RETURNS TO RESEARCH

WESTERN GRAINS RESEARCH FOUNDATION

WHEAT AND BARLEY VARIETAL DEVELOPMENT

Funded by

Western Grains Research Foundation

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Executive Summary

The Western Grain Research Foundation (WGRF) has collected check-off funds from wheat (Western Canada) and barley sales (SK, MB, BC) since the 1993-94 crop year. The investments made by the WGRF in varietal development have resulted in over 50 new wheat varieties and over 40 new barley varieties being released for commercial production by farmers[1]. This study builds on the 2005 report on the rate of return to the WGRF investment varietal development by Scott et al.

Since, 1995 the WGRF has administered a total of $82 million dollars of which $68.9 million came from the wheat check-off and $13.1 million from the barley check-off. These funds have been invested in wheat and barley breeding and germplasm development at Agriculture and Agri-Food Research centres (Swift Current, Brandon, Lethbridge, and Winnipeg), Crop Development Centre at Saskatoon, the University of Alberta at Edmonton, the University of Manitoba at Winnipeg and Alberta Agriculture Food and Rural Development at Lacombe.

A benefit/cost analysis was used to compare the cost of the check-off as the levy paid by producers to the benefits as generated by the investments in varietal R&D. The benefits arise as new WGRF funded varieties are adopted by producers in Western Canada. These varietal benefits are measured as increased yield and improvements in genetic traits over the standard variety. The net present value of the benefits and costs from adoption of WGRF funded varieties (factual scenario) is compared to a counterfactual scenario (without WGRF check-off). The difference between the two scenarios is the return to the WGRF investments in varietal R&D.

The time line for the analysis is 1995 to 2011 for the actual and 2012 to 2030 for the forecasted period. The costs are the WGRF check-off levies over the 1995 to 2011 period. The benefits period is from 1999 to 2030. The lag that exists between the investment in R&D and the registration of new varieties is accounted for by starting the benefits stream in 1999. Also, benefits to the WGRF investment in R&D over 1995-2011 will continue as new WGRF varieties are released and the genetics developed are used in non-WGRF varieties.

The area of adoption of WGRF funded varieties from 1998 to 2011 is available from the annual Canadian Wheat Board variety survey. The typical varietal adoption path over 1998-2011 is used in the estimation of adoption rates over the 2012-2030 period. The increase in production due to WGRF funded varieties is the net yield improvement to WGRF funded varieties times their area of adoption. Historical and projected farm gate prices are used to value this additional production.

A summary of the results is presented in Table E.1. The WGRF funded research has created new varieties with a 2011 present value of $2.6 billion. The reported benefit/cost ratios are the present value of producer benefits divided by the present value of costs, each calculated in 2011 dollars with a 5% real discount rate. For wheat, the WGRF has returned to producers a present value of $20.40 in benefits for each dollar of producer check-off cost. For barley $7.56 in producer benefits were generated for each dollar of producer cost. At the varietal class level

[1] Note that this does not include WGRF funded varieties that were subsequently deregistered and WGRF funded varieties that were released after 2009 as there is no data on which to base the rate of adoption by farmers.

CWAD had a return of $35.91 for each dollar invested, CWRS $31.13 and for 2-Row Malt $6.51. The benefit/cost ratio of less than one for the CPS and CWES suggest that breeders have not yet been able to create a significant breakthrough in these minor wheat classes.

Overall the WGRF portfolio has earned a very high return for producers. The percentage annual rate of return on investment of 36% for all wheat and 28% for all barley indicates that WGRF has generated a return much higher than most other investments. These high returns reveal that producers have benefited substantially and could benefit from increased investment in research.

Table E.1: Producer Benefit/Cost Ratio and Internal Rate of Return for WGRF Wheat and Barley Investments 1995-2030 (2011 dollars)

Varietal	Benefits[a] ($ '000)		Costs[b] ($ '000)		Producer	
Type/Class	Producer	Total	Producer	Total	B/C[c]	IRR[d]
All Wheat	2,360,615	2,455,040	115,721	116,987	20.40	36%
CWRS	1,159,661	1,206,047	37,257	37,729	31.13	42%
CWHW	9,799	10,191	4,406	4,545	2.22	
CWAD	864,952	899,550	24,088	24,721	35.91	44%
CPS	-	-	24,877	24,877	-	
CWES	2,327	2,420	10,378	10,384	0.22	
CWRW	16,725	17,394	13,239	13,239	1.26	
CWSWS	41,801	43,473	1,471	1,497	28.42	
All Barley	171,945	181,058	22,758	23,553	7.56	28%
2-R Malt	75,476	79,476	11,598	12,012	6.51	26%

a. Total Surplus includes both producer and consumer benefits.
b. Producer Costs are those incurred by producers in developing WGRF funded varieties while total include the consumer's share.
c. Benefit/Cost Ratio for producers is the benefits that accrue to the producers divided by the share of the costs of R&D development that are borne by the producers.
d. Internal Rate of Return is the interest rate that equates the stream of benefits to the stream of costs.

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Chapter 1: Introduction

1.1 Study Objective

The objective of the study is to estimate the return to the research and development expenditure (R&D) on wheat and barley breeding programs from the investments made from the funds collected due to the Western Grains Research Foundation (WGRF) check-off. This will be achieved by the estimation of the benefit/cost ratio (B/C) and the internal rate of return (IRR) to the growers from the check-off funds investment in varietal development from 1995 to 2011.

1.2 Organization of the Report

A brief overview of the WGRF check-off as to amounts collected, trends and crop breeding institutions funded is presented in Chapter Two.

A description of the methodology used in the estimation of the returns to the funds invested from the WGRF check-off is in Chapter Three. The benefits and costs for the factual situation (what actually happened) are compared to the benefits and costs of the counterfactual scenario (hypothetical scenario of no WGRF investment).

Empirical analysis and results from the estimation of the benefits and costs from the WGRF investments are presented in Chapter 4. Estimation of the value of the yield improvement and costs estimation are described. The benefit cost ratio and internal rate of return from the investment of WGRF funds is then calculated.

For a summary of the study findings and policy implications please see the executive summary. As well a more detailed description of the methodology used in estimating the rate of return to varietal development is presented in the Appendix.

Chapter 2: Overview of Western Grain Research Foundation Check-offs

2.1 Introduction

A description of the funds administered by the WGRF, the institutions receiving funding and varieties developed through the investment of WGRF funding are presented in this chapter.

2.2 Funds Administered by the WGRF

The WGRF administers the funds from the annual check-off on wheat and barley along with the Endowment Fund.

2.2.1 Endowment Fund

The Endowment Fund has funded over 230 research projects since 1981 for over $26 million. Interest generated from the Endowment Fund account is used to fund research on all crop types. Revenue from railways that exceed the revenue cap from the transportation of western grains is paid into the Endowment Fund. Since 2003-2004 over $76 million due to the railways exceeding the cap have been deposited into the fund which now stands at over $79 million. The expenditures and the benefits from the endowment fund are not part of the analysis of this study, which only examines the returns to check-off funded research.

2.2.2 Check-off Funds

The annual amounts collected from the wheat and barley check-offs are presented in Figure 2.1. Over the 1995 to 2011 period a total of $82 million dollars was collected of which $68.9 million came from the wheat check-off and $13.1 million from the barley check-off. The inflation adjusted amounts from the respective check-off funds are used as the cost in the Benefit/Cost calculation.

The check-off funds have been invested in the R&D of new wheat and barley cultivars which are released for commercial production by growers. Royalties on the new varieties developed from WGRF funding have also gone into funding varietal genetics research along with other activities. In 2011 royalties of $1.2 million and $88,904 for wheat and barley, respectively were received.

2.3 Barley Check-Off Fund

The barley check-off has been an annual deduction of $0.40/tonne between 1995 and 2005 that was increased to $0.50/tonne between 2006 and 2012. The check-offs were deducted from the Canadian Wheat Board Final Payment to producers in Saskatchewan, Manitoba and British Columbia. The check-off has only applied to barley marketed through the CWB. The Alberta Barley Commission collects a check-off on barley grown in Alberta that funds a separate funding program. On average the WGRF check-off has generated $773,000 in annual funds for R&D of barley varieties.

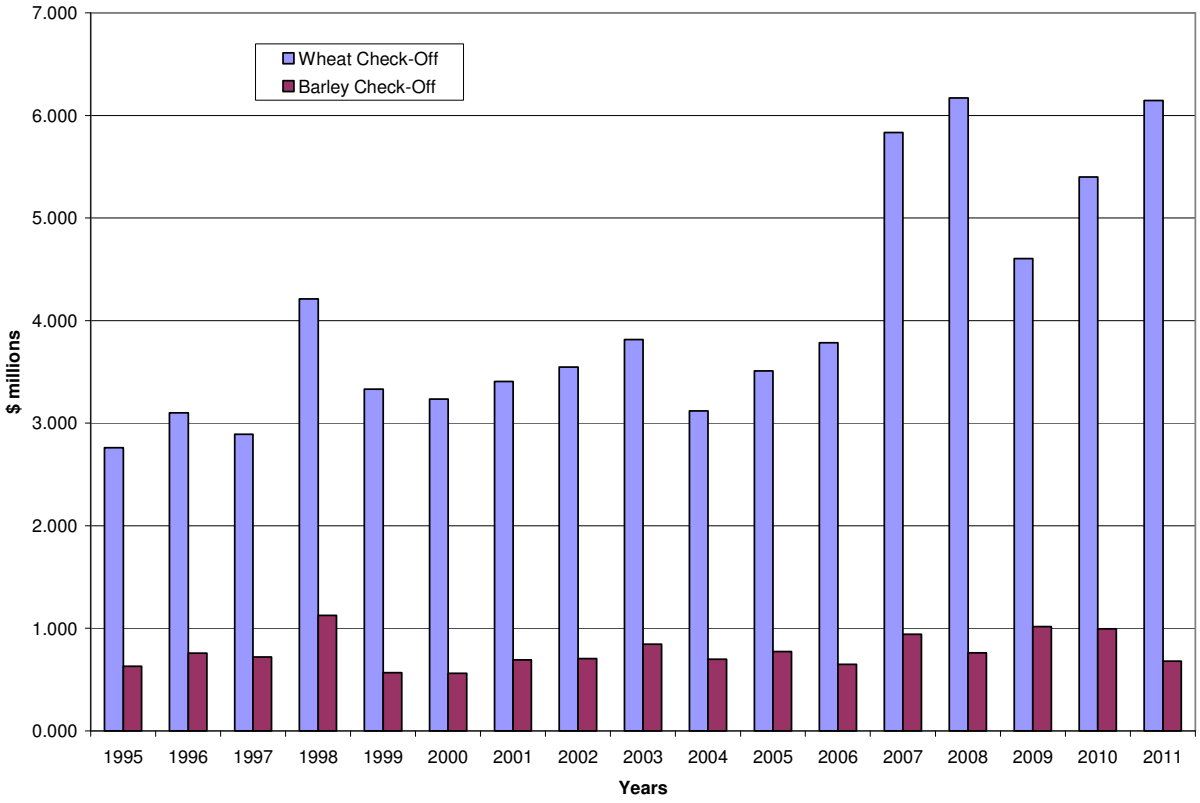

Figure 1: Wheat and Barley Check-Off Fund 1995 to 2011

Institutions allocated funding for barley varietal R&D are the Crop Development Centre (CDC) at the University of Saskatchewan and Agri-Food Canada Brandon Research Centre (AAFC Brandon). Research dollars are allocated using long term agreements with the institutions involved. The funds used for varietal development by class are presented in Table 2. To date the investment has resulted in the registration of over 40 varieties. For the purposes of this study the contribution of nine 2-Row malt varieties, 12 feed varieties, and nine Hulless varieties were used to estimate the rate of return. The development of 2-Row malt varieties has received the greatest share of WGRF barley research dollars.

Table 2: Barley Check-off Allocation by Class and Institution

	ALL	**AAFC Brandon**		**CDC U of S**	
Class	**1995-04**	**2005-09**	**2010-14**	**2005-09**	**2010-14**
2-Row Malt	*40.0%*	*50.0%*	*70%*	*45%*	*70%*
6-Row Feed	*4.0%*	*21.4%*	*0%*	*0%*	*0%*
2-Row Feed	*21.0%*	*2.9%*	*10%*	*37%*	*10%*
Hulless Feed	*24.0%*	*5.7%*	*10%*	*8%*	*10%*
Hulless Food	*11.0%*	*8.6%*	*10%*	*10%*	*10%*
Forage		*11.4%*	*0%*	*0%*	*0%*
Total	***100%***	***100%***	***100%***	***100%***	***100%***

Data analysis of crop insurance coverage for barley from Manitoba, Saskatchewan and Alberta indicates that for 2010 approximately, 47.6%, 6.6%, 0.3% and 45.5% of seeded acres were 2-Row malt, 6-Row malt, Hulless and Feed (includes forage) varieties, respectively. Of the area seeded to malt varieties 2-Row varieties occupied 87.6% of the area. The area seeded to barley in western Canada has dropped by 42% from a high point in 2007 to 2011 with greater rates of decline in area coming from Manitoba (-71%) and Saskatchewan (-50%). The barley varieties developed through WGRF funding of 2-Row malt, Feed and Hulless are presented in Tables 3 to 5, respectively.

Table 3: 2-Row Malt Barley Varieties developed with WGRF Funding

Variety	Year	Breeder
AC Bountiful	*1999*	*AAFC Brandon*
AC Calder	*2002*	*AAFC Brandon*
AC Newdale	*2001*	*AAFC Brandon*
CDC Copeland	*1999*	*CDC U of S*
CDC Landis	*2008*	*CDC U of S*
CDC Meredith	*2008*	*CDC U of S*
CDC Select	*2002*	*CDC U of S*
Major	*2010*	*AAFC Brandon*
AC Norman	*2009*	*AAFC/CDC*

Table 4: Feed Barley Varieties developed with WGRF Funding

Variety	Year	Breeder
AC Binscarth	*2006*	*AAFC Brandon*
AC Ranger	*2000*	*AAFC Brandon*
AC Rivers	*2002*	*AAFC Brandon*
AC Rosser	*1997*	*AAFC Brandon*
CDC Austenson	*2008*	*CDC U of S*
CDC Bold	*1999*	*CDC U of S*
CDC Coalition	*2007*	*CDC U of S*
CDC Cowboy	*2004*	*CDC U of S*
CDC Helgason	*2000*	*CDC U of S*
CDC Mindon	*2007*	*CDC U of S*
CDC Trey	*2003*	*CDC U of S*
Desperado	*2009*	*AAFC Brandon*

Table 5: Hulless Barley Varieties developed with WGRF Funding

Variety	Year	Breeder
AC Bacon	*1998*	*AAFC Brandon*
CDC Carter	*2008*	*CDC U of S*
CDC Freedom	*1998*	*CDC U of S*
CDC Gainer	*1997*	*CDC U of S*
CDC Lophy-I	*2007*	*CDC U of S*
CDC McGwire	*1999*	*CDC U of S*
CDC Rattan	*2003*	*CDC U of S*
CDC FIBAR	*2003*	*CDC U of S*
Millhouse	*2004*	*AAFC Brandon*

2.4 Wheat Check-off Fund

The wheat check-off fund has been an annual deduction of $0.20/tonne from 1995 to 2005 increasing to $0.30/tonne from 2006 to 2012 from the Canadian Wheat Board Final Payment to producers in Saskatchewan, Manitoba, Alberta and British Columbia. This has generated on average over $4.0 million annually in revenue to the wheat check-off fund over the 1995-11 period resulting in over 50 new varieties released to 2012. Of great importance has been the development of wheat midge resistant varieties and improved fusarium resistance which have been the two major immerging challenges facing plant breeders in the 1990s and 2000s. The first of the wheat midge resistance varieties was released in 2007 and by 2011 the total area seeded to wheat midge resistance varieties reached 19.6% in Saskatchewan, 3.2% in Manitoba and 2.6% in Alberta.

The allocation of the wheat check-off fund by class of wheat and institution since 2005 is presented in Table 6. The main institutions receiving funds are AAFC research centres at Swift Current (SPARC), Winnipeg, and Lethbridge and the CDC at U of S. The University of Alberta, Alberta Agriculture and Rural Development at Lacombe and the University of Manitoba also receive funds for wheat germplasm and varietal development. Over the 1995 to 2012 period the WGRF check-off fund has supported R&D in Canadian Western Red Spring (CWRS), Canadian Western Hard White (CWHW), Canadian Western Amber Durum (CWAD), Canadian Prairie Spring (CPS), Canadian Western Extra Strong (CWES), Canadian Soft White Spring Wheat (CSWSW) and Canadian Western Red Winter (CWRW). Of note are the elimination of funding for CWES varieties staring in 2010 and the removal of funding for the CWRW program at the CDC U of S.

Table 6: Wheat Check-off Allocation by Class and Institution

	ALL	***AAFC***		***CDC U of S***	
	1995-04	***2005-09***	***2010-14***	***2005-09***	***2010-14***
CWRS	*30.0%*	*36.9%*	*41.7%*	*30.0%*	*47.4%*
CWHW	*0.0%*	*18.7%*	*13.2%*	*0.0%*	*15.0%*
CWAD	*20.0%*	*22.6%*	*22.0%*	*25.0%*	*25.1%*
CPS	*26.0%*	*13.7%*	*11.0%*	*14.0%*	*12.5%*
CWES	*13.0%*	*0.0%*	*0.0%*	*5.0%*	*0.0%*
CSWSW	*1.0%*	*2.5%*	*3.3%*	*0.0%*	*0.0%*
CWRW	*10.0%*	*5.6%*	*8.8%*	*26.0%*	*0.0%*
Total	***100.0%***	***100.0%***	***100.0%***	***100.0%***	***100.0%***

The wheat varieties developed through WGRF funding of CWRW, CWAD, CWRS, CPS, CWES, CWSWS and CWHW that are included in the analysis are presented in Tables 7 to 13, respectively.

Table 7: CWRW Varieties Developed with WGRF Funding

Variety	***Year***	***Breeder***
AC Bellatrix	*1999*	*AAFC Lethbridge*
AC Tempest	*1999*	*AAFC Lethbridge*
CDC Buteo	*2002*	*CDC U of S*
CDC Falcon	*1998*	*CDC U of S*
CDC Ptarmigan[a]	*2007*	*CDC U of S*
CDC Raptor	*2000*	*CDC U of S*
Radiant	*2004*	*AAFC Lethbridge*

a. CDC Ptarmigan is a soft white winter wheat eligible for CWGP grades.

Table 8: CWAD Varieties Developed with WGRF Funding

Variety	***Year***	***Breeder***
AC Avonlea	*1997*	*AAFC SPARC*
AC Enterprise	*2009*	*AAFC SPARC*
AC Morse	*1996*	*AAFC Winnipeg*
AC Napoleon	*2001*	*AAFC Winnipeg*
AC Strongfield	*2004*	*AAFC SPARC*
Brigade	*2008*	*AAFC SPARC*
CDC Verona	*2008*	*CDC U of S*

Table 9: CWRS Varieties Developed with WGRF Funding

Variety	*Year*	*Breeder*
AC Abbey	*1998*	*AAFC SPARC*
AC Alvena	*2006*	*AAFC SPARC*
AC Cadillac	*1996*	*AAFC SPARC*
AC Carberry	*2009*	*AAFC SPARC*
AC Elsa	*1996*	*AAFC SPARC*
AC Fieldstar VB	*2008*	*AAFC Winnipeg*
AC Goodeve VB	*2007*	*AAFC SPARC*
AC Harvest	*2002*	*AAFC Winnipeg*
AC Infinity	*2004*	*AAFC SPARC*
AC Intrepid	*1997*	*AAFC SPARC*
AC Kane	*2006*	*AAFC Winnipeg*
AC Lillian	*2003*	*AAFC SPARC*
AC Lovitt	*2001*	*AAFC SPARC*
AC Muchmore	*2009*	*AAFC SPARC*
AC Shaw VB	*2009*	*AAFC Winnipeg*
AC Somerset	*2005*	*AAFC Winnipeg*
AC Splendor	*1996*	*AAFC SPARC*
AC Superb	*2000*	*AAFC Winnipeg*
AC Unity VB	*2007*	*AAFC Winnipeg*
AC Waskada	*2007*	*AAFC Winnipeg*
Alikat	*1999*	*U of A*
CDC Bounty	*2000*	*CDC U of S*
CDC Go	*2004*	*CDC U of S*
CDC Osler	*2004*	*CDC U of S*
Stettler	*2008*	*AAFC SPARC*

Table 10: CPS Varieties Developed with WGRF Funding

Variety	*Year*	*Breeder*
AC Crystal	*1996*	*AAFC SPARC*
AC 2000	*2000*	*AAFC SPARC*
AC Snowhite 475	*2006*	*AAFC SPARC*
AC Snowhite 476	*2006*	*AAFC SPARC*
AC Vista	*1999*	*AAFC SPARC*

Table 11: CWES Varieties Developed with WGRF Funding

Variety	*Year*	*Breeder*
AC Corrine	*1999*	*AAFC Winnipeg*
AC Glenavon	*2000*	*AAFC Winnipeg*
Burnside	*2004*	*AAFC Winnipeg*
CDC Rama	*2002*	*CDC U of S*
CDC Walrus	*2004*	*CDC U of S*
Laser	*1997*	*U of A*

Table 12: CWSWS Varieties Developed with WGRF Funding

Variety	*Year*	*Breeder*
AC Andrew	*2000*	*AAFC Lethbridge*
AC Bishaj	*2003*	*AAFC Lethbridge*
AC Meena	*2000*	*AAFC Lethbridge*
AC Sadash	*2007*	*AAFC Lethbridge*

Table 13: CWHW Varieties Developed with WGRF Funding

Variety	*Year*	*Breeder*
AC Kanata	*2006*	*AAFC Winnipeg*
AC Snowbird	*2004*	*AAFC Winnipeg*
Snowstar	*2007*	*AAFC Winnipeg*

2.5 Check-off Funding Decisions and Agreements

Long-term agreements with the institutions involved in plant breeding set the basis for how the funds are allocated to the different classes and the overall goals to be reached in terms of varietal development. Yearly reviews and progress reports are submitted by researchers in meeting the long-term objectives and for adjustments to ongoing programs.

Chapter 3: Study Methodology

3.1 Factual and Counterfactual Scenarios in Estimating the Return

In order to assess the impact of the research and development on new crop varieties on the return to WGRF funds invested the factual situation (what actually occurred) has to be compared to the counterfactual situation. The counterfactual is the hypothetical case that would have existed in absence of research and development funding in Western Canada by WGRF. We argue that in this counterfactual situation, the gains from the adoption of new varieties supported by WGRF funding would not have occurred. The consumer and producer surplus generated under the two scenarios is compared and the difference is the gain due to funding by the WGRF. The model used in this analysis is one that was used in the WGRF assessment of the rate of return by Scott et al. 2005. Some changes were made given the increased number of years that data is available and the number of WGRF varieties released. For a detailed description of the methodology used to estimate the returns to research see Appendix A.

3.2 Time Period for Measuring Costs and Benefits

3.2.1 Cost Period

Check-offs on wheat and barley from producers began in the 1993-94 crop year and have continued to the present. For the purposes of this analysis the funds collected from the 1993-94 crop year to the 2010-11 crop year represent the costs associated with development of varieties funded by WGRF.

3.2.2 Benefits Period

Because of the lag between investing in varietal research and the release of a variety and subsequent adoption by growers the benefits period does not coincide with the cost period of varietal development. At the beginning of the varietal development phase research dollars are used to fund varietal development which results in varietal releases several years later. Also, once the variety is released the adoption of the new variety will occur over a number of years well after the cost to develop the variety has been made. Scott et al. 2005 started the varietal benefit period in 1998 which extended through to 2020. The benefit period used for WGRF funded varieties in this study will therefore be assessed from 1998 to 2030 to account for recently released varieties and varieties that will result from WGRF funding to date. WGRF funded varieties registered prior to 1999 are not included in the estimation of the returns as the funds contributed by the WGRF would have been for the latter stages of varietal development and not part of the full cycle of costs incurred.

3.2.3 Adjusting for Inflation and the Discount Rate

Adjustments to the annual costs and benefits for inflation using the CPI are done to arrive at constant 2011 dollars for the stream of costs and benefits. A real discount rate of five percent is applied to the benefit and costs streams to reflect the time value of money. The adjustments for

inflation and the time value of money result in placing more importance on a dollar cost or benefit in an earlier period relative to a dollar in a later period.

3.2.4 Benefit/Cost Ratio and Internal Rate of Return Estimation

To determine the benefit/cost ratio the net present value (NPV) of the benefits is divided by the NPV of the costs using the real discount rate of five percent. The internal rate of return (IRR) is the interest rate that equates the present value of the stream of benefits to the present value of the stream of costs. Both the B/C ratio and the IRR are calculated for all the wheat varietal classes and all the barley varietal classes along with estimates for the separate classes of CWRS, CWAD, CWRW, CPS, CWES, CWSWS, CWHW and 2-Row malt.

Chapter 4: Empirical Analysis and Results

4.0 Introduction

The theoretical methodology described in the previous chapter is used to estimate the B/C ratios and the IRR due to the investment of funds by the WGRF into the wheat and barley plant breeding programs in western Canada.

4.1 Estimation of Producer Benefits

The process used to estimate producer benefits consist of identifying the benefit for each variety released due to WGRF support by

a) determining the yield improvement relative to the dominant variety in the class for each province, where the dominant variety is the variety that occupies the highest level of adoption in the class for the 1998-2002 period;

b) assessing the non-yield improvement characteristics relative to the dominant variety in the class for each province; and

c) by using the area of adoption of the variety by province.

4.1.1 Estimation of Yield Improvement

One of main benefits of breeding activity is the development of higher yielding varieties. To assess how breeding has affected yield we assume that in the absence of any breeding, the crop variety that dominated each class in the 1998-2002 period would be representative throughout the time period. Yield improvements are measured against this benchmark.

More specifically, the yield performance data from the Cooperative Performance Variety Trail (CPVT) is each province are used to compare the new variety supported by WGRF funding to the pre-existing dominant variety in each class, which is referred to as the check variety. The estimated % increase in yield for each new variety is the difference between its CPVT yield and check variety for its class.

The yield improvements by class used in the analysis are presented in Tables 14 to 23 for CWRS, CWRW, CWAD, CPS, CWES, CWSWS, CWHW 2-Row malt, Feed barley and Hulless barley, respectively.

Note:
The estimates for the yield improvement by province are from Saskatchewan Ministry of Agriculture, *Varieties of Grain Crops*, various issues; Manitoba Agriculture, *Seed Manitoba, A Growers Guide*, various issues; and Alberta Agriculture, Food and Rural Development, *Varieties of Cereal and Oilseed Crops for Alberta*, various issues.

Table 14: CWRS % Yield Increase over AC Barrie

Variety	Year	Breeder	Man.	Sask.	Alta.
AC Abbey	*1998*	*AAFC SPARC*	*-5.0%*	*-5.0%*	*-5.0%*
AC Alvena	*2006*	*AAFC SPARC*	*4.0%*	*4.5%*	*1.0%*
AC Cadillac	*1996*	*AAFC SPARC*	*5.0%*	*2.0%*	*-4.0%*
AC Carberry	*2009*	*AAFC SPARC*	*7.0%*	*10.0%*	*1.0%*
AC Elsa	*1996*	*AAFC SPARC*	*2.0%*	*3.5%*	*3.0%*
AC Fieldstar VB	*2008*	*AAFC Winnipeg*	*9.0%*	*10.0%*	*2.0%*
AC Goodeve VB	*2007*	*AAFC SPARC*	*6.0%*	*11.5%*	*6.0%*
AC Harvest	*2002*	*AAFC Winnipeg*	*8.0%*	*2.5%*	*2.0%*
AC Infinity	*2004*	*AAFC SPARC*	*5.0%*	*6.5%*	*4.0%*
AC Intrepid	*1997*	*AAFC SPARC*	*5.0%*	*2.5%*	*2.0%*
AC Kane	*2006*	*AAFC Winnipeg*	*8.0%*	*4.0%*	*-1.0%*
AC Lillian	*2003*	*AAFC SPARC*	*1.0%*	*1.5%*	*5.0%*
AC Lovitt	*2001*	*AAFC SPARC*	*1.0%*	*2.5%*	*-3.0%*
AC Muchmore	*2009*	*AAFC SPARC*	*8.0%*	*10.0%*	*11.0%*
AC Shaw VB	*2009*	*AAFC Winnipeg*	*12.0%*	*22.0%*	*13.0%*
AC Somerset	*2005*	*AAFC Winnipeg*	*4.0%*	*3.0%*	*0.0%*
AC Splendor	*1996*	*AAFC SPARC*	*-11.0%*	*-7.0%*	*-5.0%*
AC Superb	*2000*	*AAFC Winnipeg*	*5.0%*	*9.0%*	*12.0%*
AC Unity VB	*2007*	*AAFC Winnipeg*	*13.0%*	*17.5%*	*11.0%*
AC Waskada	*2007*	*AAFC Winnipeg*	*7.0%*	*14.0%*	*0.0%*
Alikat	*1999*	*U of A*	*-8.0%*	*-10.5%*	*-4.0%*
CDC Bounty	*2000*	*CDC U of S*	*6.0%*	*5.0%*	*4.0%*
CDC Go	*2004*	*CDC U of S*	*16.0%*	*2.8%*	*11.0%*
CDC Osler	*2004*	*CDC U of S*	*1.0%*	*3.0%*	*6.0%*
Stettler	*2008*	*AAFC SPARC*	*3.0%*	*13.0%*	*12.0%*

Table 15: CWRW % Yield Increase over CDC Kestrel

Variety	Year	Breeder	Man.	Sask.	Alta.
AC Bellatrix	*1999*	*AAFC Lethbridge*	*-10.9%*	*-3.8%*	*-1.9%*
AC Tempest	*1999*	*AAFC Lethbridge*	*-5.5%*	*-5.5%*	*-5.8%*
CDC Buteo	*2002*	*CDC U of S*	*0.0%*	*-5.5%*	*-4.8%*
CDC Falcon	*1998*	*CDC U of S*	*-1.0%*	*-2.5%*	*-1.9%*
CDC Ptarmigan[a]	*2007*	*CDC U of S*	*4.0%*	*10.5%*	*6.7%*
CDC Raptor	*2000*	*CDC U of S*	*-3.0%*	*-2.5%*	*-2.9%*
Radiant	*2004*	*AAFC Lethbridge*	*-5.9%*	*-3.5%*	*-1.9%*

a. CDC Ptarmigan is a soft white winter wheat eligible for CWGP grades.

Table 16: CWAD % Yield Increase over Kyle

Variety	Year	Breeder	Man.	Sask.	Alta.
AC Avonlea	*1997*	*AAFC SPARC*	*10.0%*	*6.1%*	*11.4%*
AC Enterprise	*2009*	*AAFC SPARC*	*18.9%*	*11.1%*	*15.9%*
AC Morse	*1996*	*AAFC Winnipeg*	*12.2%*	*3.3%*	*3.4%*
AC Napoleon	*2001*	*AAFC Winnipeg*	*16.6%*	*7.8%*	*0.0%*
AC Strongfield	*2004*	*AAFC SPARC*	*11.1%*	*11.1%*	*13.6%*
Brigade	*2008*	*AAFC SPARC*	*31.1%*	*19.4%*	*18.2%*
CDC Verona	*2008*	*CDC U of S*	*16.7%*	*13.9%*	*15.9%*

Table 17: CPS Wheat % Yield Increase over AC Karma

Variety	Year	Breeder	Man.	Sask.	Alta.
AC Crystal	*1996*	*AAFC SPARC*	*-3%*	*-3%*	*2%*
AC 2000	*2000*	*AAFC SPARC*	*-10%*	*-10%*	*0%*
AC Snowhite 475	*2006*	*AAFC SPARC*	*-7%*	*-7%*	*-7%*
AC Snowhite 476	*2006*	*AAFC SPARC*	*-5%*	*-5%*	*-5%*
AC Vista	*1999*	*AAFC SPARC*	*1%*	*1%*	*-1%*

Table 18: CWES % Yield Increase over Glenlea

Variety	Year	Breeder	Man.	Sask.	Alta.
AC Corrine	*1999*	*AAFC Winnipeg*	*3.8%*	*-3.8%*	*0.2%*
AC Glenavon	*2000*	*AAFC Winnipeg*	*2.9%*	*-3.3%*	*2.8%*
Burnside	*2004*	*AAFC Winnipeg*	*-3.8%*	*-8.5%*	*-8.9%*
CDC Rama	*2002*	*CDC U of S*	*1.9%*	*0.5%*	*7.1%*
CDC Walrus	*2004*	*CDC U of S*	*-7.9%*	*-4.7%*	*-12.8%*
Laser	*1997*	*U of A*	*0.0%*	*-4.9%*	*-3.8%*

Table 19: CWSWS % Yield Increase over AC Reed

Variety	Year	Breeder	Man.	Sask.	Alta.
AC Andrew	*2000*	*AAFC Lethbridge*	*9%*	*9%*	*9%*
AC Bishaj	*2003*	*AAFC Lethbridge*	*3%*	*3%*	*9%*
AC Meena	*2000*	*AAFC Lethbridge*	*3%*	*3%*	*5%*
AC Sadash	*2007*	*AAFC Lethbridge*	*10%*	*10%*	*20%*

Table 20: CWHW % Yield Increase over AC Barrie

Variety	Year	Breeder	Man.	Sask.	Alta.
AC Kanata	*2006*	*AAFC Winnipeg*	*-8%*	*-8.0%*	*-10.0%*
AC Snowbird	*2004*	*AAFC Winnipeg*	*4%*	*0.5%*	*1.0%*
Snowstar	*2007*	*AAFC Winnipeg*	*9%*	*6.5%*	*1.0%*

Table 21: Malting Barley – 2-Row % Yield Increase over AC Metcalf

Variety	Year	Breeder	Man.	Sask.	Alta.
AC Bountiful	*1999*	*AAFC Brandon*	*-9%*	*3%*	*1%*
AC Calder	*2002*	*AAFC Brandon*	*-1%*	*6%*	*0%*
AC Newdale	*2001*	*AAFC Brandon*	*10%*	*13%*	*3%*
CDC Copeland	*1999*	*CDC U of S*	*0%*	*8%*	*4%*
CDC Landis	*2008*	*CDC U of S*	*8%*	*10%*	*0%*
CDC Meredith	*2008*	*CDC U of S*	*8%*	*14%*	*8%*
CDC Select	*2002*	*CDC U of S*	*0%*	*3%*	*1%*
Major	*2010*	*AAFC Brandon*	*15%*	*15%*	*6%*
AC Norman	*2009*	*AAFC/CDC*	*3%*	*4%*	*-3%*

Table 22: Feed Barley % Yield Increase over Conlon (MB) & Dolly (SK & AB)

Variety	Year	Breeder	Man.	Sask.	Alta.
AC Binscarth	*2006*	*AAFC Brandon*	*0%*	*0%*	*0%*
AC Ranger	*2000*	*AAFC Brandon*	*19%*	*0%*	*6%*
AC Rivers	*2002*	*AAFC Brandon*	*10%*	*1%*	*-2%*
AC Rosser	*1997*	*AAFC Brandon*	*35%*	*12%*	*9%*
CDC Austenson	*2008*	*CDC U of S*	*36%*	*15%*	*10%*
CDC Bold	*1999*	*CDC U of S*	*36%*	*8%*	*5%*
CDC Coalition	*2007*	*CDC U of S*	*19%*	*9%*	*8%*
CDC Cowboy	*2004*	*CDC U of S*	*9%*	*-1%*	*-6%*
CDC Helgason	*2000*	*CDC U of S*	*17%*	*2%*	*3%*
CDC Mindon	*2007*	*CDC U of S*	*12%*	*0%*	*-2%*
CDC Trey	*2003*	*CDC U of S*	*21%*	*4%*	*3%*
Desperado	*2009*	*AAFC Brandon*	*25%*	*25%*	*25%*

Table 23: Hulless Barley % Yield Increase over CDC Dawn

Variety	Year	Breeder	Man.	Sask.	Alta.
AC Bacon	*1998*	*AAFC Brandon*	*2%*	*2%*	*2%*
CDC Carter	*2008*	*CDC U of S*	*5%*	*5%*	*5%*
CDC Freedom	*1998*	*CDC U of S*	*-5%*	*-5%*	*-5%*
CDC Gainer	*1997*	*CDC U of S*	*-6%*	*-6%*	*-6%*
CDC Lophy-I	*2007*	*CDC U of S*	*0%*	*0%*	*0%*
CDC McGwire	*1999*	*CDC U of S*	*6%*	*6%*	*6%*
CDC Rattan	*2003*	*CDC U of S*	*0%*	*0%*	*0%*
CDC FIBAR	*2003*	*CDC U of S*	*1%*	*1%*	*1%*
Millhouse	*2004*	*AAFC Brandon*	*10%*	*10%*	*10%*

4.1.2 Estimation of Non-Yield Improvements

Other factors also influence the variety adoption decision of farmers such as resistance to rust, fusarium head blight, lodging, maturity, protein, smut, sprouting, bunt, winter damage (CWRW), blotch, scald, along with wheat midge, and sawfly resistance. The importance of the various characteristics of a variety depends on the level of disease in the area or the likely occurrence of the disease or pest in the area, i.e. Fusarium Head Blight is a major concern for Manitoba and eastern Saskatchewan while sawfly resistance is more of a concern for Alberta and western Saskatchewan. These characteristics have become part of the CPVT, because they are deemed by the experts as having some economic value to producers, which can come in the form of higher field yield, higher grain quality, or pesticide savings.

The methodology used is from Scott et al. 2005 where the dominant variety's characteristics are compared to the new variety and assessed a score, if the new variety is better +1, worse -1, same 0. This methodology assumes that superior performance in any of these traits is equivalent to a 1% yield or revenue advantage in the field. Given that these traits tend to contribute more than a one percent advantage, this is conservative valuation of these traits. In turn this tends to underestimate the benefits of new varieties, which tend to be bred and selected for additional desirable traits.

The values are added to the varietal yield improvement over the dominant variety to arrive at a *net yield improvement* over the dominant variety for the new variety. The net yield improvement for CWSWS, CWHW, CWRS, CWRW, CWAD, CPS, CWES, 2-Row malt, Feed barley and Hulless barley are presented in Tables 24 to 33, respectively. Varieties developed prior to 1999 are not included in the rate of return analysis.

Table 24: CWSWS Net Improvement[a] over AC Reed

Variety	Man.	Sask.	Alta.
AC Andrew	*8.7%*	*8.7%*	*8.7%*
AC Bishaj	*5.5%*	*5.5%*	*10.7%*
AC Meena	*2.5%*	*2.5%*	*4.4%*
AC Sadash	*8.3%*	*8.3%*	*17.6%*

a. Net yield improvement is the reported CPVT results adjusted for the presence of other characteristics as described on page 15.

Table 25: CWHW Net Improvement[a] over AC Barrie

Variety	Man.	Sask.	*Alta.*
AC Kanata	*-9.0%*	*-11.0%*	*-9.0%*
AC Snowbird	*3.0%*	*0.5%*	*0.0%*
Snowstar	*11.0%*	*5.5%*	*-4.0%*

a. Net yield improvement is the reported CPVT results adjusted for the presence of other characteristics as described on page 15.

Table 26: CWRS Net Improvement[a] over AC Barrie

Variety	Man.	Sask.	Alta.
AC Abbey	*Not included*		
AC Alvena	*5.0%*	*7.5%*	*3.0%*
AC Cadillac	*Not included*		
AC Carberry	*8.0%*	*12.0%*	*3.0%*
AC Elsa	*Not included*		
AC Fieldstar VB	*8.0%*	*10.0%*	*1.0%*
AC Goodeve VB	*6.0%*	*14.5%*	*6.0%*
AC Harvest	*9.0%*	*6.5%*	*3.0%*
AC Infinity	*4.0%*	*8.5%*	*2.0%*
AC Intrepid	*Not included*		
AC Kane	*8.0%*	*5.0%*	*0.0%*
AC Lillian	*0.0%*	*3.5%*	*6.0%*
AC Lovitt	*2.0%*	*4.5%*	*-3.0%*
AC Muchmore	*8.0%*	*12.0%*	*10.0%*
AC Shaw VB	*10.0%*	*21.0%*	*11.0%*
AC Somerset	*5.0%*	*4.0%*	*0.0%*
AC Splendor	*Not included*		
AC Superb	*1.0%*	*5.0%*	*10.0%*
AC Unity VB	*12.0%*	*18.5%*	*8.0%*
AC Waskada	*10.0%*	*17.0%*	*2.0%*
Alikat	*-11.0%*	*-12.5%*	*-7.0%*
CDC Bounty	*4.0%*	*5.0%*	*1.0%*
CDC Go	*14.0%*	*2.8%*	*9.0%*
CDC Osler	*2.0%*	*6.0%*	*7.0%*
Stettler	*5.0%*	*16.0%*	*14.0%*

a. Net yield improvement is the reported CPVT results adjusted for the presence of other characteristics as described on page 15.

Table 27: CWRW Net Improvement[a] over CDC Kestrel

Variety	Man.	Sask.	Alta.
AC Bellatrix	*-11.9%*	*-1.8%*	*-0.9%*
AC Tempest	*-3.5%*	*-3.5%*	*-3.8%*
CDC Buteo	*4.0%*	*1.5%*	*0.2%*
CDC Falcon	*Not included*		
CDC Ptarmigan[b]	*3.0%*	*7.5%*	*3.7%*
CDC Raptor	*1.0%*	*1.5%*	*1.1%*
Radiant	*-4.9%*	*0.5%*	*1.1%*

a. Net yield improvement is the reported CPVT results adjusted for the presence of other characteristics as described on page 15.
b. CDC Ptarmigan is a soft white winter wheat eligible for CWGP grades.

Table 28: CWAD Net Improvement[a] over Kyle

Variety	Man.	Sask.	Alta.
AC Avonlea	*Not included*		
AC Enterprise	*20.9%*	*15.1%*	*18.9%*
AC Morse	*Not included*		
AC Napoleon	*17.6%*	*9.8%*	*-1.0%*
AC Strongfield	*11.1%*	*14.1%*	*14.6%*
Brigade	*30.1%*	*19.4%*	*17.2%*
CDC Verona	*18.7%*	*16.9%*	*17.9%*

a. Net yield improvement is the reported CPVT results adjusted for the presence of other characteristics as described on page 15.

Table 29: CPS Wheat Net Improvement[a] over AC Karma

Variety	Man.	Sask.	Alta.
AC Crystal	*Not included*		
AC 2000	*-10.6%*	*-10.6%*	*-1.0%*
AC Snowhite 475	*-4.7%*	*-4.7%*	*-7.7%*
AC Snowhite 476	*-6.6%*	*-6.6%*	*-5.6%*
AC Vista	*-0.8%*	*-0.8%*	*0.0%*

a. Net yield improvement is the reported CPVT results adjusted for the presence of other characteristics as described on page 15.

Table 30: CWES Net Improvement[a] over Glenlea

Variety	Man.	Sask.	Alta.
AC Corrine	*4.8%*	*-2.8%*	*0.2%*
AC Glenavon	*1.9%*	*-1.3%*	*1.8%*
Burnside	*-1.8%*	*-6.5%*	*-6.9%*
CDC Rama	*6.9%*	*4.5%*	*9.1%*
CDC Walrus	*-4.9%*	*-1.7%*	*-9.8%*
Laser	*Not included*		

a. Net yield improvement is the reported CPVT results adjusted for the presence of other characteristics as described on page 15.

Table 31: Malting Barley 2-Row Net Improvement[a] over AC Metcalf

Variety	Man.	Sask.	Alta.
AC Bountiful	*Not included*		
AC Calder	*2.0%*	*9.0%*	*3.0%*
AC Newdale	*13.0%*	*16.5%*	*8.0%*
CDC Copeland	*0.0%*	*8.5%*	*5.0%*
CDC Landis	*10.0%*	*11.0%*	*1.0%*
CDC Meredith	*10.0%*	*15.5%*	*11.0%*
CDC Select	*-1.0%*	*2.5%*	*2.0%*
Major	*20.0%*	*18.5%*	*12.0%*
AC Norman	*1.0%*	*0.5%*	*-3.0%*

a. Net yield improvement is the reported CPVT results adjusted for the presence of other characteristics as described on page 15.

Table 32: Feed Barley Net Improvement[a] over Conlon (MB) and CDC Dolly (SK & AB)

Variety	Man.	Sask.	Alta.
AC Binscarth	*8.0%*	*5.0%*	*0.0%*
AC Ranger	*18.1%*	*0.0%*	*3.9%*
AC Rivers	*17.1%*	*3.7%*	*3.1%*
AC Rosser	*Not included*		
CDC Austenson	*39.0%*	*17.0%*	*10.9%*
CDC Bold	*40.0%*	*10.3%*	*7.0%*
CDC Coalition	*23.1%*	*12.2%*	*7.9%*
CDC Cowboy	*15.0%*	*2.0%*	*-3.9%*
CDC Helgason	*22.9%*	*3.4%*	*7.0%*
CDC Mindon	*15.4%*	*3.5%*	*1.0%*
CDC Trey	*23.3%*	*7.9%*	*7.0%*
Desperado	*29.7%*	*22.7%*	*24.7%*

a. Net yield improvement is the reported CPVT results adjusted for the presence of other characteristics as described on page 15.

Table 33: Hulless Barley Net Improvement[a] over CDC Dawn

Variety	Man.	Sask.	Alta.
AC Bacon	*Not included*		
CDC Carter	*6.8%*	*4.8%*	*7.8%*
CDC Freedom	*Not included*		
CDC Gainer	*Not included*		
CDC Lophy-I	*4.0%*	*0.0%*	*0.0%*
CDC McGwire	*10.9%*	*8.9%*	*8.9%*
CDC Rattan	*0.0%*	*0.0%*	*0.0%*
CDC FIBAR	*0.9%*	*0.9%*	*0.9%*
Millhouse	*9.6%*	*9.6%*	*7.6%*

a. Net yield improvement is the reported CPVT results adjusted for the presence of other characteristics as described on page 15.

Note:
The estimates for the net improvement by province are from Saskatchewan Ministry of Agriculture, *Varieties of Grain Crops*, various issues; Manitoba Agriculture, *Seed Manitoba, A Growers Guide*, various issues; and Alberta Agriculture, Food and Rural Development, *Varieties of Cereal and Oilseed Crops for Alberta*, various issues.

4.1.3 Factual and Counterfactual Yield and Harvested Area

The factual yield and harvested area are from Statistics Canada actual yields and area by province for the 1998 to 2011 period and a five year rolling average to 2030. Since 1995 Statistics Canada has provided wheat yields and area by varietal class for CPS, CWES and CSWSW. Statistics Canada discontinued yearly estimates of CWAD production in 2006 for Manitoba. Yields for CWAD for Manitoba for 2006 to 2011 uses CWRS yield. For barley all varietal classes are aggregated in the Statistics Canada yearly estimates. The yield for the barley classes of 2-Row malt, 6-Row Malt, Feed and Hulless are estimated as Hulless 89.5%, malt 95%, and Feed 125% of the average yield of the Statistics Canada data. The counterfactual yields are the factual yields minus the net yield improvement for each of the WGRF varieties released over the 1998 to 2011 period. The yields are then applied to an acre base to get the crop production amounts for the factual and counterfactual scenarios.

4.1.4 Estimation of Harvested Acres for WGRF Varieties

An annual survey of varieties grown by producers from 1998 to 2011 conducted by the Canadian Wheat Board was used in determining the area of adoption of WGRF funded varieties. The percentage area for each variety from the CWB survey can then be applied to Statistics Canada data of the harvested area for the variety class. This is easily done for the wheat varietal classes as Statistics Canada provides this data at the provincial level. However, for CWAD for Manitoba the Agricultural Census data for 2006 and 2011 were used for the area estimates with a declining average used for the intervening years. The area for the barley classes of 2-Row Malt, 6-Row Malt, Feed and Hulless are estimated using crop insurance data from the Alberta, Saskatchewan and Manitoba crop insurance corporations. Area estimates for the forecast period 2012 to 2030 are a five year rolling average.

To forecast the area of the WGRF funded varieties for the 2012 to 2030 period the actual area of adoption prior to the start of the forecast period is used to assess the trend in adoption of the variety. A variety that has already reached its peak of adoption and is in decline prior to the forecast period is assumed to continue to decline at a similar rate in the forecast period reach a minimum of 0.001% for three years and then no longer grown. A variety that is increasing in area prior to the forecast period is assumed to continue the increase for several years reach a peak of adoption then decline. A typical adoption pattern of a variety is roughly a bell shaped curve. In aggregate for a varietal class the WGRF varieties in total would trace out a bell shaped curve over the period of the study. The actual and forecast adoption rates for wheat varietal classes in Saskatchewan are presented in Figure 2 and for barley varietal classes in Saskatchewan in Figure 3. For the most part in aggregate a bell shaped curve is achieved for each varietal class and in each province. This procedure has the advantage of being easily defended in that the authors' can safely say that the forecast adoption rate of WGRF varieties for

any individual varietal class used in the analysis is highly likely to be the minimum expected actual results. In aggregate, the estimate of the benefits due to WGRF funding will not be overestimated by using this procedure.

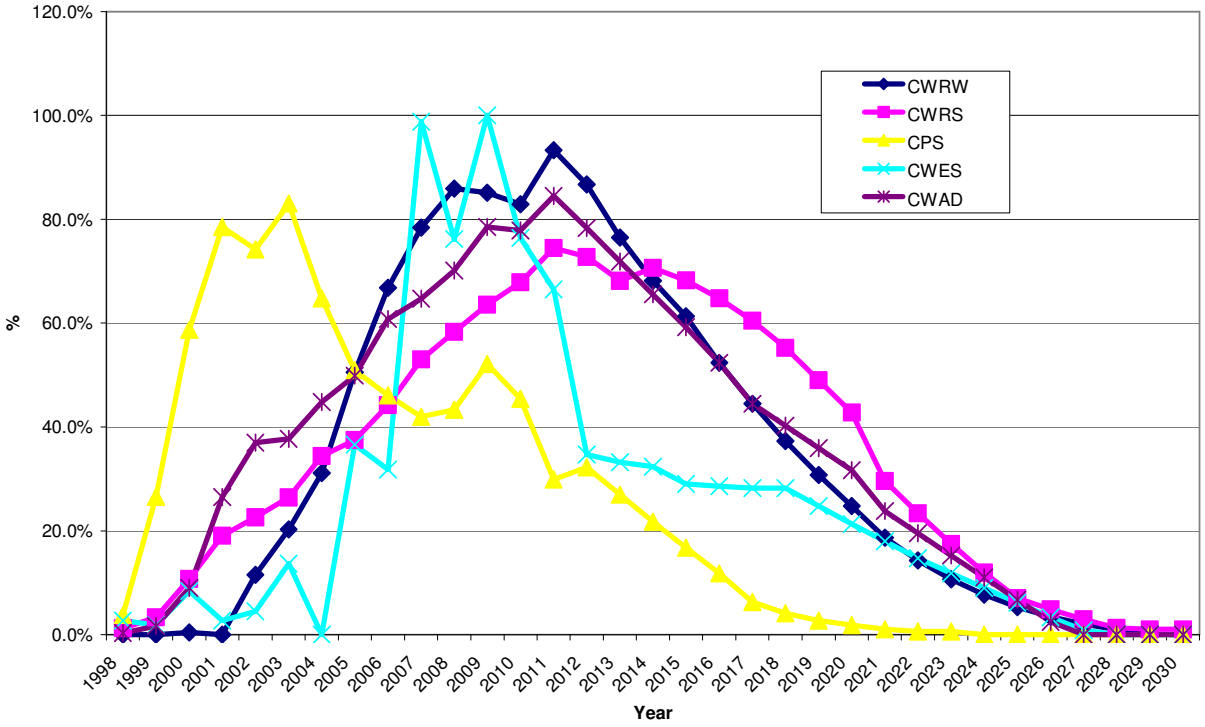

Figure 2: Actual and Forecast Adoption Rates of WGRF funded Wheat Varieties in Saskatchewan

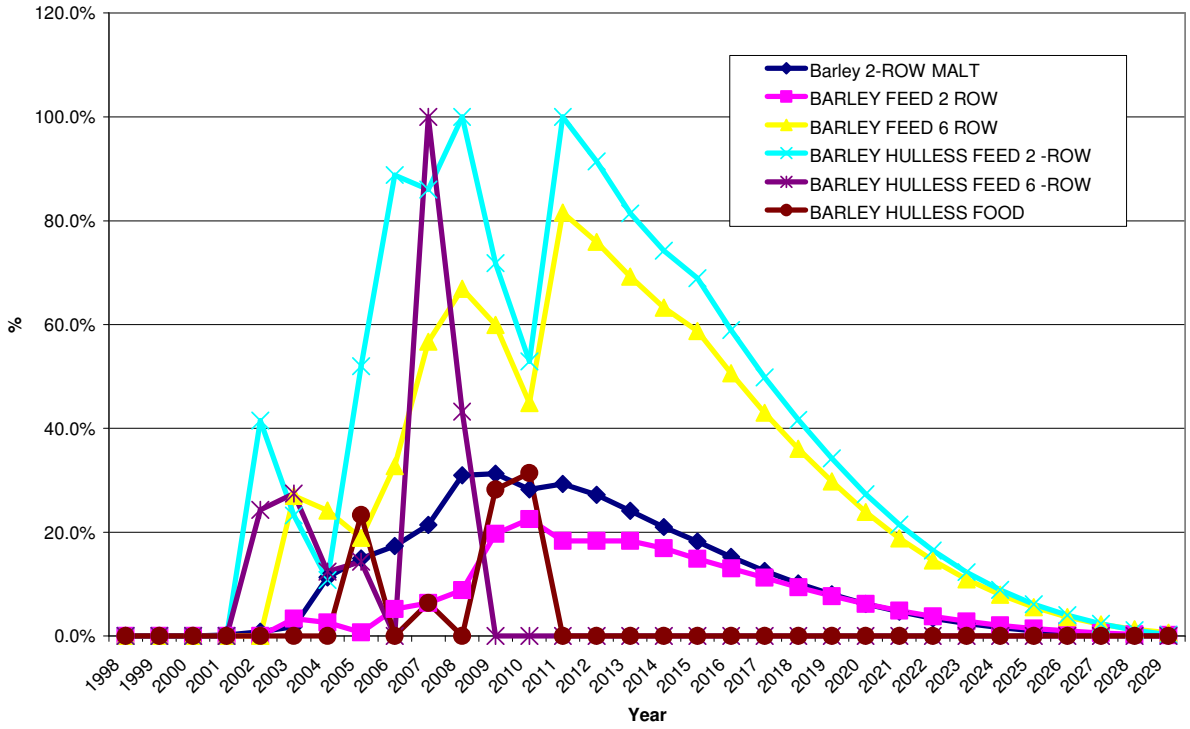

Figure 3: Actual and Forecast Adoption Rates of WGRF funded Barley Varieties in Saskatchewan

4.1.5 Acres of Varieties: The Factual and Counterfactual

Acres of the WGRF funded varieties grown in the 1998 to 2011 period and forecasted to 2030 are included in the factual scenario. In the counterfactual scenario the area of WGRF funded varieties are essentially replaced by a variety of standard performance in each varietal class as this would be the case without WGRF funded varieties.

4.1.6 Estimating Production and Value of Production

The estimation of the amount of production by crop class for the factual scenario is the annual harvested acres (which include the WGRF varieties) times the yield with the yield including the effect of the higher yield of the WGRF varieties. The production estimate for the counterfactual scenario is the annual harvested acres (with area of WGRF varieties substituted by area of the standard variety) times the yield that would have existed in the absence of the WGRF varieties. The factual production minus the counterfactual production results in the total production impact of WGRF varieties. These estimates are done for each province and each crop varietal class.

The estimate of the value of production under the assumption of no price impacts due to the introduction of WGRF funded varieties would be the annual factual and counterfactual production multiplied by the actual market price for the 1998 to 2011 period and the rolling

average of prices for the forecast period. The difference between the factual and counterfactual value of production would be the additional value from the addition of WGRF varieties. However, because of increased production due to the adoption of WGRF funded varieties a market price for the counterfactual scenario has to be estimated.

4.1.7 Adjusting for Price Changes – Supply and Demand Elasticities

Due to increased production from the adoption of WGRF funded varieties it can be expected that the market price would be expected to decline somewhat. Since, the market demands for Western Canadian wheat and barley are not characterized by perfect price elasticity; some decline in the market price due to the introduction of new cultivars can be expected.

The relative elasticities of demand and supply for wheat and barley determine the magnitude of the decline in prices and the subsequent estimate of the producer surplus. The estimates of supply and demand elasticities used in this study are from the Iowa State University FAPRI Model as shown in Table 34. Given that the share of the world market for wheat and barley that Western Canadian production represents is relatively small, the price elasticity of demand is high relative to the price elasticity of supply. Western Canadian producers of wheat and barley will capture a high proportion of the gains due to the introduction of new cultivars. These elasticities are used in the model to estimate the producer and consumer surpluses due to the introduction of WGRF funded varieties.

Table 34: Supply and Demand Elasticities by Crop (%)

Crop	Demand Elasticity	Supply Elasticity
Wheat	10.0	0.4
Barley	10.0	0.5

Source: Iowa State University FAPRI Model

4.1.8 Producer Surplus Estimates for Wheat and Barley

The supply and demand elasticities are also used to adjust the share of R&D costs between producers and consumers as the incidence of the levy is born by both consumers and producers. The same proportion of the benefits gained by each group due to varietal crop development is applied to the stream of costs.

The estimates of the increase in producer surplus due to the adoption of varieties funded by the WGRF for barley, CWRS, CWAD and CWRW are presented in Figure 4. The graph shows the actual estimates of the producer surplus to 2011 and the forecast producer surplus from 2012 to 2030 due to WGRF funded varieties. The assumption for the 2012 to 2030 estimates is that no further investment in R&D by the WGRF occurs after 2011. Producer surplus due to past WGRF investments will continue to accrue until the current stock of WGRF funded varieties is replaced by newer varieties. This assumption is made so that the returns to the funds already invested in varietal development can be made. Producer surplus will also be generated from the genetic improvement due to the varietal development as a result of WGRF investment (Legacy Effect). This genetic improvement will be part of new varieties developed past 2012 whether or not WGRF funded varieties continue to be grown. To estimate this benefit a weighted average of the 2009-2011 yield advantage of each class was made and added to the net improvement of a

variety for the 2012-2030 period. The size of the producer surplus increases rapidly starting in 2005-2006 as the number of WGRF funded varieties and the area of adoption by producers increases. The lag time between increases in funding starting in 1995 and adoption by producers of a variety is the result of the time needed for the breeding-to-commercialization process. The largest producer surplus gains are for CWRS, CWAD and barley. Given the large acreage of these crops this is not unexpected.

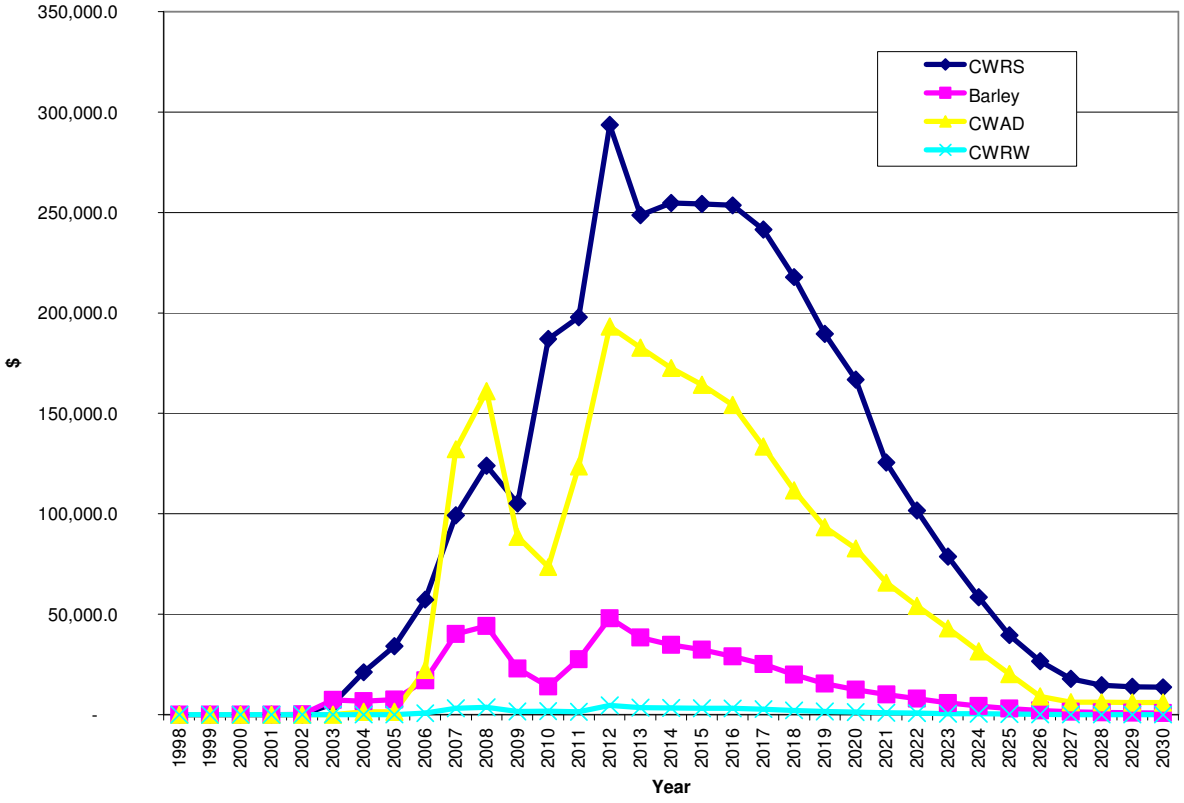

Figure 4: Producer Surplus Increase by Varietal Class due to WGRF Varieties

4.2 Attributing Benefits to WGRF Check-off Expenditures

Since, the funds from the WGRF check-off are not the only source for the R&D of varieties responsible for the increase in the producer surplus, the share of the total funding of varietal development attributed to the WGRF must be estimated. An estimate of the number of scientists employed at the research centres working on wheat and barley varietal development was made. The number of scientists engaged in wheat R&D since 2005 has ranged from 15.88 to 15.38 and for barley 4.5 (full time equivalents). To arrive at a dollar estimate an annual cost per scientist of $375 thousand was used for the 1995 to 2004 period (Scott et al. 2005). This amount per scientist was adjusted by inflation for the 2005-2011 period. The number of scientists times the cost per scientist plus the WGRF check-off is the overall cost of R&D. The percentage share of the overall cost of R&D contributed by the WGRF can be applied to the producer surplus to arrive at the amount generated by WGRF funding. The shares of the total funding by crop class over the period 1995-2011 for the WGRF funding are presented in Table 35. The shares are

then applied to the total producer surplus for a class to arrive at the share attributable to WGRF funding of R&D varietal development of that class. Note that the WGRF contribution to the overall crop breeding effort at AAFC is a smaller proportion than indicated in the table. However, as a percentage of the support for the main crop breeding activities at AAFC the WGRF funds would be closer to those in the table.

Table 35: Estimated Percentage of Total R&D Funding by WGRF

Class	all wheat	all barley	2-Row malt	CWRW	CWRS
Percentage	47.2%	38.0%	28.1%	43.9%	39.9%
Class	**CWES**	**CWAD**	**CWSWS**	**CWHW**	**CPS**
Percentage	78.0%	46.3%	25.8%	36.2%	71.8%

4.3 Benefit Cost Ratio and the Internal Rate of Return Estimates

A comparison of the stream of producer surplus benefits attributed to the WGRF funded varieties for all wheat to the WGRF check-off for wheat for the period 1995-2030 is presented in Figure 5. The increase in producer surplus due to WGRF funding is substantially larger than the check-off dollars collected.

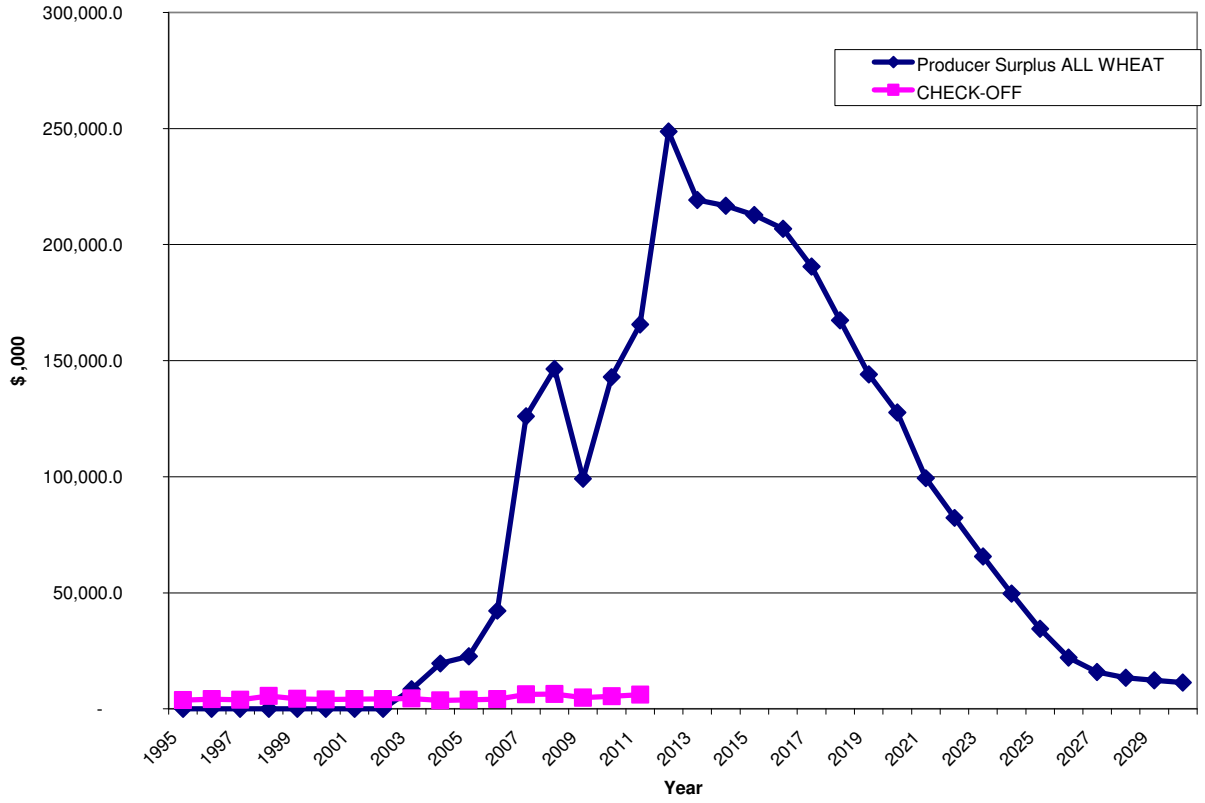

Figure 5: Producer Surplus Increase All Wheat due to WGRF Check-off

The comparison of the annual check-off to the stream of producer surplus benefits for all barley is presented in Figure 6. The increase in the producer surplus is considerably greater than the check-off collected from barley producers.

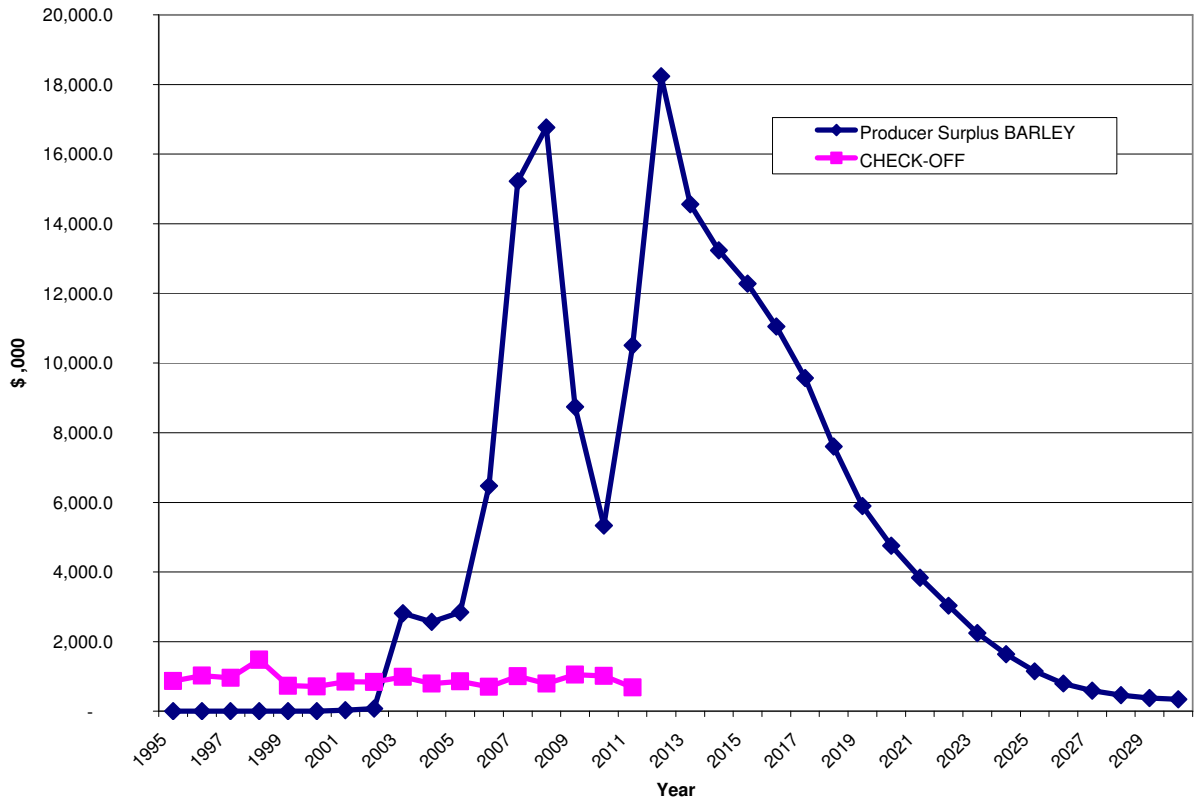

Figure 6: Producer Surplus Increase for Barley due to WGRF Check-off

The stream of annual benefits from 1998- 2030 (producer surplus) and the cost from 1995-2011 (check-off) are used in the estimation of the benefit/cost ratio and the internal rate of return for all wheat, CWRS, CWAD, CWRW, CPS, CWES, all barley and 2-Row malt. The net present value of the inflation adjusted stream of benefits (1998-2030) using a 5% real discount rate is divided by the NPV of the WGRF R&D investment (1995-2011) to arrive at the benefit/cost ratio. The results are presented in Table 36.

The return to producers from the investment of WGRF check-off funds is quite significant. The B/C ratio for all wheat is 20.4 which means that for every dollar of WGRF check-off $20.40 in producer surplus was generated. The IRR for all wheat due to the WGRF check-off is 36%. A B/C ratio of 7.56 with an IRR of 28% for all barley is achieved for the WGRF barley check-off.

The total surplus which is the sum of the producer and consumer surpluses was also estimated (not shown). The B/C ratios and IRR are only marginally higher for the total surplus over the producer because the price elasticity of demand for Western Canadian wheat and barley.

Sensitivity analysis on the values used for the non-yield improvement of varieties was done to asses the suitability of the values used in that a reasonable estimate is obtained that is neither too low or too high. The model was run at twice the non-yield improvement and half the non-yield improvement with the results presented in Table 36. The difference between the three scenarios is greater for CPS, CWES CWRW and 2-Row Malt as the difference in crop yield between the

standard variety and the WGRF funded varieties is small. Greater weight on the non- yield traits for these varieties gives significantly different results. The values of the non-yield improvements as used to estimate the 2012 benefits appear to give reasonable results given the lack of any means for a more rigorous assessment of the non-yield improvements.

Table 36: Benefit Cost Ratio (B/C) and Internal Rate of Return (IRR)

	2005[a]		2012		2x NYI[d]		.5x NYI[d]	
Varietal	**B/C[b]**	**IRR[c]**	**B/C[b]**	**IRR[c]**	**B/C[b]**	**IRR[c]**	**B/C[b]**	**IRR[c]**
Type/Class	**Ratio**	**%**	**Ratio**	**%**	**Ratio**	**%**	**Ratio**	**%**
All Wheat	4.40	23.8%	20.40	36%	23.25	37%	19.15	36%
CWRS			31.13	42%	33.80	42%	29.93	43%
CWHW			2.22		2.21		2.44	
CWAD			35.91	44%	42.67	46%	32.55	43%
CPS			-		-		-	
CWES			0.22		0.32		0.18	
CWRW			1.26		5.15		0.23	
CWSWS			28.42		26.46		29.40	
All Barley	12.40	36.0%	7.56	28%	8.37	29%	7.15	27%
2-R Malt			6.51	26%	7.76	28%	5.88	25%

Notes
a. Scott et al. 2005.
b. Benefit/Cost Ratio for producers is the benefits that accrue to the producers divided by the share of the costs of R&D development that are borne by the producers. Costs and benefits accruing to the consumers are excluded. Total Surplus or industry Benefit/Cost ratio includes both producer and consumer benefits as well as both producer and consumer costs.
c. Internal Rate of Return is the interest rate that equates the stream of benefits to the stream of costs.
d. NYI = Net Yield Improvement

In comparison to the estimates made by Scott et al. in 2005 the return on wheat is substantially higher while the B/C return to barley is reduced while still maintaining a very high IRR. The adoption of CWRS and CWAD cultivars by producers along with the rise in grain prices results in a significant difference in producer surplus than that was estimated in 2005 for wheat. The significant reduction in the area seeded to barley since 2007 (-42%) combined with a modest shift in seeded area from 2-Row malt varieties to feed varieties in Alberta has reduced the producer surplus compared to the 2005 report. Also, the 2-Row malt barley class has been dominated by Harrington to 2000 and since then by AC Metcalf with CDC Copeland the only WGRF funded variety having any real success at being adopted since 2004.

The CWAD and malt barley varietal selection by producers have tended to the production of a dominant variety that is grown on the majority of acres for extended periods of time. There is little evidence that this pattern will change at any point in the future given the market for these grains. In contrast, the dominant variety for CWRS has typically been less than 50% of the seeded area as this is a reflection of the greater diversity of climate where CWRS is grown and the different pest problems across Western Canada.

References

Alberta Agriculture and Rural Development, 2011. Agriculture Statistics Yearbook. Pp 150.

Alberta Seed Growers Association. Various Years. Seed Alberta Alberta's Seed Guide.

Agriculture Financial Services Corporation, Various Years. Acres Insured by Crop Variety.

Alberta Agriculture and Rural Development, Various Years. Agri-Facts. Varieties of Cereal and Oilseed Crops for Alberta.

Canadian Food Inspection Agency, 2011. List of Varieties which are Registered in Canada. Pp 43.

Canadian Wheat Board, 1998-2011. Canadian Wheat Board Variety Survey.

Canadian Wheat Board, 1998-2011. CWB Final Payments.

Manitoba Agriculture and Food, Various Years. Seed Manitoba Variety Selection and Growers Guide.

Manitoba Agriculture and Food, Various Years. Manitoba Agricultural Yearbook.

Manitoba Management Plus, Various Years. Yield Manitoba

Saskatchewan Ministry of Agriculture, Various Years. Varieties of Grain Crops.

Saskatchewan Ministry of Agriculture, website. Agriculture Statistics. http://www.agriculture.gov.sk.ca/agriculture_statistics/

Saskatchewan Management Plus, Various Years. Area of Crop by Crop District.

Saskatchewan Seed Growers Association, Various Years. SaskSeed Guide.

Scott, T., A. Guzel, H. Furtan, and R. Gray, 2005. Returns to Research Western Grains Research Foundation Wheat and Barley Check-offs. Report prepared for Western Grains Research Foundation. Pp 50.

Statistics Canada, Table 001-0010 Estimated areas, yield, production and average farm price of principal field crops, in metric units, annual.

Western Grains Research Foundation, Various Years. Annual Report.

Western Grains Research Foundation. Website.

Appendix A: Methodology

Adapted from Scott et al. 2005 with permission

Methodology for Estimating Returns

We turn now to the specific methodology for estimating the rate of return to wheat and barley check-off expenditures in the context of the crop variety development path. The framework for the methodology is benefit/cost (B/C) analysis.[2] The end product of this methodology will be an estimated B/C ratio and an internal rate of return (IRR) on growers' check-off funds invested in wheat and barley R&D. B/C analysis is rooted in economic theory of supply and demand. It estimates the changes in economic surpluses which arise as a result of, in this case, WGRF R&D expenditures on variety development. There are different economic surpluses, but for this study, producer surplus is the most important.

Producer Surplus

Estimating the return on producer check-off funds requires understanding: 1) how producer surplus changes when a check-off is applied on producer sales; and 2) how producer surplus changes as a result of adoption of wheat and barley varieties developed as a result of WGRF expenditure of the check-off funds. Impact of Check-off on Wheat and Barley Sales: Producer surplus is the economic profit to firms of an industry. How it changes, first in response to a check-off on sales, can be shown conceptually with a supply and demand illustration for wheat. Figure 1 shows a market equilibrium before introduction of the check-off, where the supply curve S1 and demand curve D intersect at E1. This generates corresponding market quantity Q1 and market price P1. Producer surplus is the area Ps,P1,E1. This surplus is the excess revenue for wheat producers over the minimum revenue they would accept in order to keep supplying Q1 of wheat.

[2] The concepts and principles of benefit/cost analysis are described and discussed in numerous textbooks and publications. For example, see Boardman, Greenberg, Vining and Weimer, 2001.

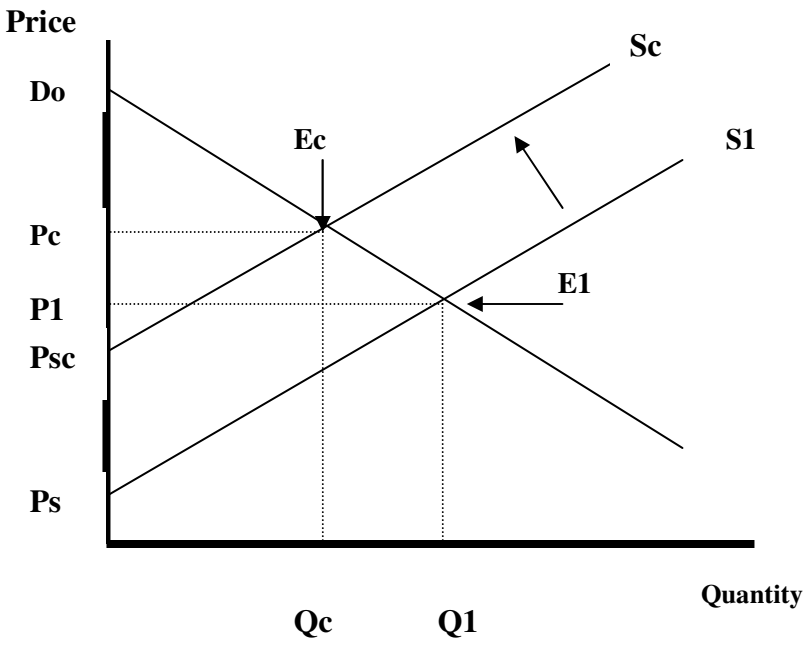

Figure 1: Cost of Check-off on Wheat Sales

The cost of the check-off is to shift the supply curve from S1 to Sc. This shift occurs because the check-off is the same as an increase in per unit cost of production. Producers' costs of supplying each quantity of wheat at alternative market prices are increased by the $0.20 per tonne check-off. The effect of the shift in supply is to move to a new market equilibrium (where Sc intersects the demand curve D at Ec) and generate a new level of producer surplus equal to area Psc,Pc,Ec. This new level of producer surplus is less than the previous surplus (Ps,P1,E1) before introducing the check-off on wheat sales. Wheat producers clearly bear a portion of the incidence of the check-off cost.[3] If there were no benefits produced from the check-off the difference between producer surplus before and after the application of the check-off would represent an economic loss to producers. Impact of Adoption of Variety Technology on Producer Surplus: The purpose of the check-off is to invest it to create benefits for producers. The check-off invested by WGRF results in new varieties which increase productivity. These varieties have productivity benefits such as increased yield, reduced losses due to disease and other natural crop perils, and improved market quality characteristics. The effect of these productivity improvements can again be illustrated with a market supply and demand illustration for wheat. Figure 2 shows a theoretical illustration for a new higher yielding wheat variety.

The initial market equilibrium is the situation that would have existed had WGRF not spent WGRF producer check-off funds to develop the higher yielding variety. This equilibrium is shown at E1 with corresponding market price P1 and market quantity Q1. Producer surplus is area Ps,P1,E1. Now introduce the higher yielding wheat variety. The supply curve shifts from S1 to St because with new technology growers produce more wheat for the same cost. They are

[3] Consumers also pick up a portion of the cost of the check-off as well in the example shown.

willing to supply each alternative quantity of wheat at a price below the price at which they were previously willing to provide that same output. At the new equilibrium Et, the market price is Pt and market quantity is Qt. Producer surplus is now Pst, Pt,Et. This surplus exceeds the producer surplus Ps,P1,E1 which was the producer surplus prior to the introduction of new higher yielding wheat technology.[4] In simple terms, this study grapples with the question of whether increased surplus for Western Canadian producers resulting from new variety technologies developed through wheat and barley check-off investments (Figure 2) exceeds, and by how much, the producer surplus decrease experienced as a result of paying the check-off (Figure 1).

Consumer Surplus

Although the study focuses on estimating changes to producer surplus, changes to consumer surplus should also be mentioned. Producers and consumers share the gains from research, so it is important to understand the factors that determine how gains are shared. When the check-off is applied to producers' sales (Figure 1) and when the new wheat variety is introduced (Figure 2), the welfare of consumers changes. In Figure 1, consumers bear the incidence of a portion of the check-off. This is evident when one compares the consumer surplus before check-off (area P1,Do,E1) to consumer surplus after check-off (area Pc,Do,Ec). The former exceeds the latter by area P1,Pc,Ec,E1. For new yield increasing technology in Figure 2, consumer surplus before the introduction of the variety is area P1,Do,E1 compared with area Pt,Do,Et after the introduction of the technology. The consumer surplus has risen by area Pt,P1,E1,Et. It can therefore be concluded that consumers have an underlying interest in whether the surplus they gain in Figure 2 exceeds the reduction they experience in Figure 1. For wheat and barley, the consumer interest plays out beyond Western Canada because so much of the wheat and barley produced in Western Canada goes into export markets.

[4] Producer surplus increases in this example, but consumer surplus also rises as a result of the new technology adoption.

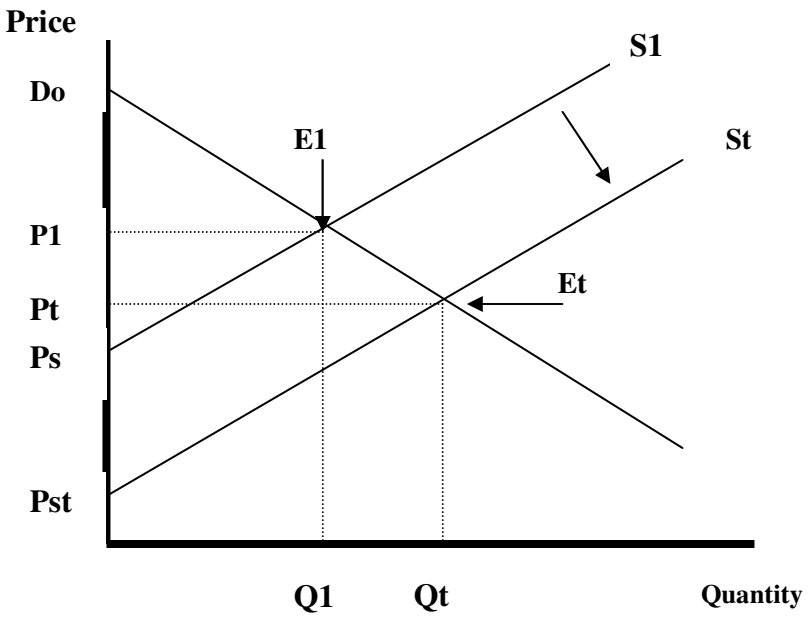

Figure 2 Producer Surplus: Effect From Adoption of a Higher Yielding Variety

Total Surplus

The combined producer and consumer surplus is the total economic surplus (often referred to in economic theory as social surplus). It can be obtained in Figures 1 and 2 by simply summing the decreases (increases) for both producers and consumers. The question of whether or not total surplus rises or falls is a relevant one. However, B/C analysis is typically conducted to determine the rate of return to a particular party or parties who pay direct costs of the investments responsible for producing benefits. In that respect, this study is typical in that the emphasis is on changes to producer surplus for growers who pay the wheat and barley check-offs.

Distribution of the Gains

Given that the main objective is to estimate the returns producers themselves are receiving from their investment, it is important to be aware of the conditions that determine whether producers or consumers benefit most from crop genetics R&D. The relative gains for producers and consumers are determined by elasticity of supply and elasticity of demand for Western Canadian wheat and barley. Conditions favourable to growers capturing a large share of the benefits can be summarized as: i.) price inelastic supply (supply not very responsive to price changes) and ii.) price elastic demand (demand responds readily to price changes). Conversely, consumers capture relatively large benefits under conditions of: i.) price elastic supply (supply responsive to price change) and ii.) price inelastic demand (demand does not change much when prices do). Generally speaking, supply is expected to demonstrate sufficient price *inelasticity (*limited factors of production) and demand is expected to demonstrate sufficient price *elasticity* (Western Canada is a small portion of the world markets) that we may expect producers to capture some reasonable share of economic surpluses resulting from their R&D investments. The elasticity estimates used in the study support that proposition.

Factual and Counterfactual Scenarios in Rate of Return Analysis

In estimating how surpluses change in response to wheat and barley check-offs, the concept of the factual and the counterfactual is critical to the analysis. The factual and the counterfactual can best be described again in relation to Figures 1 and 2. The factual scenario is, as the name implies, what exists as fact. For example, it is a statement of fact that for more than ten years wheat and barley growers have paid check-offs. Whatever the impacts of that check-off may be, they are part of the production and market results that we have observed in the past, that we observe in the present and will observe in the future. The impacts are embodied in existing yields, prices, acres grown, quantities, and profitability. In Figure 1, the factual market equilibrium, which includes the effect of the check-off, is where supply curve Sc intersects demand curve D. Similarly, the factual market equilibrium in Figure 2 is where supply curve St (which includes the impact of the new wheat variety) intersects demand curve D.

The real challenge is to discover the counterfactual. To do this, we must identify what would have been fact had the wheat and barley check-offs never existed. Since we are unable to go back in time and re-run 10 years of production and markets without the check-offs, we must find an indirect way of identifying the counterfactual. In the context of Figures 1 and 2, the challenge is to identify the original equilibrium E1, quantity Q1, price P1, and corresponding producer and consumer surpluses. This equilibrium represents the market if there had been no check-off or check-off related research. In terms of this study, the B/C analysis will describe the factual (i.e., situation with WGRF check-off impacts) through the use of existing data, such as yields, prices, and acres. For each data item, there will be a corresponding counterfactual (i.e., without WGRF check-off impacts) which will be identified indirectly. Once all components of the factual and counterfactual have been established, we subtract the counterfactual from the factual results to arrive at an estimate of the B/C ratio and IRR for check-off funds invested by WGRF on behalf of producers.

A number of other conceptual aspects of the B/C approach undertaken in the study and which will affect the study results are discussed below.

Type of Benefit/Cost Analysis

There are three types of B/C analysis. *Ex ante* B/C is analysis undertaken before a program or project investment is made with a view to determining if the anticipated benefits will justify the expected costs. *Ex poste* B/C analysis is conducted after a program is completed with a view to gaining knowledge (what worked and what did not) to guide future decisions. Neither of these describes the B/C analysis in this study. The third type of B/C analysis is *in media res* analysis. This is analysis undertaken during the life of a program or project. The objective is to provide information relevant to making ongoing program decisions such as expansion or contraction of the program, re-focussing the program, or ensuring those who are investing resources in the program that they are receiving good returns for their money. The B/C analysis undertaken in this study with respect to wheat and barley check-offs is *in media res* B/C analysis.

Groups with Standing in the B/C Analysis

For any investment where costs are shared and benefits have potential to be widely dispersed, it is necessary in B/C analysis to identify whose costs and benefits matter to the analysis. Those

groups whose costs and benefits matter and are therefore estimated in the analysis are said to have *standing*.

On the cost side, Western Canadian producers have standing in the current B/C analysis and their costs in terms of paying the wheat and barley check-off are therefore the key costs in the analysis. These costs are paid by all Western wheat and barley producers with the exception of Alberta barley producers. Other players' costs matter only to the extent that they must be quantified in order to attribute benefits appropriately to the various parties who share the costs of the R&D responsible for generating the new varieties. To attribute benefits to the appropriate players, the authors use a straight proportionality principle - if producer check-off support to wheat and barley breeding programs are ***X*** percent of total resources available to these breeding programs, then ***X*** percent of the benefits are attributed to WGRF check-off expenditures in estimating returns to the check-off investment.

On the benefits side, the study again concerns itself with benefits only for Western Canadian wheat and barley growers. It is possible (indeed probable) that some benefits generated by WGRF check-off expenditures accrue to other growers. This occurs if producers elsewhere in Canada, or beyond Canada, adopt varieties developed with support from WGRF check-off expenditures. These benefits are not included in the estimated rate of return, even though it is worth recognizing the benefits do exist. A particular issue relating to which parties have standing in the B/C analysis had to be resolved in conducting the study. Alberta growers do not contribute to the barley check-off administered by the WGRF. Alberta grower check-off goes to the Alberta Barley Commission. Even though Alberta check-off amounts are not included on the cost side of the B/C analysis, the benefits that accrue to Alberta growers from WGRF expenditure are included in the estimated returns. Alberta is a key player in barley production and the authors viewed it appropriate to include their benefits in the analysis to gain a more complete picture of WGRF's effectiveness as a contributor to crop genetics R&D. With respect to consumer surplus generated as a result of WGRF check-off investments, all consumers have standing in the analysis. B/C ratios for total surplus, which includes producer plus consumer surplus benefits, reflect benefits for Western Canadian consumers but also for all Canadian and non-Canadian consumers of varieties developed with the support of WGRF producer check-off monies.