heavy weightings on a better winter survival rate, higher yield, and higher quality than existing varieties (Table 4.8). As a general rule of thumb, factors with eigenvalues less than 1 are excluded from the analysis (Jobson, 1992) however in this case the second component had an eigenvalue of 0.999 and made rotating the factors possible to gain some clarity in the results.

The outcome of the factor analysis indicates that some attributes producers want in new varieties could be bundled. Component 1 might be called a profit factor with weightings on attributes related directly to increased profits. Component 2 is more ambiguous. Weightings on maturity, and a later seeding date are directly related to time use, however disease resistance, drought resistance and shorter stalk height are less time related. The second factor might appropriately be titled as a logistics and agronomics factor.

Figure 4.17 Scree Plot for Factor Analysis on Question 12 from the Survey (possible attribute ratings)

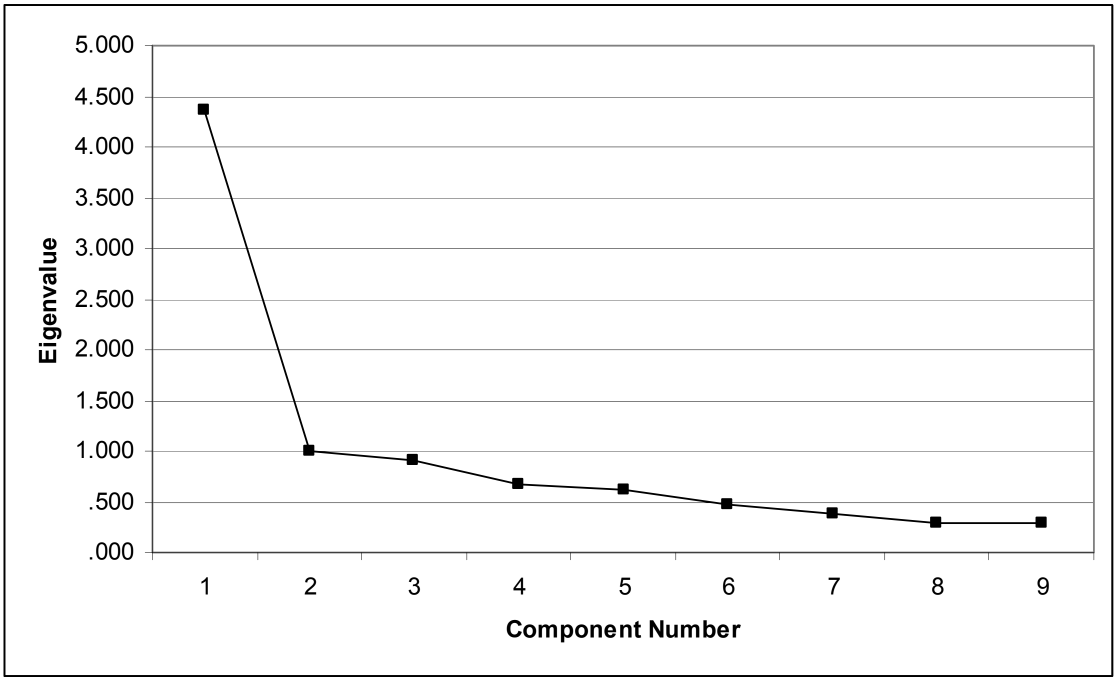


Table 4.8 Rotated Component Matrix (Using Principal Component Extraction and a Varimax rotation)

	Component	
	1	2
higher quality	**0.85**	0.20
higher yield	**0.81**	0.30
better winter survival rate	**0.76**	0.29
marketability traits	**0.71**	0.33
shorter maturity	0.17	**0.79**
disease resistance	0.31	**0.74**
shorter stalks	0.18	**0.62**
Later possible seeding date	0.33	**0.61**
drought tolerance	0.25	**0.57**

4.4 Econometric Model Results

The goal of the econometric analysis is to determine if a value exists to wheat producers of the cold tolerance and duck nesting success traits of possible new winter wheat varieties and the factors that influence that value for producers. The Cragg two stage double hurdle model is used for the analysis of this goal. The fit of the Cragg model has previously been discussed (3.2 Econometric Model) however, a Tobit model will be estimated and compared with it. The Cragg model will be tested against a Tobit model to determine if a 2 stage model provides more information than a single stage.

4.4.1 Test Between a Single Stage and Two Stage Model

A log likelihood ratio test proposed by Cragg (1971) can be performed between the two models because the log likelihood of the Cragg model is simply the sum of the log likelihoods from the first stage probit and second stage truncated regression (Greene, 2003). The tobit model is treated as a restriction of the Cragg model in this case. The procedure as suggested by the Limdep version 9 manual is as follows: (Greene, 2007)

$H_0: LL_U = LL_R$
$H_1: LL_U \neq LL_R$

Where:
LL_R = The log likelihood of the restricted model (Tobit model)
LL_U = The log likelihood of the unrestricted model (Cragg Model)

$LL_R = LL_{tobit}$
$LL_U = (LL_{probit} + LL_{truncated})$

Test Stat = $-2*(LL_{tobit} - LL_{probit} - LL_{truncated})$

The test statistic has a χ^2 distribution

Test Stat: $\chi^2 = 5422.90$
Critical Value (1%, 15df) = 30.58

The test stat is greater than the critical value so the null hypothesis that $LL_U = LL_R$ is rejected at the 1% level of confidence. The 2 stage Cragg model has more explanatory power and is superior to the Tobit.

4.4.2 Analytical Model and Results

The producer's decision is represented by equation 3.8, the first stage probit, and equation 3.9, the second stage truncated regression. To determine the adoption possibilities and rates for new winter wheat varieties based on their attributes and demographic factors the following variables were chosen for analysis. Table 4.9 gives a description of each factor and its expected effect on adoption and how many acres will be adopted. The factors in Table 4.9 will be used in the vectors of independent variables.

Table 4.9 Variables Used in the Cragg Model and Their Expected Effects on Decisions about Winter Wheat Adoption/Expansion

Variable	Description	Type of Variable	Expected Sign
WK	Winter kill rate as a percentage (bad enough to reseed)	continuous	-
GP	Gross profit attribute as a percentage compared to spring wheat	continuous	+
DN	Nesting success attribute (nests per quarter compared to spring wheat)	continuous	+
HRSACRES	Hard Red Spring Wheat Acres seeded in 2008	continuous	+
CPSACRES	Canadian Prairie Spring wheat acres seeded in 2008	continuous	+
DURACRES	Durum wheat acres seeded in 2008	continuous	-
YEARS	Years of farming experience	continuous	-
EFP	Do they have an environmental farm plan	dummy (1=existence of an EFP)	+
HUNTER	Is the respondent a hunter?	dummy (1=hunter)	+
DRAINED	Wetland drainage used on the farm	dummy (1=drainage used)	-
RESTORED	Wetland(s) has been restored with payments?	dummy (1=restoration exists)	+
INTNEST	Do they intentionally preserve nesting habitat?	dummy (1=intentional preservation)	+
WWPROD	Is the respondent a winter wheat producer?	dummy (1=producer)	+
AB	Is the respondent from Alberta?	dummy (1=from AB)	-
SK	Is the respondent from Saskatchewan?	dummy (1=from SK)	-

The factors affecting the adoption or expansion of new winter wheat varieties are not expected to be the same as those affecting the decision of how many acres to plant. The main advantage of the Cragg model is the ability to separate these two decisions and use a different vector of independent variables for each stage. This allowance of the model is exploited in the analysis seen in Table 4.10. Two different variations of the Cragg model are reported including two probit and two truncated regression models. Variation 1 of the probit and truncated regression are shown because these were used in the test between the Tobit and Cragg models. This variation also shows factors that were expected to have a possible effect in the model but did not have a significance result. Variation 2 of both the probit and truncated regression is simply variation 1 with some insignificant demographic and characteristic factors removed. Results from variation 1 and 2 are very similar so variation 2 is discussed for the sake of reducing the complexity of analysis. A Tobit model is also presented in Table 4.10 but will not be discussed due to results from the log likelihood test between the single and two stage models.

Table 4.10 Results from the Tobit and Cragg Model

			CRAGG MODEL							
	TOBIT		Probit Variation 1		Probit Variation 2		Truncated Variation 1		Truncated Variation 2	
Factor (Units)	Coefficient	ME*	Coefficient	ME*	Coefficient	ME*	Coefficient	ME*	Coefficient	ME*
CONSTANT	**0.256**	**0.200**	0.002	0.001	0.108	0.039	**-2174.330**	**-338.246**	**-2354.390**	**-342.180**
WK (% reseeding rate)	**-0.015**	**-0.012**	**-0.033**	**-0.012**	**-0.029**	**-0.011**	**-69.553**	**-10.820**	**-72.667**	**-10.561**
GP (% difference from Spring Wheat)	**0.036**	**0.028**	**0.071**	**0.026**	**0.071**	**0.026**	**30.071**	**4.678**	**32.056**	**4.659**
DN (extra successful nests)	**-0.014**	**-0.011**	**-0.033**	**-0.012**	**-0.032**	**-0.012**	7.418	1.154	8.906	1.294
HRSACRES (2008 seeded acres)	.381D-04	.298D-04	0.00012	.444D-04	**0.00016**	**.564D-04**	**0.830**	**0.129**	**0.885**	**0.129**
CPSACRES (2008 seeded acres)	**0.00015**	**0.00012**	**0.00032**	**0.00012**	**0.00035**	**0.00013**	-0.026	-0.004		
DURACRES (2008 seeded acres)	-.760D-04	-.133D-04	-.537D-04	-.195D-04	-.760D-04	-.276D-04	**0.461**	**0.072**	**0.462**	**0.067**
EFP (1=existence)	0.062	0.048	0.151	0.056			**331.646**	**51.592**	**378.545**	**55.016**
HUNTER (1=yes)	0.050	0.039	0.096	0.035			121.086	18.837		
DRAINED (1=drainage)	**-0.110**	**-0.086**	**-0.273**	**-0.099**	**-0.209**	**-0.076**	**533.224**	**82.950**	**580.372**	**84.349**
RESTORED (1=restoration)	0.082	0.064	0.185	0.065			-479.186	-74.544		
INTNEST (1=preservation)	**0.225**	**0.176**	**0.516**	**0.181**	**0.538**	**0.189**	129.920	20.211		
WWPROD (1=producer)	0.066	0.052	0.183	0.065			**287.755**	**44.764**	**305.899**	**44.458**
YEARS (farming experience)	.296D-04	.232D-04	.291D-04	.105D-04			**0.741**	**0.115**	**0.840**	**0.122**
AB (1=from AB)	0.030	0.023	0.063	0.023			**214.974**	**33.442**	**231.858**	**33.698**
SK (1=from SK)	-0.030	-0.023	-0.063	-0.023			**-213.982**	**-33.288**	**-230.995**	**-33.572**
Sigma	**0.605**	-0.025					**619.005**		**640.415**	
Log Likelihood Function	-690.70		-394.65		-398.23		-3007.50		-3009.12	
McFadden R-Squared			0.23		0.23					
% of Correct Predictions			77.81%		77.42%					

*ME = Marginal Effect

Coefficients and Marginal Effects in **Bold** are Significant at the 10% level or better

4.4.2.1 The First Stage Probit Model

Results from the first stage probit decision (variation 2) producers made about whether or not to adopt or expand a new hypothetical winter wheat variety were not too surprising. Increasing winter kill rates (WK) have a negative impact on adoption/expansion rates. For every percent decrease in winter kill rates there is an increase in the adoption or expansion probability of 1.1%. A five percent decrease in winter kill rates will increase the likelihood of adoption by 5.5% without any other improvements. An increase in gross profit (GP) compared to spring wheat has a positive impact on uptake of a new variety. For each percentage increase in profit over spring wheat a 2.6% increase in uptake is seen which means that 5% greater relative profit of a new variety will result in a 13% increase in adoption/expansion probability. The somewhat unexpected result is a decrease of 1.2% in adoption/expansion rates for an extra successful duck nest (DN). This result implies that there is a cost associated with duck nesting that is factored into producer decision making regarding new varieties. The cost may be coming from the increases in duck predation of crops.

HRS and CPS wheat acreage (HRSACRES and CPSACRES) both had a significant positive effect on adoption and expansion rates. An extra 160 acres of HRS wheat present on a producers farm resulted in a 0.9% increase in adoption and expansion rates while 160 extra acres of CPS wheat resulted in a 2.1% increase. The increase in probability of adoption or expansion of winter wheat can be scaled up to larger farms as well. For an extra 1000 acres of HRS and CPS the increases would be 5.6% and 13% respectively. This result implies that larger farms prone to growing more spring wheat are more likely to adopt new winter wheat varieties. CPS wheat may also be a closer substitute to winter wheat and producers may be more inclined to switch from CPS to winter wheat than from HRS to winter wheat. Durum acres had no effect on the probability of adoption indicating an ambiguous substitution effect.

The probit model also revealed that some previous environmental inclinations or on farm activities affecting the environment had an impact on adoption rates. If a wetland has been drained on the farm at some point (DRAINED) there is a 7.6% lower probability that the new winter wheat varieties would be adopted. Another result is that those respondents who intentionally preserved waterfowl nesting habitat on their farms (INTNEST) are 18.9% more likely to adopt the new hypothetical varieties. This may indicate a subgroup of producers who tend to engage in environmentally friendly practices and are more concerned with waterfowl nesting success.

4.4.2.2 The Second Stage Truncated Regression Model

The truncated regression modeled the decision producers made about how many acres of the new hypothetical winter wheat variety they would plant, if they chose to plant any in the first stage. The second stage of the Cragg model highlights some different factors than the first stage decision. As expected a decrease in winter kill rates (WK) of 1% produces a decision on average to plant 10.6 more acres. To encourage a producer to plant 160 acres (one quarter section of land) decreases in winter kill of about 15% is necessary in the absence of other improvements. Gross Profit (GP) had a positive effect on acreage with a 1% increase in profit compared to spring wheat inducing a 4.7 acre increase in winter wheat acreage. 160 acres of winter wheat would be planted if profit compared to spring wheat was 34% higher for winter wheat in the absence of other factors. Successful duck nests (DN) had no effect on the acreage decision for new varieties. The attribute based effects are consistent with prior predictions.

HRS (HRSACRES) and Durum acres (DURACRES) were both significant factors in the decision about how many acres to adopt. An extra acre of HRS and durum wheat on the farm spurred 0.13 and 0.07 acres of winter wheat to be planted respectively. This can be interpreted as a ratio between winter wheat and these other two types of wheat and scaled up to the number of acres that are present on any given farm. For instance if a producer is growing 500 acres of HRS or durum they would choose to plant 65 and 35 extra acres of winter wheat than someone who did not grow any HRS or durum wheat.

Durum wheat did not have an effect on adoption rates but does have an effect on the amount of acres producers are willing to adopt. Durum wheat may not play a role in the adoption of winter wheat because of the different markets it services, however it may affect the acreage decision because of rotational concerns or a scale effect. Durum also tends to be grown in Southern Alberta and Saskatchewan so the effect may be clouded by farm size differences, soil zone variation or different crop rotations. For instance less canola is grown in predominant durum growing regions. CPS wheat was not added to the variation 2 of the truncated model because of a lack of significance in variation 1.

Environmental practices also had effects in the truncated regression. If the respondent had an environmental farm plan (EFP) they chose to plant 55 more acres of winter wheat implying that producers with an environmental farm plan may be more environmentally friendly or at least more open to trialing different crops and practices with environmental benefits on their farms. The existence of a drained wetland increased the amount of winter wheat respondents chose to plant by 84 acres. It could be the case that drained wetlands are providing more land relaxing the land constraint providing more flexibility when choosing crops to plant. Interestingly, respondents who had drained a wetland were less likely to adopt new varieties in the first place but when they did choose to adopt, adopted more acres. Producers who have drained a wetland may subscribe to the “go big or go home” philosophy where they either do something in a large manner or not at all.

Those respondents in the sample who already grow winter wheat chose to plant 44 more acres than non growers. These producers may be more familiar with the crop and willing to trial new varieties on a larger scale. They may also be growing winter wheat because of a previous bias toward the crop which could contribute to a bias toward liking new varieties more than non winter wheat growers would. Years of experience was a significant factor in the acreage decision as well. For ten extra years of experience a producer was willing to plant 1.2 extra acres. Although this result is significant it is too small to have much practical use.

Which prairie province a respondent’s farm was located in mattered in the acreage decision. Compared to Manitoba, Saskatchewan was willing to plant 33 fewer acres and Alberta was willing to plant 33 more acres. The difference between provinces may be attributed to differences in soil zones, crop options and climate. Alberta has traditionally grown the most acres of winter wheat, especially in the South (Fedak, 2007) and Manitoba tends to have higher yields compared to spring wheat than the other provinces (Thoroughgood, 2008). Manitoba and Alberta also have strong markets for feed and ethanol compared to Saskatchewan which are major uses of winter wheat. These advantages may lead to more acres being hypothetically adopted by Manitoba and Alberta.

There are numerous factors found from this study affecting hypothetical adoption/expansion of new winter wheat varieties. Winter kill rates, gross profit compared with spring wheat, duck nesting success, HRS and CPS acres seeded in 2008, previous drainage of wetlands and intentional preservation of waterfowl habitat all have an impact on adoption or expansion of the hypothetical new winter wheat varieties. Factors affecting the acreage decision include winter kill rates, gross profit compared to spring wheat, HRS and durum acres seeded in 2008, the existence of an environmental farm plan, previous wetland drainage decisions, whether the producer grows winter wheat, years of experience on the farm, and which province the respondents farm is located in. A complex array of factors exists affecting the adoption of new winter wheat varieties.

4.4.3 Model Predictions vs. Survey Results

Predictions from both stages of the Cragg model (Variation 2) are compared against the decisions producers made on the survey to assess the accuracy of the model. The results of the comparisons between the probit model and producer's adoption/expansion decisions from survey responses are highlighted in Figure 4.18 and the comparison between the truncated model and the actual acreage decisions from survey responses are shown in Figure 4.19. The first stage adoption/expansion decision prediction is close to the actual adoption rates seen in the survey responses although the means are not significantly different at a 95% confidence level. The predicted mean rate from the probit regression over the whole sample is 69% adoption while the the actual adoption/expansion rate is 63%, a difference of 6%. The probit model accurately predicted if a respondent would choose to adopt or expand over 77% of the time.

Predictions from the truncated second stage regression for the number of acres are not significantly different than the acres producers chose to adopt or expand in survey responses. The model predicted on average, including the entire sample, that 280 acres would be planted by producers who chose to adopt or expand their acres while the actual average response from producers in the survey is 221 acres. The difference in survey responses and predicted acres from the truncated regression is significantly different at the 95% confidence level. Overall the model does a reasonable job of predicting whether producers will adopt a new winter wheat variety but overestimates the acreage level decision. There may be an underlying factor causing producers to act conservatively when choosing how many acres to plant that the model does not capture.

Figure 4.18 Predicted and Survey Mean Adoption/Expansion Rate

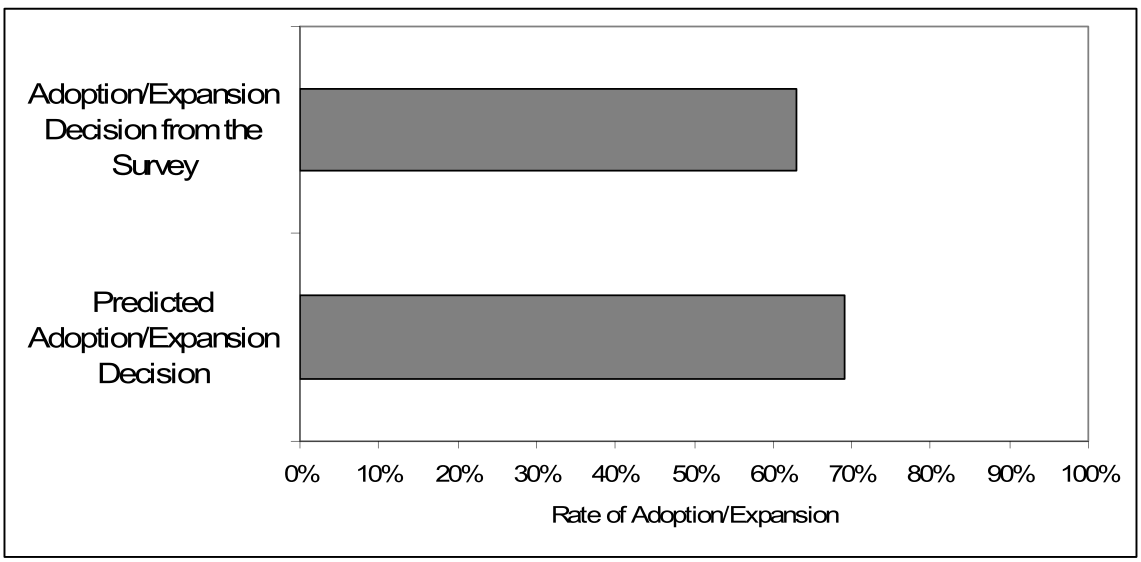


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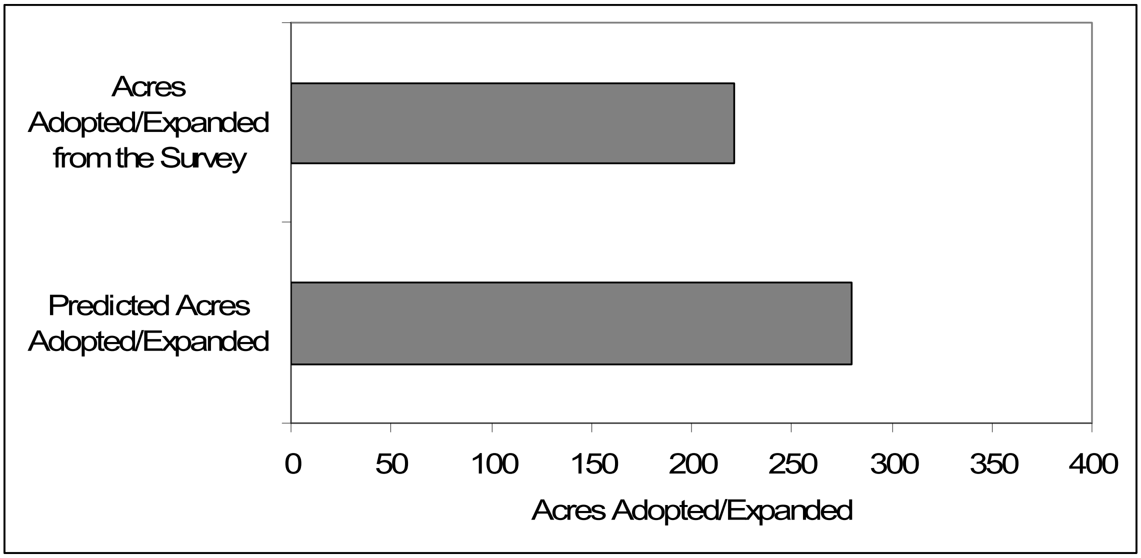
Figure 4.19 Predicted and Survey Winter Wheat Acres



4.5 Results vs. Priori Expectations and Hypothesis

Results from summary analysis of survey questions and the econometric model made few departures from the priori expectations at the onset of this study. The main findings of the econometric model regarding possible attributes of winter wheat were consistent with expectation. The effect of decreasing winter kill rates and increased profit were expected to have positive impacts on both adoption/expansion rates and acres adopted which they did. The impact of duck nesting success increases on possible new variety adoption was uncertain due to a lack of specific literature on nesting success increases.

Hypothesis that were put forward in section 1.6 were answered through survey analysis. The first hypothesis that wheat producers place a positive value on the cold tolerance attribute of winter wheat is not rejected due to the results from the Cragg model. Both stages of the model indicated that decreasing winter kill rates would have a positive impact on adoption and the number of acres adopted.

The second hypothesis, that wheat producers are willing to make tradeoffs between increases in duck nesting success and profits when adopting new varieties of winter wheat was rejected. Its rejection was based on the negative impact duck nesting success had on adoption in combination with the positive impact of gross profit increases compared to spring wheat. This hypothesis was based on the general literature surrounding conservation technology adoption and profit-environmental stewardship tradeoffs. In the case of increased duck habitat there may be other factors such as a nuisance factor of ducks or some other reason that lowers the relative value of nesting success compared with profit increases.

The third and final hypothesis put forward in the introduction and background section was that a straight cash subsidy is not as effective as another method of benefit transfer to encourage new winter wheat variety adoption. This hypothesis was not rejected based on general survey questions which indicated that producers are not as interested in cash payments to preserve habitat and are more willing to adopt the crop with increases in profitability and if certain social drivers exist.

Chapter 5: Conclusions and Implications

This study elicited values from producers for cold tolerance and duck nesting success rates in new hypothetical winter wheat varieties. The possible tradeoff between profits and duck nesting habitat was also analyzed for producers in Western Canada. Drivers and barriers to winter wheat adoption were examined to determine existing reasons for its adoption. Augmenting the existing drivers and barriers was an analysis of the demand for traits that might induce future adoption of winter wheat and aid in the development of environmentally friendly crops to meet targets for migratory waterfowl habitat and improved cereal crop options for growers.

194 producers were surveyed at farm shows and meetings in the Western Canadian provinces of Alberta, Saskatchewan and Manitoba. A summary analysis of the data revealed that the average farm size in the sample is 2779 acres, which is larger than average in the sample than the entire population of wheat producers when wheat acres from the survey were compared to wheat acres from the 2006 Canadian census of agriculture. Alberta producers planted the most HRS and CPS wheat, Saskatchewan planted the most durum wheat and Manitoba producers planted more winter wheat than the other provinces. A total of 30% of producers on the prairies grow winter wheat in the sample adding to the total of 5% of total crops seeded composed of winter wheat.

Producers in the sample were asked about environmentally related behavior and participation in certain activities concerning environmental stewardship. 74% indicated they have an environmental farm plan, 44% responded that they have a drained wetland on the farm, while 6% stated that they have restored a wetland with the help of payments. 39% said they intentionally preserve waterfowl nesting habitat while 55% said they intentionally preserve other wildlife habitat hinting that other wildlife habitat may be more desirable to preserve than waterfowl nesting habitat or at least easier to preserve.

Drivers and barriers to winter wheat production are based mostly on the profitability, agronomics, and logistics of production and less on the presence of waterfowl nesting success. Growers of winter wheat indicated that the time use and machinery efficiency is a large benefit to growing the crop. Profitability compared to spring wheat is also a large factor for growers. Growers considering expanding their winter wheat acres are concerned with profit, winter survival rates and time use and efficiency gains and are less concerned with increases in waterfowl nesting habitat although there is some concern expressed for this issue.

Non growers do not grow the crop mainly because of the barriers to seeding during harvest and the risk of winter kill. When considering the adoption of winter wheat non growers thought most about winter survival rates, profits, and available labor to seed the crop. Profits and agronomic/logistic traits emerged as the dominant barriers and drivers to winter wheat production on the prairies. This was also revealed through producer ratings of different possible attributes that might be possible to produce in new winter wheat varieties. Profitability traits such as yield, quality levels, and winter survival are the most important traits to producers followed by logistic and agronomic traits such as a later possible seeding date, disease and drought resistance.

5.1 The Cold Tolerance and Duck Nesting Success Traits of Winter Wheat

From the Cragg double hurdle model it was found that producers place a significant positive value on decreasing winter kill rates. This result is consistent with the McCorkle (2007) study on cold tolerance in spring cereals and makes sense from a profit maximizing perspective. Duck nesting success increases were found to have a significant negative value to producers in both stages of the Cragg model indicating that there is a lack of willingness to trade profits for duck nesting success when considering adopting or expanding winter wheat acres. Some possible reasons for this are that ducks are generally considered by producers to reduce yields and quality of crops in some cases and that wetland habitat is costly to producers (Cortus, 2005). While personal communication with respondents revealed at least some level of concern for waterfowl habitat it is eclipsed by profitability and agronomic factors in the economic analysis.

5.2 Implications for Winter Wheat Breeding Programs

In an era of reduced public funding for cereal breeding programs, creative and efficient ways to continue to produce high quality cereals that Canada is known for are needed. The dual outcomes from winter wheat of producer profit potential and environmental preservation may present an answer to meet targets for upland migratory waterfowl habitat desired by organizations such as Ducks Unlimited and Bayer Crop Science. A focus on the demand for waterfowl habitat could promote long term relationships with funding organizations and secure continued success for Western Canadian breeding programs.

This study presents the relative demand for possible attributes of winter wheat that might be used to efficiently induce adoption or expansion of acres in Western Canada to achieve environmental goals that are good for funding organizations as well as producers. A clear ranking from the sample population of different traits provides insight to what producers demand in new varieties. The top three attributes that producers in general reported they would like to see in new varieties, in order of importance, are higher yield, higher quality, and increases in winter survival rates. Not all of these traits may be bred simultaneously into a single variety but the results provide a reference for producer demand. Existing drivers and barriers analyzed augment the ranking to provide a picture of current issues with winter wheat production that can be used to produce varieties with desirable traits and hence, a greater chance of uptake.

5.3 Implications for Environmental Organizations

Organizations actively preserving waterfowl habitat at present include Ducks Unlimited (DU) and Bayer Crop Science. DU has historically promoted wetland preservation and restoration to preserve waterfowl populations. Winter wheat is now a focus of the organization to maintain the upland nesting grounds that compliment wetlands. Bayer Crop Science has committed funding for the development and promotion of winter wheat to the sum of 20 million dollars over five years in the United States and Canada (Ducks Unlimited, 2009a).

A goal of the partnership between Bayer and DU is to promote innovation in winter wheat development, specifically regarding the adaptation of the crop to prairie climatic conditions (Ducks Unlimited, 2009a). The findings of this study reinforce the need for increased cold tolerance in winter wheat as a driver for its adoption. Investing in winter wheat breeding programs could be the most efficient long run method to encourage winter wheat adoption and expansion by producers and achieve the targets for waterfowl nesting habitat and sustainability for waterfowl populations.

The negative value placed on ducks by producers when adopting new winter wheat varieties may not mean that producers are not willing to plant winter wheat for environmentally beneficial reasons. Other bird species not considered to be waterfowl also nest in crops including killdeer, and the vesper sparrow (United States Geological Survey, 2006a). There may be a value for the increased nesting success of these birds or other environmental benefits the crop provides. Future research could focus on these areas.

5.4 Implications for Society in General

Some questions exist for the general public surrounding the issue of who will pay for improved winter wheat varieties that preserve waterfowl nesting habitat. This study has indicated that producers may be in the early stages of an environmental Kuznet's curve (Stern, 1998) where profits tend to eclipse environmental stewardship. If increased upland habitat is desired by society in general, funds may have to come from sources such as taxes or funds raised by private organizations. In the case of winter wheat there are private sources of funding available for development such as the Bayer Cropscience-Ducks Unlimited Program "Winter Cereals: Sustainability in Action" but at the moment these have a finite lifespan.

5.5 Introducing new Varieties

Producers have communicated some important information about how to bring new winter wheat varieties to the market and increase the possibility of adoption or expansion. Three important results from the survey gave some insight on producer validation of the new varieties. The first is an indicated higher average level of trust in agronomists compared to seed companies when recommendations are made regarding winter wheat varieties. This may be a general distrust of larger organizations or the long term personal nature of relationships with agronomists. It may be helpful when promoting new varieties to partner with and support agronomists in an effort to market them in a more personal manner.

Another preference revealed by producers is success experienced by neighbors. In the survey, most producers weighted this factor fairly heavily when considering adopting new varieties of winter wheat. A practical application to marketing may be partnering with key growers in communities to trial new varieties so that information about the crops is coming not only from agronomists and seed companies but from neighbors as well.

The final suggestion that was alluded to by survey respondents is a preference for test plot results. Good test plot results were ranked highly by both winter wheat growers and non growers as an influencing factor in adoption and expansion decisions. From personal communication small plots may be less influential than large scale field trials, especially by neighbors but is important to gauge how a crop will perform in the specific area that the potential adopter or expander is from.

A proposed strategy for introducing new varieties of winter wheat targeted at producers might involve less large scale advertising and more community based social network oriented marketing. Plots could be presented in different geographical locations with a range of varying agronomic challenges. They could first be presented to a group of agronomists who could identify and invite key producers in the area who could conduct some larger field trials if interested. Whatever the strategy, a less centralized personal approach may be more effective as indicated by survey responses.

5.6 Limitations of the Study

Some limitations exist to the scope and methodology of this study that should be addressed and considered when taking the findings into account if used for any practical application. The first is the bias encountered due to the convenience sampling technique used to collect data with an in person survey. A bias toward larger farm sizes in the sample population was found when compared with the 2006 Canadian Census of Agriculture. This result may be very useful in a marketing context if the target demographic for new winter wheat varieties has larger farm sizes. McCorkle (2007) argues that new product introductions should be targeted at larger farms with higher incomes. In any case, it should be noted that a bias exists and should be taken into consideration.

Another shortcoming of the analysis lies in the survey design. When asked to rate possible attributes of new winter wheat varieties according to how much they wanted to see the occurrence of each specific attribute a measure of waterfowl nesting success was not included. Although this measure was explicitly captured by the choice questions and their analysis, inclusion of this attribute in the ranking questions may have helped reinforce the findings from the econometric model as was the case with the cold tolerance trait.

The regional difference between producers in this study was examined at a provincial level which may have missed differences expressed between smaller regions. For example, the growing conditions in Southern and Northern Alberta are quite different so growers may have much different reasons for growing or not growing particularcrops. Regional differences that were initially discussed and ultimately not included in the study were soil zones and census division regions. They were not included due to data limitations and because the provincial divisions were significant in both the adoption and acreage decision of the Cragg model.

Specific welfare estimates for the willingness to accept payment to grow the new varieties were not explored in this study. WTA estimates were not estimated since the gross profit attribute was expressed as a percentage change. Attributes of new varieties and demographic factors that have an impact on adoption rates were the main focus of the econometric model. Specific measures of welfare were extraneous in answering the main questions of concern and may be included in future research on winter wheat adoption on the prairies.

In general the scope of this study is confined to the context of winter wheat varieties in Western Canada and should not be thought of as a guideline for producer demand of the traits for all crops. The McCorkle (2007) study concerning spring cereal varieties and cold tolerance is close in scope and methodology to this one but showed dissimilar enough results to merit caution concerning the transferability of results between different crops in Western Canada.

5.7 Future Research

This study focuses on the demand for certain attributes of winter wheat varieties in Western Canada which comprises only a small portion of conservation adoption in general. There are numerous questions that could be investigated by researchers in the field as well as other questions involving winter wheat varieties outside of this general area of study. For the purpose of this comment on future research possibilities a few of the most relevant ideas will be discussed.

A logical extension to this study is the exploration of environmental outcome potentials from other crops in Western Canada. Possibilities for other crops with environmentally friendly attributes and high profit potentials could be assessed to gauge producer demand for the new varieties. Some examples might include crops with higher fertilizer efficiencies, more competitiveness against weed populations, and increased water use efficiency and the efficiency of inputs in general. Given the growing concern with environmental issues it seems relevant to explore the potential uptake by producers of new crops with an environmentally friendly position.

Another consideration arising from producer demand for environmental attributes of crops might be the study to rank numerous environmental outcomes. Some may have fewer costs to producers or some other benefit that would make certain environmental benefits more desirable to producers than others. For instance a more passive environmental trait such as increased nitrogen use efficiency may be easier to implement than a trait that takes more effort and expense to adopt such as the initial planting efforts required by winter wheat production. Knowledge of which environmental benefits were demanded by producers would not only increase adoption rates but also encourage attributes with a higher benefit cost ratio to be produced first.

Augmenting producer willingness to adopt some of these environmentally friendly crops could be studies surrounding consumer perceptions and willingness to pay for certain crop attributes that are perceived as better for the environment. The result could be paired with results of producer studies to determine the social value of given crops with environmental attributes and compared to existing varieties. Knowledge of consumer preferences could also facilitate end use marketing activities for products made with more sustainable crops creating value for consumers and producers alike.

A corollary to this study might be looking at general public demand for upland migratory waterfowl habitat. Studies that place values on wetlands do exist (see Ghermandi *et al.* (2008) for a meta-analysis including 167 studies) but upland habitat is less researched. Results from upland habitat valuation by the public could be used to determine accurate benefit transfers to primary agriculture production for generating desirable environmental outcomes.

Lastly, a continuation of this study or another study of this type may include smaller regions in the analysis. Analysis of the differences between soil zones or census divisions may give more detailed information on the sets of issues producers from each area face. This detailed information would be helpful in breeding varieties more suitable for specific areas.

5.8 Concluding Remarks

Although producers indicated a desire to preserve waterfowl habitat both verbally and through survey questions, profitability is the most important attribute of possible new winter wheat varieties. Survey responses indicate that demand of future varieties will depend on the strength of profitability and agronomic traits. The cold tolerance attribute, a profitable and agronomical trait, is a significant driver for hypothetical winter wheat adoption. Willingness to trade profit and waterfowl nesting success was not found in this study.

The results from this study can be useful for policy implementation. A significant result is a negative value placed on duck nest survival when producers are adopting hypothetical new winter wheat varieties. Programs that intend to increase winter wheat acres grown on the prairies should take this into consideration when allocating resources to achieve this goal. Funding and support may be most effective when directed at improving the profitability traits of winter wheat to provide an indirect transfer to producers rather than direct incentives such as cash payments.

References

Adamowicz, W., Louviere, J. and Swait, J. 1998. Introduction to attribute-based stated choice methods. Prepared for the National Oceanic and Atmospheric Administration (NOAA Purchase Order 43AANC601388). Available from http://www.darrp.noaa.gov/library/pdf/pubscm.pdf: Internet.

Adamowicz, W., Louviere, J. and Williams, M. 1994. Combining revealed and stated preference methods for valuing environmental amenities. *Journal of Environmental Economics and Management,* 26 (3): 271-292.

Ajzen, I. and Fishbein, M. 1980. Understanding attitudes and predicting social behaviour. Englewood Cliffs, NJ: Prentice-Hall.

Ajzen, I. 1991. The theory of planned behavior. *Organizational Behavior and Human Decision Processes,* 50 (2): 179-211.

Alberta Agriculture and Rural Development (ARD). 2006. "Historical wheat collection," Available from http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/fcd4238; (accessed February 12, 2009).

Anderson, J., Vadnjal, D. and Uhlin, H. 2000. Moral dimensions of the WTA-WTP disparity: An experimental examination. *Ecological Economics* 32: 153-162.

Archibold, O. W. and Wilson, M. R. 1980. The natural vegetation of saskatchewan prior to agricultural settlement. *Canadian Journal of Botany* 58 (19): 2031-2042.

Attum, O., Lee, Y. M., Roe, J. H. and Kingsbury, B. A. 2007. Upland-wetland linkages: Relationship of upland and wetland characteristics with watersnake abundance. *Journal of Zoology* 271 (2): 134-139.

Batt, B. D. J., Anderson, M. G., Anderson, C. D. and Caswell, F. D. 1989. 204-227. *Use of of Prairie Potholes by North American Ducks*, edited by A. van der Valk, 204. Ames: Iowa State University Press.

Batte, M. T., Jones, E. and Schnitkey, G. D. 1990. Computer use by ohio commercial farmers. *American Journal of Agricultural Economics* 72 (4): 935-945.

Beattie, B. R. and Taylor, C. R. 1985. Multiproduct production. New York: John Wiley and Sons.

Bishop, R. C. and Heberlein, T. A. 1979. Measuring values of extramarket goods: Are indirect measures biased? *American Journal of Agriculture Economics* 61 (5): 926-930.

Bockstael, N. E., Strand, I. E., McConnell, K. E. and Arsanjani, F. 1990. Sample selection bias in the estimation of recreation demand functions: An adaptation to sportfishing. *Land Economics* 66 (1): 40-49.

Boyce, R. R., Brown, T. C., McClelland, G. H., Peterson, G. L. and Schulze, W. D. 1992. An experimental examination of intrinsic values as a source of the WTA-WTP disparity. *The American Economic Review* 82 (5): 1366-1373.

Canadian Wheat Board. 2009a. "2008 CWB variety survey displayed by province," Available from http://www.cwb.ca/public/en/farmers/surveys/variety/08-09/pdf/0809results.pdf; (accessed March 24, 2009).

Canadian Wheat Board. 2009b. "CWB homepage," Available from http://www.cwb.ca/en/; (accessed January 11, 2009).

Canadian Wheat Board. 2008. "Canadian western red winter (CWRW) wheat," Available from http://www.cwb.ca/public/en/library/publications/popups/pdf/western/toc/2008/CWRW2008.pdf; (accessed June 23, 2009).

Cary, J. W. and Wilkinson, R. L. 1997. Percieved profitability and farmers' conservation behaviour. *Journal of Agricultural Economics* 48 (1): 13-21.

Chouinard, H. H., Paterson, T., Wandschneider, P. R. and Ohler, A. M. 2008. Will farmers trade profits for stewardship? heterogeneous motivations for farm practice selection. *Land Economics* 84 (1): 66-82.

Cole, J. 2008. Personal communication. (Jim Cole is a crop producer in Clive, Alberta east of Lacombe).

Cooper, J. C. 2001. A joint framework for analysis of agri-environmental payment programs. *(Presented at the August, 2001 meetings of the American Agricultural Economics Association in Chicago, Illinois.)* Available from http://ideas.repec.org/p/ags/aaea01/20493.html: Internet.

Cooper, J. C. 1997. Combining actual and contingent behavior data to model farmer adoption of water quality protection practices. *Journal of Agricultural and Resource Economics* 22 (1): 30-43.

Cooper, J. C. and Keim, R. W. 1996. Incentice payments to encourage farmer adoption of water quality protection practices. *American Journal of Agricultural Economics* 78 (1): 54-64.

Cortus, B., Jeffrey, S., Boxall, P., Unterschultz, J. and Morrison, I. 2005. The economics of wetland drainage: A case study in canada's prairie pothole region. MSc. Thesis: University of Alberta, Department of Rural Economy.

Cowan, W. F. 1982. Waterfowl production on zero tillage farms. *Wildlife Society Bulletin* 10 (4): 305-308.

Cowardin, L. M., Gilmer, D. S. and Shaiffer, C. W. 1985. Mallard recruitment in the agricultural environment of north dakota. *Wildlife Monographs* 92: 1-37.

Cragg, J. G. 1971. Some statistical models for limited dependent variables with application to the demand for durable goods. *Econometrica* 39 (5): 829-844.

Devries, J. 2002. "Incorporation of assessment data into the prairie pothole region decision support system," Available from http://www.ducks.ca/conserve/research/publications//phjv/0201/page4.html; (accessed February 22, 2009).

Devries, J. H., Armstrong, L. M., MacFarlane, R. J., Moats, L. and Thoroughgood, P. T. 2008. Waterfowl nesting in fall-seeded and spring-seeded cropland in saskatchewan. *Journal of Wildlife Management* 72 (8): 1790-1797.

Ducks Unlimited Canada. 2009a. "Ducks unlimited canada and bayer cropscience team up to increase winter wheat acres in north america," Available from http://www.ducks.ca/aboutduc/news/archives/2009/090113.html; (accessed April 6, 2009).

Ducks Unlimited Canada. 2009b. "Ducks unlimited canada homepage," Available from http://www.ducks.ca/; (accessed March 27, 2009).

Ducks Unlimited Canada. 2009c. "SpATS - glossary of terms," Available from http://www.ducks.ca/conserve/research/projects/spats/glossary.html; (accessed June 23, 2009).

Ducks Unlimited Canada. 2009d. "Values and benefits of wetland Habitat ," Available from http://www.ducks.ca/conserve/wetland_values/index.html; (accessed June 23, 2009).

Ducks Unlimited Canada. 2009e. "Winter wheat," Available from http://www.ducks.ca/conserve/programs/winterwheat/; (accessed June 23, 2009).

Duebbert, H. F. and Kantrud, H. A. 1987. Use of no-till winter wheat by nesting ducks in north dakota. *Journal of Soil and Water Conservation* 42 (1): 50-53.

Encyclopedia Britannica. 2009. "Vernalization," Available from http://www.britannica.com/EBchecked/topic/626291/vernalization; (accessed June 23, 2009).

Etzioni, A. 1986. The case for a multiple-utility conception. *Economics and Philosophy* 2: 159-183.

Fedak, G. 2007. "Early history of wheat growing in canada," Available from http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1181305178350; (accessed June 24, 2009).

Fowler, B. 2002a. "Top ten reasons to grow winter wheat in western canada," Available from http://www.usask.ca/agriculture/plantsci/winter_cereals/#topten; (accessed June 24, 2009).

Fowler, B. 2002b. "Winter wheat production manual," Available from http://www.usask.ca/agriculture/plantsci/winter_cereals/Winter_wheat/contents.php; (accessed March 12, 2009).

Fowler, D. B. and Gusta, L. V. 1979. Selection for winterhardiness in wheat. I. identification of genotypic variability. *Crop Science* 19: 769-772.

Fowler, D. B. and Limin, A. E. 1997. Breeding for winter hardiness in cereals. *Acta Agronomica Hungarica* 45 (3): 301-309.

Ghermandi, A., van den Bergh, J. C. J. M., Brander, L. M., de Groot, H. L. F. and Nunes, P. A. L. D. 2008. The economic value of wetland conservation and creation: A meta-analysis. *(Presented at the 13th Coalition Theory Network Workshop organized by the Fondazione Eni Enrico Mattei (FEEM) in Venice, Italy)* . Available from http://ideas.repec.org/p/fem/femwpa/2008.79.html: (accessed July 3, 2009).

Gibbons, W. J. 2003. Terrestrial habitat: A vital component for herpetofauna of isolated wetlands. *Wetlands* 23 (3): 630-635.

Goelitz, W. A. 1918. The destruction of nests by farming operations in saskatchewan. *The Quarterly Journal of Ornithology (Auk)* 35: 238-240.

Goldstein, J. H. 1971. Competition for wetlands in the midwest: An economic analysis. Washington D.C.: Resources for the Future.

Grafton, Q. R., Adamovicz, W., Dupont, D., Nelson, H., Hill, R. J. and Renzetti, S. 2004. Environmental valuation: Stated preference methods. *The Economics of The Environment and Natural Resources*, 249-276. Malden, MA: Blackwell Publishing.

Greene, W. H. 2007. Chapter E27 tobit, censored and truncated regression models. *Limdep Version 9.0 Manual*, edited by Anonymous , E27-1-E27-96.

Greene, W. H. 2003. Econometric analysis. Upper Saddle River, New Jersey: Pearson Education Inc.

Griliches, Z. 1957. Hybrid corn: An exploration in the economics of technological change. *Econometrica* 25 (4): 501-522.

Hanemann, M. W. and Kanninen, B. 1998. Statistical analysis of discrete response CV data. Working paper 798. Department of Agricultural and Resource Economics and Policy Division of Agricultural and Natural Resources: University of California at Berkeley. Available from http://are.berkeley.edu/~hanemann/wp798.pdf: Internet.

Hanemann, W. M. 1984. Welfare evaluations in contingent valuation experiments with discrete responses. *American Journal of Agricultural Economics* 66: 333-341.

Heckman, J. J. 1979. Sample selection bias as a specification error. *Econometrica* 47 (1): 153-161.

Hensher, D. A., Rose, J. M. and Greene, W. H. 2005. Paradigms of choice data. *In Applied Choice Analysis: a Primer*, 88-100. New York: Cambridge University Press.

Hornstein, H. A., Fisch, E. and Holmes, M. 1968. Influence of a model's feeling about his behavior and his relevance as a comparison other on observers' helping behavior. *Journal of Personality & Social Psychology* 10 (3): 222-226.

Jobson, J. D. 1992. Principal components, factors and correspondence analysis. *In Applied Multivariate Data Analysis Volume 2: Categorical and Multivariate Methods*, 345-468. New York: Springer-Verlag.

Kahneman, D. and Tversky, A. Mar., 1979. Prospect theory: An analysis of decision under risk. *Econometrica* 47 (2): 263-291.

Kansas State Historical Society. 2000. "Turkey red wheat," Available from http://www.skyways.org/history/redwheat.html; (accessed June 23, 2009).

Klett, A. T., Shaffer, T. L. and Johnson, D. H. 1988. Duck nest success in the prairie pothole region. *The Journal of Wildlife Management* 52 (3): 431-440.

Lichtenberg, E. 2004. Cost-responsiveness of conservation practice adoption: A revealed preference approach. *Journal of Agricultural and Resource Economics;* 29 (3): 420-435.

Limin, A. E. and Fowler, D. B. 1993. Relationship between gaurd cell length and cold hardiness in wheat. *Canadian Journal of Plant Science* 74: 59-62.

Lynne, G. D. 1995. Modifying the neo-classical approach to technology adoption with behavioral science models. *Journal of Agriculture And Applied Economics* 27 (1): 67-80.

Lynne, G. D., Casey, C. F., Hodges, A. and Rahmani, M. 1995. Conservation technology adoption decisions and the theory of planned behavior. *Journal of Economic Psychology* 16: 581-598.

Lynne, G. D., Shonkwiler, J. S. and Rola, L. R. 1988. Attitudes and farmer conservation behavior. *American Journal of Agricultural Economics* 70 (1): p12-19.

Martens, J. W. and McFadden, W. 1988. *Puccinia graminis* on wheat and barley in canada in 1986: Incidence, virulence, and impact. *Canadian Journal of Plant Pathology* 10: 263-267.

Maybery, D., Crase, L. and Gullifer, C. 2005. Categorising farming values as economic, conservation and lifestyle. *Journal of Economic Psychology* 26: 59-72.

McCallum, B. D. and DePauw, R. M. 2008. A review of wheat cultivars grown in the canadian prairies. *Canadian Journal of Plant Science* 88: 649-677.

McCorkle, B. 2007. Demographic influences on willingness to pay for cold tolerance technology. *American Journal of Agricultural Economics* 89 (5): 1315-1323.

McGregor, B. 2008. Personal communication. (Dr. Bill McGregor does industrial research work with agricultural herbicides and new crop varieties for Dow Agrosciences Canada. His current work includes trials with winter wheat concerning Downy and Japanese Brome control in Southern Alberta).

McKenzie, R. H. 2007. "Agronomic management of winter wheat in alberta," Available from http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11601/$file/112_10-1.pdf?OpenElement; (accessed June 13, 2009).

Meyer, L. 2008. Personal communication. (Leo Meyer is a crop producer from Woking, Alberta north of Grande Prairie).

Nijkamp, P., Rodenburg, C. A. and Verhoef, E. T. 2001. The adoption and diffusion of environmentally friendly technologies among firms. *International Journal of Environmental Technology and Management* 1 (1): 87-103.

Norton, N. A., Phipps, T. T. and Fletcher, J. J. 1994. Role of voluntary programs in agricultural nonpoint pollution policy. *Contemporary Economic Policy* 12 (1): 113-121.

Pannell, D. 1999. Social and economic challenges in the development of complex farming systems. *Agroforestry Systems* 45: 395-409.

Pearce, D., Ozdemiroglu, E. and et al. 2002. Economic valuation with stated preference techniques. Prepared for the Department of Transport, Local Government and the Regions: London. Available from http://www.communities.gov.uk/documents/corporate/pdf/146871.pdf: (accessed November 1, 2008).

Philip, L. J. and MacMillan, D. C. 2005. Exploring values, context and perceptions in contingent valuation studies: The CV market stall technique and willingness to pay for wildlife conservation. *Journal of Environmental Planning and Management* 48 (2): 257-274.

Rehman, T., McKemey, K., Yates, C. M., Cooke, R. J., Garforth, C. J., Tranter, R. B., Park, J. R. and Dorward, P. T. 2006. Identifying and understanding factors influencing the uptake of new technologies on dairy farms in SW england using the theory of reasoned action. *Agricultural Systems* 94 (2): 281-293.

Salmon, D. and Mclelland, M. 2008. "Winter wheat in the parkland area of alberta," Available from http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex94/$file/112_11-1.pdf?OpenElement; (accessed June 13, 2009).

Saltiel, J., Bauder, J. W. and Palakovich, S. 1994. Adoption of sustainable agricultural practices: Diffusion, farm. *Rural Sociology* 59 (2): 333-349.

Sen, A. K. 1977. A critique of the behavioral foundations of economic theory. *Philosophy and Public Affairs* 6 (4): 317-344.

Sikkema, P. H., Brown, L., Shropshire, C. and Soltani, N. 2007. Responses of three types of winter wheat (triticum aestivum L.) to spring-applied post emergent herbicides. *Crop Protection* 26 (5): 715-720.

Smith, A. G., Stoudt, J. H. and Gollop, J. B. 1964. 39-50. *Waterfowl Tomorrow*, edited by J. P. Linduska. Washington: U.S. Government.

Smith, V. H. and Alan, B., E. 1996. The demand for multiple peril crop insurance: Evidence from montana wheat farms. *The American Journal of Agricultural Economics* 78: 189-201.

Statistics Canada. 2009a. "2006 ag census table 5.1 "crops (hay, field crops, vegetables, fruits, berries, nuts, nursery, sod, christmas trees, greenhouse, mushrooms and maple)"," Available from http://www.statcan.gc.ca/ca-ra2006/index-eng.htm; (accessed February 18, 2009).

Statistics Canada. 2009b. "Table 10017 - estimated areas, yield, production, average farm price and total farm value of principal field crops, in imperial units, annually," Available from http://dc2.chass.utoronto.ca/chasscansim/; (accessed May 5, 2009).

Statistics Canada. 2008. "Statistics canada homepage," Available from http://www.statcan.gc.ca/; (accessed March 22, 2009).

Steele, D. 2008. Personal communication. (Dale Steele is a Technical Sales Representative with Dow Agrosciences Canada. He manages a sales territory that includes Lethbridge, Alberta and surrounding area.).

Stern, D. I. 1998. Progress on the environmental kuznets curve? *Environment and Development Economics* 3: 173-196.

Struthers, D. and Greer, K. 2003. "Basics of cold tolerance and winter survival in winter wheat (presented at the 2001 manitoba agronomists conference)," *University of Manitoba.* Available from http://umanitoba.ca/afs/agronomists_conf/2001/pdf/struthers.pdf; (accessed August 13, 2009).

Switzer, C. and Olson, T. 2005. "Farmable wetlands program with a new incentive offered by the south dakota department of game, fish, and parks," Available from http://poli.ucalgary.ca/wildlifestewardship/system/files/images/FWPIncentiveHandout.pdf; (accessed March 31, 2009).

Thoroughgood, P. 2008. Personal communication. (Paul Thoroughgood is an agronomist for Ducks Unlimited in Southern Saskatchewan. He is also a crop producer from that area.).

Tobin, J. 1958. Estimation of relationships for limited dependant variables. *Econometrica* 26 (1): 24-36.

Umberger, W., Boxall, P. C. and Lacy, C. 2009. The role of credence and health information in determining U.S. consumers' willingnes-to pay for grass-finished beef. *Australian Journal of Agricultural and Resource Economics (forthcoming)* .

United States Geological Survey. 2006a. "Bird use and nesting in conventional, minimum-tillage, and organic cropland," *Northern Prairie Wildlife Research Center.* Available from http://www.npwrc.usgs.gov/resource/birds/birduse/disc.htm; (accessed June 23, 2009).

United States Geological Survey. 2006b. "Wetlands of the prairie pothole region: Invertebrate species composition, ecology, and management," Available from http://www.npwrc.usgs.gov/resource/wetlands/pothole/prairie.htm; (accessed June 23, 2009).

Useche, P., Barham, B. and Foltz, J. 2005. A trait specific model of GM crop adoption among U.S. corn farmers in the upper midwest. (*Presented at the July, 2005 meetings of the American Agricultural Economics Association in Providence, Rhode Island.* Available from http://www.docstoc.com/docs/9926187/A-Trait-Specific-Model-of-GM-Crop-Adoption-among-US-Corn-Farmers-in-the-Upper-Midwest: Internet.

van Kooten, G. C. and Schmitz, A. 1992. Preserving waterfowl habitat on the canadian prairies: Economic incentives versus moral suasion. *American Journal of Agricultural Economics* 74: 79-89.

van Kooten, G. C., Weisensel, W. P. and Chinthammit, D. 1990. Valuing trade-offs between net returns and stewardship practices: The case of soil conservation in saskatchewan. *American Journal of Agricultural Economics* 72 (1): 104-113.

Velicer, W. F. and Jackson, D. N. 1990. Component analysis versus common factor analysis: Some issues in selecting an appropriate procedure. *Multivariate Behavioral Research* 25 (1): 1-28.

Viterra. 2009. "Viterra homepage," Available from http://www.viterra.ca/; (accessed March 30, 2009).

Warriner, G. K. and Moul, T. M. 1992. Kinship and personal communication network influences on the adoption of agriculture conservation technology. *Journal of Rural Studies,* 8 (3): 279-291.

Widaman, K. F. 1993. Common factor analysis versus principal component analysis: Differential bias in representing model parameters? *Multivariate Behavioral Research* 28 (3): 263-311.

Zenter, R. P. and Peterson, W. L. 1982. The social value of public investment in canadian wheat breeding research. Staff Paper, Department of Agricultural and Applied Economics, University of Minnesota. p82: 1-12

Zepeda, L. and Castillo, M. 1997. The role of husbands and wives in farm technology choice. *American Journal of Agricultural Economics* 79 (2): 583-588.

Appendix A. The Survey Instrument

The following survey was used for data collection. There are seven versions of the survey differing only in the attribute levels that exist in the hypothetical variety adoption questions. There were 27 different combinations of the attribute levels which were distributed among the seven versions giving 4 combinations/questions per respondent. Naturally 27 combinations are not divisible by 4 and there was a remainder of 1 which, in order to make the versions as close to each other as possible, was filled with a repeat of the combination that was arbitrarily thought as the hardest choice between yes and no. Version 1 is shown here.

Winter Wheat Attribute Survey

Winter Wheat

In Western Canada, about 1.4 million acres of winter wheat were seeded in 2007, up from around half that much in 2005. In contrast, there are roughly 20 million acres of spring wheat in this area. The difference between fall and spring seeded wheat acres could be due to some of the challenges of growing winter wheat listed in the following table:

Pros and Cons of growing winter wheat

Pros	Cons
• High yield potential • Machinery and time can be used more efficiently in most cases because of harvest timing • Good fit with conservation farming systems • More efficient water use than spring seeded crops • Avoids wheat midge damage due to early heading – less need for insecticide • There is less need for a wild oat herbicide in general with winter wheat, although not always the case. • Reduced Fusarium head blight risk due to early development and maturity. • Avoids seeding problems on late, wet springs • Earlier harvest than spring wheat • Fewer disturbances to wildlife, especially nesting waterfowl.	• Loss of nitrogen occurs unless it is applied in the spring. • Seeding during harvesting can be a challenge • Winter survival is not guaranteed – Cold damage can reduce yield or sometimes kill the crop completely • Quality is lower than spring wheat so the price is usually lower than spring wheat unless feed wheat prices are very high • In some areas (e.g. Southern AB and SK) Downy and Japanese Brome can be an issue if not managed properly • Seeding winter wheat into crops with little stubble such as peas increases the chance of winter damage

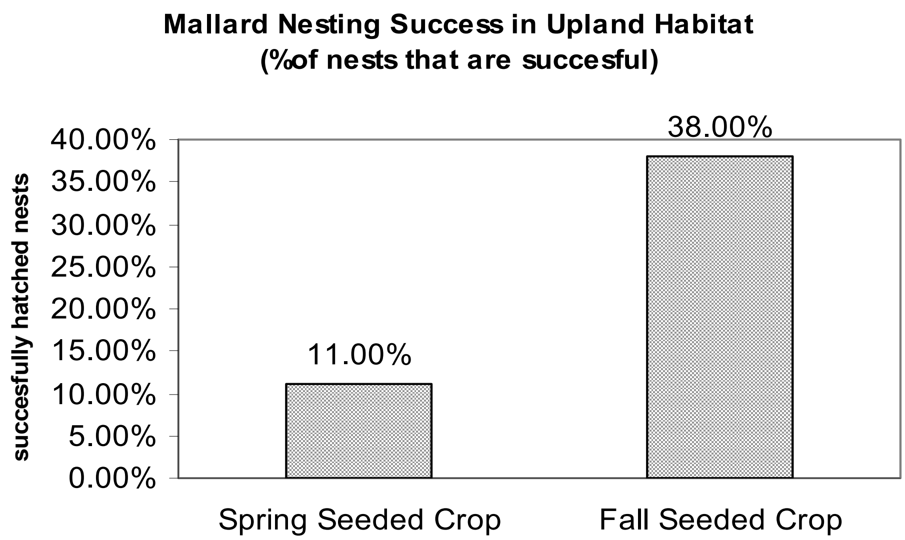
(Adapted from: http://www.usask.ca/agriculture/plantsci/winter_cereals)

New Winter Wheat varieties

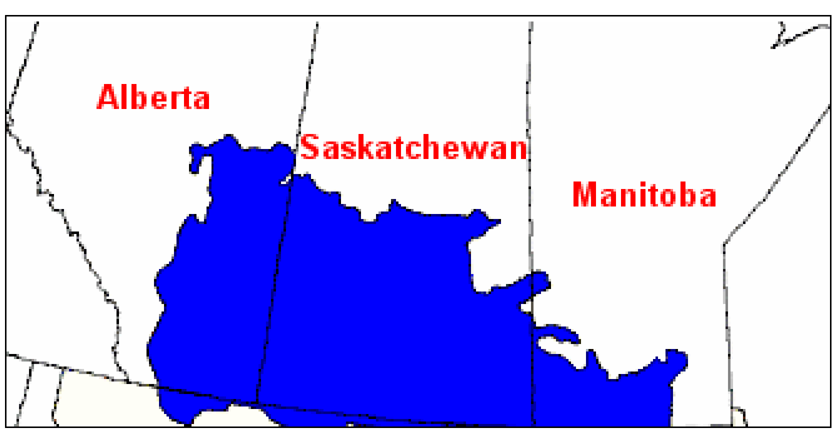
New winter wheat varieties are being developed at the University of Saskatchewan with higher yields than existing varieties. Breeding programs may also increase winter survival rates and improve quality in the future.

Upland Waterfowl Habitat on the Prairies

The prairie pothole region is the most important duck nesting habitat in North America, and a very important wheat growing region. Winter wheat provides good upland waterfowl nesting habitat because of no spring tillage and a preference by the birds for the taller grass cover it provides over spring seeded crops.



The Canadian Prairie Pothole Region (good nesting grounds)



If you have any questions or concerns filling out the survey please let us know.

Thank you in advance for your time in completing this questionnaire.

Section 1: Your Crops

The following questions concern the 2008 crop year:

1.) How many acres did you seed on your farm this year in total (all crops)? ___________

2.) How many acres of summer fallow /chem. fallow did you have this year?___________

3.) How many acres of cultivated cropland do you rent (if any)?______________________

4.) How many acres of each of the following spring wheat categories did you seed this year?

HRS (Hard Red Spring) _________________

CPS (Canadian Prairie Spring) _________________

Durum _________________

5.) Did you grow winter wheat this year?

No ☐ → **Please go to section 2, (page 4)**

Yes ☐ → **Please go to section 3, (page 5) (after completing this page)**

If yes, how many acres of winter wheat did you seed this year?_______

Section 2: For Non Winter Wheat Growers

Question 6 and 7 are only for non winter wheat growers

6.) Why don't you grow winter wheat?
(Please check all that apply)

I don't think it's as profitable as spring wheat	☐
I would have to seed it when I am harvesting	☐
I have Downy or Japanese Brome in my fields	☐
It doesn't fit in my rotation well	☐
The risk of winter damage or loss is too high	☐
A lack of good crop insurance coverage	☐
I am not familiar with how to grow it	☐
Other	☐ ________ (Please Specify if other)

7.) Assume you are considering switching some of your <u>spring</u> wheat acres to <u>winter</u> wheat. How important would the following factors be in that decision?

1 = Not important at all

5 = Very Important

	1	2	3	4	5
Higher per acre profit with winter wheat					
Availability of Labor to seed it while you are harvesting other crops					
My time and machinery could be used more efficiently					
An increase in nesting habitat for waterfowl compared to spring wheat					
A better winter survival rate than other winter varieties					
A one time per acre cash payment to adopt the new variety					
A Per acre payment every year (less than the one time payment)					
Recommended by an agronomist					
Recommended by a seed company					
The presence of Downy or Japanese Brome in your field					
Neighbors had good success with winter wheat					
Test plots showed good results for the variety compared with other varieties					

Please skip section 3 and go to section 4 (page 6), starting at question 10

Section 3: For Winter Wheat Growers

*** Question 8 and 9 are only for winter wheat growers ***

**8.) Why do you grow winter wheat?
(Please check all that apply)**

I think it's more profitable than spring wheat	
I can use time and machinery more efficiently	
Financial support from an organization or the government	
An increase in nesting habitat for waterfowl compared to spring wheat	
It was recommended	
To feed livestock	
It fit in my rotation well	
A neighbor or someone I know had good success with it	
Other	

(If recommended, by whom?)

(Please Specify if other)

9.) Assume you are considering expanding your <u>winter</u> wheat acres which will replace some of your <u>spring</u> wheat acres. How important would the following factors be in that decision?

1 = Not important at all

5 = Very Important

	1	2	3	4	5
Higher per acre profit with winter wheat than spring wheat					
Availability of Labor to seed it while you are harvesting other crops					
My time and machinery could be used more efficiently					
An increase in nesting habitat for waterfowl compared to spring wheat					
A better winter survival rate than other winter varieties					
A one time per acre cash payment to adopt the new variety					
A Per acre payment every year (less than the one time payment)					
Recommended by an agronomist					
Recommended by a seed company					
The presence of Downy or Japanese Brome in your field					
Test plots showed good results for the variety compared with other varieties					

Section 4: A New Winter Variety

10.) Assume that a new variety of winter wheat exists with attributes listed in the comparisons below. You have the option to switch some or all of your spring wheat for the new variety of winter wheat (even if you already grow some winter wheat). Please consider the scenarios that follow and make a decision for each.

<u>Scenario #1</u>

	A New Winter Wheat Variety	**My Current Spring Wheat Variety**
Complete Winter Loss Rate (Have to reseed in the spring)	1 in 20 yrs	0
Gross Profit (revenue - costs) compared to Spring Wheat	10% more	-
Number of successful duck nests per quarter (160 acres)	5	1

My decision would be to: (please check one)	Switch some acres to the new winter variety	Stick with my current spring variety
	☐	☐

If applicable, How many acres would you switch to winter wheat? ____________________

Scenario #2

	A New Winter Wheat Variety	My Current Spring Wheat Variety
Complete Winter Loss Rate (Have to reseed in the spring)	1 in 50 yrs	0
Gross Profit (revenue - costs) compared to Spring Wheat	10% more	-
Number of successful duck nests per quarter (160 acres)	5	1

My decision would be to: (please check one)	Switch some acres to the new winter variety	Stick with my current spring variety
	☐	☐

If applicable, How many acres would you switch to winter wheat? ____________________

Scenario #3

	A New Winter Wheat Variety	My Current Spring Wheat Variety
Complete Winter Loss Rate (Have to reseed in the spring)	1 in 50 yrs	0
Gross Profit (revenue - costs) compared to Spring Wheat	5% less	-
Number of successful duck nests per quarter (160 acres)	10	1

My decision would be to: (please check one)	Switch some acres to the new winter variety	Stick with my current spring variety
	☐	☐

If applicable, How many acres would you switch to winter wheat? ____________________

Scenario #4

	A New Winter Wheat Variety	**My Current Spring Wheat Variety**
Complete Winter Loss Rate (Have to reseed in the spring)	1 in 50 yrs	0
Gross Profit (revenue - costs) compared to Spring Wheat	20% more	-
Number of successful duck nests per quarter (160 acres)	10	1

My decision would be to: (please check one)	Switch some acres to the new winter variety	Stick with my current spring variety
	☐	☐

If applicable, How many acres would you switch to winter wheat? ____________________

11.) If you did not choose to plant any of the new winter wheat variety in any of the scenarios, please briefly describe why not.

**12.) What would you like to see in a new variety of winter wheat?
Please rate the following possibilities from 1 to 5**

1 = Would not like to see at all
5 = Would like to see very much

	1	2	3	4	5
A better winter survival rate than other winter wheat varieties					
Higher yield than other varieties					
Higher Quality than existing winter varieties resulting in a higher price					
Earlier maturity than other varieties					
The ability to seed it closer to freezeup in the fall					
Increased disease resistance					
Increased drought resistance					
Shorter stalks (less straw production)					
Traits that increase marketability and provide a price premium					
Other (please specify)					

Section 5: You and Your Farm

13.) How many years have you been farming? __________________________________

14.) Which of the following applies to you or your farm?
(please check all that apply)

I am the principal decision maker/manager on the farm	☐
I plan to expand within the next 5 years?	☐
I have an environmental farm plan?	☐
I participate in AgriStability/AgriInvest	☐
I allow duck or goose hunters on my land	☐
I am a duck or goose hunter	☐
Wetland drainage has been used on my farm to increase productivity	☐
I have received payments/incentives to restore wetlands on my farm	☐
I intentionally keep areas suitable for waterfowl nesting	☐
I intentionally keep areas for other wildlife habitat (e.g. bush for deer)	☐

15.) Including yourself, how many people normally work on your farm?___________

16.) Formal Education:

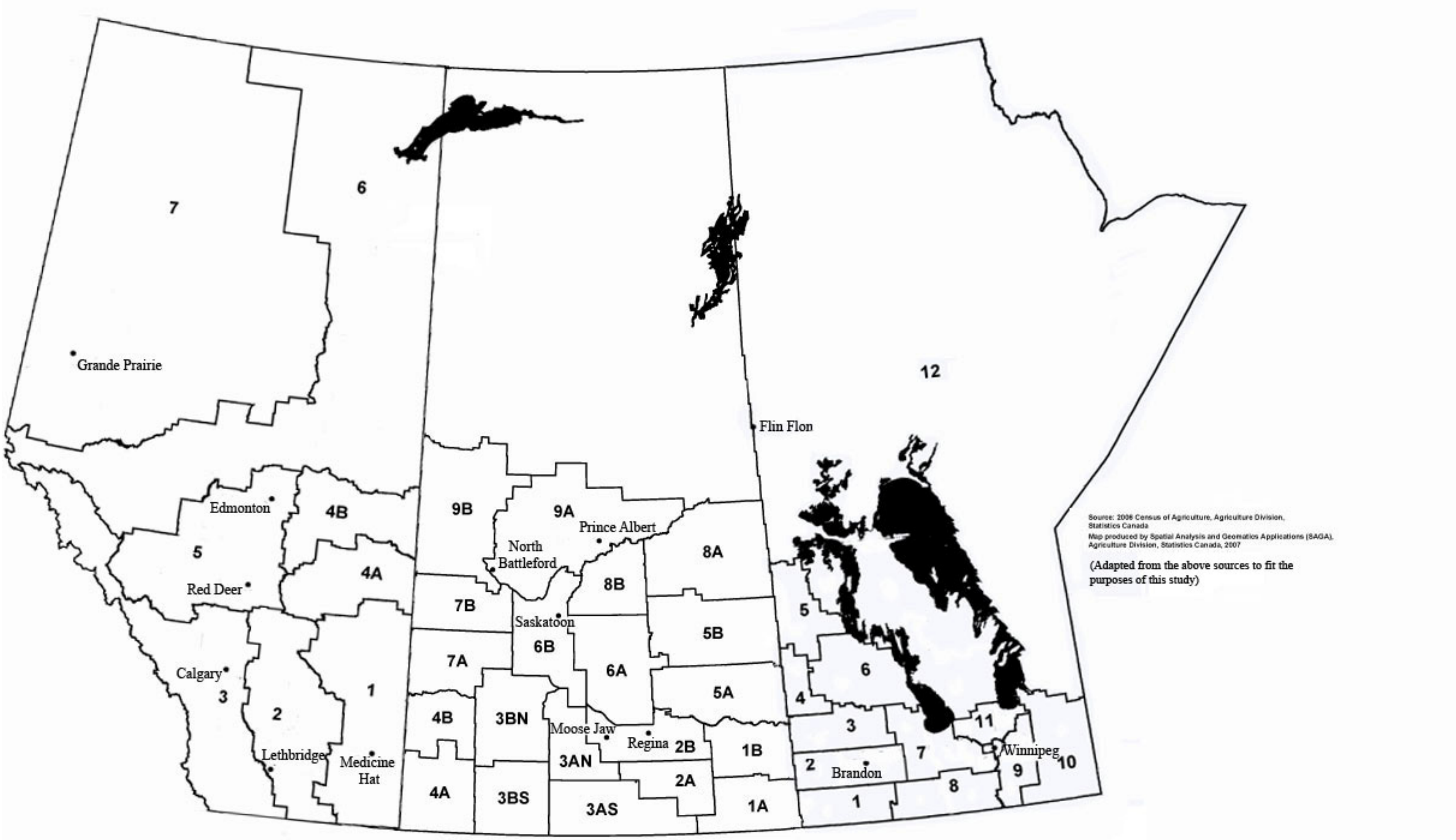
Up to High School	☐
Some High School	☐
High School Diploma	☐
Post Secondary (College, University, Apprenticeship, etc…)	☐

17.) Have you attended any agronomy seminars or similar events in the last three years?

Yes	No
☐	☐

The last question is on the back of this page →

18.) Please mark an X on the map where your farm is located



Thank you for taking the time to complete this survey. Your time is valuable and much appreciated. V1

Appendix B: Extra Summary Tables for Survey Questions

Table B.1 Number of Respondents Producing Each Type of Wheat in the Sample on the Prairies and by Province

Wheat Type	Prairies	AB	SK	MB
HRS	151	67	52	32
Durum	42	5	37	0
Winter Wheat	60	21	13	26
CPS	33	21	8	4
# of Producers Surveyed	196	77	84	35

Table B.2 Percentage of Respondents from each Prairie Province Producing Each Type of Wheat as a Percentage of Total Respondents Producing That Type of Wheat

Wheat Type	AB	SK	MB
HRS	44.4%	34.4%	21.2%
Durum	11.9%	88.1%	0.0%
Winter Wheat	35.0%	21.7%	43.3%
CPS	63.6%	24.2%	12.1%

Table B.3 Number of Non Winter Wheat Growers Selecting Each Rating Level for Factors Affecting the Decision to Switch Spring Wheat Acres to Winter Wheat on the Prairies (including AB,SK,and MB)

	Rating					
	1	2	3	4	5	Responses
Higher Profit	8	6	25	37	58	134
Available Labor	10	9	18	41	56	134
Time/Machinery Use Efficiency	12	20	35	38	27	132
Nest Habitat was Improved	38	39	32	13	12	134
Better Winter Survival	4	8	22	44	56	134
One Time Cash Payment	15	23	53	20	21	132
Cash Payment Each Year	18	21	53	27	13	132
Recommended by an Agronomist	14	23	44	39	13	133
Recommended by a Seed Company	35	29	43	19	6	132
Concerned with Downy/Japanese Brome	51	19	25	19	16	130
Neighbors had Success	11	16	37	50	19	133
Positive Test Plot Results	5	12	33	55	29	134

Table B.4 Number of Non Winter Wheat Growers Selecting Each Rating Level for Factors Affecting the Decision to Switch Spring Wheat Acres to Winter Wheat in Alberta

	Rating					
	1	2	3	4	5	Responses
Higher Profit	1	6	11	14	24	56
Available Labor	1	3	6	17	29	56
Time/Machinery Use Efficiency	1	5	16	20	13	55
Nest Habitat was Improved	18	20	11	4	3	56
Better Winter Survival	0	3	9	20	24	56
One Time Cash Payment	4	8	27	9	6	54
Cash Payment Each Year	7	7	26	11	4	55
Recommended by an Agronomist	6	10	16	18	6	56
Recommended by a Seed Company	17	13	16	8	2	56
Concerned with Downy/Japanese Brome	23	6	10	9	6	54
Neighbors had Success	6	7	12	25	6	56
Positive Test Plot Results	1	9	10	22	14	56

Table B.5 Number of Non Winter Wheat Growers Selecting Each Rating Level for Factors Affecting the Decision to Switch Spring Wheat Acres to Winter Wheat in Saskatchewan

	Rating					
	1	2	3	4	5	Responses
Higher Profit	7	0	11	21	31	70
Available Labor	9	5	11	22	23	70
Time/Machinery Use Efficiency	9	12	19	16	13	69
Nest Habitat was Improved	16	18	19	8	9	70
Better Winter Survival	4	5	11	22	28	70
One Time Cash Payment	10	13	23	11	13	70
Cash Payment Each Year	10	12	25	15	8	70
Recommended by an Agronomist	7	11	25	20	7	70
Recommended by a Seed Company	16	14	25	10	4	69
Concerned with Downy/Japanese Brome	27	12	13	8	9	69
Neighbors had Success	5	8	21	24	12	70
Positive Test Plot Results	3	2	21	30	14	70

Table B.6 Number of Non Winter Wheat Growers Selecting Each Rating Level for Factors Affecting the Decision to Switch Spring Wheat Acres to Winter Wheat in Manitoba

	Rating					
	1	**2**	**3**	**4**	**5**	**Responses**
Higher Profit	0	0	3	2	3	8
Available Labor	0	1	1	2	4	8
Time/Machinery Use Efficiency	2	3	0	2	1	8
Nest Habitat was Improved	4	1	2	1	0	8
Better Winter Survival	0	0	2	2	4	8
One Time Cash Payment	1	2	3	0	2	8
Cash Payment Each Year	1	2	2	1	1	7
Recommended by an Agronomist	1	2	3	1	0	7
Recommended by a Seed Company	2	2	2	1	0	7
Concerned with Downy/Japanese Brome	1	1	2	2	1	7
Neighbors had Success	0	1	4	1	1	7
Positive Test Plot Results	1	1	2	3	1	8

Table B.7 Number of Winter Wheat Growers Selecting Each Rating Level for Factors Affecting the Decision to Switch Spring Wheat Acres to Winter Wheat on the Prairies (including AB,SK,and MB)

	Rating					
	1	**2**	**3**	**4**	**5**	**Responses**
Higher Profit	0	2	7	16	34	59
Available Labor	3	6	11	20	18	58
Time/Machinery Use Efficiency	1	4	12	25	17	59
Nest Habitat was Improved	17	14	17	8	2	58
Better Winter Survival Rate	2	5	8	25	19	59
One Time Cash Payment	14	9	17	10	8	58
Cash Payment Each Year	12	7	16	11	11	57
Recommended by an Agronomist	14	5	21	12	5	57
Recommended by a Seed Company	18	9	18	8	4	57
Concerned with Downy/Japanese Brome	24	11	5	10	7	57
Positive Test Plot Results	2	4	15	25	13	59

Table B.8 Number of Winter Wheat Growers Selecting Each Rating Level for Factors Affecting the Decision to Switch Spring Wheat Acres to Winter Wheat in Alberta

	Rating					
	1	**2**	**3**	**4**	**5**	**Responses**
Higher Profit	0	1	2	4	14	21
Available Labor	1	3	2	9	6	21
Time/Machinery Use Efficiency	0	2	1	8	10	21
Nest Habitat was Improved	2	6	9	4	0	21
Better Winter Survival Rate	1	2	3	8	7	21
One Time Cash Payment	2	4	7	4	3	20
Cash Payment Each Year	3	2	5	5	5	20
Recommended by an Agronomist	3	2	9	3	3	20
Recommended by a Seed Company	5	6	5	2	2	20
Concerned with Downy/Japanese Brome	8	7	3	1	1	20
Positive Test Plot Results	0	4	3	8	6	21

Table B.9 Number of Winter Wheat Growers Selecting Each Rating Level for Factors Affecting the Decision to Switch Spring Wheat Acres to Winter Wheat in Saskatchewan

	Rating					
	1	2	3	4	5	Responses
Higher Profit	0	0	2	4	6	12
Available Labor	0	0	5	4	3	12
Time/Machinery Use Efficiency	0	1	4	5	2	12
Nest Habitat was Improved	3	3	3	3	0	12
Better Winter Survival Rate	0	1	1	5	5	12
One Time Cash Payment	4	2	1	1	4	12
Cash Payment Each Year	4	2	3	1	1	11
Recommended by an Agronomist	4	0	3	4	0	11
Recommended by a Seed Company	4	0	5	2	0	11
Concerned with Downy/Japanese Brome	2	3	0	4	2	11
Positive Test Plot Results	1	0	4	4	3	12

Table B.10 Number of Winter Wheat Growers Selecting Each Rating Level for Factors Affecting the Decision to Switch Spring Wheat Acres to Winter Wheat in Manitoba

	Rating					
	1	2	3	4	5	Responses
Higher Profit	0	1	3	8	14	26
Available Labor	2	3	4	7	9	25
Time/Machinery Use Efficiency	1	1	7	12	5	26
Nest Habitat was Improved	12	5	5	1	2	25
Better Winter Survival Rate	1	2	4	12	7	26
One Time Cash Payment	8	3	9	5	1	26
Cash Payment Each Year	5	3	8	5	5	26
Recommended by an Agronomist	7	3	9	5	2	26
Recommended by a Seed Company	9	3	8	4	2	26
Concerned with Downy/Japanese Brome	14	1	2	5	4	26
Positive Test Plot Results	1	0	8	13	4	26

Table B.11 Number of Respondents Selecting Each Rating Level for Possible Attributes in New Winter Wheat Varieties on the Prairies (including AB,SK, and MB)

	Rating					
	1	2	3	4	5	Responses
Survival Rate	4	3	15	52	118	192
Higher Yield	3	1	10	53	124	191
Improved Quality	5	2	13	52	119	191
Earlier Maturity	10	12	55	59	53	189
Earlier Possible Seeding Date	6	7	21	65	91	190
Improved Disease Resistance	6	6	34	63	81	190
Improved Drought Tolerance	7	12	41	53	78	191
Shorter Stalks	12	28	52	53	45	190
Marketing Attributes	4	3	11	69	103	190
Other	1	0	3	1	5	10

Table B.12 Number of Respondents Selecting Each Rating Level for Possible Attributes in New Winter Wheat Varieties in Alberta

	Rating					
	1	2	3	4	5	Responses
Survival Rate	0	1	6	24	44	75
Higher Yield	0	0	3	20	52	75
Improved Quality	0	0	5	17	53	75
Earlier Maturity	5	5	19	22	23	74
Earlier Possible Seeding Date	1	2	11	26	34	74
Improved Disease Resistance	1	4	15	31	24	75
Improved Drought Tolerance	2	6	14	24	29	75
Shorter Stalks	2	13	26	19	15	75
Marketing Attributes	0	0	3	33	39	75
Other	0	0	1	0	2	3

Table B.13 Number of Respondents Selecting Each Rating Level for Possible Attributes in New Winter Wheat Varieties in Saskatchewan

	Rating					
	1	**2**	**3**	**4**	**5**	**Responses**
Survival Rate	4	2	4	20	52	82
Higher Yield	3	1	5	21	51	81
Improved Quality	5	1	6	24	45	81
Earlier Maturity	5	5	24	27	19	80
Earlier Possible Seeding Date	4	2	8	28	39	81
Improved Disease Resistance	5	2	15	24	34	80
Improved Drought Tolerance	4	2	15	24	36	81
Shorter Stalks	8	11	19	24	18	80
Marketing Attributes	4	3	6	26	41	80
Other	0	0	1	0	2	3

Table B.14 Number of Respondents Selecting Each Rating Level for Possible Attributes in New Winter Wheat Varieties in Manitoba

	Rating					
	1	**2**	**3**	**4**	**5**	**Responses**
Survival Rate	0	0	5	7	22	34
Higher Yield	0	0	2	11	21	34
Improved Quality	0	0	2	11	21	34
Earlier Maturity	0	2	11	10	11	34
Earlier Possible Seeding Date	1	3	2	10	18	34
Improved Disease Resistance	0	0	4	7	23	34
Improved Drought Tolerance	1	4	12	4	13	34
Shorter Stalks	2	4	7	9	12	34
Marketing Attributes	0	0	2	10	22	34
Other	1	0	1	0	1	3