
NATIONAL BEEF SUSTAINABILITY ASSESSMENT AND STRATEGY

SUMMARY REPORT





THE GO-TO FORUM ON SUSTAINABLE BEEF **IN CANADA**

CANADIAN ROUNDTABLE FOR SUSTAINABLE BEEF

180-6815 8th Street NE

Calgary, AB T2E 7H7

www.crsb.ca Twitter: @CRSB_beef

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Note: The National Beef Sustainability Assessment is not intended to compare or rank beef production practices or systems. Rather, its sole intention is to provide a benchmark of the social, economic and environmental performance of the Canadian beef industry, and should be considered in its entirety.



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ABOUT THE CRSB

The CRSB is a multi-stakeholder organization focused on advancing sustainability efforts within the Canadian beef industry.

Mission

Facilitate the framework for the Canadian beef industry to be a global leader in the continuous improvement and sustainability of the beef value chain through science, multi-stakeholder engagement, communication and collaboration.

The 5 Principles of Sustainable Beef



Natural
Resources



Animal Health
& Welfare



People & the
Community



Food



Efficiency &
Innovation



Acronyms and Units

Acronyms

AAFC	Agriculture and Agri-Food Canada
E-LCA	Environmental Life Cycle Assessment
FAO	Food and Agriculture Organization of the United Nations
ISO	International Organization for Standardization
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LEAP	Livestock Environmental Assessment and Performance
NBSA	National Beef Sustainability Assessment
SETAC	Society of Environmental Toxicology and Chemistry
S-LCA	Social Life Cycle Assessment
UNEP	United Nations Environment Programme

Units

CH₄	methane
ckg	one hundred kilograms
CO₂	carbon dioxide
cwt	one hundred pounds
eq.	equivalent
g	gram
kg	kilogram
Ma	million acres
Mha	million hectares
Mm³	million metres cubed
Mt CO₂ eq.	megatonnes of carbon dioxide equivalent
m²	square metres
N	nitrogen
N₂O	nitrous oxide
SO₂	sulfuric acid
YG	yield grade



Chair's Message

The sustainability of agri-food systems has never been more important than it is today. Consumers are looking for safe, healthy and affordable food that is raised in a socially responsible and environmentally sound manner. At the same time, the economic viability of agriculture also needs to be part of the equation.

In 2014, the Canadian Roundtable for Sustainable Beef (CRSB) commissioned the National Beef Sustainability Assessment (NBSA) and Strategy to gain a comprehensive understanding of the sustainability performance of the Canadian beef industry, as well as to identify opportunities for improvement.

The assessment portion of the project is a farm to fork analysis that sets industry benchmarks regarding the environmental, social and economic sustainability of the industry.

The strategy portion of the project used the results of the baseline assessment to identify goals, key performance indicators and action items. The strategy will be used to guide the future work of the CRSB and our membership, in order to effectively and efficiently advance continuous improvement in Canadian beef sustainability.

In the following summary report you will find the assessment and strategy integrated throughout the sections; for further detail, we invite you to view the reports and other materials on our website.

Together, as members of the CRSB, we are committed to working together and advancing continuous improvement in our industry's sustainability.

This is the first time a project of this kind has been undertaken in the Canadian beef industry. We are excited to share the results with you, and hope you will join us on this sustainability journey.

Sincerely,

A handwritten signature in blue ink, appearing to read 'Cherie Copithorne-Barnes'.

Chair, Cherie Copithorne-Barnes

The Canadian beef industry spans the country, with beef producers located in every province. In total there are 68,500 beef farms, including cow-calf, background and feedlot operations. Over 98% of beef farms are family owned and operated.

Cow-calf operations, that sell cattle into background and feedlot operations, tend to have smaller herd numbers as they utilize extensive rangelands across the country. The average cow-calf herd is 63 mother cows.

Feedlot operations, where cattle are finished on a grain diet, are larger operations, typically ranging between 500-20,000 head. While beef cattle herds are spread across Canada, feedlot production is focused in Western Canada, with Alberta accounting for 70% of total production.

Processing and packaging facilities are also western-focused, representing 86% of total Canadian beef production.

The Canadian beef industry predominately produces a grass fed, grain finished product from a base *Bos taurus* (European breeds) herd. These two main contributing factors support the production of high quality products and enable Canadian producers to sell into 58 markets around the world.

Producing more than 1.2 million tonnes of beef annually, Canada is the 6th largest exporter of boxed beef and 5th largest exporter of beef and cattle in the world. The Canadian beef industry contributes more than \$41 billion to the Canadian economy and generates 228,000 jobs.

SNAPSHOT OF THE CANADIAN BEEF INDUSTRY



Methodology

National Beef Sustainability Assessment

The National Beef Sustainability Assessment (NBSA) consisted of three parts: 1) environmental; 2) social; and 3) economic assessments.

The study followed international guidelines and standards. Data were collected through surveys with 77 producers and meat packing companies across Canada as well as consultations with numerous subject matter experts. Secondary (generic) data sources were used to complement these primary (specific) data. Secondary sources included extensive literature reviews and statistical and proxy data. This top-down, bottom-up iterative approach was used to best manage data availability and to provide an accurate picture of the Canadian beef industry.

The study was guided by a CRSB steering committee and reviewed by an external third-party panel of experts.

Environmental Assessment

The Environmental Assessment of the study included two main segments: an Environmental Life Cycle Assessment (E-LCA) and a Land Use Assessment (LUA). The E-LCA examined the beef industry's impact on climate change, fossil fuel use, water use and air and land pollution potentials. The E-LCA followed the principles and framework for life cycle assessment of the International Organization for Standardization (ISO) 14040. The Food and Agriculture Organization of the United Nations (FAO) Livestock Environmental Assessment and Performance (LEAP) guidelines were also applied. The life cycle inventory was made using SimaPro, an LCA software program. The 77 surveys as well as expert consultations were used to help derive the modelling assumptions. Canadian specific data were used to assess most environmental topics, however, data availability and quality were limited for some topics and, in these cases, the most appropriate international sources were used as proxies. Figure 1 shows the stages included in the E-LCA (see Appendix A for further details).

It is important to note that the results from the E-LCA are presented in two different functional units, which **cannot** be directly compared.

The two different units are:



kilogram of live weight

refers to just the **farming stage** of the life cycle; and



kilogram of packed boneless beef (delivered and consumed)

includes all stages in the life cycle, from **farming to consumption**



LIFE CYCLE ASSESSMENT (LCA)

is a tool used to assess the environmental performance of products, processes and services. It provides a comprehensive approach to understanding relationships and trade-offs between environmental and social impacts.

The LUA portion added to the comprehensiveness of the study, as it assessed topics not well addressed in standard life cycle assessments such as biodiversity, soil carbon sequestration, water use and water risk. The LUA developed innovative science-based approaches designed specifically for this study. It should be noted that these preliminary assessments are a meaningful first step, however further research on these topics is recommended, as global methodologies develop and more site-specific data become available. More in-depth assessments will increase understanding of the topic in relation to the beef industry as well as enhance the usability of the results to drive continuous improvement. The water risk component focused on the relationship between cattle density and areas of higher potential water risk. To assess biodiversity, a modified wildlife habitat indicator was developed, building on the work of Agriculture and Agri-Food Canada (AAFC), to determine the habitat capacity of land used for beef production. Finally, land use and land management changes were modelled to estimate total land use as well as carbon sequestration.

The environmental assessment (both the E-LCA and the LUA) was conducted by Deloitte.

Figure 1

Environmental life cycle stages



Social Assessment

The social component of the study adopted a Social Life Cycle Assessment (S-LCA) approach. The S-LCA complied with the United Nations Environment Programme (UNEP)/Society of Environmental Toxicology and Chemistry (SETAC) guidelines. The data collected via 76 of the surveys were complemented with a review of suppliers, distributors, industry associations, national laws and regulations, and other existing data sources. The life cycle stages and main stakeholders assessed in each stage of the S-LCA are found in Table 1 (see Appendix B for more details). The results are categorized according to a risk scale; see Table 2 for a description of the risk scale. For this study, the term 'risk' reflects the potential for negative impact.

The S-LCA was conducted by Deloitte.

Table 1

Stages and stakeholders assessed in each stage of the S-LCA

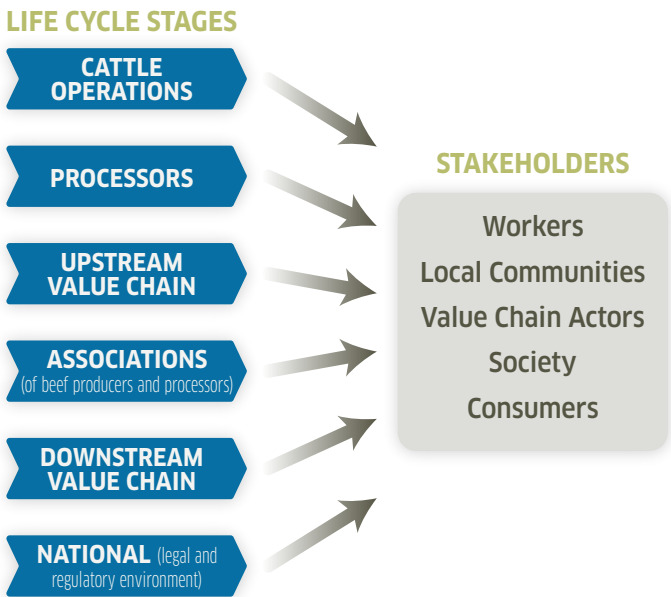
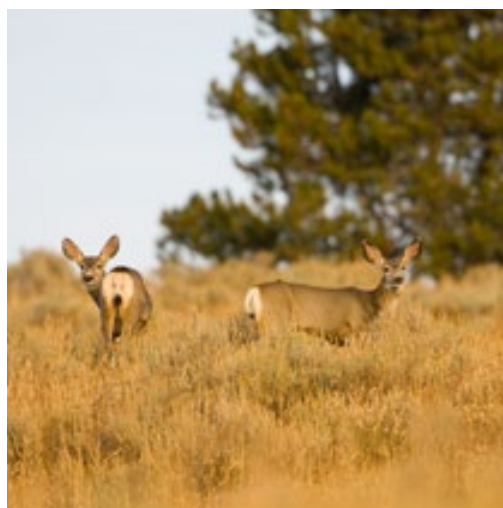


Table 2

Risk scale used in the S-LCA



Colour	Risk scale level	Definition
●	Very Low	Very low risk of negative social impact
●	Low	Low risk of negative social impact
●	Moderate	Moderate risk of negative social impact
●	High	High risk of negative social impact

Economic Assessment

An indicator approach was used to evaluate economic aspects of the Canadian beef industry. Four indicators were selected to be used as benchmarks: 1) long-term profitability; 2) long-term per unit cost of production; 3) domestic consumer demand; and 4) international consumer demand. The indicator approach allows for measurement in quantitative, qualitative and descriptive terms.

The economic assessment was conducted by Canfax Research Services.

National Beef Sustainability Strategy

The Sustainability Strategy was developed using the results of the NBSA as well as through CRSB membership priority setting. Membership priority setting took place through multi-stakeholder discussions at the 2016 CRSB semi-annual meeting. At the meeting, goals, key performance indicators and action items for the industry were identified.

The goals, key performance indicators and action items are dispersed throughout this report alongside the results of the sustainability assessment. A table summary of the strategy can be found in Appendix C. It should be noted that not all areas assessed in the NBSA were identified as areas of focus for future work in the strategy. This is largely driven by the fact that those areas were not identified as hotspots¹ within the study. In addition, some focus areas that are included in the strategy were not identified as hotspots within the study. These areas were included for reasons such as consumer interest or areas of high priority for the beef industry to continue advancing.

A common thread identified in all focus areas was the need for communication, collaboration and engagement across the beef value chain. The Canadian beef industry relies on an expanded and complex network, including 68,500 farms and ranches across Canada. The successful and continued advancement of sustainability within the Canadian beef industry requires participation from all stakeholders, including consumers. Reaching out and engaging with individuals from these organizations as well as other stakeholders of the Canadian beef value chain is crucial to advancing sustainability efforts. From this common interest, an overarching goal was identified and is outlined on the next page (see over).

¹ Hotspots are impacts showing, after analysis, a particularly high risk for one or more of the Canadian beef industry's stakeholders.

STRATEGY Overarching

Goal #1 Build a stronger and more united Canadian beef sustainability community

Key Performance Indicators

- Number of CRSB Members and Observers
- Diversity of CRSB membership

Baseline

As of June 30th, 2016 the CRSB had 53 members and 40 observers (Retail & Food Service = 10, Producer/Processor Organizations = 17, Processors = 2, NGO = 13, Food & Agriculture Business = 11, Government Observers = 12, Producer Observers = 17, Academic Observers = 9, Youth Observers = 2)

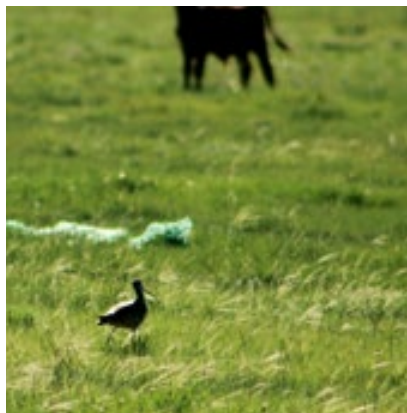
Action Items:

1. Build a trusted go-to forum on sustainable beef in Canada through diversity in membership, leading scientific information and robust frameworks to measure and advance sustainability
2. Enable the further engagement of the scientific community in the CRSB's work and membership
3. Through communications activities, engage, inform and enable information sharing that assists the Canada beef industry in advancing sustainability practices

Oversight

The National Beef Sustainability Assessment and Strategy were guided by a CRSB steering committee. The committee provided regular direction, feedback and advice to ensure the study was robust and comprehensive.

The National Beef Sustainability Assessment was additionally reviewed by an external third-party panel of experts. See page 30 of this report for more details on oversight.



Beef production requires the use of water, land and feed, which generate environmental pressures through the consumption of resources and the release of substances in water, air and soil. Cattle, as a ruminant species, are also characterized by the release of greenhouse gas emissions, mostly due to enteric fermentation, manure excretion and feed consumption. However, the beef industry also supplies many ecosystem services such as sequestering carbon in the soil, providing natural habitat for biodiversity and maintaining wetlands on the landscape. The environmental assessment covered a broad range of topics. The results of the environmental assessment are grouped into the following areas:

- Climate change
- Fossil fuel depletion
- Air
- Land use
- Biodiversity
- Water
- Meat waste

ENVIRONMENTAL ASSESSMENT RESULTS

See Appendices D and E for the results for different functional units and the contributions of different life cycle stages to the indicators in the E-LCA.

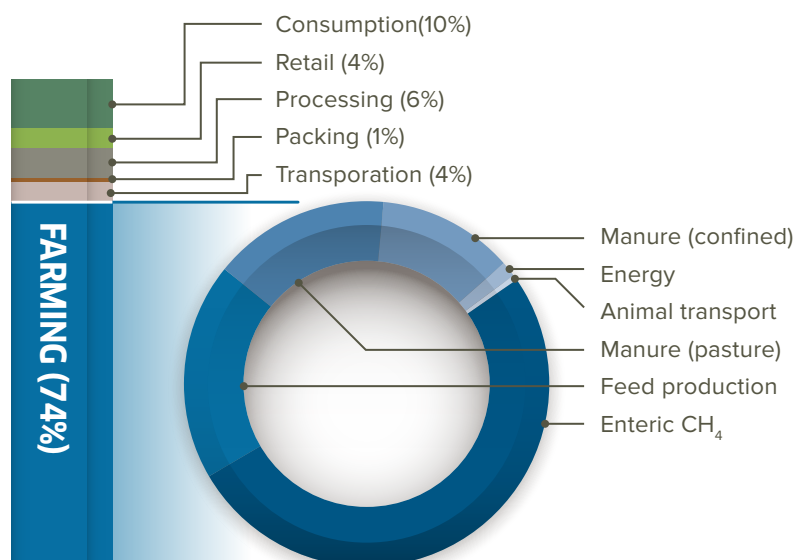
Climate Change

Canadian beef production contributes to greenhouse gas (GHG) production through three main facets: methane (CH_4)—mostly from enteric fermentation, nitrous oxide (N_2O)—from manure application and storage and use of inorganic nitrogen (N) fertilizer for crop production, and carbon dioxide (CO_2)—from fossil fuel consumption.

Canada is a very efficient beef producer in regards to GHG emissions, with a total footprint of less than half the world average at 11.4 kilograms of carbon dioxide equivalents (kg CO_2 eq.) per kg of live weight². From a value chain perspective, taking into account GHG emissions from farming to consumption, the GHG footprint is 30.8 kg CO_2 eq. per kg of packed boneless beef (delivered and consumed). The farming stage accounts for 74% of the industry's total GHG footprint, followed by consumption at 10% (Figure 2).

Figure 2

Contributions of different life cycle stages to the Canadian beef industry's greenhouse gas footprint (Total: 30.8 kg CO_2 eq./kg packed boneless beef [delivered and consumed]). (Note: individual items may not add to the total due to rounding)



While the beef industry produces GHGs, land used for beef cattle production also stores a significant amount of carbon. Approximately 1.5 billion tonnes of carbon are currently stored in the lands used by beef producers—964 million tonnes in natural land for pasture; and 589 million tonnes in cropland, tame pasture, hay, and other land. Land use and management practices can further enhance soil carbon storage. Land management practices, such as reduced tillage, can offset some of the emissions of beef production. If offsets are taken into consideration, the net GHG footprint of beef production is estimated to decrease by 8% to 10.5 kg CO_2 eq./kg live weight.

Fossil Fuel Depletion

Fossil fuel depletion refers to the consumption of fossil resources used for energy, namely peat, brown coal, hard coal, oil and natural gas. Impacts are expressed in oil eq. of fossil resource.

The production of one kg of packed boneless beef (delivered and consumed) requires the depletion of 2 kg of oil eq. Although the farming stage remains the main contributor at 58%, compared to other impact categories, packing, processing, retail and consumption have a relatively larger impact on fossil fuel depletion, for a total of 42% of the impacts. Hard coal, crude oil and natural gas consumption are the major contributors, representing 37%, 33% and 24% of the total consumed energy, respectively.

² Gerber PJ, Steinfeld H, Henderson B, Mottet A, Opio C, Dijkman J, Falcucci A, Tempio G (2013). Tackling climate change through livestock - A global assessment of emissions and mitigation opportunities. Rome: Food and Agriculture Organization of the United Nations (FAO).

STRATEGY Climate Change and Fossil Fuel Depletion

GOAL #2 Reduce the greenhouse gas footprint of Canadian beef per unit of product produced (CO₂ eq./kg)

Key Performance Indicators

Carbon footprint intensity of Canadian beef (CO₂ eq./kg)

Baseline

- 11.4 kg of CO₂ eq./kg live weight;
- 30.8 kg of CO₂ eq./kg packed boneless beef (delivered and consumed)

Action Items:

1. Optimize diets
2. Improve manure management
3. Increase carbon sequestration
4. Improve feed and forage production
5. Support the identification and selection of cattle genetics that reduce the GHG footprint of beef production
6. Increase stakeholder knowledge

Air

The potential for air pollution was assessed through two main indicators: terrestrial acidification potential and photochemical ozone formation potential.

Acidification consists of the accumulation of acidifying substances (e.g. sulphuric acid, hydrochloric acid). Deposited onto the ground by rain, acidifying pollutants have a wide variety of impacts on soil, groundwater, surface waters, biological organisms, ecosystems and materials (buildings). Impacts are expressed in grams (g) of sulfuric acid (SO₂) eq. For one kg of packed boneless beef (delivered and consumed), terrestrial acidification potential equals 327.2 g SO₂ eq. Within the farming stage, the beef industry contributes to terrestrial acidification mainly through manure storage, feed production and through manure excreted on pasture.

Minimizing nutrient losses during manure storage (e.g. covering manure, storing on waterproof grounds) as well as working on diets to further optimize animal growth while minimizing enteric emissions and manure-related emissions (mostly CH₄, N₂O, nitrogen - ammonia and phosphorus [P]) would help reduce the acidification potential and water eutrophication.

Photochemical ozone formation potential results mainly from chemical reactions induced by solar light between nitrogen oxides and volatile organic compounds, commonly emitted in the combustion of fossil fuels. Impacts are expressed in kg non-methane volatile organic compounds (NMVOC) eq. For one kg of packed boneless beef (delivered and consumed), photochemical ozone formation potential equals 47.6 g of NMVOC eq.

Feed production is the largest contributor to photochemical oxidant formation and represents 72% of the total. The main sources of the impacts are the emissions of N₂O during barley production and, to a lesser extent, during hay production. Reducing fertilizer use or optimizing fertilizer application would reduce N₂O emissions. Enteric CH₄ and on-farm energy use are also large contributors to this indicator and represent 16% and 9% of total impacts, respectively.

The beef industry's contribution to air pollution was found to be small and the risks relatively low, therefore this was not an area identified for goals within the strategy.

Land Use

Raising beef cattle to produce meat has a direct land use footprint in terms of land occupation, mainly linked to feed production and pasture grazing. Beef cattle production is currently using approximately one third or 52.2 million acres (Ma) [21.1 million hectares, Mha] of the Canadian agricultural land base, with a significant portion of that being in Western Canada (Figure 3). Cropland used for cattle feed production (e.g. barley, corn, oat and wheat) represents less than 9% of crop and summerfallow land (Figure 3) in Canada³.

Looking at just the farming stage, it takes between 37 square metres (m²) and 93 m² of land to produce one kg of live weight in Canada. This range is a result of different beef cattle production systems. Different systems have different land use requirements, depending on location, management, productivity, feed and other factors.

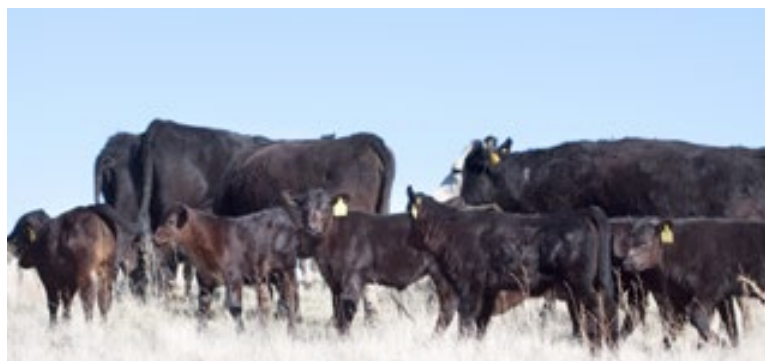
Figure 3

Land used for beef production in Canada



Biodiversity

Beef production occurs in every province across Canada, thus encompassing a variety of ecosystems through the extensive use of rangelands and cropping systems. The study assessed the capacity of the land used for beef production to support wildlife habitat. The results show that within the agriculture landscape the beef industry contributes the largest proportion of potential wildlife habitat—contributing 68% of the potential wildlife habitat on just 33% of total agricultural



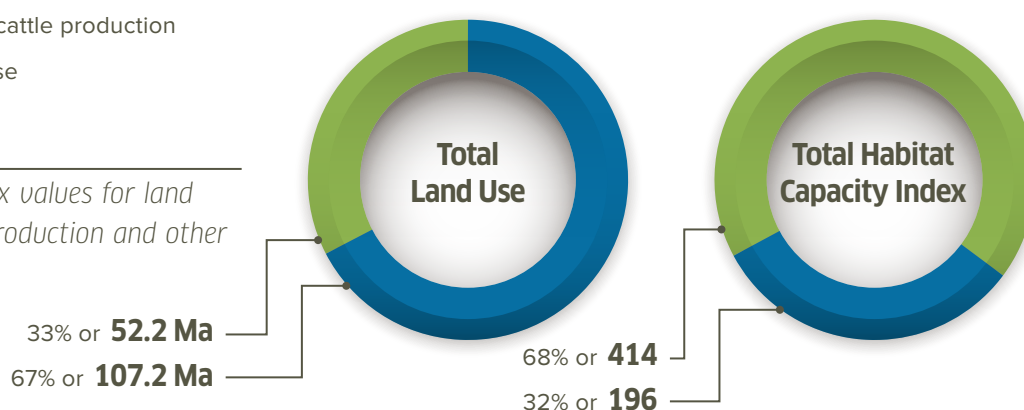
land (Figure 4). The high wildlife habitat capacity is primarily due to the high proportion of grassland (native and tame pastures) used by beef cattle in Canada, which have relatively high average habitat values.

Much of the remaining grasslands in Canada exist due to the beef industry, which utilizes 12 Ma [5 Mha] of tame or seeded land for pasture and 32 Ma [13 Mha] of native grassland. Given that Canadian grasslands are an endangered ecosystem with less than 20% remaining intact, the relationship between beef production, biodiversity and grassland conservation should not be overlooked. Further investigation into this subject area is recommended.

- Land used for beef cattle production
- Other agricultural use

Figure 4

Habitat capacity index values for land used for beef cattle production and other agricultural areas



STRATEGY Land Use and Biodiversity

GOAL #3 Enhance ecosystem services and biodiversity on lands managed by beef producers

Key Performance Indicators

- Area of native/tame grassland utilized by the beef industry
- Estimated soil carbon stock on land used for beef production, including crop, forage and pasture (tonnes of carbon)

Baseline

- The beef industry utilizes 21.2 million hectares or 33% of the 64.5 million hectares of agricultural land in Canada
 - 5 Mha of tame or seeded land for pasture and 13 Mha of native grassland
- Land used for beef production currently stores approximately 1.5 billion tonnes of carbon

Action Items:

1. Support work that enhances habitat quality on beef operations
2. Enable enhanced collaboration between industry and conservation partners to position industry as a key conservation stakeholder
3. Support research that increases the understanding of the relationship between beef production and biodiversity
4. Support the creation of ecosystem services markets and the development and dissemination of tools that monitor and measure environmental deliverables from the beef system
5. Build further awareness and use of range and riparian health assessments by producers

Water

The beef industry's impact on water was assessed in three different ways: water use; water risk; and pollution potential.

Water Use

To produce one kg of packed boneless beef (delivered and consumed), it takes 631 litres of blue water (surface and groundwater). This value accounts for blue water consumption from the farming stage through to consumption. The farming stage represents 74% of the total blue water footprint (Figure 5). At this stage, it takes 235 litres per kg of live weight—80% of the blue water used during this stage is for feed crop irrigation; 19% for drinking water for cattle; and 1% is attributed to other uses. The Canadian beef industry's blue water footprint is relatively low, primarily due to the limited amount of irrigation on feed, as well as the presence of highly efficient systems.

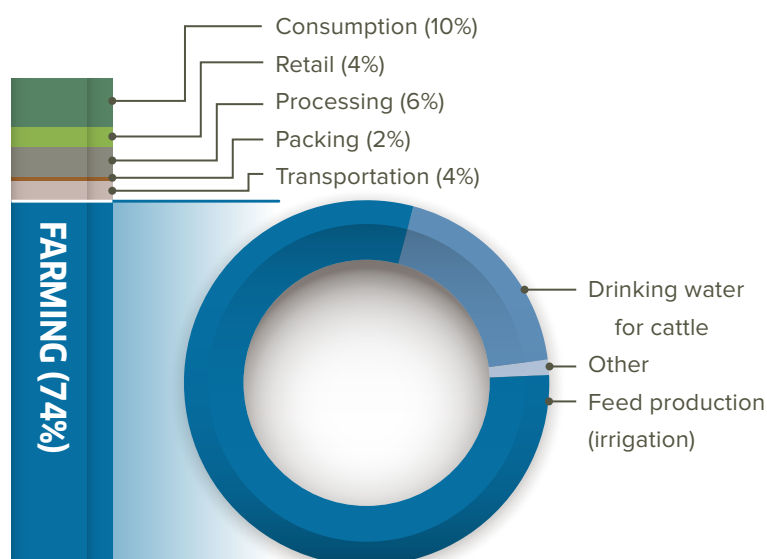


Figure 5

Contributions of different life cycle stages to the Canadian beef industry's blue water footprint (Total: 631 litres of blue water/ kg of packed boneless beef [delivered and consumed]). (Note: individual items may not add to the total due to rounding)

Water Risk

The link between water risk (i.e. water stress, inter-annual variability and drought severity) and cattle density was explored and showed that 70% of cattle production takes place in medium to high and high water risk areas. These results were anticipated, as beef cattle tend to be produced on marginal lands, often in drier regions. Furthermore, locations with low precipitation are sought after for feedlot operations that must manage manure run-off and mud accumulation within pens. The link between water risk and cattle density emphasizes the need for effective systems to manage the water. More detailed analyses are recommended to better understand water risk.

Pollution Potential

Eutrophication potential (freshwater and marine) was assessed to measure the beef industry's potential impact on water pollution. Eutrophication is a process whereby water bodies, such as lakes or rivers, receive excess chemical nutrients—typically compounds containing nitrogen or phosphorus—that stimulate excessive plant growth (e.g. algae). Nutrients can

come from many sources, such as fertilizers applied to agricultural fields, deposition of nitrogen from the atmosphere, erosion of soil containing nutrients and sewage treatment plant discharges.

Freshwater eutrophication potential is expressed in g of phosphorus (P) eq. One kg of packed boneless beef (delivered and consumed) results in the loss of 15.3 g P eq. that can have a potential impact. Feed production is the major contributor to this indicator, followed by manure excreted on pasture.

Marine eutrophication potential is expressed in g N eq. One kg of packed boneless beef (delivered and consumed) results in the loss of 197.5 g N eq. Similar to freshwater, feed production and manure excreted on pasture contribute the majority of the impacts.

The contribution of crop production and grazing to P and N losses depends significantly on the quantity and quality of P and N chemical and organic fertilizers applied, and on soil management (e.g. tillage, soil cover). The uptake of best practices were out of scope of this study, however are covered in crop sustainability assessments. A good reference point for nutrient stewardship is Fertilizer Canada's 4R Nutrient Stewardship program, which promotes Right Source, Right Rate, Right Time, Right Place.⁴

STRATEGY Water

GOAL #4 Enhance riparian health and reduce the water footprint of beef production

Key Performance Indicators

Blue water footprint intensity

Baseline

- 235 litres of blue water/kg of live weight;
- 631 litres of blue water/ kg of packed boneless beef (delivered and consumed)

Action Items:

1. Enhance producer riparian health knowledge and tools to improve riparian health
2. Encourage the enhancement and completion of the national wetland inventory and further measure the relationship between beef production and wetland conservation (to be utilized as a key performance indicator when available)
3. Support research that increases the understanding of the relationship between beef production and water, particularly in the higher risk watersheds across Canada
4. Support innovation that increases water use efficiency within the processing and packaging sectors
5. Improve feed yields/productivity, drought resistance and irrigation practices to reduce the blue water footprint of feed
6. Develop a key performance indicator for riparian health

⁴ Visit the Fertilizer Canada website for more information:
<http://www.fertilizercanada.ca/nutrient-stewardship/>

Meat Waste

Approximately one-third of all food produced for human consumption in the world is lost or wasted each year⁵. Meat waste was therefore considered in this study because it represents a considerable opportunity for full value chain sustainability.

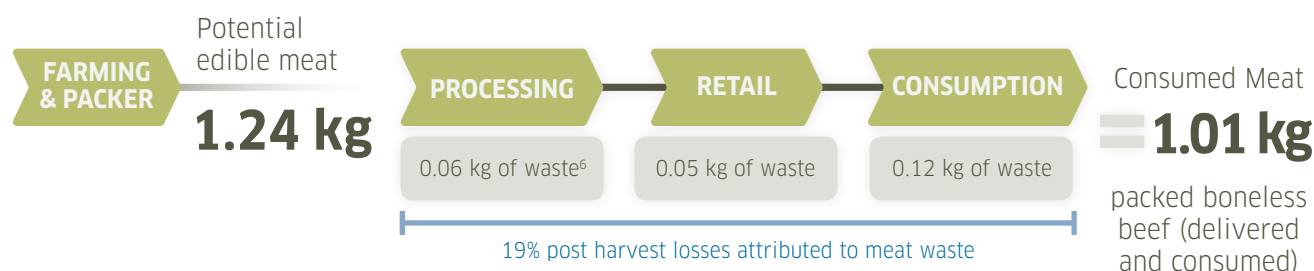
The largest environmental impacts from secondary processing through to consumption come from meat waste. Approximately 19% of edible bone free meat is wasted throughout these stages (Figure 6). It is estimated that reducing meat waste by 50% could save up to 3 kg CO₂ eq. and 60 litres of water per kg of packed boneless beef (delivered and consumed). This could avoid the release of 1.6 megatonnes of carbon dioxide equivalents (Mt CO₂ eq.) and save up to 31 million metres cubed (Mm³) of water per year.

It should be noted that the data used in the NBSA regarding food waste are not representative solely of beef nor of Canada; but rather of meat from North America and Oceania. An in-depth study on the subject specific to the Canadian context would enhance understanding and identify opportunities for improvement.

Highly correlated to meat waste is carcass quality and utilization. For example, the reduction in yield grade (YG) 3 cattle in Canada would reduce trimming of the carcass that ends up on the fabrication floor. Other areas identified to reduce meat waste included consumer knowledge, enhancing understanding of post-harvest waste in Canada, and improving packaging.

Figure 6

Meat waste occurring during secondary processing, retail and consumption (Note: individual items may not add to the total due to rounding).



⁵ Food and Agriculture Organization of the United Nations (FAO) (2016). Food loss and food waste. www.fao.org/food-loss-and-food-waste/en/

⁶ Losses refer to trimming and spillage during additional industrial processing

STRATEGY Meat Waste

GOAL #5 Reduce post-harvest meat waste

Key Performance Indicators

Overall meat waste (% of edible bone free meat)

Baseline

Total post-harvest losses equals 19%: 5% at processing, 4% at retail, 10% at consumer level

Action Items:

1. Reduce food waste at consumer level
2. Further enhance understanding of food waste specific to Canada and pertinent markets
3. Promote improved product packaging
4. Improve carcass quality and utilization

Along with the economic and environmental aspects, social parameters are a key component of a product's sustainability. Social sustainability aims to assess the processes and practices that promote the well-being of stakeholders, including workers and local communities, as well as animals. The social assessment adopted a social life cycle assessment (S-LCA) approach and provides a baseline of industry hotspots pertaining to:

- **Working conditions, including temporary foreign workers and regulations**
 - **Animal welfare**
 - **Antimicrobials**
-

SOCIAL ASSESSMENT RESULTS



Working Conditions

Most indicators related to working conditions showed very low to low risks. Farmers and packers scored well on hourly wages, and health and safety training and prevention. The S-LCA identified four social hotspots along the Canadian beef value chain that were directly linked to working conditions:

- the rights of temporary foreign workers at the national level;
- the fatality rate at the supplier level;
- the wage of workers at the distribution level; and
- the work load at the beef producer level.

Social impacts for temporary foreign workers were found to be a low risk in terms of social benefits, average hourly wage, and unionization rate. However, the legal rights of migrant workers show a high risk because Canada is neither a signatory nor a State Party of the United Nations International Convention on the Protection of the Rights of All Migrant Workers and Members of their Families—the indicator used to evaluate legal rights in this study.

The wage of workers at the distribution level showed that fast-food chains have a low score, as median wages and salaries are less than 50% of the national median wages and salaries⁷. The beef industry's upstream suppliers of seeds, grains, fertilizers, feed, salt and mineral all have a fatal injury rate above the country average of 2.7 per 100,000 employees—a high risk category; however their non-fatal injury rate is below the country average of 1,522 per 100,000 employees⁸.

At the downstream level, the fast-food chain sector has both fatal and non-fatal injury rates below the country average⁹. Sectors of veterinary products and retailers both have a fatal injury rate below the country average, but a non-fatal injury rate above the country average¹⁰.

Workload for beef producers was also identified as a high risk category, with 54% of respondents exceeding a 48 hour work week for more than 13 weeks of the year.

STRATEGY Working Conditions

GOAL #6 Promote farm safety and responsible working conditions

Key Performance Indicators

Percentage of farms reporting injuries

Baseline

The agricultural fatality rate was 12.9 per 100,000 farm population (including non-workers) between 1990-2008

Action Items:

1. Promote farm safety awareness and best practice implementation
2. Support dialogues regarding safety from upstream value chain actors, rights of migrant workers and adequacy of median income for downstream value chain actors
3. Promote culture of diversity, inclusion and transparency within the beef supply chain

⁷ The national median wages and salaries for 2010, used as the reference point for the assessment, was \$48,964.

⁸ International Labour Organization (ILO) – Yearbook of Labour Statistics.
<http://laborsta.ilo.org/STP/guest>

⁹ Ibid

¹⁰ Ibid

Animal Welfare

The Canadian beef industry showed low risks in the animal health and welfare section of the assessment, which is reflective of the industry's investment in developing and disseminating the Code of Practice for the Handling and Care of Beef Cattle¹¹. The indicators assessed in the study showed very low and low risks to animal welfare throughout the entire value chain (Table 3). For example, 62% of producers surveyed had read the Code of Practice and implemented all of the requirements. In the surveys, packers also noted that animal welfare audits are becoming an increasing requirement from their customers and other stakeholders. Pain control for branding was found to be a moderate risk, highlighting an area for improvement; no high risk indicators were found.

Table 3

Rating level for the animal health and welfare indicators examined in the S-LCA

Rating Level	Life Cycle Stage	Indicator
Very low risk 	Packers	<ul style="list-style-type: none"> • Animal harvest method • Animal stunning method • Animal welfare audit • Technology and infrastructure to support animal welfare • Internal communication of animal welfare regulations • Transporters' certification
	Farmers	<ul style="list-style-type: none"> • Health prevention • Health assessment • Housing and feeding • Euthanasia method • Handling injuries • Handling training • Breeding injuries • Transport certification • Calving assistance
	Associations	<ul style="list-style-type: none"> • Animal welfare promotion
Low risk 	Farmers	<ul style="list-style-type: none"> • Housing condition • Castration • Weaning conditions • Disbudding and dehorning pain control • Handling issues • Code of Practice awareness and implementation
Moderate risk 	Farmers	<ul style="list-style-type: none"> • Branding pain control
High risk 	None	<ul style="list-style-type: none"> • None

¹¹ National Farm Animal Care Council (2013). Code of practice for the handling and care of beef cattle. http://www.nfacc.ca/pdfs/codes/beef_code_of_practice.pdf

STRATEGY Animal Care

GOAL #7 Promote excellence in animal care

Key Performance Indicators

Uptake and implementation of the Code of Practice for the Care and Handling of Beef Cattle

Baseline

- 5% of beef producers who filled in the NBSA-S-LCA survey have read the Code of Practice and both requirements and some or all of the recommended practices are implemented on their operations.
- 57% of respondents have read the Code of Practice and implemented all of the requirements.
- 24% have read the Code of Practice and basic requirements are partially implemented
- 14% have not read the Code of Practice.

Action Items:

1. Promote animal care awareness and implementation of good practices through the dissemination of the Beef Code of Practice
2. Support training for animal transportation
3. Support research and innovation regarding better pain control protocols and products
4. Communicate importance of adopting pain control protocols and products
5. Investigate opportunities to alter branding requirements for older animals (CAN brand and feedlot branding)

Antimicrobials

The use of antimicrobials (whether in livestock, companion animals, or human medicine) increase the risk that resistance will develop. Although the majority of antimicrobials that are used in Canadian beef production are of low importance in human health (category IV, which are not used in human medicine), it is important to assess antimicrobial stewardship for continued effective use and public concern.

The use of antimicrobials can be reduced and minimized through the adoption of best management practices. The study found the potential for antimicrobial misuse to be a very low to low risk in Canada due to the uptake of best management practices, training and measuring and monitoring. For example, of the producers surveyed, 90% pre-condition their calves and/or have taken Verified Beef Production training. Pre-conditioning programs enhance immune function and minimize stress during weaning thus mitigating the need for antimicrobials. The Verified Beef Production Plus (VBP+) program focuses on appropriate and responsible use of antimicrobials as well as maintaining a veterinarian and client-patient relationship.



STRATEGY Antimicrobials

GOAL #8 Support the further development, monitoring and dissemination of best practices regarding antimicrobial use

Key Performance Indicators

- The proportion (%) of isolates in beef cattle resistant to Category I (Very High Importance in human medicine)
- The proportion (%) of isolates in retail beef resistant to Category I (Very High Importance in human medicine)

Baseline

- The proportion (%) of isolates resistant to Ciprofloxacin in beef cattle equals 5%, while the proportion (%) of isolates resistant to Ceftiofur equals 0%.¹²
- Resistance levels in retail beef of category I β -lactams remained low (< 4%) with the exception of British Columbia where category I β -lactam resistance ranged between 6% and 9%.¹³

Action Items:

1. Support the development of a database for robust measuring and monitoring of antimicrobial use and resistance, aligned with the National Beef Antimicrobial Research Strategy
2. Support the further development and dissemination of best practices regarding antimicrobial use
3. Develop responsible antimicrobial use guidelines for verified sustainable beef
4. Support consumer understanding of the importance of responsible use of antimicrobials in the beef industry to ensure animal care



¹² Government of Canada. Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) (2015). 2013 Annual Report – Chapter 2. Antimicrobial Resistance. Public Health Agency of Canada, Guelph, Ontario. http://publications.gc.ca/collections/collection_2015/aspc-phac/HP2-4-2013-2-eng.pdf

¹³ Ibid

'Economic sustainability' is defined as the ability of a system to maintain productivity in spite of a major disturbance, as well as slow shifts in consumer preferences. The beef industry is a small margin business; margins are not anticipated to increase continually over time, nor are producers expected to be profitable each year. Producer viability and consumer resilience were the key assessment areas for the economic assessment.

ECONOMIC ASSESSMENT RESULTS

Producer Viability

Producer viability is the financial ability and incentive for a producer to continue producing a product. An economically sustainable Canadian beef operation is characterized by the ability to:

1. at least return the cost of capital;
2. fund all operating expenses via internal working capital;
3. pay labourers and owners at least the average standard wage;
4. have capacity to repay debt principle;
5. maintain a safe level of equity (e.g., 85%);
6. provide capacity for independent retirement of owners;
7. survive business succession with the family structure intact;
8. and survive and prosper in the long-term without the erosion of environmental capital.¹⁴

Investment in the cattle industry is long-term; it is a small margin business with long-term profitability near breakeven. Producers face price and weather risks, and must therefore plan carefully to avoid disastrous outcomes.

Historically, profitability drives the cattle cycle, which typically lasts for 10-12 years. In 2013, most cow/calf operations were covering short-term (i.e., cash costs), medium-term (i.e., including depreciation costs), and long-term costs (i.e., including opportunity costs). At the feedlot, high feed grain prices had a major short-term influence on margins in 2013, and data from agri benchmark indicate feedlot enterprises were unable to cover even short-term (cash) costs when selling on the cash market. At the packer level, there are only a few, large players and data are unavailable; however it is known that similar to the cow/calf and feedlot sectors, this is a small margin business. A sustainable business in the beef industry may therefore experience short-term financial loss, while remaining profitable in the long run.

Long term average margins from a 200 head cow herd of \$9,650 with paid labour of \$7,909 provides a total annual income of \$17,559 (nominal, excludes government program payments). This is below Statistics Canada's low-income cut-off, and does not support an average family. These operations must rely on other sources of income; for example, the cow/calf sector has a high reliance on off-farm income, ranging from 75% to 84% over the last decade.

For all enterprises, unpaid labour, erosion of equity and the inability to service debt in a timely manner are threats to producer viability at certain times in the cattle cycle.

¹⁴ McLean I, Holmes P and Counsell D (2014) The Northern beef report: 2013 Northern beef situation analysis, Prepared for Meat and Livestock Australia Report B.COM.0348, April.

STRATEGY Producer Viability

GOAL #9 Increase the financial viability of beef production in Canada

Key Performance Indicators

- Long term Cost of Production (2005-14 avg)
- Long term Profitability (2005-14 avg)

Baseline

- Long term cost of production, 2013 baseline (deflated)
 - Cow/calf \$120/one hundred pounds (cwt), or \$264/kg
 - Feedlot \$106.67/cwt, or \$235/kg

- Long Term profitability, 2013 baseline (deflated)
 - Cow/calf \$93.03/cow
 - Feedlot -\$0.09/cwt (cash), or -\$0.20/kg

Action Items:

1. Increase producer financial knowledge and viability
2. Increase production efficiency and innovation
3. Communicate the role of technology and innovation in relation to the environmental, social and economic benefits to the beef industry

Consumer Resilience

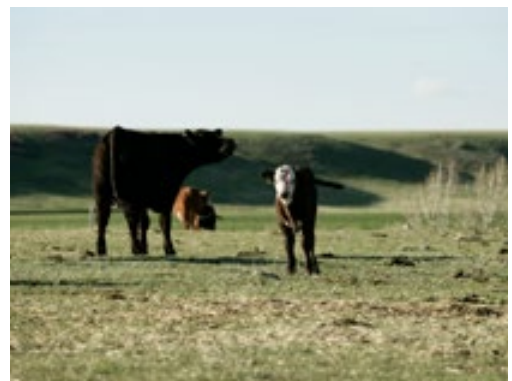
Consumer demand is the ultimate driver for the long-term development of the cattle industry. A sustainable cattle industry has to evolve with the consumer market and respond to changes in consumer preferences. This includes identifying fads that have become trends and ensuring the systems are set up to respond to those consumer demands.

Long-term trends, medium-term perceptions, and short-term market impacts were assessed in determining consumer demand of Canadian beef. Long-term trends include a growing middle class and shifting consumer demographics with more urbanization. Medium-term perceptions are impacted by food awareness, including perceptions of food safety, beef quality, nutrition, and healthfulness of beef. Short-term shifts may be due to prices and availability of substitute protein options.

DEMAND is a consumer's willingness to pay for a specific quantity and quality of product.

TRENDS are the result of fundamental changes in technology, society and the economy that play out over years or even generations.

FADS are driven by changes in current consumer inclinations; they come and go.



STRATEGY Consumer Resilience

GOAL #10 Increase demand for Canadian beef through consumer awareness of sustainable beef production

Key Performance Indicators

- Canadian Retail Beef Demand
- International Demand

Baseline

- 2013 Retail Beef Demand baseline:
 - 104 (Index 2000=100)
- 2013 International Demand baseline:
 - 82 (Index 2000=100)

Action Items:

1. Increase the capacity of the beef supply chain to respond to market demands
2. Support the critical examination of newly developed technologies within a sustainable beef framework
3. Support responsible communication and marketing of production practices that are of interest and concern to the consumer



Moving Forward

The NBSA provides a benchmark of the social, economic and environmental performance of the entire Canadian beef value chain. The results identified the areas where the beef value chain is doing well as well as opportunities for improvement. The results show that the greenhouse gas and blue water footprints of Canadian beef are among the lowest in the world; land used for beef production supports wildlife habitat and biodiversity, and also stores carbon; farmers and packers are leaders in animal health and welfare practices; the risk of antimicrobial misuse is low in Canada; and social impacts to temporary foreign workers, and in general, working conditions are not a risk. From an economic perspective, producer viability is influenced by a variety of factors, and the ability to respond to consumer demand is critical.

Opportunities for improvement include further reductions in greenhouse gas and blue water footprints through, for example, improvements in feed efficiency/productivity and manure management. Reducing food waste is another significant opportunity to reduce the environmental footprint of Canadian beef. From a social sustainability perspective, the promotion of responsible working conditions and safety across the value chain are important areas to focus upon. And in terms of economics, producer viability needs to be increased.

The Canadian beef industry has a strong desire to see improvements that reduce its environmental footprint and support society's values while at the same help it remain economically viable. This commitment is demonstrated, in part, through the work of the CRSB.

The CRSB's goals to advance the sustainability of the Canadian beef industry are summarized in Table 4. A detailed summary of the goals, key performance indicators and action items can be found in Appendix C. The strategy will be used to track progress and guide the future work of the CRSB and its membership. As a next step on the sustainability journey, the CRSB will be undertaking projects alongside membership to advance the goals outlined in the strategy through its third pillar of work, Sustainability Projects (Figure 7).

Figure 7

CRSB's three pillars of work

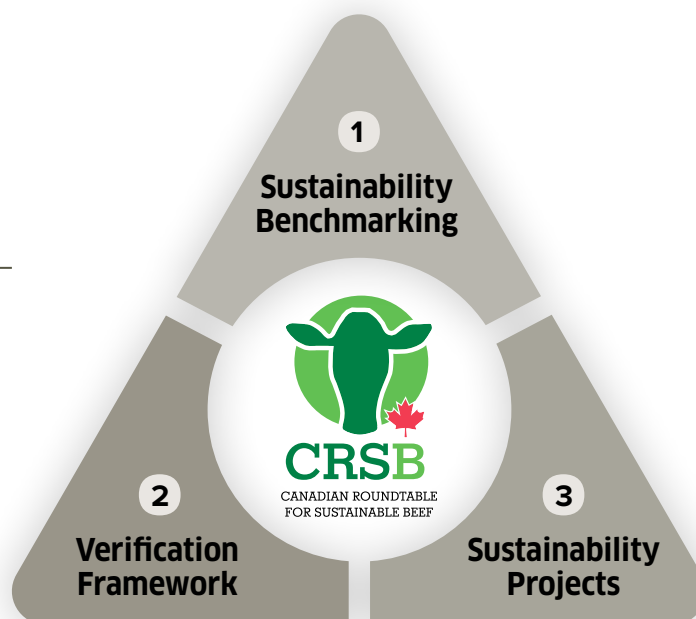


Table 4

Sustainability goals identified by the CRSB

Summary of Goals

Overarching	
Goal #1	Build a stronger and more united Canadian beef sustainability community
Environmental	
Goal #2	Reduce the greenhouse gas footprint of Canadian beef per unit of product produced (CO ₂ eq./kg)
Goal #3	Enhance ecosystem services and biodiversity on lands managed by beef producers
Goal #4	Enhance riparian health and reduce the water footprint of beef production
Goal #5	Reduce post-harvest meat waste
Social	
Goal #6	Promote farm safety and responsible working conditions
Goal #7	Promote excellence in animal care
Goal #8	Support the further development, monitoring and dissemination of best practices regarding antimicrobial use
Economic	
Goal #9	Increase the financial viability of beef production in Canada
Goal #10	Increase demand for Canadian beef through consumer awareness of sustainable beef production

The CRSB will review both the NBSA and Strategy approximately every five years, both to evaluate industry's progress over time and to update the work based on newly available data and methods.

Visit our website for more information and to access the full reports: www.crsb.ca



Acknowledgements

Project Manager

Fawn Jackson, Canadian Roundtable for Sustainable Beef

Community Engagement Manager

Monica Hadarits, Canadian Roundtable for Sustainable Beef

Steering Committee

- Dr. Karen Beauchemin, Agriculture and Agri-Food Canada
- Dr. Reynold Bergen, Beef Cattle Research Council
- Clint Dobson, Alberta Livestock and Meat Agency
- Dr. Dan Farr, Alberta Biodiversity Monitoring Institute
- Brenna Grant, Canfax Research Services
- Kerrienne Koehler-Munro, Alberta Agriculture and Forestry
- Tom Lynch-Staunton, Canadian Cattlemen's Association/ Alberta Beef Producers (Chair, Steering Committee)
- Dr. Tim McAllister, Agriculture and Agri-Food Canada
- Lauren Stone, Cargill
- Carrie Selin, Alberta Biodiversity Monitoring Institute
- Rich Smith, Alberta Beef Producers
- Paul Thoroughgood, Ducks Unlimited

External Panel of Experts

Environmental and Social Assessments

- Dr. Greg Norris, Harvard University (Life Cycle Analysis Specialist)
- Dr. Frank M. Mitloehner, University of California, Davis (Industry Specialist, United States)
- Janice Bruynooghe, Spring Creek Land and Cattle Consulting (Industry Specialist, Canada)
- Nicole Tichenor, Tufts University (Food Systems Specialist, United States)
- Dr. Robin Reid, Center for Collaborative Conservation (Biodiversity Specialist, United States)

Economic Assessment

- Dr. Jill Hobbs, University of Saskatchewan (Agriculture and Resource Economist)
- Dr. Scott Jeffrey, University of Alberta (Production and Resource Economist)

Deloitte project team

Maeva Charles, Yasmina Chicha, Valerie Chort, Noëllie Hestin, Olivier Jan, Madhu Kaushik, Marion Loubière, Jacob Madsen, Christophe Ménigault, Jerome Pétigny, Gildas Poissonnier, Marion Sarteel, Manu Sharma, Henry Stoch, Anne Turbé.

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Canfax Research Services project team

Brenna Grant, Huiting Huang

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APPENDICES



Appendix A

Life cycle stages examined in the E-LCA

Life Cycle Stages	Environmental impacts considered
Farming	<ul style="list-style-type: none">• Energy consumption• Cattle digestion: enteric CH₄ emissions• Feed rations: production, transport and use• Manure emissions: CH₄ and N₂O from manure on pasture and in confinement• Water use: production and crop irrigation, farm operations (e.g. cleaning) and direct consumption (by cattle)• Land used for grazing
Transportation between farms and packers	Transportation, losses of animal weight during transportation
Packing	Energy, materials, chemicals for cleaning and disinfection, water consumption and effluents for processing and packing meat
Secondary processing	Production of packaging and bone-free meat losses during processing. Energy consumption was not included
Retail	Loss of packaged beef bone-free meat during retail. Refrigeration was not included
Consumption	Waste associated with packaged bone-free meat by consumers

Appendix B

Life cycle stages and stakeholders examined in the S-LCA

Life Cycle Stage	Workers	Local Communities	Value chain actors	Society	Consumers
Cattle operations	Cattlemen and farm workers	Local communities where beef farms are located	Partners and suppliers associated with cattle production	Canadian society	Consumers of Canadian beef
Processors	Processing plants' workers	Communities where processors are located	Processors' partners and suppliers		
Upstream value chain	Suppliers' workers	Communities where suppliers' operations are located	Suppliers: seed, grain, fertilizer, feed, salt and minerals, veterinary products		
Downstream value chain	Retail sector and fast food chains' workers	Communities where retailers and fast-food chains are located	Retailers and fast-food chains		
Associations [of beef producers and processors]	Workers represented by the beef producers and processor associations	Communities in which the associations operate	Value chain actors of the sectors represented by the beef producers and processor associations		
National [legal and regulatory environment]	Canadian workers	Local communities in Canada	Value chain actors located in Canada		

Appendix C

National Beef Sustainability Strategy summary – goals, key performance indicators and action items

Key Performance Indicators	Baseline	Action Items
Goal #1. Build a stronger and more united Canadian beef sustainability community		
Number of CRSB Members & Observers	As of June 30th, 2016 the CRSB had 53 members and 40 observers:	1. Build a trusted go-to forum on sustainable beef in Canada through diversity in membership, leading scientific information and robust frameworks to measure and advance sustainability
Diversity of CRSB membership	Retail & Food Service (10), Producer/Processor Organizations (17), Processors (2), NGO (13), Food & Agriculture Business (11), Government Observers (12), Producer Observers (17), Academic Observers (9), Youth Observers (2)	2. Enable the further engagement of the scientific community in the CRSB's work and membership 3. Through communications activities, engage, inform and enable information sharing that assists the Canada beef industry in advancing sustainability practices
Goal #2. Reduce the Greenhouse Gas Footprint of Canadian Beef per unit of product produced (CO₂ eq./kg)		
Carbon footprint intensity of Canadian beef (CO ₂ eq./kg)	11.4 kg of CO ₂ eq./kg live weight; 30.8 kg of CO ₂ eq./kg packed boneless beef (delivered and consumed)	1. Optimize diets 2. Improve manure management 3. Increase carbon sequestration 4. Improve feed and forage production 5. Support the identification and selection of cattle genetics that reduce the GHG footprint of beef production 6. Increase stakeholder knowledge
Goal #3: Enhance ecosystem services and biodiversity on lands managed by beef producers		
Area of native/tame grassland utilized by the beef industry	The beef industry utilizes 21.2 million hectares or 33% of the 64.5 million hectares of agricultural land in Canada	1. Support work that enhances habitat quality on beef operations
Estimated soil carbon stock on land used for beef production, including crops, forage and pasture (tonnes of carbon)	<ul style="list-style-type: none"> • 5 Mha of tame or seeded land for pasture and 13 Mha of native grassland Land used for beef cattle production currently stores approximately 1.5 billion tonnes of carbon	2. Enable enhanced collaboration between industry and conservation partners to position industry as a key conservation stakeholder 3. Support research that increases the understanding of the relationship between beef production and biodiversity 4. Support the creation of ecosystem services markets and the development and dissemination of tools that monitor and measure environmental deliverables from the beef system 5. Build further awareness and use of range and riparian health assessments by producers

Key Performance Indicators	Baseline	Action Items
Goal #4: Enhance riparian health and reduce the water footprint of beef production		
Blue water footprint intensity	<p>235 litres of blue water to produce one kg of live weight;</p> <p>631 litres of blue water to produce one kg of packed boneless beef (delivered and consumed)</p>	<ol style="list-style-type: none"> 1. Enhance producer riparian health knowledge and tools to improve riparian health 2. Encourage the enhancement and completion of the national wetland inventory and further measure the relationship between beef production and wetland conservation (to be utilized as a key performance indicator when available) 3. Support research that increases the understanding of the relationship between beef production and water, particularly in the higher risk watersheds across Canada 4. Support innovation that increases water use efficiency within the processing and packaging sectors 5. Improve feed yields/productivity, drought resistance and irrigation practices to reduce the blue water footprint of feed 6. Develop a key performance indicator for riparian health
Goal #5: Reduce post-harvest meat waste		
Overall meat waste (% of edible bone free meat)	Total post-harvest losses equal 19%; 5% at processing; 4% at retail; and 10% at consumer level	<ol style="list-style-type: none"> 1. Reduce food waste at consumer level 2. Further enhance understanding of food waste specific to Canada and pertinent markets 3. Promote improved product packaging 4. Improve carcass quality and utilization
Goal #6: Promote farm safety and responsible working conditions		
Percentage of farms reporting injuries	The agricultural fatality rate was 12.9 per 100,000 farm population (including non-workers) between 1990-2008	<ol style="list-style-type: none"> 1. Promote farm safety and best practice implementation 2. Support dialogues regarding safety from upstream value chain actors, rights of migrant workers and adequacy of median income for downstream value chain actors 3. Promote culture of diversity, inclusion and transparency within the beef supply chain
Goal #7: Promote excellence in animal care		
Uptake and implementation of the Code of Practice for the Care and Handling of Beef Cattle	<ul style="list-style-type: none"> • 5% of beef producers who filled in the NBSA-SLCA survey have read the Code of Practice and both basic requirements and some or all of the recommended practices are implemented on their operations. • 57% of respondents have read the code of practice and implemented all of the basic requirements. 24% have read the Code and basic requirements are partially implemented, 14% have not read the Code of Practice 	<ol style="list-style-type: none"> 1. Promote animal care awareness and implementation of good practices through the dissemination of the Beef Code of Practice 2. Support training for animal transportation 3. Support research and innovation regarding pain control protocols and products 4. Communicate importance of adopting pain control protocols and products 5. Investigate opportunities to alter branding requirements for older animals (CAN brand and feedlot branding)

Key Performance Indicators	Baseline	Action Items
Goal #8: Support the further development, monitoring and dissemination of best practices regarding antimicrobial use		
<p>The proportion (%) of isolates in beef cattle resistant to Category I (Very High Importance in human medicine)</p> <p>The proportion (%) of isolates in retail beef resistant to Category I (Very High Importance in human medicine)</p>	<p>The proportion (%) of isolates resistant to Ciprofloxacin equals 5%. The proportion (%) of isolates resistant to Ceftiofur equals 0%</p> <p>Resistance levels of category I β-lactams (amoxicillin-clavulanic acid, ceftriaxone, and ceftiofur) remained low (< 4%) in beef E. coli isolates in 2013 with the exception of British Columbia where category I β-lactam resistance ranged between 6% (amoxicillin-clavulanic acid) and 9% (ceftriaxone and ceftiofur)</p>	<ol style="list-style-type: none"> 1. Support the development of a database for robust measuring and monitoring of antimicrobial use and resistance, aligned with the National Beef Antimicrobial Research Strategy 2. Support the further development and dissemination of best practices regarding antimicrobial use 3. Develop responsible antimicrobial use guidelines for verified sustainable beef 4. Support consumer understanding of the importance of responsible use of antimicrobials in the beef industry to ensure animal care
Goal #9: Increase the financial viability of beef production in Canada		
<p>Long term Cost of Production (2005-14 avg)</p> <p>Long term Profitability (2005-14 avg)</p>	<p>2013 Baseline (deflated)</p> <ul style="list-style-type: none"> • Cow/calf \$120/cwt, or \$264/ckg • Feedlot \$106.67/cwt, or \$235/ckg <p>2013 Baseline (deflated)</p> <ul style="list-style-type: none"> • Cow/calf \$93.03/cow⁹ • Feedlot -\$0.09/cwt (cash), or -\$0.20 ckg 	<ol style="list-style-type: none"> 1. Increase producer financial knowledge and viability 2. Increase production efficiency and innovation 3. Communicate the role of technology and innovation in relation to the environmental, social and economic benefits to the beef industry
Goal #10: Increase demand for Canadian beef through consumer awareness of sustainable beef production		
<p>Canadian Retail Beef Demand</p> <p>International Demand</p>	<p>2013 baseline: 104 (Index 2000=100)</p> <p>2013 baseline: 82 (Index 2000=100)</p>	<ol style="list-style-type: none"> 1. Increase the capacity of the beef supply chain to respond to market demands 2. Support the critical examination of newly developed technologies within a sustainable beef framework 3. Support responsible communication and marketing of production practices that are of interest and concern to the consumer

⁹Includes opportunity cost for unpaid labour

Appendix D

Results from the E-LCA for different functional units

*Note: the results for different functional units **cannot** be directly compared

Potential impacts indicators		Units	Results from Environmental Life Cycle Assessment for different functional units			
			One kilogram of live weight at the farm gate	One kilogram of carcass weight at packers end gate	One kilogram of bone-free meat at packers end gate	One kilogram of packed boneless beef which is then packaged, delivered and consumed
Climate change	Global warming potential	kg CO ₂ eq.	11.4	18.7	24.5	30.8
Resource Consumption	Fossil fuel depletion	kg oil eq.	0.6	1.0	1.4	2.0
	Water depletion	Litres	235.0	382.4	508.3	631.4
Air pollution	Terrestrial acidification	g SO ₂ eq.	124.1	202.4	264.3	327.2
	Photochemical oxidant formation	g NMVOC eq.	16.7	27.9	37.2	47.6
Water pollution	Marine eutrophication	g N eq.	75.8	123.4	160.7	197.6
	Freshwater eutrophication	g P eq.	5.8	9.5	12.5	15.3
Land use	Agricultural land occupation	m ²	93.1	151.5	196.4	240.9

Appendix E

Percent contributions of different life cycle stages to the indicators examined in the E-LCA

Indicators	Life cycle stage contributions to E-LCA indicators (%)						Total (%)
	Farming	Transport to Packing	Packing	Processing	Retail	Consumption	
Greenhouse Gas footprint	74	4	1	6	4	10	100
Fossil Fuel depletion	58	5	6	16	7	10	101
Blue water depletion	74	4	2	6	4	10	100
Agricultural land occupation	77	4	0	5	4	10	100
Marine eutrophication	77	4	0	5	4	10	100
Freshwater eutrophication	77	4	1	5	4	9	100
Terrestrial acidification	76	4	1	6	4	10	100
Photochemical oxidant formation	70	5	2	8	5	9	100

*Note: individual items may not add to the total due to rounding





CANADIAN ROUNDTABLE FOR SUSTAINABLE BEEF

180-6815 8th Street NE

Calgary, AB T2E 7H7

www.crsb.ca Twitter: @CRSB_beef

