

Beef Value Chain Roundtable

**Canadian Beef Research and
Technology Transfer Strategy
2018 - 2023**

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November 30, 2016

I. Executive Summary

The world population is projected to grow from 7.3 billion in 2015 to 9.7 billion in 2050. It is estimated that feeding this growing population will require 70% more food compared to 2010 production levels. The global agriculture community is challenged with meeting the increased food demand, while land and natural resources allocated to agriculture, including beef production, will be increasingly pressured.

Sustainably meeting the nutritional needs of the growing global population requires using fewer resources and instead focusing on productivity growth for both beef cattle and feed. Canada has an opportunity to play a leading role in meeting global food production needs through its renewed and enhanced investments in agricultural research across a variety of disciplines over the next twenty years.

This document presents the renewed five year **Canadian Beef Research and Technology Transfer Strategy 2018 - 2023**. Building upon the successes of the 2012 National Beef Research Strategy developed by the Beef Cattle Research Council (BCRC) and the national Beef Value Chain Roundtable (BVCRT), this document highlights the global beef market outlook, the role of research in today's competitive environment, and key research priorities and outcomes over the next five years. The BCRC and BVCRT have led the development of the Canadian Beef Research and Technology Transfer Strategy 2018 - 2023 with ongoing engagement of researchers, funders and grassroots producers. Throughout the Strategy development process, input was sought from these stakeholders through various means including direct consultation, an online survey, and most importantly, two workshops. This engagement helped to identify needs in research capacity, infrastructure, programming, funding and coordination, and to ensure priority industry outcomes are being addressed.

As outlined in this document, the three core research objectives are:

1. *To enhance industry sustainability and improve production efficiencies*, priority outcomes are to enhance feed and forage production, increase feed efficiency and decrease the impact of animal health issues and production limiting diseases.
2. *To improve consumer confidence and beef demand*, priority outcomes are to reduce food safety incidences, define quality and yield benchmarks supporting the Canadian Beef Advantage, and improve beef quality through primary production improvements and the development and application of technologies to optimize cutout values and beef demand.
3. *To improve public confidence in Canadian beef*, outcomes are to improve food safety, strengthen the surveillance of antimicrobial use and resistance, develop effective antimicrobial alternatives, ensure animal care, demonstrate the safety and efficacy of new production technologies, improve environmental sustainability and measure the beef industry's environmental benefits.

Supporting these core research objectives, specific outcomes were developed under each of the following industry-identified priority areas:

- Beef Quality
- Food Safety
- Animal Health and Welfare

- Antimicrobial Use, Resistance and Alternatives
- Feed Grains and Feed Efficiency
- Forage and Grassland Productivity
- Environmental Sustainability
- Technology Transfer

Each priority area section includes overarching and more specific outcomes. These sections also include an overview of the priority area, summarized results of online survey responses about industry's research needs and a summary of research funded since 2012.

The Canadian Beef Research and Technology Transfer Strategy 2018 – 2023 directly supports the 2013-2018 National Beef Strategy and its four pillars, namely beef demand, competitiveness, productivity and connectivity. It promotes research to maintain or improve consumer confidence and demand for Canadian beef by investing in beef quality and food safety research, and to maintain or improve production competitiveness with advancements in animal health and welfare, feed grains and efficiency, and forage and grassland production. It further emphasizes the importance of coordinated technology transfer to ensure continued productivity improvements within the beef industry.

The BCRC and BVCRT will continue to engage industry stakeholders as the Canadian Beef Research and Technology Transfer Strategy 2018 – 2023 is implemented to ensure priority research needs are met in a coordinated manner to advance the competitiveness and sustainability of the Canadian beef industry.

The Canadian Beef Research and Technology Transfer Strategy 2018 - 2023 is a dynamic document intended to continue to evolve based on stakeholder feedback and ongoing review as research outcomes are achieved and new outcomes arise. Feedback is welcome at any time and can be directed to the BCRC at www.beefresearch.ca.

II. Background

a. Overview of the BCRC and the BVCRT

The **Beef Cattle Research Council (BCRC)** is Canada's only national industry-led funding agency for beef research. The BCRC plays an important role in identifying the industry's research and development priorities and subsequently influencing public sector investment in beef research. The BCRC is funded primarily through a portion of a producer-paid National Check-off and is directed by a committee of beef producers from across the country.

The BCRC receives on average 18 cents of every cattle and beef National Check-off dollar collected in Canada. The Check-off revenue and additional funding from industry and government stakeholders is used to leverage funding from Agriculture and Agri-Food Canada (AAFC) through the Beef Cattle Industry Science Cluster. In turn, the BCRC funds research and development activities to improve the competitiveness and sustainability of Canada's beef industry.

The Canadian **Beef Value Chain Roundtable (BVCRT)**, established by the federal minister of agriculture in 2003, is comprised of industry and provincial and federal government members representing the entire beef value chain. It provides leadership in addressing issues of importance to Canada's beef industry. The BVCRT identified research as a priority and subsequently formed a working group in partnership with the BCRC. The collaboration between the BCRC and this working group, the Canadian **Beef Value Chain Research Committee**, resulted in the development of the first National Beef Research Strategy in 2012. Under the direction of the BCRC and the National Beef Value Chain Research Committee, stakeholders from industry and provincial and federal governments were consulted throughout the comprehensive strategy development process. The BCRC continues to manage the 2012 National Beef Research Strategy, reporting regularly to the BVCRT and its Research Committee.

b. Highlights of the 2012 National Beef Research Strategy

Forecasting industry needs in beef and forage research and strategically investing in all elements – including improvements in productivity, food safety and quality, maintaining critical research capacity, and science to address social license questions - is a challenge. It is particularly challenging considering the large number of funding agencies (30+) involved in funding beef and forage research at both national and provincial levels and across both government and industry.

Consequently the BCRC and the national BVCRT recognized the importance of taking a careful and strategic approach to the development of a comprehensive National Beef Research Strategy in 2012. The intent of the 2012 National Beef Research Strategy was to provide a framework to achieve national coordination of beef research priorities, funding and communication efforts. Having clearly defined research outcomes that the BCRC could develop the Science Cluster around was a significant benefit of the Strategy. The 2012 Strategy was also intended to influence and guide the investments of other funding agencies in order to encourage greater collaboration and coordination of limited funding and resources, thereby reducing duplication and ensuring high priority research and capacity needs were addressed in a coordinated manner.

The 2012 National Beef Research Strategy was developed through a comprehensive analysis of the beef research funding portfolio in Canada and extensive consultation and engagement of a very broad group of value chain stakeholders including producers, researchers, government, and funding agencies to identify the key research outcomes that the beef industry needed to address through 2018. The 2012 National Beef Research Strategy has been a dynamic document intended to evolve based on stakeholder feedback and ongoing review as research outcomes are achieved and new outcomes arise.

Overall the 2012 National Beef Research Strategy has contributed to significant progress including more regular sharing of information between industry and government funding agencies. More importantly, the National Beef Research Strategy is often present when funding agencies define priorities and make funding decisions. It has also assisted in informing and encouraging more proactive industry and government discussions about needed infrastructure and capacity, and how to work together moving forward.

From a research perspective, the 2012 National Beef Research Strategy provided a greater focus on specific, targeted research outcomes with clear direction to researchers and allows industry to more clearly communicate what is being funded and how research funding aligns with industry goals. This, along with a focus on enhanced communication and coordination within industry regarding the importance of research, has encouraged increased industry investment. The 2012 National Beef Research Strategy is available on the BCRC website at www.beefresearch.ca.

Now approaching the end of the fourth year of the five year National Beef Research Strategy, the Strategy is proving to be instrumental in guiding industry and government research investments at both national and provincial levels across multiple funding agencies. Through implementation of the Strategy, the BCRC continues to work in partnership with industry and government funding agencies across Canada to be more efficient with limited funding and to ensure key research, capacity, and infrastructure priorities are addressed. This partnership is a driving force in the development of a renewed five year Strategy, the Canadian Beef Research and Technology Transfer Strategy 2018 - 2023.

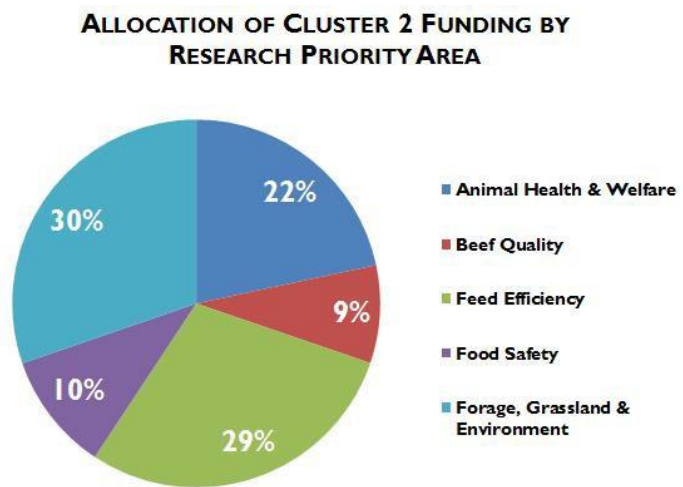
c. Overview of Funding Under the 2013-2018 Beef Cattle Industry Science Cluster

The Beef Cattle Industry Science Cluster is a partnership between AAFC and the BCRC to ensure that proactive and strategic investments in applied research are allocated to programs that have the greatest potential to advance the Canadian beef cattle industry. The partnership is focused on enhanced coordination and collaboration, and alignment of research activities with industry priorities to increase productivity, reduce costs, advance sustainability, and increase demand for Canadian beef.

Joint industry and government funding commitments to the second Beef Science Cluster, running 2013 to 2018, totaled \$20 million. This funding included \$14 million from AAFC and \$5 million from the research allocation of the National Check-off and provincial beef industry groups, with additional investments by provincial governments. Funding was directed to 26 research projects to be completed by March 31, 2018.

The research programs established under the second Beef Cattle Industry Science Cluster followed an extensive process initiated by the development of the 2012 National Beef Research Strategy. Desired research outcomes were directly aligned with objectives established under the 2012 Strategy. Investments were focused on a portfolio of research contributing to the industry’s ability to meet the growing global demand for high quality, safe beef through responsible and profitable production practices that support a sustainable future for the Canadian beef cattle industry. There were three core research objectives under which more specific research programs were established:

- 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.
- 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.
- 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, videos, webinars and cost of production decision making tools, and promoting and enabling the engagement of researchers with industry.



Details on the 26 projects funded under the second Cluster can be found at <http://www.beefresearch.ca/about/funding/canadas-beef-science-cluster.cfm>. Annual results reports and the first Cluster results report can be found at <http://www.beefresearch.ca/resources/reports.cfm>.

III. Industry Competitiveness

a. Global Market Outlook

The world population is projected to grow from 7.3 billion in 2015 to 9.7 billion in 2050, with the majority of the 33% population growth in developing nations. Compared to 2010 production levels, feeding the global population will require 70% more food to be produced. Meanwhile land and natural resources allocated to agriculture will be increasingly pressured and are likely to be reduced globally due to competition between agriculture production sectors, urban pressures, and other resource and commercial activities. This implies that triple the amount of people need to be fed using less resources, which has important implications on how beef production grows globally and within Canada to meet growing demand.

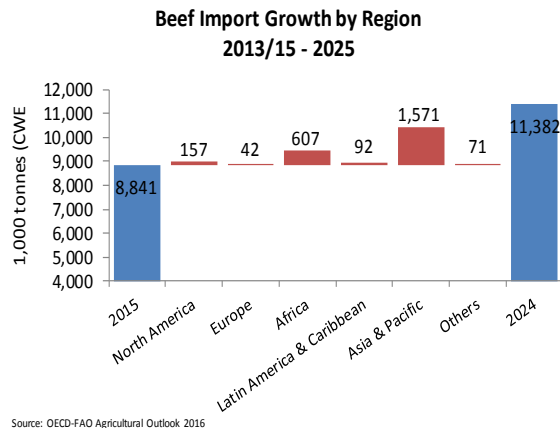
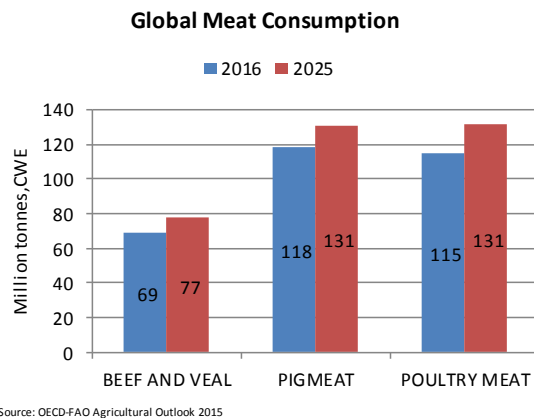
Global Beef Demand and Supply

Global population growth is expected to be accompanied by growing disposable incomes in developing countries where the demand for protein, edible fat, dairy and other foods is growing at a remarkable rate. Over the next ten years the Food and Agriculture Organization of the United Nations (FAO) has projected beef consumption to grow 1.8 million tonnes or 6% in developed countries and 6.8 million tonnes or 17% in developing countries. This consumption increase supports the continued growth of international beef trade.

From a trade perspective, imports are expected to rise over the next ten years to meet growing demand. The most significant growth in imports is expected to occur in African and Asian markets where increasing populations and rising disposable incomes will see the greatest growth in beef consumption.

The question remains: Which countries will be in a position to meet growing global demand for beef in the near term and over the longer term?

The fact that the differential in relative costs of production between low-cost grass fed beef exporting nations (i.e. Brazil, Australia) and higher cost grain fed exporting nations (i.e. United States, Canada) has narrowed is significant. Land prices continue to inflate due to competition for acreage and production, while labour costs increase in South America and elsewhere. Furthermore, with the global agriculture land base facing continued pressures from urban growth, other resources and commercial activities, the relative margins between agricultural commodities will play an increasingly important role in determining which agriculture sectors expand in any given production region. This



implies that profitability alone will not result in expansion of beef production. Instead, relative profitability will determine agriculture resource allocations and the regions where beef production will grow.

The landscape for global beef production and beef exports is changing. Countries such as Brazil have focused significant investments on improving productivity within their herd to derive more pounds of beef per animal and/or per acre. At the same time, they are challenged by increasing environmental regulations that are creating uncertainty and increasing costs for their industry. Australia has remained a major beef exporter in the global market and is currently expected to rebuild its herd size over the next five years while focusing on productivity and drought resilience. Drought is often the Australian industry's greatest challenge when it comes to maintaining or expanding its size.

Global exporters such as India are less predictable. India has risen rapidly to become a significant exporter of beef on the global market. The expectation is that India's cattle and water buffalo population will remain strong over the next decade based upon steady growth in the dairy sector. India has the potential to substantially increase production and exports if they can focus on productivity and infrastructure to support export development. Other countries like Mexico have moved from being a net importer to a net exporter through investments in infrastructure along the supply chain and improving feed production and animal productivity.

Global agriculture markets and trade, including beef, are increasingly challenged with price volatility. This is driven primarily by pressure on supplies as food demand grows at varying rates. Any major impact on supplies from drought, other detrimental weather conditions, food safety, animal health and disease issues can result in dramatic swings in the market. Continued improvements in agricultural productivity are imperative to allow for greater resilience to these issues. This resilience comes from continuous improvement in productivity (per acre or animal) and innovations in management that address these different aspects of risk.

Beef Production

Over the next ten years, the United States and Canada are expected to be in a very similar situation when it comes to their ability to grow beef production and global beef exports. Expansion will be highly contingent upon a multitude of factors, not the least of which being domestic industry profitability. There is potential for expansion and growth within the Canadian and American beef industries but both are highly responsive to market signals, which will ultimately drive production decisions. Expansion will be contingent upon growing demand for North American beef globally through trade agreements and the reduction of tariff and non-tariff barriers. Regulatory competitiveness between Canada and the United States and globally will also play a significant role in determining where and if expansion occurs within the North American industry. Regulatory competitiveness is impacted by a multitude of areas including food safety, environment, animal health and welfare, and access to resources and labour. The relative valuation of currency will also play a role in competitiveness.

The overarching goals of the Canadian beef industry are to increase the carcass cutout values, increase production efficiency and reduce cost disadvantages to main competitors. As an export dependent industry with 45% of beef production going to other countries, the Canadian beef industry as a whole

must remain competitive and be able to provide a cost competitive high quality product that meets the standards and quality expectations of both domestic and international customers.

The Canadian beef industry can meet growing global demand for beef. The challenge is to manage continued industry growth in a sustainable manner that allows for industry profitability, while also ensuring environmental sustainability and the maintenance of public confidence. Compared to other global beef industries, the Canadian beef industry has a unique asset: access to sufficient arable land and water resources in the coming decades. There are significant opportunities within Canada to increase productivity and the amount of beef production derived per acre of land or per animal.

In 2011 pasture land accounted for 31% (50 million acres) of Canada's total farm land. In most cases this land is unsuitable for annual crop production and consequently its use for beef production is a means to contribute to food production in a sustainable way. In the Canadian grain-fed production system, over 80% of a beef animal's diet over its lifetime is forages. This key resource to the cow-calf sector also contributes to biodiversity, wildlife habitat, carbon sequestration, water and nutrient cycling and ecosystem services to society. Maintaining this important land reservoir for biodiversity and environmental benefits is contingent upon the grasslands remaining healthy and invigorated through grazing, careful management and stewardship of the land.

b. Role of Beef Research

“We, the G20 Agriculture Ministers, are committed to meeting the challenge of global food security and nutrition for an expected world population of nine billion by 2050. We stress that intensifying pressures on natural resources and biodiversity and the impacts of climate change mean that we should raise productivity while moving towards food systems that are more sustainable in all their dimensions – economic and social as well as environmental...”
(Final communique, G20 Agriculture Ministers Meeting, Istanbul, May 8, 2015)

Sustainably meeting the nutritional needs of a growing global population and its demand for beef requires using fewer resources and greater productivity of both beef cattle and their feed. According to the Agricultural Institute of Canada, feeding a growing world population against the backdrop of the intensifying pressures of climate change, food safety issues and other factors needs to be informed by a strong scientific base. A substantial investment in agricultural research will be the primary source of innovation and productivity enhancements needed to meet these future challenges. Canada can play a leading role in meeting these challenges and opportunities by renewing and enhancing its efforts in agricultural research across a variety of disciplines over the next twenty years. The Organisation for Economic Co-operation and Development (OECD) Food and Agricultural Review “Innovation, Agricultural Productivity and Sustainability in Canada” stated four recommendations for Canada,

1. Improve incentives for private investment;
2. Improve capacities and services for innovation;
3. Remove unintended impediments to innovation; and
4. Strengthen direct incentives to innovation in food and agriculture.

Maintaining and enhancing industry and government investments in beef and forage research and extension programming, capacity and infrastructure is a top priority for the Canadian beef industry. The Canadian beef industry views innovation as integral to advancing its competitiveness and sustainability. Recognizing this, the Canadian beef industry has increased its investments into research and is working to further increase their research investments through the National Check-off.

Canada has a significant opportunity to lead the response to increased global demand through production and export of safe, high quality grain-fed beef. With finite land and resources and with increased competition from other agricultural sectors, continued productivity advancements in production efficiency while being globally competitive are critical. Three primary avenues to increase productivity in the beef industry through innovation are:

1. Practices – improving management
2. Products – using new, tools and technologies
3. Genetics – enhancing desired traits in plants and animals

Adoption is key to the successful innovation. Further investments in applied research should be done with a deliberate and focused effort on technology transfer within the beef industry. Adoption, after research has become commercially available, has been historically low in some cases within the primary production sectors which impedes improvements in productivity. This emphasizes the need to have a coordinated research and technology transfer strategy to ensure continued improvements via innovation and subsequent adoption of innovations in a more expedient manner.

There is potential to advance productivity within the Canadian beef sector in a sustainable manner. Over the last several decades significant advancements have been made within the beef industry because of research and development particularly in the areas of beef quality and safety, animal and plant genetics, reproductive efficiencies, animal nutrition, animal health and welfare, disease control, biotechnology, and environmental stewardship. A 2015 study on the environmental footprint of Canadian beef production demonstrated that each 1 kilogram of Canadian beef produced in 2011 created 15% less greenhouse gases than in 1981 due to improved production practices. Comparing the same period, it took 29% fewer cattle in the breeding herd and 24% less land to produce the same amount of beef, contributing positively to reduced water and resource use and manure production.

Current progress is positive, but opportunities remain for continued improvements that contribute positively to enhanced productivity while further reducing the environmental footprint of Canadian beef production. There are significant opportunities within beef cattle genetics to advance quality, disease resistance, feed efficiency, and reproductive efficiencies. Similarly on the plant side, there are opportunities to continue to focus on genetic and agronomic improvements that contribute positively to forage and feed grain productivity through enhanced yields, disease and drought resistance, and nutritional quality. Continued advancements in animal health and welfare, including new strategies and vaccines for disease management, parasite control, reduced antimicrobial use and the development of effective antimicrobial alternatives are also key to enhancing productivity.

Access to new technologies, innovations, practices, and desirable genetics are essential to meet global food security challenges in a manner that fulfills expectations around food safety, animal welfare, and environmental sustainability. Despite this knowledge there is a growing perception by a portion of the

population that the industry should return to previous production practices due to perceptions of the impacts innovations have on food safety, the environment and animal welfare. Research is key to addressing these perceptions.

Research is integral to providing science-based information to address growing public confidence concerns in the areas of beef quality and nutrition, food safety, production and animal health practices, animal welfare, antimicrobial resistance and use, and environmental sustainability. Independent peer-reviewed science provides an important voice to regulatory, policy, trade, and public discussions that can ultimately have a significant impact on the beef industry's ability to continue in a sustainable and competitive manner that contributes positively to global food security.

The Canadian beef industry is a trade-dependent sector and therefore it cannot stand still in areas of productivity and innovation given competition from Brazil, the United States, Australia and others. These competitors are aggressively pursuing opportunities to increase productivity. With limited global agriculture resources, countries with the most efficient and sustainable beef production systems will ultimately be the most competitive. Access to innovations through a supportive science-based policy and regulation environment is particularly important in the Canadian beef industry.

Research is required to inform regulation and ensure it achieves the desired objectives but does not impede or negatively impact the industry's competitiveness or access to new innovations and technologies. Key areas of regulatory focus include animal welfare and transport, water quality and nutrient management, product development and approval (feed, drugs, etc.), specified risk material (SRM) management and disposal, food safety interventions, and antimicrobial resistance.

Research programs are envisioned to lead to several benefits, including:

1. Maintaining and improving production competitiveness;
2. Supporting science-based policy, regulation and trade;
3. Providing science-based information to support public education and advocacy;
4. Supporting the Canadian Beef Advantage and demand for Canadian beef;
5. Maintaining professional research capacity to ensure that experienced professionals are in place to effectively respond to emerging or critical issues; and
6. Encouraging greater uptake of research knowledge and technologies by industry.

c. Canada's National Beef Strategy

Canada's beef industry has evolved over the years and its current state is shaped by factors both in and out of its control. Faced with new challenges and opportunities, in 2014 the Canadian beef industry collaborated on the development of a five year National Beef Strategy. Canada's National Beef Strategy is about positioning the Canadian beef industry for greater profitability, growth and continued production of a high quality beef product of choice in the world.

The National Beef Strategy presents priorities, goals and funding needs, including research, to ensure the Canadian beef industry thrives well into the future. Under four pillars, namely connectivity, productivity, competitiveness and beef demand, the National Beef Strategy aims to achieve targeted industry goals identified as being crucial to long-term competitiveness of the industry and all its

stakeholders including grassroots producers. These goals include increasing the carcass cutout value, reducing cost disadvantages compared to main competitors and increasing production efficiency. Visit www.beefstrategy.com for more information on the National Beef Strategy.

The Canadian Beef Research and Technology Transfer Strategy 2018 – 2023 directly supports the four pillars of the National Beef Strategy through its outcomes to advance the competitiveness and sustainability of the Canadian beef cattle industry. More specifically, the Canadian Beef Research and Technology Transfer Strategy 2018 - 2023 supports research to maintain or improve consumer confidence and demand for Canadian beef by investing in beef quality and food safety research, and to maintain or improve production competitiveness with advancements in animal health and welfare, feed grains and efficiency, and forage and grassland production.

Specific to the productivity, competitiveness and beef demand pillars of the National Beef Strategy, research programs are established to validate and enhance the Canadian Beef Advantage, to increase, maintain and enhance consumer confidence, and address social license issues of priority. Further, programs are developed to increase productivity through investments in genetic selection, research and development, and technology development and extension. Research programs also support long-term competitiveness through investments in new and priority research capacity, and research to support long-term industry sustainability. With regards to the connectivity pillar, programs under the Canadian Beef Research and Technology Transfer Strategy 2018 – 2023 encourage researchers, industry, and other funding agencies to collaborate for more efficient use of limited research dollars to ensure priority research outcomes are achieved, and encourage greater adoption of new technologies and practices.

IV. Research Funding Review and Coordination

a. Industry Engagement on Priorities

The BCRC and BVCRT have accepted a leading role in the development and implementation of the Canadian Beef Research and Technology Transfer Strategy 2018 – 2023. This role requires as well as encourages ongoing engagement of other industry and government funding agencies and research institutions. This industry collaboration helps to identify gaps in research needs, research capacity, infrastructure, and programming and ensures priority industry outcomes are being addressed.

To ensure the Canadian Beef Research and Technology Transfer Strategy 2018 - 2023 development process remained truly collaborative and highly focused to target future research priorities and funding, industry input was sought through various means including direct stakeholder consultation, an online survey, and two workshops. Researchers, funders and grassroots producers were engaged throughout the Strategy development process. The online beef research priority survey provided input from 506 industry stakeholders across the beef value chain.

A national research priority workshop was held in Calgary on June 22 and 23, 2016. Over the 1½ days, 103 participants considered the progress on research outcomes of the 2012 National Beef Research Strategy and assessed and defined where continued research is required. Attention was focused on identifying new and emerging research priorities that should be included in the Canadian

Beef Research and Technology Transfer Strategy 2018 – 2023. The workshop also provided a forum to review the National Beef Research Inventory (discussed below) to examine projects that have been funded over the last five years across all funding agencies. The BCRC and the BVCRT engaged provincial and federal government and industry funders in discussions about opportunities to improve funding coordination and delivery of research that clearly aligns with industry's established research priorities and defined research outcomes.

A national beef technology transfer workshop was held in Saskatoon on September 28, 2016. At this one-day workshop 29 extension specialists from across Canada, representing provincial and national organizations, discussed beef extension priorities. The workshop resulted in increased awareness of and collaboration between extension groups, and identification of innovations that, if adoption rates increased, would have the greatest potential to advance the competitiveness and sustainability of the Canadian beef industry.

A list of the stakeholders represented at the workshops is included in section VI(b). A summary of the survey results is included in section VI(c).

b. National Beef Research Inventory

A core component of encouraging greater collaboration amongst beef research funding agencies and alignment with the Canadian Beef Research and Technology Transfer Strategy 2018 – 2023 was the development of a national beef research inventory system. The intent of the system is to collect data from major beef research funding agencies and to share the data across agencies to better inform funding directions and decisions.

The inventory system tracks two areas. Firstly, participating funders provide information about the proposals they receive and whether the proposals have been funded. This helps track the interests and expertise of researchers, and provides funders with industry's views on the relevance of the research, whether similar work is already ongoing somewhere else, or potential collaborators. The second area tracked is projects that are underway. By comparing the research objectives of each proposal with the target research outcomes in the Canadian Beef Research and Technology Transfer Strategy 2018 – 2023, an assessment can be made on how research funding is aligned with the Strategy, which outcomes are being addressed, which research areas are potentially being over-funded, and which outcomes are not being addressed at all.

The BCRC has accepted responsibility for developing and maintaining the national beef research inventory system. Over the next five years, the BCRC will continue to actively engage funders to encourage increased participation and grow the number of projects and funders represented in the database.

V. Research Priorities and Outcomes

a. Outcome and Priority Setting Processes

Rather than concentrating on research priorities, it is necessary to establish more specific research outcomes. Having targeted industry outcomes helps to ensure applied research funding is focused. For example, a priority may be something such as ‘improved forage and grassland productivity’, whereas a targeted industry outcome may be ‘the production of legumes with a 30% improvement in yields, longer stand life and reduced bloat risk’. Priorities are relatively easy to identify; establishing specific outcomes is more challenging but is important to ensure research is aligned more directly with industry’s needs.

The development of priority research outcomes for the Canadian Beef Research and Technology Transfer Strategy 2018 – 2023 involved several steps including the review of beef research funded over the past five years, an online beef research priority survey, in-person workshops, and direct stakeholder engagement.

The Beef Research Priority Survey conducted March to May 2016 allowed participants to rate the importance of research issues from the 2012 National Beef Research Strategy. The 506 survey respondents included cow-calf producers (49%), seedstock breeders (5%), feedlot operators (4%), veterinarians (3%), researchers (9%), abattoir staff (0.4%), government staff (10%), industry staff (9%) and other (10%) - mainly producers involved in more than one sector. Feeding into the workshop and broader priority setting process, particular attention was paid to issues that were identified as ‘very’ or ‘extremely’ important by a large proportion of respondents, as well as those rated as ‘low’ or ‘not’ important by many respondents.

The second step used historical funding information from the National Beef Research Inventory to assess key funders’ research allocations and outcomes achieved with respect to the National Beef Research Strategy since January 2012. The combination of this analysis and the survey responses directly fed into presentations and discussions at the Beef Research Strategy workshop. The workshop saw over 100 attendees representing industry (seedstock, cow-calf, feedlot, processing, forage and feed production, and animal health), funders (industry, provincial and federal government) and researchers who, through specific breakout groups, worked to identify target research outcomes for 2018-23.

This was followed by a compilation and validation of proposed target research outcomes through consultation with key stakeholders including the Science Advisory Panel for the Beef Cattle Industry Science Cluster, the BCRC members, and other organizations and individuals as appropriate. Members of the BVCRT were involved throughout the process and the final draft of research outcomes was presented to the BCRC and the BVCRT for feedback and approval.

b. Historical Priorities and Funding Allocations

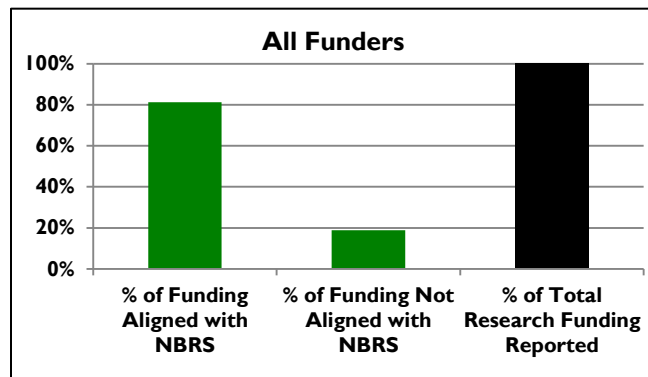
Utilizing information drawn from the National Beef Research Inventory, overall forage, cattle and beef funding allocations between January 1, 2012 and December 31, 2015 (557 projects worth \$127.4 million funded by 13 organizations) were compared to 2007-2011 (593 projects worth \$93 million

funded by 23 organizations). The proportion of funding allocated to forage, feed grain and feed efficiency research each increased by 10 percentage points, animal health and food safety funding each increased by 5 percentage points, and beef quality funding declined by six percentage points between 2007-11 and 2012-15.

National Cattle, Forage and Beef Research Funding in Canada



Over 80% of national beef research funding allocated across all priority areas between January 1, 2012 and December 31, 2015 was clearly aligned with the research outcomes identified in the 2012 National Beef Research Strategy (NBRS).



c. Core Research Objectives

The beef industry has defined three core research objectives for the Canadian Beef Research and Technology Transfer Strategy 2018 – 2023 under which more specific priorities are established:

1. **To enhance industry sustainability and improve production efficiencies**, priority outcomes are to enhance feed and forage production, increase feed efficiency and decrease the impact of animal health issues and production limiting diseases.
2. **To improve consumer confidence and beef demand**, priority outcomes are to reduce food safety incidences, define quality and yield benchmarks supporting the Canadian Beef Advantage, and improve beef quality through primary production improvements and the development and application of technologies to optimize cutout values and beef demand.
3. **To improve public confidence in Canadian beef**, outcomes are to improve food safety, strengthen the surveillance of antimicrobial use and resistance, develop effective antimicrobial alternatives, ensure animal care, demonstrate the safety and efficacy of new

production technologies, improve environmental sustainability and measure the beef industry's environmental benefits.

d. Overarching Aims for Reaching Priority Areas

For all Priority Areas, proposed research needs to give strong consideration to the following overarching aims:

1. Improved communication, collaboration and understanding between researchers and industry, with research/industry collaborations increasing to account for 25% of research activities.
2. Cost-benefit analysis completed to support recommendations and knowledge transfer from research projects that impact production profitability.
3. Encouragement of interdisciplinary teams undertaking systems-based approaches integrating appropriate parts of the value chain.
4. Investigate technologies with the potential to reduce labour and improve production efficiencies throughout the forage, cattle and beef production chain.
5. Enhanced awareness and consideration of relevant international research and development activities to avoid duplication and identify opportunities for collaboration.
6. Enhanced awareness of consumer and public questions/issues/concerns to allow for more targeted responses supported by research.

e. Desired Research and Technology Transfer Outcomes

i. Beef Quality

1. Overview as a research priority

The objective of beef quality research is to increase demand for Canadian beef through production and processing improvements to reduce inconsistencies and increase product quality for consumers.

Canadian per capita beef consumption declined 38% from 28.7 kilograms in 1980 to 17.8 kilograms in 2015. Overall beef consumption in Canada declined to 875,000 tonnes, 8% below the long term average (953,500 tonnes carcass weight). Population growth has not offset declines to maintain total consumption. The Beef Demand Index measures consumer willingness to pay for beef based on deflated retail prices. Canada's index has ranged from 125 in 1989 to a low of 91 in 1997. Demand was at a 25 year high in 2015.

A number of factors contribute to beef demand such as:

Disposable income – As the baby boomer generation retires, age and fixed finances influence their beef purchase decisions along with a desire for a smaller portion size, resulting in an overall decline in per capita consumption. Economic uncertainty that negatively affects disposable income is a major factor affecting consumers' purchasing power and food choices.

Price and price relative to competing proteins – Beef is the most expensive protein. When economies weaken and purchasing power decreases, consumers switch to cheaper cuts or proteins.

Health concerns – Nutrition, fat content, and other health factors all influence consumers' protein choices. The information needed to compare the nutritional value of beef to foods on a per unit weight, per dollar or per calorie basis is lacking.

Public confidence concerns – Perceptions and concerns related to issues such as food safety, antimicrobial use and resistance, growth promotants, animal health and welfare, and environmental impact can affect consumer behavior, public confidence and policy development.

High variability in beef quality is a significant challenge with beef demand. The top three meat attributes for consumers are tenderness, consistency and convenience. Quality (marbling and maturity) grades do not adequately differentiate steaks by tenderness. It is difficult to make progress without clear market signals linked to tenderness, juiciness and flavor. Research focused on tenderness genetics, developing technologies to measure tenderness in-plant, and processing interventions to increase tenderness in undervalued cuts is important.

Canada trailed the United States in producing AAA and Prime beef in 2015 (64.1% vs. 72.3% respectively). Since 1997, the percentage of Yield Grade I (YG1) carcasses has declined from 71% to 42%. Market signals encouraging higher marbling and heavier weights have offset penalties for YG2 or YG3 carcasses. Dark cutters remain above the 1999-2008 average in Western Canada (1.3% vs. 1.0%) and below in Eastern (1.8% vs. 3.7%).

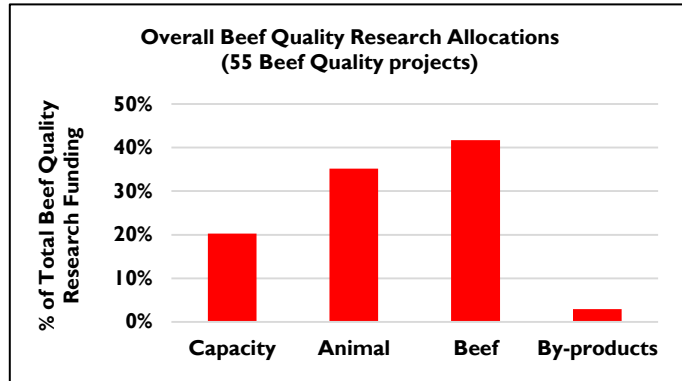
2. 2016 National Beef Research Priority Survey beef quality results

Increased consistency and quality, benchmarking consumer satisfaction with Canadian beef, updating nutritional information with comparison to other foods, and benchmarking and validating attributes of Canadian beef and the Canadian Beef Advantage were high priorities to seedstock, cow-calf and feedlot respondents. Feedlot respondents also identified validating the effectiveness and value of genetic markers for tenderness in commercial cattle, potential interactions between tenderness genotype and animal management practices, validating objective in-plant measures of tenderness, and packaging and other technologies to improve shelf life as high priorities.

3. Beef quality research funded since 2012

From 2012 to 2015, cattle-focused research accounted for 35% of overall beef quality funding, and was overwhelmingly aimed at genetic improvement of tenderness, marbling and general carcass traits. Beef product quality research accounted for 42% of beef quality research funds, and was primarily directed towards beef grading, functional fatty

acids, and quality audits. Capacity investments accounted for 20% of beef quality funding, and were directed towards core funding for genetics research (13%) and technology to facilitate carcass composition research (7%). By-product research received 3% of overall beef quality funding.



4. Beef quality research outcomes 2018 - 2023

Outcome 1: Improve customer satisfaction with Canadian beef; detailed outcomes include:

- Beef Quality Audit demonstrates a reduction in carcass defects below 2016 levels and maintained or improved consumer satisfaction for tenderness, juiciness and flavor of inside round, cross-rib, top sirloin and strip-loin steaks
- Develop and implement processes that facilitate the automated collection, recording, evaluation and communication of desirable (e.g. high lean yield/high marbling/healthy livers) and undesirable (e.g. low lean yield/low marbling/ abscessed livers) characteristics to enhance the Beef Quality Audit
- Re-evaluate electrical stimulation recommendations in commercial environments to reflect increased carcass weights
- Validate objective in-plant measures of tenderness that can be used at line speed
- Demonstrate the cost-effectiveness and value of genetic markers for tenderness in commercial cattle
- Identify potential interactions between tenderness genotype and animal management (e.g. implants, backgrounding, grassing, finishing, etc.) and develop appropriate breeding and management recommendations

Outcome 2: Validate and support the Canadian Beef Advantage; detailed outcomes include:

- Improved algorithms for predicting lean meat yield and / or retail product percentage
- Implement genomic and grading technologies that allow for market segmentation according to carcass quality and/or yield
- Develop packaging and other technologies to improve shelf life and appearance for export
- Complete a systematic literature review on the nutritional attributes of beef relative to other foods to address consumer concerns, inform consumer education programs, and identify appropriate research directions and applications
- Collect data regarding the nutrient density (per g) and value (cost per unit nutrient)

of beef relative to other foods, including protein, mineral, vitamin, and lipid components

Outcome 3: Extension, outreach and policy; detailed outcomes include:

- Conduct demographic (young adults, parents, retirees) research addressing consumer perceptions, attitudes, stated preferences and buying behavior with respect to Canadian beef and offal products (e.g. importance of price, cultural factors, production methods, convenience, quality, nutritional attributes, healthfulness and enjoyment)
- Enhance consumer education regarding their role and responsibility in ensuring beef quality through selection of appropriate cut-specific preparation and cooking methods
- Increase information exchange between sectors along the supply chain to help inform production decisions that ultimately improve carcass value and consumer satisfaction

ii. Food Safety

I. Overview as a research priority

Food safety research is important to maintain domestic and international consumer confidence and beef demand by developing improved food safety interventions, methods to quantify the effectiveness of food safety interventions, and developing food safety interventions that counteract multiple pathogens.

Human illness linked to beef and product recalls due to pathogens continues to be a major concern for the Canadian beef industry. Interventions such as lactic acid washes and carcass pasteurization implemented by the processing sector have effectively reduced pathogen contamination on the carcass. More recent efforts have focused on effectively cleaning equipment, conveyor belts, knives, gloves, etc. to avoid recontaminating beef on the fabrication line. Not all of the food safety interventions that have been demonstrated to be effective for Canadian beef have been approved in key international markets. In some cases, additional research may be necessary to help address these concerns and regulatory barriers.

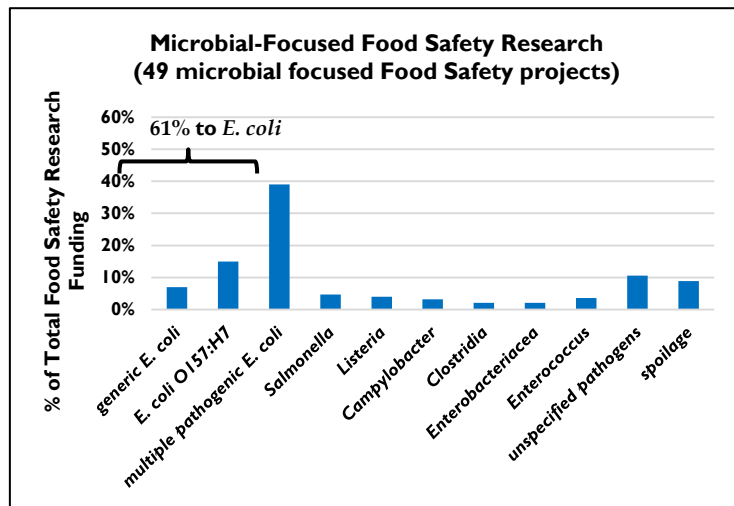
The Public Health Agency of Canada's National Enteric Surveillance Program shows that 3.8 people in 100,000 were infected with *E. coli* O157:H7 in 2002 compared to 1.4 in 100,000 in 2014. Since 2013, there have been six multi-jurisdictional enteric outbreaks of *E. coli* investigated in Canada (2013 = 3, 2014 = 1, 2015 = 2). Beef was not implicated as the source of any of these outbreaks. In two of these outbreaks, the source was either suspected or confirmed to be a food other than beef; the source of the remaining four outbreaks was not identified.

2. National Beef Research Priority Survey food safety results

All cattle sector respondents indicated that verifying the effectiveness of packing equipment cleaning processes was a clear priority. Surveillance to detect, characterize and quantify the relative human health risk of (re) emerging pathogens was a priority to cow-calf and feedlot respondents. Feedlot respondents identified all additional food safety issues (Developing technologies targeting multiple pathogens in cattle and beef processing facilities, developing interventions to eliminate pathogens for beef, and surveillance of antimicrobial resistance in beef) as high priority.

3. Food safety research funded since 2012

Over the past five years, 61% of food safety research funding was directed towards *E. coli*, with less than 10% allocated to *Salmonella*, *Listeria*, *Campylobacter*, *Clostridia*, or *Enterococcus*. Most research (44%) focused on interventions to eliminate spoilage, pathogenic and indicator bacteria, and 34% to detection of bacteria in food and water.



4. Food safety research outcomes 2018 - 2023

Outcome 1: Improved food safety along the beef supply chain; detailed outcomes include:

- Develop and implement cost-effective technologies targeting multiple pathogens in cattle and beef production and processing facilities, including heat- and acid-resistant *E. coli* and biofilm-forming bacteria
- Develop and implement cost-effective technologies to rapidly and effectively detect STEC (e.g. *E. coli* O157) contamination in beef and trim
- Develop objective, cost-effective approaches for verifying effectiveness of packing plant equipment cleaning processes, and adopt them for 85% of processed cattle
- Increase surveillance to detect, characterize and quantify the relative human health risk of (re)emerging pathogens

Outcome 2: Improved beef quality and food safety research and training capacity; detailed outcomes include:

- Establish an industry meat science research chair to address issues facing the beef packing and processing sectors, and reinvigorate food safety research program capacity
- Establish a meat science program at a Canadian university with educational and research components to produce highly qualified personnel serving Canada's beef industry

Outcome 3: Extension, outreach and policy; detailed outcomes include:

- Encourage the consistent adoption of known best practices to minimize the risk of pathogen contamination in beef processing plants through enhanced processor education encouraging the consistent adoption of proper and thorough cleaning of conveyor belts, personal equipment, processing and grinding equipment, etc.
- Enhance consumer education regarding their role and responsibility in ensuring food safety in the home, including the relative efficacy of alternative in-plant interventions and at-home food handling and storage practices to ensure food safety
- Generate science-based information to inform the regulatory approval of trim and ground beef irradiation in Canada
- Generate science-based information to inform the regulatory approval of effective food safety interventions in key international markets (e.g. European Food Safety Authority approval of peroxyacetic and citric acid interventions for beef)
- Generate science-based information to inform regulatory approval of cost-effective methods of separating specified risk material (SRM) from non-SRM in order to reduce SRM disposal costs and the amount of material directed to landfill

iii. Animal Health and Welfare

I. Overview as a research priority

Animal health research develops cost-effective management, diagnostic, and treatment tools to reduce the losses caused by major production limiting diseases and animal health issues. Animal welfare research provides the knowledge needed to inform science- and outcome-based best management practices, regulations and public communication regarding the animal welfare impacts of beef production practices.

Canada is world renowned for producing healthy beef cattle in a pristine environment, and for having a strong commitment to animal health and welfare. However, the 2003 discovery of BSE in Canada's cattle herd demonstrated how quickly things can change and the slow pace of regaining market access. Animal health and welfare must continue to be a priority for Canada to be a global leader in animal health and food safety and ensure production competitiveness. Increasing pre-weaning survival rates from current levels

(85%) to levels seen in the 1990s (90%) would be worth at least \$160 million to the beef industry.

For cow-calf producers, good reproductive rates are critical to profitability regardless of calf prices. It is generally expected that each breeding age female in the herd produces and weans a healthy calf each year. Cows that do not produce calves every year use resources that could be used to support more productive cattle.

In feedlots, approximately 65-80% of total morbidity (sickness) occurs within the first 45 days on feed, primarily from respiratory disease, though acidosis can also occur during this period. Miscellaneous issues, respiratory, and digestive disorders represent 44.1%, 28.6% and 25.9% of deaths respectively over the entire feeding period. Morbidity is also costly in terms of treatment and labour costs and reduced growth and efficiency compared to healthy calves.

Animal welfare is closely linked with animal health. Understanding how different stressors affect the animal and identifying cost-effective, less stressful alternatives will benefit industry practice and help address public confidence issues related to beef production.

2. National Beef Research Priority Survey animal health and welfare results

Reproductive efficiency and cow nutrition were priorities for seedstock and cow-calf respondents. Immunology and vaccinations were a high priority to cow-calf, feedlot and veterinarian respondents. Shipping fever/bovine respiratory disease (BRD) was a priority to feedlot respondents. Nutritional diseases associated with high concentrate rations (e.g. acidosis, liver abscesses, laminitis) were a priority to veterinarians.

All livestock sector and veterinary respondents rated animal welfare as a high priority public confidence issue. However, many survey respondents classed research studying dehorning (all livestock sectors), weaning (feedlot respondents), branding (all livestock sectors and veterinarians) and transport (feedlot respondents) as relatively low priorities. Lameness was a much higher priority to veterinarians than to livestock respondents. The contrast between animal welfare as an important public confidence issue and the lower importance placed on individual welfare research issues may not have occurred if references to “pain management” or “science-based regulation” had been incorporated into individual questions.

3. Animal Health and Welfare research funded since 2012

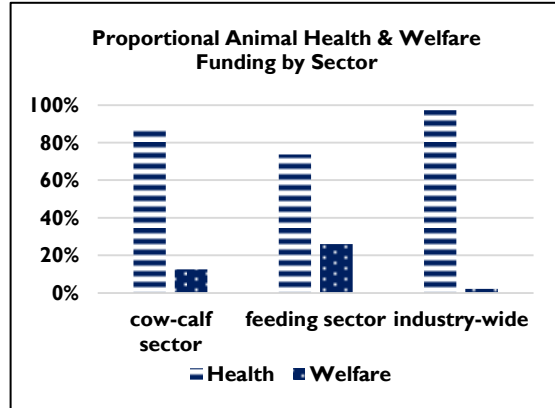
Since 2012, animal health and welfare funding was directed towards the cow-calf (27%), feeding (46%) and industry-wide (28%) research. Animal health and welfare funding was primarily (85%) directed towards animal health, with 15% to animal welfare.

Cow-calf health research was primarily directed towards reproductive issues (42%, mainly investigating the role of nutrition), Johne’s disease (16%) and bovine viral diarrhoea (15%).

Feedlot oriented research focused on bovine respiratory disease (73%), with the remainder mainly focused on gastrointestinal health (23%). Industry-wide animal health funding focused on prion research (45%), with toxin, anaplasmosis and traceability research each receiving between 12 and 14%.

Cow-calf welfare funding mainly focused on pain mitigation (74%) and rumen health during winter grazing (11%).

Feedlot animal welfare funding focused on lameness (57%), rumen health (32%) and transport (10%).



4. Animal health and welfare research outcomes 2018 - 2023

Outcome 1: Improved Surveillance of Production Limiting Disease and Welfare Issues; detailed outcomes include:

- Expand the Western Canadian benchmarking initiative to a national survey of the incidence and economic impact of production limiting diseases, nutritional and health management, biosecurity practices, and welfare practices in cow-calf, backgrounding and feedlot operations
- Develop a national production limiting disease surveillance program, identifying opportunities to collaborate with wildlife disease surveillance programs
- Establish a national surveillance system to monitor the incidence of and etiology of (re)emerging production limiting diseases

Outcome 2: Improved prevention of animal disease and welfare issues; detailed outcomes include:

- Conduct clinical trials to identify commercially available vaccines that stimulate an effective immune response and reduce the incidence of disease in calves pre- and post-weaning
- Develop and promote cost-effective vaccination and management strategies that can be widely adopted throughout the beef production system to improve health, reproductive and performance outcomes
- Identify or develop cost-effective management or treatment options that lead to improved control of internal and external parasites
- Develop revised feed mycotoxin levels to avoid adverse animal health and welfare impacts
- Develop and maintain a prioritized list of the 10 best animal health management practices to improve cow-calf sector profitability (e.g. vaccine timing, mineral nutrition, parasite control, etc.)

- Evaluate the cost-effectiveness of pain control products and strategies for avoiding or mitigating acute and chronic pain
- Define appropriate feed, water and rest intervals that optimize transport outcomes for different classes of long-haul beef cattle transported across Canada
- Identify potential trailer design modifications to minimize bruising and injury

Outcome 3: Improved animal health and welfare research and training capacity; specifically:

- Ensure maintenance and transition of key animal health and welfare research, diagnostic and extension expertise and facilities

Outcome 4: Extension, outreach and policy; detailed outcomes include:

- Encourage producers to continually update and implement a herd health program developed in partnership with a veterinarian, which consider the following:
 - vaccination
 - utilization of feed and water testing, and proper formulation of feed and supplement rations to ensure animal nutrition and prevent exposure to toxins
 - prompt and accurate diagnosis of animal illness and injury to inform appropriate treatment methods
 - necropsies
- Encourage producers to understand and comply with the requirements and recommendations in The Code of Practice for the Care and Handling of Beef Cattle, including:
 - confirming death immediately after euthanizing
 - avoiding and minimizing acute and chronic pain
 - minimizing stress during weaning
 - optimizing transportation decisions to prevent injury and stress
- Develop an on-farm decision making tool to determine the reproductive rate of highest profitability with recommendations of known best practices to optimize reproduction and longevity, including consideration of
 - selection and breeding of heifers
 - accurate measurement of fat cover on animals to inform feeding strategies and maintain animals in ideal body condition

iv. Antimicrobial Use, Resistance and Alternatives

1. Overview as a research priority

Antimicrobial resistance concerns and expertise can be found in both livestock and human health, opening more opportunities for collaborative research approaches than ever before. New technologies allow new antimicrobial resistance genes and transfer mechanisms to be discovered on a regular basis, and allow much more precise evaluation of the relationships between antimicrobial resistance genes and bacterial isolates collected

from humans and animals. The Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) does not conduct national on-farm antimicrobial resistance surveillance for beef or dairy cattle or bob/veal calves, although they do for broilers and swine. CIPARS plays an important role in routine collection and antimicrobial resistance testing of bacterial isolates from healthy feedlot finished cattle at abattoirs (*E. coli* and *Campylobacter*) and retail beef (*E. coli*).

Antimicrobial use raises the prevalence of antimicrobial resistance, although the time it takes for resistance to develop is both bacteria- and antibiotic-dependent. CIPARS tracks on-farm antimicrobial use in the broiler and swine sectors but not in beef, although a framework to do so has been developed. Antimicrobial use data in beef cattle is extremely limited. Some Canadian antimicrobial use data has been collected in feedlot-level pilot studies; cow-calf antimicrobial use data is much less well documented, and still less data exists for market dairy cows and bob/veal calves.

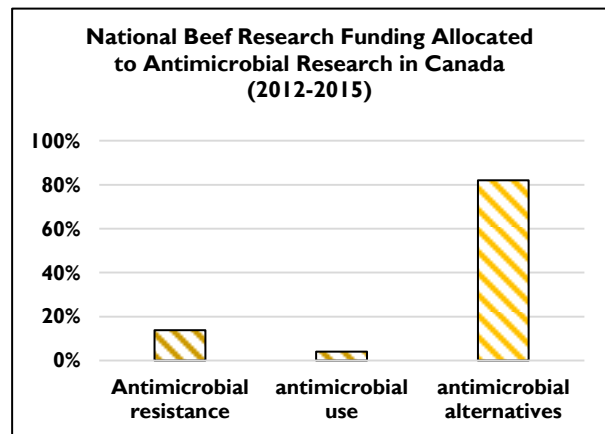
Antimicrobial alternatives are numerous and vary widely in their state of development, effectiveness and level of adoption. Several, including low-stress weaning, vaccination, environmental and nutritional adaptation, low stress animal handling and transportation, direct marketing to feedlots, and preconditioning have demonstrated effectiveness in applied research situations. Other alternatives, including bacteriophage, essential oils, tannins, phenolics, seaweed extracts, citrus products, organic acids, direct fed microbials, prebiotics, probiotics, bacteriocins and rapid diagnostics, have so far shown inconsistent efficacy and require further research and development.

2. National Beef Research Priority Survey antimicrobial results

Antimicrobial use and resistance was a high priority public confidence issue for all livestock and veterinarian respondents, and was a high priority animal health research issue for seedstock, feedlot and veterinarian respondents.

3. Antimicrobial use, resistance and alternatives research funded since 2012

Previously, antimicrobial-related research has been considered in the context of food safety or animal health priority areas. Between these two areas, approximately 8% of national beef research funding was directed towards antimicrobial research in Canada between 2012-2015, with the majority of funding directed towards antimicrobial alternative research.



Antimicrobial resistance research received 14% of antimicrobial-related funding since January 1, 2012. This funding was directed towards antimicrobial resistance to cattle pathogens (*M. bovis*, *H. somni*, and other BRD pathogens), indicator organisms and human pathogens (*Campylobacter*, Enterococci, and *E. coli*), and One-Health research encompassing cattle production, human environments, and the potential for AMR determinants to be transmitted between them through manure, soil and water.

Antimicrobial use research received 4% of antimicrobial-related funding since January 1, 2012. This research studied antimicrobial use in both the cow-calf and feeding sectors.

Antimicrobial alternative research received most (82%) of national beef antimicrobial research funding allocated since January 1, 2012. The majority of these funds (56%) were directed toward vaccine-related research for common production limiting diseases pathogen (e.g. BVD, *M. haemolytica*, *M. bovis*, *H. somni*). Research into nasal and oral pre/pro/synbiotics to combat respiratory pathogens or replace antimicrobial growth promoters accounted for 13% of antimicrobial alternative funding. Another 12% was directed to management practices to reduce nutritional, physiological and behavioral stress and antimicrobial use. The remaining 17% of antimicrobial alternative funds was directed towards studies examining the effectiveness of alternative disease treatments (e.g. essential oils, nitric oxide, bacteriophage) immunomodulators (β -defensins and other host defence peptides, antimicrobial peptides, nanoparticles), and animal genetics for disease resistance.

4. Antimicrobial use, resistance and alternatives research outcomes 2018 - 2023

Outcome 1: Evidence-based antimicrobial resistance decision making and communication to the veterinary, producer and medical communities;

detailed outcomes include:

- Increase CIPARS activities to encompass on-farm, abattoir and retail beef antimicrobial resistance surveillance, including *Enterococcus hirae* or other indicator organisms that are informative with regard to macrolide resistance
- Conduct pilot projects to identify whether the prevalence of antimicrobial resistance in market beef cows, dairy cows and bob/veal calves differ from fed cattle, and include any found to have concerning levels of antimicrobial resistance into ongoing CIPARS surveillance
- Develop methodology to evaluate and monitor the potential movement of antimicrobial resistant genes from cattle associated environments to human environments via manure, soil, food and water
- Implement ongoing surveillance of antimicrobial resistance through sampling of live animals at feedyards, focusing on BRD pathogens and enteric bacteria
- Conduct clinical trials to confirm best antimicrobial treatment options to minimize antimicrobial resistance throughout the cattle production cycle
- Develop rapid, accurate, cost-effective technology to detect antimicrobial resistance

in production environments

- Develop and verify best practices at the farm level to reduce antimicrobial resistance in bacterial isolates from both healthy animals and clinical cases

Outcome 2: Develop a broader toolbox for disease management; detailed outcomes include:

- Conduct an evidence-based risk-assessment of the effectiveness of alternative production practices (e.g. preconditioning, methods of reducing stress in weaned calves)
- Develop cost-effective nutritional and other management strategies to effectively reduce the need for antimicrobials to control liver abscesses
- Re-invest in vaccine development, with a specific focus on pathogens associated with bovine respiratory disease in Canada (e.g. *Mycoplasma spp*, *Mannheimia haemolytica*, *Histophilus somni*, *Pasteurella multocida*, bovine herpesvirus, bovine respiratory syncytial virus, bovine viral diarrhoea virus, bovine coronavirus), liver abscesses (e.g. *Fusobacterium necrophorum*, *Trueperella pyogenes*), footrot (e.g. *F. necrophorum*) and digital dermatitis (e.g. *Treponema spp.*)
- Investigate and develop simple, cost-effective alternative vaccine delivery methods to improve vaccination rates in the cow-calf sector
- Develop rapid, accurate, cost-effective chute-side diagnostic tests to evaluate whether cattle have been effectively vaccinated against specific pathogens
- Develop rapid, accurate, cost-effective diagnostic tools to detect disease before symptoms become apparent
- Develop a better understanding of the respiratory and gut microbiomes, their establishment and development in the neonate, and their relation to immunity and disease
- Investigate the impact of animal genetics on disease susceptibility and resistance
- Develop cost-effective non-antimicrobial products to prevent, treat and control disease

Outcome 3: Ensure that Canada's beef industry continues to have access to antimicrobials to protect animal health and welfare by developing a database to quantify and validate responsible antimicrobial use in beef production;

detailed outcomes include:

- Establish a working group to determine the governance, structure, potential data sources (veterinary, farm and feedlot data, CgFARAD, VBP, etc.), data collection methodology (e.g. sentinel vs. random sampling), data reporting (e.g. kg active ingredient, animal defined daily doses, population corrected unit, etc.) and resources required to develop an antimicrobial use database for the beef industry
- Conduct pilot projects to identify which sectors of the beef and veal industries (cow-calf, feedlot, dairy, bob/veal) pose the greatest antimicrobial use risk (classes of antimicrobials used, treatment rates, etc.)
- Develop a database to track antimicrobial use in sectors deemed to be highest risk

- Use the database to monitor changes in antimicrobial use over time and relate changes in antimicrobial use practices to changes in antimicrobial resistance in cattle pathogens and indicator organisms isolated from cattle, beef and cattle-associated environments

Outcome 4: Extension, outreach and policy; specifically:

- Encourage producers to proactively work with their veterinarian to adopt management practices that reduce the need to use antimicrobials, to use antimicrobials responsibly when needed, and to have a thorough understanding of how and when to use particular antimicrobials for effective treatment

v. Feed Grains and Feed Efficiency

1. Overview as research priority

Feed efficiency research develops and validates cost-effective methods to identify more efficient cattle, feedstuffs and feeding strategies. A 1% improvement in feed efficiency could have an economic effect four times greater than a 1% improvement in average daily gain (BCRC, 2016). Improving the feed-to-gain ratio (feed:gain) by 1% would save Canada's feedlot sector an estimated \$11.6 million annually. At times of high grain prices or forage shortages, feed efficiency plays an even larger role in the value equation. A difference in conversion of one pound represents \$90 per head, based on US\$4 corn.

Feed efficiency - Feed efficiency is heritable ($h^2 = 0.35$ to 0.40) and will respond to selection. The challenge is that measuring individual feed intake is time consuming and costly. Feed:gain is genetically correlated with average daily gain ($r_g = 0.5$), so selecting for average daily gain will also improve feed:gain. Identifying and validating reliable DNA markers for feed efficiency could significantly reduce testing costs and speed the rate of genetic improvement. However, current genetic markers for feed efficiency have very limited accuracy outside of the discovery population. The strength and nature of the genetic relationship between feed efficiency in growing and feed efficiency and fertility traits mature cows is unclear. There is also no consensus on the best way to define or express feed efficiency in mature cows.

In addition to genetic improvement, genomic tests that could quickly, cost-effectively and accurately sort individual feeder cattle according to their genetic potential for feed efficiency or to achieve different finish weights, quality or yield grades would facilitate the assembly of more uniform, economically optimal marketing groups, less re-sorting of cattle on feed, and more strategic implanting and feeding practices.

Feed grain yields - Canadian corn yielded 11 to 16% less than United States corn in 1980-2010, but only 1% less in 2010-15. This has been a significant change in competitiveness, particularly for producers in eastern Canada. Recent corn breeding investments made by

Monsanto and DuPont Pioneer in Canada will likely contribute to expanded corn acreage in Western Canada.

Canadian barley yields remained 12% lower than the United States yields from 2010-15, compared to 6% lower in the 1990's and 2% higher in the 1980's. Between 1981 and 2011 the number of Canadian farms growing barley dropped 70%, and barley acreage dropped 50% (2011 Census of Agriculture). During 2011 to 2015, barley acres averaged 6.70 million acres, 25% below the 2006-2010 average (Statistics Canada).

Alternative feeds and feed processing - Alternative energy sources for feeder cattle (e.g. screenings, dried distillers' grains (DDGS)) become more economically attractive when feed grain is scarce and/or costly. However, alternative feeds can pose unique challenges (e.g. high sulphur levels in DDGS, mycotoxins in screenings). It is important to be able to cost-effectively incorporate alternative feeds into cattle rations while anticipating and proactively mitigating potential risks.

Price per tonne is the main feed grain purchasing consideration for cattle feeders. Considerably less attention is paid to nutrient profile, feed quality or processing characteristics. For example, when kernel size varies widely, setting grain rollers to adequately process the smallest kernels will over-process large kernels, produce excessive fines, and increase the risk of acidosis and liver abscesses. Alternatively, setting rollers to optimizing processing of large kernels allows small kernels to pass through unprocessed. This reduces grain digestibility, reduces feed efficiency and increases the amount of intact grain that passes through into the manure. No cost-effective solution has been developed to address this dilemma.

Strategies to improve production and feed efficiencies appear to be quickly adopted by industry at both the feedlot and cow-calf levels. Steer carcass weights increased 9 lbs per year between 2010 and 2015, slightly higher than the long term average of 7 lbs per year. Feed efficiency in Canadian feedlot cattle has improved by more than 40% (12.5:1 to 6.5:1) since the 1950s. The technology to increase animal gain and overall performance is readily available and widely publicized. While research in this area is being done by private pharmaceutical companies who obtain a return on their investment by selling patented products, more basic research is needed to advance feed efficiency. A 5% improvement in feed efficiency could have an economic effect four times greater than a 5% improvement in average daily gain (BCRC, 2016).

Feed efficiency and a lower feed:gain ratio in cattle at all stages of the life cycle (pre-weaning, post-weaning, backgrounding, grassing and feedlot) is key to reducing cost of production and ensuring industry competitiveness. However, this must not be done to the detriment of cow efficiency. Feed:gain is of little value in mature cows that are maintaining or regaining body condition rather than growing.

2. National Beef Research Priority Survey feed grains and efficiency results

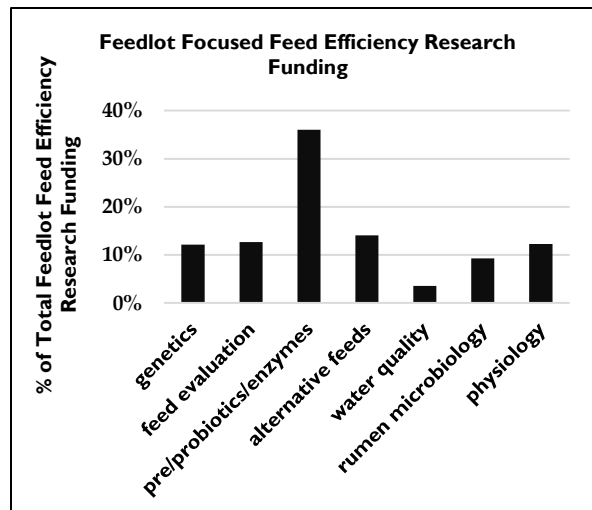
Barley yield was not viewed as a particularly important by many seedstock respondents, and corn yield was viewed similarly by seedstock, cow-calf and feedlot respondents. Comments indicated that this work should be supported by seed companies or the grain sector rather than by cattle producers. This approach has been effective for corn breeding. Corn's separate male and female flowers have allowed private breeding companies to develop genetically superior hybrid lines that will not breed true if seed is saved and replanted. This ensures future seed sales, and provides private breeders with the incentive to pursue further breeding efforts, including the use of biotechnology to incorporate additional agronomically beneficial traits. Barley's self-pollinated nature makes commercial development of hybrid lines very difficult. Farm-saved barley seed greatly limits the breeder's ability to recoup variety development costs. Because of this, barley and other small grain breeding has remained in the public realm with support from industry and government funding agencies.

Identifying and evaluating alternative feeds and feeding strategies, and the impacts of feedlot management on feed efficiency was important to feedlot respondents. The impact of feed quality on feed efficiency was important to both feedlot and cow-calf respondents. Identifying genetic markers for feed efficiency was more important to seedstock respondent, than to cow-calf or feedlot respondents. Feedlot respondents considered differences in feeding costs between either high and low residual feed intake cattle to be relatively unimportant for both cows and feeder cattle. This may reflect a lack of confidence in the commercial value of residual feed intake with respect to feed:gain. Numerous comments reflected concerns about how selection for improved feed efficiency in high energy diets may impact efficiency and other economically important traits in range production situations. Several comments also mentioned the need for simple, cost-effective, accurate chute-side tests to identify efficient animals in feedlot production environments.

3. Feed grains and feed efficiency research funded since 2012

Funding was allocated equally between feed grain and animal-focused research. More feed grain funding was directed to breeding (72%) than to agronomics (20%) or capacity (7%). Feed grain breeding research was focused on barley (54%), corn (29%) and triticale (16%).

Animal-focused feed efficiency research was targeted at feedlot (46%) cow-calf (42%) and capacity investments (13%). Cow-calf feed



efficiency research was focused on genetics (46%) and nutrition (54%). Feedlot efficiency research was largely focused on pre- and probiotics and feed enzymes (36%), with 4 to 14% directed towards animal genetics, feed evaluation, alternative feeds, water quality, rumen microbiology and animal physiology.

4. Feed grains and feed efficiency research outcomes 2018 - 2023

Outcome 1: Improved feed efficiency through animal breeding; detailed outcomes include:

- Quantify the genetic relationships between feed intake and efficiency in cow-calf and feedlot production, and their relationships with other economically relevant beef production traits (longevity, fertility, weaning weight, wintering costs, carcass weight, yield and quality grades, tenderness, etc.)
- Identify genes with functional roles in microbiological and physiological processes that affect feed intake and efficiency in feedlot and cow-calf production
- Determine the impact of cow-calf management practices on feed intake and efficiency in feedlot calves
- Develop a cost-effective method to easily and accurately quantify forage intake in grazing cattle

Outcome 2: Improved feed supply and utilization; detailed outcomes include:

- Identify cost-effective agronomic strategies to increase feed grain energy yield per acre
- Develop new feed grain varieties with improved feed grain energy yield per acre, N and water use efficiency
- Identify, evaluate and calculate the cost-effectiveness of alternative / by-product energy feeds, considering impacts on animal performance, health, product quality, and nutrient management
- Develop feeding strategies to optimize animal performance, nutritional value and cost of gain (e.g. ideal forage inclusion rates, grain processing/blending, high moisture corn, wheat, etc.)

Outcome 3: Maintained feed grains and feed efficiency research and training capacity; specifically:

- Ensure maintenance and transition of key feed efficiency research and extension expertise and facilities

Outcome 4: Extension, outreach and policy; detailed outcomes include:

- Enhance producer education to improve feed efficiency through management techniques to the point of highest profitability while responsibly maintaining animal welfare and environmental stewardship
- Improve feed efficiency through genetic selection, in breeds for which EPDs for feed efficiency exist

vi. Forage and Grassland Productivity

1. Overview as research priority

Forage and grassland productivity research develops annual and perennial forage varieties and management strategies to increase yield, maintain or improve nutritional value, and contribute to economically competitive cow-calf production and backgrounding operations.

Approximately 80% of Canada's beef production occurs while animals consume forage. Cow-calf producers feed preserved forages for part of the October to May period, varying with location and weather. Extending the winter grazing season is a major opportunity to reduce feeding costs. Winter feed and bedding is the largest cost for cow-calf operations, followed by grazing. Some research has been done on the viability of various winter grazing alternatives but has not evaluated various combinations of swath-, bale- and stockpiled grazing that would help encourage wider adoption among producers. Keeping all of Canada's beef cows and replacement heifers on pasture for one more day every winter would save the cow-calf sector an estimated \$4.9 million annually.

The four western provinces have 96% of Canada's natural land for pasture, 92% of the nation's tame pasture and 87% of the beef cows. Cereals are grown on the majority of cultivated lands but the farm value of forage conserved as hay and silage generally account for 40-60% the value of feed grain crops. Canadian hay production was estimated at 25 million tonnes in 2015. The five-year (2010-15) average hay yield of 1.9 tons/acre was up 17% from the 2000-10 average, but below the peak of 2.2 tons/acre in the 1980s. As annual crop acreages increase, producers grow forages on increasingly marginal land, which makes maintaining yield and productivity more difficult. Raising hay yields by 33% to 1990's levels would be worth \$453 million.

A long-term decline in investment in forage research and expertise appears to be reversing, with new researchers hired at the Universities of Manitoba and Saskatchewan, and new AAFC positions filled in Beaverlodge, Swift Current, St. John's, Quebec and Kentville. At the same time the long time frame to develop and test new varieties and a lack of producers willing to grow certified forage seed when grain prices are high means that industry has not been able to benefit from new and emerging forage varieties to the optimal extent.

Maintaining international competitiveness requires improved forage yields and beef production (fewer acres per cow or more beef per acre) on marginal land. Higher yielding varieties have been developed but have not fully compensated for the move to less productive marginal land. Public investment into forage varieties is necessary as the ability of companies to recoup their initial investment in a reasonable timeframe is low.

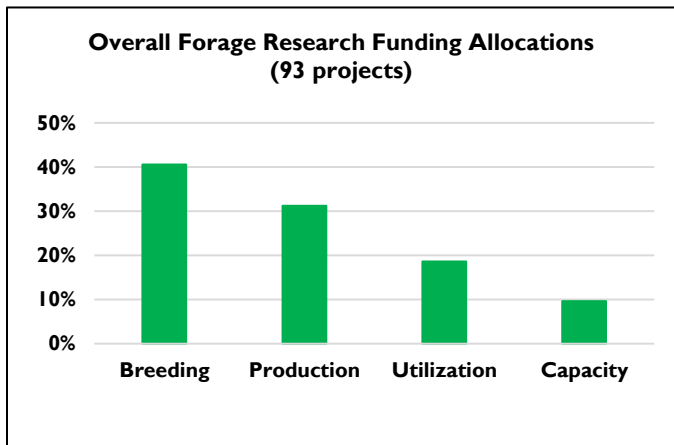
2. National Beef Research Priority Survey forage and grassland results

Improved forage yields were a priority for both cow-calf and feedlot respondents, and improved forage stand life and forage quality were priorities for cow-calf respondents. Regional differences were evident for some issues. Drought resistance and forage stand rejuvenation were higher priorities for B.C., Alberta and Saskatchewan respondents than for those from Manitoba, Ontario, Quebec or the Maritimes. Eastern producers placed less priority on salinity and acid tolerance than western producers. Flooding tolerance was a lower priority for both western and eastern producers, possibly because flooding is often a predominantly local concern. Both western and eastern producers considered grazing management and winter feeding strategies to be high priority issues.

3. Forage and grassland research funded since 2012

Since 2012, 40% of forage research funds have been directed towards breeding, 31% to production research, 19% to forage utilization research, and 10% to capacity.

Tame and native forage breeding research focused primarily on establishment and persistence (25%), yield (24%) and quality (22%). Tame forage breeding focused on alfalfa (26%), sainfoin (16%), hybrid brome (10%) and crested wheatgrass (9%). Annual forage breeding funding was focused on improving quality (32%) and yield (53%) in barley (62%) and triticale (21%).



Production research focused on improving seed yield (50%), soil fertility (26%) and weed control (24%) in native species, improving forage yield (41%), forage quality (16%) and stand establishment (15%) in tame forages, and improving yield (28%), quality (26%), and agronomic management (21%; e.g. seeding dates, variety selection, fertility management) in annual forages.

Forage utilization research focused on swath grazing (32%), summer grazing management (18%), bale grazing (16%) and silage (15%).

4. Forage and grassland productivity research outcomes 2018 – 2023

Outcome 1: 15% Improvement in yields and nutritional quality of tame, native and annual species through improved pasture, forage and grazing management and plant breeding; detailed outcomes include:

- Develop new annual and perennial grass and legume varieties with improved stand longevity, quality, yield, and adaptability (e.g. flood and drought resistance) through traditional and/or advanced plant breeding techniques
- Characterize corn and cereal forage variety differences in nutrient profile and ensiling potential
- Quantify varietal and species differences in the ability of grasses, legumes and annual forages to maintain nutritional quality throughout the grazing season and in extended stockpiled or swath grazing systems to help inform producers' seed selection decisions
- Identify or develop improved grazing and range management strategies that optimize forage and beef production from native range and tame perennial pastures
- Investigate and refine regionally-appropriate methods of combining native, tame (annual and perennial) species and extended winter grazing practices to lengthen the grazing season and reduce winter feed costs, while meeting animal requirements
- Quantify the economic and agronomic benefits of integrated annual crop, forage and beef production systems

Outcome 2: Maintained forage research and training capacity; detailed outcomes include:

- Establish industry research chairs focused on forage and grazing management and economics established to serve Central and Eastern Canada and in the Prairies and B.C.
- Reinvigorate and enhance long-term breeding programs, while capturing near-term opportunities that are currently under development

Outcome 3: Extension, outreach and policy; detailed outcomes include:

- Producer extension programs used to foster collaboration between producers and researchers and the adoption of cost-effective, sustainable production and management practices
- Improve native and tame pasture management for optimum yields and forage quality and responsible environmental stewardship, including species establishment, fertilization, weed control and grazing management or harvesting techniques that have the highest and longest lasting return on investment for the regional conditions
- Increase information exchange between forage producers and forage seed growers to help inform decisions to improve forage production and minimize weeds
- Increase understanding of the costs, risks and benefits (economic and environmental) of pasture rejuvenation, weed control, fertilization, and the

incorporation of forages into cash crop rotations and the development of on-farm decision making tools to quantify the return on investment of these various strategies.

vii. Environmental Sustainability

1. Overview as research priority

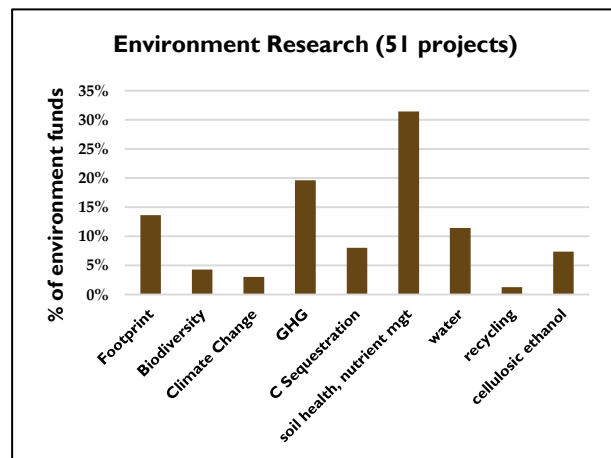
Environmental sustainability research pertaining to beef production has grown in profile, importance and relevance in recent years. Environmental research was previously viewed purely as a “public good”. Although data of direct relevance to environmental sustainability was often collected in the course of production-focused research projects (e.g. methane production, nutrient loss in urine and manure, root growth, soil organic matter, etc.), the focus of these projects was on improving growth rates and efficiency, animal health and reproductive performance, and feed productivity. Simultaneously improving productivity while reducing resource use benefits environmental sustainability, though these impacts have only received specific attention in recent years.

2. National Beef Research Priority Survey environmental results

All livestock respondents rated the environmental impact of the beef industry as a high priority. In response to the question “Are there additional priority areas that should be added?”, 44% of producer respondents suggested environment-related issues such as carbon sequestration, greenhouse gas, environmental impact, biodiversity, and ecosystem services.

3. Environmental sustainability research funded since 2012

From 2012 to 2015, environment research received 10% of national beef research funding, primarily under the Forage and Grassland research priority area. Soil fertility and nutrient management (31%), greenhouse gas production (20%), quantifying the environmental footprint of Canada’s beef industry (14%), water (11%), carbon sequestration (8%) and cellulosic ethanol (7%) were the main focus areas funded in this area.



4. Priority environmental sustainability research outcomes 2018 - 2023

Outcome 1: Science-based information to inform the development of effective public communication and policy development regarding environmental goods and services provided by the beef industry; detailed outcomes include:

- Develop cost-effective methods of reducing GHG emissions in forage-based diets
- Quantify factors impacting the rate and extent of C sequestration in tame and native pastures across Canada
- Quantify the impacts of native and tame pasture management on plant, animal, bird and insect biodiversity across Canada
- Quantify the impacts of native and tame pasture management on water use, cycles and watersheds across Canada
- Identify cost-effective cleaning technologies to reduce water use in beef packing and processing facilities
- Quantify N and P excretion rates in grazing animals, and N impacts on GHG emissions and P runoff and leaching impacts on water quality / eutrophication
- Develop feedlot manure management best practices to reduce the risk of phosphorus overload in soils

Outcome 2: Extension, outreach and policy; specifically:

- Increase the uptake of manure management practices that protect soil and water resources, including handling systems which minimize nutrient emission to air and leaching or run-off during storage or use
- Enhance public education regarding the impact of Canada's forage and beef industry on Canada's environment and economy

viii. Technology Transfer

1. Overview as a priority

Effective science-based knowledge dissemination and technology transfer to influencers of beef production is critical to realize the value of investing in research and enable producers to make informed decisions and adopt innovations to maintain the sustainability and competitiveness of their operations and the industry.

Governments and universities previously employed many extension specialists and supported field days, seminars and other initiatives, but these activities have greatly declined in many regions over the past two decades due to decreased funding. While industry groups have worked to fill the growing and damaging gaps in extension, generally the current state of beef and forage extension in Canada is fragmented and underfunded. This has contributed to shortfalls in industry adoption of beneficial knowledge and technologies.

Researchers and developers of innovations can be extremely valuable members of technology transfer teams because of their depth of knowledge and because of the potential for technology transfer practices to inform the development or modification of innovations, but several constraints prevent them from making meaningful contributions to technology transfer. This is particularly true for those employed by universities. Constraints include heavy teaching and administrative burdens, lack of technology transfer skills, limited industry networks, limited familiarity with production, and limited support and incentives from employers to participate in technology transfer.

Additional challenges in effective technology transfer include the ability to deliver information to producers and other potential adopters because of numerous demands on their time, their remote locations and limited internet access in some rural areas. It can be difficult for producers to interpret the value and applicability of innovations on their own operation. While interactive decision making tools and economic calculators that run scenarios and predict outcomes can help, economic calculators are very difficult if not impossible to create for some innovations because of their vast complexity. It may also take several years or be impossible to observe or quantify direct and indirect impacts of adoption.

Adopting innovations improperly or before they are fully ready for adoption can lead to failures and loss. Inappropriate adoption may unfairly impact producers' judgment of the value of the innovation and lead to decreased adoption.

A major challenge in effective technology transfer is extension specialists' inability to measure success. It is difficult and often impossible to measure the impact of technology transfer initiatives. Challenges to effective technology transfer speak to the need for these efforts to be diverse and abundant, and for targeted, thoughtful and persistent information exchange with producers in order for beneficial change to occur.

2. National Beef Research Survey technology transfer results

Seedstock, cow-calf and feedlot respondents reported using social media most frequently to learn about science-based information. Following social media, magazines and newspapers, websites and blogs, radio, and smartphone apps are used most frequently to access scientific information.

The survey results found that veterinarians are the most influential or relied upon source of science-based information in decision making, particularly for seedstock and feedlot producers. Following veterinarians, producers' peers, producer associations, and the BCRC were rated most influential. Feeders reported relying on professional consultants more than seedstock producers, and much more than cow-calf producers.

There was little difference between the frequency of access or influence of science-based sources of information between producers in Eastern and Western Canada.

3. Technology transfer outcomes 2018 - 2023

Outcome 1: Improved efficiency and effectiveness of technology transfer in the Canadian beef industry through greater collaboration and empowerment of technology transfer agents; detailed outcomes include:

- Host regular National Beef Technology Transfer Workshops to discuss opportunities, challenges, best practices and priorities
- Establish collaborative working groups to assemble, update or create comprehensive technology transfer resource packages focused on a particular topic or outcome and encourage industry-wide utilization of the resources to reach and maintain desired adoption levels. Project topics may include:
 - Forage and grazing management
 - How and when to utilize genomic selection
 - Feed testing / ration supplementation / nutritional management to improve reproduction and longevity of cowherd
 - Identifying, collecting and using the key records that help inform management decisions
- Enhance awareness and consideration of relevant international research and development activities to avoid duplication and identify opportunities for collaboration
- Continued industry mentorship of new scientists, with an additional 15 scientists completing the BCRC's Beef Researcher Mentorship program by 2023
- Increase influence on research institution administrators to appreciate the value that industry places on academics' participation in technology transfer with the goal to increase scientists' ability and motivation to incorporate technology transfer as a key component of their research projects and careers
- Develop and deliver tools and guidelines that assist scientists in their development and execution of technology transfer initiatives
- Develop resources that assist veterinarians and other technology transfer agents to easily and effectively deliver information of greatest benefit to producers as opportunities for education, persuasion, decision making, implementation or confirmation arise
- Measure and monitor adoption of innovations by compiling known adoption rates of various innovations through existing data collection means and enhance measurement of innovation adoption levels where necessary and possible
- Improve understanding of how to effectively facilitate adoption of innovations across industry sectors to enable further refinement of technology transfer and extension activities
 - Enhance understanding of producers' evaluation of short- and long-term costs (economic and otherwise) of adoption versus short- and long-term benefits of adoption
 - Enhance understanding of the influences and tipping points of operations' profitability and sustainability (economic, environmental and social sustainability)

Outcome 2: Increased producer adoption of relevant technologies and production practices through improved information management; detailed outcomes include:

- Encourage thorough record keeping by producers and analysis of their data in order to identify opportunities for improvement, make informed decisions, and determine the impacts of modifications to production practices
- Enhanced information sharing between members of the beef supply and forage supply chains within the Canadian beef industry to enable decision making that supports the achievement of priority technology transfer outcomes

VI. Appendix

a. Beef Research Stakeholders

Funding stakeholders:

Industry:

- Beef Cattle Research Council and Beef Cattle Industry Science Cluster
- Maritime Beef Council
- Beef Farmers of Ontario
- Manitoba Beef Producers
- Saskatchewan Cattlemen's Association
- Alberta Beef Producers
- B.C. Cattlemen's Association

Agriculture and Agri-Food Canada

Provincial Governments:

- Ontario Ministry of Agriculture, Food, and Rural Affairs
- Manitoba Agriculture, Food and Rural Initiatives
- Saskatchewan Agriculture and Food
- Alberta Agriculture and Forestry
- Alberta Innovates Bio Solutions
- Alberta Crop Industry Development Fund
- B.C. Industry Development Fund

Other stakeholders:

- Alberta Barley
- Canadian Cattlemen's Association
- Canadian Roundtable for Sustainable Beef
- Dairy Farmers of Canada
- National Cattle Feeders' Association

b. Industry Stakeholders Represented at the BCRC Workshops

National Beef Research Strategy Workshop, June 22-23, 2016

Agriculture and Agri-Food Canada	Dairy Farmers of Canada
Agricultural Research Institute of Ontario	Fédération Producteurs Boeuf du Québec
Alberta Agriculture and Forestry	Feedlot Health Management Services
Alberta Barley	Foothills Forage Association
Alberta Beef Producers	Genome Alberta
Alberta Livestock and Meat Agency	Gowans Feed Consulting
B.C. Cattlemen's Association	Grassland Agriculture Consulting
Beef Cattle Research Council	JBS
Beef Farmers of Ontario	Manitoba Agriculture
Beef Improvement Ontario	Manitoba Beef Producers
Boehringer	National Cattle Feeders' Association
Canada Beef	Ontario Ministry of Agriculture, Food and Rural Affairs
Canadian Angus Association	Saskatchewan Cattlemen's Association
Canadian Beef Breeds Council	Saskatchewan Forage Network
Canadian Beef Cattle Research, Market Development and Promotion Agency	Saskatchewan Ministry of Agriculture
Canadian Cattlemen's Association	Southern Cross Livestock
Canadian Forage & Grasslands Association	Thompson Rivers University
Canadian Hereford Association	University of Alberta
Canadian Roundtable for Sustainable Beef	University of Calgary
Canfax Research Services	University of Guelph
Cargill	University of Manitoba
Cattlemen's Young Leaders Development Program	University of Saskatchewan
Coaldale Vet Clinic	University of Saskatchewan - VIDO
	University of Calgary
	Veterinary Animal Health Services
	Western College of Veterinary Medicine

National Beef Technology Transfer Workshop, September 28, 2016

Agriculture and Agri-Food Canada

Alberta Agriculture and Forestry

Alberta Beef Producers

Beef Cattle Research Council

Beef Farmers of Ontario

British Columbia Cattlemen's Association

Canadian Beef Breeds Council

Canfax Research Services

Farm Business Communications

Manitoba Beef Producers

Peace River Forage Association of British Columbia

Perennia / Government of Nova Scotia

Saskatchewan Cattle Feeders' Association

Saskatchewan Cattlemen's Association

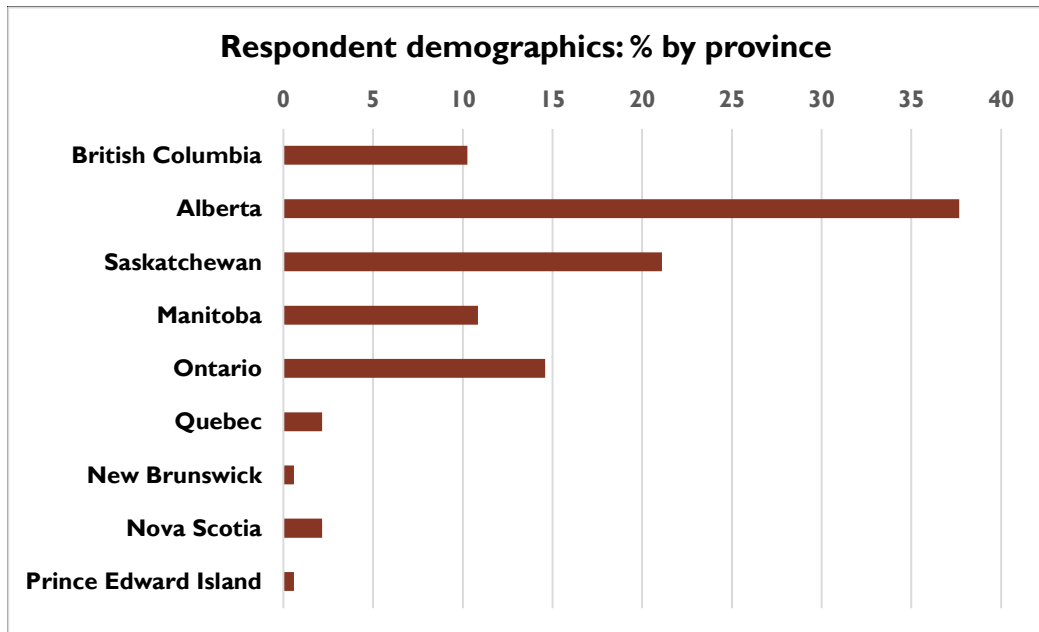
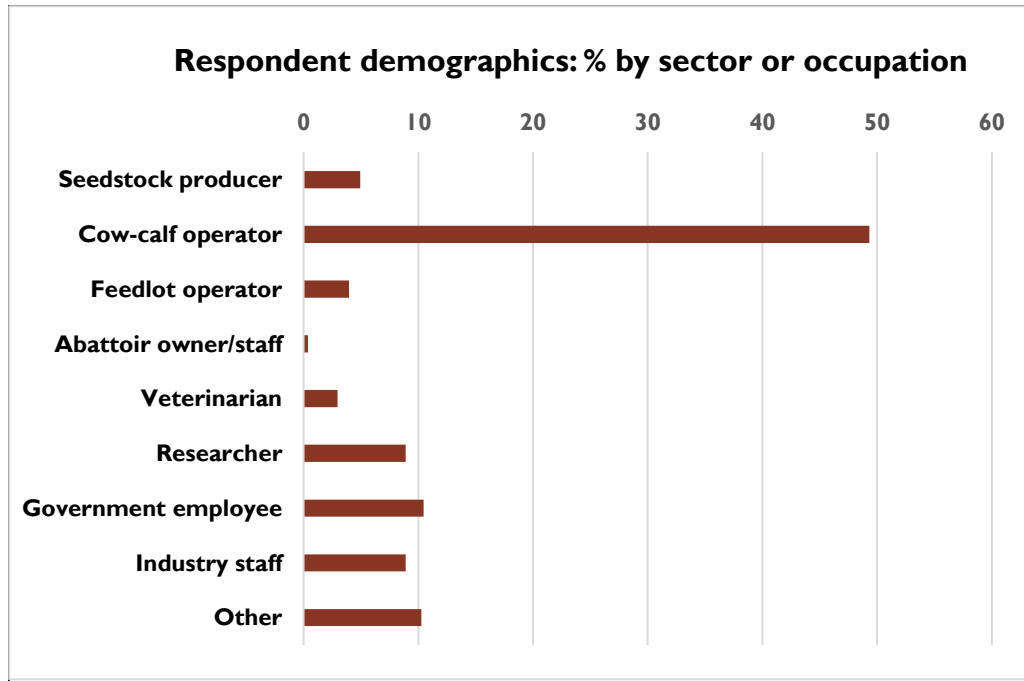
Saskatchewan Forage Network

Saskatchewan Ministry of Agriculture

University of Calgary Faculty of Veterinary Medicine

c. 2016 Beef Research Priority Survey Response Summary

Demographics of survey respondents, March to May 2016



BEEF CATTLE RESEARCH COUNCIL

Survey Responses: Beef Quality Issues

	Seedstock (25 respondents)			Cow-Calf (222 respondents)			Feedlot (20 respondents)		
	Extremely or Very Important	Moderate Importance	Slightly or Not Important	Extremely or Very Important	Moderate Importance	Slightly or Not Important	Extremely or Very Important	Moderate Importance	Slightly or Not Important
Increased product consistency and quality	96%	0%	4%	77%	19%	3%	88%	13%	0%
New product development and cut utilization	67%	25%	8%	67%	26%	5%	94%	6%	0%
Benchmark consumer satisfaction with Canadian beef	79%	17%	4%	75%	19%	5%	88%	13%	0%
Reduce losses associated with carcass defects and meat quality issues	67%	17%	13%	69%	25%	4%	71%	29%	0%
Update nutritional information on beef with comparison to other protein options	83%	17%	0%	80%	14%	4%	81%	6%	13%
Benchmark and validate attributes of Canadian beef and the Canadian Beef Advantage (i.e. attributes as they relate to quality, grading, beef production, nutrition and health, genetics)	91%	9%	0%	75%	18%	6%	94%	6%	0%
Validate the effectiveness and value of genetic markers for tenderness in commercial cattle	54%	29%	17%	61%	28%	10%	82%	12%	6%
Re-evaluate electrical stimulation recommendations to reflect increased carcass weights	14%	41%	23%	28%	35%	15%	38%	38%	13%
Validate objective in-plant measures of tenderness	54%	29%	13%	55%	29%	11%	75%	19%	0%
Identify potential interactions between tenderness genotype and animal management practices	68%	23%	9%	68%	23%	7%	88%	6%	6%
Develop packaging and other technologies to improve shelf life	43%	43%	13%	49%	34%	13%	76%	24%	0%

BEEF CATTLE RESEARCH COUNCIL

Survey Responses: Food Safety Issues

	Seedstock (25 respondents)			Cow-Calf (222 respondents)			Feedlot (20 respondents)			Veterinarians (15 respondents)		
	Extremely or Very Important	Moderate Importance	Slightly or Not Important	Extremely or Very Important	Moderate Importance	Slightly or Not Important	Extremely or Very Important	Moderate Importance	Slightly or Not Important	Extremely or Very Important	Moderate Importance	Slightly or Not Important
Develop technologies targeting multiple pathogens in cattle and beef production and processing facilities	63%	33%	4%	67%	25%	3%	75%	13%	6%	80%	13%	0%
Verify the effectiveness of packing equipment cleaning processes	83%	17%	0%	77%	15%	5%	94%	0%	0%	73%	20%	0%
Surveillance to detect, characterize and quantify the relative human health risk of (re) emerging pathogens	67%	29%	4%	78%	17%	3%	75%	13%	13%	60%	27%	13%
Develop effective interventions to eliminate pathogens for beef	71%	21%	8%	74%	18%	5%	94%	6%	0%	67%	20%	7%
Surveillance of antimicrobial resistance in beef	63%	29%	8%	71%	22%	6%	88%	6%	6%	73%	27%	0%

Survey Responses: Animal Health and Welfare Issues

	Seedstock (25 respondents)			Cow-Calf (222 respondents)			Feedlot (20 respondents)			Veterinarians (15 respondents)		
	Extremely or Very Important	Moderate Importance	Slightly or Not Important	Extremely or Very Important	Moderate Importance	Slightly or Not Important	Extremely or Very Important	Moderate Importance	Slightly or Not Important	Extremely or Very Important	Moderate Importance	Slightly or Not Important
Animal Health Issues												
Reproductive efficiency	92%	4%	4%	90%	9%	1%	74%	11%	11%	57%	36%	7%
Cow nutrition	84%	12%	4%	86%	10%	3%	65%	12%	12%	60%	27%	13%
Neonatal diseases	67%	17%	17%	60%	29%	9%	50%	28%	11%	60%	27%	13%
Immunology and vaccinations	72%	20%	8%	82%	15%	3%	85%	10%	5%	80%	20%	0%
Shipping fever/bovine respiratory disease (BRD)	64%	28%	8%	72%	20%	6%	70%	25%	5%	73%	27%	0%
Nutritional diseases associated with high concentrate rations (e.g. acidosis, liver abscesses, laminitis)	42%	46%	13%	53%	31%	13%	60%	25%	15%	80%	7%	7%
Parasite control	63%	29%	8%	67%	25%	8%	55%	45%	0%	27%	67%	7%
Antimicrobial resistance	76%	12%	12%	73%	19%	7%	95%	5%	0%	93%	0%	7%
Animal Welfare Issues:												
Castration	40%	48%	12%	52%	30%	18%	68%	16%	16%	53%	27%	20%
Dehorning	40%	32%	28%	41%	33%	24%	63%	16%	21%	47%	40%	13%
Branding	20%	36%	44%	40%	31%	28%	44%	22%	33%	40%	13%	40%
Weaning	60%	24%	16%	55%	32%	12%	33%	44%	22%	40%	53%	7%
Extreme weather and housing conditions	44%	32%	24%	46%	36%	17%	42%	47%	11%	47%	47%	7%
Shipping fever/bovine respiratory disease (BRD)	68%	28%	4%	67%	23%	9%	79%	16%	5%	60%	40%	0%
Nutritional diseases associated with high concentrate rations (e.g. acidosis, liver abscesses, laminitis)	48%	36%	16%	54%	31%	13%	68%	16%	16%	67%	33%	0%
Lameness	52%	32%	16%	54%	33%	12%	53%	32%	16%	93%	7%	0%
Transportation	60%	32%	8%	65%	26%	8%	53%	21%	26%	60%	40%	0%

BEEF CATTLE RESEARCH COUNCIL

Survey Responses: Feed Grains and Feed Efficiency Issues

	Seedstock (25 respondents)			Cow-Calf (222 respondents)			Feedlot (20 respondents)		
	Extremely or Very Important	Moderate Importance	Slightly or Not Important	Extremely or Very Important	Moderate Importance	Slightly or Not Important	Extremely or Very Important	Moderate Importance	Slightly or Not Important
Barley yield	29%	25%	46%	42%	37%	17%	67%	27%	7%
Corn yield	21%	33%	46%	31%	36%	29%	47%	27%	20%
Identification and evaluation of alternate feeds and feeding strategies	58%	25%	17%	66%	28%	5%	75%	19%	6%
Feed quality impact on feed efficiency	65%	35%	0%	75%	20%	4%	87%	0%	13%
Feedlot management impact on feed efficiency	67%	21%	13%	62%	27%	8%	75%	25%	0%
Genetic markers for feed efficiency	79%	17%	4%	63%	29%	6%	67%	27%	7%
Differences in wintering costs between low and high residual feed intake (RFI) cows	71%	29%	0%	68%	25%	5%	54%	15%	23%
Differences in wintering costs between low and high residual feed intake (RFI) feeder cattle	65%	30%	4%	61%	29%	6%	57%	21%	21%
Reliable across-breed genetic markers for RFI	71%	17%	13%	61%	26%	8%	63%	19%	13%

BEEF CATTLE RESEARCH COUNCIL

Survey Responses: Forage and Grassland Productivity

	Seedstock (25 respondents)			Cow-Calf (222 respondents)			Feedlot (20 respondents)		
	Extremely or Very Important	Moderate Importance	Slightly or Not Important	Extremely or Very Important	Moderate Importance	Slightly or Not Important	Extremely or Very Important	Moderate Importance	Slightly or Not Important
	Forage yield	61%	26%	13%	78%	17%	5%	86%	14%
Forage stand longevity	78%	9%	13%	81%	13%	6%	64%	29%	7%
Forage drought resistance	78%	4%	17%	74%	17%	9%	86%	7%	7%
Salinity and acid tolerance	52%	22%	26%	51%	32%	15%	57%	43%	0%
Flood resistant forages	39%	35%	26%	43%	31%	25%	46%	54%	0%
Forage quality	74%	13%	13%	83%	13%	4%	79%	7%	14%
Fertilization (organic and chemical)	50%	32%	18%	60%	29%	12%	57%	29%	14%
Stand establishment	61%	26%	13%	69%	25%	5%	71%	21%	7%
Stand rejuvenation	83%	4%	13%	73%	23%	4%	57%	36%	0%
Development of new varieties and species mixtures	70%	22%	9%	70%	22%	8%	71%	21%	0%
Invasive species & weed control	68%	23%	9%	67%	24%	9%	71%	29%	0%
Feed storage systems	35%	39%	26%	49%	36%	15%	69%	23%	8%
Grazing management strategies	78%	9%	13%	81%	16%	3%	64%	21%	7%
Winter feeding strategies	74%	17%	9%	76%	20%	4%	64%	21%	14%

Survey Responses: Public Confidence Issues

	Seedstock (25 respondents)			Cow-Calf (222 respondents)			Feedlot (20 respondents)			Veterinarians (15 respondents)		
	Extremely or Very Important	Moderate Importance	Slightly or Not Important	Extremely or Very Important	Moderate Importance	Slightly or Not Important	Extremely or Very Important	Moderate Importance	Slightly or Not Important	Extremely or Very Important	Moderate Importance	Slightly or Not Important
	Antimicrobial Use and Resistance	83%	13%	4%	76%	19%	4%	100%	0%	0%	92%	8%
Growth enhancing technology (e.g. hormones, beta agonists)	78%	9%	13%	66%	17%	16%	93%	7%	0%	77%	15%	8%
Animal welfare	87%	13%	0%	85%	12%	3%	100%	0%	0%	92%	8%	0%
Environmental impact	77%	23%	0%	80%	16%	4%	93%	7%	0%	92%	8%	0%
Nutritional attributes of beef	83%	13%	4%	74%	22%	4%	93%	7%	0%	38%	54%	8%

BEEF CATTLE RESEARCH COUNCIL

Survey Responses: Technology Transfer

How often do you use the following communication channels to learn about science-based information?

	Seedstock (23 respondents)			Cow-Calf (187 respondents)			Feedlot (14 respondents)		
	Daily/Weekly	Monthly to 7x /year	Fewer than 1x/year	Daily/Weekly	Monthly to 7x /year	Fewer than 1x/year	Daily/Weekly	Monthly to 7x /year	Fewer than 1x/year
Beefresearch.ca	17%	65%	17%	27%	43%	30%	31%	23%	46%
Conferences/Seminars/Workshops	5%	45%	50%	1%	38%	61%	0%	50%	50%
Magazines and newspapers	48%	39%	13%	40%	52%	7%	57%	36%	7%
Other print materials	13%	61%	26%	11%	70%	18%	23%	69%	8%
Other Websites and blogs	29%	62%	10%	37%	45%	18%	54%	23%	23%
Professional consultants	5%	55%	41%	4%	30%	66%	43%	50%	7%
Radio	36%	18%	45%	30%	24%	47%	57%	21%	21%
Smartphone apps	47%	16%	37%	25%	20%	54%	69%	15%	15%
Social Media	70%	9%	22%	52%	14%	34%	77%	0%	23%
Veterinarians	9%	73%	18%	6%	55%	40%	50%	50%	0%
Videos	10%	33%	57%	13%	39%	48%	23%	31%	46%
Webinars	0%	32%	68%	2%	33%	65%	0%	31%	69%

How influential are the following sources of science-based information (or how heavily do you rely on the following) in your professional decision making?

	Seedstock (23 respondents)		Cow-Calf (186 respondents)		Feedlot (14 respondents)	
	Extremely/Very Important	Slightly/Not at All	Extremely/Very Important	Slightly/Not at All	Extremely/Very Important	Slightly/Not at All
	BCRC	65%	9%	41%	26%	69%
Calculators / decision tools	38%	33%	23%	32%	67%	8%
Gov't extension	23%	18%	34%	30%	36%	21%
Media	36%	27%	39%	16%	50%	21%
Peers	65%	13%	51%	18%	79%	14%
Producer Assoc.	68%	18%	44%	19%	64%	21%
Professional consultants	62%	14%	37%	32%	86%	7%
Researchers	35%	30%	38%	29%	57%	21%
University extension	30%	22%	29%	37%	62%	31%
Veterinarians	86%	5%	67%	14%	93%	7%

