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cutting through complexity

Management Consulting Service

Saskatchewan Ministry of Agriculture

Evaluation of the Strategic Research Program (SRP) and Agriculture Development Fund (ADF)

Final Report

May 15, 2013

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1. Executive Summary

The Study. This evaluation of the Agriculture Development Fund (ADF) and Strategic Research Program (SRP) was commissioned by the Saskatchewan Ministry of Agriculture (SMA) to investigate two major areas: (1) Assess the policy rationale for public sector intervention in support of agricultural research and development (R&D), including possible gaps in programming; and (2) Estimate the economic returns to ADF and SRP expenditures, using a benefit-cost analysis technique appropriate for R&D programs, and in particular to ensure that Saskatchewan's investment in these two programs was justified. Item (2) was the key focus of this study.

The ADF and SRP. Both programs were created in 1986. The ADF was created to ensure that research relevant to Saskatchewan's agriculture is undertaken to help farmers and ranchers be successful, and to keep Saskatchewan's agriculture and food industry competitive in global markets. The ADF is a response-driven granting program. Over 3,300 ADF projects have been conducted or are in process since the inception of the initiative, with a total of almost $294 million (current dollars, undiscounted) in SMA funding.

The SRP is a capacity-building program, funding research Chairs in key strategic areas through a series of five-year agreements which provide salaries and benefits to Chairs at institutions performing ag/ag-food R&D. The current SRP funding agreement provides $3.2 million to 15 Chairs in four theme areas: seven Chairs in crop genetics, three Chairs in livestock development, three Chairs in food and bioproducts, and two Chairs in soils and environment. Chairs are also active participants in the ADF.

Methodologies. Key methodologies included: (1) A literature review of 44 documents related to the economic impacts of ag/ag-food R&D and/or the rationale for public intervention in such R&D; (2) interviews with 35 key informants in industry, Saskatchewan and federal government departments, other research centres, members of the ADF Advisory Committee, and senior SMA management; (3) a comparative review of similar R&D initiatives in five other Canadian and US jurisdictions; and (4) partial benefit-cost analysis (PBCA) of a selection of R&D initiatives supported by ADF and SRP.

In the PBCA component, detailed case studies were conducted of a small sample of research themes supported by ADF and/or SRP which were believed to have had the most significant impacts on Saskatchewan's economy. The case study selection was done in several iterations to identify and investigate themes which had impacts as high as possible, which could be quantified in dollar terms, and which were attributable, at least in large part, to ADF and/or SRP. PBCA findings represent a rigorous, defensible lower bound on total program impacts, since many research projects and themes are not studied, and many impacts cannot be defensibly quantified.

Findings on Policy Rationale. The ADF and SRP are fully in line with both Canadian and international government policy rationales regarding how best to use R&D to serve both the public good and the private sector within the agricultural and ag-food areas. These rationales are mainly based on the need to correct market failures.

Findings from the Comparative Review. The ADF and SRP share many features of similar ag/ag-food R&D programs in the other jurisdictions reviewed, and in most respects are founded upon best practices; e.g., having both short-term responsive and long-term strategic elements, providing support

for fundamental and applied research, supporting capacity building, facilitating technology and knowledge transfer, and providing for substantial input from, and dissemination to, industry end-users.

General Findings on Economic Returns to the Saskatchewan Economy. The key stakeholders were unanimous in believing that these programs have contributed greatly to the Saskatchewan economy, and many were able to point to examples of the programs' contributions to the province, including impacts in specific sectors, attracting large business to Saskatchewan, putting the province "on the map" in terms of expertise in ag/ag-food areas, and attracting top scientists to the University of Saskatchewan.

Findings from PBCA. In PBCA, the net revenues and/or cost savings associated with *only* a small sub-set of the "highest impact" cases are compared to the *total* cost of the R&D conducted across all projects and sectors, including costs to all partners (and in this case, the costs for both ADF and SRP combined), since program initiation. This is an effective way of assessing the economic impacts of R&D programs, since typically a small – or even tiny – proportion of the projects creates a very large proportion of the total program impacts.

The difference between the sum of the benefit stream and the sum of the cost stream over time (both deflated and discounted) represents the programs' Net Present Value (NPV), and the ratio of the sum of benefits and sum of costs is the benefit:cost ratio (B/C).

A total of 13 "short list" cases were investigated, of which seven could be quantified in dollar terms for PBCA within the scope of this study. (Such a narrow focus is entirely usual in PBCA studies, and does not imply anything unusual about the ADF or SRP economic impacts.) Table E.1 summarizes the findings from the PBCA component of this study, based *only* on the benefits arising from the seven "highest impact" cases quantified, but compared to the total costs of both programs over time, including costs to major external partners (e.g., industry associations or individual firms) wherever they were known.

Table E.1: Net Present Value and Benefit:Cost Ratio from PBCA Cases

	Lower Bound ($million, 2008$)				Upper Bound ($million, 2008$)		
Discount rate	*2%*	*5%*	*8%*		*2%*	*5%*	*8%*
Net benefits in "high impact" cases	9,232	11,492	14,739		13,939	16,765	20,806
Program costs (1987-2011)	555.3	747.2	1,057.0		555.3	747.2	1,057.0
Net Present Value	*8,676.8*	*10,745.1*	*13,681.8*		*13,381.3*	*16,017.9*	*19,749.2*
Benefit-Cost Ratio	*16.62*	*15.38*	*13.34*		*25.10*	*22.44*	*19.68*

The literature review of other economic impact studies in the ag/ag-food areas showed that benefit/cost ratios are commonly about 5:1 to ~10:1, and a few range from about 15:1 to roughly 20:1. By comparison, the ADF and SRP benefit/cost ratios seen in Table E.1 are at the very top end of results from other studies seen in the Canadian and international literature[1]. We would note here that a conservative estimation methodology was used for the analysis, first and foremost being the use of PBCA, which is itself a conservative methodology, and within this using many conservative assumptions for both the cost and benefit streams (e.g, including significant external partner R&D funding for the former, and modeling the benefits from the most significant PBCA case, crop diversification, only through 2012, for the latter).

The upper bound B/C ratio of ~20:1 to 25:1is at the high end of findings seen elsewhere, but likely represents the unusual situation afforded by the Crop Diversification R&D, which increased SK's usable farmland by about 40%. (Probably this was a "one-time-only" opportunity.) Even eliminating the relatively unusual Crop Diversification case from analysis, the resulting B/C ratios are roughly 9:1 to 11:1, or typical of the mid- range seen in similar ag./ag-food R&D programs. This suggests that, through responses to more typical research opportunities (i.e., other than Crop Diversification), the ADF and SRP have been highly successful in identifying key opportunities, and researching and applying leading-edge findings in the field.

Although it is clear that crops R&D represents the most easily quantifiable impacts, soil and environment work is likely at least equally important as represented by the large variety of impacts represented in the Crop Diversification case (e.g., SEHAC R&D underpins much of the Crop Diversification R&D, and many of the impacts are related to very long-term maintenance of soil quality and quantity).

Gaps in Programming. Overall, the study team did not identify many gaps in the design and delivery of ADF and SRP. However, there are some opportunities for improvements, one being potentially quite significant, and the others being more minor:

- In terms of sector gaps, the PBCA findings (and comments from key stakeholders) show that primary production in the crops area, with associated impacts within the soils and environment area (especially in the Crop Diversification case) have provided by far the most concrete economic impacts that can be investigated through PBCA. By implication, there are areas that are not currently providing as many impacts: livestock, and value-added and processing. This is the most important apparent gap in programming.
- In terms of design and delivery, there are two possible gaps: (1) provide more scope for development of strategic initiatives (possibly including multi-sectoral or even multi-ministry flagships); and (2) create opportunities for more high-level strategic alignment with Provincial and national R&D strategies. Some key stakeholders also believe the ADF application and review process are too lengthy and might benefit from two Calls for Proposal per year, although the system was recently re-designed in response to researcher and industry feedback. This, in turn, perhaps presents an opportunity for increased and/or more effective communication with stakeholders concerning the process.

[1] The Federal Treasury Board of Canada currently recommends a discount rate of 8%, and we have highlighted these figures.

Conclusions. The economic impacts of these two programs have been profound, and fully justfiy the province's investments in agricultural and ag-food R&D.

Overall, the ADF and SRP are fully in line with both Canadian and international government policy rationales regarding how to use R&D to serve both the public good and the private sector within the agricultural and ag-food areas. Through these programs, which contain both horizontal and vertical linkages among key players, the SMA also helps catalyze important R&D initiatives, avoids duplication, and creates collaborations and synergies.

The programs have had a substantial impact on the economic performance of Saskatchewan's primary production in the crops sector. Many individual crops have been improved through intensive long-term breeding programs in terms of yield, net value, resistance to pests and pathogens, and market acceptance. One key impact has been crop diversification, which has resulted in a 40% increase in the total land now seeded and harvested in the Province, along with new methods being developed to ensure the long-term quantity and health of the underlying soil resource, including low till methods. There have also been substantial improvements to the methods used in the beef, swine, and poultry sectors, also impacts there have not been as substantial.

Net of all R&D costs, the benefits to Saskatchewan are estimated to be at least $9 billion to $20 billion in 2008 dollars over the period 1986 through 2025 (with some impacts modeled into the future), depending on the exact assumptions used. The ratio of net benefits to costs is from 13:1 to 25:1, again depending on assumptions. These figures are at the very top end of results from similar programs world-wide assessed by other investigators. Even if the singular case of Crop Diversification is eliminated from the analysis, the benefit:cost ratios are from 8.4:1 to 12:1, again from the mid- to top rank of similar programs.

There are few weaknesses apparent. The only major one, at least based on PBCA, is that the livestock/forage area does not appear to be performing as well as the crops/environment areas in terms of translating R&D into practical economic impacts, although the reasons for this are unknown. A more minor sector-based weakness is that few substantial economic impacts in processing or value-added areas were found, although the potential here is equally unknown. We note, however, that the study design was not primarily focused on sector strengths and weaknesses, nor on the performance of individual SRP Chair sectors, and these PBCA findings simply point at issues that should be investigated (e.g., Are these sectors actually performing poorly? Or are their benefits too difficult to quantify for PBCA? Or has there been insufficient investment in these areas to provide high economic returns? Etc.).

Other more minor issues are related to program design and delivery, in which there is the opportunity to (1) provide more scope for development of strategic initiatives within ADF; and (2) develop more high-level strategic alignment with Provincial and national R&D strategies. There may also be room to simplify and streamline the application, review, approval, and funding processes, although the current system has several advantages, especially in terms of the ability to interact with respondents.

2. Evaluation Objectives and Context

2.1 Evaluation objectives and scope

The evaluation of the Agriculture Development Fund (ADF) and Strategic Research Program (SRP) commissioned by the Saskatchewan Ministry of Agriculture (SMA) has two major areas of focus and seven underlying objectives:

(a) Estimate the economic returns to ADF and SRP expenditures, using a benefit-cost analysis:

1 Determine the effectiveness and contribution of the ADF and SRP programs to the agricultural economy

2 Determine the impact of ADF and SRP on producer profitability

3 Determine what was the quantitative economic impact of ADF and SRP investments and Return on Investments (ROI)

4 Compare the ADF-ROI with ROI in other similar organizations.

(b) Assess the policy rationale for public sector intervention in support of agricultural R&D

1 Articulate a collective understanding of the policy rationale for public intervention in support of agricultural R&D and the balance between ADF and SRP

2 Compare the SMA's funding structure and approach to other jurisdictions

3 Identify gaps in the SMA's research funding programs.

The evaluation Steering Committee specifically limited the work to determining impacts to the province of Saskatchewan.

2.2 Context for the evaluation

2.2.1 Objectives and scope of the ADF

According to the Terms of Reference for the evaluation and information on the SMA's public web site, the ADF was created in 1986, to ensure that research relevant to Saskatchewan's agriculture is undertaken to help farmers and ranchers be successful, and to keep Saskatchewan's agriculture and food industry competitive in global markets. The ADF is currently investing about $10 million per year on a competitive basis. The funding is provided, to researchers in public and private research and development organizations, to create future growth opportunities and to enhance the competitiveness and long-term sustainability of the provincial agriculture industry. This investment is expected to lead to new knowledge, information and choices of technologies for producers and food processors, including feed and nutrition information for ranchers, and new crop varieties and production information for farmers. Co-funding of projects by third-party organizations is encouraged.

ADF projects are expected to contribute to one or more of a set of nine expected outcomes established by the SMA:

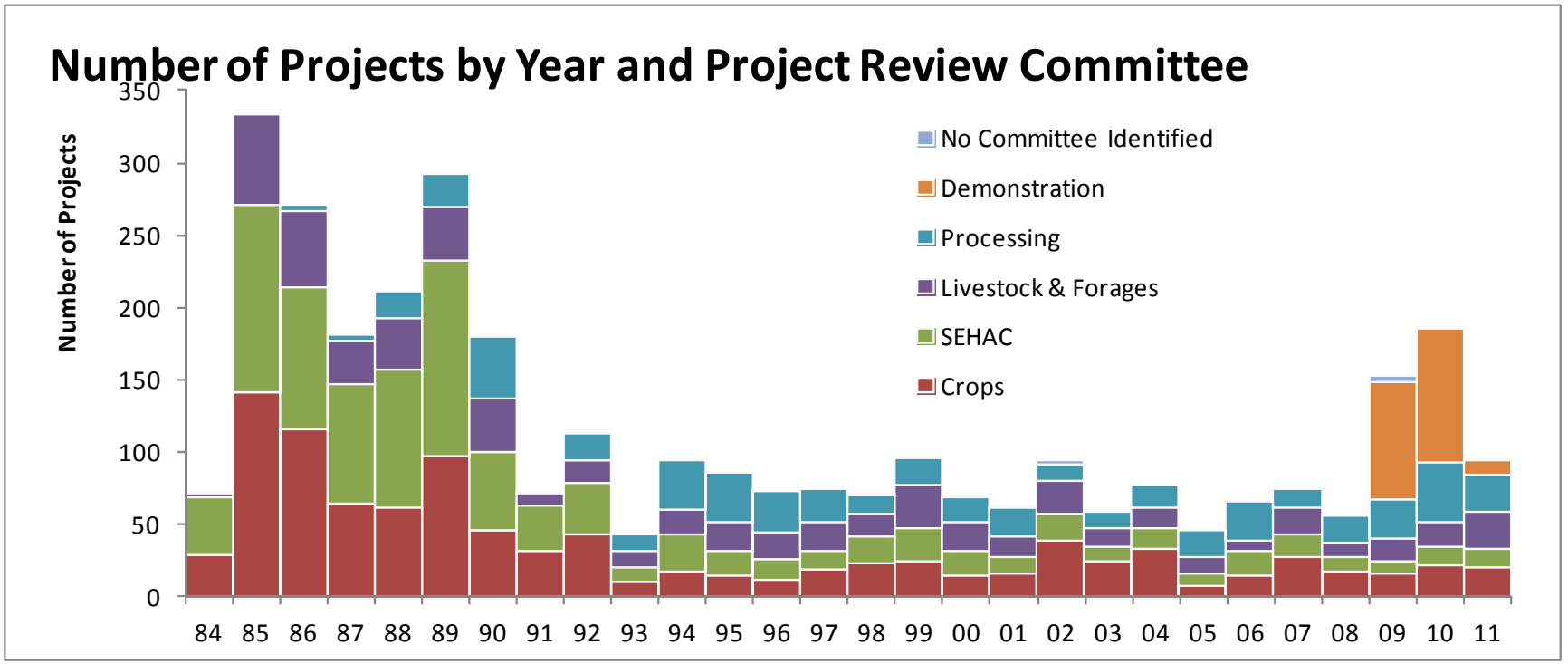
- New crops and/or cultivars meeting market demands and consumer preferences
- Increased livestock competitiveness
- Optimized livestock feeding systems
- New and innovative food, bioproducts, and processing technologies
- Improved food quality
- Innovative and sustainable farming systems and practices
- Enhanced adaptive capacity of the Provincial soil and ecosystem resources
- Utilization of biotechnology to enhance agriculture and value-added production
- Decreased agricultural production risks.

Applications for ADF funding are invited annually and evaluated against the following criteria:

- Strategic alignment:
  - Fit with SA strategic goals and ADF outcomes
  - Degree of industry support
- Scientific and research feasibility:
  - Research plan
  - Literature review
  - Scientific capacity
- Impact:
  - Potential economic impact
  - Industry adoption
  - Potential environmental impact.

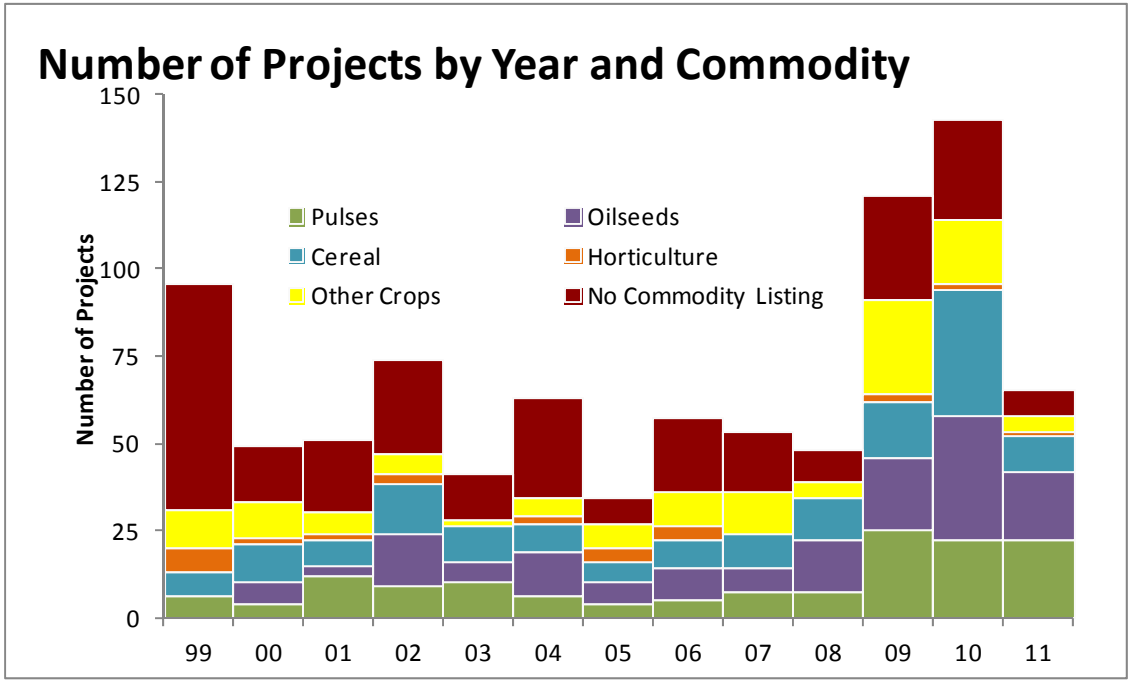
As shown in Exhibit II-1, over 3,300 ADF projects have been conducted or are in process since the inception of the initiative with a total of almost $294 million in SMA funding.

Exhibit II-1
Number of Projects by Year and Project Review Committee

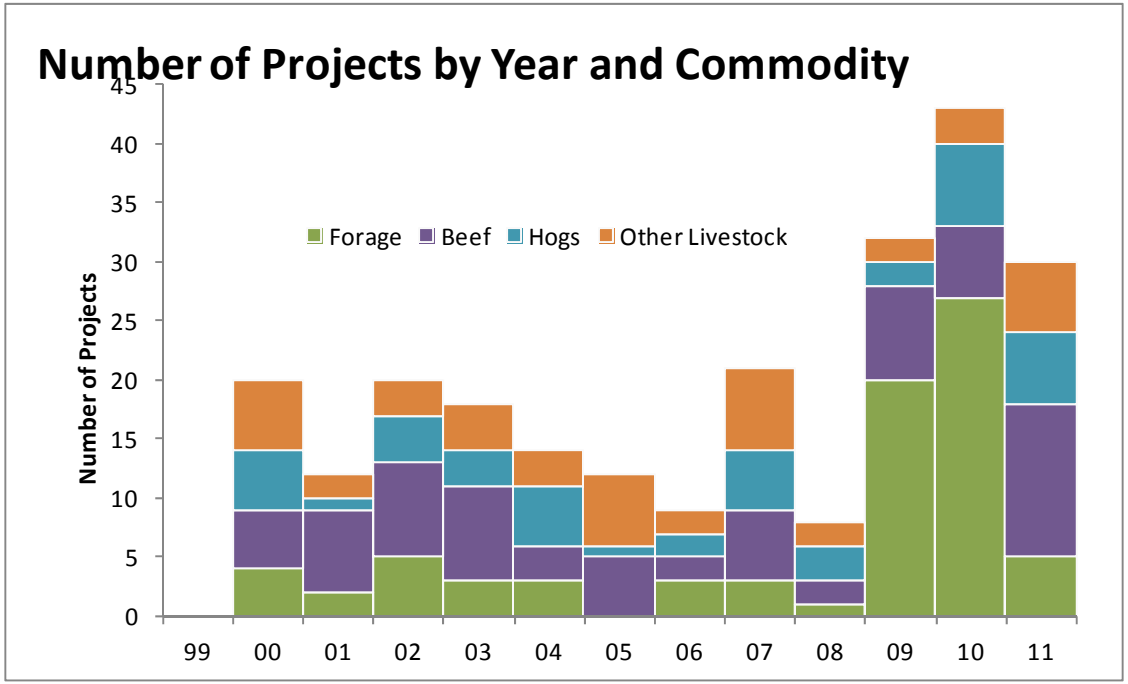


	Project Year																											
Committee	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	**Total**
Crops	29	141	115	65	61	97	46	31	43	10	17	14	12	19	23	24	15	16	39	25	33	8	15	27	17	16	21	20	**999**
SEHAC	39	130	99	82	96	135	54	32	36	10	26	18	14	12	19	23	16	11	19	10	14	8	16	16	11	9	13	13	**981**
Livestock & Forages	4	62	53	30	36	37	37	8	16	11	17	20	18	20	15	30	20	15	22	13	14	11	8	18	9	15	18	26	**603**
Processing		2	4	4	18	23	43	2	18	12	34	34	29	23	13	19	18	20	12	11	16	19	27	13	19	27	41	26	**527**
Demonstration																										82	92	10	**184**
No Committee Identified	1	1													1			1	2							4	1		**11**
Total	**73**	**336**	**271**	**181**	**211**	**292**	**180**	**73**	**113**	**43**	**94**	**86**	**73**	**74**	**71**	**96**	**69**	**63**	**94**	**59**	**77**	**46**	**66**	**74**	**56**	**153**	**186**	**95**	**3,305**

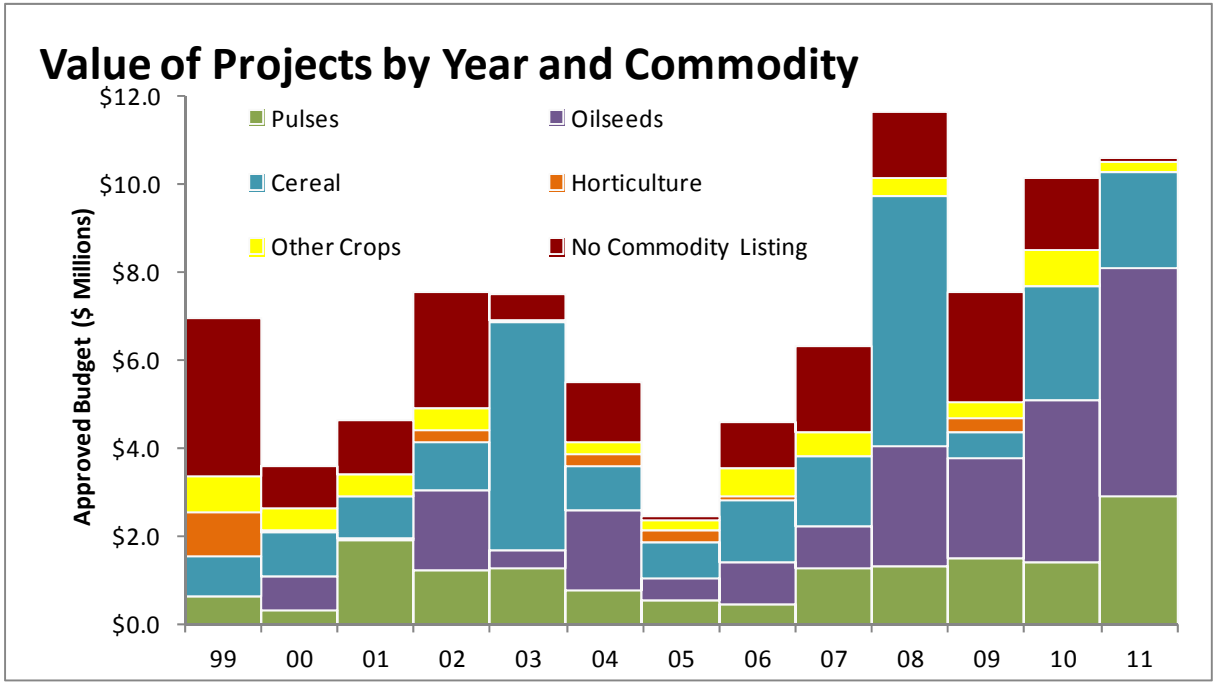
Some representative data of how the funding has been allocated by sector and commodity over 1999 – 2011 are found below.



	Project Year													
Commodity	99	00	01	02	03	04	05	06	07	08	09	10	11	**Total**
Pulses	6	4	12	9	10	6	4	5	7	7	25	22	22	**139**
Oilseeds		6	3	15	6	13	6	9	7	15	21	36	20	**157**
Cereal	7	11	7	14	10	8	6	8	10	12	16	36	10	**155**
Horticulture	7	2	2	3		2	4	4			2	2	1	**29**
Other Crops	11	10	6	6	2	5	7	10	12	5	27	18	5	**124**
No Commodity Listing	65	16	21	27	13	29	7	21	17	9	30	29	7	**291**
Sub-Total	**96**	**49**	**51**	**74**	**41**	**63**	**34**	**57**	**53**	**48**	**121**	**143**	**65**	**895**

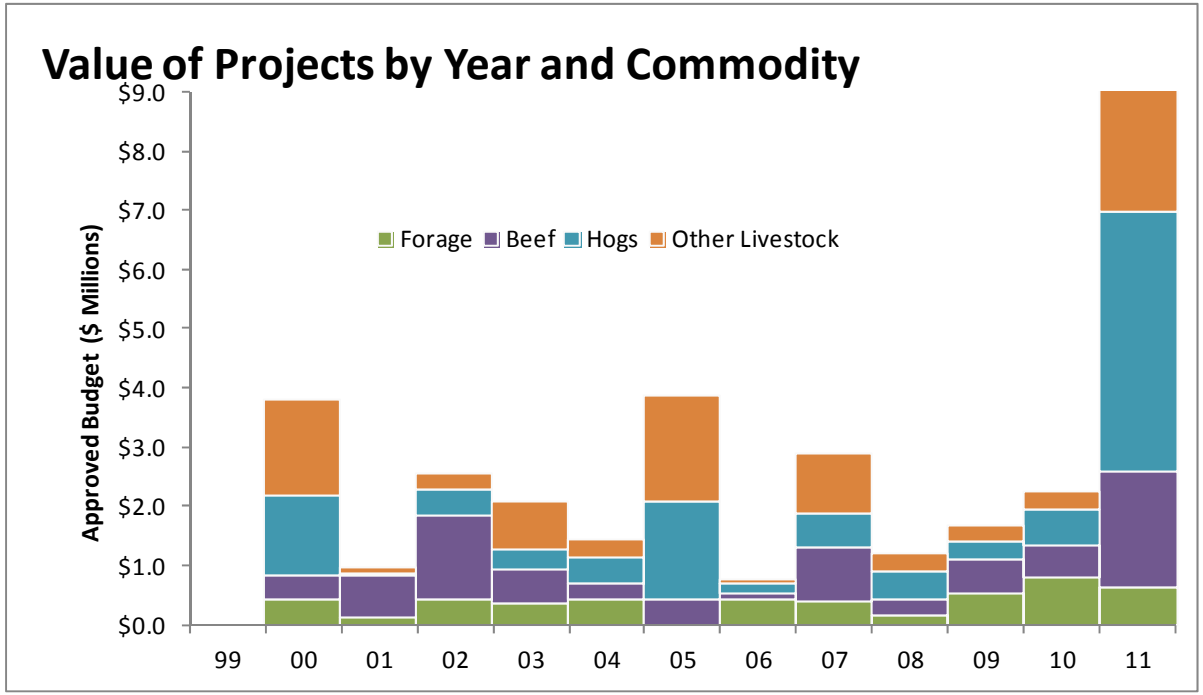


	Project Year													
Commodity	99	00	01	02	03	04	05	06	07	08	09	10	11	**Total**
Forage		4	2	5	3	3		3	3	1	20	27	5	**76**
Beef		5	7	8	8	3	5	2	6	2	8	6	13	**73**
Hogs		5	1	4	3	5	1	2	5	3	2	7	6	**44**
Other Livestock		6	2	3	4	3	6	2	7	2	2	3	6	**46**
Sub-Total	**0**	**20**	**12**	**20**	**18**	**14**	**12**	**9**	**21**	**8**	**32**	**43**	**30**	**239**
Total	**96**	**69**	**63**	**94**	**59**	**77**	**46**	**66**	**74**	**56**	**153**	**186**	**95**	**1,134**



	Project Year													
Commodity	99	00	01	02	03	04	05	06	07	08	09	10	11	**Total**
Pulses	$0.6	$0.3	$1.9	$1.2	$1.3	$0.7	$0.5	$0.4	$1.3	$1.3	$1.5	$1.4	$2.9	**$15.2**
Oilseeds		$0.7	$0.1	$1.8	$0.4	$1.9	$0.5	$1.0	$1.0	$2.7	$2.3	$3.7	$5.2	**$21.2**
Cereal	$0.9	$1.0	$0.9	$1.1	$5.2	$1.0	$0.8	$1.4	$1.6	$5.7	$0.6	$2.6	$2.2	**$25.1**
Horticulture	$1.0	$0.0	$0.0	$0.3		$0.2	$0.3	$0.1			$0.3	$0.0	$0.0	**$2.3**
Other Crops	$0.8	$0.5	$0.5	$0.5	$0.0	$0.3	$0.2	$0.6	$0.6	$0.4	$0.4	$0.8	$0.2	**$5.8**
No Commodity Listing	$3.6	$0.9	$1.2	$2.6	$0.6	$1.4	$0.1	$1.0	$2.0	$1.5	$2.5	$1.6	$0.1	**$19.2**
Sub-Total	**$6.9**	**$3.6**	**$4.6**	**$7.5**	**$7.5**	**$5.5**	**$2.4**	**$4.6**	**$6.3**	**$11.6**	**$7.5**	**$10.1**	**$10.6**	**$88.7**

*Year's current dollars (i.e., not normalized)



	Project Year													
Commodity	99	00	01	02	03	04	05	06	07	08	09	10	11	**Total**
Forage		$0.5	$0.1	$0.4	$0.4	$0.5		$0.5	$0.4	$0.2	$0.5	$0.8	$0.7	**$4.9**
Beef		$0.4	$0.7	$1.4	$0.6	$0.3	$0.4	$0.1	$0.9	$0.3	$0.6	$0.5	$1.9	**$8.1**
Hogs		$1.4	$0.0	$0.4	$0.3	$0.4	$1.7	$0.2	$0.6	$0.5	$0.3	$0.6	$4.4	**$10.8**
Other Livestock		$1.6	$0.1	$0.3	$0.8	$0.3	$1.8	$0.1	$1.0	$0.3	$0.3	$0.3	$2.1	**$8.9**
Sub-Total	**$0.0**	**$3.8**	**$1.0**	**$2.6**	**$2.1**	**$1.4**	**$3.9**	**$0.8**	**$2.9**	**$1.2**	**$1.7**	**$2.3**	**$9.1**	**$32.7**
Total	**$6.9**	**$7.4**	**$5.6**	**$10.1**	**$9.6**	**$6.9**	**$6.3**	**$5.3**	**$9.2**	**$12.8**	**$9.2**	**$12.4**	**$19.7**	**$121.4**

*Year's current dollars (i.e., not normalized)

2.2.2 Objectives and scope of the SRP

Initiatied in 1986, the SRP involves a series of five-year agreements to provide funding for the salaries and benefits of research chairs at instititutions performing research into agricultural production and food processing issues. The five-year funding commitment for each chair assures stable funding to facilitate the recruitment and retention of the best research personnel. SRP chairs are also expected to attract funding for their research programs and projects from programs offered by public and private sector organizations. Each chair has a program framework, developed with SMA, and a five-year research plan. Annual reports on progress against the plan and framework are required.

The current SRP funding agreement was initiated in 2009/10 and provides $3.2 million focused on four theme areas:

- *Crop Genetic Improvement*. Research to improve the agronomic and quality characteristics of pulse crops, cereals and flax for food, feed, and industrial uses. Diversification within these crops to develop new market classes that add value and provide the basis for value-added processing and industrial development within the province is a key expectation. Seven SRP chairs are funded under this theme; all located at the University of Saskatchewan's Crop Development Centre:
  - CWRS Wheat, Specialty Wheats and Canaryseed Breeding and Genetics
  - Durum and High-Yield Wheat Breeding and Genetics
  - Barley and Oat Breeding and Genetics
  - Flax Breeding and Genetics
  - Field Pea Breeding and Genetics
  - Cereal and Flax Crop Pathology
  - Pulse Crop Pathology.
- *Livestock Development* – Work with other researchers and livestock producers to develop new knowledge and technologies to support the development of a stronger beef value chain and sustainable livestock sector. Three chairs are supported; one in the University of Saskatchewan's College of Agriculture and Bioresources and two at the Western Beef Development Centre:
  - Feed Research and Development
  - Economics of Cow-Calf Production
  - Cow-Calf and Forage Systems.
- *Food and Bioproducts Development* – Research to establish a foundation for the creation of new markets and additional demand for crops that may lead to realization of significant value-added potential for primary commodity crops produced in Saskatchewan. Three chairs are supported; two of which are in the College of Agriculture and Bioresources and the third position is currently vacant:
  - Agricultural Material Utilization and Bioprocess Engineering
  - Lipid Quality and Utilization
  - Protein Quality and Utilization.

- *Soils and Environment* – Research to determine optimal use of natural resources while enhancing or maintaining the economic and environmental sustainability of Saskatchewan's soils and cropping systems. Two chairs are supported, both in the College of Agriculture and Bioresources:
  - Soil Biological Processes
  - Soil Nutrient Management

3. Methodologies

The methodolgies employed for this study were as follows:

3.1 Literature review

The literature review investigated publicly available documents and other published information focused on:

- Rationale for public intervention to support agricultural R&D and areas where such intervention is most heavily warranted, including areas where private sources of support (by private companies and/or cooperative approaches by producers) may better enable the achievement of policy goals.
- Estimated economic rates of return for agricultural R&D programs in Saskatchewan and other jurisdictions.

A total of 44 documents were reviewed and coded to fall into one of two categories for analysis namely impacts of R&D programs and rationale for public intervention in agricultural R&D. The complete list of documents can be found in Appendix A.

3.2 Internal and external key informant interviews

A series of key informant interviews were conducted, involving 35 internal and external key informants. These stakeholders spanned industry groups, comissions and sector councils; federal government departments, other research centres, internal Ministry program personel and senior management as well as a number of members of the ADF Advisory Committee.

A purposive sampling approach was used to select prospective candidates for the key informant interviews, focusing on the selection of respondents who were involved with the ADF and SRP delivery and thus able to provide informed comments on the effectiveness of current ADF and SRP funding and project selection and review processes, positioning of the ADF and SRP vis-à-vis other providers of research funding, and emerging research needs and priorities.

In addition, SRP Chairs and ADF researchers who were contacted as part of the PBCA screening method (see Appendix C) were also provided the opportunity to respond to these evaluation questions.

3.3 Comparative Review

The purpose of the comparative review was to compare the models of selected organizations with the ADF and SRP model. A preliminary working paper outlining an overview of the organization and its R&D funding programs along with rationale for selection was provided to SMA for approval. A total of 5 organizations were selected for review. Information was gathered from each organization in a two-stage process:

- The organization's web site and other available documentation was researched, and the information relevant to each of the items investigated was summarized.
- Telephone interviews were held with individuals knowledgeable about each organization being studied. During the interviews, we filled any information gaps from the web research and posed questions related to process and best practices.

The organizations reviewed were:

- Ontario Ministry of Agriculture, Food and Rural Affairs
- Alberta Innovates Bio Solutions
- Agriculture Funding Consortium (Alberta)
- Manitoba Agri-Food Research and Development Initiative
- Agricultural Research Fund -- North Dakota State Board of Agricultural Research and Education.

3.4 Partial benefit-cost analysis (PBCA)

Partial benefit-cost analysis (PBCA) is a means of providing evidence on external socio-economic impacts created by research and development (R&D) programs. By "external", we mean impacts outside the academic community; i.e., for industry, the health care system, general society, the environment, etc.

PBCA provides a defensible lower bound on dollar impacts of an R&D program. It does not attempt to estimate the total impacts of R&D programs, since this would require some means of quantifying (in dollar terms) impacts which have not yet been imagined (as when the research leads to entirely unexpected knock-on impacts years later), impacts which are not yet understood to be important (as when the research is currently promising, but its full transformative importance has not yet been realized), and "intangible" impacts which are very difficult to quantify in the first place (such as those for the environment, public safety, consumer confidence, quality of life, etc.)

The strength of PBCA lies in the fact that, for those impacts which are modeled, the modeling is done in very concrete, quantitative, and easily understood ways, making the analysis highly defensible. Further, readers understand that there are many impacts which are not quantified, and so the Net Present Value (NPV) and Benefit/Cost ratio (B/C) values are lower bound – the true impacts are almost certainly higher.

In PBCA:

- The gross and net benefits of a small sub-set of "high impact" projects are calculated. These "high impact" projects are those which have the highest benefits which can be identified, quantified, and which can be assigned a dollar value. Each "high impact" project is treated as a separate case for detailed economic analysis.
- The net benefits of these "high impact" projects are compared to the total cost of the R&D program, by calculating the Net Present Value (NPV) and/or benefit-cost (B-C) ratio, after both benefit and cost streams are deflated and discounted.

Thus PBCA is a "partial" approach, since not all projects, and not all impacts, are investigated. The NPV is a conservative (sometimes very conservative) lower bound of socio-economic impacts, since only the benefits of the highest impact projects are estimated, but they are compared to the total program costs. Note that because "high impact" projects are deliberately chosen for analysis, no extrapolation to the program as a whole is done.

To identify the high impact projects, a multi-pronged screening process was used as follows:

- PBCA was initiated by the development of long list of 34 candidate cases (high impacts, quantifiable in dollar terms, attributable to ADF and/or SRP), based on initial interviews with SMA, SRP chairs, ADF researchers, sector experts, and third party R&D organizations (e.g., CDC, VIDO). It is notable that the long list included candidates from every sector
- Screening of "long list". The "long list" was screened by the study team using criteria such as likely impact size, ability to quantify the impacts in dollars, likely attribution of the impacts to the ADF or SRP programs, and willingness of the PI and/or industry to participate in the study
- Preliminary feasibility ratings (yes, no, maybe) for suitability for PBCA were derived for each potential case. The ratings were discussed in a working paper with the SMA project authority
- Refinement into a short list of 11 best candidates (highest impacts, most amenable to quantification, and the most defensible)
- Short list candidates investigated by:
  - Interviews with PIs re. key impacts, assumptions, appropriate quantification methods
  - Interviews with partners, industry, associations, etc. as appropriate to confirm nature, size, and timing of impacts
  - Review of quantitative data from StatsCan, SMA, industry associations
  - Confirmation of modeling assumptions with key informants
- Seven cases were developed that included case-by-case quantitative modelling of gross revenues, net revenues, and any additional case-specific costs that should be included.
- Although several cases have created Canada-wide impacts, these broader impacts were not modelled – only economic benefits to Saskatchewan are presented.
- Attribution to the ADF and SRP was high in all the cases (this was one criterion of PBCA selection). However, in some individual cases attribution was modelled as follows:
  - An estimated proportional attribution based on expert opinion was used, taking into account the contributions of other actors in the innovation system, including industry associations, funding through Checkoff, the University of Saskatchewan, and individual firms. This is not a preferred option, since the attribution is relatively subjective, even though based on the opinions of highly knowledgeable individuals
  - Where the R&D investment of major partners was known, their funding support was included in the total cost stream for the analysis. In other words, the ADF, SRP, and other organizations were treated as collaborating partners in performing and applying the research findings, and the attribution is then treated as being 100% for the collaborative venture (and their joint, total funding). This is the preferred route, since it more realistically reflects the reality that all partners to the R&D are critical to achieving practical impacts, as well as the practical difficulties associated with estimating proportional attribution[2]

[2] Proportional attribution is often based simply on proportional funding of the different partners. This is usually inappropriate, in that multiple parties are often critical to the success of the R&D, and without any one of them the practical impacts would be far lower, or even zero.

- In a few cases where attribution was especially difficult to judge and it was possible to overestimate the contribution of ADF and SRP, we used both of the methods mentioned above, which is an especially conservative approach.

- Discounting was used to reflect effects such as the implicit social preference for having benefits sooner rather than later, and the next best use of the capital involved. A variety of discount rates was used:
  - 2%, reflecting recent Bank of Canada rates for real return bonds (i.e., exclusive of inflation), and being perhaps more appropriate when considering the likely long- and very long-term impacts of ADF and SRP which may be very significant, but which are heavily penalized by high discount rates
  - 5%, reflecting recent practice for S&T programs
  - 8%, reflecting recent federal Treasury Board recommendations[3], but which perhaps unduly penalizes S&T programs which provide significant unforeseeable benefits over the long term.

3.5 Limitations and constraints

The evaluation employed qualitative and quantitative methods to assess the effectiveness, contributions and impacts of the ADF and SRP to the Saskatchewan economy. A number of considerations and limitations associated with the study methodologies used should be considered with reviewing the report and its findings:

- The work was limited to, and KPMG's observations and reporting are based on, the detailed Evaluation Framework and Work Plan designed to undertake this review on behalf of SMA. The scope of our engagement was, by design, limited, and therefore the resulting findings should be considered in the context of the work plan executed. We relied on information and representations of interviewees (at the approval of SMA) for the completeness and accuracy of information provided. All data and information provided by SMA and others in the course of our engagement is considered factual for the purposes of our findings, analysis and recommendations.
- The limited number of overall interviews (across all respondent groups) is such that assumptions about representativeness cannot be made within particular respondent groups. Particularly, a very limited number of general ADF researchers (those outside the SRP program) were interviewed. This may partially limit the depth of coverage of the evaluation issues. (However, findings were quite consistent across respondents and lines of evidence, and KPMG is confident that the findings are generally representative.)

3.6 Restrictions

This report has been prepared by KPMG LLP ("KPMG") for the Saskatchewan Ministry of Agriculture ("Client") pursuant to the terms of our engagement agreement with Client dated January 31, 2012 (the "Engagement Agreement"). KPMG neither warrants nor represents that the information contained in this report is accurate, complete, sufficient or appropriate for use by any person or entity other than Client or for any purpose other than set out in the Engagement Agreement. This report may not be relied upon by any person or entity other than Client, and KPMG hereby expressly disclaims any and

[3] Canadian Cost-Benefit Analysis Guide, Regulatory Proposals, *Treasury Board of Canada Secretariat, 2007. Catalogue No. BT58-5/2007*, ISBN 978-0-662-05039-1

all responsibility or liability to any person or entity other than Client in connection with their use of this report.

This report, and the comments and conclusions expressed herein, are valid only in the context of the whole report. Selected comments or conclusions should not be considered outside of the context of the report in its entirety.

4. Findings on policy rationale for public sector intervention in support of agricultural R&D

4.1 What is the policy rationale for public intervention in support of agricultural R&D?

A wide range of publications and studies have investigated the rationale for public intervention in support of agricultural R&D and provides the starting point for the analysis of the role of the SMA in support of agricultural R&D, the extent to which it supports the competitive positioning of production and processing sectors, and the extent to which gaps exist or the allocation of effort needs to be adjusted. The economic rationale for public support of R&D may be best summarized in the following terms:

- Public intervention is justified on the basis of correcting a market failure – insufficient funds are invested in R&D by the private sector, including producers. Principal reasons for this type of market failure include:
  - Individual firms and producers are unable to capture the full returns on their investments in R&D
  - Limited availability of intellectual property rights
  - Lack of incentives for private sector R&D performers to take public benefits into account in their decision-making.
- The rationale for public R&D is generally strongest for basic research.
- Public R&D can be a catalyst or enabler for collectively funded R&D by producers, e.g., through check-off programs.
- Public research ideas/products can be used over and over. Access to technology benefits the whole sector.
- Less duplication. Increase sharing among researchers and research institutes.

As an example of the published research on the rationale for intervention, Gray and Weseen (2007) summarize the essential features of public support for agricultural R&D in the following terms:

> *Many economic studies have found high rates of return to research continuing to present day (Gray and Malla, 2007). The high rates of return suggest a need to find mechanisms to fund areas of public research with high rates of return, where private industry and levy-funded research organizations will not invest. Where the private sector is able to invest, analysis is needed to determine what incentives, if any, are needed to create the maximum net benefit from research.*

The literature points to the spillover effects of R&D on the social good as one inhibitor to the optimal amount of investment by private industry in agriculture and agri-food R&D. A recent policy brief developed by the Canadian Agricultural Innovatin Research Network (Oct 2007) summarizes the rationale:

> *It has been shown that private firms invest less in R&D than the socially optimal amount even with fully appropriate intellectual property rights because they cannot fully appropriate all the research benefits generated from their investment. Given that the research firm making the investment in research cannot capture the increase in surplus going to the buyers of their product (i.e., farmers), their private marginal benefit from research is less than the socially marginal benefit. Research firms are only concerned with their private benefits from an R&D investment and not the spillover effects that their action may have on others. Therefore, they will underinvest in R&D relative to the social optimum.*

Through the anlalysis of stakeholder interviews there was generally strong backing for government support of agriculture and agri-food research. Interviewees felt that without public support for basic, longer-term research, a large gap would be created due to lack of interest from private sector to invest. Many agriculture and agri-food issues need long-term support to be successful (e.g., incremental improvements to varieties, soil quality, market development) and sometimes early government investment is needed to attract industry. Interviewees felt that some seed funding needs to be in place and that public funding helps to share the risk in early investment.

Again, Gray (2008) defines the investment of public resources in basic science to be a a key component for best practice in agriculture innovation "[Basic science] is a proven component of national innovations sytems. Private companies have little incentive to invest in these activities but as complements to private research activities, they cause a "crowding in" of applied research. These activities also train high quality personnel for industry, which increases the ability to innovate."

4.2 What form of public intervention/support are most effective?

The literature suggests that horizontal and vertical linkages beteween constituents making up an industry sector (i.e., from producer to processor) play an important role in agricultural innovation but that government also has a role. Gray et al (2008) suggest:

> *"The atomistic structure of the industry (particularly primary producers) requires horizontal and vertical linkages to coordinate and fund industry level initiatives. Without some govermment support, the tendency for parts of the industry to free ride will result in underinvestment in these critical activites."*

This was synomomous with the findings from a discussion paper produced by Agriculture and Agri-Food Canada in support of the Growing Foward II renewal[4]:

> *There is wide agreement that a more collaborative approach to knowledge creation and application is critical. In the past, governments have taken a*

[4] Discussion paper 7 of 9, http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1299870092742&lang=eng#a1, accessed November 13, 2012.

> *leading role in conducting basic and applied research related to the agriculture and agri-food sector. Recent programs such as Growing Forward's Agri-Science Clusters have moved towards a more open innovation model by encouraging the development of clusters/networks which include governments, universities, and the industry.*
>
> *These types of programs enable the sector to play a role in the focusing and setting of research priorities, building capacity through incremental investments and executing research agendas. Moving forward, increased sector engagement is important as industry is best positioned, as the primary beneficiaries of most innovation investment, to set the sector's strategic direction based on the interplay among the various players (producers, processors, retailers, etc.) along the value chain.*

Interviewees believe government plays a strong role in encouragement, establishment, coordination of networks and collaborations to support common goals and partnerships. In some cases, spurred by co-funding, assisting to get early buy-in from industry to drive change. Interviewees also felt government plays a key role in providing assistance to technology transfer activities through identification and connection of key players and drawing partners together.

Heisey et al. (2010) also discuss the coordinating role of government

> *Because the public sector has such a large role in performing and funding research, it can often be uniquely positioned to coordinate research effort. In agriculture, the public sector funds or performs a plurality of R&D. As a result, public science agencies can take advantage of their predominant role in the overall research system to prevent duplication of research effort and to promote the dissemination of new research results.*

Interviewees also felt that publicly funded research allows for more public access to research results and the wider dissemination of information so that more can benefit sooner. The PBCA cases (see section 7) confirmed the critical importance of this fact. Again, Heisey et al (2010) identify the dissemination of research results as another coordinating role for public research: "Research across different scientific fields, with different applications or requiring multidisciplinary perspectives, can produce useful results that go unnoticed. In areas of common public mission, different agencies can coordinate efforts and form long-term working relationships to facilitate information sharing. Public coordination can help bring the relevant agencies and scientific disciplines together."

The common theme emerging from the literature review and interviews is that there is a definite role for public support in agriculture R&D. Public research dollars can be used as leverage to make research go further, help create partnerships between research, industry and other communities and drive dissemination of research results to foster innovation.

4.3 What are the current and emerging needs for public R&D support in the agricultural production and food processing sectors in Saskatchewan?

Agriculture and Agri-Food Canada's Growing Forward discussion paper on the context[5] of the current state and trends of the global agriculture and agri food market provides an assessment in terms of the opportunities and challenges in existing and new markets for the Canadian sector. Eight key trends are identified:

- Population growth is expected to increase demand for food.
- A growing middle class in emerging economies is increasing demand for higher value food products.
- World trade in agriculture and agri-food products continues to increase.
- Globally, the supply chain, including the retail sector, has changed significantly in the past two decades.
- Global retailers and processors are establishing new or adopting existing private standards.
- Demand for non-food uses of agricultural products continues to grow.
- Growth in agricultural and agri-food production is affected by natural resource constraints (for example, land, water).
- New technological breakthroughs will help increase productivity and reduce environmental impacts of production.

Findings from the analysis of interview responses align well to most of these system challenges. For consideration of SMA, the key thematic current and emerging areas for public R&D support identified by the interviewees included (in no order of priority):

- Climate variation
- Global population pressures and commodity production
- Land and soil as strategic renewable resources
- Forage and feed grain research
- Food safety and sustainability
- Value added products and processing
- Pest management (insect, weed and disease control)
- Livestock – feed and nutritional component
- Infrastructure support and capacity building (belief there may be less federal research presence in future as well as key federal researchers retiring and not being replaced).
- Moving products through to commercialization

While it was not within the scope of this study to undertake a formal foresighting exercise, the literature review and findings from the comparative review point to the importance of formalizing priority setting processes and foresighting exercises.

[5] http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1299859709146&lang=eng, accessed November 13, 2012.

Gray and Weseen (2008) cite the Australian Grain Research Development Corporation (GRDC) as a model that contrasts with others in that it "takes a demand pull" approach to setting its research priorities, relying on market signals to direct research. This strategy involves the establishment and maintenance of strong linkages across producer and other business groups, which is accomplished by the creation of a Board and advisory panels that are composed of producers, downstream industry groups, scientists and executive managers."

All organizations researched in the comparative review (see section 6) also undertook formal priority setting exercises on a system-wide basis. For example, OMAFRA research priorities are identified through three main advisory groups, which incorporate and consider advice from industry, academia, government and the public to obtain long term and on-going input to development. The Agricultural Research Institute of Ontario provides advice to the Minister on the overall direction for agri-food research. An expert panel is employed every five years to develop the strategic priorities and Theme Advisory Groups (TAGs) meet annually to review the priorities and identify emerging issues and opportunities. The TAGs also review research that has taken place over the last few years and recommends where increased, continuing or new focus should be placed for OMAFRA-funded research programs in seven theme areas.

5. General findings on the economic returns to ADF and SRP expenditures

This section discusses the views of key stakeholders regarding the ADF and SRP.

5.1 In what ways and by what means have the ADF and SRP enhanced the performance of Saskatchewan's agricultural economy?

The key stakeholders were unanimous in believing that these two programs have contributed greatly to the Saskatchewan economy, and many were able to point to examples of the programs' contributions to the province, including impacts in specific sectors, attracting large business to Saskatchewan, and putting the province "on the map" in terms of expertise in ag/ag-food areas, and attracting top scientists to the University of Saskatchewan and VIDO. (Although they did not know details of the economic impacts, this is not surprising.)

By far, respondents mentioned the crops area most frequently, including plant breeding for new varieties that produce improved yields and and can serve new markets (especially pulses). They also mentioned agronomic production improvements, especially with ADF's early involvement in direct seeding and no/low-till methods that are seen to have transformed agicultural practices. New livestock feeding systems and technologies that have helped increased production and reduce feed costs were also mentioned, but less frequently. It was also noted that R&D into biofuels started in the province and are spreading more widely into the economy. On the engineering side, good work was mentioned in areas such as improved agricultural machines (including those involved in low/no till), improved safety, increased efficiency monitoring, and better production and processing control proceses and technologies.

5.2 Which aspects of the ADF and SRP's design and delivery have been most effective, and which less so?

The respondents generally believed that the two programs were working well, and (with some exceptions noted below), were working effectively and efficiently. As for specific impacts, key stakeholders were not well informed about the detailed design and delivery mechanisms for ADF and SRP, but the study team believes this is actually a good sign in that few notable problems are known to the broader community. Specific areas in which the programs were considered operating well were:

- Through the ADF there has been good sharing of information, feedback on achievements, and consultation on opportunities; e.g., between the Ministry and industry (through the ADF Committee), and with other organizations and industry associations around Letters of Intent (for proposal development). *"They are consulting with us to be effective with the money."*
- The ADF and SRP work hand in hand to balance shorter- and longer-term research objectives. The ADF supports shorter term practical research and provide a nimble response to immediate priorities, while the SRP is a long-term, more strategic investment to address future needs, attracting talented scientists and building new human capacity.
- The ADF provides operational funding to several Saskatchewan R&D organizations, including the Crop Development Centre (CDC), the Vaccine and Infectious Disease Organization (VIDO), and the Prairie Agricultural Machinery Institute (PAMI). While not intended to directly support

research projects (researchers in these organizations obtain funding from ADF and/or SRP) this funding provides very important support for developing partnerships and for technology and knowledge transfer, without which the economic impacts described in this report would be far more limited.

5.3 Which aspects of the ADF and SRP's design and delivery have been most effective, and which less so?

The most effective elements are noted in section 5.1.2. Many respondents noted the following constraints to the ADF program, listed in roughly decreasing order of importance. (The workings of the SRP are not well-known by the key stakeholders, although the Chairs often mentioned that longer contracts would be welcomed.)

- The ADF project approval timelines were noted to be too long by key respondents in Saskatchewan, but were also believed by respondents from R&D organizations outside Saskatchewan as being overly lengthy. Reference to long timeframes was brought forward by a quarter of the key informant interviewees representing all respondent groups, including industry organizations, University, SMA staff, and researchers. The timeframe before formal approval for ADF is roughly from April (letters of intent, for which there were nearly 200 in 2012, of which nearly 100 were invited to prepare full proposals) through early November (when the ADF Advisory Committee forwards full proposals that have been reviewed and tentatively approved to the Minister for final approval), for a elapsed period of about seven months until the Minister receives the recommendations. Respondents noted that the full elapsed time from the LOI stage until funding is received is typically a year.
- The single ADF application per year does not easily respond to seasonal issues (e.g., spring project start-up), and results in a heavy review burden, with about 100 full proposals typically going on to about 60 approved projects. Some similar programs have two or three applications per year.
- Taken together, respondents noted that these factors limit leveraging opportunities from potential partners – in particular, industry finds it difficult to justify contributions when the time scale is too long.
- Increased dissemination of general results from both ADF and SRP would be welcomed (the ADF web database is not enough). This would include more communication on research undertaken in SRP Chair programs – many key stakeholders were quite uninformed about Chair activities and results.

With respect to the single annual call for applications and the somewhat lengthy review process, please see section 6.3.

5.4 To what extent have the ADF and SRP had a positive net impact on the financial performance of producers in Saskatchewan?

There was no clear understanding of this from key stakeholders, although their opinions were all positive.

6. The Comparative Review

6.1 Program design

Most other organizations reviewed rely on some form of third party or partnership delivery mechanisms, where these external parties have responsibility for proposal review and fiduciary responsibility for funding.

- Respondents from the external organizations believed that potential benefits of such a model would include faster response times and more flexibility to respond to short-term issues or changing industry needs.
- However, due diligence and accountability by SMA would likely be more complex. (The ADF and SRP model is essentially a hybrid, in that external organizations such as the University of Saskatchewan, VIDO, CDC, WGRF, and PAMI/WBDC act partially in third party mode, especially through their operational funding.)

6.2 Advisory functions

All other models have Advisory Bodies that include industry representation. Some advisory bodies also include academic and government (although not all members may have voting rights). The ADF Advisory Committee may have as many as 13 people although currently there are nine, of which six are industry members and three from SMA, all appointed by the Minister and all with voting rights (usually by consensus). This committee solicits feedback from industry regarding individual ADF proposals to ensure relevance and usefulness, and some industry associations (e.g., Saskatchewan Pulse Growers) have co-funding available, and/or may fund some research proposals independently from SMA.

- A potential weakness of the current ADF structure is that there is currently no representation from AAFC, possibly limiting coordination of efforts. (However, a recently announced major flagship program for wheat research will include AAFC in addition to the University of Saskatchewan, SMA, and the National Research Council, so this does represent coordination at the national level.)
- Also, current industry representatives are from the primary production side, with none from processing and value-added industries (possibly limiting the ability to identify important research efforts in these areas. This point was also mentioned by a few key stakeholders, and the PBCA results discussed in Section 7 tend to support this idea.

6.3 Application and review processes

While ADF has only one call for proposals annually, all the other models reviewed have more than one (typically two or three). The external program officials interviewed believed that this helped deal in a timely fashion with seasonal issues, and also reduced the number of proposals reviewed at once, and thus the time and effort required. Their typical complete review times are from six weeks to six months, while ADF's is roughly a year from letter of intent to funding being received.

- SMA notes that coordination of reviews across the multiple industry associations is already complicated, and might be more so if there were multiple calls per year. As noted earlier, some of the industry associations (e.g., WGRF, SPG) are asked to comment on individual proposals, and some co-fund ADF projects but may also fund projects independently, and their application and

review timelines may differ from SMA's. For example, this year the WGRF did not issue their own Requests for Applications (RFAs), but asked their researchers to apply to ADF instead, out of which WGRF would then select projects to co-fund or fund independently. Further, the boards of some associations do not meet until late November; i.e., after the ADF Advisory Committee has made its decisions.

- In addition, some non-Saskatchewan organizations are also consulted if there are potential synergies, introducing another potential timing complication.
- Saskatchewan researchers are believed by SMA to prefer the "one stop shopping" afforded by the current coordination through SMA and one call per year.

A final note is that SMA has modified the application and review process in recent years in response to requests from the research and industry communities. In earlier years there were two, or even four, annual calls. However, the current process allows easier planning for both researchers and SMA, in that the single call allows more predictability of likely future funding, it provides for up to two months for SMA to interact with applicants to refine and improve proposals, and it does not require a significant proportion of ADF funding to be set aside for a second call for proposals later in the year, with uncertainty as to the quality of proposals that will be received. The KPMG study team notes that the ability to interact with applicants has been found in other S&T studies to be an important feature, and losing this feature would be a significant detriment to the process (and one unlikely to be overcome by the benefits of being able to respond slightly better to seasonal issues).

6.4 Peer review

All the other organizations reviewed use an external peer review process, possibly supplemented by an internal business case review. Such a system can have both pros and cons. A potential drawback is that academic review may focus more on science and knowledge production and less on near-term (or even long-term) industry applications. Potential benefits is that peer review can identify science that may be very important in the long-term that is not necessarily obvious to industry, and may help align the R&D with broader priority areas (e.g., provincial or national), and help identify potential collaborators (and avoid duplication) world-wide.

6.5 Priority setting

Most of the other organizations reviewed have system-wide strategic priority setting exercises on regular basis, with participation from key external organizations and stakeholders in industry, academia, and government. For SMA, the SRP priorities are set through contracts with the participating institutions as well as in five-year Framework Agreements with individual Chairs and through annual reviews by SMA against plans. There is no formal industry input into the SRP reviews, although SMA sector experts keep in close contact with the private sector, especially in the crops sector. There is no overall priority setting for ADF (which is response-driven to proposals), although there are informal notional allocations among sectors that the Advisory Committee discusses, as well as the appropriate balance between topics that are currently high profile, vs. others that may be important but of lesser visibility. Individual researchers also often maintain close ties with industry, and typically know their priorities from meetings held in the spring.

- On the face of it, the study team believes there is an opportunity to be more strategic with at least a portion of the ADF, for example by having a funding allocation for targeted RFAs and/or for work anticipated to pay off in the mid- to long-term. Such work is by no means entirely neglected at present, as many researchers, and especially SRP Chairs, do maintain long term research programs

that are partially supported by chains of ADF grants over several years, but a more explicit strategic mechanism may help direct funding into critical areas.

6.6 Partnerships

All the external R&D organizations reviewed use partnerships to help avoid duplication and increase efficiencies in use of research dollars. However, all struggle with how to work with other research funders more effectively. They believe that using formal funding consortia provides a good handle on what other groups are interested in, and find this process transparent. It is also efficient for researchers, as one submission can be seen by many funders, allowing refinement of each proposal to best suit needs.

The study team finds that the relationships between SMA and the external Saskatchewan industry associations as well as through the SRP Chairs (and in some cases with R&D organizations in other provinces, or indirectly through Chairs with yet other organizations such as Genome Prairie) function in many ways like formal consortia. We did not identify any specific instances where a more formal arrangement would be clearly preferable.

- Having said this, the current system for consulting with key stakeholders, identifying sector priorities, reviewing proposals, and identifying opportunities for co-funding and/or collaboration appears quite complex, onerous, and time-consuming. There are very many organizations and individuals involved, with potentially overlapping responsibilities and timelines.
- Further, there is no clear mechanism (certainly none that appears even semi-formal) for aligning SMA, ADF, and SRP priorities to broader ones such as those of the Province or Canada as a whole, for example in areas such as the environment, water or energy security, etc.
- The study team suggests that a review "from scratch" of how the entire consultation, RFA, and proposal review system might be designed to work most effectively, across all sectors, and including linkages to broader priorities, might well identify significant opportunities for improvements and efficiencies.

6.7 Capacity development

Unlike the SRP, only one of the programs reviewed had an explicit capacity development mechanism. An exception is the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA) with their partnership agreement with University of Guelph: research funding is transferred to the University to be provided to their researchers. In addition to direct project operating funding, the partnership helps support an agri-food faculty pool, scientific and technical staff and physical research capacity (research station infrastructure). Within this study, the long-term research programs operated by SRP Chairs were essential in each of the PBCA case studies for developing a series of incremental improvements which, over the years, summed to substantial improvements. Several of the Chairs were noted to have substantial Canadian and international visibility and credibility that greatly assisted in fostering trust and take-up by industry.

7. Findings from Partial Benefit-Cost Analysis on ADF and SRP Impacts

7.1 Overview

A total of 13 "short list" cases were investigated (see section 3), of which seven could be quantified in dollar terms for partial benefit-cost analysis (PBCA) within the scope of this study. Such a narrow focus is entirely usual in PBCA studies, and does not imply anything unusual about the ADF or SRP economic impacts. The study team believes that the five "short list" cases not quantified do in fact represent significant economic impacts; it was simply the case that some analytic challenges could not be overcome at the present time.

For context, we first present findings from the literature review of other economic impact studies in ag/ag-food R&D in section 7.2. This is followed by a short description of each PBCA case and the major analytic PBCA assumptions in section 7.3, and then summary conclusions and interpretation of the PBCA component in section 7.4.

7.2 General findings from the literature review of other economic impact studies

The literature review of other economic impact in this sector studies provides a useful benchmark against which to compare the results discussed below. Almost all of the Canadian and international reports reviewed found high rates of return to agricultural and ag-food R&D:

- Rates of return of 20% - 40% are common. However, ROI figures are highly variable, from well less than 20% to up to 60% - 100%. A meta-analysis found an ROI median over 34 studies of about 40%.
- Benefit/cost ratios are commonly about 5:1 to ~10:1, and a few range from about 15:1 to roughly 20:1.
- Canadian examples follow the same pattern.

Most studies are related to individual sector/product R&D programs, but some also attempt analysis of ag/ag-food R&D programs in general, although there is not a clear pattern in terms of the findings (e.g., it does not appear to be the case that sector-specific studies usually find higher, or lower, ROIs than more global studies). The high rates of return reflect the fact that research in this sector typically provides findings that are non-protected and widely distributed within industry. Even protected intellectual property is often taken up by agri-food firms that provide necessities for these sectors (e.g., better seed varieties, improved tilling machines) and are therefore widely adopted. Although there are some exceptions (see section 7.3), this is a recipe for high ROIs and benefit-cost ratios.

7.3 Summary of "short list" cases quantified for PBCA

7.3.1 Crop Diversification

Overview

In the early 1970s, Saskatchewan crops were mainly limited to cereals (especially wheat), crop rotation practices did not take into account how different seasonal and annual schedules of rotating individual crops affected subsequent yields and soil quality, and tilling methods were labour-intensive and harmful to the soil. Summerfallow acreage needed to be extensive in order to "rest" the soil sufficiently to keep soil quality at acceptable levels.

A primary goal of the Crop Development Centre (CDC) was to diversify Saskatchewan's crop productions through detailed examination of the impacts of different rotation schedules, development of new seed varieties for traditional crops that were better matched to Saskatchewans regmines of climate and pests/diseases, improvements to non-traditional crops (e.g., oilseed such as canola, pulses such as lentils) to make them easier and more productive to grow and harvest, and introduction of new farm machinery able to take advantage of these new varieties. These efforts were conducted by many researchers within CDC, the SRP program, and other organizations such as PAMI, and were tremendously successful, affecting crop production across Saskatchewan and with impacts likely to be felt far into the future.

Sources indicated a very high attribution not just to CDC, but to ADF through both project and core CDC funding, and through SRP support to key Chairs who were investigating key crops such as wheat, barley, flax, etc., and whose long-term R&D programs had substantial impacts not just on the varieties developed (especially in that CDC did virtually all the molecular-level R&D), but on outreach and the willingness of producers to trust and use them. Other innovations (e.g., zero till drills, new herbicides such as Roundup) certainly had an impact, but the modern crop diversification *systems* (as opposed to small incremental advances) would certainly not have happened absent long term R&D investigations to integrate these various new ideas. Nonetheless, we have adjusted for attribution to ADF and SRP in two ways in the PBCA model: (1) in some crops by assigning a percentage attribution to ADF/SRP, based on expert opinion; and/or (2) by including known costs to partners to the R&D within the cost stream, which essentially assigns 100% attribution to the collective actions of ADF, SRP, CDC, and partners, as each organization was critical in developing the results. Note that combining methods (1) and (2) is a conservative method of estimating attribution, and likely underestimates the contribution of ADF and SRP.

Quantitative benefits:

- The key benefit modeled for PBCA is that less land is now needed for summerfallow, dropping from almost 17 million acres prior to the formation of the CDC to just over six million acres now, or roughly 10 million additional acres. This additional acreage is available in Saskatchewan for crop production, and the additional net revenues from these previously unused lands are direct incremental economic impacts of CDC. This "additional acreage" represent roughly 40% of the total Saskatchewan area now seeded, so its impacts are highly significant.
- The crops grown on this additional acreage were modelled by:
  - Assuming only 5% of this land was available in 1990 (i.e., a four-year time lag from when the ADF began), increasing linearly over time to the present;

- The proportion of each major crop planted on the "additional acreage" has been proportionally the same as the 10-year average for 2001 – 2010 (seeding by crop data from SMA & StatsCan).

- The value of these crops was modelled by:
  - Data on net revenues per acre were taken from the SMA Crop Planning Guide for 2001. There are data available up to and including 2011, but no archived data easily available prior to 2001. Net revenues have been generally increasing over time (though with some variability by crop), so the 2001 data were used as a approxmiate average roughly between our starting and end time points.
  - Total values were therefore the net revenues per acre per individual crop, times the additional acreage per year assumed planted in that crop.
  - Since it is unknown if different soil types were more/less affected by crop diversification impacts, and it is unknown exactly what crops were planted on the "additional acreage" (as opposed to Saskatchewan farmland in general), the analysis used the *minimum value*, per crop, of the modeled lower and upper bound net revenues per acre across Black, Dark Brown, and Brown soils. However, it was assumed that any crops with net losses in these minimum values would not be planted at all; these crops were simply modeled as having zero revenues; i.e., we did not assume that a higher-revenue crop would be planted in its place.

- Lower and upper bounds were estimated by:
  - Lower bound net revenues/acre of each major crop = gross revenues per acre – (100% of variable costs/acre + 40% of fixed costs). All figures calculated per crop. The 40% value was used assuming that some fixed costs would have to increase, and would be roughly in proportion to the additional acreage that was being seeded as a proportion of the total in Saskatchewan.
  - Upper bound net revenues/acre of major crops = gross revenues per acre – (100% of variable costs/acre). All figures calculated per crop. This assumes that most additional costs are variable (e.g., seed, fertilizer, fuel), and that if a producer already has excess equipment and infrastructure in place to take advantage of the additional acreage, then few additional fixed costs will be incurred.

- Attribution was modelled by:
  - Flax attribution was modeled at 90%. While the University of Saskatchewan contributes considerable in-kind resources, the cash value is unknown. AAFC also does R&D in flax, but the main impacts are expected in future and have not been modeled.
  - The attribution adjustment to pulses was done by adding all known R&D costs borne by Saskatchewan Pulse Growers and other producers (from Gray *et al*, 2008[6], the total was $102.67 million in 2008$) into the cost stream, and assuming attribution was 100% to the combined actions of these parties, including two SRP Chairs working in this area.

[6] *Returns to Pulse Crop Research & Development and the Management of Intellectual Property Rights.* December 2008, A Report Funded by the Saskatchewan Pulse Growers. Final Report by Richard Gray, Cecil Nagy, Viktoriya Galusko, Simon Weseen. This support was for both CDC core funding and project support; for our purposes they are treated equally in the cost analysis.

- For wheat, the situation is complex, with mainly provincial funding up to 1997 but support from other organizations (e.g., WGRF, BASF, Viterra, SeCan) subsequent to that. We have made a conservative assumption: attribution for wheat was modeled by: (1) assuming attribution is 80% over our entire study period; AND (2) in the cost stream we included all known producer costs. The WGRF has contributed $13.2 million from 1995-2011 for CDC core breeding activities, plus project funding of another $4.5 million. We thus included a total of $17.7 million in total WGRF costs over the past 16 years[7], plus costs of about $500k/yr. for the other producer organizations from 1997 to the present.

- For barley, we estimated attribution by assuming: (1) only 20% attribution in 1986, but rising linearly to 100% by 1995, AND (2) in the cost stream we included WGRF funding for malt barley research as discussed above, PLUS roughly $100k/yr. from other producer organizations.

There are several unknowns (and these are probably unknowables) in this analysis, especially how crop diversification affects different soil types, and what crops were planted in the "additional acreage". For this crop, there were insufficient data to model lower and upper bounds. The model chosen strikes a balance between conservative and liberal assumptions, but on balance is probably conservative:

- Using net revenues per acre from 2001 may be slightly liberal, but is offset by any overestimates of revenues in earlier years being applied to smaller estimated amounts of "additional acreage", and it definitely underestimates revenues post-2001.
- Using the minimum net revenues per acre, per crop, across different soil types is almost certainly too conservative – higher value crops will be more likely to be planted in any given year and soil type.
- Modelling crops with negative net revenues per acre as having zero value is certainly too conservative – other crops would have been planted instead.
- Overall, the true net revenues over the period of impacts modelled (1990 – 2012) is likely close to the figures modelled:
  - Some fixed costs (e.g., machinery investment and depreciation, building investment and depreciation) might well increase when "additional acreage" was planted. However, many fixed costs are unlikely to increase as much (e.g., property taxes, insurance, and especially the single greatest fixed cost: land investment).

  - Overall, crop diversification has added roughly 40% to Saskatchewan's arable land by 2012. Over the five year period 2006-2010 Saskatchewan's gross farm income was nearly $6 billion. Assuming a profit margin of 10%8 implies net revenues of about $600 million, of which 40% is $240 million. In 2012 our model assumes net revenues of $170M - $350M, so certainly "in the ballpark".

- However, the analysis is still very conservative in the sense that – unlike in the other PBCA cases – we did not model any attributable impacts from ADF and SRP subsequent to 2012; i.e., we assume

[7] This is total funding for wheat and barley, and was expended in a ratio of roughly 2:3 for barley to wheat. However, since we are not estimating PBCA per crop, we simply added the entire amount to the cost stream.

[8] Averaging positive profit margins in the Crop Planning guide for 2012 produces a 14% profit margin. (We presume that crops with negative margins are not planted by most farmers.)

zero benefits from 2013 onwards. This reflects the fact that the diversification methods now being used are very well accepted, and producers might be now using them (even if at lower take-up) based on R&D done in other jurisdictions. This is likely a significant underestimate of the long term impact of ADF and SRP, but makes for more defensible modelling. (This tack was also taken for malt barley, described below.)

Non-quantitative benefits

Other benefits not modeled in PBCA include the greater productivity associated with improved soil quality arising from improved rotation patterns, risk reduction for farmers because there is a greater variety of crops that can now be planted (giving producers more options to pursue as crop prices fluctuate year to year), and very long-term maintenance of soil quantity and quality.

7.3.2 Malt Barley

Overview

There are two main types of barleys: feed barleys used in production of livestock, and malt barley used for human food, beer malting, and production of distilled beverages. Malt barleys typically sell for a price premium over feed barleys, but for a crop to be classified as malt barley it must conform to a very specific, narrowly defined set of characteristics. For beer production, for example, malt barley must provide highly consistent and predictable germination for malsters. This was difficult with barleys in which the seeds grew in six rows, since there was considerable variation in the size and properties of individual seeds.

The CDC developed a two-row variety, Harrington, in 1981 which marked a sea change in the agronomics, yield potential, disease resistance, and brewing characteristics of barley, to the point that more than 90% of malt barley grown in Saskatchewan came to be Harrington. Peak production of this variety was in 1991, being planted on about 4.7M acress across Western Canada. It has been estimated that over the last 30 years this one variety has been grown on 60M acres, yielding 68M tonnes, and with an estimated gross value of $15 billion[9].

Although this variety was released before ADF and SRP began, the CDC has continuously worked on updating the improving malt barley varieties (e.g., the Copeland and Kendall varieties, which have up to a 15% higher yield than Harrington, and to a lesser extent Meredith, but all of which are based on genetic characteristics of Harrington), and to provide knowledge and technology transfer to producers and malsters. Much of this was through operational funding from SMA, and the ADF and SRP programs were also considered to have had a significant impact on the early development of these key varieties (including that support from the SRP Chair for oats and barley encouraged industry to contribute to the breeding program - a “seal of approval” factor).

These varieties have also revolutionalized the way malting is done, with significant cost savings to malsters because of less time required in malting, and fewer batches that malt poorly since the new varieties ferment more consistently. Canada is considered to have been put “well ahead of the game” in this arena, and the CDC now has significant partnerships with major brewers in Canada and abroad such as Anheuser Busch and Sapporo.

[9] *Headline: Turning 40: Four decades after its formation, Saskatchewan’s Crop Development CDC continues to produce outstanding varieties for western Canadian farmers.* Brian Cross, Western Producer. (Provided by the CDC.)

Attribution to ADF and SRP is complex. The programs' support to CDC was essential in helping convince malsters (a very conservative industry) to take the risk to use Harrington and later varities developed by CDC. The CDC also used ADF program funding to develop new technologies such as micro-malters that reduced industry risks and increased yield. The SRP Chair's world-class laboratory allowed the Chair and CDC to become internationally known as a source of malt barley expertise, and without this reputation take-up by industry would have been markedly slower. We have made some conservative modeling assumptions below.

Quantitative benefits:

- Benefits were modeled overall as the difference in net revenues between malt and other barleys, multiplied by the estimated malt barley acreage grown in Saskatchewan.
- The difference in net revenues for malt vs. other barleys was derived from the SMA Crop Planner. As for the Crop Diversification case, there was insufficient information to assess variability in acreage sown by soil type, so the analysis again used a conservative value: only the minimum differences in values by soil type were modeled.
- The acres of barley harvested was taken from Saskatchewan barley production and value tables[10], which contain production information over the period 1986 – 2010.
    - These data do not distinguish between malt and feed barleys[11], and so the acreage was adjusted by the assumed malt percentage – increasing from 50% in 1986 of the total to 85% today[12].
    - Total net revenues were therefore (acreage harvested) x (assumed percentage malt barley) x (net revenues per acre) for each year. Net revenues for malt barley are not available in the Crop Planning guide in earlier years; the figures for 2012 were used.
    - Since the contribution of CDC through ADF and SRP is waning over time as newer varieties are further from Harrington, and since the commercial viability of future malt varieties is unknown, we have taken the conservative approach of only estimating benefits up through 2012; i.e., no future benefits are estimated.
- As for the Crop Diversification case, the lower bound is net of all variable costs plus 40% of fixed costs, while the upper bound is net of variable costs alone. For this case, the lower and upper bounds are identical, as the Crop Planner assumes that fixed costs for malt barleys and feed barleys are identical (and variable costs nearly so).
- Attribution was modelled at only 20% beginning in 1986 since some of the key malt barley varieties (e.g., AC Metcalfe) were not developed by CDC, but rising linearly to 100% by 1995[13]. To be even more conservative, core and project funding to CDC from WGRF have been included in the cost stream.

The estimates for malt barley are probably quite conservative overall: although 2012 net revenue figures will overestimate revenues in earlier years, no benefits have been modeled subsequent to 2010 (the last year for which figures are available), which is likely a notable underestimate of the impact of this research.

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[10] Source: http://www.agriculture.gov.sk.ca/agriculture_statistics/HBV5_Result.asp.

[11] The Canadian Wheat Board no longer collects varietal data.

[12] Based on key respondent data at the Canadian Wheat Board.

[13] A more conservative estimate post-1995 would be 80%, but in this case WGRF funding should not be included in the cost stream.

Qualitative benefits:

The new varieties absorbed water more quickly in the steeping process than older ones, saving maltsters up to a day in processing (say from five days down to four), and also produced more germinate more consistently for better mal quality and fewer rejected batches. In brewing it filters better and more quickly as well (possibly allowing up to one extra brew per day). These impacts can likely be quantified for Canadian malsters, but was not possible within this study's timeframe..

7.3.3 Pulses

Overview

The original intent of the Pulses case study was only to model lentils, but an attempt has been made to model impacts for pulses overall.

The case of lentils provides useful lessons, as they have enjoyed significant impacts from CDC's efforts to improve their agronomics. The native plants grew low to the ground, suffered from pests and pathogens partially because of the restricted air flow as a result, could not compete with high-growing weeds, were intolerant of herbicides to control those weeds, and were therefore difficult to harvest economically. In earlier years, this made lentils very much a marginal crop in Saskatchewan with insignificant acreage devoted to them, and little effort was made to find markets for this crop. A collaborative research program between the CDC and Saskatchewan Pulse Growers (which provided Check-off funding), with industry assistance through Nutragenesis, Clearfield, and BASF, produced lentil varieties adapated to Saskatchewan growing conditions. These had double the tolerance to herbicides (allowing additional spraying to deal with the weed problem), increased the size and height of the plant (allowing easier differentiation from weeds, better pest resistance, and making it faster and easier to harvest), and reduced the number of rocks picked up by the harvesters, all of which increased producer acceptance. Zero tillage methods also allowed producers to reduce costs. The CDC additionally promoted pulse crops such as lentils to Saskatchewan producers, and these are now tremendous export markets for the province (over 850,000 tons as of 2006/2007[14]).

For pulses overall, there were only perhaps fifty to a hundred thousand acres grown in Saskatchewan in the 1980s, while in 2011 it was at least five million acres. Lentils alone accounted for more than 2.3 million acres by 2009.

Quantitative impacts

Data problems prevented easy modeling of lentils alone. There are significant differences in net revenues by variety and these data are available, but data on varietal harvests are very difficult to obtain. In addition, the appropriate analysis would be to model the delta in net production value between lentils and the crops that were replaced, and this is difficult or impossible to determine. Overall, it was not felt that a defensible model could be developed.

However, an earlier analysis of returns to Saskatchewan pulse research in general (as sponsored by Saskatchewan Pulse Growers) was conducted in 2008[15]. It was possible to adapt their conclusions to fit the methods used in this study, as most of of the SPG research is done through the CDC and/or through the relevant SRP Chairs (two of whom work specifically on pulses):

[14] *Milestones in Food Legumes Research.* Eds. Masood Ali and Shiv Kumar. 2009, IIPR, pp. 58-72.

[15] *Op cit.*

- This study's Net Present Value (NPV) estimates were based on returns through 2025, which is very close to our 2024 end period for analysis. The Gray *et al* report used a 5% discount rate; this is not easily adjusted to other discount rates without having access to the detailed benefit and cost streams, but is one of the rates the present study team uses in the sensitivity analysis.
- The Gray *et al* study estimated a producer surplus of $682.5 million (2008 dollars) through 2025. It also estimated consumer surplus of $529.8 million and $483.0 million from value-added sectors.
  - The KPMG study allocated NPV impacts to SPG according to SPG's proportion of total funding[16]. (Some funding was also provided by industry directly.) This proportion was 67%, and we therefore extrapolated this (by a factor of 1/0.67) to total pulse impacts; i.e., including any additional funding through ADF, SRP, or any other sources.
  - The estimated SPG and other partner funding of $102.67 million (in 2008$) was included in the ADF and/or SRP cost streams, so this is appropriate; i.e., the PBCA model estimates the total benefits associated with all partners to the R&D.

- The lower and upper bounds in the present KPMG study were estimated as:
  - In the lower bound we only modelled the producer surplus.
  - In the upper bound we included producer surplus, the consumer surplus, and value-added figures. Consumer surplus values are always subject to differing interpretations, and we are not entirely certain of the degree to which the CDC, ADF, and SRP contributed to the value-added products (although they were likely quite important), and the Gray *et al* report notes that much of this work has yet to be commercialized[17].

Qualitative impacts

The use of pulses in crop rotation has been one of the key factors in the Crop Diversification impacts, allowing substantial improvements to soil quality and maintenance.

7.3.4 In-Field Winter Feeding Strategies Bale Process/Bale Graze on pasture

Overview

High winter feeding costs present a challenge to beef producers in Western Canada. Producers are looking for methods that are more cost and labour efficient. Producers use several management systems for wintering beef cows, with each system having a different impact upon the plant-animal-soil interface, as well as the sustainability of the operation. Least-cost production systems are essential when dealing with the economics associated with animal agriculture; however, agriculture has been criticized concerning negative impacts on the environment. The need for environmentally sensitive, low cost feeding systems is crucial.[18]

Bale grazing on fields is a method of providing feed to beef cattle during the winter months. With this system, livestock are allowed access to bales previously placed on a field or wintering site. This is opposed to cows being wintered in drylot pen systems where feed is hauled into pens and manure is hauled out.

[16] *Op cit.* Footnote to Table 1, p. 3.

[17] *Op cit.* Page 4.

[18] Low-cost Winter Feeding Systems for Cow-Calf Producers, ADF Final Report, Lardner et al, 2008.

The objectives of this SRP research program were to:

- Evaluate the effect of winter feeding systems on cow performance, apparent intake and reproductive efficiency
- Evaluate the efficiency of intensive and extensive cow-wintering systems for managing nutrients from beef cattle manure
- Evaluate subsequent crop response post-winter feeding
- Evaluate the economic differences (total cash and overhead costs) between wintering systems.

This research began in 2003/04 with trials in 2003, 2005, 2006 and continues with numerous extension activities. The scientific outputs resulting from this project will directly contribute to enhancing beef producers ability to lower operational costs.

The take-up rate for this feeding method are high. The Statistics Canada 2011 Census of Agriculture data indicate 81.5% of Sask beef farms reporting through the Census identify use of in-field winter grazing or feeding. The Saskatchewan Cattlemen's Association also confirmed high take-up rates of this feeding method.

Quantitative Benefits

Through economic analysis conducted as part of the research study it was determined that bale process on pasture and bale graze on pasture offer producers potential cost savings of $0.07/head/day savings and $0.05/head/day saving respectively. Costs for feed, labour, machinery and fossil fuels, both in the feeding of the bales and manure handling were considered in these estimates.

The number of cattle impacted by implementation of this feeding method was modelled by using:

- Statistics Canada Cattle Statistics for province of Saskatchewan from 2003 through 2012.
- The estimated number of beef cattle beyond 2012 was modelled to decrease by 0.09% per year to reflect the average decrease in number of beef cattle on Saskatchewan farms over the previous 10 years.
- Estimated take up rates based on diffusion of innovation theory over a 10 year period where take up were estimated by:
    - 2.5% innovators assumed being in place in advance of 2003 – the practice was noted to be surfacing in late 90s/early 2000, additionally, the practice is likely in place without being known as best practice. No savings were counted for Year 0.
    - 15% early adopters for three years (2004 -2006)
    - +33% early majority for three years – take up 48% (2007-2009)
    - +33% late majority for three years – take up 81% (2010 – 2012). Consistent with Statistics Canada data.
    - 2% increase/annum starting in 11th year to max take-up level of 92% in year 2018. Then level at 92% for future years.

- The modelled maximum take-up rate of 92% is conservative at year 2018 based on highest levels reported in Statistics Canada 2011 Census of Agriculture data, where 89% of Alberta cattle ranching and farming reporting through the Census identify use of in-field winter grazing or feeding currently.

The value of the cost savings to producers was modelled by:

- Savings per/head per/day were set at $0.06, based on average of bale process on pasture savings of $0.07/head/day and bale graze on pasture savings of $0.05/head/day. The model assumed producers employ an equal proportion of both strategies (i.e., 50% of producers bale process and 50% of producers bale graze).
- Bale process/bale graze is the most conservative cost savings estimated for in-field winter feeding. Other strategies researched (i.e., straw/chaff pile grazing) range from $0.59/head/day to $0.79/head/day.
- Winter feeding days were set conservatively at 120 (minimum December to March at 30 days/month). The Western Beef Development Centre Cost of Production survey participants average winter feeding period is 160 days (source: WBDC, 2010 Saskatchewan Cow-Calf Cost of Production Analysis, Kathy Larson, WBDC Economist). The Saskatchewan Cattlemen's Association noted a range of winter feeding days from 100-150. The winter feeding period for beef cattle (Bos taurus) in Western Canada is typically 200 days per year (Mathison, 1993), as cited in Lardner et al, Low-cost Winter Feeding Systems for Cow-Calf Producers, ADF Final Report, 2008.

Qualitative benefits

Other benefits not modelled in PBCA include the potential for increased capture and utilization of manure nutrients and the subsequent benefits to increased forage growth as well as reduced greenhouse gas emissions from reduced manure piles/packs and diesel burning

7.3.5 Backgrounding Strategies – Extending fall grazing for calves

Overview

The objective of this research was to evaluate different annual forages for their economics, production potential and use in low-cost backgrounding systems for calves. The research looked at alternative extended backgrounding of beef calves grazing swathed whole plant Golden German millet or Ranger barley and were then were compared to calves bunk fed in drylot pens. This research was conducted beginning in the winter 2007/08 and continued through the winter 2009/10.

The results of the research indicated that the targeted calf performance was achieved in field backgrounding systems with calves gaining 1.9 and 1.4 lb/day grazing either swathed barley or millet, respectively. Calves fed in drylot gained 1.7 lb/day. Finally, calves were evaluated during feedlot finishing. The method resulted in cost of gain in field grazing systems being 35% less than backgrounding calves in drylot pens. The calculated savings included reduced yardage and less manure hauling costs resulting in savings of $0.55 to $0.68 per head/per day (depending on crop).

The economic impact model was built using conservative assumptions on take up as this practice of field feeding calves is generally new and only been researched in last 5 years. Take up rates assumed to be quite slow due to producer hesitation, newness of research, and producer preference to house

calves "closer to home" and pen feed feeder calves. Additionally, existing empirical data on take-up levels was not available. The Saskatchewan Cattlemen's Association confirmed take-up levels are currently unknown indicating 5% currently at most.

Quantitative Benefits

The number of calves impacted by implementation of this feeding method was modelled by:

- Data on the number of calves on Saskatchewan farms, January 1 of each year beginning 2003 through 2012 were taken from Statistics Canada, *Cattle Statistics 2012 and 2009*.
- The number of calves beyond 2012 was modelled to increase by 0.92% per year to reflect average increase over previous 10 years.
- Take up of 2.5% was modelled in years 1-3, 5% in years 4-6, 10% in years 7- 9 and 15% in year 10.
- Maximum take up of 15% in 10 years was assumed due to more proven research required (estimate from Western Beef Development Centre).

The value of the cost savings to producers was modelled by:

- Savings per/head per/day were set at $0.68, based on the assumption that producers are more comfortable growing barley vs. other test crop of golden German millet ($.55/head/day).
- Field feeding will be done for a 90 day period (December 1 to March 1).

7.3.6 Ractopamine – Swine finishing

Overview

Ractopamine is a beta-adrenoceptor agonist which, when fed to pigs during finishing, redirects nutrients to encourage the growth of more protein and less fat. Overall its use allows producers to finish pigs more quickly, feed them less, and produce a leaner and more attractive carcass which sells for a premium. It is commercially available from Elanco Animal Health, a division of Ely Lilly and Company. Although ractopamine has been approved for use in swine intended for human consumption in over 20 countries, until recently its use was baned in Canada, and it is still not used in the EU, China, and Taiwan. The US approved its use about ten years ago, creating a market disadvantage for Canadian producers.

The Prairie Swine Centre (PSC) conducted the first studies of efficacny and human safety in Canada, and the results were used for Canadian registration of Paylean (ractopamine). The PSC showed that ractopmanine was effective even at dosages as low as 5 ppm/kg of feed, although other countries allow dosages of up to 20 ppm/kg in some circumstances. The initial work by PSC indicated net revenues to producers of $2 or more per pig marketed[19]. However, use of ractopmanie is only cost-effective if feed prices are high, but this has been true for last 10 years. Feed prices are currently at a record high,

[19] *Impact of Research on the Saskatchewan Pork Industry*. Prepared by Prairie Swine Centre for Agricultural Development Fund. December 16, 2011.

running about $120 per animal, where it was commonly $50-60 in the past, and nutrition is the single greatest cost in swine production, so any improvements here are very important. KPMG has modeled the anticipated effect of feed prices based on respondents' expert opinions (and using conservative assumptions that respondents agreed were reasonable.)

Ractopamine is only fed to pigs for a short time at the end of feed period, e.g., for 20-21 days in one of the last finisher diets. Use of Paylean increases the cost of the finisher diet from $285 without it, to $325/ton with Ractopamine added. Some cost is for the Ractopmaine itself, but some is required to increase the amount of protein, minerals, and vitamins used in the diet in order for the impacts to be obtained.

Use of the product tends to be restricted to larger operations which have both the cash flow to accept the higher finishing costs, and multi-phase, multi-barn, and highly managed feeding operations that make it easier to track how the animals are using the product. Conversely, smaller "Farrow to Finsh" operations using simple management and single-barn systems may not have the capability to ensure the correct animals are fed the product properly. (Most producers in Saskatchewan are large operations.)

Quantitative benefits

- Benefits were modelled overall as the number of pigs marketed per year in Saskatchewan, times the estimated net increase in revenues per pig, over the estimated time over which Ractopamine is expected to be used.
- There are good data available on net impacts per pig – at least $2/head. Several industry respondents (from Sask Pork, and veterinarians) suggested this is conservative, and savings often $3 to $4/pig, and even up to $5 in exceptional circumstances.
- We modelled about ~1.6M pigs marketed per year[20]
- Use of Ractopamine in Saskatchewan and Canada began ~2006. We modelled a linear take-up increasing to 75% in 2012. (Respondents said up to 95%, but some markets such as China do not allow Ractopamine to be used, and some Saskatchewan producers serve this or other specialty markets such as organic production.)
- Upper bound assumed $4 net savings, R. to be used another 10 years (i.e., until 2022), but only every other year in years 6 – 10 to account for possible drop in feed prices.
- In addition to the testing costs borne by PSC, there were costs for Eli Lilly, the industry manufacturer of Ractopamine; however, we were not able to obtain data on any Canadian portion of these costs.
- The lower and upper bounds were modelled as:
  - Lower bound – net savings assumed to be $2/pig, with Ractopamine to be used for another five years (i.e., until 2017). Respondents indicated these were very safe assumptions.

[20] *Hog Statistics at a Glance Canada for the week ending December 31, 2011*. Agriculture and Agri-Food Canada. Data for Saskatchewan in 2010 used (figures in 2011 are slightly higher).

- Upper bound – net savings assumed to be $4/pig, with product to be used for another 10 years (e.g., until 2022). To account for a possible drop in feed prices, we modelled the use of Ractopamine only every other year from 2018 through 2022).

The main unknown in modeling these impacts is for how long into the future to assume Ractopamine continues to be used, and in how many years feed prices are high enough to make it use economically valuable. On the first point, no other similar work on growth hormones for pigs is currentlybeing done, and respondents considered new products were unlikely to be approved even if there were, so our modeling for another 10 years is probably conservative. On the latter point, this is simply unknown, although feed prices have been consistently high for the past 10 years, stopping the model after 10 years takes into account a possible drop in prices. We have also not modeled any possible increase in Saskatchewan pig production. Overall, then, the model is probably quite conservative.

Qualitative benefits

The PSC work has allowed swine producers in other Canadian regions to use Ractopmamine as well, increasing the competitiveness of Canadian producers oveall. Respondents indicated take-up is roughly 50% in Alberta, Manitoba, and Ontario, and up to 80% in Québec. Although not shown in the PBCA results in section 7, these represent additional Canadian impacts (discounted, deflated, over the same time frames) of from $140 million to $290 million.

7.3.7 Quantum Genetics – Leptin Gene Test

Overview

Typically, feedlot production is an in-out process: A group of animals is put in a pen for approximately 150 days, and then slaughtered based on when the average animal in the pen is ready for market. However, there is a large degree of variation in the time they are actually ready. In industry studies, roughly half the animals in North America coming out of feedlots are either underfed or overfed, which means that many of the animals do not reach their potential.[21]

Research into leptin gene variants supported by ADF funding was initiated approximately 10 years ago. The objective of the research was to identify genotype in animals that indicated more or less fat deposition and through this developed the leptin gene variant test. This technology was subsequently licensed out by the University of Saskatchewan and Quantum Genetics, based in Saskatoon, was created based on the technology.

Quantum Genetics has built a whole genetics company around this technology. It provides testing services across Western Canada and into the US and the leptin gene variant test has been built into an animal management services system.

The tool uses DNA testing and genotyping to help producers and feedlot operators distinguish between genetic variations in beef cattle that are related to growth and fat profiles. These profiles tell feedlot operators the best feeding schedules for the animals. They also tell feedlot operators when the animal has reached the targeted body fat profile. This prevents feedlot operators from spending additional money keeping the animal on the feedlot unnecessarily and allows them to process more cattle quickly - and more profitably. It also helps feedlot operators and producers capture premiums for their product for attributes like marbling and tenderness.

[21] Ag-West Bio-Bulletin August 2010

Quantitative benefits:

The scientific outputs resulting from this research directly contribute to enhancing the ability of producers and feedlot operators to increase feeding efficiencies.

The number of cattle impacted by implementation of this test method was modelled by:

- Number of cattle on feeding operations based on Cattle inventory from Statistics Canada.
- Does not include individual producer samples – even though there are sales in this area, they are proportionally much smaller.
- Used average 9 year trend of cattle on feeding operations to model estimates from 2012 to 2018.
- Volume of cattle calculated on annual number of single tests sold. Based on actual and projected sales provided by Quantum Genetics.
- Company sales are currently 50% in Canada and 50% in the U.S. The model uses 50% of feedlot sample tests sold/year based on Canadian proportion of feedlot sample tests in 2011. Assumed proportions of Canadian vs. US tests sold were assumed to stay the same over the modeled period.
- Increased use of tests on feeding operations to reach maximum of 50% of Canadian cattle on feeding operations in five years (following 2013 projections) based on Quantum Genetics sales estimates.
- Quantum Genetics could not provide split of sales in Saskatchewan vs. other western provinces so assumed proportion of impact to Saskatchewan would equal provincial proportion of feeding operations in western provinces. .

The value of the cost savings to feedlot operators was modelled by:

- Quantum Genetics estimate of $20/head improved carcass value based on appropriate feeding strategies.

Qualitative benefits

Other benefits not modeled in PBCA include sales revenue of Quantum Genetics, feedlot operators administration of less expensive beta-agonist (growth stimulation technologies), grid pricing premiums of $5-$40/head depending on how cattle are sorted to and demanded by packing plants and there has been eight full-time jobs created at Quantum Genetics since inception.

Other intangible benefits not modelled could include improved business reputation, and increased market penetration for industry.

7.4 PBCA Results and Interpretation

7.4.1 Overall findings

Table 1 summarizes the findings from the PBCA component of this study, based only on the seven quantified “high impact” cases discussed in section 7.3.

Table 1: Net Present Value and Benefit:Cost Ratio from PBCA Cases

	Lower Bound ($million, 2008$)				Upper Bound ($million, 2008$)		
Discount rate	*2%*	*5%*	*8%*		*2%*	*5%*	*8%*
Net benefits in "high impact" cases	9,232	11,492	14,739		13,939	16,765	20,806
Program costs (1987-2011)	555.3	747.2	1,057.0		555.3	747.2	1,057.0
Net Present Value	***8,676.8***	***10,745.1***	***13,681.8***		***13,381.3***	***16,017.9***	***19,749.2***
Benefit-Cost Ratio	***16.62***	***15.38***	***13.34***		***25.10***	***22.44***	***19.68***

Overall, the ADF and SRP have returned benefits of at least $9 billion to $20 billion (in 2008 dollars) to the Saskatchewan economy, net of all government and private sector R&D costs. Further, the benefit:cost ratios seen in Table 1 are at the very top end of results from other studies seen in the Canadian and international literature on ag/ag-food R&D, as seen in section 5.2. Although some assumptions have been made that are almost certainly too optimistic, there are many countervailing conservative assumptions, as explained in the detailed case study discussions in section 7.3. The reader should especially remember that not all important impacts have been (or ever will be) quantified. If other significant benefits were able to be quantified, of course the NPV and B/C figures would only increase.

- The upper bound B/C ratio of ~20:1 to 25:1 is exceptionally high, but likely represents the unusual situation afforded by the Crop Diversification R&D, which increased SK's usable farmland by about 40%. (Probably this was a "one-time-only" opportunity.)
- The results vary considerably depending on lower *vs.* upper bound assumptions, and by discount rate used. However, this variability is entirely normal in PBCA studies, but points out the inherent uncertainties involved.
    - This uncertainty is especially true regarding future take-up of the R&D finding, and points out the importance of activities related to dissemination, translation, knowledge transfer, etc.

In PBCA of most S&T programs, higher discount rates lead to lower NPVs because most costs are typically in the early years, while most benefits are in later years. KPMG recommends using the figures associated with the 5% discount rate as this reflects the cirucumstance of most R&D programs in terms of considering the cost vs. benefit timeline. The ADF and SRP are typical in that higher discount rates lead to lower B/C ratios.

7.4.2 Findings by case study

Table 2 shows the benefits by individual "high impact" PBCA case investigated. We have chosen to list Crop Diversification first in Table 2 because we believe the impacts have almost certainly been understimated.

Table 2: Benefits by PBCA case

	Lower Bound ($million, current $)				Upper Bound ($mllion, current $)		
Discount rate	*2%*	*5%*	*8%*		*2%*	*5%*	*8%*
- Crop diversification	2,430	2,769	3,231		5,376	6,124	7,148
- Malt barley	4,733	6,125	8,105		4,733	6,125	8,105
- Pulses	1,017	1,017	1,017		2,527	2,527	2,527
- Cows - winter feeding	77	70	63		111	93	80
- Calves - fall grazing	32	25	20		66	47	34
- Ractopamine	24	22	20		56	49	44
- Leptin	6	5	4		6	5	4

The distribution of benefits by case is quite unequal, but is by no means unusual in PBCA. In fact, this common situation is the underlying reason for focusing only on "high impact" cases in the first place.

- Although it is clear that crops R&D represents the most easily quantifiable impacts, soil and environment work is likely at least equally important as represented by the large variety of impacts represented in the Crop Diversification case (e.g., SEHAC R&D underpins much of the Crop Diversification R&D, and many of the impacts are related to very long-term maintenance of soil quality and quantity).
- The Crop Diversification case alone represents about a quarter of the net benefits in the Lower Bound, using a discount rate of 5%, and the benefits of this case are almost certainly substantially underestimated, especially remembering that these impacts were only modelled through 2012.
- Since this case is so unusual, challenging to quantify, and likely unrepresentative of future opportunities for truly large single impacts arising from these programs, a sensitivity analysis shows the effect of removing this case from the analysis. The results are found in Table 3.

Table 3: Sensititvity Analysis – No Benefits from Crop Diversification

	Lower Bound ($million, 2008$)				Upper Bound ($million, 2008$)		
Discount rate	*2%*	*5%*	*8%*		*2%*	*5%*	*8%*
Net benefits in "high impact" cases	5,562	6,933	8,898		6,668	8,104	9,963
Program costs (1987-2011)	555.3	747.2	1,057.0		555.3	747.2	1,057.0
Net Present Value	*5,006.3*	*6,185.9*	*7,841.2*		*6,112,7*	*7,267.1*	*8,905.6*
Benefit-Cost Ratio	*10.01*	*9.28*	*8.42*		*12.01*	*10.73*	*9.43*

The resulting B/C ratios of 9:1 to 11:1 are more typical of the mid-range seen in similar ag./ag-food R&D programs. This suggests that, through responses to more typical research opportunities (i.e., other than Crop Diversification), ADF and SRP have been highly successful in identifying key opportunities, and researching and applying leading-edge findings in the field.

8. Implications Regarding Gaps in Programming

8.1 Overview

Overall, the study team did not identify many gaps in the design and delivery of ADF and SRP. However, there are some opportunities for improvements, one being potentially quite significant, and the others being more minor. The data come from several sources: key informants, the comparative review, and the PBCA findings. Two different types of gaps were identified: gaps in the sector and/or value chain needs, and gaps in program design and delivery.

8.2 Gaps in sector or value chain needs

Key stakeholders did not provide a consensus view of specific sector needs that were not being addressed, so their input is somewhat difficult to interpret (and often seemed clearly tied to "their" sector). Some points of interest:

- Respondents alluded to the need for an increased focus for SRP and ADF to identified priority areas for agriculture and agri-food areas through the involvement of, and balance between, government and industry input at the least, and many also mentioned academic input.
  - The study team notes that this is certainly attempted by SMA through a variety of mechanisms, but as noted earlier the current system is complex and cumbersome.
- There needs to be a more balanced approach to addressing the needs of the entire supply and value chain, as well as needs of ultimate consumers, not just primary production.
- There is a need for more technology transfer and demonstration projects, "interpretation research".
  - The study team notes that there are other mechanisms for this (e.g., the ADOPT program) that were not investigated in this study.

The PBCA findings in section 7 tend to support these opinions, in that they show primary production in the crops area, with associated impacts within the soils and environment area (especially in the Crop Diversification case) has provided by far the most concrete economic impacts that can be investigated through PBCA. By implication, the livestock area and the value-added and processing areas are not currently providing as many impacts: This is the most important apparent gap in programming.

Regarding livestock, over the five year period 2006 – 2010 the gross returns to Saskatchewan from crops and livestock were about $7,604 million:

- Crops: $5,964 million, or 78% of the total
- Livestock: $1,640 million, or 22% of the total

The pattern of spending within ADF is roughly similar to this over 1999 – 2011, with:

- Crops receiving about $88.7 million, or 73% of the total; and
- Livestock (including forage) receiving about $32.7 million, or 27% of the total.
- The pattern in terms of numbers of individual ADF projects is similar as well.

On the face of it, then, the livestock area does not appear to be suffering from simple lack of funding, which raises the questions:

- Is the livestock R&D simply not performing well? This might be because the research itself is not very successful, or there has been insufficient investment in this sector, or the research projects are performing well but are not targeted at the most important targets, or there is insufficient take-up of important research results by industry (e.g., due to poor technology or knowledge transfer, economic or receptor barriers not being addressed), etc.
- Or is the livestock area simply not able to benefit as much from R&D as the crops area? This may be for positive reasons; e.g., because it is already highly effective and efficient, or is already using the highest technology products and processes. Or it may be for negative reasons; e.g., the sector is unable to identify areas where science can provide significant impacts, or production and processing problems are so complex that research to date has been unable to identify ways to solve them.
- Or is the PBCA technique unable to identify appropriate "high impact" projects which should have been investigated, but were not? Appendix C shows that although some projects in this sector were identified in the PBCA "long list", they were few in number relative to those in crops. It is unclear if this is because there simply weren't many to identify, or our early respondents from SMA and SRP during the PBCA case study screening process were not able to identify key impacts.

Value-added and processing

Data for funding for value-added and processing projects within ADF projects are not easily available, so the study team cannot comment on the relative proportion of funding targeted to these topics, but we note that several key stakeholders pointed to these areas as a potential weaknesses, and virtually no cases were identified in the PBCA "long list" (and none in the "short list") that are related to these areas (see appendix C).

The SRP Chairs

Most of the areas investigated as important PBCA cases were initiated and maintained by SRP Chairs, sometimes without their being obvious potential for benefits in their early years (e.g., lentils). It is notable that within the top 25 researchers identified by level of ADF funding received over the years, nine of the current 15 Chairs appear in the list. This represent 60% of the current Chairs. (One previous Chair also appears, which would bring this figure to 66%.) Most of these Chairs are from the crops area, but there is also one within each of the other focus areas (i.e., Livestock, Food & Bioproducts, Soils). Within the list of the top 25 researchers by ADF funding also appear the heads of the Crop Development Centre, the Prairie Swine Centre, and the Vaccine and Infectious Disease Organization, indicating the very active research presence of these individuals, whose duties in some regards are similar to those of Chairs.

However, the study team is unable to comment on the importance of specific sectors addressed by the SRP Chairs, or on the performance of Chairs within those sectors. To do so would require a detailed analysis of each Chair's Framework Agreement with SMA, their performance against expectations, the quality and quantity of research publications, degree of training of highly qualified personnel, impact on the reputation of Saskatchewan science, attraction of top-flight PhD and postdoctoral fellows, and attraction of companies and resources to Saskatchewan. All of these were beyond our remit, and we note that SMA conducts a detailed annual review of each Chair's performance as part of the accountability requirements found in the contracts with the University and each Chair.

8.3 Gaps in design and delivery

Potential gaps in design and delivery were identified through two data sources: the key stakeholders, and the comparative review (see section 6). Key findings included:

- Key stakeholders commented that a long-term strategic vision is required. But they noted that to have a more balanced and integrated approach to priority setting implies that this is not done by SMA alone. Especially if thinking about the entire supply or value chain, this should be done with input from other ministries such as Environment, Economy, Transportation, Health, etc. Priorities need to be set at this system level in order to engage all relevant players.
  - As noted in section 6, there is not currently a good mechanism for linking SMA priorities, including those of ADF and SRP, to broader ones within Saskatchewan or Canada as a whole. The study team[22] would further note that this lack of coordination is quite common within sector-specific R&D programs, so SMA cannot be unduly faulted. However, deliberately investigating such linkages might provide benefits through identification of unexpected collaborations, partnerships, and resources.
- Stakeholders commented that there is a need for longer-term research funding. ADF projects are fairly short in length and even within the SRP program the challenge becomes maintenance of research program: e.g., attraction of PhD and post doctoral students, or maintenance of long-term research resources such as lands set aside for research.
  - The study team notes that although ADF is response-driven and project-specific, it has been used by researchers within the University of Saskatchewan and other organizations such as VIDO, PAMI, etc. (and especially by the SRP Chairs) to effectively support research programs (as opposed to individual projects) that in some cases have lasted for many years or even decades, so to a considerable degree this problem has been mitigated.
  - Nonetheless, the study team believes that there is room for a mechanism that more explicitly addresses strategic sector priorities. This might be done, for example, by setting aside a portion of the ADF funding for targeted Requests for Applications that are identified in advance, or for Flagship initiatives (perhaps cross-cutting several sectors, or even several ministries). To identify such priorities some form of Foresight exercise might be used.
  - Further, the study team notes that not having such a targeted RFA mechanism is relatively unusual. Even though the strategic element is partially addressed through the SRP, that program focuses more on human capacity development. Further several stakeholders commented that there is some silo mentality right now, with researchers seeing each other as competitors. While this is a reality in any proposal-driven research funding mechanism, broader-based strategic components could foster collaboration between groups and individuals.

[22] Our study team members have been involved in over 100 studies of R&D initiatives.

9. Conclusions

The economic impacts of these two programs have been profound, and fully justfiy the province's investments in agricultural and ag-food R&D.

Overall, the ADF and SRP are fully in line with both Canadian and international government policy rationales regarding how best to use R&D to serve both the public good and the private sector within the agricultural and ag-food areas. These rationales are mainly based on the need to correct market failures, in which the private sector cannot or will not commit sufficient resources into scientific and engineering endeavours to solve critical problems, for example because of limited funds being available or because intellectual property rights and economic benefits cannot be appropriated by individual firms. Through these programs, which contain both horizontal and vertical linkages among key players, the SMA also helps catalyze important R&D initiatives, avoids duplication, and creates collaborations and synergies.

The programs have had a substantial impact on the economic performance of Saskatchewan's primary production in the crops sector. Many individual crops have been improved through intensive long-term breeding programs in terms of yield, net value, resistance to pests and pathogens, and market acceptance. In some cases crops of little apparent value (e.g., lentils) have been transformed into major export products for the Province, or crops with higher potential for value-added have been developed to the point where producers have taken them up instead of staying with traditional crops (e.g., canola sometimes substituting for wheat). Of greatest significance is crop diversification: the number of crops, the number of varietals within those crops, the tailoring of crops to Saskatchewan's growing conditions, the methods of rotating these crops, and the machinery used to seed and harvest them, have all been dramatically improved through these programs. The net result has been a 40% increase in the total land now seeded and harvested in the Province, along with new methods being developed to ensure the long-term quantity and health of the underlying soil resource. There have also been improvements to the methods used in the beef, swine, and poultry sectors, although impacts here have not been as substantial.

Net of all R&D costs, the benefits to Saskatchewan will be at leaset $9 billion to $20 billion (in 2008 dollars, depending on assumptionss) over the period 1986 through 2025 (with some impacts modeled into the future), depending on the exact assumptions used. The ratio of net benefits to costs is from 13:1 to 25:1, again depending on assumptions. These B/C figures are at the top end of results from similar programs world-wide, as assessed by other investigators. Even if the singular case of Crop Diversification is eliminated from the analysis, the benefit:cost ratios are from 8.4:1 to 12:1, again from the mid- to top rank of similar programs.

There are few weaknesses apparent. The only major one, at least based on PBCA, is that the livestock/forage area does not appear to be performing as well as the crops/environment areas in terms of translating R&D into practical economic impacts, although the reasons for this are unknown. A perhaps more minor sector-based weakness is that few substantial economic impacts in processing or value-added areas were found, although the potential here is equally unknown. We note, however, that the study design was not primarily focused on sector strengths and weaknesses, nor on the performance of individual SRP Chair sectors, and these PBCA findings simply point at issues that should be investigated (e.g., Are these sectors actually performing poorly? Or are their benefits too difficult to quantify for PBCA? Or has there been insufficient investment in these areas to provide high economic returns? etc.).

Other more minor issues are related to program design and delivery, in which there is: (1) scope for development of more strategic initiatives, either as a component of ADF or separate from it (e.g., in cross-sectoral or cross-Ministry flagship programs); and (2) opportunity for more high-level strategic alignment with Provincial and national R&D strategies. There may also be room to simplify and streamline the application, review, approval, and funding processes, although the current system has significant advantages in terms of the ability to interact with respondents, and has been recently re-designed in response to stakeholder feedback.

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Appendix B: Key Stakeholder Interviews

1. Dr. Ernie Barber, Professor and Dean, College of Engineering, University of Saskatchewan
2. Dr. Graham Scoles, Associate Dean, Research and Graduate Studies, College of Agriculture and Bioresources, University of Saskatchewan
3. Dr. Mary Buhr, Dean and Professor, College of Agriculture and Bioresources, University of Saskatchewan
4. Dr. Paul McCaughey, Science Director - Bioproducts Platforms & Genomics, Agriculture and Agri-Food Canada
5. Dr. Sue Abrams, Acting Director-General, National Research Council
6. Dr. Faouzi Bekkaoui, Executive Director, Wheat Improvement Flagship Program, National Research Council
7. Jerome Konecsni, Chief Executive Officer, Innovation Saskatchewan
8. Garth Patterson, Executive Director, Western Grains Research Foundation
9. Dwayne Anderson, Chair, Saskatchewan Oat Development Commission
10. Carl Potts, Executive Director, Saskatchewan Pulse Growers (with Crystal Chan).
11. Ryan Sommerfeld, Chair, Research Committee, Saskatchewan Cattlemen's Association
12. Andrea Brocklebank, Research Manager, Canadian Cattlemen's Association
13. Dr. Reynold Bergen, Science Director, Beef Cattle Research Council, Canadian Cattlemen's Association
14. Pat Flaten, Research Manager, Saskatchewan Canola Development Commission
15. Linda Braun, Executive Director, Saskatchewan Flax Development Commission
16. Janice Bruynooghe, Executive Director, Saskatchewan Forage Council
17. Dan Prefontaine, President, Saskatchewan Food Industry Development Centre Inc.
18. Murad Al-Katib, President and Chief Executive Officer, Alliance Grain Traders Inc.
19. Mark Pickard, President, InfraReady Products (1998) Ltd.
20. Jack Grushcow, Founder, President and CEO, Linnaeus Plant Sciences Inc.
21. Rex Newkirk, Director, Research and Business Development, Canadian International Grains Institute

22. Todd L. Lahti, President & CEO, MCN BioProducts Inc.

23. Tim Oleksyn, Member, Agriculture Development Fund Advisory Committee, Chair, Strategic Advisory Committee, Western Beef Development Centre

24. Joe Kleinsasser, Member, Agriculture Development Fund Advisory Committee, Former Chair, SaskPork

25. Tom Hewson, Member, Agriculture Development Fund Advisory Committee, Director, Western Barley Growers Association

26. Jack Hextall, Member, Agriculture Development Fund Advisory Committee, Past Chair, Saskatchewan Cattlemen's Association

27. Cherilyn Nagel, Member, Agriculture Development Fund Advisory Committee, Past President, Western Canadian Wheat Growers Association

28. Bill Copeland, Member, Agriculture Development Fund Advisory Committee, Pioneer in commercial lentil production in Saskatchewan

29. Dr. Wilf Keller, President and CEO, Ag-West BIO

30. Reno Pontarollo,Chief Scientific Officer, Genome Prairie

31. Nithi Govindasamy, Associate Deputy Minister, Saskatchewan Ministry of Agriculture

32. Doug Billett, Director, Crops Branch, Member, Agriculture Development Fund Advisory Committee, Saskatchewan Ministry of Agriculture

33. Lee Auten, Director, Regional Services Branch, Saskatchewan Ministry of Agriculture

34. Jonathan Greuel, Assistant Director, Policy Branch, Saskatchewan Ministry of Agriculture

35. Grant Zalinko, Cattle Analyst, Saskatchewan Ministry of Agriculture

Appendix C: Potential Candidates for PBCA Case Studies

Initial PBCA Candidate project list

Last Name	First Name	Position	Category
Reaney	Martin	Chair	Lipid Quality and Utilization
Nickerson	Michael	Chair	Protein Quality and Utilization
Lardner	Bart	Chair	Cow-Calf and Forage Systems
Yu	Peiqiang	Chair	Feed Research and Development
Schoenau	Jeff	Chair	Soil Nutrient Mgmt.
Niu	Catherine	ADF PI	Ethanol Dehydration With Canola Meal
Laarveld	Bernard	ADF PI	Novel Nutraceutical Feed Products
Stilling	Denise	ADF PI	Saskatchewan Fibre, Biodegradable, Mouldable Product Industry
Tabil	Lope	ADF PI	Flax-Based Biocomposites
Hill	Gordon	ADF PI	Bioethanol
Romo	Jim	ADF PI	Forage Production
Penner	Gregory	ADF PI	Forages used in swathgrazing or greenfeed systems
Chibbar	Ravi	ADF PI	Pulses (Lentils) and Barley
Rowland	Gordon	Past-Chair	Flax
Keller	Wilf	ADF PI	Flax
McCartney	Curt	ADF PI	Oat
Coulman	Bruce	ADF PI	Oat
Bunyamin	Taran	ADF PI	Pulses (Chickpeas)
Classen	Henry	ADF PI	Livestock
Zulstra	Ruurd	ADF PI	Prairie Swine Centre, Livestock & Forages
Predicala	Bernardo	ADF PI	Prairie Swine Centre, Livestock & Forages
Patience	John	ADF PI	Prairie Swine Centre, Livestock & Forages
Agblor	Kofi	Director	Crop Development Centre
Banniza	Sabine	Chair	Pulse Crop Pathology
Warkentin	Tom	Chair	Field Pea Breeding and Genetics
Pozniak	Curtis	Chair	Durum and High-Yield Wheat
Rossnagel	Brian	Retired	Barley and Oat Breeding
Beattie	Aaron	Chair	Barley and Oat Breeding
Hucl	Pierre	Chair	CWRS Wheat, Specialty Wheats
Vendenberg	Albert	ADF PI	Crop Development Centre
Potter	Andrew	CEO r	VIDO (Vaccine and Infectious Disease Organization)

Prarie Swine Centre
PAMI (Prairie Agricultural Machinery Institute)
Western Grain Research Foundation

Appendix D: Introductory Note to PBCA Candidate Investigators, Criteria for PBCA Case Selection, and PBCA Template

Introductory Note:

Evaluation of SRP and ADF

The Saskatchewan Ministry of Agriculture's Research Branch has recently embarked on a very important evaluation of the Strategic Research Program and the Agriculture Development Fund. This evaluation study focuses on performing benefit/cost analysis to estimate economic returns of ADF and SRP expenditures; and researching the policy rationale for public sector intervention in support of agricultural R&D. The Saskatchewan Ministry of Agriculture (SMA) has engaged KPMG LLP (KPMG) to undertake this evaluation and the project is just starting to get underway.

This email is to let you know that you may be contacted directly by KPMG and asked for further details about your research projects. As part of the benefit/cost component of the evaluation, KPMG is in the process of identifying potential research projects or themes of research projects that may lend themselves to case study.

Preliminary interviews with SMA Program Managers, and a preliminary review of SMA program data, have resulted in the identification of a few key areas of interest. However, KPMG would like to obtain further details from key individuals to help in the identification of projects, or thematic groupings of projects, that have had high impacts (i.e., quantifiable dollar benefits, impacts on program/policy design, and/or highly significant public good benefits). The potential demand on your time will be limited to a 20-30 minute telephone interview.

Should you have any questions about this study, please do not hesitate to contact me at (306)787-5960 or Abdul.Jalil@gov.sk.ca , Sid Friesen, (306) 787-9768 or sidney.friesen@gov.sk.ca ,
or Karen Croteau from KPMG, at 613-212-2899 or kcroteau@kpmg.ca.

We appreciate your participation in this very important initiative.

Best regards,

Lori Marinos (for) Abdul Jalil
Executive Management Assistant
Saskatchewan Ministry of Agriculture
Agriculture Research Branch
Room 329, 3085 Albert Street REGINA SK S4S 0B1
Tel: (306) 787-6566
Fax: (306) 787-2654
email: lori.marinos@gov.sk.ca

Criteria for ADF/SRF Case Study Selection of "Big Winner" Thematic Groupings of High Impact Projects

Introduction: KPMG is working with the Saskatchewan Ministry of Agriculture to identify the economic impacts of the Agriculture Development Program (ADF) and Strategic Research Program (SRP). The approach we are taking is to use partial benefit-cost analysis (PBCA).

In PBCA, our first step is to identify a list of "big winner" research funded (at least in part) by ADF and/or SRP, that program officials and researchers believe has had the most significant economic impacts. We will then investigate the suitability of each of these candidates for PBCA, and select a "short list" of cases for detailed economic impact analysis.

We are asking your help in thinking about ADF and SRP research that has had especially important impacts for producers, processors, government, and other end-users. The notes below discuss the types of impacts and research we are interested in, and is to be used along with the "template" to help us identify a manageable number of research projects/themes to study.

A.1 Identifying Suitable Projects

Introduction*.** The intent is to identify ***a small number of very high impact ("big winner") R&D projects/themes suitable for PBCA. These are thematic groupings of projects that have had impacts which are:

- Very high for Canadian users in the production, processing, and/or distribution side of ag and ag-food;
- Possible to quantify in some way – and even more important, you believe they can be quantified in dollar terms; and
- Incremental and attributable, at least in part, to ADF/SRP (e.g., the impacts would likely not be as large, or would not have occurred as soon, or would not have as great a reach, if the ADF/SRP work had not been done, or the external grant had not been made). Other funding (e.g., from producer groups, industry, AAFC, NSERC, NRC) may also have been involved, so long as ADF/SRP support was very important in the research process.

Usually there are groups of individual related R&D projects. We don't need to identify the impacts of each individual project – it is much more useful for us to study groups of related projects as a whole; i.e., by ***THEME***. It is MUCH BETTER to give us detailed information on 1-2 projects/themes which you think are true "big winners" (in the PBCA sense), than a huge amount of generic information on every project you have worked on since 1986.

We care about the ***PRACTICAL OUTCOMES and IMPACTS*** of the R&D, not the CONDUCT or INTENT of the R&D – so the more information you can give us on how the R&D was actually used by producers, processors, etc., the better.

Type of project/theme. It is often the case in ag/ag-food R&D that findings from a series of projects on a given topic combine to provide the ultimate impact for end-users. For example, there may be multiple projects investigating cereal breeding and genomics, which together are intended to develop a new cultivar with higher yield through faster growth. In such a situation, we would investigate the impacts of all these projects together as a theme. In other cases, there are multiple kinds of research which,

combined, form a large and synergistic impact. For example, wheat yield may be increased through a combination of better cultivars, improved tilling methods, and better rust resistance. We may also address these together as a large-scale theme. For the moment, do not worry about exactly how much each kind of R&D has made to the improvement, just discuss how each line of research has contributed.

Timeframe. The most useful high impact projects are those in which the innovations are already in active use or are expected in the very near future, simply because it's easier to assign a defensible dollar value to them. It may be that some applications are still in the early stages of take-up – if the innovation looks really significant and it is possible to model future take-up, these may be suitable for PBCA. But impacts which may be very important, but which won't happen for years to come (or may not happen at all), are much more difficult for us to study.

- Usually, work done in the past 5 – 10 years is the most useful for us: enough time for impacts to happen, but not so long that everyone's forgotten what happened.
- Going far back in time (e.g., to 1986, when these programs began) is good in the sense that there's more chance of practical impacts being in existence, but may be impossible to study in that it may be very difficult to find anyone who remembers the R&D – if you identify some of this older research, think about the practical difficulties on getting information on them.

A.2 Nature of Innovations and Impacts

Essentially, we are interested in any "big winner" impact for Canadians, so long as it can be quantified in dollar terms, and some examples are discussed below. Although most of these may reflect impacts for producers and processors, there may be other impacts relevant to the general public, government organizations, the environment, etc.

In ag/ag-food R&D, end-user impacts are often very important. An innovation which creates only a small benefit for the organization commercializing it, but creates large benefits for the purchasers or ultimate users of the technologies may be of great interest, since PBCA will dollarize these end-user impacts. For example, the value of increased production arising from using better feeds or cultivars will usually be far greater than the sales revenues of the feeds or cultivars themselves. These end-user impacts tend to be common in situations without IP protection.

Industrial innovations. Industrial innovations are obviously of interest, since it is usually easy to dollarize the impacts for producers and processors in terms of:

- Sales revenues from new/improved products or services; and/or
- Improved productivity from using the new products or services; and/or
- Cost savings from new/improved processes

Protected/non-protected IP. For our purposes, it does not matter much whether the IP has been protected. In fact, non-protected IP often has impacts as high, or higher, than protected IP:

- In situations where there has been no IP protection, economic returns are maximized by making the outputs freely available to growers or processors. Examples include new varieties of seeds that have little/no intellectual property protection (e.g., wheat or pulses), or dissemination of best practices (e.g., on fertilization, seeding practices, pest control) to the entire industry. These can be very important for PBCA because so many producers and/or processors benefit.

- Innovations with high private sector participation and direct IP protection and commercialization (e.g., development, licensing, and sale of new crop varieties incorporating patented genetic modifications, such as for canola) will generate sales revenues for the seed companies, and productivity improvements for producers. These are usually somewhat easier for us to study in PBCA, but the returns may be lower because fewer companies benefit.

Market maintenance. The net result of some R&D may be that Saskatchewan maintains national and international competitiveness; i.e., the Province would have lost significant market share in some sectors without the ability to apply research findings from the ADF or SRP programs. These effects can be very important, but tend to be difficult to study if the impacts are very diffuse.

However, if a very concrete set of research projects can be clearly shown to have had an explicit impact in a very specific situation, then this is of great interest to PBCA. An example is one where international concerns about quality issues in a specific food product might have resulted in a trade sanction, but the sanction was avoided because of the ability to provide scientific evidence of the safety of these Canadian products.

Non-industrial innovations. Important impacts for PBCA are *not* restricted to those arising from traditional industrial technology transfer (i.e., patenting, licensing, spin-off companies). Although this route can be important, non-industrial impacts are also important, presuming that there may be some way to quantify and dollarize them; e.g., impacts for:

- government regulators
- policy makers
- the environment
- not-for-profits, etc.
- the general public or society in general

We suggest that you flag such innovations if there are concrete examples given of external usage (as opposed to vague generalizations), and the innovations appear to be very important; e.g., they, have a broad reach, represent a significant advance in treating a critical problem, represent potential for long-term systemic change, etc.

Non-traditional routes. Do not neglect considering non-traditional, indirect, and non-linear routes for creating impacts. These can also be important – and sometimes extremely important – for both industrial and non-industrial innovations. These include:

- access to expertise, the "seal of approval" implicit in a technology developed in collaboration with ADF/SRP or a university, access to crucial highly qualified personnel (HQP), etc.
- changes to sector or corporate strategy – often the IP is not as important as showing an industry (or an individual company and its key decision-makers) that a new direction in commercialization or production could make them "first to market" in an important new area;
- "knock-on" impacts that arise some years after the original research was done;
- "spin-off" impacts (not to be confused with spin-off companies) that arise in areas quite different from those in which the original research was done ; and
- Highly Qualified Personnel (HQP) are often the most important for partners – sometimes specific individuals are in fact the "big winner" cases, and this may especially be the case for the SRP.

Template to Identify "Big Winners" – Return on Investment from "High Impact" ADF/SRP Research

Name:
Position:
Phone Number:
Email:

Important: Please first read the note "Criteria for ADF/SRF Case Study Selection of "Big Winner" Impact Projects"

Please fill in the following table to the best of your ability for research projects/themes that you believe represent "big winners", and tell us why they have had important economic impacts. If there's something we don't ask about that you think is important, please add it. Remember that we need enough information to help us understand and assess the magnitude of existing (or high potential) economic impacts of your candidate projects/themes.

Information	Comments
Nature of research. This may be a formal research theme, or a group of related projects that have a common important outcome	For example, title of project(s)/theme, program supporting it, purpose of the research.

Information	Comments
Why is this research important? For example, who has used it, and what general kinds of economic impacts have they obtained?	
Specific nature of the benefits Examples include sales of improved seed varieties, increased crop productivity (e.g., from higher yields, better disease/pest resistance), higher meat production (e.g., from better facility design, earlier disease treatment or prevention), lower production costs (e.g., less use of fertilizers, pesticides), improved processing techniques, fewer environmental impacts (e.g., lower pesticide use, run-off control, better soil quality management), improved regulatory and policy development, etc.	Please be as concrete as possible.

Information	Comments
Estimated Scale of Benefits How wide-spread are these benefits? For example, how many suppliers, growers and/or processors have been affected, how many diseases/pests will be controlled, over what timeframe, etc. – any information that can help us understand how large the benefits are. (Note: at this point we just need an order of magnitude)	
Are there any known "dollar value" benefits? This might include, e.g., incremental sales revenues for new cultivars, higher yields, better production management, and/or lower costs for herbicides, pesticides, fertilizers, antibiotics, feeds and forage, facility operation, etc. If there are national or international trade implications (e.g., maintenance/protection of market share, new market development, better public acceptance of new food products, trade sanction implications, etc.) please discuss these.	

Information	Comments
Contact information for the lead researcher involved (phone, e-mail)	
Contact information for the main external users of this R&D	

Thank you! Please e-mail responses to Karen Croteau: kcroteau@kpmg.ca.

If you have any questions, please call Karen Croteau at 613-212-2899, or Dennis Rank at 604-275-4604.

Appendix E: PBCA Interview Guide

Interview Guide Agriculture Development Fund (ADF) and Strategic Research Program (SRP)

Case under review	
Contact name	
Tel.	
Email	

We are investigating economic impacts related to support from the ADF and/or SRP. Ideally, we wish to discuss impacts that are *already in existence*; i.e., innovations already taken up and being used by producers or processors, and/or with commercial products already in the marketplace. We know that some ADF/SRP impacts may not be quite at this stage, so we are also interested in *"nearly there" applications*; i.e., those very close to being applied in the field or processing plant, and/or with commercial applications in the pipeline – however, we would wish to discuss how likely it is that these applications will actually prove viable.

Three important points:

- Because we would like to estimate dollar values for ADF/SRP impacts, please provide as much quantitative information as possible.
- If sensitive commercial information is being discussed, we will keep these data confidential to the degree you require – please discuss this during the interview.
- We are especially interested in exactly how the ADF and/or SRP impacts arose. For our purposes it does not matter whether they are through direct technology transfer (e.g., with protected IP), or more indirectly (e.g., through changes to industry practices or commercial standards)

General questions about the research and application

1. We wish to be sure we understand exactly what practical applications are likely from this research – please discuss.

2. What problems are the main targets of this work? Are they potentially applicable to other industry problems?

Stage of development

3. At what stage of development is this work in terms of practical application by producers or processors, or by government policy makers, or other industry interests?

Quantitative information

4. To what extent will (or have) agricultural or agri-food practices or products be affected? Be as specific and concrete as possible. Some general categories are shown below, but please discuss specific outcomes relevant to this case.

5. To what extent will (or have) agricultural or agri-food practices or products be affected? Be as specific and concrete as possible. Some general categories are shown below, but please discuss specific outcomes relevant to this case.

General questions about the research and application

6. We wish to be sure we understand exactly what practical applications are likely from this research – please discuss.

7. What problems are the main targets of this work? Are they potentially applicable to other industry problems?

Stage of development

8. At what stage of development is this work in terms of practical application by producers or processors, or by government policy makers, or other industry interests?

Quantitative information

9. To what extent will (or have) agricultural or agri-food practices or products be affected? Be as specific and concrete as possible. Some general categories are shown below, but please discuss specific outcomes relevant to this case.
   - Development of new or improved crops and/or cultivars;
   - Optimized livestock feeding systems;
   - New and innovative food, bioproducts or processing technologies;
   - Innovative farming systems and practices;
   - Reduced harmful environmental impacts; or
   - Enhanced capacity to respond to agricultural production risks (including cross-border trade issues).

10. How many users (e.g., producers, processors, firms) are/will be affected? (Where relevant, please discuss factors such as:

    a. Market sizes
    b. Hectares of land under cultivation that may be affected

    Please note annual impacts, to date and expected in future (i.e., when is take-up expected to begin, and how will it ramp up over time). **PLEASE BE AS QUANTITATIVE AS POSSIBLE.**

    c. In Saskatchewan?
    d. In Canada?
    e. (if applicable) World-wide?

11. What are the implications regarding the dollar values of new or improved commercial products (e.g., gross sales revenues) or commercial practices (e.g., cost savings)? *Again, please note annual impacts to date and expected in future;* **PLEASE BE AS QUANTITATIVE AS POSSIBLE.**

    a. In Saskatchewan?
    b. In Canada?
    c. (if applicable) World-wide?

    Please discuss how confidential these figures are. (Can they be reported to the Saskatchewan Ministry of Agriculture? Can they be used in a public report? If not, we will aggregate them with data from other cases so that individual dollar values cannot be identified.)

12. If there are new or improved commercial products arising from this R&D, to what extent will the sales revenues be captured by Saskatchewan firms? Canadian firms?

    Please discuss how confidential these figures are. (Can they be reported to the Ministry? Can they be used in a public report?)

13. If there are new or improved commercial products arising from this R&D, what profit margins are expected?

    Please discuss how confidential these figures are. (Can they be reported to the Ministry? Can they be used in a public report?)

Other research and development costs

14. What other costs outside ADF or SRP grants were incurred to bring these innovations into commercial use? (For example, further research costs borne by granting councils or partner organizations, industry development and ramp-up costs, capital for increased production capacity, costs associated with implementing new industry practices, etc.)

Role of ADF and/or SRP Chairs programs

15. What was the specific role of ADF and/or the SRP Chairs?
    a. If many other research organizations were involved, what would have happened without ADF/SRP support?

16. What were the most effective elements of the ADF program? The least effective?

17. What were the most effective elements of the ADF program? The least effective?

18. What would you change in the ADF program if you could? The SRP program?

Contacts and other information

19. Are there reports available on this application that would help us?

20. Who else should we talk to?

Appendix F: Key Stakeholders Interview Guide

Interview Guide Agriculture Development Fund (ADF) and Strategic Research Program (SRP)

Case under review	
Contact name	
Tel.	
Email	

We are evaluating the ADF and/or SRP programs for the Saskatchewan Ministry of Agriculture. As part of this study, we would like to ask you about your view of the impacts of these programs on the viability of Saskatchewan's' agricultural economy, the continued need for provincial support for this type of R&D, and (if the programs are still relevant) possible adjustments to program design or delivery.

Policy rationale

1. Is there still a role for public intervention in support of Saskatchewan's agricultural R&D?

    - Why, or why not?
    - What form (or forms) of public intervention are likely to be most effective in Saskatchewan?
    - How would these public roles most effectively complement the roles of other supporters of agricultural R&D in Saskatchewan?

2. Does the ADF have a clearly defined and necessary role?

3. Does the SRP have a clearly defined and necessary role?

Program Achievements

4. In what ways have the ADF and SRP enhanced the performance of Saskatchewan's agricultural economy?

    - What has been their overall net impact?
    - What have been some of the key individual impacts?
    - Which sectors have benefitted the most?
    - Which have benefitted the least?

Current R&D needs

5. What are the current and emerging needs for public R&D support in the agricultural production and food processing sectors in Saskatchewan? For example:

   - What are the key pressures?
   - Are there any gaps in the Saskatchewan Ministry of Agriculture's coverage of these needs?
   - How should priority areas for agriculture and agri-food areas of research be identified? Who should be involved?

Are there any key gaps in public R&D support in the following areas, or are there any areas that do <u>not</u> require continuing public R&D support?

- Within any of the crops improvement areas?
- Within any of the livestock development areas?
- Within any of the food and bioproducts development areas?
- Within any of the soils and environment areas?

Design and delivery

6. Which aspects of the ADF and SRP's design and delivery have been most and least effective?

   - Which mechanisms have been the most effective in ADF?
   - Which have been the least effective in ADF?

   - Which have been most effective in the SRP?
   - Which have been the least effective in SRP?

   - Which aspects of program design or delivery would you change in the ADF program if you could?
   - In the SRP program?

Other

7. Do you have any other comments?