National Beef Research Strategy

JUNE 2012

BCRC
BEEF CATTLE RESEARCH COUNCIL

NATIONAL BEEF VALUE CHAIN ROUNDTABLE

I. Executive Summary

Research will play a critical role in the future advancement of the Canadian beef cattle industry and has been identified as a priority by the Beef Cattle Research Council (BCRC), a division of the Canadian Cattlemen's Association, and the National Beef Value Chain Roundtable.

The Canadian beef industry is a key driver for the Canadian economy, contributing over $26 billion annually and is the largest source of farm cash receipts. Canada is the fifth-largest cattle and beef exporter in the world, with 2011 exports worth over $1.3 billion.

Canada is in a position to benefit from global growth in beef demand, supported by favourable production and regulatory conditions, and a continued focus on overall industry competitiveness. Future enhancement of competitiveness depends in large part on investment in research to help the industry manage costs and increase efficiency. Research will also be instrumental in supporting the industry's value proposition, informing regulation and advocacy, and expanding beef exports through science-based regulations and trade agreements.

For Canadian beef cattle producers, research delivers a direct and tangible benefit. Every check-off dollar invested in national research programs delivers an average return of $46 in producer benefits.[1] This extremely high return from research relates to the fact that applied research tools are directly available to producers.

More than ever, future success is heavily reliant on achievement of research outcomes to ensure the industry is strongly positioned and that research programs and funding are targeted as effectively as possible to address industry needs and benefit producers.

This document represents the first ever National Beef Research Strategy with defined research outcomes and the commitment of major research funders to achieving those outcomes.

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[1] Evaluating the Economic Benefits from the Canadian Beef Check-off. Dr. John Cranfield, Professor, University of Guelph with assistance from Michael von Massow. 2010

The strategy has been developed by the BCRC and National Beef Value Chain Roundtable following comprehensive analysis of the beef research situation in Canada, extensive consultation and validation with all stakeholders, and collaboration with funders toward coordinating and aligning funding priorities.

The analysis of the beef situation in Canada confirmed that overall funding and infrastructure, human capital, and technology transfer to support beef and beef cattle research are fragmented and have declined significantly in Canada in recent decades. A first-of-its-kind inventory of beef research funded over the past five years and survey of research funders indicated that some areas have been overfunded while more basic production research has been overlooked. As well, there are over 30 agencies funding beef research operating in an uncoordinated manner when setting priorities and funding projects.

In developing this National Beef Research Strategy, a meeting of major funders was convened in March 2012, at which all participants agreed that the Canadian beef industry is in need of a national framework that builds on current efforts. **Funders unanimously supported the BCRC and Beef Value Chain Roundtable in developing a national research strategy aimed at achieving target industry research outcomes.**

Research outcomes have beef defined in the priority areas of:

- Beef Quality
- Food Safety
- Animal Health and Welfare
- Feed Grains and Feed Efficiency
- Forage and Grassland Productivity

The outcomes were established through a series of workshops that engaged over 75 participants representing various industry sectors (seedstock, cow-calf, feedlot, processing, forage and feeds production, and veterinary health), and funding agencies (industry and provincial and federal government), as well as researchers. The outcomes were further vetted with the Science Advisory Panel for the Beef Cattle Industry Science Cluster, the national Beef Value Chain Roundtable Research Committee, and the BCRC for feedback and approval.

The outcomes are presented in this strategy document in each priority area. The research priority sections include an overview as a research priority, summary of

research funded over the past five years, what's needed, and the specific research outcomes.

Next funding coordination steps moving forward are described in Chapter V *(Research Funding Review & Priority Coordination)*. The intent is to present the National Beef Research Strategy to funding stakeholders to obtain further feedback on the collaboration process with a focus on gaining ongoing commitment. In addition, attention will be placed on defining opportunities to improve coordination of funding and reporting functions. A key element will be the development of a National Research Inventory as a basis for the funding coordination process. An annual forum of beef research funding stakeholders is also suggested to review progress against defined research outcomes and identify areas for future coordination.

The development of this National Beef Research Strategy has been a huge undertaking by the BCRC and National Beef Value Chain Roundtable that has resulted in a truly collaborative and highly focused plan for targeting future research funding and programs to meet industry needs. The BCRC and Beef Value Chain Roundtable are excited about the implementation of the strategy and the opportunity to continue working with all stakeholders moving forward.

This is a dynamic document and process which is 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.

II. Background

The National Beef Value Chain Roundtable and Beef Cattle Research Council recognized the need to review the beef research situation in Canada and starting in 2008, initiated a process which led to the development of this **National Beef Research Strategy**.

The Beef Cattle Research Council (BCRC) is Canada's national industry-led funding agency for beef research, investing 15 per cent on average of every National Check-off dollar. The BCRC funds research and development activities to improve the competitiveness and sustainability of Canada's beef industry. As the national beef industry research funding body, the BCRC has a responsibility to take the lead in coordinating research, identifying research priorities and defining target industry research outcomes.

The National Beef Value Chain Roundtable, established by the federal minister of agriculture in 2003, is comprised of industry and government representatives representing the entire value chain and has provided leadership in addressing issues of importance to Canada's beef industry. The Roundtable has identified research as a priority and subsequently formed a working group in partnership with the Beef Cattle Research Council to develop a National Beef Research Strategy in consultation with all stakeholders from industry, provincial governments, and the federal government through Agriculture and Agri-Food Canada (AAFC).

A comprehensive approach has been undertaken to develop this National Beef Research Strategy including:

- Review of the overall beef research situation involving assessment of historical and current states of Canadian beef and beef cattle research; comparison of Canadian and international research models; an initial draft framework to coordinate Canadian beef research priorities, funding and technology transfer

- First of its kind inventory of beef research projects funded during the past five years

- Consultation with stakeholders and workshop to define -short, -medium, and -long term research outcomes in the priority areas of (1) Beef Quality, (2) Food Safety, (3) Animal Health and Welfare, (4) Feed Grains and Feed Efficiency; and (5) Forage and Grassland Productivity

- Collaboration with funders to ensure that research funding allocations adequately address industry research priorities, and develop a framework to work together on enhancing extension activities.

RATIONALE FOR A NATIONAL BEEF RESEARCH STRATEGY

Research and innovation play a critical role in addressing many of the competitiveness issues facing the Canadian beef industry. However, overall funding and infrastructure, human capital, and technology transfer to support beef and beef cattle research are fragmented and have declined significantly in recent decades.

An independent review of the beef research situation in Canada in 2008[2] provided a comprehensive assessment of beef research capacity, infrastructure and resources; analysis of historical and current beef research funding; and a comparison of beef research and funding priorities and coordination across Canada. The review also examined models from other major beef producing jurisdictions comparing research, commercialization and technology transfer and infrastructure.

Seventeen distinct institutions involved in conducting beef research in Canada were surveyed. Responses confirmed that beef research infrastructure and human capital resources has significantly declined. Those challenges are compounded by a large number of funding agencies, each with relatively limited amounts of research funding, lacking commonly agreed upon research priorities and no clear focus on desired outcomes.

Of particular concern is the fact that **federal beef research funding was cut across the board by 15 per cent in 1994-95, and at least another 30 per cent (inflation adjusted) since then.** Provinces have shifted from a technology transfer and adoption focus to research spending, commercialization and value added. However, provincial investments in beef research have generally been issue- or infrastructure- specific and often are grant-based allocations that have a limited funding term (three to five years).

On the industry side, **check-off funding accounted for only five per cent of research funding**. While industry investment has a significant influence in leveraging government funds (up to $6 for every check-off dollar) and delivers an

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[2] Canadian Beef Value Chain Roundtable National Beef Research Review & Strategy. Framework Partners Inc., Integrity Intellectual Property Inc. December 2008

exceptional rate of return, **industry funding is very small**. Every check-off dollar invested in national research programs in Canada delivers an average return of $46 in producer benefits.[3]

In summary, key findings from the 2008 Canadian Beef Value Chain Roundtable National Beef Research Review were that:

- There are over 30 agencies funding beef research operating in an uncoordinated manner when setting priorities and funding projects

- Beef research and infrastructure is severely underfunded and is continually declining

- Producers contribute a very small amount of research funding

- The current fractured technology transfer process does not encourage industry investment

- Some 'hot topics' have been overfunded, while more basic long-term production research has been overlooked

- The absence of a coordinated technology transfer program limits adoption by industry.

While there are many positive examples of government and industry striving to work together to define priorities and deliver research results, an overall common shared vision is lacking, with priorities often being defined very broadly and typically not being articulated in terms of the desired outcomes to be achieved.

Limited, fragmented funding does not complement, or adequately support, a national value proposition positioning Canada as a leader in animal health, food safety, and quality. Clear direction of funding allocations across funding agencies to achieve specific outcomes that adequately address industry research priorities is required, with emphasis on investing in a 'portfolio' of research that includes both near-term and long-term research.

With both federal and provincial governments looking to renew their investment in beef research, industry recognizes that in order to achieve government commitment, it is important to demonstrate leadership and clarity. **A National Beef Research Strategy involving the participation of and agreement with all**

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[3] Evaluating the Economic Benefits from the Canadian Beef Check-off. Dr. John Cranfield, Professor, University of Guelph with assistance from Michael von Massow. 2010

stakeholders will strengthen future funding requests. This is important; given the fact every producer check-off dollar attracts up to another $6 of supplementary funding from other sources.

A key step towards a National Beef Research Strategy was the development of a **Beef Cattle Industry Science Cluster** under Growing Forward in 2009. Growing Forward Science Clusters are designed to support national industry leadership in developing and managing applied science and technology research plans that are aligned with industry's priorities.

The Beef Cattle Industry Science Cluster saw the largest industry and government funding agencies, BCRC and AAFC respectively, partner to deliver research addressing a set of key research outcomes. The coordination of resources and alignment of research with industry priorities as a result of the Science Cluster was significant in achieving an increased level of industry research investment and leadership, capacity development in critical areas, improved research collaboration across research institutions, and a technology transfer and knowledge dissemination strategy focused on delivering applied research results to industry.
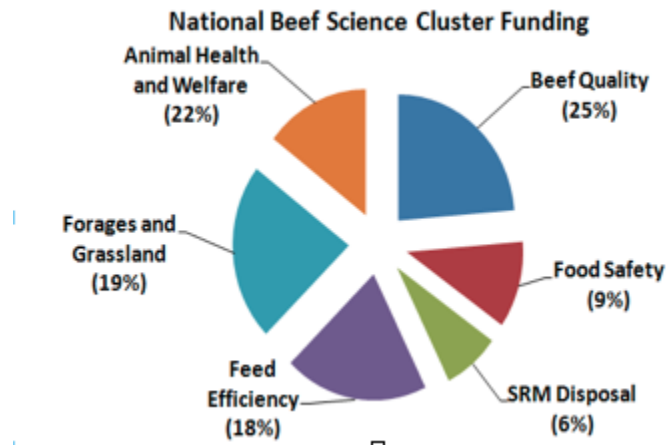
The Beef Cattle Industry Science Cluster is a four year initiative ending March 31, 2013. Funding was allocated to 32 research projects in the <u>following six priority areas</u>:

Improve Product Value

1. Beef quality & carcass optimization
2. Food safety

Increase Production Efficiencies

3. Feed efficiency
4. Animal health and welfare & production limiting diseases
5. Forage and grassland productivity
6. SRM Disposal

National Beef Science Cluster Funding

- Animal Health and Welfare (22%)
- Beef Quality (25%)
- Food Safety (9%)
- SRM Disposal (6%)
- Feed Efficiency (18%)
- Forages and Grassland (19%)

2009 Beef Science Cluster Funding Allocation by Priority Area

The first Beef Cattle Industry Science Cluster has proven to be a very successful step toward improving coordination of beef research funding in Canada. Building on this positive experience, the BCRC and national Beef Value Chain Roundtable recognized that continued focus needs to be placed on achieving alignment and commitment of other provincial and national industry and government funders to develop a single national research strategy. This is very well-timed as the development of the next science cluster is currently underway. The next cluster is expected to start April 1, 2013 and would run to March 31, 2018. Not only will collaboration with funding stakeholders at this critical planning stage help focus the next Beef Industry Science Cluster and best target available funding, it will also accelerate the research outcomes achieved over the past four years and in the future. Ongoing engagement and coordination with funders beyond the science cluster will ensure meaningful research results for the beef industry through a more coordinated and strategic approach.

MARCH 2012 STAKEHOLDER WORKSHOP AND FUNDER CONSULTATION

To continue the momentum coming out of the first Beef Cattle Industry Science Cluster initiative, the national Beef Value Chain Roundtable established a working group in partnership with the BCRC focused on the implementation of a National Beef Research Strategy, with participation from the beef industry, provinces, and Agriculture and Agri-Food Canada.

The primary objective of the working group was to define a five year National Beef Research Strategy that establishes desired industry research outcomes and improves coordination of funders, including:

1. Defining national short, medium, and long-term beef industry research outcomes that address industry priorities

2. Facilitating the achievement of desired industry research outcomes through the alignment and coordination of funding across major government and industry research funders

3. Facilitating the alignment of funding and research processes across major government and industry research funders to reduce administration burden and ensure appropriate allocation of research funding across research priorities

It was identified that convening a workshop with key industry stakeholders, industry and government research funders, and researchers was foundational to moving forward with the development of a national strategy. It is important to emphasize that the workshop was a single step in an ongoing process, with work already underway through the Beef Cattle Industry Science Cluster and further work necessary beyond the workshop to engage funders directly. For the purposes of the workshop, emphasis was placed on the following areas:

- Completing a broad review of all beef research funded in Canada over the past five years to inform future investment strategies

- Bringing together the appropriate stakeholders to develop clearly defined research outcomes through the workshop and direct engagement where appropriate.

- Facilitating discussion on the proposed roles of various funding organizations in achieving increased coordination

- Creating buy-in and commitment to the alignment of various funding organizations' internal beef research strategies with the national strategy

Stakeholder Workshop

The first day of the workshop (March 14, 2012) engaged over 75 participants representing various industry sectors (seedstock, cow-calf, feedlot, processing, forage and feeds production, and veterinary health), and funding agencies (industry and provincial and federal government), as well as researchers. Researchers were from government, academia, and private industry including Agriculture and Agri-Food Canada; Canadian Food Inspection Agency; universities (Alberta, Calgary, Saskatchewan [including VIDO], Manitoba, Guelph); Agriculture Institute of Ontario; Beef Improvement Opportunities;

private companies such as Feedlot Health Management Services, Veterinary Animal Health Services, Elanco, Viterra, Secan; Canadian Forage and Grasslands Association and Saskatchewan Forage Council; Western Beef Development Centre; Alberta Crop Industry Development Fund; Genome Alberta; and provincial government researchers from across Canada and researchers from industry associations.

The workshop began with a plenary session that reviewed the current state of Canada's beef industry, current research priorities for Canada's main beef research funders, and the allocation of research funding in Canada over the past five years based on a BCRC survey of 25 federal, provincial, and industry beef research funders. Workshop participants were then divided into breakout groups: (1) Beef Quality and Food Safety, (2) Animal Health and Welfare, (3) Feed Grains and Feed Efficiency, and (4) Forage and Grassland Productivity. Each group was provided a detailed overview of the research funding portfolio in that area over the past five years. The summary of research funded in the priority area was followed by a facilitated discussion with focus on questions such as what may have received enough attention, and what needs more attention or has been overlooked. The breakout groups then discussed the threats and opportunities for the industry which could be resolved through research, as well as research that could result in a competitive advantage for the Canadian beef industry, with a focus on identifying key research outcomes over the next three, five, and 10 years.

Consultation with Beef Research Funders

On the second day of the workshop (March 15, 2012), the BCRC and Beef Value Chain Roundtable engaged provincial and federal government and industry funders in a discussion around opportunities to improve funding coordination and delivery of research that clearly aligns with industry's established research priorities and defined research outcomes. Representatives included beef research funders from government (Agriculture and Agri-Food Canada, Ontario Ministry of Agriculture and Food, Manitoba Agriculture and Rural Initiatives, Saskatchewan Agriculture and Food, the Alberta Livestock and Meat Agency) and industry (BCRC and provincial and national affiliate cattle associations). *See Appendix for list of Beef Research Funding Stakeholders.*

Further results from the BCRC survey of beef research funders were presented that identified issues arising from the current system.

The survey indicated that there is significant variation in how funders identifying priorities. Overall, there is a lack of clearly established research outcomes and substantial overlap in funding portfolios across funders.

The survey found that a large number of research projects had multiple funders (up to seven) and individual funders were not always aware of other contributors to a project. It is important to note this does necessarily mean that a project has been overfunded, but may be symptomatic of the need to piece together funding from multiple agencies in order to sustain a single research program. However, the need to prepare at least seven letters of intent, at least seven research proposals, seven funding contracts, and seven interim and final reports consumes a significant amount of time and resources from both a researcher and funder standpoint. Funders readily agreed this is not the best use of a researchers' time or funding agencies' time.

The survey also identified that the realities of the current funding system have often limited the ability of one particular funder to fully fund a single initiative due to funds available, leveraging requirements, timelines, and other restrictions. None of the 23 funders surveyed were able to fund projects longer than five years, with an average funding timeline of three years. This type of timeframe makes it difficult to attract capacity and maintain long-term research programs around animal breeding, forage and feed grains breeding and production, and environmental research. The maintenance of long-term research programs becomes particularly difficult in light of unpredictable gaps in government funding programs, which exacerbate funding issues and make it difficult to retain capacity and achieve continuous progress.

The overlap between funders and limitations / challenges of the current research funding situation calls to question whether research programs are achieving results towards targeted outcomes and whether all industry research outcomes are being addressed.

Funders recognize the need to increase the level of communication and cooperation in order to maximize the value of research dollars (while maintaining regional flexibility) and unanimously agreed to support the BCRC and Beef Value Chain Roundtable in developing a national research strategy aimed at achieving target industry research outcomes.

Funders agree the Canadian beef industry is in need of a national framework for coordinating beef research that builds on and coordinates the efforts currently

underway across the country. The ideal would consist of all beef research funders supporting complementary research outcomes that enhance the profitability of the Canadian beef industry and expand demand for Canadian beef in both domestic and export markets.

Points of Agreement from research funder consultation:

1. There is benefit to greater coordination through a national process to establish research outcomes

2. Where feasible the improved coordination of funding processes

3. Increased communication regarding established research outcomes, funding decisions, and funding portfolios

4. To work together to reduce duplication and facilitate a more strategic allocation of limited resources
    - » Identifying which funders are in the best position to address individual outcomes
    - » Avoiding project and infrastructure funding gaps, and
    - » Avoiding overfunding of the latest next big thing

Next Steps for future funder collaboration:

1. BCRC to oversee a National Research Inventory
    - » Acting as a custodian of beef research; including funding portfolios, decisions, and other relevant information

2. Deliver a robust priority setting process that identifies specific national research outcomes on a 5-year basis

3. Define a strategy that considers outcomes against individual funding portfolios, infrastructure, capacity, etc., to define the most appropriate strategy moving forward

4. Gain commitment from funders to various 'pieces' to ensure high priorities not left on the table

5. Exploration of additional mechanisms to coordinate funding processes

6. Explore opportunities to consolidate extension efforts

III. The Role of Research in Supporting Competitiveness

The overarching goals of the Canadian beef industry are to expand beef demand and enhance profitability. The domestic market is the single largest market for Canadian beef, absorbing half of what we produce. The industry depends on export markets for the other 50 per cent of its production. The industry as a whole needs to stay 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. There have been significant gains from investment in research over the years that have contributed to the Canadian beef industry's ability to stabilize beef demand domestically and compete internationally. A large part of this has been managing input costs and adding value through finishing and processing.

The value of applied beef research in supporting industry competitiveness of the Canadian beef industry can be easily demonstrated. Extended grazing research initiated in the 1990s resulted in successful feeding strategies that allowed cow/calf producers to reduce daily cow winter feeding costs by nearly 50 per cent. In addition to helping the industry survive the low calf and market cow prices through the BSE years; this research continues to support industry competitiveness in an era of high fuel and feed costs and low labour availability.

Similarly, Canadian beef's reputation for safety and quality led to strong domestic Canadian consumer confidence that contributed to a 6.3 per cent increase in beef consumption and a 3.3 per cent increase in beef demand in the first year of BSE (2003) compared to the previous year. This had never been seen anywhere else in the world.

Future growth in productivity depends in large part on investment in research and development. Research will play a critical role in supporting the industry's Canadian Beef Advantage and value proposition to provide high quality grain-fed beef and be a global leader in animal health and food safety. Research is necessary to enhance production competitiveness, to help the industry manage costs and increase efficiency. Research will continue to be the underpinning for the industry to take a leadership role in advocacy areas such as food safety, animal health practices, animal care and the environment. Research will play an

increasingly important role in the area of expanding beef exports and trade, to inform science-based regulations and trade agreements.

The industry faces a number of opportunities and challenges and is also subject to many factors beyond its control such as input costs, currency fluctuations, and the state of the global economy. More than ever, future success is heavily reliant on achievement of research outcomes to ensure the industry is strongly positioned to address opportunities and challenges, and manage factors beyond its control as much as possible.

The Canadian beef industry continues to recover from losses incurred due to BSE-related market access issues and market-related losses resulting from record high feed costs, an appreciated Canadian dollar, strong energy and labour markets, and weak global consumer demand due to recession.

The global population is expected to continue to grow, increasing to over nine billion over the next 50 years. The result is the need for increased food production while the number of arable acres available for food production is expected to decrease as urban populations grow and expand and there is greater competition for acreage for crops

directed towards fuel production. This will require improvements in technology to increase productivity and efficiencies in food production.
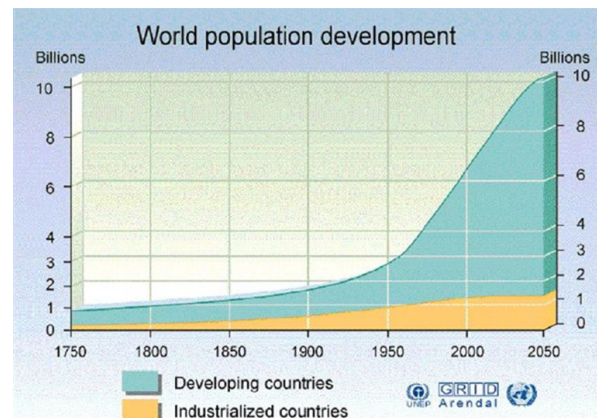
Along with population growth, there is also evidence of a rising middle income class in several major regions including Asia, South America, the Middle East and North Africa. Food consumption, and more particularly protein consumption, increases as incomes continue to grow and populations move away from poverty. Global beef consumption is projected to continue to grow,
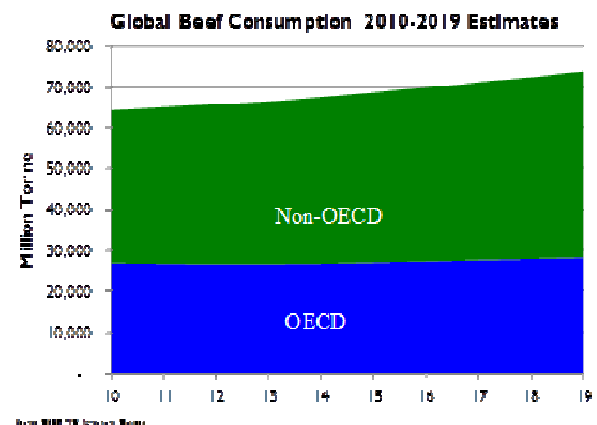
primarily driven by consumption increases in developing regions. In tandem with this, demand for beef from exporting nations is expected to increase.

Growing beef demand and reduced global beef supplies over the past five years have caused record high cattle prices in many major markets including Canada. Changing production dynamics are also evident throughout the world, with increased competition for acreage for crop production and higher labour costs affecting the costs of production in many major beef producing regions. This has narrowed the cost of gain advantage previously attributed to areas such as South America due to lower land and labour costs.

The narrowing of other countries' cost of gain advantage does not imply that Canada and other higher cost grain-fed beef producers can ease focus on ensuring cost competitiveness and product marketing. Rather, it emphasizes the growing shift in global food production, as competition for resources increases and improvements in productivity in food production lag behind demand growth.

Record high cattle and beef prices due to reduced supplies and strong demand would historically have seen rapid growth in the beef cattle industry; however, Canada and other major beef producers are now operating in a new realm. A strong Canadian dollar, record high feed and energy costs, and increased volatility across financial,

Global Beef Production
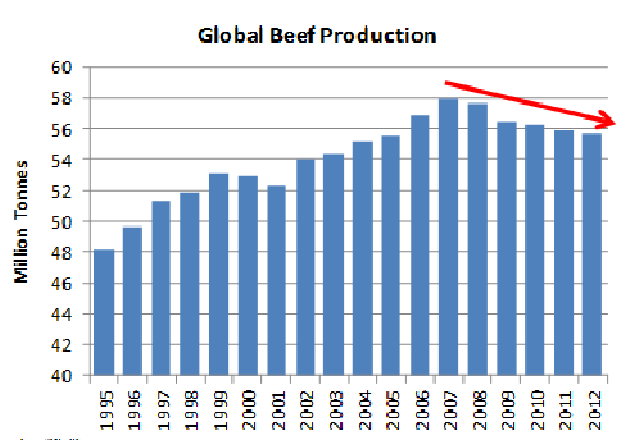
commodity, and resource markets means that margins are narrower than what would historically encourage expansion. In addition, risks associated with market access, input price volatility, economic uncertainty and changing industry structure result in the need for new operating and management systems and knowledge requirements to ensure competitiveness and sustainability.

Over the long term, Canada is in a position to respond to global growth in beef demand, supported by favourable production conditions, industry competitiveness and long-term demand for our product domestically and internationally. Research is integral to supporting industry growth and

development moving forward across a multitude of areas. Key areas include the following.

Supporting the Canadian Beef Advantage *to provide high quality grain-fed beef and being a global leader in animal health and food safety*

Research is necessary to support:

» Quality, grading and yield improvements
» Validation of product quality and yield advantages
» Reduction and mitigation of pathogens and food safety risks and ongoing monitoring of antimicrobial resistance
» Genetic and production improvements
» Environmental and animal welfare attributes of Canada's beef production system
» Utilizing the Beef InfoXchange System to support research, identify priorities, and measuring adaptation

Enhancing the Production Competitiveness of the Canadian Beef Industry

Research is necessary to support:

» Management of high feed costs through improved feed efficiency and reduced winter feeding costs (e.g. extended grazing)
» Increased feed grain yields
» Increased forage production and quality
» Access to new products and technologies (animal health products, feed additives, etc.)
» Ongoing advancement of best management practices to improve herd health management
» Increased reproductive efficiency

Supporting Industry Advocacy through Science-based Research

Consumers are increasingly focused on how food is produced while being increasingly removed from agriculture production which consequently creates a knowledge gap. As a result, it is recognized that industry must take a leadership role in positively positioning the beef cattle industry through the provision of credible science-based information in the following areas:

» Food safety, beef quality, and nutrition
» Production and animal health practices
» Animal welfare (transport, lameness, pain mitigation)

» Quantify the positive environmental contributions made by Canada's beef industry and identify potential areas of improvement

Regulatory Competitiveness and Foreign Trade

Growth of the Canadian beef industry is contingent on the expansion of beef exports and trade. Research is critical to informing science-based regulations and trade agreements relative to food safety, production practices, and the industry's environmental footprint.

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

Research Expertise and Infrastructure

Research capacity that can address issues of importance to the Canadian beef industry and speak objectively to consumers, global trading partners and other interested stakeholders on an independent basis is critical in core areas such as food safety, animal health and welfare, environmental impact, and other production areas. Despite established future planning, not all research needs can be planned ahead. Consequently, there is value in ensuring ongoing investment in high-risk discovery research that ensures expertise and capacity is available when required and addresses competitiveness issues proactively through continued long-term investment in core areas.

IV. Research Priorities and Outcomes

2011 BEEF RESEARCH FUNDER SURVEY

As part of defining research outcomes under a National Beef Research Strategy, it was deemed important to complete a review of how research has been funded in Canada over the past five years in order to assist with informing the discussion. The BCRC surveyed 25 industry and government research funders across Canada. The survey asked questions regarding funding processes and policies, priority setting processes, priorities and research outcomes, and what each funder's five year research funding portfolio included. The funding portfolio included information on all projects funded such as the title, researchers, objectives and deliverables, funding, funding partners, etc.
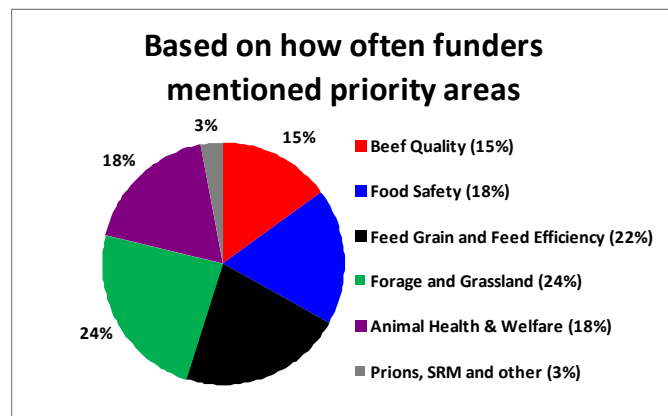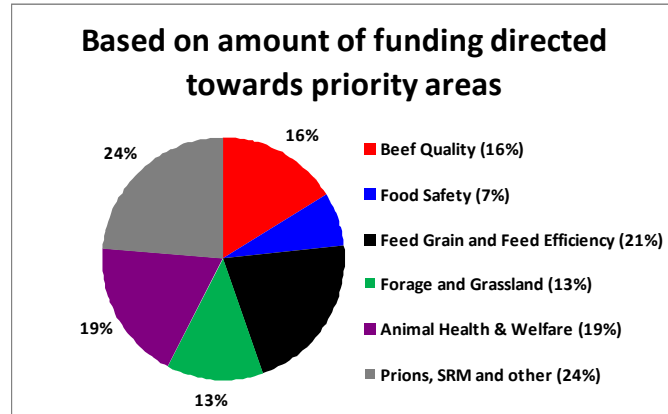
Priorities vs. Outcomes

There has been an identified need to move away from focusing on research priorities and move towards the establishment of 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, whereas establishing specific outcomes is more challenging but important to ensure research is aligned more directly with industry's needs.

FIVE YEAR PRIORITIES AND FUNDING ALLOCATION

As part of the research evaluation, an assessment was completed to evaluate the relative importance placed by funders on various priorities and how that aligned with actual funding allocations. The comparison is presented in the tables below. Priorities and actual funding allocations for beef quality, feed grains and feed efficiency, and animal health and welfare were relatively consistent. Food safety received only seven per cent of total research funding as opposed to 18 per cent based on priority ranking, and forages and grassland productivity received only 13 per cent as opposed to 24 per cent based on priority ranking. The most significant variation between priorities and funding allocations was for specified risk materials (SRM) and BSE-related research, which was the largest

single funding category over the past five years despite ranking relatively low (three per cent) in terms of priorities.

Based on amount of funding directed towards priority areas

- Beef Quality (16%)
- Food Safety (7%)
- Feed Grain and Feed Efficiency (21%)
- Forage and Grassland (13%)
- Animal Health & Welfare (19%)
- Prions, SRM and other (24%)

Based on how often funders mentioned priority areas

- Beef Quality (15%)
- Food Safety (18%)
- Feed Grain and Feed Efficiency (22%)
- Forage and Grassland (24%)
- Animal Health & Welfare (18%)
- Prions, SRM and other (3%)

Some of the differentials may be a result in variations of the cost of various types of research. The National Beef Research Strategy suggests that priorities continue to be monitored against funding allocations to ensure alignment and also to address capacity related issues that have limited funding in certain areas. There is an understanding across funders that in the areas of food safety and forage and grassland productivity, limited capacity has meant that limited research proposals have been forthcoming for funding. Consequently, efforts need to be made to address capacity issues in these areas to facilitate advancement of priority research.

OUTCOME AND PRIORITY SETTING PROCESS

The review of beef research funded over the past five years and survey of funder priorities and funding allocations fed into a comprehensive outcome and priority setting process.

The first step was a workshop that engaged over 75 participants representing various industry sectors (seedstock, cow-calf, feedlot, processing, forage and feeds production, and veterinary health), and funding agencies (industry and provincial and federal government), as well as researchers.

The second step was a compilation of information from the workshop that also incorporated the submitted information in preparation for the workshop discussions.

The third step was engagement and validation through consultation with key stakeholders including vetting of proposed research outcomes with the Science Advisory Panel for the Beef Cattle Industry Science Cluster.

Members of the national Beef Value Chain Roundtable were involved throughout the process and the final draft of research outcomes was presented to the Beef Cattle Research Council for feedback and approval.

BEEF INDUSTRY CORE RESEARCH OBJECTIVES

The beef industry has defined <u>two core research objectives</u> under which more specific priorities are established:

1. To *enhance industry sustainability and reduce production costs*, priority outcomes are to enhance feed and forage production, quantify the environmental impact of Canada's beef industry, increase feed efficiency, decrease the impact of animal health issues and production limiting diseases, and ensure animal care.

2. To *improve beef demand and quality*, 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.

OVERARCHING AIMS FOR RESEARCH PRIORITY AREAS

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

- Improved communication, collaboration and understanding between researchers and industry, with research/industry collaborations increasing to account for 25% of research activities.
- Established internship program to mentor new scientists with industry collaborators; having 10 scientists complete the program by 2016.
- Cost-benefit analysis completed to support recommendations and knowledge transfer from research projects that impact production profitability.
- Encouragement of interdisciplinary teams undertaking systems-based approaches integrating the entire value chain where appropriate.

It is important to note that a key element of the National Beef Research Strategy is the maintenance of long-term, basic, high-risk, discovery research. Research capacity that can address issues of importance to the Canadian beef industry and speak objectively to consumers, global trading partners and other interested stakeholders on an independent basis is critical in core areas. Funding this basic research is also critical as the knowledge gained through this research will

underlie the practical solutions that will be further developed through future downstream applied production research. The knowledge gained through basic research also provides considerable benefits to society at large. Despite established future planning, not all research needs can be planned ahead. Consequently, there is value in ensuring ongoing investment in high-risk discovery research that ensures expertise and capacity is available when required and addresses public good and competitiveness issues proactively through continued long-term investment in core areas.

The following sections include the desired research outcomes as determined and validated through stakeholder consultation in the research priority areas of:

- Beef Quality
- Food Safety
- Animal Health and Welfare
- Feed Grains and Feed Efficiency
- Forage and Grassland Productivity

An overview and summary of research funded over the past five years is included for each area along with identified outcomes.

NOTE: Specific outcomes listed are identified as short-, medium-, and long-term, which are expected to be achieved by 2016, 2018, and 2023 respectively.

Beef Quality

OVERVIEW AS A RESEARCH PRIORITY

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

Over the last 30 years Canadian **per capita beef consumption** has declined 30 per cent from 28.7 kgs in 1980 to 20.2 kgs in 2010. Despite the falling per capita consumption, overall consumption of beef in Canada has been relatively steady over the last decade at around one million tonnes (carcass weight), with population growth maintaining total disappearance.

The **Beef Demand Index** is a measure of consumer willingness to pay for the per capita consumption based on deflated retail beef prices. Over the last 20 years, the Canadian beef demand index has fallen from 60 in 1990 to a low of 47 in 1997 before climbing back to 59 in 2003. Over the last five years, the index has declined from 55 to 50.

A number of factors contribute to beef demand such as:

1. <u>Disposable Income</u> – As the baby boomer generation retires, age and fixed finances influence their beef purchase decisions along with a desire for a smaller portion size. The result of a smaller portion size is an overall decline in per capita consumption. Economic weakness and uncertainty that negatively affects disposable income is a major driver; affecting consumers' purchasing power and consequently food choices.
2. <u>Price and price relative to competing proteins</u> – Beef is the most expensive protein. Consequently when economies weaken and purchasing power decreases, consumers move to consuming cheaper cuts or alternative protein sources.
3. <u>Health Concerns</u> – There is significant competition in the protein section, with nutrition, fat levels, and other health factors all playing a role in selecting the proteins consumed.
4. <u>Food Safety Concerns</u> – Food safety is of utmost priority to both consumers and industry and is addressed next as a separate research priority area.

A significant challenge with beef demand historically has been the high variability in quality. In 1995 the top five ranked beef quality concerns in the United States were: (1) low overall uniformity and consistency; (2) inadequate tenderness; (3) low overall palatability; (4) excessive external fat; and (5) high price for the value received. Low satisfaction with beef tenderness has been an issue for several years. Quality grades have historically been assumed to differentiate steaks by tenderness, but have not been completely adequate in this regard and cannot address the issue in isolation of other factors that impact tenderness. Without clear market signals linked to beef quality it is difficult to make progress in this area. Current genetic research is trying to identify tenderness traits and there is also focus on reducing variability through new technologies to measure tenderness in-plant and increasing the tenderness of undervalued cuts via processing interventions.

BEEF QUALITY RESEARCH FUNDED OVER THE PAST FIVE YEARS

Over the past five years, **improving product tenderness** and research into **functional foods** were the top two categories funded, each receiving just under 25 per cent of funding allocated to beef quality. Funding allocated to improving tenderness was primarily focused on identifying genetic markers for tenderness, with a relatively smaller proportion invested in further processing and animal management. Funding allocated to functional foods was primarily directed towards identifying genetic markers and development of feeding strategies to enhance the presence of healthy fatty acids, (CLAs and omega-3s). Other areas of research that received a relatively smaller portion of funding included a national beef quality audit, carcass composition research, and evaluation of the presence and cause of dark cutters.

Beef Quality Funding Breakdown (56 projects)
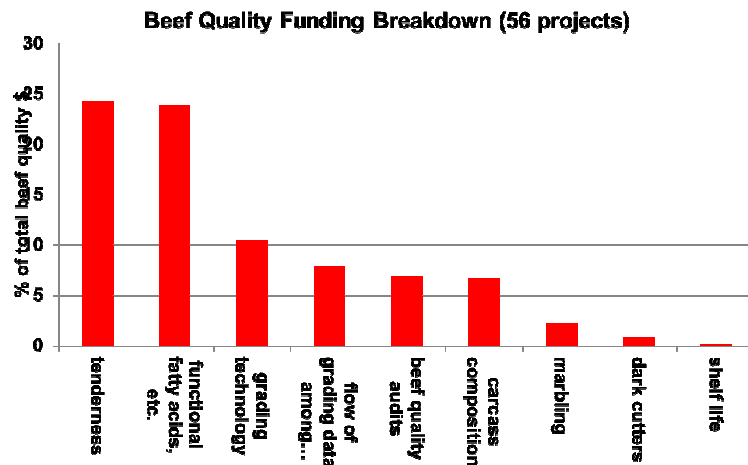
WHAT'S NEEDED TO IMPROVE BEEF QUALITY

Meat product attributes such as tenderness, consistency, and convenience are the top three attributes of priority to consumers. The eating experience and the perception of quality for money directly influence consumers' purchasing decisions.

A lack of consistency in tenderness has plagued the beef industry for years. While marbling is related to juiciness it has little correlation with tenderness. It's also important to note that Canada lags behind the U.S. in terms of production of AAA and prime beef. Per capita consumption is also lower in Canada; although Canadian consumers are willing to pay more for beef. Improvements in yield have plateaued and actually reversed in some cases, with current market signals encouraging heavier weights and offsetting the penalty for YG2 or YG3 animals. Furthermore, the incidence of dark cutters has increased since 2004; particularly in the West. While overall numbers have declined since 2008, levels are still above the historic average.

Improving beef quality is critical to achieving the Canadian beef industry's overall goals of expanding beef demand and enhancing profitability. During the consultation for the development of this National Beef Research Strategy, stakeholders identified beef quality research outcomes focused on monitoring changes in industry practices and identifying emerging issues; genetic markers; processing plant measures of tenderness; genomic, grading and new packaging technologies; enhanced Canadian beef quality benchmarking data to help drive tangible improvements in this priority area and support the Canadian Beef Advantage; and the establishment of a meat science program at a Canadian university.

BEEF QUALITY RESEARCH OUTCOMES

Outcome 1: Improved Consumer Satisfaction with Canadian Beef

Short Term

a. Effectiveness and value of genetic markers for tenderness validated in commercial cattle.
b. Electrical stimulation recommendations re-evaluated to reflect increased carcass weights.

c. Objective in-plant measures of tenderness that can be used at line speed validated.

Medium Term

a. National Beef Quality Audit (consumer satisfaction) demonstrating that 65% of inside round, 80% of cross-rib, 90% of top sirloin and 99% of strip-loin steaks are sufficiently tender and that no tenderness enhancement is necessary.
b. Potential interactions between tenderness genotype and animal management (e.g. implants, backgrounding, grassing, finishing, etc.) identified and appropriate breeding and management recommendations developed.

Long Term

a. Data collected to inform consumer messaging regarding the relevant nutritional characteristics of beef, including protein, mineral, vitamin, and lipid components.

Outcome 2: **Validation of the Canadian Beef Advantage Relative to International Competitors**

Short Term

a. Packaging and other technologies to improve shelf life and appearance for export developed.
b. Canada's beef carcass quality and yield benchmarked relative to international competitors.
c. Beef InfoXchange System data integrated with research analysis in order to monitor changes in industry practices and identify emerging issues.

Medium Term

a. Improved algorithms for prediction of lean meat yield and / or retail product percentage.
b. Genomic and grading technologies that allow for market segmentation according to carcass quality and/or yield implemented.
c. Beef Quality Audit enhanced through development and implementation of processes that facilitate the automated collection, recording and evaluation of carcass quality parameters.
d. Beef Quality Audit demonstrating a reduction in carcass defects below 2012 levels.

Long Term

a. Data collected through the Beef InfoXchange System analyzed to benchmark Canada Beef Advantage attributes, refine research priorities, and identify improvement opportunities.

Outcome 3: **Extension, Outreach and Policy**

Short Term

a. Complete a systematic literature review on the nutritional attributes of beef to address consumer concerns, inform consumer education programs, and identify appropriate research directions and applications.
b. Enhanced consumer education regarding their role and responsibility in ensuring beef quality through selection of appropriate cut-specific preparation and cooking methods.

Food Safety

OVERVIEW AS A RESEARCH PRIORITY

The objective of research in the area of food safety is to maintain domestic and international consumer demand for beef by developing improved food safety interventions, methods to quantify the effectiveness of food safety interventions, and develop food safety intervention strategies that counteract multiple pathogens.

Human illness linked to beef and product recalls due to the adulteration of meat products with pathogens continues to be a major concern for the Canadian beef industry. The industry has been proactive in conducting research on mitigation strategies in cattle and beef production and processing facilities. Considerable investment in antimicrobial procedures such as lactic acid washes and carcass pasteurization have been implemented by the processing sector. Despite these steps, recalls continue to occur. E.coli incidents have also been linked to cattle operations. Additional interventions are being developed to help address the presence of *E. coli O157:H7* in the environment. On the farm, these include vaccines, best management practices, water treatments, and probiotics.

Greig and Ravel (2008) analyzed food borne outbreak data reported internationally from 1988-2007 and found that of the 4,093 food borne outbreaks that had an identified source, almost 70 per cent were attributed to *Salmonella* (46.9%), Norovirus (13.5%) and *E.coli* (9.5%). Internationally the most common pathogen reported in beef is *E.coli* (34.6%), with the majority of reporting in the US (63%) followed by Canada (27%) and the EU (10%).[4]

Since 2000, there have been 13 *E.coli* outbreaks in Canada where the source of contamination was confirmed as beef. The number of cases associated with each outbreak varied from few to several. Since 2000 there have been 11 outbreaks where the source of contamination was suspected to be beef but was not confirmed and no food recall occurred.[5] This data reflects incidence of national investigations which cross provincial borders and does not include outbreaks that occurred on a provincial basis.

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[4] J.D. Greig and A. Ravel (2008) Analysis of foodborne outbreak data reported internationally for source attribution. International Journal of Food Microbiology (2009), doi:10.1016/j.ijfoodmincro.2008.12.031
[5] Science to Policy Division, Laboratory of Foodborne Zoonoses, Public Health Agency of Canada

The National Enteric Surveillance Program (NESP) collects data on laboratory confirmed isolations of pathogens from provincial laboratories. Provincially, PEI had the highest incident rate in 2009 at 6.38 per 100,000 followed by Alberta (4.47), British Columbia (3.70) and Manitoba (3.68). As with the national trend, declines have been seen in all provinces from 2001 to 2009.

Another issue of priority is monitoring antimicrobial use in the livestock sectors which has been identified as a potential risk factor in the development of human pathogens that are resistant to antimicrobials. Of particular concern are antimicrobial agents that belong to the same chemical family as antimicrobials commonly used to treat bacterial infections in humans. Repeated studies conducted in Canada have found no evidence that antimicrobial use in beef cattle contributes to antimicrobial resistance to drugs of the highest importance in human medicine. The Canadian beef cattle industry is continuing to use antimicrobial agents and will need to continue to closely monitoring this issue in order to demonstrate to the public that industry uses antimicrobials prudently. Technical reviews continue to be initiated in other countries such as the U.S., accompanied by calls for increased regulation of antimicrobial use in food animals.

FOOD SAFETY RESEARCH FUNDED OVER THE PAST FIVE YEARS

Over the past five years, 60 per cent of funding allocated to food safety was focused on research studying multiple pathogens, while 40 per cent was focused on issues related to a single pathogen. *E.coli* (generic and O:157) was the primary focus of single pathogen research (~75 per cent), while *Listeria* was distant second. Multiple pathogen research focused on *E.coli, Salmonella* and *Listeria.*
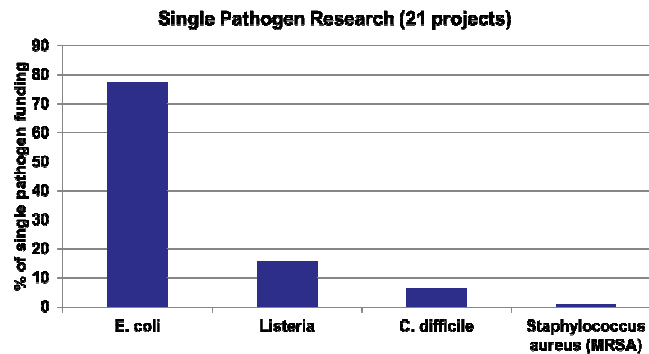
The majority of funding was focused on evaluating and improving the effectiveness of pathogen mitigation, primarily pathogens on beef carcasses and

trim where temperature treatments and sprays were the most heavily funded interventions. This was followed by examining pathogens in cattle, with 30 per cent of funding allocated to on-farm interventions. Only five per cent was allocated to retail level food safety research and interventions. No other category received more than 10 per cent of funding including detection and prevalence of other pathogens, antimicrobial resistance, and new strain identification.

Mitigation strategies studied (27 projects)
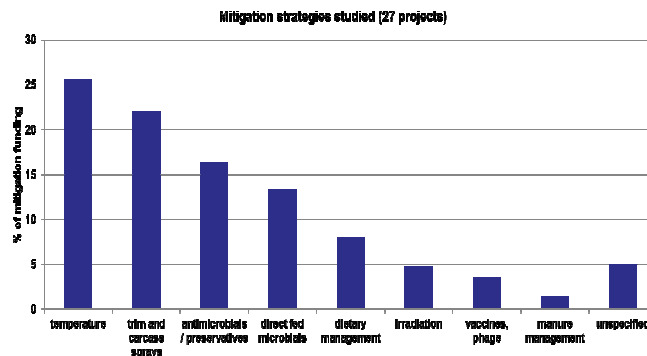
WHAT'S NEEDED TO IMPROVE FOOD SAFETY

The safety of beef as a food product must continue to be a top priority for the Canadian beef industry to maintain domestic and international consumer confidence. Food safety improvements throughout the entire beef supply chain, from on-farm to consumer plate, need to be vigoursly pursued for Canada to be a global leader in food safety and support the Canadian Beef Advantage. We must be as good as or better than the competition. Other major beef-producing nations are strongly invested in beef safety research and supply chain interventions to mitigate risk. The future success of the Canadian beef industry in all markets in large part hinges on providing a safe high quality food product.

During the consultation for the development of this National Beef Research Strategy, stakeholders identified food safety research outcomes focused on enhanced surveillance and interventions, new technologies, significantly improved research and training capacity, and to be able to demonstrate responsible microbial use supported by enhanced data and further investigation including genome sequencing. Education has been identified as an ongoing and important need to achieve improvements throughout the beef production chain and with consumers to ensure proper at-home handling.

FOOD SAFETY RESEARCH OUTCOMES

Outcome 1: Improved Food Safety along the Beef Supply Chain

Short Term

a. Technologies targeting multiple pathogens in cattle and beef production and processing facilities developed and implemented.

Medium Term

a. Objective approaches for verifying effectiveness of packing plant equipment cleaning processes developed and adopted for 85% of processed cattle.
b. Increased surveillance to detect, characterize and quantify the relative human health risk of (re)emerging pathogens.
c. Effective probiotic intervention to eliminate pathogens from beef developed.

Outcome 2: Responsible Antimicrobial Use Demonstrated

Short Term

a. On-farm data collection and food safety pathogen incidence incorporated into the Canadian Integrated Program for Antimicrobial Resistance Surveillance for beef cattle.
b. Microbial genome sequencing used to investigate potential associations between pathogen incidence and antimicrobial use in cattle and the presence of pathogens and development of antimicrobial resistance in microbes found in retail beef and human clinical cases.

Medium Term

a. Statistics collected through the Canadian Integrated Program for Antimicrobial Resistance Surveillance (surveillance) demonstrate that:
   - generic *E. coli* samples collected from abattoir samples demonstrate 0% resistance to five or more antimicrobials and 0% resistance to antimicrobials of very high importance in human health, and
   - generic *E. coli* samples collected from retail beef demonstrate less than 2% resistance to five or more antimicrobials, and less than 1% resistance to antimicrobials of very high importance in human health.

Outcome 3: Improved Beef Quality and Food Safety Research and Training Capacity

Short Term

a. An industry meat science research chair to address issues facing the beef packing and processing sectors, and reinvigorate food safety research program capacity established.

Long Term

a. A meat science program is established at a Canadian university with educational and research components to produce highly qualified personnel serving Canada's beef industry.

Outcome 4: Extension, Outreach and Policy

Short Term

a. Enhanced processor education to encourage the consistent adoption of known best practices to minimize the risk of pathogen contamination in beef processing plants.
b. Enhanced further processor education to encourage the consistent adoption of proper and thorough cleaning of processing and grinding equipment.
c. Enhanced 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.
d. Research results used to inform the regulatory approval of trim and ground beef irradiation.

Animal Health and Welfare

OVERVIEW AS A RESEARCH PRIORITY

The objective of research on <u>animal health</u> is to develop effective and economical management, diagnostic, and treatment tools to reduce the costs and losses incurred by major production limiting diseases and animal health issues that affect primary production sectors.

The objective of research on <u>animal welfare</u> is to develop a scientific base for best management practices. The cattle industry is being increasingly pressured to demonstrate the impacts of current practices on animal welfare and address consumer perceptions. Scientifically valid information on the impact of practices used by the industry is beneficial in advancing best management practices, identifying areas of priority, as well as supporting industry and public communication.

Animal health problems in cow/calf operations differ from those seen in stocker and feedlot operations due to difference in age and in metabolic stressors. Feedlot cattle experience considerably more metabolic disorders due to the high-energy diets fed to maximize feedlot performance.

For cow/calf producers, there are two things that have a significant impact on their bottom line regardless of the price calves are selling for: maximizing reproductive efficiency and minimizing feed costs relative to feed efficiency. Good reproductive rates are critical to operational success and profitability. It is generally expected that each breeding age female in the herd produces a healthy calf each year and raises each calf to weaning. Cows that do not produce calves on an annual basis 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, but acidosis also may occur in this timeframe with transition of diet. Morbidity is typically less than a third of this rate after 45 days in the feedlot. Miscellaneous issues, respiratory, and digestive disorders represent 44.1%, 28.6% and 25.9% of deaths respectively over the entire feeding period.

While mortality (death loss) is of primary concern, morbidity represents a significant cost to the feedlot operator as there is the expense of medication, labour in treatment, and the expense of reduced performance during and after the illness. The difference in average daily weight gain between calves that remain healthy and calves that suffer from respiratory disease can be substantial. As well, digestive disorders depress ensuing performance due to reduced intake or digestive function. The presence of parasites in the digestive tract can leave persistent scars that will depress nutrient digestibility and absorption for several months.

Animal welfare is closely linked with animal health. Overall, understanding how multiple stressors affect the animal and determining the least stress alternatives will inform industry decisions. Welfare is primarily concerned with transportation practices and pain control relative to specific production practices (castration, dehorning) and animal health issues (acidosis, lameness, etc.).

**ANIMAL HEALTH AND WELFARE RESEARCH OVER THE PAST FIVE YEARS**

Over the past five years, **animal health and welfare research has been allocated on a 90:10 split** respectively. Animal welfare research primarily focused on evaluating transport conditions and animal condition, acidosis, and castration pain control.
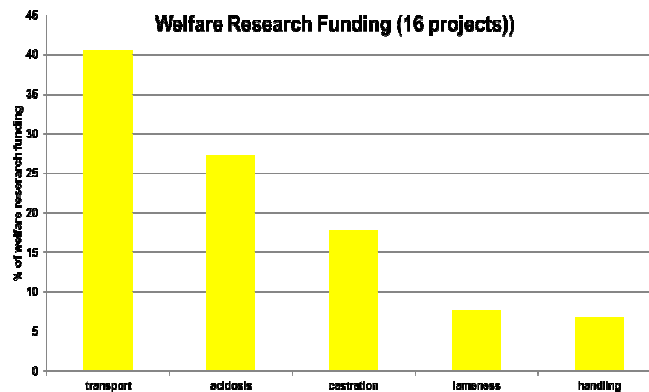
Animal health research can be broken out into three general categories. Forty per cent of research was directed towards issues related to the cow/calf sector, 35 per cent was directed towards issues in the feedlot sector, and 25 per cent to overarching animal health issues.

Cow/calf Health Research Funding (31 projects)
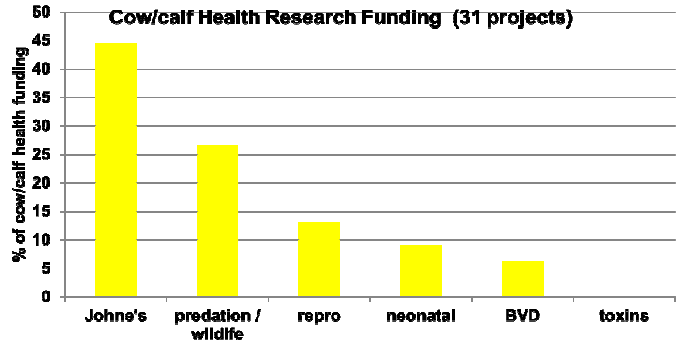
Research related to the cow/calf sector was primarily focused on Johne's disease, with close to 50 per cent of funding being allocated in this area. Half of Johne's disease research efforts were focused on diagnostic tests, 30 per cent towards vaccine development, and the remainder measuring disease prevalence and development of best management practices. A variety of wildlife and predation studies received a quarter of cow/calf health funding, while other cow/calf issues (reproduction, neonatal issues, and BVD) were at or below 10 per cent of cow/calf funding.

Feedlot Health Research Funding (28 projects)
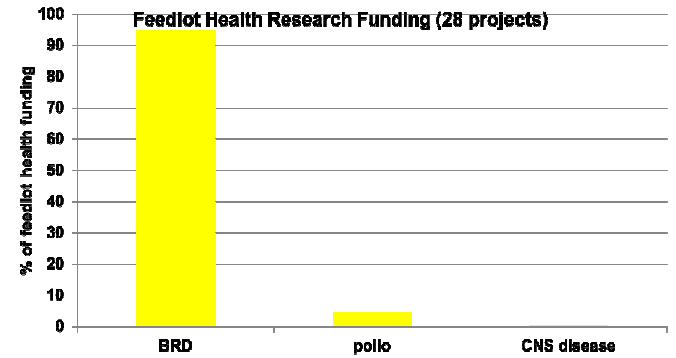
Research related to the feedlot sector was primarily directed towards respiratory disease issues, with 90 per cent of funding allocated in this area. The main respiratory pathogens researched were *Mycoplasma bovis, Mannheimia haemolytica, BVD,* and *bovine herpes virus-1.* The majority of respiratory disease research funding (60 per cent) was aimed at improving vaccines, while 20 per cent was directed towards treatment strategies.

Research related to overarching animal health issues primarily focused on carcass disposal (over 30 per cent) which included Foot-and-Mouth Disease simulations that examined deadstock disposal requirements. Anaplasmosis and

Bluetongue research received 25 per cent of the overarching funding, followed by internal parasites and an improved diagnostic test for TB.

WHAT'S NEEDED TO IMPROVE ANIMAL HEALTH AND WELFARE

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 incidence of BSE in Canada's cattle herd in 2003 demonstrated how quickly things can change and the long term recovery process to regain 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. Raising preweaning survival rates from current levels (85%) to levels seen in the 1990s (90%) would be worth at least $160 million to the beef industry.

Research will help the industry further improve herd and feedlot health, increase reproductive efficiency, advance treatments, and adopt best management practices. With consumers becoming increasingly concerned about the treatment of food animals and how their food is produced, stronger research commitment is necessary to better understand and manage animal welfare issues to ensure Canada is strongly positioned on this front, and to support animal welfare claims under the Canadian Beef Advantage.

ANIMAL HEALTH AND WELFARE RESEARCH OUTCOMES

Outcome 1: Improved Surveillance of Production Limiting Disease and Welfare Issues

Short Term

a. Improved diagnostic tests for production limiting diseases.
b. Nation-wide benchmarking survey of the incidence and economic impact of production limiting diseases, health management, biosecurity practices, and welfare practices in beef cattle (cow-calf, backgrounding and feedlot) conducted.

Medium Term

a. National production limiting disease surveillance program developed, identifying opportunities to collaborate with wildlife disease surveillance programs.

Long Term

a. National surveillance system in place to monitor the incidence of and etiology of re- and emerging production limiting diseases.

Outcome 2: Improved Understanding and Management of Pain and Stress in Beef Cattle

Short Term

a. Practical, cost-effective methods of objectively quantifying and mitigating pain and stress in beef cattle under production conditions developed (e.g. diet, castration, dehorning, branding, weaning, transport).

Medium Term

a. Benchmarks to understand the additive effects of beef production practices on pain, stress, immunity and health developed.
b. Scientifically valid beef cattle welfare audit program developed.

Outcome 3: Improved Prevention of Animal Disease and Welfare Issues

Short Term

a. Strategies to optimize or improve the effectiveness of existing vaccination programs identified and developed.
b. Reduced incidence of reproductive failure through improved nutritional management, diagnostic tests, vaccination and biosecurity.
c. Reduced neonatal loss through improved maternal nutrition, timing of vaccinations, and extension / technology transfer to cow/calf sector.
d. Modifications to current beef production practices that reduce the need for antimicrobials to prevent or treat respiratory disease in the feedlot identified or developed (e.g. vaccination, weaning, transport and diet).
e. Improved control of internal and external parasites.

Medium Term

a. Practical modifications to high energy feeding programs that reduce the incidence of metabolic diseases in feedlot cattle identified or developed (e.g. acidosis, bloat, acute interstitial pneumonia).
b. Improved immune system function, vaccine efficacy and animal health management to reduce the need for Health Canada Category I and II antimicrobial drugs by 50%.

Long Term

a. Reduced incidence of metabolic diseases in beef feedlots without increased use of antimicrobials.
b. Implementation of improved animal management systems in the industry which will reduce stress and improve animal health and productivity.

Feed Grains and Feed Efficiency

OVERVIEW AS A RESEARCH PRIORITY

The objective of research on improving feed efficiency is developing and validating economical methods to identify more feed efficient seedstock and by developing alternative feeding strategies. *Improving feed to gain by 1% would save Canada's feedlot sector an estimated $11.6 million annually.* As feed costs increase (either through higher grain prices or a shortage of forage) feed efficiency plays an even larger role in the value equation, with inefficient cattle or management strategies costing more. A difference in conversion of one pound represents $90 per head, based on US$4 corn. There are many aspects of feed efficiency – but broadly speaking there is genetic improvement and management.

Genetic Improvement

The heritability in feed efficiency is around 35-40%. Thus, selecting feed efficient breeding stock will improve feed efficiency of the population over time. The challenge is that measuring how much feed each individual animal consumes in order to calculate Residual Feed Intake or Feed to Gain Ratios is time consuming and expensive. Feed:gain is genetically correlated with average daily gain. About a quarter of the genes involved in growth rate are also involved in feed:gain ratio. This stands to reason, since average daily gain is part of the feed:gain calculation. So selecting for average daily gain will also improve feed:gain ratio. In addition, identifying and validating reliable DNA markers for feed efficiency could reduce testing costs and speed the rate of genetic improvement.

Feed efficiency encompasses a variety of traits associated with feed utilization (e.g. feed conversion ratios (F:G), residual feed intake (RFI), efficiency of growth, maintenance efficiency). The advancement of feed efficiency in beef production depends on the combination of many traits accounting for the breeding herd and terminal cattle, growth rate, mature size and reproductive rate. Selection for a lower RFI can lead to a reduction in the intake of young cattle and cows with no compromise in growth performance or increase in cow size. However, selection for a reduced feed:gain ratio may increase growth rates and lead to larger cow size and feed intake. The challenge is seeing benefits derived from genetic

selection strategies at both the cow/calf and feedlot levels, when each is looking for different characteristics.

Management Strategies to Improve Feed Efficiency

The second aspect of feed efficiency is management at the feedlot and cow/calf level. Every breed is different with unique feeding requirements. By grouping similar animals together an operator can maximize the feed efficiency of the group. Some cattle marble well and therefore can be targeted to specific grading and branding programs. At the same time cattle that grade higher are not necessarily the best feed converters; other cattle will gain well but not grade as well. This makes it challenging to find an optimum medium between performance and carcass quality. Due to strong competition on all sides, the feedlot industry is relatively homogeneous in purchase and selling price of cattle and grain costs. Therefore, feed efficiency becomes the most important factor a feedlot can control to gain an advantage over the competition.

Yields

Canadian corn yields have averaged 16% less than the U.S. over the last decade. Delays in technology being made available in Canada have resulted in corn yields trailing the U.S., constantly in catch up mode. Delays in variety approval have also occurred and left the plant breeding industry in flux, while competitor countries continue to innovate.

Improvements in Canadian barley yields have struggled even more than corn. Overall barley yields increased 28% over the last 20 years, while U.S. corn yields increased 30%. This difference in percentages is relatively small but considering that corn yields in 1990 were 118 bushels per acre, while barley yields were 46.5 bushels per acre, the difference has been amplified. Barley's competitive disadvantage is highlighted by the fact that the number of acres in barley production has declined 37% from 1976 to 2011 with the number of farms growing barley down 70% according to Agriculture Census 2011.

Dried Distillers Grains

During the past few years, considerable research has been conducted in Canada and particularly in the U.S. around feeding Dried Distillers Grains (DDGs) and alternative feeds to cattle. As the production of ethanol has increased and feed grain prices have moved higher, DDGs and other alternative feeds have become an alternative source of feed for cattle and hogs.

FEED EFFICIENCY RESEARCH OVER THE PAST FIVE YEARS

Over the past five years, the vast **majority** (90 per cent) of feed grains and feed efficiency research was **directed towards the cattle feeding sector**. Funding directed towards the cow/calf sector was primarily focused on seeking genetic markers for residual feed intake (RFI) and the advancement of epigenetics (68 per cent); 12 per cent was allocated to strategies to measure and manage manure and animal methane production. Twenty per cent was allocated to cost of production analysis.
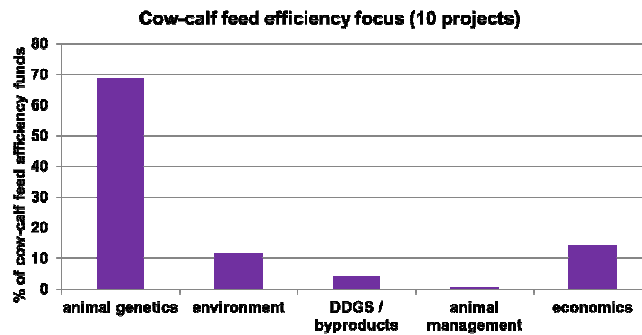
Research directed towards the cattle feeding sector was divided as follows: 23 per cent was allocated towards developing strategies to optimize the use of dried distillers grains (DDGS) and other by-products, identifying genetic markers for residual feed intake (RFI) and feeding management strategies each received approximately 17 per cent of funding. Investments in grain evaluation and grain breeding studies to enhance yield and quality received approximately 30 per cent of funding allocated.
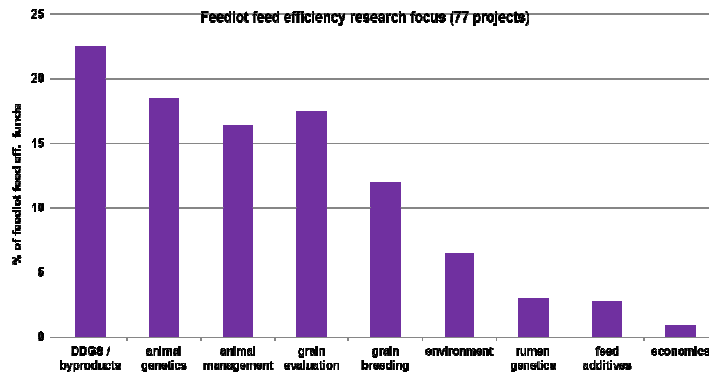
WHAT'S NEEDED TO IMPROVE FEED GRAINS AND FEED EFFICIENCY

Strategies to improve production/feed efficiency appear to be quickly adopted by industry at both the feedlot and cow/calf levels. Large gains have been seen in weaning and slaughter weights. Steer carcass weight represented 1.17 of the cow carcass weight in 1980 and has increased to 1.26 in 2010. 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 are able to see a return on their investment by selling patented products, there is still basic research that needs to be done to advance feed efficiency and feed grain production.

Feed efficiency and a lower feed:gain ratio in cattle at all stages of the life cycle (pre-weaning, post-weaning, backgrounding, grassed and feedlot) is key to **reducing cost of production and ensuring industry competitiveness**. However, this must not be done at the expense of the cow herd efficiency. On the cow side feed:gain is of little value given that cows are no longer growing but maintaining or regaining body condition making RFI the more appropriate measure.

The goal is to find ways to increase average daily gains, reduce feed:gain ratio and keep a manageable sized, fertile cow that can be efficiently fed through the winter. This will be a balancing act driven primarily from the cow/calf sector which is adopting genetic improvements. Programs like the Beef InfoXchange System (BIXS) that provides cow/calf producers information that has not been historically available to them through traditional indicators (EPDs, weaning weights, etc.) will help industry advance in the area of feed efficiency.

During the consultation for the development of this National Beef Research Strategy, stakeholders identified feed research outcomes including improving feed efficiency through animal breeding, improved feed supply and utilization, improved management of manure nutrients, and enhanced research training and capacity.

FEED GRAINS AND FEED EFFICIENCY RESEARCH OUTCOMES

Outcome 1: Improved feed efficiency through animal breeding

Short Term

a. Cost-effectiveness of genetic markers for feed efficiency validated in commercial feedlot cattle.

Medium Term

a. Impacts of genetic selection for feed efficiency on other economically relevant beef production traits (longevity, fertility, weaning weight, wintering costs, carcass weight, yield and quality grades, tenderness, etc.) quantified.
b. Potential interactions between feed efficiency genotype and management (e.g. implants, backgrounding, grassing, finishing, etc.) identified and appropriate breeding and management recommendations developed.

Long Term

a. Relative contributions of various animal digestive and metabolic processes and rumen microbes to feed efficiency quantified.

Outcome 2: Improved feed supply and utilization

Short Term

a. The cost:effectiveness of alternative / by-product energy feeds, considering impacts on animal performance, health, product quality, and nutrient management have been identified, evaluated and determined.
b. Corn and cereal forage variety differences in nutrient profile and ensiling potential characterized.
c. Feeding and production systems that improve feed efficiency by 15% developed.

Medium Term

a. Agronomic strategies to increase feed grain energy yield per acre identified.

Long Term

a. New feed grain varieties developed with improved feed grain energy yield per acre.

Outcome 3: Improved management of manure nutrients

Medium Term

a. Nutrient management decision tools that incorporate diet nutrient composition, manure handling and transport costs, value of manure nutrients and organic matter, manure management systems (e.g. raw vs. stockpiled vs. composted) soil types, and nutrient uptake by crops developed.

Outcome 4: Research Training and Capacity

a. Key feed efficiency research capacity (expertise and facilities) is maintained
b. Feed grain breeding research capacity (expertise) is reinvigorated.

Forage and Grassland Productivity

OVERVIEW AS A RESEARCH PRIORITY

The objective of research on forage and grassland productivity is to increase research program capacity to develop annual and perennial forage varieties with increased yield, drought resistance, maintain or improve nutritional value, and provide an economic alternative to current sources. Improving grassland management to increase productivity and sustainability is also a core objective.

Approximately 80% of Canada's beef production occurs while animals consume forage. Cow/calf producers tend to feed livestock with preserved forages for periods as long as October to May depending on location and annual weather. It is estimated that two-thirds of the feed protein in Canada comes from hay, grazing or forages and fodder corn production. *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 $3.5 million annually.*

Canada's forage resources include native rangelands and tame legumes, and crops. The forage resource used for livestock grazing and production of forage crops covers over 36 million hectares or 3.6% of Canada's land base, compared to 25 million hectares in grain and oilseed crops. This is divided into 72% native range (26 million hectares), 11% cultivated pastures (4 million hectares) and 17% forage crops (6 million hectares).

The four western provinces have 96% of the 26 million hectares of Canadian rangeland used for livestock production with 36% in British Columbia, 29% in Alberta, 24% in Saskatchewan and 8% in Manitoba. The western provinces also have 82% of the nation's cultivated pasture (tame), 64% of the nation's forage crop area, and 84% of the nation's beef cow herd. Cereals are grown on the majority of cultivated lands but the farm value of forage conserved as hay and silage account for 40-60% the value of feed grain crops. Canadian hay production was estimated at 30 million tonnes in 2010.

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 validated the economic benefits that would help encourage wider adoption with producers.

Hay production is an important part of the Canadian beef industry; being the primary feed source for the cow herd and high roughage backgrounding rations. Forages make up more than 80% of livestock feed in Canada and most producers use seeded forages to produce tame hay or silage. There has been a significant decline in investment and expertise dedicated to research in forages. The long-term process associated with testing new varieties and a dearth of certified growers willing to grow forage seed when grain prices are high, means that industry has not been able to benefit from new and emerging forage varieties.
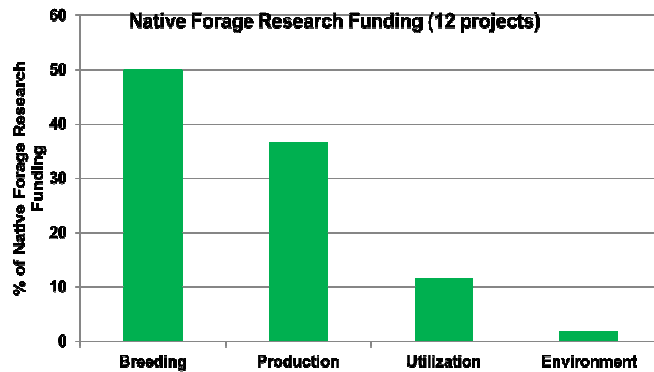
A few other areas to highlight where industry has encouraged research are native pasture productivity and finding alternative legumes to alfalfa which reduce the incidence of bloat in cattle.

FORAGE AND GRASSLAND RESEARCH OVER THE PAST FIVE YEARS

Forage research includes research directed towards improvements in breeding (quality and yield), production (planting, harvesting, storage), and the utilization of forages in feeding and grazing strategies across tame, annual, and native species. Over the past five years, 68 per cent of funding has been allocated to research focused on **tame forages**, 21 per cent to research focused on **annuals**, and 11 per cent to research focused on **native rangelands**.
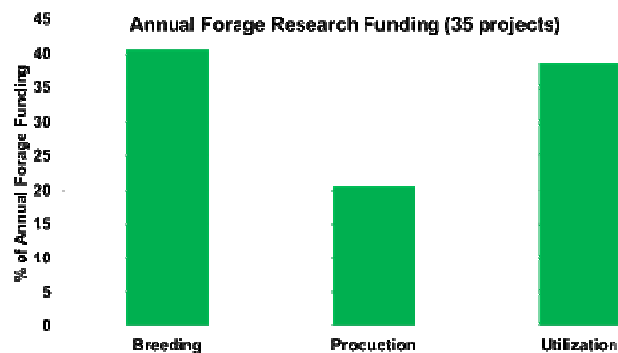
Annual forage research was split evenly between breeding and utilization research (approximately 40 per cent each); less funding was allocated towards production research. Only two projects were conducted around native forage species, with an emphasis on breeding and some focus on production work to identify pasture rejuvenation strategies and improve weed and pest control.

Native Forage Research Funding (12 projects)

A bar chart titled "Native Forage Research Funding (12 projects)". The y-axis is labeled "% of Native Forage Research Funding" ranging from 0 to 60. The bars are: Breeding (~50), Production (~37), Utilization (~11), Environment (~2).

Research around tame forages was split between breeding and production, with less focus on utilization. Breeding work was primarily focused on two species: alfalfa and sainfoin. Some work was also completed around 'environmental' measurement looking at legumes in the context of soil health, carbon sequestration, water use efficiency, and monitoring of animal methane production.

Tame Forage Research Funding (71 projects)

A bar chart titled "Tame Forage Research Funding (71 projects)". The y-axis is labeled "% of Tame Forage Funding" ranging from 0 to 35. The bars are: Breeding (~29), Production (~30), Utilization (~14), Environment (~26).
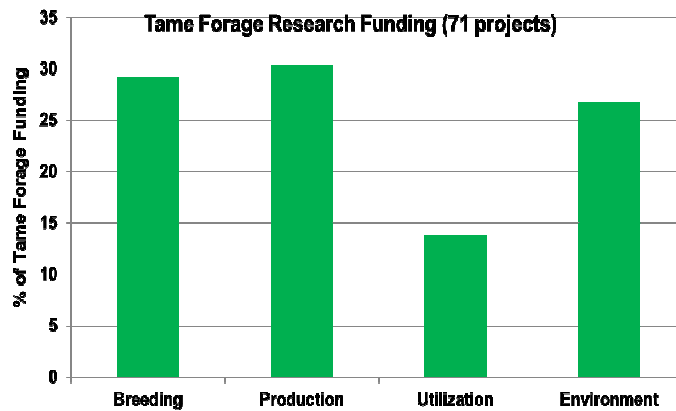
WHAT'S NEEDED TO IMPROVE FORAGE AND GRASSLAND PRODUCTIVITY

Forage and grassland productivity research has significantly declined over the past few decades and investment in this priority is necessary to ensure competiveness and that Canada is a leader in environmental management and sustainability. Raising hay yields by 33% to levels seen in the 1990s would be worth $453 million.

Forage and Grassland Productivity indicators show that hay yields have been declining over time and a larger number of acres are required to produce enough forage for the beef industry. This inefficiency means producers need a larger

land investment than U.S. competitors and more land than previously required. Increasing yield on marginal land to be internationally competitive will be important over the long run. There have been a number of new varieties developed over the years but they do not appear to have fully compensated for the move to increasingly marginal land. Variety development cannot only focus on drought resistance or stand longevity but must also improve yield. Public investment into forage varieties is necessary as the ability of companies to recoup their initial investment is low.

During the consultation for the development of this National Beef Research Strategy, stakeholders strongly identified the need for continued and reinvigorated forage and grassland productivity capacity and research to ensure that Canada fully capitalizes on its natural advantages for beef production, is improving plant yields and nutritional qualities, and is committed to environmental management and sustainability. Environmental management is a key attribute of the Canadian Beef Advantage.

Stakeholders identified improvements in yields and nutritional quality through improved pasture, forage and grazing management and plant breeding as the highest priority research outcome, with the recognition that capacity must be reinvigorated in order to deliver.

FORAGE AND GRASSLAND RESEARCH OUTCOMES

Considerable regional variability exists among soil types and climate across Canada. As a result grass, legume and annual forage varieties that thrive in one region of the country may not be optimal for another region. This means that it is necessary to maintain a basic core regional element in forage breeding research. Ensuring that new varieties developed at core breeding locations are then evaluated in a broader range of environments will help to match new varieties with the environments to which they are best suited.

Outcome 1: **33% Improvement in Yields and Nutritional Quality of tame, native and annual species through improved pasture, forage and grazing management and plant breeding**

Short Term

a. Improved grazing and management strategies that optimize hay yields and beef production from native range and tame pastures.

b. 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 quantified.

Medium – Long Term

a. 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 developed.

Outcome 2: Environmental Sustainability

Short Term

a. The "environmental footprint" (carbon sequestration, plant and animal biodiversity, endangered species, soil erosion, watershed protection, etc.) and socio-economic (environmental goods and services) impact of the forage-beef sector in Canada, including the effects of optimal environmental production practices (e.g. stocking rates, riparian area protection) on the above has been quantified.

Outcome 3: Research and Training Capacity

Short Term

a. Industry research chairs focused on tame grass and legume breeding and management/grazing established to serve Central and Eastern Canada and in the Prairies and B.C. established.

Long Term

a. Reinvigorate and enhance long-term breeding programs, while capturing near-term opportunities that are currently under development.

Outcome 4: Extension, Outreach and Policy

a. Enhanced public education regarding the impact of Canada's forage and beef industry on Canada's environment and economy.
b. Grazing Mentorship Program or other similar formal producer extension programs used to encourage pasture rejuvenation every 5 years and the

adoption of grazing-tolerant, drought resistant and bloat-safe legumes into pasture mixtures.

c. Annual and perennial varieties that have been previously developed and registered but are not commercially available are investigated, and varieties showing significant potential benefits for the beef industry are accelerated to be market ready.

d. On-farm decision making tools quantifying the return-on-investment from pasture rejuvenation, weed control, fertilization are developed.

V. Research Funding Review & Priority Coordination

The National Beef Value Chain Roundtable and Beef Cattle Research Council recognized the need to review the beef research situation in Canada and starting in 2008, initiated a process which led to the development of this National Beef Research Strategy.

As part of the process, beef research funding stakeholders were brought together for the first time to discuss opportunities to improve funding coordination and delivery of research that clearly aligns with industry's established research priorities and defined research outcomes.

This feeds into the very successful collaboration between Canada's largest public (AAFC) and industry (BCRC and ABP) funders to develop the Beef Cattle Industry Science Cluster which has proven to be a good model on applied beef research. It has resulted in significant steps toward re-building some capacity, and brought focus to achieving outcomes of high priority to the beef industry.

Funders unanimously agree the Canadian beef industry is in need of a national framework for coordinating beef research that builds on and coordinates the efforts currently underway across the country. The ideal would consist of all beef research funders supporting complementary research outcomes that enhance the profitability of the Canadian beef industry and expand demand for Canadian beef in both domestic and export markets.

Initial next steps include the following and will be more fully defined as the process moves forward.

ENGAGEMENT OF VESTED RESEARCH FUNDERS

1. Present the National Beef Research Strategy to beef research funding stakeholders and obtain further feedback on collaboration process and their involvement (through one-on-one meetings with key contacts, followed by presentations to their respective boards and/or management groups)
    o Review the objectives and established research outcomes defined under the National Beef Research Strategy

       o   Consider roles of various funding agencies and research organizations in delivering on established research outcomes based on their resources, infrastructures, and priorities

2. Gain commitment of individual funding and research agencies to the overall and/or components of the strategy

3. Further define funding coordination process and opportunities to improve coordination of funding and reporting functions

4. Provide the National Research Inventory and engage funding stakeholders to inform funding strategies

5. Convene an annual forum of beef research funding stakeholders to review progress against defined research outcomes and identify areas of focus moving forward

NATIONAL RESEARCH INVENTORY AND LIAISON

Beef research funding stakeholders have agreed that the BCRC would be the most appropriate entity to develop and maintain a national beef research inventory.

Objectives:

1. Coordinating funding processes and improving funder collaboration

2. Monitoring and informing funding strategies

3. Monitoring progress to inform future national priority setting processes

Strategy:

1. Engage funding stakeholders to define more detailed objectives and deliverables

2. Review existing systems that could be adopted, adapted or build upon

3. Define a plan for the implementation of a National Beef Research Inventory and review with funding stakeholders

4. Finalize system attributes and components

5. Coordinate funding and implementation of a National Beef Research Inventory

Timeline: An estimated time to implementation is Summer 2013

VI. Appendix

BEEF INDUSTRY CORE RESEARCH OBJECTIVES

1. To *enhance industry sustainability and reduce production costs*, priority outcomes are to enhance feed and forage production, quantify the environmental impact of Canada's beef industry, increase feed efficiency, decrease the impact of animal health issues and production limiting diseases, and ensure animal care.

2. To *improve beef demand and quality*, 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.

OVERARCHING AIMS FOR RESEARCH PRIORITY AREAS

- Improved communication, collaboration and understanding between researchers and industry, with research/industry collaborations increasing to account for 25% of research activities.
- Established internship program to mentor new scientists with industry collaborators; having 10 scientists complete the program by 2016.
- Cost-benefit analysis completed to support recommendations and knowledge transfer from research projects that impact production profitability.
- Encouragement of interdisciplinary teams undertaking systems-based approaches integrating the entire value chain where appropriate.

TARGET OUTCOMES

Beef Quality	
Outcome 1: Improved Consumer Satisfaction with Canadian Beef	
2016	a. Effectiveness and value of genetic markers for tenderness validated in commercial cattle. b. Electrical stimulation recommendations re-evaluated to reflect increased carcass weights. c. Objective in-plant measures of tenderness that can be used at line speed validated.
2018	a. National Beef Quality Audit (consumer satisfaction) demonstrating that 65% of inside round, 80% of cross-rib, 90% of top sirloin and 99% of strip-loin steaks are sufficiently tender that no tenderness enhancement is necessary. b. Potential interactions between tenderness genotype and animal management (e.g. implants, backgrounding, grassing, finishing, etc.) identified and appropriate breeding and management recommendations developed.
2023	a. Data collected to inform consumer messaging regarding the relevant nutritional characteristics of beef, including protein, mineral, vitamin, and lipid components.
Outcome 2: **Validation of the Canadian Beef Advantage Relative to International Competitors**	

2016	a.	Packaging and other technologies to improve shelf life and appearance for export developed.
	b.	Canada's beef carcass quality and yield benchmarked relative to international competitors.
	c.	Beef InfoXchange System data integrated with research analysis in order to monitor changes in industry practices and identify emerging issues.
2018	a.	Improved algorithms for prediction of lean meat yield and / or retail product percentage.
	b.	Genomic and grading technologies that allow for market segmentation according to carcass quality and/or yield implemented.
	c.	Beef Quality Audit enhanced through development and implementation of processes that facilitate the automated collection, recording and evaluation of carcass quality parameters.
	d.	Beef Quality Audit demonstrating a reduction in carcass defects below 2012 levels.
2023	a.	Data collected through the Beef InfoXchange System analyzed to benchmark Canada Beef Advantage attributes, refine research priorities, and identify improvement opportunities.

Outcome 3: Extension, Outreach and Policy

| 2016 | a. | Complete a systematic literature review on the nutritional attributes of beef to address consumer concerns, inform consumer education programs, and identify appropriate research directions and applications. |
| | b. | Enhanced consumer education regarding their role and responsibility in ensuring beef quality through selection of appropriate cut-specific preparation and cooking methods. |

Food Safety

Outcome 1: Improved Food Safety along the Beef Supply Chain

2016	a.	Technologies targeting multiple pathogens in cattle and beef production and processing facilities developed and implemented.
2018	a.	Objective approaches for verifying effectiveness of packing plant equipment cleaning processes developed and adopted for 85% of processed cattle.
	b.	Increased surveillance to detect, characterize and quantify the relative human health risk of (re)emerging pathogens.
	c.	Effective probiotic intervention to eliminate pathogens from beef developed.

Outcome 2: Responsible Antimicrobial Use Demonstrated

2016	a.	On-farm data collection and food safety pathogen incidence incorporated into the Canadian Integrated Program for Antimicrobial Resistance Surveillance for beef cattle.
	b.	Microbial genome sequencing used to investigate potential associations between pathogen incidence and antimicrobial use in cattle and the presence of pathogens and development of antimicrobial resistance in microbes found in retail beef and human clinical cases.
2018	a.	Statistics collected through the Canadian Integrated Program for Antimicrobial Resistance Surveillance (surveillance) demonstrate that:
		▪ generic *E. coli* samples collected from abattoir samples demonstrate 0% resistance to five or more antimicrobials and 0% resistance to antimicrobials of very high importance in human health, and
		▪ generic *E. coli* samples collected from retail beef demonstrate less than 2% resistance to five or more antimicrobials, and less than 1% resistance to antimicrobials of very high importance in human health.

Outcome 3: Improved Beef Quality and Food Safety Research and Training Capacity

| 2016 | a. | An industry meat science research chair to address issues facing the beef packing |

	and processing sectors, and reinvigorate food safety research program capacity established.
2023	a. A meat science program is established at a Canadian university with educational and research components to produce highly qualified personnel serving Canada's beef industry.

Outcome 4: **Extension, Outreach and Policy**
2016	a. Enhanced processor education to encourage the consistent adoption of known best practices to minimize the risk of pathogen contamination in beef processing plants. b. Enhanced further processor education to encourage the consistent adoption of proper and thorough cleaning of processing and grinding equipment. c. Enhanced 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. d. Research results used to inform the regulatory approval of trim and ground beef irradiation.

Animal Health and Welfare

Outcome 1: **Improved Surveillance of Production Limiting Disease and Welfare Issues**
2016	a. Improved diagnostic tests for production limiting diseases. b. Nation-wide benchmarking survey of the incidence and economic impact of production limiting diseases, health management, biosecurity practices, and welfare practices in beef cattle (cow-calf, backgrounding and feedlot) conducted.
2018	a. National production limiting disease surveillance program developed, identifying opportunities to collaborate with wildlife disease surveillance programs.
2023	a. National surveillance system in place to monitor the incidence of and etiology of re- and emerging production limiting diseases.

Outcome 2: **Improved Understanding and Management of Pain and Stress in Beef Cattle**
2016	a. Practical, cost-effective methods of objectively quantifying and mitigating pain and stress in beef cattle under production conditions developed (e.g. diet, castration, dehorning, branding, weaning, transport).
2018	a. Benchmarks to understand the additive effects of beef production practices on pain, stress, immunity and health developed. b. Scientifically valid beef cattle welfare audit program developed.

Outcome 3: **Improved Prevention of Animal Disease and Welfare Issues**
2016	a. Strategies to optimize or improve the effectiveness of existing vaccination programs identified and developed. b. Reduced incidence of reproductive failure through improved nutritional management, diagnostic tests, vaccination and biosecurity. c. Reduced neonatal loss through improved maternal nutrition, timing of vaccinations, and extension / technology transfer to cow/calf sector. d. Modifications to current beef production practices that reduce the need for antimicrobials to prevent or treat respiratory disease in the feedlot identified or developed (e.g. vaccination, weaning, transport and diet). e. Improved control of internal and external parasites.
2018	a. Practical modifications to high energy feeding programs that reduce the incidence of metabolic diseases in feedlot cattle identified or developed (e.g. acidosis, bloat, acute interstitial pneumonia). b. Improved immune system function, vaccine efficacy and animal health management to reduce the need for Health Canada Category I and II antimicrobial drugs by 50%.
2023	a. Reduced incidence of metabolic diseases in beef feedlots without increased use of antimicrobials.

	b.	Implementation of improved animal management systems in the industry which will reduce stress and improve animal health and productivity.

Feed Grains and Feed Efficiency

Outcome 1: Improved feed efficiency through animal breeding

2016	a.	Cost-effectiveness of genetic markers for feed efficiency validated in commercial feedlot cattle.
2018	a.	Impacts of genetic selection for feed efficiency on other economically relevant beef production traits (longevity, fertility, weaning weight, wintering costs, carcass weight, yield and quality grades, tenderness, etc.) quantified.
	b.	Potential interactions between feed efficiency genotype and management (e.g. implants, backgrounding, grassing, finishing, etc.) identified and appropriate breeding and management recommendations developed.
2023	a.	Relative contributions of various animal digestive and metabolic processes and rumen microbes to feed efficiency quantified.

Outcome 2: Improved feed supply and utilization

2016	a.	The cost:effectiveness of alternative / by-product energy feeds, considering impacts on animal performance, health, product quality, and nutrient management have been identified, evaluated and determined.
	b.	Corn and cereal forage variety differences in nutrient profile and ensiling potential characterized.
	c.	Feeding and production systems that improve feed efficiency by 15% developed.
2018	a.	Agronomic strategies to increase feed grain energy yield per acre identified.
2023	a.	New feed grain varieties developed with improved feed grain energy yield per acre.

Outcome 3: Improved management of manure nutrients

2018	a.	Nutrient management decision tools that incorporate diet nutrient composition, manure handling and transport costs, value of manure nutrients and organic matter, manure management systems (e.g. raw vs. stockpiled vs. composted) soil types, and nutrient uptake by crops developed.

Outcome 4: Research Training and Capacity

	a.	Key feed efficiency research capacity (expertise and facilities) is maintained
	b.	Feed grain breeding research capacity (expertise) is reinvigorated.

Forage and Grassland Productivity

Outcome 1: 33% Improvement in Yields and Nutritional Quality of tame

2016	a.	Improved grazing and management strategies that optimize hay yields and beef production from native range and tame pastures.
	b.	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 quantified.
2018–2023	a.	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 developed.

Outcome 2: Environmental Sustainability

2016	a.	The "environmental footprint" (carbon sequestration, plant and animal biodiversity, endangered species, soil erosion, watershed protection, etc.) and socio-economic (environmental goods and services) impact of the forage-beef sector in Canada, including the effects of optimal environmental production practices (e.g. stocking rates, riparian area protection) on the above has been quantified.

Outcome 3: Research and Training Capacity

2016	a.	Industry research chairs focused on tame grass and legume breeding and

		management/grazing established to serve Central and Eastern Canada and in the Prairies and B.C. established.
2023	a.	Reinvigorate and enhance long-term breeding programs, while capturing near-term opportunities that are currently under development.
Outcome 4: Extension, Outreach and Policy		
	a.	Enhanced public education regarding the impact of Canada's forage and beef industry on Canada's environment and economy.
	b.	Grazing Mentorship Program or other similar formal producer extension programs used to encourage pasture rejuvenation every 5 years and the adoption of grazing-tolerant, drought resistant and bloat-safe legumes into pasture mixtures.
	c.	Annual and perennial varieties that have been previously developed and registered but are not commercially available are investigated, and varieties showing significant potential benefits for the beef industry are accelerated to be market ready.
	d.	On-farm decision making tools quantifying the return-on-investment from pasture rejuvenation, weed control, fertilization are developed.

Beef Research Funding Stakeholders

Industry

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

Agriculture and Agri-Food Canada

Canadian Agriculture Adaptation Programs:

- National Program
- Provincial CAAP Programs (PE, NS, NB, ON, MB, SK, AB and BC)

Provincial Governments:

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