



# **BCRC 2013-2018 Results Report**

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## CHAIRMAN'S MESSAGE



Ryan Beierbach  
BCRC Chair

Beef research is key to enhancing the Canadian beef industry's ability to play a leading role in meeting global food production in a safe, sustainable, and profitable manner.

The Beef Cattle Research Council (BCRC) recognizes its responsibility to report quantified results of progress in each research priority area to stakeholders to optimize use of research dollars.

Evaluating the impact of research can be challenging due to the lag time between the investment into research, the adoption by industry, and the presence of measurable results. The BCRC is proud to present this Results Report summarizing funding activities from 2013-2018.

Research has multiple applications including: to maintain or improve production efficiencies; maintain or improve beef demand and consumer confidence; maintain or improve technology transfer; support competitiveness; identify emerging issues and maintain or improve research capacity.

Technology transfer and knowledge dissemination is an ongoing focus for the BCRC, with continued regular communication to industry, development of new resources and partnerships, measurement of successes, and modifications to the tools and strategy throughout Beef Cluster II. The Council is proud of the work in this area. Successes have been recognized by the Agriculture Institute of Canada's 2016 Report of Canadian agricultural research dissemination best practices. Increased investment in technology transfer has ensured that research results from Beef Cluster II are communicated to industry under the ten-year Knowledge Dissemination and Technology Transfer Plan (2011-2021) and informed by the "Adoption Rates of Recommended Practices of Cow-Calf Operators in Canada" report (2019).

The Government of Canada's development of the Science Clusters in 2009 was welcomed by the beef industry. This increased dialogue on the importance of continued support for basic research and focused use of limited dollars on areas of industry priority. The Science Cluster program has leveraged resources and accelerated performance through a systems approach, encouraging collaboration between researchers across the country.

Beef Cluster II gave rise to many important research findings with direct implications for the beef industry. Beef Cluster III (2018-2023) builds on Beef Cluster II research to move towards the beef industry's long-term objectives as set out in Canadian Beef Research and Technology Transfer Strategy 2018-2023. This ten-year strategy has provided all partners with clear industry priorities, giving direction to move forward.

The increase of the Canadian Beef Cattle Check-Off to \$2.50 per head in most provinces by 2018 and change in allocations to research has opened up opportunities for greater investment by industry to address gaps in knowledge, and to support consumer confidence, especially in the areas of food safety, environmental sustainability, and animal welfare.

Ryan Beierbach, Chair

Beef Cattle Research Council

## EXECUTIVE SUMMARY

The Canadian beef industry is highly dynamic, with constantly shifting demands from domestic consumers, international trading partners, producers, and processors. Research sharpens Canada's competitive edge through contributing to industry's ability to innovate, adapt to market pressures, and address consumer issues.

The Beef Cattle Industry Science Clusters bring together industry check-offs and public funding through Agriculture and Agri-food Canada (AAFC) and the Beef Cattle Research Council (BCRC) to fund research directly relevant to the beef industry. The 2009-2013 Canadian Beef Cattle Industry Science Cluster (Beef Cluster I) directed \$10.5 million to 32 research projects. For the 2013-2018 Canadian Beef Cattle Industry Science Cluster (Beef Cluster II), joint industry and government contributions totaled \$20 million for 26 research projects. Funding sources for Beef Cluster II included: AAFC (\$14 million), provincial governments (\$1 million), and the research allocation of the Canadian Beef Cattle Check-off and provincial beef industry groups (\$5 million). An overview of all the research projects in Beef Cluster II is presented in a comprehensive document available on the BCRC website, [www.beefresearch.ca](http://www.beefresearch.ca).

Research funding is focused on outcomes directly aligned with the beef industry's vision and priorities. As a result, Cluster investments have generated applicable knowledge, new technologies, and extension tools to increase adoption of the innovations. Both Clusters have delivered solid results and progress toward coordinating beef research funding across institutions and encouraging collaboration between researchers across Canada including. A priority for the BCRC is coordinating research funding via information sharing and formal collaborations with AAFC, provincial governments, provincial cattle associations, and other industry funders. It acts as a central research funding provider so that research studies are not duplicated, collaboration across institutions is encouraged, expertise in key areas of beef cattle research is maintained, technology transfer and extension outcomes are improved, and investment from industry is motivated.

Evaluating the impact of research can be challenging due to the lag time between the investment into research, the successful completion of the study, the adoption by industry, and the presence of measurable results. The BCRC recognizes its responsibility to report quantified results of progress in each research area to stakeholders to optimize use of limited research dollars. The Beef Cluster I Results Report disseminates the evaluation of the effectiveness of research activities funded through the BCRC. In the resulting financial impact to industry, the largest improvements were in the priority areas of Animal Health & Welfare and Feed Grains & Feed Efficiency as these areas are highly applied, which allows for swift adoption of new technology and attracts a high level of private research investment.

Research outcomes of Beef Cluster II are directly aligned with the objectives of the 2012 National Beef Research Strategy. The development of the National Beef Research Strategy was led by the BCRC and the national Beef Value Chain Roundtable (BVCRT), and involved the participation of key stakeholders and major beef research funders across Canada. The National Beef Research Strategy coordinates beef research priorities, funding, and technology transfer across Canada.

The four core research objectives under the Beef Cluster II research program were:

1. *Improve production efficiencies*: through enhanced feed and forage production, increased feed efficiency, and decreased impact of animal health and welfare issues and production limiting diseases.

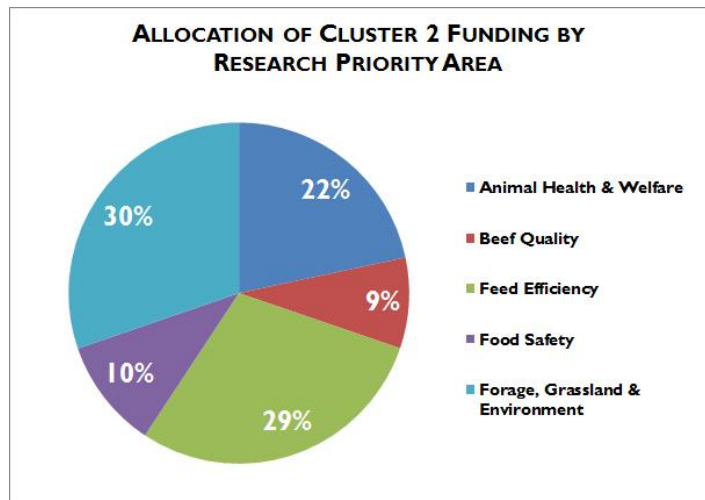
2. *Improve beef demand and consumer confidence:* through reduced food safety incidents, supporting the Canadian Beef Advantage and improved beef quality through an audit program and primary production improvements, development and application of post processing technologies to optimize cutout values, and evaluation of the environmental footprint of beef production with recognition of positive contributions to present a balanced perspective.
3. *Improve technology transfer:* through implementation of a long term Knowledge Dissemination and Technology Transfer strategy which focuses on regular communication to industry through extension tools including [www.beefresearch.ca](http://www.beefresearch.ca), videos, webinars and cost of production decision making tools, and promoting and enabling the engagement of researchers with industry.
4. *Competitiveness, emerging issues and research capacity:* through flexibility in funding that allows industry to respond to emerging or critical issues in an expedient manner while maintaining professional capacity.

The 2013-2018 Beef Cluster II invested \$20 million in 26 research projects across five priority areas: Animal Health and Welfare (22%), Feed Grains and Feed Efficiency (29%), Forage and Grassland Productivity, including Environment (30%), Beef Quality (9%), and Food Safety (10%).

**Animal Health and Welfare (6/6 successfully completed projects)**

Maintaining animal health and welfare is critical to the economics of cow-calf and feedlot production. Changes in reproductive efficiency, disease incidence, and carcass quality can have large impacts financially. Using 2017 data, improving reproductive efficiency by 1% is predicted to increase revenue by \$12 per cow. Aggregated on the industry level, the effect can be significant. For example, in a five-year period (2012 to 2017), increased feedlot survival rate resulted in an industry gain of \$575 million, while liver discounts in 2016/17 resulted in a \$61.2 million loss for industry (NBQA Carcass Audit 2018). It is recognized that higher animal health and welfare outcomes may require investment and changes in management.

In the area of Animal Health and Welfare, Beef Cluster II research focused on an array of diseases, the popularity of different management practices, and ruminant gastrointestinal function. More effective microarray tests for bovine respiratory and enteric diseases (i.e., using a single chip to detect multiple pathogens) have been developed and validated. Research has also found additional proteins that can serve as a diagnostic tool for Johne's disease, including detection for asymptomatic cattle in early or subclinical stages of disease. Further work is being undertaken to develop the diagnostic tools, and a patent for these specific biomarkers has been submitted. Ticks that can cause anaplasmosis in cattle were tracked and mapped across Canada, providing an understanding of their preferred habitat as well as predictions of their current and future distributions, which aids in monitoring and identifying areas at high risk for the transmission of tick-borne pathogens.



A study was conducted on pain management for castration of calves and found that meloxicam and reducing the age at castration reduced pain responses. One study established a veterinary and producer network as part of a long-term project to re-establish an animal health surveillance system; efforts included collecting data on factors such as reproductive efficiency, disease prevalence, nutrient deficiencies, management practices, and antibiotic use across the Canadian beef industry. Studies also developed a deeper understanding of ruminant gastrointestinal barrier function, allowing for the development and evaluation of strategies to mitigate the effect of disease; for example, the recovery of the gastrointestinal tract can be accelerated by reducing the proportion of concentrate in a diet after a period of low feed intake.

The tools and knowledge developed through this 2013-18 Animal Health and Welfare-related research:

- are being further developed into commercially available diagnostic tests (in the case of Johne's disease biomarkers, bovine respiratory disease and bovine enteric disease microarray chips)
- will help industry develop producer recommendations to manage the risk of exposure to vectors of a de-regulated disease (tick-borne anaplasmosis)
- inform the development of science-based pain management regulations
- establish the foundation for a nationwide animal health surveillance network

#### **Feed Grain and Feed Efficiency (5.5/6 successfully completed projects)**

Feed efficiency has increased considerably in the past 50 years. The rise in efficiency is particularly attributable to breeding practices, improved animal health, growth promoting technologies, and nutritional management. With feed costs comprising the largest proportion of variable input costs for cow-calf and feedlot production, this represents significant savings. On the industry level, a 5% improvement in feed efficiency in the feedlot sector can reduce feed costs by over \$19 million annually (2017 prices). New developments in genomics and feed quality further improve feed efficiency. Five-year averages of Feed:Gain ratio have been reducing steadily— from 6.78 in 2003-2007 to 6.70 in 2008-2012, and dropping to 6.25 in 2013-2017 (Canadian Journal of Animal Science<sup>1</sup>). A 2% lower feedlot Feed:Gain ratio reduces feed costs by \$7/head. In addition, cattle in 2017 finished 15 days earlier on average than cattle in 2012, accounting for 41.5 million fewer days in total (Canadian Journal of Animal Science). This has major implications for reducing both feedlot costs and environmental footprints.

Research in this area created new crop varieties, feed efficiency selection strategies, and nutritional protocols. Varieties with increased yield, improved quality, and lower susceptibility to diseases have been obtained. Overall, 10 barley varieties were approved, with two undergoing commercialization. Two studies were conducted on cattle attributes associated with higher feed efficiency, and to monitor responses to increased feed efficiency. Results show more feed efficient cattle spend more time in a desirable pH range, have greater papillae thickness, higher bacterial concentration, and lower methanogen populations. In terms of reproductive performance, improved feed efficiency may negatively impact bull reproductive function without affecting maternal performance. A corn silage study revealed high variability in quality, emphasizing the importance of feed tests, and that high energy corn silage can replace grain without compromising animal performance. A breakthrough approach was developed by researchers for understanding how prebiotics, probiotics, and synbiotics function in the animal promote gut health, and improve feed efficiency.

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<sup>1</sup> Average daily gain values for control and trial groups from beef feedlot studies in the Canadian Journal of Animal Science were averaged for each year

The tools and knowledge developed through this 2013-18 Feed Grain and Feed Efficiency-related research:

- are undergoing commercialization (new barley varieties)
- will help industry develop nutritional recommendations (feed tests for corn silage)
- inform the development of selection programs for improved feed efficiency

One project had partial results as a large-scale feeding trial was made into a series of more detailed metabolic and metabolomic trials.

### **Forage and Grassland Productivity** (5/6 successfully completed projects)

Forage quality significantly influences cattle performance, especially for the cow-calf and backgrounding sectors. Not only can maintaining high productivity grasslands result in direct economic benefits for cattle production, ecosystem services can also be generated. Continual improvements in forage productivity is necessary to support Canada's international competitiveness. A key challenge is measuring and valuing forage, as the majority is produced and used on farm and only a small proportion of forage is traded. This creates difficulty in establishing a stable market price. Furthermore, the costs of forage production are rarely measured and are highly variable across regions. These factors can result in underinvestment in this critical area.

Beef Cluster II research projects studied winter feeding practices, forage breeding, silage quality, forage seed mixes, and the environmental impact of beef production. Two studies on winter nutrition management identified economical and environmentally responsible extended grazing practices that can maintain nutritional requirements throughout the season. For example, corn enables cattle to graze longer without seeking shelter and as corn maintains nutrient quality better than cereals. This suggests that producers may want to graze cereals early in the season and corn grazing can be saved for later in winter.

Another study used both traditional and genomic forage breeding approaches to produce several potential lines for commercialization that have increased ability to establish, persist in the stand, resist weeds, and produce higher forage and seed yields under a variety of growing conditions. One project studied the effect of barley variety on silage quality, and found the effect of barley variety is less significant than growing and ensiling conditions. Research was also done on identifying combinations of forage seed varieties that optimize forage quality, yield, and animal productivity, where it was found that mixtures containing Birdsfoot trefoil have higher performance than those with alfalfa. A preliminary environmental assessment found that the efficiency of cattle production has increased greatly over the past few decades, greatly reducing water use and ammonia emissions.

The tools and knowledge developed through this 2013-18 Forage and Grassland Productivity-related research:

- are being further developed into new commercially available forage varieties
- will help industry develop silage management and winter grazing recommendations
- inform the development of more productive forage seed mixtures

One project had partial results due to inadequate data on biodiversity and carbon sequestration. They were still able to estimate ammonia emissions. Efforts to fill the regional data gaps are ongoing.

### **Beef Quality** (3/4 successfully completed projects)

Improvements in beef quality support consumer preferences for beef, and results in increased consumption and a higher willingness to pay for beef. On a sensory level, beef quality can be reflected



through tenderness, juiciness, flavour, and consumer satisfaction. Overall, quality attributes can encompass animal production strategies, health and beef safety, quality, and nutrition. Through establishing the distinct quality of Canadian beef, a competitive advantage can be created. Canadian beef can be differentiated in international and domestic markets as a leader in beef quality.

The National Beef Quality Audit (NBQA) identified areas of improvement for beef quality and food safety in processing plants and at retail. The prevalence of horns, bruising, and condemnations have decreased while branding, injection site lesions, and liver abscesses increased. Quality grades have also improved while yield grades decreased. At the consumer level, satisfaction levels have remained stable.

Research evaluated high pressure processing (HPP) for beef products, dark cutting incidence, and biomarkers for tenderness. HPP for marinated steaks can significantly extend shelf life without adverse effects on the meat quality, nutrition, or sensory attributes measured. The application of HPP to teriyaki and honey garlic steak were submitted to Health Canada for approval on June 3, 2015. Research found that dark cutting is more likely in cattle that are female, light weight (at weaning or slaughter), slow growing, or have low feed intake. The risk of dark cutting was highest in cattle that were briefly moved from the abattoir to a temporary feedlot and then returned to abattoir. One study identified six genetic markers associated with beef tenderness, specifically collagen levels and solubility. If successfully validated in a genetically-independent population, these markers may provide another avenue to improve beef quality in seedstock and commercial beef cattle.

The tools and knowledge developed through this 2013-18 Beef Quality-related research:

- are providing a foundation for validated genetic markers for beef tenderness
- are being further developed into commercially available processes (application for HPP for marinated steaks submitted to Health Canada)
- will help industry develop recommendations to reduce the incidence of dark cutting beef

One project was incomplete due to insufficient data on the effects of implants, beta-agonists and MGA on the risk of dark cutting.

### **Food Safety (2/3 successfully completed projects)**

Food safety recalls have steep costs to the industry, both logistically and in the loss of consumer confidence. Reduced incidence of *E. coli* is a crucial priority; however, the negative impact to industry is not necessarily reduced when a recall does occur. Thus, measuring the direct value of reduction is challenging. The core benefit of *E. coli* incidence reduction is from preventing recalls and their associated costs. The costs from foodborne illnesses include: food recall and disposal, outbreak investigation, medical costs, suffering and potential loss of life, and loss in human productivity from sick days.

The number of reported *E. coli* O157:H7 cases from the Public Health Agency of Canada (PHAC) shows a reduction of 70% since 2002. In fact, with the exception of the waterborne outbreak of *E. coli* O157:H7 in Walkerton, Ontario in 2000, which took the lives of seven people and affected hundreds more, the decline of reported cases began in 1995. In 2016, the national incidence rate for *E. coli* O157:H7 was 1.1 cases per 100,000 people, down 21% from 1.4 cases per 100,000 people in 2011. In 2016, this accounts for some 415 individuals infected with *E. coli* O157:H7. For every case reported by a patient to a doctor, an estimate of between ten and 47 cases go unreported. Even applying a conservative estimate of ten unreported cases for every captured one, roughly 4,150 Canadians suffer the effects of *E. coli* O157:H7 infection each year, at a significant cost to the health care system.

Beef Cluster II research studied pathogen prevalence and transmission from beef processing operations, as well as the transfer of antimicrobial resistance from manure. One study found the prevalence of Top 6



non-O157 STEC is very low in Canadian beef processing operations, and the food safety risks associated with the Top 6 STEC associated with beef appear to be low and likely less than for *E. coli* O157:H7. One project studied the effectiveness of beef packing plant practices for controlling pathogenic and spoilage bacteria, and found that dry chilling and hide-on carcass washes are very effective interventions for controlling *E. coli* on beef carcasses while cleaning practices of beef plants are not entirely effective at reducing bacterial numbers on equipment surfaces. Methods to inactivate bacterial spores responsible for blown pack spoilage were also developed.

The likelihood of antimicrobial resistant (AMR) bacteria and genes transfer from manure to soil and water supplies was investigated. The study found composting manure can reduce the flow of AMR genes into the environment, and that soil samples originating from the agricultural fields adjacent to the feedlot had a resistome unique from the feedlot resistome.

The tools and knowledge developed through this 2013-18 Food Safety-related research:

- provide science-based evidence of food safety risks of Canadian beef
- will help industry develop recommendations for food safety (efficacy of on-hide washes, dry chilling, and methods to inactivate bacterial spores) and antimicrobial resistance transmission

One project was incomplete due to only having Ontario data for pathogen prevalence in processing operations; however, an independent study jointly funded by ALMA and AI-BIO studied this question in large commercial plants in Alberta.

### Benefit Cost Ratios

To track the impact of research on industry and identify where limited research funding can have the largest return Benefit Cost Ratios can be studied. The Benefit Cost Ratio (BCR) is calculated through dividing the total value generated through the investment by the cost. The higher the ratio, the larger the return for dollar invested – however, high ratios are also indicative of underinvestment. When the ratio is one to one (1:1), the investment breaks even. Typically, investments follow diminishing returns where the BCR gets smaller with larger investments.

Area of Investment (\$ millions)		2008-2013	2013-2018
Animal health and welfare	Net change in value to industry	-213.03	405.09
	Total BCRC Investment	1.24	3.94
	Benefit: Cost Ratio	-171.31	102.77
Feed grain and feed efficiency	Net change in value to industry	366.91	568.94
	Total BCRC Investment	1.66	4.20
	Benefit: Cost Ratio	220.77	135.31
Forage and grassland productivity	Net change in value to industry	0.14	0.07
	Total BCRC Investment	1.93	5.15
	Benefit: Cost Ratio	0.07	0.01
Beef quality	Net change in value to industry	6.39	22.61
	Total BCRC Investment	1.98	1.24
	Benefit: Cost Ratio	3.23	18.19

Overall, investments in the Beef Cluster I and II research were estimated to have positive benefit cost ratios. Animal Health and Welfare had a negative value to industry from 2008-2013 due to a large decline in weaning to slaughter survival rate for that time period, but rebounded in the 2013-2018 time period. For Beef Cluster II research, the largest returns were in Feed Grains and Feed Efficiency, followed by Animal Health and Welfare, Beef Quality, then Forage and Grassland Productivity. BCR were larger during

2013-18, compared to the 2008-13 time period for Animal Health and Welfare, and Beef Quality. Smaller although still positive BCR for Forage and Grassland-related research investments productivity indicate that the current level of investment is close to ideal. The smaller though still large BCR for Feed Grains and Feed Efficiency indicate further investment would be beneficial.

It should be noted that the values used in the BCR calculations are based on *selected measurable indicators*. These may not reflect the true total value to industry due to the exclusion of factors that are difficult to measure; for example, the effect of improved pain management.

### **Knowledge and Technology Dissemination**

Technology transfer and knowledge dissemination is an ongoing focus for the BCRC, with continued regular communication to industry, development of new resources and partnerships, measurement of successes and modifications to the tools and strategy throughout Beef Cluster II. Increased investment in technology transfer has ensured that research results from Beef Cluster II will be communicated to industry.

Beef Cluster II delivered many technology transfer goals:

1. *Regular communication with industry*: BCRC led many beef research extension initiatives, with efforts recognized by the Agriculture Institute of Canada's 2016 Report as Canadian agricultural research dissemination best practices. The online presence of extension efforts was greatly strengthened with large increases in viewer engagement for online resources such as videos, blog posts, and webinars.
2. *Production of new resources*: Many new extension tools were released including videos, decision making tools, webinars, fact sheets, and Bov-Innovation (engaging presentations (in-person or remotely), with scientific experts accompanied by early-adopting producers sharing their experiences and real-life lessons learned on their operations)
3. *Enhancements to website functionality*: A new web tool for extension specialists to create and post fact sheets on BeefResearch.ca, improved display on mobile devices, website search functionality was improved along with search engine optimization.
4. *Engagement of researchers with industry*: Two key ways the BCRC engages researchers with industry are through pairing researchers with beef industry mentors such as cattle producers through the Beef Researcher Mentorship Program and through recognizing highly engaged researchers with the Canadian Beef Industry Award for Outstanding Research and Innovation
5. *Evaluation and modifications to the Knowledge Dissemination and Technology Transfer Plan*: BCRC constantly analyzes and evaluates website usage statistics and feedback from producers, researchers, extension groups and other industry stakeholders

Beef Cluster II gave rise to many important research findings with direct implications for the beef industry. Beef Cluster III (2018-2023) builds on Beef Cluster II research to move towards the beef industry's long-term objectives as set out in Canadian Beef Research and Technology Transfer Strategy 2018-2023. Beef research is key to enhancing the Canadian beef industry's ability to play a leading role in meeting global food production in a safe, sustainable, and profitable manner.

## INTRODUCTION

The Beef Cattle Research Council (BCRC), established in 1997, is Canada's industry-led funding agency for beef cattle and forage research. As the only national beef cattle industry research agency, the BCRC plays a key role in determining research and development priorities for the Canadian beef industry, administering the Canadian Beef Cattle Check-Off funds allocated to research, and subsequently influencing additional investment in beef cattle research. The Canadian Beef Cattle Check-Off is a mandatory levy per head of cattle sold, generating \$7.5 million annually. The BCRC received approximately 18% or 18 cents of every Check-Off dollar between April 2013 and March 2018. The BCRC is led by a committee of beef producers, where members proportionally represent each province's research allocation of the Check-Off.

Continual improvements in industry practices are critical as the Canadian beef industry competes internationally with over 40% of Canadian beef production being exported. Competitiveness is multi-faceted considering both cost of production, consistent quality supporting demand and informing public debate around production practices, domestic regulations and trade. Overall, beef research has the potential to impact industry's ability to meet increasing global food demand sustainably and supports the profitability of Canadian beef producers. Investments in beef research are designed to:

1. Support the Canadian Beef Advantage to provide high quality grain-fed beef and being a global leader in animal health and food safety
2. Enhance the production competitiveness of the Canadian beef industry
3. Support industry advocacy through science-based research
4. Regulatory competitiveness and foreign trade
5. Research expertise and infrastructure <sup>2</sup>

In 2012, the inaugural National Beef Research Strategy was released. It focused on encouraging greater collaboration among the many funding bodies and research institutions and improving efficiency in using limited funding to drive research of priority to the industry. A significant benefit was having clearly defined research outcomes listed in the Strategy for all funders to work towards. This strategy informed and guided the 2013-18 Beef Cattle Science Cluster. In 2016, an updated Canadian Beef Research and Technology Transfer Strategy 2018-23 was published.

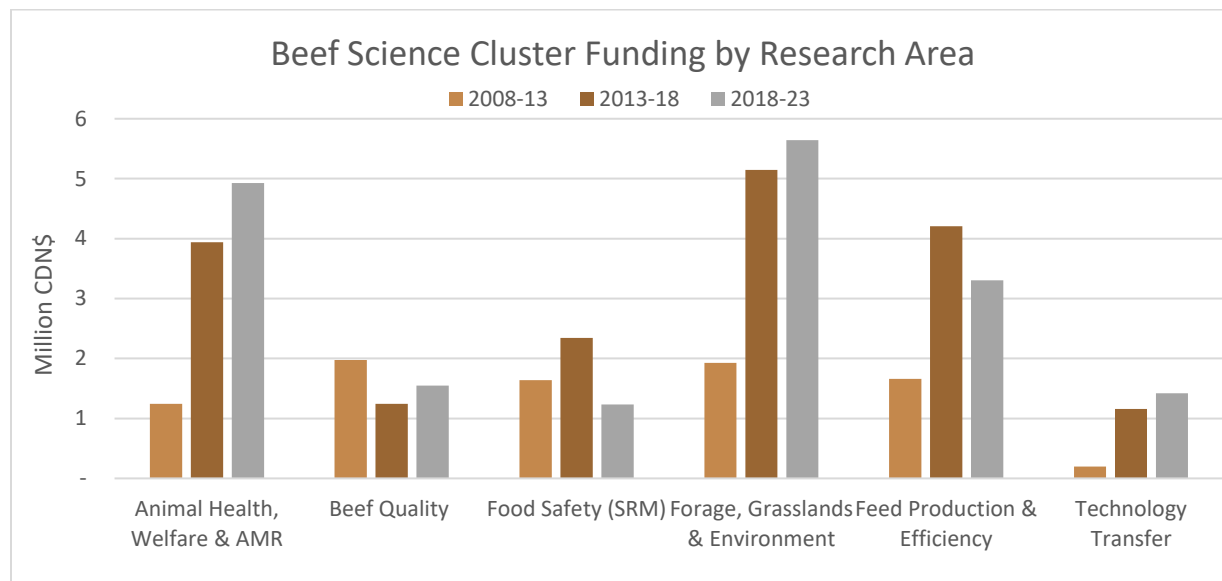
The Beef Cattle Industry Science Cluster brought together industry check-offs and public funding through Agriculture and Agri-Food Canada (AAFC) and BCRC to fund research directly relevant to the beef industry. The 2009-2013 Canadian Beef Cattle Industry Science Cluster (Beef Cluster I) directed \$10.5 million to 32 research projects. For the 2013-2018 Canadian Beef Cattle Industry Science Cluster (Beef Cluster II), joint industry and government contributions totaled \$20 million for 26 research projects. Sources included: AAFC (\$14 million), provincial governments (\$1 million), and the research allocation of the Canadian Beef Cattle Check-off and provincial beef industry groups (\$5 million).

Research funding during 2013-18 focused on outcomes directly aligned with the beef industry's vision and priorities outlined in the 2012 National Beef Research Strategy. As a result, Cluster investments have generated applicable knowledge, new technologies, and improved extension tools to increase adoption of the innovations. Both Clusters have delivered solid results and progress toward coordinating beef

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<sup>2</sup> National Beef Research Strategy, 2012

research funding across institutions and researchers across Canada including AAFC, BCRC, provincial governments, provincial cattle associations, and other industry funders. It is a priority for the BCRC to encourage coordination and facilitate funding in a manner that ensures research studies are not duplicated, collaboration across institutions is encouraged, expertise in key areas of beef cattle research is maintained, technology transfer and extension outcomes are improved, and investment from industry is motivated.



Maintaining progress in all areas of research is critical to the long-term success of the beef industry. The Canadian beef industry has a tremendous opportunity to increase productivity and grow Canadian beef exports to support broader economic growth. Research, past and present, is key to realizing that opportunity through advancing beef science, capitalizing on market opportunities, improving the industry’s antimicrobial and environmental stewardship, and providing Canadian beef producers with practical knowledge and innovations that can improve their business and end products.

**PERFORMANCE MEASURES**

One of the challenges in evaluating research is that progress is made over a long period of time. The initial investment may take years to provide a result that then needs to be commercialized and adopted by industry. Consequently, the industry is currently benefiting from historical investments in research. It is well recognized that any evaluation of research funding must reflect the time frame of the task undertaken. This is broken into long-term performance measures, medium-term research indicators and short-term deliverables reflecting the appropriate evaluation period for each goal and activity.

**Long Term (6-10 years):** The Canadian Beef Cattle Check-Off Evaluation showed that the benefit cost ratio to research were 46:1 in 2010; this is partly due to under-investment. This decreased to \$34.5 in 2016 indicating that while increased investment has been beneficial, further investment is warranted.

**Medium Term (4-6 years)** research indicators monitor progress in the various priority areas. The BCRC commissioned a “Historical Evaluation of Research in BCRC Priority Areas” in 2012 that reviewed various

<sup>3</sup> Excludes management, in-kind and other government

medium term research indicators. These indicators are expected to be impacted over the medium term as research is directed to addressing various challenges the industry is facing.

In this report *Research Indicators*, are medium term indicators provided for each priority area under the section titled “Value - What Does it Mean for Industry”. This give an overview of historical trends. These are not directly attributable to BCRC projects as they are outside of BCRC’s direct influence and are impacted by all (private and public) research success of commercialization and producer adoption of new technology, as well as outside environmental influences (which frequently impact animal health and death loss) making them difficult to interpret over the short term. However, they provide an indicator of where advancements are being made and where they are stagnant or in decline. Medium term indicators do play an important role in assisting in identifying research needs and priorities moving forward. Appendix A provides a summary of the calculations and assumptions used in these value sections.

These research indicators should not be confused with short term deliverables which are more specific measures utilized to evaluate results of specific research projects funded by the Council. It is important to have realistic expectations of when results in these indicators will appear.

**Short Term** (1-4 years) deliverables for BCRC are directly related to projects funded. This in-depth look at BCRC operations allows for an internal evaluation of whether objectives are being met or not and where changes may be made to improve. In order to evaluate the five years of funding, focus is placed on the short term goals outlined under the Beef Cluster II (2013-2018).

Answers to research questions are not guaranteed, even with a well-designed project. In this report each project deliverable is given a designation (✓✗?) indicating if results were achieved. The ✓ designation does not indicate that the results were favourable for the beef industry; only that answers to the questions were found that will inform the industry on how to proceed.

✓ - Solid Results      ✗ - Failed      ? - Partial Results or Incomplete

Industry has invested in a number of initiatives that have provided exciting results. The “Findings” section under each priority area summarizes results, but industry has yet to reap the full reward of this work. Discovering that something does not work can still move the industry forward in finding a solution.

Not all research goals have a direct impact that can be measured or even seen indirectly by producers. Basic research may not achieve applied outcomes on its own, but is critical to producing the scientific advancements needed to apply the practical outcomes in applied downstream research. Many of the research goals work together like building blocks where the value of the whole is greater than the sum of the individual studies/projects. Basic research should not be discounted as it provides an important piece of innovation. Without the underlying foundation of basic research, applied research cannot occur. The success of applied research projects depends heavily upon the work of basic research which may not have been undertaken with a specific purpose in mind or potentially with a completely different end use in mind.

Research can take many years before paying off. The process of investing into an idea, the basic research required, the development of an application, commercialization and adoption is a long one. Industry invests with the expectation of this process occurring, but not all investments result in successful applications or commercialization.

## ANIMAL HEALTH &amp; WELFARE

## OVERARCHING OBJECTIVE:

Increasing overall levels of animal health and welfare through avenues such as pain management and effective prevention, diagnosis, and treatment of major production limiting diseases and animal health issues.

**Background:** Animal health is a major component of animal welfare and farm profitability. Mortality and morbidity factors such as survival rate, condemnations, bruising, and liver abscesses represent economic costs to producers who are also under increased scrutiny from consumers to show how they are providing the highest degree of animal care and positively contribute to animal welfare. In addition, infectious diseases and nutritional disorders can greatly affect animal performance, whether it is on the feedlot or the cow/calf operation.

## OUTCOMES

**OUTCOME #1: Improved Surveillance of Production Limiting Disease and Welfare Issues:** A lack of information regarding animal health and welfare and associated on-farm management issues and practices makes it difficult to appropriately prioritize related research in the cow-calf sector. In addition, fragmented, minimal animal disease surveillance leaves the Canadian beef industry unprepared for ongoing and potential new health events. The National Animal Health Monitoring System (NAHMS) in the US is an example of a system that could be improved upon to meet Canada's needs.

**OUTCOME #2: Improved Understanding and Management of Pain and Stress in Beef Cattle:** Increased public pressure and elevated industry awareness (e.g. Code of Practice for the Care and Handling of Beef Cattle) is increasing the need to better practically and cost-effectively measure, manage and mitigate the pain and stress associated with branding, castration, dehorning and nutritional management. Related work done in dairy calves does not necessarily translate to beef calves due to differences in management, genetics and production considerations.

**Outcome #3: Improved Prevention of Animal Disease and Welfare Issues:** Prevention of animal disease requires a multi-faceted approach, including improvements in diagnostics, vaccines, alternatives to antimicrobials, and understanding of animal physiology, disease vector dynamics and host-pathogen interactions.

## PROJECT FINDINGS

**ANH.01.13 - Identifying *Mycobacterium avium* subsp. *paratuberculosis* (MAP) exproteome components recognized early during infection to develop diagnostic and vaccine targets**

**Key highlights:** Johne's disease has no effective vaccines and is difficult to accurately diagnose, particularly in the early stages of infection. This research set out to identify potential vaccine candidates screen antigens for immunogens with diagnostic value. 162 unique proteins were identified, of which 66 had not been previously described secreted by MAP. Subsequent screening of MAP secreted proteins found four antigens that reacted on immunoblotting with individual sera from 35 MAP-infected cows. Moreover, these antigens reacted with sera from 6 low-MAP shedders, and 3 fecal-culture positive cows labeled as ELISA seronegative. The specificity of these antigens was demonstrated using negative control sera from uninfected calves (n = 5) and uninfected cows (n = 5), which did not react to any of these antigens by immunoblotting. As three of the four proteins have not been previously reported as antigens, their characterization and incorporation into an ELISA-based format will aid in detecting asymptomatic cattle in early or subclinical stages of disease.

Success Story: The proteins identified both contribute to the growing list of potential diagnostic reagents for Johne's disease and provide a basis for future investigation into the use of these components as better tools for the control of this significant veterinary pathogen. A patent has been applied for "Biomarkers for *Mycobacterium avium paratuberculosis* (MAP)" U.S. Provisional Application No. 61/881,756. Further work is continuing in collaboration with VIDO with funding from NSERC.

✓ - Solid Results

### **ANH.12.13 - Geographic variation in abundance and genetics of *Dermacentor andersoni*, a vector of bovine anaplasmosis**

Key highlights: The Rocky Mountain tick (*Dermacentor andersoni*) and American Dog tick (*Dermacentor variabilis*) can carry and spread the bacteria that causes anaplasmosis in cattle. The CFIA no longer treats anaplasmosis as a reportable disease, so the costs of dealing with the disease now falls to individual producers. A better understanding of where these ticks are and are likely to be is essential to developing recommendations to help avoid anaplasmosis. This is the most comprehensive study conducted to determine the abundance of ticks in western Canada. Ticks were monitored at 201 different sites in British Columbia, Alberta, Saskatchewan, and Manitoba in the spring and summer of 2014-2016. Results confirmed that *D. variabilis* is expanding northward in Saskatchewan and Manitoba, and *D. variabilis* is expanding westward, but the chance of encountering ticks and the risk of disease transmission varies greatly during different years and at different locations.

Success stories: Data collected during this study also allowed researchers to identify specific habitat characteristics that ticks are more likely to be present in. This has allowed researchers to develop the first statistical equations for predicting the distribution and the relative density of ticks throughout Western Canada. This is an important step for identifying and monitoring areas of greater risk of encountering ticks and for potential transmission of tick-borne pathogens, such as *Anaplasma marginale*.

✓ - Solid Results

### **ANH.13.13 - Development of a fully-automated DNA microarray chip for multiplex detection of bovine pathogens**

Key highlights: Bovine respiratory disease (BRD) and bovine enteric diseases (BED) are often associated with multiple pathogens. However, current diagnostic tests for these diseases are primarily single pathogen tests. The main objective of this project was to develop two fully-automated DNA microarray chips for multiplex detection of bovine respiratory and enteric pathogens.

Four multiplex PCR assays were designed to detect target genes of respiratory (5 viruses and 4 bacteria) and enteric (4 viruses, 5 bacteria and 3 protozoa) pathogens. A panel of capture probes specific for each pathogen was designed and demonstrated using laboratory pathogen strains and clinical samples, and sensitivity limits were demonstrated. A panel of 61 probes was selected to develop two fully-automated DNA microarray chips, one for respiratory and one for enteric pathogens. The chips were successfully validated using a panel of clinical samples on the Rheonix Encompass MDx™ platform with fully automated sample extraction, multiplex PCR, and microarray detection. Once fully validated, these DNA microarray chips may provide a rapid, efficient, and cost-effective method for detecting multiple pathogens associated with respiratory and enteric diseases in cattle.

Success Story: The development and initial validation of two microarray chips (i.e. BRD chip and BED chip) to be used on a user-friendly fully-automated microarray platform to simultaneously detect multiple respiratory and enteric pathogens of beef cattle has been successfully completed.

✓ - Solid Results



### **ANH.21.13 - Effect of age and handling on pain assessment and mitigation of common painful routine management procedures**

Key highlights: Public concerns with beef cattle welfare often focus on painful procedures like castration, dehorning and branding. Castration and branding are particularly challenging because of the large numbers of animals affected, and because of legal requirements for branding in some cases. This study looked for cost-effective ways to manage the pain associated with branding and castration in beef calves.

Success stories: The project provides science-based evidence that castration should occur as young as possible to minimize pain. Meloxicam reduced some physiological and behavioral pain responses in calves regardless of age of castration, with greater benefits seen in older age groups. Meloxicam administered at the time of castration was as beneficial as meloxicam administered up to six hours before castration.

✓ - Solid Results

### **ANH.23.13 - Implementation of a longitudinal disease surveillance network for cow-calf operations in Western Canada**

Key highlights: A gradual and long-term decline in provincial and federal government animal health surveillance means that Canada's beef industry has little knowledge of the prevalence or economic impact of many production limiting diseases. This project established a veterinary and producer network to gather some of this information as part of a long-term effort to re-establish a surveillance system. *Neospora caninum* seroprevalence was determined to be 6.7%, with 68% of herds having at least one positive cow. Bovine leukosis virus seroprevalence was determined to be 2.3%, with 15% herds having at least one positive cow. Evidence-based guidelines for interpreting PCR tests suitable for use under field conditions for *T. foetus* and *C. fetus* spp. *venerealis* in beef bulls from western Canada were developed and shared with veterinarians. Data was gathered to assess the prevalence and geographic distribution of micronutrient deficiencies in young and mature cows from western Canada. Baseline data was collected to evaluate reproductive performance and calf loss. This baseline data will inform productivity benchmarks for Western Canadian management practices and identify opportunities for improvement. Animal welfare practices have been documented along with information on producer's perceptions of painful procedures. Data on antibiotic use in the cow-calf sector was also recorded and used to develop an app to enhance on farm recording of antibiotic use. Estimates of gastro-intestinal parasite levels and parasite control efforts were recorded and provided valuable information about parasite levels as well as potential resistance.

Success stories: Updated information on disease prevalence and management will inform future animal health research priorities for the cow-calf sector. Results from this project showed that producers are following the Code of Practice for the Care and Handling of Beef Cattle and using antimicrobials judiciously. Benchmarking data will be extremely valuable in assessing disease trends across the Canadian prairies. This initiative will be as a nationwide initiative in 2018-23.

✓ - Solid Results

### **ANH.33.13 - Improving the barrier function of the gut: an approach to minimize production limiting disease**

Key highlights: The cells lining the digestive tract need to absorb nutrients while preventing pathogens and antigens from entering the bloodstream. Studies were conducted to evaluate barrier function among regions of the ruminant gastrointestinal tract, to evaluate whether nutritional challenges affect gastrointestinal barrier function, and whether feeding management strategies can be used to accelerate recovery of gastrointestinal barrier function.

The first study characterized the barrier function across the gastrointestinal tract (rumen, omasum, cecum, and colon tissues). Results indicate that large molecules pass more easily across the omasum and rumen than lower in the digestive tract (opposite to monogastrics).

The second study found that feed restriction and ruminal acidosis do not differentially affect gastrointestinal tract permeability. The duodenum and rumen are likely regions with greatest permeability. Expression of genes relating to barrier function and immune response in the gastrointestinal tract are differentially affected by nutritional stressors. Nutritional challenges affect the expression of genes related to barrier function and immune response in the gastrointestinal tract. This may have implications in identifying how cattle adapt to nutritional challenges and to identify strategies to improve gut barrier function.

The third study determined the effect of low feed intake on ruminal fermentation and gastrointestinal barrier function in lambs fed a high-grain diet and 2 potential strategies to improve recovery to the challenge. As expected, feeding lower concentrate diet after a period of low feed intake helped lambs recover with respect to DMI and ruminal pH. Moreover, low feed intake appears to result in a compensatory increase for genes related to barrier function. Compounds that stimulate gastrointestinal development (butyrate, betaine, and antioxidants) may enhance absorptive capacity following low feed intake and reduce the permeability of the gastrointestinal tract.

Success Story: This was the first study to evaluate selective permeability among regions of the gastrointestinal tract for ruminants and identified that while the rumen and omasum have relatively low permeability, they are more permeable to large molecules than the intestinal tract. The proximal regions of the small intestine have greatest permeability for small molecules. These are unique features for ruminants as the regional permeability differs from monogastric animals.

The gastrointestinal tract attempts to prevent an increase in permeability by upregulating the expression of genes for tight cell junction. Knowing that the rumen, omasum, duodenum, and jejunum are most affected by ruminal acidosis and low feed intake allows for the development and evaluation of strategies to mitigate the effect or accelerate recovery.

The recovery of the gastrointestinal tract can be accelerated by reducing the proportion of concentrate in a diet after a period of low feed intake and that provision of betaine, butyrate, and an antioxidant blend may help support ruminal epithelial function.

 - Solid Results

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## VALUE – WHAT DOES IT MEAN FOR INDUSTRY

Within the Animal Health and Welfare priority area, 6/6 projects were successfully completed.

Maintaining animal health and welfare is critical to the economics of cow-calf and feedlot production. Changes in reproductive efficiency, disease incidence, and carcass quality can have large impacts financially. Using 2017 data, improving reproductive efficiency by 1% is predicted to increase revenue by \$12 per cow. Aggregated on the industry level, the effect can be significant— in a five-year period (2012 to 2017), industry gain from increased feedlot survival rate reached \$575 million, while liver discounts in 2016/17 resulted in a \$61.2 million loss for industry (NBQA Carcass Audit 2018). It is recognized that higher animal health and welfare outcomes may require investment and changes in management.

The National Beef Quality Audit (NBQA) identified that the prevalence of horns, bruising, and condemnations have decreased while branding, injection site lesions, and liver abscesses increased.

A benefit cost ratio can track the impact of research and is calculated through dividing the total value generated through the investment by the cost. The higher the ratio, the larger the return for dollar invested. Typically, investments follow diminishing returns where the benefit cost ratio steadily shrinks with larger investments. Research investment in Animal Health and Welfare were negative from 2008-2013 due to lower weaning to slaughter survival rates during that time period. However, weaning to slaughter survival bounced back strongly in the 2013-2018 time period offsetting other costs to industry resulting in a positive benefit cost ratio.

RESEARCH INDICATORS	FINANCIAL IMPACT TO INDUSTRY ‡ (MILLION \$)	
	2012	2017
Reproductive efficiency increased from 86% in 2008 to 90% in 2012, and decreased to 86% in 2017	+\$141.8	-\$199.6
Survival (birth to weaning) decreased from 96.8% (2003-07 average) to 95.7% (2008-11 average), and increased to 96.9% (2012-17 average)	-\$39.0	+\$57.0
Survival (weaning to slaughter) decreased from 88% in 2008 to 82% in 2012, and increased to 91% in 2017	-\$294.0	+\$575.4
Feedlot survival (overlap with above) increased from 87% in 2008 to 91% in 2012, and decreased to 89% in 2017	+\$169.0	-\$143.2
<b>Total liver discounts:</b> <ul style="list-style-type: none"> <li>• Liver abscesses in fed cattle resulting in condemnation increased from 13% in 1998/99 to 23% in 2010/11 and 22% in 2016/17</li> <li>• Liver abscesses in fed cattle resulting in livers being discounted to pet food have decreased from 10% in 1998/99 to 8% in 2010/11, and increased to 10% in 2016/17</li> <li>• Liver condemnations in non-fed cattle increased from 18% in 1998/99 to 26% in 2010/11 and remained steady at 26% in 2016/17</li> <li>• Liver abscesses in non-fed cattle resulting in livers being discounted to pet food decreased from 33.7% in 1998/99 to 23.9% in 2010/11 to 17.6% in 2016/17</li> </ul>	-\$20.4	-\$32.0
Liver damage resulting in lost weight gain cost \$46.7 million in 2016/17 up from \$20.5 million in 2010/11 and \$2.99 million in 1998/99 as the cost of feed increased and cattle stayed on feed longer to get to finished weight	-17.5	-26.2
Horns - the percentage of hornless cattle increased approximately 20% from 1998/99 in fed and non-fed cattle to 88% in 2010/11, and increased to 91% in 2016/17	-\$0.1	\$0
Bruises -The percentage of non-fed cattle with bruises increased from 76.4% in 1998/99 to 85.7% in 2010/11, and dropped to 63% in 2017; while the percentage of fed cattle with bruises decreased from 49.2% in 1998/99 to 34.1% in 2010/11 to 32.6% in 2016/17	-\$2.4	+\$1.2
Heads and tongue condemnations rates decreased from 5% in 1998/99 to 3.8% in 2010/11	-\$3.64	N/A
Carcass condemnations have decreased from 31.0 per 10,000 head slaughtered in 2008 to 27.5 in 2012 and to 18.9 in 2017	+\$1.1	+\$3.4
<b>Net Change in cost to industry</b>	<b>-\$213.03</b>	<b>+\$405.09</b>
Total BCRC Investment	+\$1.24	+\$3.94
Benefit: Cost Ratio	-171.31	102.77

‡For assumption and calculation details, refer to Appendix A.

The Canadian Beef Research and Technology Transfer Strategy 2018-2023 has outlined four Animal Health and Welfare research outcomes over the next five years, under which more specific target objectives are listed:

- Improved surveillance of production limiting disease and welfare issues
- Improved prevention of animal disease and welfare issues
- Improved animal health and welfare research and training capacity
- Extension, outreach, and policy

## FEED GRAINS & FEED EFFICIENCY

### OVERARCHING OBJECTIVE

Improve feed efficiency through a variety of methods including: improving feed quality through genetics and processing, developing more effective nutritional management and feeding practices, and enhancing the animal's ability to extract and use nutrients.

**Background:** Feed efficiency reflects the animal's ability to convert feed energy into usable products. Feed costs are the largest variable cost for beef operations, and feed efficiency is a key determinant of economic competitiveness throughout the beef industry. In addition, efficient cattle have direct environmental implications as they emit less methane, require less feed, and spend less days on feed. Feed efficiency has been steadily improving through the decades. Identifying novel strategies to further increase efficiency is important for economic viability, and potential avenues can be through genomics, probiotics, and new grain varieties.

### OUTCOMES

**OUTCOME 1: Improved feed efficiency through animal breeding:** Canada's beef industry has made significant improvements in feed conversion efficiency through improved animal health, diet and feed management and the adoption of growth promoting technologies. Improved feed efficiency through genetic selection is slow due to the long generation interval in beef cattle, as well as the need to understand potential impacts on correlated traits (e.g. reproductive traits and beef quality).

**OUTCOME 2: Improved feed supply and utilization:** Feed costs represent the largest variable cost in feedlot production and maintaining the cow herd through the winter. Improvements in feed grain and annual forage quality and yields per acre are essential to ensure growers seed feed crops, keep per acre feed costs down, and maintain competitive feeding costs.

**OUTCOME 3: Improved management of manure nutrients:** Nothing relevant to this was funded under the 2013-18 Beef Cluster

**OUTCOME 4: Research Training and Capacity:** Research expertise in the areas of animal and feed grain and annual forage breeding and management have declined over the last two decades. Supporting post-doctoral researchers and graduate students with potential leadership characteristics for future annual forage and feed grain research is needed to help slow and ideally reverse this decline.

### PROJECT FINDINGS

#### **FDE.04.13 - Germplasm and variety development of barley and triticale for animal feed with a focus on feed quality, yield and disease resistance of both grain and annual forage production**

*Key highlights:* The goal of this project was to create barley and triticale varieties with higher yield and better quality. This project has been able to increase yield and obtain varieties that have better quality and are less susceptible to diseases.

*Success stories:* 10 barley varieties were approved for registration: one two-row covered malting or dual-purpose variety ('Lowe') released in 2016, two two-row covered malt / dual-purpose varieties (TR13606 and TR14617), five six-row covered (BT596, BT598, SR15507, SR16511 and 'AB CattleLac') and two six-row hulless (HB623, HB542) barley varieties with superior yield and quality. Progress has also been achieved in triticale yield and other characteristics. Three new varieties were released in 2018, with two already undergoing commercialization.

✓ - Solid Results

### **FDE.07.13 - The impact of genomic selection for feed efficiency on the cow-calf sector, performance parameters and underlying biology**

Key highlights: Improving feed efficiency is crucial to the sustainability of the beef industry. However, the direct assessment of feed efficiency in the bovine is not practical for commercial operations due to the duration of the assessment and equipment and labor costs. Moreover, single trait selection for feed efficiency may lead to deleterious correlated genetic selection responses. Efforts were made to identify novel parameters that could be used to indirectly identify feed efficiency, and to monitor responses to improved feed efficiency in beef heifers and bulls.

Efficient heifers had greater lymphocytes, immunoglobulin M response, and lower alkaline phosphatase (ALP) concentrations. Efficient pregnant heifers had lower concentrations of cholesterol and globulin. Estrus was strongly associated with fluctuations of ALP, aspartate aminotransferase, beta-hydroxybutyric acid, creatine kinase and triiodothyronine concentrations. However, age, body size and composition may influence such associations. There is potential for hematological parameters to serve as proxies of metabolic shifts related to feed efficiency and estrus state.

Heart rate (HR; BPM) is associated with feed efficiency. Feed efficient heifer calves had a lower overnight heart rate and an increased heart rate upon acute stress. However, acute stress HR results varied in yearling heifers, suggesting previous handling experience and maturity alter acute stress response. Pending further development (predictive ability), the acute stress assessment could have potential for on-farm application as a feed efficiency proxy in young heifers.

Investigation of rumen physiological characteristics and their association with feed efficiency can provide biological markers for selecting more feed efficient cattle. More feed efficient cattle spend more time in a desirable pH range, have greater papillae thickness, higher bacterial concentration, and lower methanogen concentration compared to less feed efficient cattle. Using biological markers to develop selection programs can reduce production costs and improve environmental conservation of beef production.

Feed efficiency and bull fertility are two major factors affecting profitability of the beef industry. However, there is concern of an antagonistic relationship between these two factors, highlighting the need to clarify the relationship between age, feed efficiency and sexual development. Younger and more efficient bulls exhibited lower testosterone and triiodothyronine levels, respectively. Younger bulls had smaller scrotal circumference, higher scrotal radiant heat loss and fewer normal sperm. Efficient bulls had lower scrotal circumference, scrotal radiant heat loss, and a trend towards lower testicular echogenicity and higher sperm head defects. Metabolic differences associated with variation in feed efficiency may impact reproductive function as illustrated by features of delayed sexual development in efficient bulls.

Success Story: The Maritime Beef Test Station in Nappan, NS is normally not used during the summer. The research team enrolled 20 producers from the Maritimes who brought 144 heifers to the facility to be tested for feed efficiency, reproductive development and performance. This also served to promote training and education for six students (1 PhD, 3 MSc, 1 vet and 1 international undergraduate). Heifers also were part of an open-house and used to demonstrate handling practices for 4H kids. The samples and data collected from the heifers also are serving as the basis for 2 MSc thesis. The comprehensive assessment made on these heifers were compiled in a user-friendly report that was shared with beef producers, assisting them to make decisions in the breeding herd.

✓ - Solid Results

### **FDE.09.13 - Increased use of high energy forages in conventional feedlot beef production**

*Key highlights:* Corn has higher biomass yields and whole-plant energy content than many other annual crops. This research investigated whether diets containing higher levels of corn silage could potentially reduce both cost of gain and barley grain levels in backgrounding and finishing diets for feedlot steers. There were no statistically significant differences in growth rate, feed efficiency or days on feed for steers backgrounded on 60% barley silage compared to those fed 40, 75 or 90% corn silage. Numerical differences in terms of growth rate, feed efficiency and days on feed faster favored steers backgrounded on barley silage.


*Success stories:* This research highlighted the variability in corn silage and why it is critical for producers to do a feed test on corn silage before incorporating it into a diet. This research also showed that with high energy corn silage it is possible to increase the level of forage in backgrounding diets without compromising performance. It is also possible to decrease grain use by substituting some grain for high energy corn silage, or by extending the backgrounding phase without compromising performance.

 - Solid Results

### **FDE.15.13 - Prebiotic, probiotic, and synbiotic technologies for targeted applications in food safety and ruminant productivity**

*Key highlights:* Prebiotics (feed ingredients that the animal can't digest but that bacteria can), probiotics (bacteria that benefit the host) and synbiotics (combinations of pre- and probiotics) are actively being used in diverse livestock sectors and hold promise to increase overall cattle performance and beef production. However, commercially available pre- and probiotics have been plagued by variable composition, challenges with on-farm application, and highly variable performance outcomes.

*Success stories:* Researchers developed a new way to look at interactions between prebiotics, probiotics, or synbiotics and how they interact with microbial communities in the host animal. This approach is a breakthrough for understanding how prebiotics, probiotics, and synbiotics function in the animal, promote gut health, and improve feed efficiency. These advances will set the stage for determining how prebiotics function in cattle and help create performance benchmarks for evaluating their outcomes in production.

 - Solid Results

### **FDE.17.13 - Improvement of cow feed efficiency and the production of consistent quality beef using molecular breeding values for RFI and carcass traits**

*Key highlights:* Feed costs are a leading production cost in both cow-calf and feedlot operations. Identifying cattle with the genetic potential to use feed more efficiently would be of tremendous value, provided there are no negative consequences on other economically important traits, particularly reproductive performance. This project divergently selected different cattle populations for high and low feed efficiency, and, looked for impacts on other traits. Keeping in mind that only three to four years of replacements have been selected to date (with few reaching maturity or culling yet), it appears that incorporating feed efficiency in a selection index has not had an immediate adverse effect on maternal traits in a cow-calf operation.

*Success stories:* Cows subjected to selection were able to repeat their maternal performance as selection progressed. Despite the short-term selection program and the limited sample size used in this study, it appears that a genetic improvement program that incorporates RFI in a selection index may not adversely affect maternal traits.



This study also used molecular breeding values (MBV) for carcass traits to sort feeder cattle into carcass endpoint groups. Less variability and more uniform carcass values were observed for steers sorted into MBV-Quality and MBV-Lean groups. For most of the slaughtered steers, MBV-Quality had heavier carcasses with more marbling while MBV-Lean had leaner carcasses. Additional validation is required on unrelated populations of commercial feedlot cattle.

✓ - Solid Results (*although five years is too brief to draw practically meaningful conclusions*)

### **FDE.19.13 - Understanding the physiology behind changes in feed efficiency throughout the finishing period**

Key highlights: Feed conversion efficiency declines the longer cattle are on feed. This is traditionally thought to be because they are getting fatter, and more feed energy is required to deposit fat than to grow muscle. However, some of this decline in efficiency may be related to digestive physiology and nutrient metabolism (e.g. insulin resistance), and, may be overcome by changing the dietary energy source from starch to fat.

Success stories: This research showed that partial substitution of barley or corn grain with a high-lipid high-fiber by-product pellet can be an effective dietary strategy for finishing beef cattle, with added benefits for rumen health. The high lipid pellet produces less efficient gains than barley or corn grain, so the decision to use this strategy will depend heavily on the relative costs of oilseed byproducts and cereal grains. Some of this loss in efficiency may be prevented by switching to a high lipid pellet only during the final stages of finishing.

🔍 - Partial or Incomplete Results    A large-scale feeding trial planned to validate results observed in the small pen feeding trials was not conducted due to collaborator hesitancy regarding trial cost and the value of further information derived from such a trial. Instead, a series of more detailed metabolic and metabolomic trials were conducted.

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## VALUE – WHAT DOES IT MEAN FOR INDUSTRY

Within the Feed Grain and Feed Efficiency priority area, 5.5/6 projects were successfully completed.

From 2008-12 to 2013-2017, the five-year average barley yield increased 14.5% or 8.7 bu/acre to 68.2 bu/acre. This means 415,640 fewer acres were required to produce the same amount of barley. Higher grain prices over the last decade has resulted in farmers switching to more profitable crops. From the 2011 to 2016 Census of Agriculture, the number of farms reporting barley decreased 17% from just under 30,000 farms to 25,000 farms. The number of acres in barley declined 3% or 200,000 acres to 6.7 million acres in 2016. Higher yields has meant more barley is currently being produced; more than offsetting the reduction in barley acres reported. More varieties are being registered with 31 barley and 6 triticale varieties between registered with CFIA between 2013 and 2017.

Feed efficiency has increased considerably in the past 50 years. The rise in efficiency is particularly attributable to breeding practices, improved animal health, growth promoting technologies, and nutritional management. With feed costs comprising the largest proportion of variable input costs for cow-calf and feedlot production, this represents significant savings. On the industry level, a 5% improvement in feed efficiency in the feedlot sector can reduce feed costs by over \$19 million annually (based on 2017 prices). New developments in genomics and feed quality further improve feed efficiency. The Feed:Gain ratio has been steadily declining 1.1% from 6.78 in 2003-2007 to 6.70 in 2008-2012, and declined another 6.7% to 6.25 in 2013-2017 (Meta-analysis of Canadian Journal of Animal Science



publications<sup>4</sup>) representing a saved value of \$61 million to industry in 2017. In addition, cattle in 2017 finished 15 days earlier on average than cattle in 2012, accounting for 41.5 million fewer days in total (Canadian Journal of Animal Science). This has major implications for reducing both feedlot costs and environmental footprints. For every 2% reduction in feed:gain, feed costs are reduced by \$7/head.

The calculated benefit cost ratio suggests large returns for research invested in Feed Grain and Feed Efficiency. For 2008-2013, the benefit cost ratio was 221, and every dollar invested into research created \$135 of value between 2013-2018.

RESEARCH INDICATORS	FINANCIAL IMPACT TO INDUSTRY <sup>†</sup> (MILLION \$)	
	2012	2017
From 2003-07 to 2008-12, the five-year average barley yield increased 4% (2.5 bu/acre) from 57.0 bu/acre to 59.5 bu/acre. From 2008-12 to 2013-2017, the five-year average barley yield increased 14.5% (8.7 bu/acre) to 68.2 bu/acre. This means 415,640 fewer acres were required to produce the same amount of barley. <i>Barley Varieties</i> <ul style="list-style-type: none"> <li>19 Triticale varieties were registered from 2008 to 2012, 6 Triticale varieties between 2013-2017</li> <li>48 Barley varieties were registered from 2008 to 2012, 31 Barley varieties between 2013-2017</li> </ul>	+\$94.0	+\$186.6
From 2003-07 to 2008-12 (five year average), the Feed:Gain ratio in finishing feedlots reported by journal articles has decreased 1.1% from 6.78 to 6.70. From 2008-12 to 2013-17, the Feed:Gain ratio further decreased 6.7% to 6.25. A 2% lower feedlot feed:gain reduces feed costs by \$7/head.	+\$13.9	+61.0
From 2008 to 2012, the average daily gain in feedlots reported by journal articles has increased 8.8% from 3.4lb/day to 3.7lb/day. From 2012 to 2017, the ADG further increased 10.8% to 4.1lb/day. This means 15 fewer days emitting GHG per head and 41.5 million fewer days in total.		
Steer carcass weights have increased 3.7% (31 lbs) from 842 lbs in 2008 to 873 lbs in 2012, and increased 2.7% (24 lbs) to 897 lbs in 2017	+\$159.5	+\$180.2
Weaning weight increased 13.8 lbs from 548.9 lbs (2003-07 average) to 562.7 lbs (2008-11 average) and another 16.1 lbs to 578.8 lbs (2013-17 average)	+\$99.7	+\$141.1
Productivity per cow decreased 13 lbs from 574 lbs/cow (2003-07 average) to 561 lbs/cow (2008-12 average) and another 46 lbs to 515 lbs/cow (2013-17 average). This is influenced by a larger proportion of cows and heifers in the slaughter mix.	-\$121.5	-\$562.3
<b>Net Change in cost to industry</b>	<b>+\$366.91</b>	<b>+\$568.94</b>
Total BCRC Investment	+\$1.66	+\$4.20
Benefit: Cost Ratio	220.77	135.31

<sup>†</sup>For assumption and calculation details, refer to Appendix A.

The Canadian Beef Research and Technology Transfer Strategy 2018-2023 has outlined four Feed Grains and Feed Efficiency research outcomes for the next five years, under which more specific target objectives are listed:

- Improved feed efficiency through animal breeding
- Improved feed supply and utilization
- Maintained feed grains and feed efficiency research and training capacity
- Extension, outreach, and policy

<sup>4</sup> Average daily gain values for control and trial groups from beef feedlot studies in the Canadian Journal of Animal Science were averaged for each year

## FORAGE & GRASSLAND PRODUCTIVITY

### OVERARCHING OBJECTIVE

Improve forage and grassland productivity in terms of nutritional value, yield, and ecosystem services. For example, through grassland management and developing annual and perennial forage varieties with increased biomass yield per acre, improved nutritional value, improved water efficiency, and appropriate economic characteristics.

**Background:** In terms of acreage, forage and grassland are the largest crops in Canada, with over 70 million acres used for livestock grazing, forage seed production, and the growing of forage crops (Yungblut, 2012). Forage is a crucial component of cattle diets and comprise the majority of cow-calf rations. The importance of improving forage and grassland productivity is increasing—higher grain prices result in the conversion of pasture to the production of annual crops, where productivity must increase on remaining land to support the same level of beef production. In addition, higher grain prices increase feeding costs, which exerts downward pressure on feeder calf prices and narrows the margins for cow-calf producers, increasing the need to reduce production costs. Developing forage varieties to improve yields and nutritional quality, as well as identifying innovative grazing and feeding strategies, will increase beef productivity per acre. Improved forage productivity has implications for both economic return and environmental sustainability through improved carbon sequestration, soil health, biodiversity, wildlife habitat, and watershed protection.

### OUTCOMES

**OUTCOME #1: Improvement in yields and nutritional quality of tame, native and annual forage species through improved pasture forage and grazing management and plant breeding:** Improved forage yields and nutritional quality are important to help offset the decline in forage acre due to competition from annual crops, and to ideally reverse this decline and the acreage seeded to tame and native forages. The objective of research on forage and grassland productivity is to increase research program capacity to develop annual and perennial forage varieties with increased yield, drought resistance, and nutritional value.

**OUTCOME #2: Environmental Sustainability:** Improvements in productivity and efficiency have clear implications for environmental sustainability. Improvements in feed efficiency reduce the amount of methane and manure produced and resources used per pound of beef. Improvements in forage productivity lead to several environmental benefits, including increased carbon sequestration, improved wildlife habitat and biodiversity, watershed maintenance, and reduced soil erosion. However, these environmental benefits of the Canadian beef industry have never been thoroughly quantified.

**OUTCOME #3: Research and Training Capacity:** Forage breeding and management research expertise have been in decline for over three decades. Supporting graduate students and post-doctoral researchers with potential leadership characteristics for future forage breeding and management research is needed to help slow and ideally reverse this decline.

**OUTCOME #4: Extension, Outreach and Policy:** Translating research results into a form and forum that is accessible and useful to producers and policy-makers is essential to ensure industry uptake and improved beef industry competitiveness and sustainability, and that policy potentially impacting Canada's beef industry is based on sound science.

### PROJECT FINDINGS

#### **FRG.04.13 - Innovative swath grazing/increasing forage research capacity**

*Key highlights:* Winter feed costs are the largest variable production cost facing cow-calf producers in Canada. The focus of this research was to identify optimal combinations of annual crops, agronomic

practices and regional considerations that provide the most economical extended grazing practices to meet the cow herd's nutritional requirements through the winter-feeding period. These approaches have economic and environmental benefits. Significantly less fuel is needed to bale, transport, process, and deliver feed, clean pens and spread manure. Forage quality throughout the grazing period was extremely variable but corn maintained its nutrient quality better than cereals. This suggests that producers may want to graze cereals early on in the grazing season and save corn grazing for later.

*Success stories:* Through this project researchers calculated that on average, swath grazing 100 cows for 100 days reduces diesel fuel use by 2,534 L. Researchers were also able to show that one cow winter grazed for 100 days reduces her carbon footprint by 18.27 kg of carbon.

✓ - Solid Results

### **FRG.08.13 - Development of native plant material (grasses, legumes) and mixtures for forage production in the Prairie Region**

*Key highlights:* This long-term breeding program has been a collaboration between researchers in Saskatchewan, Alberta, Manitoba and Quebec. They have used both traditional and genomic breeding approaches to characterize differences in the ability of native grasses (nodding brome, rough fescue, prairie sand reed, northern wheatgrass, bluebunch wheatgrass), native legumes (purple prairie clover, white prairie clover, slender milkvetch, Canadian milkvetch, ascending milkvetch), tame grasses (hybrid brome, crested wheatgrass, green wheatgrass, meadow brome) and tame legumes (alfalfa, sainfoin) to establish, persist in the stand, resist weeds, and produce high yields of forage and seed yields under a range of soil moisture and nutrient conditions.

*Success stories:* Breeding efforts have produced several potential lines for commercialization. These were aided by new genomic tools developed in the program for grasses as well as new selection techniques specifically for alfalfa.

There were benefits to adding native plant materials to mixtures such as improved stability and production under extreme climatic situation that will result in decreased production risks.

Inclusion of sainfoin with grass at a 30:70 improved productivity.

✓ - Solid Results

### **FRG.09.13 - Nutritional Evaluation of Barley Forage Varieties for Silage and Swathgrazing**

*Key highlights:* This project was designed to help beef producers decide which barley variety to grow for high yielding, high quality barley silage.

Barley varieties grown for silage by beef and dairy producers vary in nutrient content and digestibility of structural carbohydrates including the NDF fraction, which could impact intake, rumen function and performance. Little effect of silage variety was observed over the entire feeding period, but cattle fed CDC Cowboy (higher NDF) exhibited poorer performance during backgrounding, although this did minimize issues with digestive disturbances by minimizing pH reduction.

When the three varieties previously identified as differing in NDF digestibility were grown at the same location and ensiled at same stage of maturity, no differences in NDFD were identified. This suggests that barley variety may have less of an impact on NDFD than growing and ensiling conditions. However, differences observed among varieties were noted in terms of VFA concentrations such as higher butyrate and acetate that could impact aerobic stability of the silage. A continuation of research in this field would need to take into account the differences in growing seasons. However, first and foremost, producers must ensure they have the best ensiling practices possible; attempting to improve silage digestibility is wasted if the technique is not conducive to quality fermentation.

There was no difference in digestibility of the barley silage varieties selected based on *in vitro* NDFD of field silage samples. Selection for *in vitro* NDFD of field samples of barley silage may not improve total tract digestibility or lamb performance, as the silage varieties did not maintain their field NDFD ranking in the feeding trial. Selection of barley forage varieties with improved NDFD based on analysis of silage could prove difficult owing to the myriad of factors that can influence the nutrient composition and digestibility of silage.

Success story: Nutritional characteristics such as neutral detergent fiber (NDF) content and digestibility vary between varieties so consideration to nutritional as well as agronomic characteristics is important when selecting varieties for silage production. This finding is supported by the results of the feedlot performance trial where cattle fed CDC Cowboy (a variety with high NDF content) had poorer performance in the backgrounding period than those fed Xena or CDC Copeland. Silage variety was not as critical when finishing steers or lambs due to the reduced silage content of finishing diets. There was no marked effect of variety on total tract nutrient digestibility in either lambs or heifers. Finally, there were minimal differences between varieties in silage quality other than poorer aerobic stability for CDC Cowboy.

NDFD is difficult to maintain from one year to the next, particularly when environment, location and soil type vary. While agronomic factors and ensiling technique remain critical factors affecting silage quality, there are differences in nutritional parameters such as NDF content that can affect animal performance.

✓ - Solid Results

#### **FRG.13.13 - Pasture mixtures and forage legumes for the long-term sustainability of beef production**

Key highlights: Commercial forage seed mixtures are usually developed to achieve a particular seed price. This research is focused on identifying combinations of forage seed varieties that optimize forage quality, yield and animal productivity in Eastern Canada.

Success stories: Animal gain per hectare was 40% higher in cattle grazing mixtures containing trefoil than for those grazing mixtures containing alfalfa. This result was unexpected, given that alfalfa-based mixtures had greater forage yield, protein content, and total digestible nutrients. Forage mixtures with timothy and meadow fescue showed a greater average daily gain than those with tall fescue. Some forage species and some cultivars within species were shown to have greater yield and nutritional quality than others. A broader national evaluation comparing species and cultivar combinations under grazing would benefit Canada's beef industry.

✓ - Solid Results


#### **FRG.14.13 - Building long-term capacity for resilient cow-calf production systems through creation of a forage industry chair supporting training and research in evaluation and utilization**

Key highlights: Crop selection and winter grazing management recommendations need to be developed on a regional basis to ensure that they appropriately reflect and consider regional variations in the length and severity of both growing seasons and winter temperatures. This project evaluated a range of perennial and annual forage varieties for extended winter grazing of mature cows and bred heifers in Manitoba. This research provided valuable information regarding the ability of alternative extended winter feeding systems to meet the nutritional needs of younger animals that have higher nutrient demands to accommodate continued animal growth as well as maintain pregnancy and body condition score.

Success stories: There is good potential to extend the grazing season using stockpiled forages in Manitoba. Corn offers the highest potential based on yield, total digestible nutrients and relative feed value but protein supplementation may be needed depending on the maturity of animals grazing and stage of gestation.

Corn significantly alters grazing behavior of cattle during adverse weather, enabling them to graze for longer periods of time without seeking shelter.

Stockpiling perennial grass and legume species can produce greater than 3.0 tonnes/ha of forage from July to mid-October in Saskatchewan. Meadow brome grass produced the highest stockpiled and seasonal yields in both pure stands in a mixture with legumes.

 - Solid Results

### **ENV.02.13 - Environmental footprint of the Canadian beef industry**


*Key highlights:* The environmental impact (footprint) of agricultural commodities, including beef, has become increasingly important and is attracting public interest and debate. The environmental footprint of the beef industry is complex with implications for greenhouse gas emissions, nutrient cycling, water and air quality, carbon storage, and grassland and wetland ecosystems.

The beef industry's potential environmental impacts (both negative and positive) are understood in a general sense as many individual impacts have been studied in research projects over the years. This project is the first to pull all available data together into a reliable summary of what the greenhouse gas, water and ammonia footprints of Canada's beef industry actually are, and how they have changed over the years. The project also established frameworks for assessing the water footprint, impact on biodiversity and ecosystem services provided by the livestock sector, laying the groundwork for subsequent quantitative analyses for these two important aspects of a holistic environmental footprint assessment.

*Success stories:* The analysis of greenhouse gas emissions from Canadian beef production between 1981 and 2011 showed that producing the same amount of beef in 2011 required 29% less breeding stock, 27% fewer slaughter cattle and 24% less land, with a 15% reduction in greenhouse gas emissions compared to 1981.

The water use intensity of Canadian beef production (liters per kg beef) declined by 17% over the 30-year period between 1981 and 2011. Since feed production accounted for 99% of water use in beef production, further reductions in water use intensity will need to focus on improved feed production and feed efficiency.

Comparing ammonia emissions showed that ammonia losses per kilogram of beef decreased by 20% from 1981 to 2011. This reduction in emission intensity was mainly attributed to increases in reproductive efficiency, average daily gain and slaughter weight, and an overall improvement in productivity per breeding herd over the study period.

 - Partial or Incomplete Results    The project plan originally called for estimation of the beef industry's impact on biodiversity and C sequestration, provided adequate data was available to do so (with the Council's understanding). The data available for both factors was incomplete, and highly regional. Ammonia emissions were estimated instead. Efforts to gather additional C sequestration and biodiversity data are ongoing.

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### **VALUE – WHAT DOES IT MEAN FOR INDUSTRY**

Within the Forage and Grassland Productivity priority area, 5/6 projects were successfully completed.

Forage quality significantly influences cattle performance, especially for the cow-calf and backgrounding sectors. Not only can maintaining high productivity grasslands result in direct economic benefits for cattle production, ecosystem services can also be generated. Continual improvements in forage productivity is

necessary to support Canada's international competitiveness. A key challenge is measuring and valuing forage, which can result in underinvestment in this critical area. As only a small proportion is traded, where the majority is produced and used on farm, a stable market price can be difficult to establish. This is compounded by the fact that costs of forage production are rarely measured and are highly variable across regions.

Canadian tame hay yields increased 8% on average from 1.69 tons per acre in 2003-07 to 1.84 tons per acre in 2008-12 and increased another 2% to 1.88 tons per acre in 2013-2017. Higher yields however are not offsetting smaller acres which have reduced total hay production from 27.8 million tons in 2008-12 to 26.6 million tons on average in 2013-17. Total hay acres have decreased 28.2% from 19.7 million acres in the 2006 Census of Agriculture to 14.1 million acres in the 2016 Census of Agriculture. In addition to weather disruptions, this has resulted in higher hay prices negatively impacting cow-calf competitiveness. Alberta hay prices have increased from \$62.16/ton in 2008-12 to \$116.39/ton in 2013-18. The Canadian cow-calf sector is unlikely to expand without a more competitively priced source of winter feed.

In 2016, 21,164 farms (35.4% of beef farms) reported they used in-field winter grazing or feeding, down from 30,260 farms (44.2% of beef farms) in 2011 (Census of Agriculture). Data from Alberta indicates that confinement feeding costs increased from approximately \$1.75/head per day in 2013 to \$2.80-3.50/head (mixed ration vs. straight hay with yardage and bedding) per day in 2018, while grazing stockpiled pasture costs increased from approximately \$1.02/head per day in 2013 to \$1.50/head per day in 2018. Each day of extended grazing increased in value from \$0.73/head per day in 2013 to \$1.30-1.75/head per day in 2018 depending on the ration. As hay costs have increased the savings from extensive grazing during the winter have increased as well. Extending the grazing season by a single day, for 4.4 million beef cows and replacement heifers (as of January 1, 2018), would represent nation-wide savings of nearly \$6.7 million per year. This does not include the cost savings associated with increasing productivity that allows for increased carrying and feeding capacity on fixed acreage, which will also reduce winter feeding costs. Producers must balance the cost savings from in-field or extensive winter feeding with the trade-offs of maintaining body condition scores and impacts on reproductive efficiency.

The calculated benefit cost ratio suggests returns are decreasing for research investment in Forage and Grassland Productivity. For 2008-2013, the benefit cost ratio was 0.07, and 0.01 for 2013-2018, suggesting that every dollar invested into research created \$0.01 of value for 2013-2018. This is positive but also indicates that further investment would not necessarily be beneficial.

RESEARCH INDICATORS	FINANCIAL IMPACT TO INDUSTRY <sup>5</sup> (MILLION \$)	
	2008-12	2013-17
The five-year average <sup>5</sup> tame hay yield increased 8% from 1.69 tons/acre in 2003-07 to 1.84 tons/acre in 2008-12 and increased another 2% to 1.88 tons/acre in 2013-17	+\$0.14	+\$0.07
<i>Newly registered forage varieties</i>	<u>2008-12</u>	<u>2013-17</u>
• Alfalfa	58	68
• Bromegrass	6	3
• Ryegrass	4	27
• Clover	11	18
• Birdsfoot trefoil	1	1
• Orchardgrass	8	16
<i>Grassland productivity</i>	From 2006 to 2011, total hay acres decreased by 14.0% or 2.7 million acres from 19.7 million to 16.9 million acres. From 2011 to 2016, total hay acres decreased 16.6% or 2.8 million acres to 14.1 million acres.	

<sup>5</sup> As annual forage yields can be significantly impacted by weather patterns (drought, flooding). The five-year average is used here.

<ul style="list-style-type: none"> <li>• From 2006 to 2011, natural pasture acres decreased by 4.7% or 1.8 million acres from 38.16 million to 36.33 million acres. From 2011 to 2016, natural pasture acres decreased 3.0% or 1.1 million acres to 35.24 million acres.</li> <li>• From 2006 to 2011, tame or seeded pasture acres decreased by 2.4% or 340,000 acres from 14.01 million to 13.67 million acres. From 2011 to 2016, tame or seeded pasture acres decreased 8.2% or 1.1 million acres to 12.56 million acres. This decline reflects the reduced cattle inventories and consequently reduced demand for forage.</li> <li>• From 2006 to 2011, percentage of Canadian agricultural land in pasture decreased by 0.1% from 31.3% to 31.2%. From 2011 to 2016, percentage of Canadian agricultural land in pasture decreased by 1.1% from 31.2% to 30.1%.</li> </ul>		
<i>Best management practices</i>		
<ul style="list-style-type: none"> <li>• In 2016, 29,713 farms (49.7% of beef farms) reported they use rotational grazing, compared to 51,589 farms (75.4% of beef farms) in 2011 and 70,798 farms or 82% in 2006. Part of the decline is from producers leaving the industry.</li> <li>• In 2016, 21,164 farms (35.4% of beef farms) reported they used in-field winter grazing or feeding, compared to 30,260 farms (44.2% of beef farms) in 2011</li> <li>• The number of acres that receive fertilizer have been steady from 2006 (37.5% of total farm area) to 2011 (38.4% of total farm area), and increased from 2011 to 2016 (44.3% of total farm area)</li> </ul>		
<b>Net Change in cost to industry</b>	+\$0.14	+\$0.07
Total BCRC Investment	+\$1.93	+\$5.15
Benefit: Cost Ratio	0.07	0.01

†For assumption and calculation details, refer to Appendix B.

The Canadian Beef Research and Technology Transfer Strategy 2018-2023 has outlined three Forage and Grassland research outcomes for the next five years, under which more specific target objectives are listed:

- 15% Improvement in yields and nutritional quality of tame, native and annual species through improved pasture, forage and grazing management and plant breeding
- Maintained forage research and training capacity
- Extension, outreach and policy



## BEEF QUALITY

### OVERARCHING OBJECTIVE

To increase consumer demand and willingness to pay for Canadian beef, both domestically and internationally, through increasing carcass quality and uniformity, product development, improving the consumer sensory experience, and continued investments in carcass quality and grading technologies.

**Background:** The quality of Canadian beef is an important factor that differentiates Canadian beef from competitors' beef, contributing to Canada's competitiveness locally and around the world. Traditionally Canada has successfully produced a youthful, lean product from a primarily grain-based feedlot production system that responds to a grading system that rewards for certain characteristics. As consumer preferences and competitor attributes continually change, the beef industry recognizes the importance of strengthening Canada's competitive advantages through evolving carcass and meat quality and adapting to market demands.

One key method of Canadian beef differentiation is through building the Canadian Beef Advantage brand in domestic and international markets. Significant effort has been invested by industry to develop this strategy, which focuses on several differentiating attributes relating to animal production, profitability, health and beef safety, quality, and nutrition. Through establishing a distinct value to customers, a competitive advantage for Canadian beef is developed. Successful brand differentiation is contingent upon consistent delivery of high-quality tender beef that meets consumer expectations.

The National Beef Quality Audit (NBQA) and carcass and meat quality research that provide objective measures are central to the goal of improved beef quality. Firstly, through identifying areas for improvement along the supply chain to accelerate enhancements in quality. Secondly, through establishing objective indicators of quality that substantiate the points of differentiation for Canadian beef, enhancing our industry's ability to position Canadian beef against competitive products domestically and internationally.

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### OUTCOMES

**OUTCOME #1: Improved Consumer Satisfaction with Canadian Beef:** While previous research findings have shown that consumer education is needed to maximize eating quality, additional beef quality research is needed to improve tenderness in lower quality cuts and improve product consistency by reducing carcass quality defects, such as dark cutters. Further research on genetic markers of tenderness is needed to determine how selecting for tenderness may impact other important production traits such as reproductive performance.

**OUTCOME #2: Validation of the Canadian Beef Advantage Relative to International Competitors:** Research is needed to ensure that claims made regarding the quality, safety and practices used to produce Canadian beef are defensible in both domestic and international markets

**OUTCOME #3: Extension, Outreach and Policy:** When research develops cost-effective methods of improving the quality of Canadian beef, it is essential that this information be communicated to the cattle producers or packers who may benefit from implementing it. Similarly, research results that can inform relevant beef grading regulations or regulatory approvals need to be made available to the relevant policy makers.

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### PROJECT FINDINGS

#### **BQU.01.13 - Effect of high pressure processing on quality, sensory attributes and microbial stability of marinated beef steak during refrigerated storage**

**Key highlights:** High pressure processing is used for commercial applications in many parts of the world to extend the shelf life of ready-to-eat meat products. However, research has shown that fresh muscle foods are susceptible to pressure-induced colour change which has limited the adoption of HPP for raw meat

applications. Marinating is commonly used by the meat industry to enhance moisture and improve the texture of meat products. Colour imparted by the marinade may partially mask undesirable discoloration caused by the HPP treatment. The objective of the study was to determine the effects of high pressure treatments on quality, nutrition, sensory and shelf life extension of marinated beef steaks.

Beef steaks were marinated and further processed using HPP technology at the Food Processing Development Centre (FPDC). Preliminary screenings altered product formulations and processing parameters including pressure and time of HPP to find the best potential parameters for this product.

Treatment of marinated steaks at 450 MPa/3min significantly extends shelf life without adverse effects on the meat quality, nutrition, or sensory attributes measured in this study. This work demonstrates that marinating raw meats prior to HPP has the potential to expand the application of HPP to value added raw meat products.

Success Story: The application of HPP to teriyaki and honey garlic steak were submitted to Health Canada for approval on June 3, 2015. This project contributes to the Health Canada's decision that "any food except fish and seafood that has been treated for HPP for the sole purpose of shelf life extension is no longer considered a novel food". A letter of non-novelty for these HPP-treated foods was issued by Health Canada on April 8, 2016.


 - Solid Results

### **BQU.03.13 - Genetics and Proteomics of dark cutting cattle in Alberta**

Key highlights: Data from a single farm (44 heifers, 136 steers) from three normal beef quality grades and the dark cutting grade (n = 35 AAA, 106 AA, 28 A and 11 B4, respectively) were used to identify relationships between sex, live animal and carcass characteristics and the incidence of dark cutting. Dark cutting is more likely in cattle that are female, light weight (at weaning or slaughter), slow growing, or have low feed intake.

The risk of dark cutting was highest in cattle that were briefly moved from the abattoir to a temporary feedlot and then returned to abattoir. Differences existed in enzymes controlling metabolism of glycogen. Early genetic association studies indicated that four gene regions are of interest for dark cutting. Further research on data collected from industry partners will be used to test the influence of growth promotants on the incidence of dark cutting.

Success Story: This project was conducted with industry engagement, represented a comprehensive study of dark cutting, and improved our understanding as to why dark cutting occurs in Canada.

 - Partial or Incomplete Results

The research team was unable to determine the effects of implants, beta-agonists and MGA on the risk of dark cutting were not determined because the commercial co-operators were unable or unwilling to share this information.


The researchers originally intended to screen genomic databases for SNP markers related in the gene regions identified, but this was not completed.

### **BQU.06.13 - Genetics of the eating quality of high connective tissue beef**

Key highlights: Inconsistent tenderness is one of the main consumer beef quality concerns. Tenderness is determined by both muscle cell proteins (how quickly they break down during aging), as well as connective tissue. Muscles like the outside round that have higher amounts or more extensively linked connective tissue are tougher than those with less. Genetic markers for beef tenderness based on the calpain and calpastatin genes (which are involved in tenderization during aging) have been available for several years

and work well in muscles with low connective tissue content (e.g. ribeye). However, these markers do not identify animals that differ in connective tissue content or cross-linking (e.g. outside round).

Success stories: This project identified six genetic markers associated with collagen levels and solubility. If successfully validated in a genetically-independent population, these markers may provide another avenue to improve beef quality in seedstock and commercial beef cattle.

 - Solid Results

### **BQU.07.13 – National Beef Quality Audit**


Key Highlights: The current National Beef Quality Audit (NBQA) identified areas where overall improvement has occurred in industry practices, translating to measurable differences in beef quality and food safety in processing plants and at retail. Importantly, success is also measured by identifying areas where concerns are developing such that strategies can be developed to mitigate them.

At the plant level, incremental progress has been made in the reduction of prevalence of horns, bruising, and condemnations, indicating industry adoption of welfare-friendly practices is occurring. However, the NBQA also identified increases in fed-cattle brands which may be related to protection against theft due to record high prices since 2014. At the same time, there have been increases in injection site lesions and the severity of liver abscesses. The cooler audit indicated a shift towards higher quality grades (increased marbling) with a decrease in yield grade (decreased lean meat yield). Overall the cost of these defects has increased by 15% for fed cattle and 5% for non-fed cattle.

At retail, progress has been made at improving the quality of the more economical cross-rib and inside round cuts, with smaller improvements for the higher priced strip loin and top sirloin cuts. Evaluation against competitors' product entering Canada (Mexican beef strip loins) demonstrated measurable quality advantages for Canadian product. Tenderness may have reached an upper limit in higher value cuts. Continued increase in carcass weights and rib-eye areas necessitate thinner retail steak fabrication to meet ideal portion sizes, which continues to impact top sirloin and inside round cuts. Consumer satisfaction scores obtained following preparation of steaks at home (79%) are essentially equivalent to those found in the previous audit (80%).

Success Stories: The 2014-2018 National Beef Quality Audit represents the most comprehensive benchmark of beef quality ever performed in Canada. Elements included a Customer Satisfaction Survey, Beef Tenderness Survey, Shelf Life Microbiology Survey, Injection Site Lesion Survey, Meat Case Survey, Cooler Carcass Audit, Processing Floor Audit, and a stakeholder survey focused on current perceptions and quality priorities with input from processors, retailers, foodservice, distributors, feedlot and cow-calf producers.

The 2014-18 NBQA findings indicate that beef quality and consumer satisfaction attributes are most often slightly improved or stable relative to the NBQA completed five years prior. Some carcass defects show improvement, while others need further improvement. The overall cost of quality defects at the carcass level is estimated at \$84.49/head for fed cattle and \$47.27 for non-fed animals. On a cumulative basis the total losses due to carcass quality defects approach \$200 million for the Canadian cattle sector.

 - Solid Results

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### **VALUE – WHAT DOES IT MEAN FOR INDUSTRY**

Within the Beef Quality priority area, 3/4 projects were successfully completed.

Improvements in beef quality support consumer preferences for beef, and results in increased consumption and a higher willingness to pay for beef. On a sensory level, beef quality can be reflected

through tenderness, juiciness, flavour, and consumer satisfaction. Overall, quality attributes can encompass animal production strategies, health and beef safety, quality, and nutrition. Through establishing the distinct quality of Canadian beef, a competitive advantage can be created. Canadian beef can be differentiated in international and domestic markets as a leader in beef quality.

While quality grading continues to improve, Canada remains well behind the sharp gains seen in the United States. At the same time, the portion of yield grade (YG) 3 cattle are on the verge of overtaking the number of YG1 cattle. This is a trend seen across North America with strong demand for marbling offsetting any price signal for yield grades.

The proportion of dark cutting carcasses decreased in the last five years closer to historic levels. And consumer satisfaction remains high.

The calculated benefit cost ratio suggests returns are increasing for research investment in Beef Quality. The benefit cost ratio was 3.23 for 2008-2013 and increased to 18.19 for 2013-2018, suggesting that every dollar invested into research created \$18.19 of value for 2013-2018.

RESEARCH INDICATORS	FINANCIAL IMPACT TO INDUSTRY <sup>†</sup> (MILLION \$)																																																																																											
	2008-12	2013-17																																																																																										
<i>Quality Grading</i> AAA and Prime as a percentage of all A grades increased from 51.6% in 2008 to 56.7% in 2012 and increased to 63.2% in 2017.	+\$4.6	+\$19.0																																																																																										
<i>Yield Grades</i> 1. Y1 decreased 12% from 60.8% in 2008 to 48.8% in 2012, and decreased 13% from 2012 to 2017 to 36.2% in 2017 2. Y2 increased 5.2% from 28.4% in 2008 to 33.5% in 2012, and stayed steady at 33.5% in 2017 3. Y3 increased 6.9% from 10.9% in 2008 to 17.7% in 2012, and increased 13% from 2012 to 2017 to 30.3% in 2017	-\$18.8	-\$38.9																																																																																										
<i>Dark Cutters</i> From 2008 to 2012, B4 incidence declined 0.2% from 1.4% of youthful slaughter in 2008 to 1.2% in 2012. From 2012 to 2017, B4 incidence increased 0.4% from 1.2% to 1.6% in 2017	+\$0.91	-\$3.6																																																																																										
<i>Tenderness</i> <ul style="list-style-type: none"> <li>Overall consumer satisfaction rose from 73% in 2001 to 80% in 2009, and dipped slightly to 79% in 2015</li> <li>Satisfaction drivers: percentage of satisfied customers*</li> </ul> <table border="1"> <thead> <tr> <th rowspan="2">Steak Type</th> <th colspan="3">Tenderness</th> <th colspan="3">Juiciness</th> <th colspan="3">Flavour</th> <th colspan="3">Overall</th> </tr> <tr> <th>2015</th> <th>2009</th> <th>2001</th> <th>2015</th> <th>2009</th> <th>2001</th> <th>2015</th> <th>2009</th> <th>2001</th> <th>2015</th> <th>2009</th> <th>2001</th> </tr> </thead> <tbody> <tr> <td>Strip loin</td> <td>85%</td> <td>84%</td> <td>82%</td> <td>81%</td> <td>87%</td> <td>82%</td> <td>86%</td> <td>86%</td> <td>85%</td> <td>88%</td> <td>87%</td> <td>84%</td> </tr> <tr> <td>Top sirloin</td> <td>80%</td> <td>83%</td> <td>76%</td> <td>80%</td> <td>88%</td> <td>81%</td> <td>83%</td> <td>90%</td> <td>82%</td> <td>83%</td> <td>86%</td> <td>83%</td> </tr> <tr> <td>Boneless cross rib</td> <td>68%</td> <td>71%</td> <td>58%</td> <td>74%</td> <td>72%</td> <td>62%</td> <td>81%</td> <td>79%</td> <td>69%</td> <td>75%</td> <td>75%</td> <td>65%</td> </tr> <tr> <td>Inside round</td> <td>60%</td> <td>63%</td> <td>55%</td> <td>60%</td> <td>65%</td> <td>61%</td> <td>71%</td> <td>70%</td> <td>69%</td> <td>68%</td> <td>69%</td> <td>59%</td> </tr> <tr> <td>ALL STEAKS</td> <td>73%</td> <td>76%</td> <td>68%</td> <td>74%</td> <td>78%</td> <td>72%</td> <td>80%</td> <td>82%</td> <td>76%</td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>*A satisfied customer was defined as one who gave a rating of 7/10 or higher</p> <p>Laboratory measurements backed up consumer comments. Shear force tests conducted at the AAFC Lacombe Research Centre found the percentage of steaks requiring no tenderness enhancement increased for inside round (2001 52%; 2011 61%; 2015 87%) and cross-rib (2001 65%; 2011 76%; 83%) steaks, while it fluctuates for striploin (2001 89%; 2011 99%; 2015 85%) and top sirloin (2001 70%; 2011 87%; 2015 84%) steaks.</p>			Steak Type	Tenderness			Juiciness			Flavour			Overall			2015	2009	2001	2015	2009	2001	2015	2009	2001	2015	2009	2001	Strip loin	85%	84%	82%	81%	87%	82%	86%	86%	85%	88%	87%	84%	Top sirloin	80%	83%	76%	80%	88%	81%	83%	90%	82%	83%	86%	83%	Boneless cross rib	68%	71%	58%	74%	72%	62%	81%	79%	69%	75%	75%	65%	Inside round	60%	63%	55%	60%	65%	61%	71%	70%	69%	68%	69%	59%	ALL STEAKS	73%	76%	68%	74%	78%	72%	80%	82%	76%			
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<b>Net Change in cost to industry</b>	+\$6.39	+\$22.61																																																																																										
Total BCRC Investment	+\$1.98	+\$1.24																																																																																										
Benefit: Cost Ratio	3.23	18.19																																																																																										

†For assumption and calculation details, refer to Appendix A.

The Canadian Beef Research and Technology Transfer Strategy 2018-2023 has outlined three Beef Quality research outcomes for the next five years, under which more specific target objectives are listed:

- Improve consumer satisfaction with Canadian beef
- Validate and support the Canadian Beef Advantage
- Extension, outreach and policy

## FOOD SAFETY

### OVERARCHING OBJECTIVE

Reduce food safety incidences to maintain consumer demand for beef domestically and internationally through the development of improved food safety interventions, methods to quantify the effectiveness of food safety interventions, and the development of food safety intervention strategies that counteract multiple pathogens.

**Background:** Food safety incidents have severe consequences in terms of health risks, economic cost of recalls, and loss of consumer confidence. Recalls can result in short, medium, and long term losses from lost confidence. Thus, maintaining domestic and international consumer confidence and trust is of the utmost importance. Canada has made large strides towards reducing food safety risks, with the number of reported *E. coli* O157:H7 cases from the Public Health Agency of Canada (PHAC) reducing 70% from 2002 to 2016.

### OUTCOMES

**OUTCOME #1: Improved Food Safety along the Beef Supply Chain:** Investments in food safety research improve the effectiveness and practicality of interventions that eliminate pathogens and reduce risks of contamination. Despite considerable improvements in beef safety, studies have shown that STEC, the most common pathogen, accounts for 34.6% of incidents internationally. Since 2000, 13 STEC outbreaks linked to beef have occurred in Canada, which resulted in costly product recalls. While technologies implemented at the processing level involving heat and sprays have been shown to be effective in removing STEC from carcasses, further work with commercial packing plants is necessary to evaluate whether these interventions are being appropriately implemented, operated and monitored to avoid contamination of beef and equipment in the packing plant, as well as to improve product safety and shelf life.

**OUTCOME #2: Responsible Antimicrobial Use Demonstrated:** Research to date has generally found that antimicrobial resistance found in bacteria associated with beef is very low and has not increased over time. However, continued research on antimicrobial resistance is needed to monitor the issue, as well as to study whether antimicrobial use in a feedlot may lead to 'downstream' resistance in the environment and humans.

**OUTCOME #3: Improved Beef Quality and Food Safety Research and Training Capacity:** Research capacity is needed to help address issues of importance to the Canadian beef industry and to speak objectively to consumers, global trading partners and other interested stakeholders on an independent basis. There is also value in ensuring that expertise and capacity available when required to quickly address unanticipated research needs and to proactively addresses public good and competitiveness issues.

**OUTCOME #4: Extension, Outreach and Policy:** It is essential that research findings with the potential to cost-effectively improve the safety of Canadian beef be communicated to cattle producers or packers who could best implement it. Similarly, research results that can inform relevant food safety regulations need to be made available to the relevant policy makers in an understandable manner.

### PROJECT FINDINGS

#### **FOS.01.13 - Prevalence, Persistence and Control of Non-O157 Shiga Toxin Producing *Escherichia coli***

**Key highlights:** The primary objective of the study was to determine the prevalence of and characterize the Top 6 STEC isolated from beef processing operations. The study compared three AOAC approved RT-PCR screening methods for Top 6 STEC. Samples were collected from the holding area, stun floor, hides

and de-hided carcasses. The GDS-Biocontrol RT-PCR returned a presumptive prevalence of 54% Top 6 non-O157 STEC with BAX and PALLgene recording a prevalence >88%. However, attempts to recover Top 6 non-O157 STEC from presumptive positive cultures proved unsuccessful, with only 114 of the 2400 isolates screened possessing the full complement of virulence factors (*stx*, *eae*). The virulence factors of all but two of the 114 isolates were unstable and readily lost during sub-culturing. The only virulent isolates harboring stable virulence factors were identified as O76 and O187:H52, neither of which belong to the Top 6 non-O157 STEC. These results indicate that the prevalence of Top 6 non-O157 STEC is very low in Canada, although cattle harbor a diverse range of *E. coli* serotypes. However, significant genetic exchange during enrichment can lead to an over-estimation of prevalence and problems when attempting to undertake culture confirmation of presumptive positive samples. The clinical significance of temporary acquisition of virulence factors by *E. coli* needs to be elucidated.

**Success Story:** Virulence genes (principally *stx* encoding for shiga toxin) that are required to make *E. coli* toxigenic, are widely distributed in processing and associated with cattle. However, strains harboring all the virulence factors associated with cattle and their environment are relatively rare.

Rapid screening genetic tests based on detection of virulence genes and genes encoding for O serogroups return a high level of false-positive results. The false-positives were not the result of gene mis-identification, but because the targets were present in different cells. There was also evidence that *stx* genes are mobile during enrichment, leading to false-positive results.

No Top 6 colonies were recovered from any of the samples screened. A total of 74 isolates harbored virulence genes along with a toxin producing phenotype, but only two were EHEC. Shiga toxin production in the other 72 isolates was unstable and readily lost.

Although no Top 6 serotypes were recovered from samples of Enteropathogenic *E. coli*, the EPEC could be converted to Top 6 by acquisition of *stx*. However, acquired toxin producing ability was unstable and readily lost. In Canada, the food safety risks associated with the Top 6 STEC associated with beef appear to be low and likely less than for *E. coli* O157:H7.



- Partial or Incomplete Results

The original research plan also called for sample collection in both Alberta and Ontario, but only Ontario samples were collected. Fortunately, an independent study jointly funded by ALMA and AI-BIO studied this question in large commercial plants in Alberta.

#### **FOS.04.13 - Identification and validation of commercially practicable practices and procedures for improving the microbiological safety stability of beef**

**Key highlights:** In commercial practice, *E. coli* can essentially be eliminated from dressed beef carcasses. However, this achievement is not always maintained due to sporadic (re)contamination. This project characterized which beef packing plant practices are effective for controlling pathogenic and spoilage bacteria.

The efficacy of an on-line hide-on carcass wash, a practice currently being used at some large commercial packing plants, was tested in winter, spring and fall. The hide-on wash was effective for reducing the numbers of bacteria on carcasses. *E. coli* was susceptible to the treatment but can be transferred from the hide to the carcass during skinning as well as from sources other than the hide during the dressing process.

Dry chilling is commonly used in small beef abattoirs in many countries, but its effects on the rate and extent of inactivation of bacteria on carcasses during commercial dry chilling were largely unknown. Dry chilling reduced the numbers of aerobes by 1 log unit after the first hour of cooling, and by a further log



unit during the subsequent 23 hour of chilling. Coliforms (predominantly *E. coli*) were recovered from carcasses before chilling at numbers about 2 log cfu 4000 cm<sup>-2</sup>. Very few coliforms or *E. coli* were recovered after 24 h, and no such organisms were recovered after 67 h. The dry chilling process at the packing plant involved in the study was very effective for improving the microbiological safety and quality of beef carcasses.

A common process used to clean and sanitize commercial fabrication facilities and equipment was found to be largely ineffective for reducing numbers of indicator bacteria. The cleaning process was modified and found to effectively reduce the numbers of all three indicators organisms on conveying equipment.

Even though a storage life of 120 to 140d is attainable in vacuum packaged beef, it can spoil well before this due to blown pack spoilage (BPS) caused by gas produced by *C. estertheticum*. As few as 30 *C. estertheticum* spores can pose a risk of BPS for vacuum packaged beef of normal or higher pH. To cause BPS, the spores of *C. estertheticum* have to germinate. Spores can resist harsh environments like the decontaminating interventions routinely applied at meat packing plants. To control BPS, interventions were developed to induce spore germination, then inactivate the germinated spores.


#### Success Stories:

1. The on-line hide on carcass microflora showed that the hide-on wash is a very effective intervention for controlling *E. coli* on beef carcasses. These findings have been communicated with the management of the large federally inspected plant involved in the study and our provincial counterpart for the potential use at smaller provincial packing plants.

2. The cleaning practice of a beef plant was not entirely effective for reducing the numbers of bacteria on the surfaces of equipment. The root cause for this problem was investigated and a model cleaning practice was developed for the plant that greatly improved the microbiological conditions of the equipment and that of the product.

3. Dry chilling can reduce the number of generic *E. coli* on dressed carcasses to an undetectable level and thus can be considered an effective intervention.

4. Methods were developed to extend the storage life of vacuum packaged beef by inactivating bacterial spores responsible for blown pack spoilage.

 - Solid Results

#### **FOS.10.13 - Surveillance of *E. coli*, enterococci, antimicrobial resistance (AMR) and *Enterococcus* species distribution in beef operations-associated environments**

Key highlights: Antimicrobial use and resistance are concerns for consumers, the public, and beef producers. Ongoing surveillance programs are largely focused on the risk of AMR transmission through the food chain, with relatively little attention being paid to the likelihood of AMR bacteria or genes being transferred from manure to soil, water, and municipal water supplies.

*Enterococcus* are found in a range of habitats, being associated with soil, plants, fresh and salt water, sewage and the gastrointestinal tract of including mammals, birds, fish, reptiles, insects and humans. Although enterococci are usually harmless, *Enterococcus faecalis* and *Enterococcus faecium* are associated with a variety of clinical infections in humans including urinary tract infections, hepatobiliary sepsis, endocarditis, surgical wound infections, bacteraemia and neonatal sepsis. *Enterococci* readily acquire resistance to many antibiotics, most notably vancomycin.

Success stories: Samples collected in and around four beef feedlots in Alberta over two years showed that *E. faecalis* and *E. faecium* posing the greatest risk to humans are seldom found in cattle. At the same time,

the *E. hirae* that predominates in cattle do not survive well outside the animal, and, are quickly outcompeted by other *Enterococci* that are better adapted to specific environments

Resistance to category I antibiotics including  $\beta$ -lactams and quinolones was found in 4 and 5% of beef production isolates, respectively compared to 15 and 25% in human clinical sterile and non-sterile site isolates.

Soil samples originating from the agricultural fields adjacent to the feedlot had a small and unique resistome and did not overlap with the feedlot resistome.

Composting of feedlot manure can reduce the flow of AMR genes into the environment. Composting is still a preferred method over manure stockpiling to prevent the spread of veterinary antibiotic residues and transmission of antimicrobial resistance during land-application of manure.

In the world's largest study of its kind, records from over 2.6 million commercial feedlot cattle quantified what antibiotics are being used in feedlot production, when they are used, what they used for, what category of importance in human medicine these antibiotics belong to and developed scientifically sound metrics for measuring and reporting antibiotic use in cattle.

 - Solid Results

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#### VALUE – WHAT DOES IT MEAN FOR INDUSTRY

Within the Food Safety priority area, 2/3 projects were successfully completed.

Food safety recalls have steep costs to the industry, both logistically and in the loss of consumer confidence. Reduced incidence of *E. coli* is a crucial priority; however, the negative impact to industry is not necessarily reduced when a recall does occur. Thus, measuring the direct value of reduction is challenging. The core benefit of *E. coli* incidence reduction is from preventing recalls and their associated costs. The costs from foodborne illnesses include: food recall and disposal, outbreak investigation, medical costs, suffering and potential loss of life, and loss in human productivity from sick days. The average number of illness days as a result of infection by *E. coli* O157:H7 is 17, where seven are unhospitalized and ten are hospitalized; the average duration of sequelae from *E. coli* O157:H7 is 15,695 days for mild to moderate renal disease and 1,102 days for end stage renal disease (Minor et al. 2015). Studies estimate that the combined costs for each case of *E. coli* O157:H7 is approximately \$10,000 (Minor et al. 2015, Scharff 2012).

The number of reported *E. coli* O157:H7 from the Public Health Agency of Canada (PHAC) shows a reduction of 70% since 2002. In fact, with the exception of the waterborne outbreak of *E. coli* O157:H7 in Walkerton, Ontario in 2000, which took the lives of seven people and affected hundreds more, the decline of reported cases began in 1995. In 2016, the national incidence rate for *E. coli* O157:H7 was 1.1 cases per 100,000 people, down 21% from 1.4 cases per 100,000 people in 2011. In 2016, this accounts for some 415 individuals infected with *E. coli* O157:H7. For every case reported by a patient to a doctor, an estimate of between ten and 47 cases go unreported. Even applying a conservative estimate of ten unreported cases for every captured one, roughly 4,150 Canadians suffer the effects of *E. coli* O157:H7 infection each year, at a significant cost to the health care system.

## RESEARCH INDICATORS

### Incidence of *E. coli* O157:H7

1. The number of reported *E. coli* O157:H7 from the Public Health Agency of Canada (PHAC) shows a reduction of 70% since 2002. In fact, with the exception of the waterborne outbreak of *E. coli* O157:H7 in Walkerton, Ontario in 2000, which took the lives of seven people and affected hundreds more, the decline of reported cases began in 1995.

Incidence of <i>E. coli</i> O157:H7 per 100,000 people in Canada	2002	2010	2016
	3.8	1.2	1.1

2. In 2016, the national incidence rate for *E. coli* O157:H7 was 1.1 cases per 100,000 population, down 21% from 1.4 cases per 100,000 population in 2011. However, the incidence rate varied greatly across provinces and territories.

Incidence of <i>E. coli</i> O157:H7 per 100,000 people	BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL	YT	NT	NU
	0.57	2.48	1.56	1.28	1.05	0.92	0.26	0.74	3.36	0.38	2.66	---	13.46

3. The PHAC reports that 1.14 Canadians in 100,000 were infected with *E. coli* O157:H7 in 2016 – or some 415 individuals. While this number may appear low, given that Canada's surveillance and tracking system relies solely on patients reporting their symptoms to a health practitioner to be captured in the data, the actual number of infections is speculated to be considerably higher. For every case reported by a patient to a doctor, an estimate of between ten and 47 cases go unreported. Even applying a conservative estimate of ten unreported cases for every captured one, roughly 4,150 Canadians suffer the effects of *E. coli* O157:H7 infection each year, at a significant cost to the health care system.

*E. coli* O157:H7 infections have been declining over the past decade. PHAC is responsible for tracking these infections, and medical laboratories that test patient blood samples report any STEC cases confirmed through testing weekly to the Agency's National Enteric Surveillance Program.

### Canadian outbreaks reported for beef associated with *E. coli* O157:H7 (compiled by PHAC)

Vehicle	Location	Year	Cases	Source	Details
Beef	Ontario	2010	At least 2	CFIA	All cuts of raw beef, including but not limited to tenderloin, beef chunks and ground beef were recalled from a store in North York. CFIA was aware of an <i>E. coli</i> O157:H7 illness outbreak in Ontario.
Hamburger	Ontario	2010	6	CFIA	Outbreak associated with beef burgers - some of the cases occurred at a youth camp in Ontario and one was hospitalized.
Veal	British Columbia	2011	At least 2	CFIA	Recall of grain fed veal liver in British Columbia, Ontario and Quebec or beef liver at one Quebec retail location, between June 1st and June 14, 2011 inclusive. There were reported illnesses associated with the consumption of this product.
Beef	Alberta, Newfoundland and Labrador, Quebec, British Columbia	2012	17	CFIA, PHAC	Confirmed illnesses associated with outbreak related to large beef processor: cases in Alberta (7), Newfoundland and Labrador (1), Quebec (6) and British Columbia (3). The recall of meat from the plant involved more than 1800 products including steaks, ground beef and roasts and spanned all of Canada, most USA states and Hong Kong. There was no indication of any US or Hong Kong cases of <i>E. coli</i> O157:H7 illnesses linked to the consumption of the beef products. Four Edmontonians became ill with <i>E. coli</i> O157:H7 after consuming Strip Loin Grilling Steaks – the beef originated from the processing plant - officials suggested the pathogen may have been introduced into the meat during a tenderizing process in a local store.

Hamburger	Ontario, Alberta	2012	5	CFIA, PHAC	Frozen burgers recalled. Tests revealed two presumptive positives for <i>E. coli</i> O157:H7 in one lot of frozen burgers. The burgers were distributed throughout Canada. The illnesses have not been definitively linked to the recalled burgers but four cases of illness in Ontario and Alberta have an identical genetic fingerprint. This particular genetic fingerprint has not been seen before in Canada or in the U.S. and the genetic data distinguishes this strain from the one involved in the recent outbreak associated with a large processing plant.
Hamburger	Ontario	2013	6	CFIA & ProMED Digest, Vol 16, Issue 7	Burgers made in Toronto for retail sale recalled due to 6 cases of illness among Ontario consumers - 4 hospitalized. The burgers were distributed in Ontario, New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador. The onsets of the 6 cases in Ontario were between 16 Aug 2013 and 15 Sep 2013.
Beef	Quebec	2013	7	Foodborne Path Dis 2015:12(7) : 612-618	Three different Canadian provinces - 2 hospitalized - one with severe HUS. Two restaurant locations serving different tartare meals including, beef, veal, salmon, tuna, and duck were identified as potential sources of the outbreak. No deficiencies at the restaurant locations were observed during inspections by food inspectors. The risk of consuming tartare can be lowered when basic hygienic rules are followed, temperature is strictly controlled, and fresh meat is used.
Hamburger	Canada	2013	8	CFIA	Frozen beef burgers - distributed in Ontario, Manitoba, Saskatchewan, Alberta, British Columbia and Northwest Territories. The recall was the result of <i>E. coli</i> O157:H7 product testing by the CFIA related to an ongoing outbreak investigation.
Beef	Quebec	2014	7	ProMED Digest, 19(30) 2014	7 contracted <i>E. coli</i> from tartare. 1 hospitalized. The ministry confirmed that it had traced all 7 instances back to the same restaurant, but it has refused to release the name of the restaurant or even the city that it's located in.

t. For assumption and calculation details go to Appendix A

The Canadian Beef Research and Technology Transfer Strategy 2018-2023 has outlined four Food Safety research outcomes for the next five years, under which more specific target objectives are listed:

- Improved food safety along the beef supply chain
- Improved beef quality and food safety research and training capacity
- Extension, outreach and policy

## KNOWLEDGE AND TECHNOLOGY DISSEMINATION

### OVERARCHING OBJECTIVE

Improve and support research extension strategies to facilitate the rapid adoption of innovation by producers to sharpen industry's competitive advantage

**Background:** Knowledge dissemination and technology transfer is a critical component of the research process. Through disseminating relevant applications of new strategies and innovations, the economic, environmental and social benefits of investments in beef research are realized. For industry to adopt and profit from research, clear communication of the benefits of the research and its practical implementation to producers is necessary. Not only must there be communication from researchers to industry, there must also be ongoing communication from industry to researchers regarding producer concerns, the shifting marketplace, and industry priorities. Improved communication, collaboration and understanding between researchers and industry result in dissemination of meaningful research results to stakeholders along the production chain, influence management decisions concerning beef production, and improve beef products for all customer segments and markets.

Extension also supports science-based regulations and policies, consumer awareness, and continued investments in research. However, extension efforts from governments and universities has greatly declined over the past two decades, resulting in significant shortfalls in industry adoption of new knowledge and technology. This represents lost opportunities for industry to positively impact profitability and sustainability through improved production efficiencies and beef demand. Having recognized the potential in connecting research and industry, the BCRC has placed greater emphasis on playing a leadership role in Canada to renew knowledge and technology transfer among stakeholders in the beef cattle industry.

As part of Beef Cluster I, a 10-year Knowledge Dissemination and Technology Transfer Plan (TEC Plan) was developed. The plan includes a full-range of technology transfer activities with a clear focus on accelerating the uptake of research results and outcomes by industry. Development of the TEC Plan included: a situation assessment that analyzed the context in which BCRC operates, gathered information about technology transfer needs from stakeholders and reviewed existing organizations known for best practices in technology transfer globally. The strategic direction of technology transfer efforts was determined and the following mandate was established.

In addition, the BCRC led national coordination of extension efforts, supported technology transfer efforts initiated by industry partners, and collaborated with external consultants on extension projects. The intention was not to duplicate existing industry extension efforts, but to enhance or accelerate them, and fill in gaps where needed.

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### OUTCOMES

**TECHNOLOGY TRANSFER GOAL #1:** Regular communication with industry.

A significant milestone achieved during the project was recognition of the BCRC as a leader in technology transfer among Canadian agriculture sectors. This is evident in part by the Agriculture Institute of Canada's 2016 Report, Agricultural Research Dissemination – A Collection of Best Practice. Two of the BCRC's extension initiatives, namely the BCRC's video series and The Beef Researcher Mentorship Program, were noted within twenty examples of best practices for agricultural research dissemination in Canada.

The following communication resources were developed (2013-2018):

- News releases (21)

- Blog posts (200+) - announced the latest research findings, promoted extension resources, offered recommendations to producers during the appropriate season, and shared the experiences of early adopting producers.
- Monthly articles written for Canadian Cattlemen magazine
- Fact sheets (80+) - summarized Cluster-funded research projects meaningfully to lay/producer audiences.
- Radio clips (25) - delivered information through rural radio stations, thereby reaching producers that do not actively seek out science-based information.
- Social media (Facebook and Twitter) – announced new resources and gave seasonal reminders of existing resources. As of 2018, BCRC social media engagement numbers:
  - BCRC blog: 2092 subscribers, up from 155 in 2013
  - Twitter: 5609 followers, up from 2662 in 2015
  - Facebook: 2601 likes, up from 820 in 2015
  - YouTube: 302 subscribers, up from 87 in 2015

**TECHNOLOGY TRANSFER GOAL #2:** Production of new resources.

Numerous new resources were developed over the five years (2013-18):

- Videos (6) - featured researchers, industry experts and experienced producers. They encouraged utilization of knowledge and innovations in a story-telling manner that is engaging, memorable and inspirational to end users while overcoming the time and geography challenges typically encountered when communicating to broad audiences.
- Webinars (39) - virtually connected researchers with producers. Webinar presentations delivered valuable science-based information to industry stakeholders across Canada in a format that was interactive, convenient, low cost, and easily accessible. Recordings of BCRC webinars are readily available on BeefResearch.ca and the BCRC YouTube Channel
- Webpages (100+) – provided overviews of research topics and other information of value to Canadian beef producers
- Interactive decision-making and economic analysis tools (5) - enabled industry stakeholders to make informed decisions on adopting innovation. Calculators and prediction models enable producers to interact with information and manipulate virtual scenarios to understand complexity and impacts. The tools help them to determine how compatible and beneficial adoption of a particular innovation may be on their own operation, moving them beyond awareness to a decision and implementation.
- Infographics (28) - drew attention to new or overlooked facts and drove traffic to related resources on [www.beefresearch.ca](http://www.beefresearch.ca). There were 9 factoids + 17 other images/infographics, all are available at <http://www.beefresearch.ca/resources/images.cfm>.
- USB sticks loaded with the above resources - for producers with limited internet access

*Success Story:* one of the videos in the series is titled ‘What beef producers need to know about environmental footprint’. As of April 27, 2018, it has been viewed more than 40,000 times (on Facebook and YouTube combined). This video was part of a package of resources that worked to successfully communicate the results of ENV.02.13. Through a collaborative effort with the research team, the Canadian Roundtable for Sustainable Beef, and the Canadian Cattlemen’s Association, a comprehensive communication plan was developed and executed to communicate new information about the environmental footprint of Canadian beef production. Several resources were developed including the aforementioned video, a shorter video aimed at the general public, two news releases, speaking points for project spokespeople, a BCRC “factoid” (quirky image highlighting reduced GHG emissions), two 2-page fact sheets summarizing the project, several shareable articles about the results for industry

audiences, and a PowerPoint presentation available for use by interested like-minded groups. These resources enabled widespread, consistent delivery of information to numerous audiences in numerous formats and venues among industry and the general public. Numerous industry groups and publications utilized and distributed the resources, several media outlets requested interviews with project spokespeople and reported on the project's results, and several industry events invited spokespeople to present the project results. The comprehensive extension strategy for the results of ENV.02.13 have increased awareness and understanding of continuous improvement and sustainability in the beef industry both within and outside the industry, and are believed to have increased motivation within industry to further understand and minimize the industry's environmental footprint.

### **Bov-Innovation**

Increasingly beef producers and other industry stakeholders are looking for alternate means to access information on new developments in research and technology that can be implemented within their existing operations to improve their competitiveness and sustainability. In addition, decision making by producers and other industry stakeholders is a complex process, and requires varied types of information and delivery to move them from awareness of an innovation through to continued effective adoption.

In some situations interpersonal exchanges, such as face-to-face events, are a useful means to facilitate greater understanding of and adoption of either well-known or new/emerging production and management practices and technologies. At the same time, traditional, independent field-day approaches to extension, while effective, are often not conducive to most technology transfer strategies as they often require producers to travel long distances, be away from their operations for longer periods of time than is feasible, and can be costly to deliver and attend.

Expanding upon the tools developed to date and advancing them to the next level of adoption, the BCRC launched Bov-Innovation, which is a program that develops modular technology transfer sessions that can be conjoined with other industry events at a national, provincial, regional, and web-based level. The intent of the sessions is to persuade industry stakeholders to make an informed decision on adopting a technology by featuring engaging presentations (in-person or remotely), with scientific experts accompanied by early-adopting producers sharing their experiences and real-life lessons learned on their operations. Innovations promoted will cover a wide range of research focused on through the Beef Cattle Industry Science Cluster programming and that are relevant to seedstock, cow-calf, and feedlot producers.

### **Improving Beef Production Economic Knowledge in the Canadian Beef Industry**

Adoption of some well-known and new/emerging production and management practices remains low despite clear research of the benefits. Producers have noted the importance of economic information in their decision to adopt practices or not. Extension activities are ideally focused on adoption of innovations with most economic potential to individual producers and industry as a whole.

**Sub-activity 3.1:** Pilot study: Understanding the production practices and disease prevalence among Ontario cow-calf herds (**BPE.01.02**)

The information available on the Ontario cow-calf industry is limited and dated. The most recent information collected in Ontario was done so during the Red Meat Project in 1980. The Ontario Cow-Calf 2017 Production survey was conducted to gather information about the industry and to provide researchers with the information, tools and knowledge to learn how to adapt and change to market demands seen by producers in the province.

**Sub-activity 3.2:** A proof-of-concept software tool for Canadian beef producers to estimate economic impact from selecting among various GIN management options (**BPE.01.04**)



It is not uncommon for beef cattle producers to treat all cattle at least once annually for gastrointestinal (GIN) parasites, commonly known as stomach and intestinal worms, often with the same drug each year. A growing body of research indicates this routine practice is likely to lead to drug resistance, and has done so for some species of GIN parasites in North America. The broader objective is to encourage producers to consider prudent use of anthelmintics in light of the increasing evidence of anthelmintic resistance. While there may well be short term benefits from use of anthelmintics in one season, the longer term impact on pastures or GIN resistance to anthelmintics will result in negative long term consequences due to unsustainable production systems and possibly drug resistant species of gastrointestinal nematodes.

**Sub-activity 3.3:** Factors affecting the adoption and exploitation of data management systems in the Canadian beef industry (**BPE.01.05**)

Adopting a new technology without exploiting it fully is not conducive for long term success. From a financial management perspective, the inability to fully exploit a technology or practice may reduce the probability that the Net Present Value (NPV) of the adoption decision is positive (positive NPV investments improve farm balance sheets). What this study was able to find is the disparity between the collection and use of farm records among this sample of beef producers in western Canada.

With practices such as record-keeping, which is built on computer technology, there are many benefits to increasing the utilization of farm data. First, farmers and ranchers that use farm records to set goals and compare to past and peer performance are able to see more clearly trends in performance, and therefore can make better informed decisions on how to allocate time and resources in the search for improved performance and genetics.

The purpose of this sub-activity was to better understand the reasons behind the adoption of herd data management tools as well as the factors that influence greater utilization and effectiveness of these tools on certain farms and ranches. Prior studies have shown there to be significant economic returns to farm record keeping in western Canada (Manglai, 2016), however we know that the uptake and exploitation of these tools is not widespread.

Given the continued need to increase competitiveness through productivity gains through the adoptions and use of innovative technologies, the purpose of this research is to study the factors affecting the adoption of record keeping tools among western Canadian producers. Herd management systems, and record-keeping in general, have the potential to increase herd and financial performance for adopters as it allows producers to make more informed decisions while also alerting the producer to areas where improvements could be made in production and financial performance. Secondly, this study will provide a better understanding of the key success factors that are present in firms that are better able to exploit these tools to deliver improvement in herd and financial performance. As this is a complex system that requires sustained effort and a different level of managerial skill in order to utilize the full benefits of adoption, this study will also examine the farm-level and managerial factors that affect the ability of a particular adopter to more fully exploit this technology.

**TECHNOLOGY TRANSFER GOAL #3:** Enhancements to website functionality.

Ongoing feedback from industry stakeholders, evidence of audience use and interests through analytics and changes in technology inform enhancements to BeefResearch.ca.

Website enhancement over the 5 years include:

- A new web tool was finalized that provides the ability for other Canadian beef research funding organizations to easily create and post fact sheets onto BeefResearch.ca (following review and approval by the lead researcher and the website administrator). This will maximize the

accessibility of valuable research information to industry stakeholders, and provide a collaborative opportunity for extension specialists to accelerate ongoing improvements in technology transfer best practices.

- The display of BeefResearch.ca and BCRC Blog on mobile devices was improved, making it easier for producers and other website audiences to consume information from the website while they're away from their computer.
- The website search functionality was improved on two occasions. From a single search bar found at the top of every page, now results found throughout the website, on fact sheets, and in blog posts are shown at once in separate tabs, making information easier to find and more readily consumed. Fact sheets that summarize Cluster-funded activities are also now more readily found using search terms and activity #'s on the website's search bar.
- Search engine optimization of BeefResearch.ca was improved, making information on BeefResearch.ca easier to find and more readily consumed by users of search engines such as Google.

#### **TECHNOLOGY TRANSFER GOAL #4:** Engagement of researchers with industry.

The Beef Researcher Mentorship Program has facilitated greater engagement of upcoming and new applied researchers with Canada's beef industry providing thirteen (13) participants to date with opportunities to deepen their understanding of the needs of the beef industry in a practical and meaningful way. Participants were given a travel budget and paired with innovative cattle producers and other industry professionals for a one-year mentorship. Mentors helped the researchers build their knowledge, skills and network through ongoing discussions and by initiating various introductions, tours and meetings, and were valuable resources of information about day-to-day cattle and forage production, industry structure and influences, and perspectives on industry challenges and opportunities at regional and national levels. As a result, the participants report having met several producers and industry leaders with whom they have asked questions and had meaningful discussions, have attended industry events and toured farms to better understand the impacts, practicalities and economics of adopting research results, and have learned about and observed ongoing production challenges, all of which help inform their current and future research and extension programs.

BCRC is recognizing highly engaged researchers with the Canadian Beef Industry Award for Outstanding Research and Innovation, established in 2015. Recipients include:

- 2018 - Dr. Eugene Janzen
- 2017 - Dr. Karen Schwartzkopf-Genswein
- 2016 - Dr. Tim McAllister
- 2015 - Dr. John McKinnon

#### **TECHNOLOGY TRANSFER GOAL #5:** Evaluation and modifications to the Knowledge Dissemination and Technology Transfer Plan.

In the spring of 2016, an online survey was conducted to help inform technology transfer strategies. It asked questions on the frequency of access and influence of science-based information sources. More than 500 industry stakeholders responded.

Both government and industry make significant investments to continually find better and more efficient methods of producing high quality beef and beef cattle, but effective technology transfer is needed to realize the benefits of research efforts. Governments and universities used to employ many extension specialists and support field days, seminars and other initiatives but these activities have greatly declined

over the past two decades. This has resulted in significant shortfalls in industry adoption of new knowledge and technology.

The purpose of this project was to improve knowledge dissemination by supporting and delivering a range of technology transfer mechanisms with a clear focus on accelerating the uptake of research results and outcomes by industry. As a result of enhanced and coordinated extension initiatives, industry stakeholders have more of the tools they need to improve production efficiencies and beef demand, which positively impacts the profitability and sustainability of the industry. A primary focus of the initiative was extension of results from research projects completed under the Beef Cattle Industry Science Cluster.

Analysis of website usage statistics and feedback from producers, researchers, extension groups and other industry stakeholders continually influenced BCRC's approach to technology transfer.

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#### VALUE – WHAT DOES IT MEAN FOR INDUSTRY

Technology transfer and knowledge dissemination will remain an ongoing focus for the BCRC, with continued regular communication to industry, development of new resources and partnerships, measurement of successes and modifications to the tools and strategy. Extension, outreach and policy are key components under a number of the priority areas (Beef Quality, Food Safety, Forage and Grassland Productivity) in the Canadian Beef Research and Technology Transfer Strategy 2018-2023 going forward.

Between 2015 and 2017 cow-calf surveys were conducted in all provinces across Canada, providing benchmarks on adoption rates in all regions for the first time. BCRC's "Adoption Rates of Recommended Practices of Cow-Calf Operators in Canada" (BCRC, March 2019) report details trends and opportunities for technology transfer regionally.

Increased investment in technology transfer has ensured that research results from Beef Cluster II will be communicated to industry. Extension efforts encourage adoption of new technology and provide recommendations for management changes that can incrementally improve productivity on individual operations, keeping Canadian beef producers on the cutting edge of the international market.

The Canadian Beef Research and Technology Transfer Strategy 2018-2023 has outlined two technology transfer outcomes for the next five years, under which more specific target objectives are listed:

- Improved efficiency and effectiveness of technology transfer in the Canadian beef industry through greater collaboration and empowerment of technology transfer agents
- Increased producer adoption of relevant technologies and production practices through improved information management

## REFERENCES

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## APPENDIX A : CALCULATIONS AND ASSUMPTIONS USED IN VALUE SECTIONS

The value sections throughout this document were provided by Canfax Research Services and are based on the Research Indicators set out in "A Historical Evaluation of Research Indicators in BCRC Priority Areas" April 2012.

### **ANIMAL HEALTH & WELFARE**

#### ***Reproductive efficiency***

*Definition:* Calves <1 year old on July 1<sup>st</sup> divided by total cow inventories (beef and dairy)

*Source:* Statistics Canada

- From Statistics Canada, reproductive efficiency has increased from 86% in 2008 to 90% in 2012, and decreased to 86% in 2017
  - In eastern Canada, reproductive efficiency increased from 73% in 2008 to 74% in 2012, and decreased to 72% in 2017. In the west, reproductive efficiency increased from 90% in 2008 to 95% in 2012 and decreased to 90% in 2017.
  - In comparison, average reproductive efficiency reported by the Western Canadian Cow-Calf Survey was steady at 85% in 2014 and 2017.
- The reduction in reproductive efficiency from 2012 to 2017 represents a loss of \$179.8 million to the industry
  - 4 less calves were born to every 100 cows
  - Assumes an average \$1192/head for a 550 lbs steer calf (using 2017 average price = \$217/cwt)

*Calculation:* If 4 less calves were born to every 100 cows then  $4\% \times 3,771,100$  head of beef cows on July 1, 2017 = 167,441 less calves valued at \$1192/head = \$199.6 million loss

#### ***Survival rate from birth to weaning***

*Definition:* Survival rate is the proportion of calves weaned compared to the number of calves born

- Conversely, death loss of calves = # calves died/ live births

*Source:* Alberta Agriculture, AgriProfit\$ (contact: Anatoliy Oginskyy)

- From AgriProfit\$, survival rate (birth to weaning) decreased from 96.8% (2003-07 average) to 95.7% (2008-11 average), and increased to 96.9% (2012-17 average)
  - In comparison, average survival rate reported by the Western Canadian Cow-Calf Survey was 93.1% in 2014 and 94.6% in 2017
- The increase in average survival rate from 2008-11 to 2012-17 represents an increase in value of \$57 million to the industry.
  - Assumes an average \$1192/head for a 550 lbs steer calf (\$217/cwt)
  - Assumes 2017 calf crop level (4.05 million head)

*Calculation:* 1.2% increase in survival rate = 47,782 more calves weaned in 2017  
Valued at \$1192/head = \$57 million additional revenue for the cow-calf industry

#### ***Survival rate from weaning to slaughter***

*Definition:* Survival rate is the number of calves from July 1<sup>st</sup> cattle inventory report compared to the number exported as feeders, heifers retained and fed cattle slaughtered and exported the next year. Note this includes death losses in backgrounding and finishing lots.

*Source:* Statistics Canada

- Survival rate has decreased from 88% in 2008 to 82% in 2012, and increased to 91% in 2017
- The increase in survival rate from 2012 to 2017 represents \$575.5 million of additional revenue for the industry
  - Calf crop on July 1st 2017 = 4.045 million head
  - 9% increase in survival rate = 366,181 more cattle survived in 2017
  - \$1,571/head value per animal (2017 average of \$185/cwt on 850 lbs)

*Calculation:* 9% increase in survival rate x 4.045 million head of calves = 366,181 additional cattle survived for export or domestic slaughter in 2017. Valued at \$1,571/head = \$575.5 million additional revenue to the beef industry

### **Feedlot Survival Rate**

*Definition:* Feedlot survival rate is estimated by the number of cattle being marketed as a percentage of the number of cattle placed into feedlot

*Source:* Alberta & Saskatchewan Cattle on Feed Report from Canfax

- Feedlot survival rate has increased from 87% in 2008 to 91% in 2012, and decreased to 89% in 2017
- The reduction in survival rate from 2012 to 2017 represents \$143.2 million of lost revenue for the feedlot industry
  - 2017 Fed cattle marketings = 2.864 million
  - 2% reduction in feedlot survival rate = 70,128 less fed cattle marketed in 2017
  - \$2,042/head value per fed animal (2017 average of \$151/cwt on 1350 lbs)

*Calculation:* 2% reduction in survival rate = 70,128 less fed cattle marketed in 2017

Valued at \$2,042/head = \$143.2 million loss for the feedlot industry

### **Liver abscesses**

*Source:* National Beef Quality Audit, 1999-2011 National Beef Quality Audit and 2016/17 Plant Carcass Audit

- Liver abscesses in fed cattle resulting in condemnation increased from 13% in 1998/99 to 23% in 2010/11 and 22% in 2016/17
- Liver abscesses in fed cattle resulting in livers being discounted to pet food have decreased from 10% in 1998/99 to 8% in 2010/11, and increased to 10% in 2016/17
- Liver condemnations in non-fed cattle increased from 18% in 1998/99 to 26% in 2010/11 and remained steady at 26% in 2016/17
- Liver abscesses in non-fed cattle resulting in livers being discounted to pet food decreased from 33.7% in 1998/99 to 23.9% in 2010/11 to 17.6% in 2016/17
- Combined discounts on fed and non-fed cattle represent a cost of \$61.2 million to industry (\$20.98/head) up from \$29.2 million (\$9.36/head) in 2010/11 and \$8.8 million (\$2.66/head) in 1998/99. The increase in cost is due to a larger discount for pet food and condemned livers.
- The largest loss from liver damage was not from condemns or discounts but from lost weight gain at \$46.7 million in 2016/17, up from \$20.5 million in 2010/11 and \$2.99 million in 1998/99 as the cost of feed increased and cattle stayed on feed longer to get to finished weight.

### **Horns**

*Source:* National Beef Quality Audit

- The percentage of hornless fed cattle increased from 69.8% in 1998/99 to 87.5% in 2010/11 to 90.8% in 2016/17. For non-fed cattle, the percentage of hornless cattle was 89.4% in 1998/99 and 2010/11, and increased to 91.7% in 2016/17.
- Processors lost \$176,086 in 2017 (\$0.06/head), compared to \$192,535 in 2011 (\$0.06/head) and \$106,003 (\$0.032/head) in 1998/99
  - Although the industry loss in 2011 exceeded that in 1998/99, the increase was a result of higher labour costs of horn removal, representing a lost value of \$0.1 million to industry.
  - Processor loss in 2016 is smaller than 2011 due to similar labour costs and lower incidence of horned cattle

### **Bruises**

*Source:* National Beef Quality Audit

- The percentage of non-fed cattle with bruises increased from 76.4% in 1998/99 to 85.7% in 2010/11, and dropped to 63% in 2017; while the percentage of fed cattle with bruises decreased from 49.2% in 1998/99 to 34.1% in 2010/11 to 32.6% in 2016/17.
- The economic loss to the industry due to bruises on the carcasses was \$5.6 million in 2017 compared to \$6.7 million in 2010/11 and \$4.3 million in 1998/99.
- From 2010/11 to 2016/17, this represents savings of \$1.1 million for industry

### **Head, tongue and carcass condemnations**

*Definition:* Carcasses or parts of the carcass deemed unfit for human consumption

*Source:* National Beef Quality Audit

- N/A for 2017

	1998/99	2010/11	2016/17	\$/Head* 2010/11 ###	\$/Head* 2016/17 ###	% Change ## from 2010/11
Liver abscesses (condemned)	13.4% †	23.2% †	22.0% †	9.36	20.98	+124
Liver abscesses (pet food)	10.4% †	8.0% †	10.0% †			
Horns	30.2% †	12.5% †	90.8% †	0.06	0.06	+0
	10.6% ##	10.6% ##	91.7% ##			
Bruising	49.2% †	34% †	32.6% †	2.10	1.90	-10
	76.4% ##	85.7% ##	63.0% ##			
Heads condemned	5% ###	3.8% ###	N/A	0.16	N/A	N/A
Tongue discount	5% ###	3.8% ###	N/A	0.32	N/A	N/A
Carcasses condemned	0.3% ###	0.25% ###	0.14% ###	3.44	3.20	-7
Injection site lesions**	0.4% †	0.56% †	4.45% †	0.21	0.56	+169%
	0.5% ##	7.34% ##	13.69% ##			

† Fed cattle only    # Non fed cattle only    ### All cattle

\*Total industry loss divided by total cattle slaughtered

\*\*The 1999 audit included a purveyor audit where injection site lesions were determined in cuts. This separate study was not conducted in 2010/11. The purveyor study in 1998/99 indicated a cost of injection site lesion amounting to \$5.45/hd. The cost of internal injection site lesions is not accounted for in the 2010/11 audit and therefore caution is advised when comparing the costs between the two studies.

### **Condemnations**

*Definition:* Carcasses or parts of the carcass deemed unfit for human consumption. Condemnation rate is estimated by the percentage of the number of cows condemned as % of cows slaughtered.

*Source:* Canadian Beef Grading Agency

- The condemnation rate has decreased from 31.0 per 10,000 head slaughtered in 2008 to 27.5 in 2012 to 18.9 in 2017
- The reduction in condemnation rate from 2012 to 2017 represents a saved value of \$3.08 million to industry.
  - 2017 total slaughter(Federal and Provincial plants) = 2.75 million head
  - 0.09% decrease in condemnation rate = 2,376 less condemned cattle
  - Assumes an average \$1,176/head for a 1,350 lb cattle (using 2017 average D3 cow price of \$87.14/cwt)
  - Assumes an average \$250/head disposal fee for a condemned animal weighed 1,350 lbs
  - A value of \$1,176/head on D3 cows plus a disposal cost of \$250/head for condemned cattle resulting in a total loss of \$1,426/head
  - 2,376 less condemned cattle at \$1,426/head = \$3.39 million saved

*Calculation:* 0.09% decrease in condemnation rate x 2.75 million head total slaughter (fed and non-fed) = 2,376 fewer head cattle being disposed. Value per head of cattle at \$1,176 + disposal fee per head at \$250 = loss per head of cattle at \$1,426. Reduced number of condemned cattle of 2,376 x loss per condemned cattle = \$3.39 million.



## **FEED GRAINS & FEED EFFICIENCY**

### **Barley yields**

*Definition:* Bushels per acre

*Source:* Agriculture and Agri-Food Canada

- The five-year average<sup>6</sup> barley yield has increased 14.5% (8.7 bu/acre) from 59.5 bu/acre in 2008-12 to 68.2 bu/acre in 2013-17
- This represents a saved value of \$186.6 million to industry through increased production
  - Assumes holding harvested area at 5.2 million acres (2017 level)
  - Assumes average barley price = \$4.13/bu<sup>7</sup>

*Calculation:* 14.5% increase in yield = 8.7 additional bushels per acre; 5.2 million acres x 8.7 bushel/acre = 45.2 million bushels of barley produced at \$4.13/bu for a total value of \$186.6 million

- This means 415,640 fewer acres were required to produce the same amount of barley. This land can be put into other production – representing a significant gain opportunity for producers.
  - Assumes holding barley production steady at 355.9 million bushels (2017 level)
  - 14.5% increase in yield = 415,640 fewer acres of land required
- Higher grain prices in recent years has resulted in farmers switching to more profitable alternatives that bring a higher return. From the 2006 Census of Agriculture to 2011, the number of farms reporting barley acreage decreased 31%. From 2011 to 2016, number of farms reporting barley decreased 17% from just under 30,000 farms in 2011 to 25,000 farms in 2016. The number of acres in barley was down 24% (or 1.23 million acres) at 6.9 million acres from 2006 to 2011, and down 3% (0.2 million acres) from 2011 to 2016 to 6.7 million acres..

### **Barley Varieties**

*Definition:* Number of varieties registered

*Source:* Canadian Food Inspection Agency

- 19 Triticale varieties have been registered from 2008 to 2012, 6 Triticale varieties between 2013-2017
- 48 Barley varieties have been registered from 2008 to 2012, 31 Barley varieties between 2013-2017

Type	Varieties		
	2008	2012	2017
Spring triticale	-	15	21
Winter triticale	-	4	4
<b>Total triticale varieties</b>		<b>19</b>	<b>25</b>
Barley, six-row, spring	119	125	135
Barley, six-row, spring, hull-less	7	8	9
Barley six-row, for spring forage	8	8	8
Barley, two-row, spring	84	88	99
Barley, two-row, spring, hull-less	18	17	25
Barley two-row, for spring forage	2	2	3
Barley, winter	4	4	4
<b>Total barley varieties</b>	<b>242</b>	<b>252</b>	<b>283</b>

### **Feed:gain ratio**

*Definition:* The pounds of feed required for one pound of gain averaged over the finishing period

*Source:* Values reported in the Canadian Journal of Animal Science articles compiled by Canfax Research Services

- From 2003-07 to 2008-12 (five year average), the Feed:Gain ratio in finishing feedlots reported by journal articles has decreased 1.1% from 6.78 to 6.70. From 2008-12 to 2013-17, the Feed:Gain ratio further decreased 6.7% to 6.25.

<sup>6</sup> As annual barley yields can be significantly impacted by weather patterns (drought, flooding), the long term trend (5-year average) is used in this discussion

<sup>7</sup> Based on 2017 Lethbridge barley price – source: Canfax

- The reduction in Feed:Gain from 2008-12 to 2013-17 represents a saved value of \$61.0 million to industry
  - 2017 fed cattle marketing = 2.864 million head
  - Assumed 550 lb/head gained in the feedlot (800 lbs in-weight & 1350 lbs out-weight)
  - Assumes \$190/tonne of feed for average ration - Lethbridge barley price 2017

*Calculation:* 550lb/head weight gain x 2.864 million heads of cattle marketed = total weight gain of 714,590 tonnes. A 0.45 decrease in feed:gain ratio = 321,565 fewer tonnes of feed required at average price of \$190/tonne = savings in feed of \$61.0 million

### **Average daily gain**

*Definition:* Total gain over feeding period divided by the number of days on feed

*Source:* Values reported in the Canadian Journal of Animal Science articles compiled by Canfax Research Services

- From 2008 to 2012, the average daily gain in feedlots reported by journal articles has increased 8.8% from 3.4lb/day to 3.7lb/day. From 2012 to 2017, the ADG further increased 10.8% to 4.1lb/day.
- The increase in ADG from 2012 to 2017 means 15 fewer days emitting GHG per head and 41.5 million fewer days in total.
  - Assumes 550 lbs gained in the feedlot on average (800 lb in-weight and 1350 lb out-weight)
  - 2017 fed cattle marketing = 2.864 million head

*Calculation:* 550 lbs gained at 4.1 lbs per day is 134 days on feed compared to 550 lbs gained at 3.7 lbs per day is 149 days on feed. Therefore a higher ADG reduces days on feed by 15 days from 149 days to 134 days. 15 days x 2.864 million fed cattle = 41.5 million fewer days on feed.

## **PRODUCTION EFFICIENCY**

### **Steer carcass weight**

*Definition:* Warm carcass weight

*Source:* Canadian Beef Grading Agency

- Steer carcass weights have increased 3.7% (31 lbs) from 842 lbs in 2008 to 873 lbs in 2012, and increased 2.7% (24 lbs) to 897 lbs in 2017
- The increase in steer carcass weight represents a revenue gain of \$180.2 million to industry
  - Assumes 2017 fed cattle marketings (2.864 million head) and composite cutout value (\$262/cwt)

*Calculation:* 24 additional lbs per animal x 2.864 million fed cattle marketed = 68.74 million additional pounds valued at \$2.62/lb (composite cutout weighted for AAA/AA production) = \$180.2 million in additional revenue to the feedlot industry from increased carcass weights

### **Weaning weight**

*Definition:* Average weight at weaning

*Source:* Alberta Agriculture, *Agri-Profit\$*, provincial average

- From *Agri-Profit\$*, Weaning weight increased from 548.9 lbs (2003-07 average) to 562.7 lbs (2008-11 average) to 578.8 lbs (2013-17 average)
  - In comparison, average weaning weight reported by the 2017 Western Canadian Cow-Calf Survey was heavier at 597.5 lbs (611 lbs for steers, 584 lbs for heifers)
- The increase in weaning weight from 2008-11 to 2013-17 represents \$141.1 million additional revenue for the industry
  - Assumes 4.05 million head calf crop is weaned (July 1, 2017 level)
  - Assume calf price at \$217/cwt (2017 level)

*Calculation:* 16.1 additional lbs per calf weaned x 4.05 million calves = 65.1 million additional pounds Valued at \$217/cwt = 141.1 million in additional revenue to the cow-calf industry

### **Productivity per cow**

*Definition:* Productivity per cow is measured by total beef production (including live cattle exports) divided by the total number of cows (beef and dairy) from two years prior.

*Source:* Statistics Canada, Canadian Beef Grading Agency

- Productivity per cow decreased from 574 lbs/cow (2003-07 average) to 561 lbs/cow (2008-12 average) to 515 lbs/cow (2013-17 average).
- The reduction in productivity from 2008-12 to 2013-17 represents a lost value of \$562.3 million
  - Assumes composite cutout of \$262/cwt (2017 level)
  - Assumes 4.65 million head of cow (2015 Jul 1<sup>st</sup> level)

Calculation: 46 fewer lbs of beef produced per cow x 4.65 million cows in 2015 = reduced beef production of 214 million lbs at \$262/cwt = reduced revenue of \$562.3 million

### **Weaning weight as a % of mature cow weight**

*Source:* Alberta Agriculture, AgriProfit\$

- Weaning weight as a % of mature cow weight increased from 42.4% (03-07 average) to 43.2% (08-11 average), then dropped to 42% (13-17 average)

### **Steer carcass weight as a % of cow carcass weight**

*Source:* Canadian Beef Grading Agency

- Steer carcass weight as a % of cow carcass weight has increased from 124% in 2008 to 130% in 2012, and decreased to 122% in 2017.

## **FORAGE & GRASSLAND PRODUCTIVITY**

### **Forage Yields**

*Definition:* Tons per acre harvested for hay

*Source:* Statistics Canada Table 001-0017

- The five-year average<sup>8</sup> tame hay yield increased 8% from 1.69 tons/acre in 2003-07 to 1.84 tons/acre in 2008-12, and increased 2% from 2008-2012 to 1.88 tons/acre in 2013-2017
- This represents a saved value of \$66,000
  - Assumes holding harvested area at 14.2 million acres (2017 level)
  - Assumes average hay price = \$116.39/ton (Alberta price, 2017)
- This means 0.32 million fewer acres were needed to produce the same amount of hay at the 2017 level. This land can be put into other production – representing a significant gain of opportunity for producers.
  - Assumes holding forage production steady at 2017 level at 25.4 million tons.

### **Registered varieties**

*Definition:* New varieties registered

*Source:* Canadian Food Inspection Agency

- 58 alfalfa varieties have been registered from 2008 to 2012, 68 alfalfa varieties between 2013-17
- 6 bromegrass varieties have been registered from 2008 to 2012, 3 bromegrass varieties between 2013-17
- 4 ryegrass varieties have been registered from 2008 to 2012, 27 ryegrass varieties between 2013-17
- 11 clover varieties have been registered from 2008 to 2012, 18 clover varieties between 2013-17
- 1 birdsfoot trefoil varieties have been registered from 2008 to 2012, 1 birdsfoot trefoil varieties between 2013-17
- 8 orchardgrass varieties have been registered from 2008 to 2012, 16 orchardgrass varieties between 2013-17

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<sup>8</sup> As annual forage yields can be significantly impacted by weather patterns ( drought, flooding). The five year average is used here.

Type	Varieties			Type	Varieties		
	2008	2012	2017		2008	2012	2017
Alfalfa	175	228	279	Alsike clover	4	4	4
Alfalfa hybrids	1	6	4	Red clover, single cut	2	3	4
<b>Total alfalfa</b>	<b>176</b>	<b>234</b>	<b>285</b>	Red clover, double cut	27	35	41
Meadow brome	4	7	7	Sweet clover	2	2	1
Smooth brome	10	13	14	White clover, low-growing	-	1	4
<b>Total bromegrass</b>	<b>14</b>	<b>20</b>	<b>22</b>	White clover, tall-growing	12	13	16
Annual ryegrass	17	19	34	<b>Total clover</b>	<b>47</b>	<b>58</b>	<b>70</b>
Perennial ryegrass	16	18	25				
Altai wildrye	3	3	3	<b>Birdsfoot trefoil</b>	<b>10</b>	<b>11</b>	<b>12</b>
Dahurain wildrye	2	2	2				
Russian wildrye	4	4	3	<b>Orchardgrass</b>	<b>39</b>	<b>47</b>	<b>60</b>
<b>Total ryegrass</b>	<b>42</b>	<b>46</b>	<b>67</b>				

### **Grassland productivity**

Source: 2016 Census of Agriculture, Statistics Canada

- From 2006 to 2011, natural pasture acres decreased by 4.7% or 1.8 million acres from 38.16 million to 36.33 million acres. From 2011 to 2016, natural pasture acres decreased 3.0% or 1.1 million acres to 35.24 million acres.
- From 2006 to 2011, tame or seeded pasture acres decreased by 2.4% or 340,000 acres from 14.01 million to 13.67 million acres. From 2011 to 2016, tame or seeded pasture acres decreased 8.2% or 1.1 million acres to 12.56 million acres. This decline reflects the reduced cattle inventories and consequently reduced demand for forage.
- From 2006 to 2011, percentage of Canadian agricultural land in pasture decreased by 0.1% from 31.3% to 31.2%. From 2011 to 2016, percentage of Canadian agricultural land in pasture decreased by 1.1% from 31.2% to 30.1%.

### **Best management practices**

Source: 2016 Agriculture Census, Statistics Canada

- In 2016, 29,713 farms (49.7% of beef farms) reported they use rotational grazing, compared to 51,589 farms (75.4% of beef farms) in 2011 and 70,798 farms or 82% in 2006. Part of the decline is from producers leaving the industry.
- In 2016, 21,164 farms (35.4% of beef farms) reported they used in-field winter grazing or feeding, compared to 30,260 farms (44.2% of beef farms) in 2011.<sup>9</sup>
  - Data from Alberta indicates that hay-based confinement feeding costs increased from approximately \$1.75/head per day in 2013 to \$2.80-3.50/head (mixed ration vs. straight hay, yardage and bedding) per day in 2018, while grazing stockpiled pasture costs increased from approximately \$1.02/head per day in 2013 to \$1.50/head per day in 2018. Each day of extended grazing increased in value from \$0.73/head per day in 2013 to \$1.30-1.75/head per day in 2018 depending on the ration. As hay costs have increased the savings from extensive grazing during the winter have increased as well.
  - Extending the grazing season by a single day, for 4.4 million beef cows and replacement heifers (as of January 1, 2018), would represent nation-wide savings of nearly \$6.7 million per year. This does not include the cost savings associated with increasing productivity that allows for increased carrying and feeding capacity on fixed acreage, which will also reduce feeding costs substantially.
- In 2011, 41,541 farms reported they used nutrient management planning: 41.7% of the 99,573 agricultural operations that applied manure (includes all livestock manure, not just cattle) **(2016 data N/A)**

<sup>9</sup> New for 2011; therefore comparison with 2006 is not possible

- The number of acres that receive fertilizer have been steady from 2006 (37.5% of total farm area) to 2011 (38.4% of total farm area), and increased from 2011 to 2016 (44.3% of total farm area)

## **BEEF QUALITY**

### ***Tenderness***

Source: 2015 Retail Beef Satisfaction Benchmark Survey & National Beef Quality Audit (shear force tests conducted at the AAFC Lacombe Research Centre)

- Overall consumer satisfaction rose from 73% in 2001 to 80% in 2009
- Satisfaction drivers: Percentage of satisfied customers\*

<b>Steak Type</b>	<b>Tenderness</b>			<b>Juiciness</b>			<b>Flavour</b>			<b>Overall</b>		
	<b>2015</b>	<b>2009</b>	<b>2001</b>	<b>2015</b>	<b>2009</b>	<b>2001</b>	<b>2015</b>	<b>2009</b>	<b>2001</b>	<b>2015</b>	<b>2009</b>	<b>2001</b>
Strip loin	85%	84%	82%	81%	87%	82%	86%	86%	85%	88%	87%	84%
Top sirloin	80%	83%	76%	80%	88%	81%	83%	90%	82%	83%	86%	83%
Boneless cross rib	68%	71%	58%	74%	72%	62%	81%	79%	69%	75%	75%	65%
Inside round	60%	63%	55%	60%	65%	61%	71%	70%	69%	68%	69%	59%
ALL STEAKS	73%	76%	68%	74%	78%	72%	80%	82%	76%			

\*A satisfied customer was defined as one who gave a rating of 7/10 or higher

Laboratory measurements backed up consumer comments. Shear force tests conducted at the AAFC Lacombe Research Centre found the percentage of steaks requiring no tenderness enhancement increased for inside round (2001 52%; 2011 61%; 2015 87%) and cross-rib (2001 65%; 2011 76%; 83%) steaks, while it fluctuates for striploin (2001 89%; 2011 99%; 2015 85%) and top sirloin (2001 70%; 2011 87%; 2015 84%) steaks.

### ***Quality grading***

Definition: Quality grades are determined by maturity (age), sex, conformation (muscling), fat (colour, texture & cover) and meat characteristics (colour, texture & marbling).

Source: Canadian Beef Grading Agency

- AAA and Prime as a percentage of all A grades increased from 51.6% in 2008 to 56.7% in 2012 to 63.2% in 2017
- The increase from 2012 to 2017 represents an additional value of \$19.0 million to industry through improvements in grading quality
  - Using 2,315,356 head of A grade cattle in 2017 (federal and provincial slaughter)
  - The difference due to quality is 150,498 head with a steer carcass weight of 897 lbs in 2017 this means 135 million additional pounds of AAA+ product produced
  - The AAA/AA spread was \$14.07/cwt in 2017

### ***Yield grades***

Definition: Y1 is >=59% lean, Y2 is 54-58% lean, and Y3 is <=53% lean

Source: Canadian Beef Grading Agency

- Y1 decreased 12% from 60.8% in 2008 to 48.8% in 2012, and decreased 13% from 2012 to 2017 to 36.2% in 2017
- Y2 increased 5.2% from 28.4% in 2008 to 33.5% in 2012, and stayed steady at 33.5% in 2017
- Y3 increased 6.9% from 10.9% in 2008 to 17.7% in 2012, and increased 13% from 2012 to 2017 to 30.3% in 2017
- Considering all the yield grades, from 2012 to 2017, this represents a loss of \$38.9 million to industry
  - Using 2,315,356 head of A grade cattle in 2017
  - Assumes yield discounts of \$67/carcass on Y2, \$134/carcass on Y3<sup>10</sup>
  - Total discount on the additional Y2 carcasses = -\$0.01 million

<sup>10</sup> Based on reduced revenue from red meat per carcass using average cutout price in 2012 at \$180/cwt

- Total discount on the additional Y3 carcasses = \$38.9 million

**Calculation:**

A 0.01% decrease in Y2 x 2,315,356 head of A grade cattle = 162 less Y2 carcasses  
 A 12.6% increase in Y3 x 2,315,356 head of A grade cattle = 290,878 additional Y3 carcasses  
 Using the 2017 average cutout prices at \$262/cwt and assuming average carcass weight = 850 lb  
 Estimated reduced revenue from lean meat per Y2 carcass = 850 lb x \$262/cwt x (59% - 56%) = \$67/carcass  
 Estimated reduced revenue from lean meat per Y3 carcass = 850 lb x \$262/cwt x (59% - 53%) = \$134/carcass  
 Total discount on the addition Y2 carcasses = -162 heads x \$67/carcass = -\$0.01 million  
 Total discount on the addition Y3 carcasses = 290,878 heads x \$134/carcass = \$38.9 million

**Dark cutters**

**Definition:** A dark cutter is removed from Canada’s quality A grades and given a designation of B4

**Source:** Canadian Beef Grading Agency

- The number of dark cutter (B4) increased from 0.8% of youthful slaughter in 1998 to 1.4% in 2008. The number decreased to 1.2% in 2012, and increased again in 2017 to 1.6%.
  - Using 2,362,898 head of Maturity 1 cattle slaughtered in 2017 (federal and provincial slaughter)
  - From 2012 to 2017, the 0.4% increase in B4 cattle resulted in a difference of 10,107 head (Note: there were 11,978 head more B4’s in 2017 due to higher slaughter numbers as well as the increased percentage; inventories are held constant here).
- The 0.4% increase in B4 represents a cost of \$3.6 million to industry
  - Assuming \$359/head discount on dark cutting cattle on the additional 10,107 head of B4 cattle.<sup>11</sup>
  - Based on the actual 11,978 head, the cost to industry was \$4.3 million
- Reducing B4 level from 1.6% in 2017 to 0.8% seen in 1999 will save the industry \$6.44 million
  - Assumes \$359/head discount on dark cutting cattle on the 17,961 fewer head of B4 cattle

**FOOD SAFETY**

**Incidence of E. coli O157:H7**

**Source:** The National Enteric Surveillance Program (NESP), Public Health Agency of Canada (PHAC)

- The number of reported *E. coli O157:H7* from the Public Health Agency of Canada (PHAC) shows a reduction of 70% since 2002. In fact, with the exception of the waterborne outbreak of *E. coli O157:H7* in Walkerton, Ontario in 2000, which took the lives of seven people and affected hundreds more, the decline of reported cases began in 1995.

Incidence of <i>E. coli O157:H7</i> per 100,000 people in Canada	<b>2002</b>	<b>2010</b>	<b>2016</b>
	3.8	1.2	1.1

- In 2016, the national incidence rate for *E. coli O157:H7* was 1.1 cases per 100,000 population. However, the incidence rate varied greatly across provinces and territories.

Incidence of <i>E. coli O157:H7</i> per 100,000 people	<b>BC</b>	<b>AB</b>	<b>SK</b>	<b>MB</b>	<b>ON</b>	<b>QC</b>	<b>NB</b>	<b>NS</b>	<b>PEI</b>	<b>NL</b>	<b>YT</b>	<b>NT</b>	<b>NU</b>
	0.57	2.48	1.56	1.28	1.05	0.92	0.26	0.74	3.36	0.38	2.66	---	13.46

- The PHAC reports that 1.14 Canadians in 100,000 were infected with *E. coli O157:H7* in 2016 – or some 415 individuals. While this number may appear low, given that Canada's surveillance and tracking system relies solely on patients reporting their symptoms to a health practitioner to be captured in the data, the actual number of infections is speculated to be considerably higher. For every case reported by a patient to a doctor, an estimate of between ten and 47 cases go unreported. Even applying a conservative estimate of ten

<sup>11</sup> Canfax survey for Canadian discount. The following link provides the US discount <http://www.youtube.com/watch?v=0y9NZM985mo&feature=related> see 6:34 minute

unreported cases for every captured one, roughly 4,600 Canadians suffer the effects of *E. coli* O157:H7 infection each year, at a significant cost to the health care system.

*Canadian outbreaks reported for beef associated with E. coli O157:H7 (compiled by PHAC)*

Vehicle	Location	Year	Cases	Source	Details
Beef	Ontario	2010	At least 2	CFIA	All cuts of raw beef, including but not limited to tenderloin, beef chunks and ground beef were recalled from a store in North York. CFIA was aware of an <i>E. coli</i> O157:H7 illness outbreak in Ontario.
Hamburger	Ontario	2010	6	CFIA	Outbreak associated with beef burgers - some of the cases occurred at a youth camp in Ontario and one was hospitalized.
Veal	British Columbia	2011	At least 2	CFIA	Recall of grain fed veal liver in British Columbia, Ontario and Quebec or beef liver at one Quebec retail location, between June 1st and June 14, 2011 inclusive. There were reported illnesses associated with the consumption of this product.
Beef	Alberta, Newfoundland and Labrador, Quebec, British Columbia	2012	17	CFIA, PHAC	Confirmed illnesses associated with outbreak related to large beef processor: cases in Alberta (7), Newfoundland and Labrador (1), Quebec (6) and British Columbia (3). The recall of meat from the plant involved more than 1800 products including steaks, ground beef and roasts and spanned all of Canada, most USA states and Hong Kong. There was no indication of any US or Hong Kong cases of <i>E. coli</i> O157:H7 illnesses linked to the consumption of the beef products. Four Edmontonians became ill with <i>E. coli</i> O157:H7 after consuming Strip Loin Grilling Steaks – the beef originated from the processing plant - officials suggested the pathogen may have been introduced into the meat during a tenderizing process in a local store.
Hamburger	Ontario, Alberta	2012	5	CFIA, PHAC	Frozen burgers recalled. Tests revealed two presumptive positives for <i>E. coli</i> O157:H7 in one lot of frozen burgers. The burgers were distributed throughout Canada. The illnesses have not been definitively linked to the recalled burgers but four cases of illness in Ontario and Alberta have an identical genetic fingerprint. This particular genetic fingerprint has not been seen before in Canada or in the U.S. and the genetic data distinguishes this strain from the one involved in the recent outbreak associated with a large processing plant.
Hamburger	Ontario	2013	6	CFIA & ProMED Digest, Vol 16, Issue 7	Burgers made in Toronto for retail sale recalled due to 6 cases of illness among Ontario consumers - 4 hospitalized. The burgers were distributed in Ontario, New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador. The onsets of the 6 cases in Ontario were between 16 Aug 2013 and 15 Sep 2013.
Beef	Quebec	2013	7	Foodborne Path Dis 2015:12(7) : 612-618	Three different Canadian provinces - 2 hospitalized - one with severe HUS. Two restaurant locations serving different tartare meals including, beef, veal, salmon, tuna, and



					duck were identified as potential sources of the outbreak. No deficiencies at the restaurant locations were observed during inspections by food inspectors. The risk of consuming tartare can be lowered when basic hygienic rules are followed, temperature is strictly controlled, and fresh meat is used.
Hamburger	Canada	2013	8	CFIA	Frozen beef burgers - distributed in Ontario, Manitoba, Saskatchewan, Alberta, British Columbia and Northwest Territories. The recall was the result of E. coli O157:H7 product testing by the CFIA related to an ongoing outbreak investigation.
Beef	Quebec	2014	7	ProMED Digest, 19(30) 2014	7 contracted E. coli from tartare. 1 hospitalized. The ministry confirmed that it had traced all 7 instances back to the same restaurant, but it has refused to release the name of the restaurant or even the city that it's located in.