Abstract
The Canadian livestock industry is a large and complex industry contributing between $49 billion and $51 billion to the gross domestic product (GDP) each year.\(^1\) It produces high-quality, safe animal protein to supply the Canadian and export markets. There are many market forces, environmental challenges and societal trends which will demand that the Canadian livestock sector be more efficient producing the same or even more meat and milk with fewer inputs. Canada does not have a coordinated national livestock feeds research strategy that involves buy-in and support from the complete livestock feeds value chain and government. Such a research strategy would determine the research programs and ensure feed research addresses the challenges and trends associated with maintaining a supply of high quality animal protein for Canadians. Canada has a clear role in helping meet the rising global demand for animal protein, while being environmentally and socially responsible with resources and mitigating risks in the marketplace. The national feeds research strategy will be developed and led by the Livestock Research Innovation Corporation (LRIC) with support from a panel of experts from across Canada representing academia, the livestock feed industry, livestock producers and government.

LRIC will work with the provincial and federal governments to secure funding from Growing Forward 3 (vote 1 and 10) and will develop industry partnerships to support the development and delivery of a multi-year national livestock feeds research strategy.

Background Information
The Livestock Feeds Industry
The Canadian livestock feeds industry is an important part of the livestock sector. Total feed production in Canada is just over 30 million tonnes with 10 million tonnes being produced on-farm and 20 million through commercial production. The commercial industry generates total revenue of just over $4 billion annually. There are approximately 500 commercial feed mills in Canada. Corn, wheat and barley are the most widely used feed grains. Canola and soybeans are the major sources of protein\(^2\). Across Canada, feed rations differ based on what is produced in the area, with Western Canada relying on wheat, barley and canola and Eastern Canada using corn and soybeans. Worldwide, commercial feed production is approaching 1 billion tonnes annually. Global commercial feed manufacturing generates an annual estimated turnover of $370 billion (US$). Commercial feed production occurs in more than 130 countries and directly employs more than a quarter million people in skilled positions worldwide\(^3\).

---

\(^1\) Statistics Canada annual reports 2011 and 2012.
\(^3\) International Feed Industry Federation - http://www.ifif.org/pages/t/The+global+feed+industry
**Increasing Demand for Protein Globally**

The United Nations (UN) estimates the world population will be 9.6 billion people by 2050\(^4\). This is an increase of 2.4 billion people from the current population. Most of this growth will take place in developing regions including the African nations, India, Pakistan and Indonesia. Along with more mouths to feed, the rise in gross domestic product (GDP) impacts the type of food people choose to eat. In an article published in PNAS (Proceedings of the National Academy of Science USA), David Tilman et al, illustrates that rising per capita GDP is strongly correlated to the per capita demand for crop calories and/or crop and animal protein. When applying the projected rates of GDP with the UN population estimates for 2050, Tilman forecasts that global demand for crop calories would increase by 100% ± 11%, whereas demand for crop protein will increase by 110% ± 7% (mean ± SE) from 2005 to 2050.\(^5\)

The rising population coupled with the rising GDP over the next 35 years will result in a much greater demand for meat, dairy, eggs and the raw materials required to produce them.

**Land, Water and Environmental Pressures**

Demand for animal protein is increasing but land and water availability is not. Livestock producers around the world will be pressured to increase production through sustainable intensification; which means they will have to produce more livestock on the same amount of land using a similar amount of resources\(^6\). One of the major challenges of sustainable intensification is protecting the environment. Feed research in the future will need to consider how to reduce the volume of water required for meat production and how greater numbers of animals can be raised on the same amount of agricultural land. Efforts will be needed to reduce the amount of greenhouse gas emissions while managing excess nutrients and mitigating the market risks associated with severe weather events caused by climate change.

**Competing for Traditional Feed Stuffs**

Significant advances have been made in product development and developing new markets for traditional feed crops. In 2011, 39.6% of corn grown in the United States was used in ethanol production (of that, 12.2% was returned to the feed industry as distillers grain).\(^7\) Canada exports approximately 600,000 tonnes of forage annually valued at $150 million, primarily to United States and Asia, with emerging markets in the Middle East and Mexico.\(^8\) These new markets while beneficial to the feed crop producers, impact the availability and price of feed crops for the Canadian livestock producer.

---


\(^6\) Tim McAllister presentation – Alternative Feeds Symposium, February 2014.

\(^7\) Ethanol Producer Magazine citing 2012 World of Corn by the National Corn Growers Association http://www.ethanolproducer.com/articles/8611/world-of-corn-report-breaks-down-corn-used-for-ethanol-ddgs

\(^8\) Canadian Forage and Grasslands Association home page http://www.canadianfga.ca
Societal Trends
Consumers and large food retailers (e.g. Walmart, Loblaws and McDonalds) drive trends in the food industry with regard to how and what food is produced as well as how it is packaged, displayed and plated. Food safety, food quality, traceability, antibiotic use, organic, dieting trends, animal welfare and the local food movement are all societal trends that the livestock industry needs to monitor to ensure it is producing a product that is desired by the marketplace. What and how the livestock sector feeds their animals in the future will matter to consumers and the retail and food service sector that interfaces with them.

A National Livestock Feeds Research Strategy
In the past, the agriculture industry was simpler and much more regionally focused. Livestock farmers would have grown some or all of their own feed ingredients. Societal trends didn’t play the role they do today. Markets were more regional and less global. Research was more regionally focused as well.

Today, there are complex market forces, societal trends and environmental issues to balance with producing livestock. If Canada wants to contribute to the opportunity of helping meet the world’s rising protein demands over the next 35 years, feed research must improve the bottom line for livestock producers so they can produce more with less. There has to be advantage found through nutritional science research and improvement in feed crop yields and/or quality. Feed processing and nutritional improvements will also be key to improving quality. Cost benefits discovered in alternative systems, co-products and alternative products will also play a significant role in industry profitability. Research must be coordinated to ensure that all of the important research areas are being investigated and shared across the industry.

Canada has had success with research clusters in bringing together multidisciplinary teams of scientists to solve complex problems and to create synergies in research efforts. The cluster approach helps make the most of available resources. Brazil has used a similar approach to increase their livestock production. Brazil used to be a food importer but is now the largest exporter of beef, poultry and sugarcane. They have been very calculated in the way they have expanded their agriculture industry by developing a network of research centres across the country with a focus on gaining expertise and then passing that expertise and knowledge onto farmers through extension programs. They have increased their production through sustainable intensification methods including triple-cropping and agroforestry while adhering to their forest code developed to protect the sensitive amazon basin environment.

If Canada is to emulate the Brazilian experience for the livestock sector it will need to develop a coordinated national research strategy for livestock feeds. The

---

http://www.cp-rc.ca/news.php#Growing_Foward
development and delivery of this research strategy needs contributions and support from academia (intellectual), the feed industry, livestock producers, crop producers and government. An expert panel representing each of these areas has been formed by LRIC. The role of the expert panel is to determine the important areas of feed research required to ensure research programs are designed that will lead to triple bottom line outcomes including increases in profitability, business sustainability, nutritional efficiency and food safety while satisfying environmental and societal expectations.

There are significant challenges in the livestock feed value chain that need to be well understood and considered when developing research programs. The expert panel has identified several of these challenges, which will be discussed in the following section.

**Challenges to the Livestock Feeds Sector**

**Understanding Market Forces**
The price of farmland continues to climb in Canada, which leads to increased commodity prices. At what prices does feeding corn to livestock no longer make sense? When other countries can produce the same products as Canada and ship them around the world to be placed on our supermarket shelves for less than we can produce the products locally, do we continue to produce them? How will the price of input commodities today, affect the price of energy and protein we can produce in future years? The answers to these economic questions will help guide the direction of the scientific research to ensure the research leads to increased profitability for the livestock sector.

The rise of the bio-fuels industry has created an economic challenge to the livestock industry. Approximately 40% of US corn is sold to the ethanol industry. This new and very large market has contributed to an increased price of corn. There is a direct link between higher corn prices and food costs because higher corn prices translate directly into higher feed costs, which eventually translate into higher prices for meat, eggs and dairy products\(^{11}\). Rising feed costs and availability of feed inputs is a significant risk to the livestock industry.

**Climate Change and Water Availability**
Demand for animal protein is increasing but land and water availability are not. Globally, there is very little land available to be converted into agricultural land. Livestock producers around the world will be pressured to increase production through sustainable intensification; which means they will have to produce more livestock on the same amount of land using a similar amount of resources\(^{12}\).

---

\(^{11}\) CARD Policy Brief 11-PB5 Iowa State University, 2011 http://www.card.iastate.edu/policy_briefs/display.aspx?id=1155

\(^{12}\) Tim McAllister presentation – Alternative Feeds Symposium, February 2014.
It takes a large amount of water to produce a pound of meat protein, with beef protein requiring the most water in the livestock sector. Water is used at all points of the meat industry from growing the feed to processing the animal. Although Canada is fortunate to have significant fresh water resources, it is critical that we don’t abuse our ecosystems through over-use or pollution of this asset. The broader community is already starting to take an interest in the water used to produce food. This is being reflected in the major supermarket brands across the globe looking at the water use efficiency of the products they sell.

Scientific studies indicate that extreme weather events such as heat waves and large storms are likely to become more frequent or more intense with human-induced climate change\textsuperscript{13}. Droughts, high winds and cool wet growing seasons cause significant challenges to livestock producers as feed prices increase due to lack of supply. The 2012 drought significantly reduced pasture yields in Ontario and led to record high corn and soybean prices. Although rising feed prices can eventually translate into higher meat prices, it doesn’t happen immediately. In the short term, livestock farmers have few choices but to pay more to feed their animals and accept the loss.

Greenhouse gas emissions from livestock production (especially ruminants) will come under increasing scrutiny as livestock operations intensify and there will be more pressure placed on natural systems to dispose of animal waste. Nutrient management and manipulation through feed will be key in protecting water sources and improving soil and air quality.

**Understanding Societal Trends Driven by Consumers and the Food Industry**

When considering research projects for livestock feed it will be very important to consider them in concert with societal trends. Current trends include: food safety, food quality, traceability, antibiotic and hormone use in livestock, animal welfare and diet trends such as the organic and local food movements.

**Food Safety**

There have been numerous cases around the world of food safety disasters. In China in 2008, melamine was added to milk to increase its protein content, which was then used in the production of baby formula. Sadly the result was an estimated 54,000 babies being hospitalized and six dying from kidney stones and other kidney damage\textsuperscript{14}. The food safety issue damaged China’s reputation leading several nations to ban imports of Chinese dairy products. Canada has had its own challenges with food safety. In 2003, BSE was discovered in an eight-year old cow. The BSE cow never entered the human food chain and yet Canada’s beef industry was decimated over this food safety issue. Borders were closed and imports of Canadian beef

\textsuperscript{13} Environmental Protection Agency - http://www.epa.gov/climate/climatechange/science/indicators/weather-climate/index.html

stopped by countries all over the world. Cattle prices dropped at one Alberta auction from $1.20/lb to $0.32/lb before most cattle were taken off the market\textsuperscript{15}.

**Food Quality**

Food quality in this context refers to nutritional aspects and shelf life, as well as organoleptic parameters of appearance, texture and smell. These attributes are important to all buyers at all levels including food importers, retail food service buyers and of course end consumers.

New methods of producing feed and new or manipulated ingredients in alternative feeds requires research to understand how the quality of the end product will be affected by such new ingredients. For example feeding laying hens flax to increase Omega 3 in eggs is an excellent example of alternative feeds leading to increased value in the marketplace without impacting organoleptic qualities. Similar Omega 3 results can be obtained using fish oil but also can lead to off odours and flavours.

**Traceability**

Traceability is a growing trend stemming from a number of factors including food safety and food quality. Understanding the complete supply chain can benefit an industry during times of crisis. In a food safety recall or disease outbreak, knowing where inputs come from is vitally important. This means that the industry must be cognizant of the fact that origin is important for more than consumer satisfaction. Having said that, traceability can also be used in marketing strategies as part of the product’s story on food safety, food quality and local foods.

**Antibiotic and Hormone Use in Livestock**

There is growing concern by consumers and the scientific community regarding the in-feed use of antibiotics in the livestock industry. The use of antimicrobial compounds in food animal production provides demonstrated benefits, including improved animal health, higher production and, in some cases, reduction in foodborne pathogens. However, use of antibiotics for agricultural purposes, particularly for growth enhancement, has come under increasing scrutiny, as it risks contributing to an increase in the prevalence of antibiotic-resistant bacteria of human significance\textsuperscript{16}.

Growth hormones have been approved by the Canadian Food Inspection Agency (CFIA) and fed to beef cattle for over forty years in Canada. This is a prevalent practice in several large beef producing nations in the world, yet there are opponents to this practice. The A&W burger chain recently started an advertising campaign stating their hamburgers are made using beef from cattle that did not receive antibiotics or added hormones. Future feed research must be cognizant of any trending opposition to both antibiotic use and/or hormone use in livestock.


feeds. Regardless of whether negative statements are true or false, the industry needs to have an accurate and easily understood message to give. Replacing these tools will also mean changes to production systems and potentially profitability and sustainability.

Animal Welfare
With the continued trend of the global population becoming more urbanized, people are more removed from agriculture than ever before. Consumers simply don't know where their food comes from and this leads to questions, particularly in ‘wealthy’ communities. All agricultural research needs to consider animal welfare, its real and perceived concerns. As well, feed research opportunities that could potentially improve animal health, for example, feeding animals pre/probiotics or medicinal herbs could translate into good news stories for the sector. The complete livestock feeds industry must be prepared to provide credible answers and engage in meaningful conversation about livestock feeds, feeding methods, and the welfare of the animal. Research will play a key role in the accomplishment of these objectives.

Diet Trends, Organic Foods and the Local Food Movement
Understanding healthy eating has never been more complex. Consumers are barraged with information about food, health and the environment by the media, entertainment industry, food companies, government and the healthcare system. The average family shops for only 300 different items in a grocery store annually yet many supermarkets have upwards of 45,000 stock keeping units\(^\text{17}\). The information overload and the tremendous amount of food choices make it easy for consumers to “go” organic, gluten free, high protein/low carb etc. choices which continue to drive market trends. Feed research needs to understand the current food trends and anticipate future trends to capitalize in the marketplace.

Legislation and Regulatory Challenges
The CFIA is responsible for administering and enforcing numerous acts and regulations including the Feeds Act and Feeds Regulations, 1983. It is important when researching alternative feeds, feeding systems and feed processing methods that any legislation or regulations that could impact the feasibility of the new feeds are considered. The process of changing acts and regulations can be a slow-to-impossible feat; therefore regulatory impacts/requirements need to be considered at the outset of research. The CFIA is currently working toward simplifying and consolidating its regulations, streamlining processes and providing a single-window access to services. The generation of sound science and better technology supported by research will be the key to achieving these improved regulatory efficiencies\(^\text{18}\).

Timely Technology Transfer and Extension
The final consideration in determining research projects for livestock feed is how to move the science to the producer. Currently, the seed and feed industry play a

\(^{17}\) http://www.canadiangrocer.com/research/eight-ways-consumers-shop-your-store-7284

\(^{18}\) Dr. Bruce Archibald, Update on CFIA Priorities, December 2013 http://inspection.gc.ca/about-the-cfia/accountability/consultations/consultative-groups/consumer-association-roundtable/december-2013/eng/1403277212771/1403277213974#
critical role in extension and this should continue. Because feed is used every day and feed reps are a constant on many farms, utilizing this network to drive research uptake should be straightforward. However, where a new feed innovation will necessitate farming system changes there will be lag time to adoption. Consequently, during the design phase of the research program, a concerted effort must be made to include knowledge translation and transfer, behavioural change and adoption methods as an integral element of the program.

**Research Areas to Explore in the National Livestock Feeds Research Strategy**

The ultimate goal of the research will be to provide nutritional solutions that optimize animal health and maximize the efficiency of livestock production. There are six areas to explore in feed research as determined by the expert panel. Projects falling into these areas would take into consideration sustainable intensification to meet rising demands for protein, understanding market forces and societal trends, protecting our environment and being cognizant of Canada’s regulatory framework and any extension needs.

Please note: potential research projects discussed in this white paper are examples to generate discussion only. The expert panel will work together to determine the actual research programs as the national livestock research strategy is developed.

1. **Animal Science and Nutrition**

What is the best diet formulation? It is a delicate balance between the cost of feed and the productivity of the animal. The animal’s job is to convert low quality ingredients that humans cannot utilize into high quality, safe animal protein\(^{19}\).

The livestock industry needs more research completed on improved nutritional profiling of the many feed ingredients that have been developed through fractionation and co-products. Understanding precisely, the animal’s ability to use the nutrients they are fed is key. Wasted nutrients that are excreted from the animal create additional costs and environmental challenges to producers. The industry also needs to develop a greater understanding of the connections between animal uptake of additives, vaccines, nutraceuticals, probiotics, energy, etc., and positive health status. Research in this area must include the economic benefit of differing diets.

Canola is a good example of a high quality protein that we grow in Canada but much of it is exported around the world. Should we be adding more canola or canola fractions to livestock rations? Will it provide a better return on investment for the livestock producer and the canola grower?

The livestock industry also needs more research completed and published on methods to avoid the negative environmental aspects of raising livestock, specifically, reducing greenhouse gas emissions and managing animal waste safely.

---

\(^{19}\) Dr. Tom Scott, Alternative Feed Symposium presentation, February 2014.
in Canadian conditions. For sustainable intensification to occur in the livestock industry, there will need to be research in this area.

2. Feed Processing Improvements
Depending on the species, feeding animals accounts for up to 75% of the cost of raising livestock\(^\text{20}\). Finding savings in feed costs should be an opportunity for producers to improve their profitability and for the livestock industry to grow. There is opportunity for research to physically improve the product we are feeding to livestock for greater feed efficiencies and business efficiencies. Pellet quality, separating feed grade seeds from food grade and the use of NIR in-line technology to better understand nutritional quality in feed inputs and balance the nutrients required in the animal’s diet are examples of technologies that will potentially increase efficiencies if these objectives can be advanced through research.

Ninety percent of broilers are fed a pelleted diet globally. Pellet quality significantly affects feed intakes, nutrient availability, digestibility and nutrient retention, food safety and ultimately producer satisfaction\(^\text{21}\). There is more science needed in the ‘art’ of pellet manufacturing to elucidate production gains and economic savings.

Typically a very small percentage (usually 2-3% but up to 15%) of grains in a batch cause a load to be downgraded. If wheat could be separated into three fractions, there would be significant savings in feed costs. Using additional technology, the fractioned wheat could be mixed into a more precise ration resulting in improved animal production efficiencies.

Research that develops more precise rations can also lead to a greater understanding of the bioavailability of nutrients to the animal, how these systems work and ultimately better diet formulations for greater feed efficiencies.

3. Agronomy
Improvements to yield per acre and quality will help meet the rising demand for livestock feeds without using additional land resources. Universities, government researchers, seed companies and crop protection companies have provided significant productivity improvements through grains and oilseed research. Corn, soybean and canola yields continue to climb decade-over-decade. There is however less research in forages in as it is more complex and significantly less profitable. That being said, harvesting, storage and feeding losses can often outweigh any yield advantage gained with new forage varieties\(^\text{22}\).

Canada can benefit significantly from a national forage research program that exploits regional advantages. More work on the plant science of forages, alternative systems in cutting, storing and feeding forages and animal science research on feeding forages is required. Forage agronomy research could include:

\(^\text{21}\) Dr. Tom Scott, Alternative Feed Symposium presentation, February 2014.
\(^\text{22}\) Duane McCarthey, Alternative Feeds Symposium presentation, February 2014.
• Studying the agronomic influences of forage nutrient quality and yield in harvested forages and pastures – weed control, disease, insect pests, fertility, and establishment.
• Determining how differing management practices affect the quality of different varieties – manure application, intensive cutting schedules. Forage variety performance trials.
• Fertility management – influence of nitrogen, phosphorus, potassium and other nutrients.
• Studying the impact of climate change on forage species23.

4. Alternative Systems
There are a number of opportunities for improving the way we feed livestock. It may not always be bold new changes, but simply a new way of doing things, or even returning to an old way of doing things. Research is needed to study the affects of changing feeding systems to ensure productivity for the animal and profitability for the producer. In some cases, the research is complete and extension is the missing element. According to forage expert, Duane McCarthey, there are forage research opportunities in:
• Double-cropping with annual cereals to allow for grazing in the fall and early winter.
• Using spring seeded annual cereals for improved summer and fall grazing.
• Winter swath grazing and bale grazing in the snow.
• Grazing on harvested cornfields.

Studied regionally but as part of a national program, research into such topics as those described above should lead to the development of regionally specific ‘best’ forages. This would provide livestock producers with appropriate product and advice developed with specific context, geographic region and climate in mind that best suits their farming system.

5. Co-Products
The price of traditional feed sources (corn, soybeans and wheat) has increased dramatically over the last decade mainly due to the biofuel industry. Many industries use only portions of raw materials or produce by-products not needed in the primary industry. This is a large opportunity for the livestock industry to use more co-products as feed sources to reduce feed costs.

As well, there is a societal benefit in recycling back into to the primary industry as a functional product for the livestock industry, what would have been considered waste. Examples of co-products include dried distiller’s grains and solubles (DDGS), crude glycerol, oilseed meal, sugar beet pulp and food waste from each part of the food value chain.

More research is needed into the conversion of co-products into safe, good quality (see definition earlier), highly stable meals to use as feed ingredients. Co-product development must include nutrient profiling to determine the nutrient value and how it is metabolized in the animal. Concomitant research to determine how different livestock converts the new products into high value protein will be needed. Attention to food safety and Canada’s regulatory framework is essential when utilizing co-products.

6. Alternative Products

There may be many however, one that is gaining traction in Europe and North America is insects. Insects are eaten in many parts of the world. They are a good protein source (comparable to beef) and they are richer in iron, which is important as 1 billion of the world’s population is anemic and 2 billion are iron deficient. Insects convert food into protein much more efficiently than livestock and they produce 100 times less greenhouse gases than conventional livestock. Insects take less land to grow compared to conventional feedstuffs. The case for insect development is strong however, currently the price of producing insects is high, but efficiencies could be found through mechanization. Insects have been successfully mixed into the rations for poultry, pigs and aquaculture.

Despite the fact that humans can purchase and consume insects in many jurisdictions, there are significant regulatory hurdles to overcome in many countries. For example currently in the European Union animals cannot be fed to animals. This legislation was developed after the BSE crisis in 1996 before feeding insects was considered. (Insects are considered to be animals.)

There is also a significant societal hurdle to be overcome before the average North American consumer will consider insects as food, but more importantly as protein in livestock rations. Having taken this into account the major growth in meat demand over the next 35 years will occur in developing nations that already eat insects as a regular part of their diet.24

Feeding insects to livestock is used in this paper simply as one example of how the livestock sectors need to look beyond traditional sources of protein, as well as energy if they are to remain profitable and sustainable and become a major contributor to the world’s protein market.

Conclusion

Canada is well positioned to contribute to the rising global demand for animal protein. It is important that our contributions are made through sustainable intensification. A national livestock feeds research strategy needs to be developed and delivered to forward the capability of the livestock industry in producing more high quality animal protein in a sustainable manner. The Livestock Research

---

Innovation Corporation (LRIC) working with an expert panel has the oversight capacity to develop and guide a research strategy that will deliver research results that are profitable, efficient, safe, nutritious, equitable and green. LRIC will look to Growing Forward 3 and industry partnerships for funding to deliver on this objective.

Livestock Research Innovation Corporation would like to thank those people who contributed to this document.

Shabtai Bittman
Dominique Bureau
Kees de Lange
Ruurd Zijlstra
Ron Lackey
Ming Fan
Paul Uys
Paul Luimes
Duane McCartney
Alfons Weersink
Bill Revington
Jack Kyle
Joe Hill
Tim McAllister