GROUPE AGÉCO

UPDATE TO THE CANADIAN ROUNDTABLE FOR SUSTAINABLE BEEF'S (CRSB) NATIONAL BEEF SUSTAINABILITY ASSESSMENT (NBSA)

PRESENTED TO

CRSB
Canadian Roundtable for Sustainable Beef

FINAL REPORT

APRIL 2023

PROJECT TEAM – CANFAX

Brenna Grant, M.Sc.	Project manager
Robyn Paddison, M.Sc.	Analyst
Huiting Huang, M.Sc.	Analyst

PROJECT TEAM – GROUPE AGÉCO

Jean-Michel Couture, M.Sc.	Project manager
Julie-Anne Chayer, Eng.	Project manager
Baishali Dutta, Ph.D.	Senior analyst
Hugues Imbeault-Tétreault, Eng., M.A.Sc.	Quality assurance
Simon Nadeau, B.Sc.	Analyst
Gayathri Valappil, M.ES.	Analyst
Caroline Vanderghem, Ph.D.	Consultant
Ryan Johnson, M.A.	Copyeditor

PROJECT TEAM – SERECON

Robert E. Burden, MBA, CVA, P.Ag.	Industry expert
Markus Weber, MBA, LL.B., P.Ag.	Industry expert
Lisa Loewen, AACI, P.App.	Industry expert

Special thanks to Steven K. Javorek, Matt Grant, Emily Hale, Sarah Pogue, Steven Kega, and Brian McConkey from the Science and Technology Branch at Agriculture and Agri-Food Canada, Edward Bork and Majid Irvani from University of Alberta, Gabriel de Oliveira Ribeiro from University of Saskatchewan, Steve Duff, Megan van Shaik, and James Byrne from OMAFRA, Darryl Gibb from Gowans Feed, Shawn Elgert and Jollin Charest from Alberta Agriculture and Forestry, and to all the farmers and industry representatives who took time to answer the surveys and participate in interviews.

ABBREVIATIONS AND ACRONYMS

AAFC	Agriculture and Agri-Food Canada
ABMI	Alberta Biodiversity Monitoring Institute
ADG	Average Daily Gain
AMR	Antimicrobial Resistance
AMU	Antimicrobial Use
BCRC	Beef Cattle Research Council
BMPs	Beneficial Management Practices
BRD	Bovine Respiratory Disease
CAHRC	Canadian Agricultural Human Resource Council
CAIR	Canadian Agricultural Injury Reporting
CAPI	Canadian Agri-Food Policy Institute
CASA	Canadian Agricultural Safety Association
CCA	Canadian Cattle Association
CFA	Canadian Federation of Agriculture
CFFI	Canadian Center for Food Integrity
CFIA	Canadian Food Inspection Agency
CH_4	Methane
CIPARS	Canadian Integrated Program for Antimicrobial Resistance Surveillance
CLT	Canadian Livestock Transport
CFA	Canadian Federation of Agriculture
CF	Characterization Factor
CO_2 eq	Carbon Dioxide Equivalent
CO_2 we	Carbon Dioxide Warming Equivalent
CRS	Canfax Research Services
CRSB	Canadian Roundtable for Sustainable Beef
CRSC	Canadian Roundtable for Sustainable Crops
CSMOTA	Comité Sectoriel de main-d'oeuvre en transformation alimentaire
CSR	Corporate Social Responsibility
CSS	Carbon Soil Sequestration
DFC	Dairy Farmers of Canada
E-LCA	Environmental Life Cycle Assessment
FAO	Food and Agriculture Organization of the United Nations
FBC	Food and Beverage Canada
FCC	Farm Credit Canada
F:G	Feed to Gain Ratio
FMC	Farm Management Canada
FMS	Farm Management Survey (conducted by Statistics Canada)
FPSC	Food Processing Skills Canada
FU	Functional Unit
GET	Growth-Enhancing Technologies
GHG	Greenhouse Gas
GRI	Global Reporting Initiative
GRSB	Global Roundtable for Sustainable Beef
GWP	Global Warming Potential
GWP*	Global Warming Potential Star

HR	Human Resources
HSM	Habitat Suitability Models
IDF	International Dairy Federation
ILCD	International Reference Life Cycle Data
IPCC	Intergovernmental Panel on Climate Change
KPIs	Key Performance Indicators
kg	Kilograms
L	Litres
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
LCI	Life Cycle Inventory
LEAP	Livestock Environmental Assessment and Performance
LUC	Land Use Change
LMIA	Labour Market Impact Assessment
LMC	Land Management Change
MGA	Melengesterol Acetate
MIA	Medically important antibiotics
Mt CO_2	Mega tonnes of carbon dioxide
Mt CO_2 eq	Mega tonnes of carbon dioxide equivalent
NBSA	National Beef Sustainability Assessment
NFACC	National Farm Animal Care Council
NO_x	Nitrogen oxides
OHS	Occupational Health & Safety
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affairs
PAACO	Professional Animal Auditor Certification Organization
PH&S	People's Health & Safety
PPE	Personal Protective Equipment
RAC	Ractopamine
SAC	Scientific Advisory Committee
SETAC	Society of Environmental Toxicology and Chemistry
S-LCA	Social Life Cycle Assessment
SLC	Soil Landscape of Canada Unit
SOC	Soil Organic Carbon
SO_2 eq	Sulfur dioxide equivalent
TBA	Trenbolone Acetate
TFW	Temporary Foreign Workers
UNEP	United Nations Environment Programme
VBP+	Verified Beef Production Plus Certification
VCPR	Veterinary Client-Patient Relationship
VOC	Volatile Organic Compounds
WCCCSN	Western Canadian Cow-Calf Surveillance Network
WRI	World Resources Institute
WHCI	Wildlife Habitat Capacity on Agricultural Land Indicator

EXECUTIVE SUMMARY

UPDATE OF THE NATIONAL BEEF SUSTAINABILITY ASSESSMENT

This update to the 2016 NBSA of Canadian beef production provides a revised perspective on the environmental and social performance of the sector. The results of this LCA will support the beef industry as they work to meet their 2030 goals by providing valuable recommendations and direction for the coming years.

OBJECTIVES

The Canadian beef sector is one of the main pillars of Canadian agriculture, generating an output of almost CAD$9 billion of farm sales, with exports to more than 50 countries worth $2.8 billion and growing. Aligned with its mission to advance continuous improvement in the sustainability of the Canadian beef industry through multi-stakeholder engagement, collaboration, communication and science, the Canadian Roundtable for Sustainable Beef (CRSB) published the National Beef Sustainability Assessment (NBSA) in October 2016. The objectives of this environmental and social assessment were to present existing sustainability efforts within the industry, implement a science-based monitoring framework, and communicate results of the study to stakeholders. The assessment was conducted using the ISO 14040:2006 and ISO 14044:2006 standard requirements and has been reviewed by an external panel of experts. The CRSB has committed to updating this assessment every 5-7 years to monitor progress and improvement. This assessment contributes to ensuring consumers have confidence in the Canada Beef brand and that Canada remains a competitive global leader in sustainable beef production.

The main objectives of this project are to provide:

- A comprehensive update on the environmental, land use, and social impacts of beef production in Canada.
- The identification of key strengths and weaknesses that should be the focus of research, communication, policy, and other supply chain initiatives.
- Recommendations on action items and beneficial management practices (BMPs) to address these areas of concern or opportunity.

METHODOLOGY

This project applies both environmental and social life cycle assessment (LCA) methodologies.

Environmental life cycle assessment (E-LCA) is a common approach for evaluating the environmental impacts of a product or service and is widely recognized by industries, governments, and the scientific community. It is a systematic quantitative assessment used by organizations to gauge environmental impacts and is guided by the International Organization for Standardization (ISO 14040:2006/14044:2006). An E-LCA's major strength lies in its holistic approach, which includes all relevant environmental aspects of a product life cycle, from resource extraction (cradle) to its end-of-life (grave) or another relevant stage of its life cycle, such as the farm gate or the consumer's plate. E-LCA therefore ensures that major environmental hotspots are considered, and no trade-offs are omitted.

While the E-LCA approach can provide the potential environmental impacts from land use to produce one kilogram of beef, a dedicated approach to ascertaining the complexity of land use impacts in Canada was needed. The land use assessment (LU) included impacts on biodiversity using the Wildlife Habitat Availability on Farmland Indicator model, potential water risks in cattle production regions based on the Aqueduct tool, an evaluation of carbon sequestration based on land management change and land use change, and finally a qualitative evaluation of antimicrobial use by cattle farmers.

The major areas covered in the environmental life cycle assessment and the land use assessment are shown below.

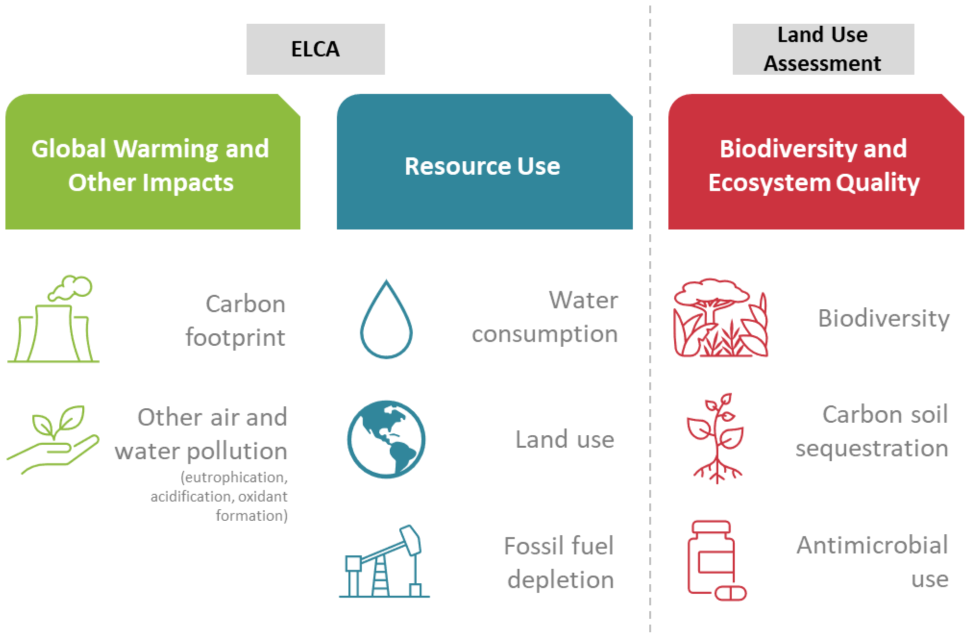


Figure i: Environmental Issues Covered and Related Indicators Considered in the Environmental Performance Assessment.

In this project, the social performance of the Canadian beef industry was assessed to provide an evidence-based assessment of the positive contributions as well as of the potential risks associated with the industry's activities with respect to four priority social issues: Labour Management, People's Health and Safety, Animal Care, and Antimicrobial Use. Similar to an E-LCA, a social life cycle assessment (S-LCA) evaluates the socioeconomic performance of a product at different stages in its life cycle, from cradle to grave. But, instead of measuring the potential impacts of physical processes, the approach can be used to assess the social performance of organizations across the value chain to establish socioeconomic impacts with respect to the organization's main stakeholders and to different social issues. The S-LCA methodology relies on the *Guidelines for Social Life Cycle Assessment of Products and Organizations* (UNEP, 2020).

From a methodological standpoint, this S-LCA innovates by combining different approaches and methodologies. In this sense, it differs to some extent from the approach prescribed in the S-LCA guidelines as well as the one used in 2016. Specifically, three building blocks comprise the methodology used in this assessment. Each is the result of an iterative and stepwise development process. First, a Scoping Phase was performed using a Q-Sort method to identify priority, consensus, and contention issues within the current beef sustainability dialogue through a participatory approach. In conjunction with the Scoping Phase, a framework was developed to document and assess the social performance of Canadian beef farmers with respect to different social issues. This framework was designed to evaluate the degree of social responsibility of Canadian beef producers based on interviews, on-farm and packer surveys and secondary data. Lastly, the results from the Scoping Phase and Practice-Based Assessment were used to inform deep-dive assessments. The deep-dive assessments provide an evidence-based assessment of how, at the Canadian beef industry level, social issues of high priority are managed in a way that positively or negatively impact people (employees; farmers; communities) and animals.

Together, the three phases provide an evidence-based assessment of the positive contributions as well as the potential risks (or hotspots) associated with beef production in Canada and inform practical and action-oriented recommendations to improve the industry's performance over time.

Figure ii: Social Issues and Related Themes Considered in the Social Performance Assessment.

The data collection was carried out in 2013/14 and 2021 for the publication years of NBSA 2016 and 2023, respectively.

E-LCA Results

A carbon footprint of 10.5 kg CO_2 eq per kilogram of live weight was observed in the West (BC, AB, SK, MB), while in the East (ON, QC, Atlantic), a slightly lower carbon footprint of 9.8 kg CO_2 eq per kilogram of live weight was observed. The proportion of enteric emissions of the overall carbon footprint generally increased since 2013/14 because dry matter intake also increased. The dry matter intake increase can be attributed to increased body weights throughout the production system. However, due to reductions in production periods, fewer emissions were released across the production period meaning that enteric emissions were lowered per kilogram of live weight over the past five years. As a result, emissions intensities were reduced by 17% in the West and 20% in the East. In fact, a reduction was observed across all indicators, other than terrestrial acidification, where an increase in impacts was observed, mainly due to ammonia emissions from manure during confinement; these emissions are directly related to feed ration composition differences between 2013/14 and 2021.

According to GWP*, which is not an LCA approach, degradation of short-lived methane from the sector's historical emissions outweighs current methane emissions from the sector. This is due to decreasing methane emissions in the last 20 years, caused both by a reduced herd and increased efficiency in production. Therefore, the overall effect on the climate is a net cooling equivalent to 0.26 Mt CO_2. Further reduction in emissions or herd size could continue the downward trajectory, perpetuating the cooling effect introduced by reduced biogenic emissions. However, it must be kept in mind that the GWP* indicator does not consider how current methane emissions will warm the atmosphere in the future.

The other E-LCA indicators considered in this study are fossil fuel depletion, water consumption, agricultural land use, freshwater eutrophication, terrestrial acidification, and photochemical oxidant formation. In general, values comparable to other beef life cycle assessments were found for each indicator. Some indicators varied slightly, but differences in Canadian production practices can explain these variations. In terms of water consumption, impacts were reduced between NBSA 2016 and this current update using 2021 data in both the West and the East by 68 L per kg live weight. Increased feed efficiency is likely the cause of this reduction because irrigation levels and water consumption for drinking and cleaning remained relatively consistent between the years. Similarly, for land use, impacts were reduced by 6.15 m^2a annual crop eq per kilogram of live weight in the West and 1.89 m^2a annual crop eq per kilogram of live weight in the East due to changes in time on pasture. Overall, improvements have been observed throughout the production stage.

Land Use Assessment Results

Results from the biodiversity assessment indicate that proper grazing management is vital to the continued support beef cattle provide to biodiversity both on reproductive and feeding habitats. In general, higher habitat capacity was found on land cover types used by beef cattle for grazing, rather than annual crops using to produce feed rations. Furthermore, increased habitat capacity was observed where greater proportions of grazing lands were allocated to beef cattle, while reductions in habitat capacity generally occurred where more land was allocated to annual crop cover types, which typically occurs at the cost of natural and semi-natural cover types. This implies that there is a strong link between biodiversity and grazing practices.

The water risk assessment revealed that the highest risks coincided with areas of high cattle density in the Prairies. Saskatchewan, parts of Alberta, and southern Manitoba are especially at risk. Competition among users, including other agricultural stakeholders, is likely to be high in Saskatchewan during periods when irrigation is required. Most of the drought risk was observed in southern Saskatchewan. While droughts are also a common occurrence in Alberta, presence of irrigation infrastructure in the province and growing investments into drought relief mean that the risk is not as elevated as it is for Saskatchewan. A significant risk of interannual variability is present across the country, however, most of it does not coincide with areas of high cattle concentration. It should further be noted that cattle production often occurs on drought-prone lands since crops cannot be grown there.

The results of the carbon soil sequestration assessment were in alignment with the biodiversity findings, indicating that grasslands represent the largest land resource for Canadian beef production. Land used for beef production is estimated to store nearly 66% of the total soil organic carbon (SOC) stock (Mt) on Canada's agricultural land. Beef cattle production uses 40% of agricultural land use with a significant portion of that being in Western Canada. On the other hand, cropland used for cattle feed production represents less than 9% of the total cropland in Canada. The carbon footprint of 10.5 kg CO_2 eq per kilogram of live weight calculated in the E-LCA for the western beef production system is lowered to 9.9 kg CO_2 eq per kilogram of live weight when carbon soil sequestration is considered.

S-LCA Results

In-keeping with the three building blocks comprising the S-LCA methodology devised for this report, namely the Scoping Phase, the Practice-Based Assessment and Deep-Dive Assessment, it led to the identification of key observations associated with positive contributions as well as potential risks for the industry.

With respect to Labour Management, results suggest that labour availability, recruitment and retention are increasing workload levels with potential negative repercussions on people working in the industry. While there is a broad awareness and recognition that labour management is a critical area requiring additional attention from everyone within the industry, each sector of the industry is facing risks related to labour management, with cow–calf operations being perceived as particularly vulnerable. In particular, the adoption rate of practices, which may have the potential to limit the negative repercussions on employees over time, remains low at the farm level. In addition, the assessment suggests that farm and packing plant businesses need to consider innovative approaches to dealing with workload levels and ensuring job satisfaction for the people working in the industry. Besides, recent research shows that immigrant workers at packing plants may face particular risks with respect to their working conditions. The difficulty to attract the younger generation into the industry was also mentioned as a challenge facing packers. To attract and retain employees, businesses often need to adopt practices that go beyond legal requirements. This is particularly the case given the current labour shortage facing the Canadian beef industry. Overall, even if actions are being taken and there is a clear recognition among farm owners and packers, improvements are still needed with respect to labour management.

With respect to People's Health and Safety, the assessment shows that efforts are made by producers and packers to manage safety risks at the workplace. However, health and safety is also identified as an area that can be overlooked and where more dedicated efforts are needed, especially regarding training. Room for improvement remains with respect to the adoption of practices to prevent accidents, particularly on farms. Besides, results highlight that a large proportion of producers experience severe stress due to their on-farm occupation. On the other hand, most farmers are adopting practices to manage their physical and mental fatigue. At the packing level, given the physical and mental strains of their work, the occupational health and safety (OHS) programs are all the more important and a high priority for the industry representatives, especially for at-risk populations.

When it comes to Animal Care, there is a widespread recognition within the industry that healthy animals and welfare are instrumental in ensuring beef operations' financial viability over time. However, areas for improvement remain with respect to certain on-farm practices. In particular, the adoption rates of certain practices, including the uptake and implementation of the Beef Code and the adoption of low-pain/low-stress techniques during typical procedures (e.g., castration) could still be increased. Well-trained workers with experience and knowledge about animal handling practices can have beneficial impacts on animal welfare. In addition, specific areas would require additional scrutiny, including animal transportation (on and off-farm), the management of newly arrived cattle on the farm, and how needle injections are administered. Furthermore, ensuring animal care is a shared responsibility across businesses, sectors, and other stakeholders. As the results of the S-LCA suggest, increased coordination and communication across businesses, sectors, and industries may be needed to ensure animal care throughout the cattle's life cycle as results suggest that coordination is likely suboptimal.

Lastly, the deep-dive assessment of the complex topic of AMU suggests that there is a variety of opinions and perceptions within the industry related to the performance of Canadian beef producers with respect to AMU that may not be fully informed by an objective assessment of the actual situation. This could pose risks to the industry, as these perceptions or beliefs may influence how decisions are made and messages communicated. In addition, results suggest that room for improvement exists with respect to the adoption of management practices associated with AMU, reducing potential risks with respect to optimal use of antimicrobials on the farm.

CONCLUSIONS

In terms of the E-LCA, various indicators were assessed which revealed several "hotspots." The results themselves were generally in the lower-end of the range found in literature and from other national-scale beef assessments. Furthermore, most impacts have been reduced since 2013/14.

The most impactful contributor to impacts was feed rations composition. Feed production and consumption influence a broad range of indicators, both directly and indirectly. Direct energy, water, and chemical inputs for fertilizers and pesticides resulted in feed having the greatest impact on fossil fuel depletion, water consumption, freshwater eutrophication, and photochemical oxidant formation. Feed rations also indirectly contribute to enteric and manure-related emissions, which are the largest hotspots for carbon footprint and terrestrial acidification. Finally, grazing land required to feed animals is the largest contributor to land use. In addition, scenario assessments revealed further information about the beef production system. When regional production practices were compared, it was found that Eastern production was generally lower in impact than Western due to lower land use, less fossil-based energy, and less irrigation. Similarly, yearling-fed production was higher in impact than calf-fed production due to longer production periods, resulting in greater feed and resource consumption. However, different production systems are needed to provide beef twelve months a year in a country dominated by spring calving.

In terms of the land use assessment, the biodiversity assessment revealed the key role that the beef industry plays in preserving biodiversity on grazing lands. Therefore, best management practices must be kept in place to ensure that grazing does not negatively affect wildlife and continues to support wildlife for feeding and breeding purposes.

The water risk assessment revealed that the highest risks coincided with areas of high cattle density in the Prairies. Saskatchewan, parts of Alberta, and southern Manitoba are especially at risk. The assessment indicates that competition among users, including other agricultural sectors, is likely to be high in Saskatchewan during periods when irrigation is required but presence of irrigation infrastructure and growing investments into drought relief could reduce risk.

According to the carbon soil sequestration assessment, the top 30 cm of native grasslands, which is the land cover type used for beef production, contains 40% more soil carbon (Mt) than cropland and 66% more than tame pastures. However, the potential of carbon sequestration (C sequestration) is believed to be finite and thus the beef industry should continue to focus on enhancing the general understanding of rangeland management practices, in particular, how livestock grazing regulates soil carbon storage and sequestration in northern temperate grasslands. Conservation of grassland species largely depends on sustainable cattle grazing practices that can play a valuable role in improving ecological services and wildlife habitat.

Finally, in terms of antimicrobial use (AMU), the qualitative assessment showed that the majority of medically important antimicrobials administered were Category II and III. Certain drugs in these categories, such as macrolides, tetracyclines, and sulfamethazine, could possibly pose environmental risks due to long detection periods and mobility in water based on experimental findings. Appropriate use of catch-basins can prevent run-off from feedlots. The growth enhancing technology (GET) ractopamine must also be appropriately managed. However, the findings of the assessment were inconclusive due to the wide range of drugs within this category.

On the other hand, the S-LCA also provides a wealth of insights on the positive contributions as well as on the potential risks associated with beef production and processing in Canada for the four priority social issues addressed in this assessment.

Specifically, the results reinforce the idea that promoting responsible working conditions throughout the Canadian beef industry is instrumental to sustaining operations and contributing to the mental, emotional, and physical health of the individuals working at each stage of the value chain. That said, the assessment shows that the overall challenge of labour management is experienced differently depending on the sector and the size of the operation, with cow–calf operations being perceived as being particularly vulnerable. Nonetheless, there is a recognition that sound labour management practices are needed to address workload levels and efforts are being made by individual businesses, both at the farm and packing plant levels. To that end, farm and packing plant businesses need to consider innovative approaches to deal with workload levels and ensure job satisfaction for the people working in the industry.

Creating a culture of safety across the beef supply chain and reducing incidents through the support for education, awareness and improvements on farm and ranch safety are among the National Beef Strategy 2030 goals. The assessment shows that efforts are made by producers and packers to manage safety risks at the workplace. However, health and safety is also identified as an area that can be overlooked and where more dedicated efforts are needed, especially regarding training. Mental health is a growing concern in the Canadian farming community and received particular attention in this assessment. Results highlight that a significant proportion of producers experience disturbing stress due to their on-farm occupation. On the flip side, most farmers are adopting practices to manage their physical and mental fatigue. Increased awareness, particularly from the younger generation, also makes this issue less of a taboo.

Promoting excellence in animal care is one of CRSB's sustainability goals. As such, the topic received particular attention within the Canadian beef industry over the years, with tangible and positive results. However, areas for improvement remain with respect to certain on-farm practices. In addition, specific areas would require additional scrutiny, including animal transportation (on and off-farm), the management of newly arrived cattle on the farm, and how needle injections are performed. Also, increased coordination and communication across businesses, sectors, and industries may be needed to ensure animal care throughout the cattle's life cycle.

Lastly, the assessment highlighted that while the presence of regulations at the federal level provides confidence that producers are doing the right things with respect to antimicrobial use (AMU), different perceptions exist as to the current situation taking place in the Canadian beef industry. Results also show that ensuring the optimal management of AMU requires well-informed on-farm decisions and evidence suggests access to additional resources would be needed at the farm level. In this respect, results show that room for improvement still exists at the farm level.

Recommendations

Several recommendations for the Canadian beef sector and its future endeavours came from this assessment, both from an environmental and a social perspective.

Based on the E-LCA and LU assessments, the following recommendations can be made:

- Optimization of both feed quantities and nutrients to make feed to gain ratios more efficient and reduce emissions.
- Similarly, inputs associated with feed production, such as fertilizers, pesticides, and energy, are also of concern. Beneficial management practices being implemented at the level of crop production would reduce impacts further along the value chain.
- Efficiency measures for irrigation should be in place in the Prairies to both reduce water use and reduce drought-related vulnerability. Additional trade-offs, including the impacts of importing feed from regions requiring less irrigation, could also be considered in future assessments.
- Finally, grazing plays an important role for biodiversity and grassland for carbon soil sequestration, but proper management is key. Some beneficial management practices that are growing in importance in the industry include rotational grazing, understanding of stocking capacity and grazing days per acre, and soil health. These aspects should be further examined through technical assessments to understand their influence.

On the social side, key recommendations include the following:

- Put people's well-being at the forefront of the CRSB's sustainability agenda.
- Document the motivations for and the expectations of the younger generations to work in the Canadian beef industry.
- Build on research results regarding mental health and the main stressors affecting beef producers' and their employees' well-being to develop/promote targeted and adapted resources.
- Document the lessons learned during the COVID-19 pandemic regarding labour management, in particular at packing-plant level, to identify opportunities to improve employees' safety and well-being.
- Establish clear expectations as to what basic practices are expected to take place on farms regarding health and safety, in particular vis-à-vis vulnerable groups of employees (e.g., basic specifications to be added in work contracts and/or job description).
- Take advantage of the publication of the new Beef Code (to be updated in 2023 and released in 2025) to inform and train producers and their employees about best practices for animal care.
- Along with the publication of the upcoming Transportation Code, collaborate with packers, feedlot operations and transport companies to ensure best practices are in place and channels are established to provide feedback and continuous improvement of animal care.
- Investigate the potential impacts and risks associated with labour shortage on the industry's ability to meet and maintain performance in animal care.

- Research the drivers and success factors associated with the adoption of key BMPs among VBP+ certified producers and explore how they could be applied to conventional beef farmers.
- Promote awareness of the resources available that outline responsible antimicrobial use within the industry for industry stakeholders and consumers.
- Collaborate further with industry members to improve communication and transparency between cattle buyers and sellers and explore incentives to support practices that target responsible antimicrobial use.

It is apparent that the recommendations go beyond the boundaries of beef production itself to include upstream value chain members, particularly crop producers. Deepened communication between all players would serve as a valuable and strategic tool moving forward as the beef industry continues to manage and improve its environmental performance.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. OBJECTIVES AND METHODOLOGY

1.1 INTRODUCTION AND CONTEXT

The Canadian beef sector is one of the main pillars of Canadian agriculture, generating an output of almost CAD$9 billion in farm sales, with exports to more than 50 countries of $2.8 billion and growing. The market is evolving, and the entire value chain of the Canadian beef industry is seeking to conduct business more ethically and to adopt environmentally sound and responsible practices to meet the expectations of customers and stakeholders. With the growing demand for sustainable and responsible food, such a commitment is important. The Canadian beef value chain takes responsibility in sustainably managing resources; however, it also recognizes that quantification of sustainability indicators and proof of continual improvement is important for the future success of the industry.

Aligned with its mission to advance continuous improvement in Canadian beef industry sustainability through multi-stakeholder engagement, collaboration, communication and science, the Canadian Roundtable for Sustainable Beef (CRSB) published the National Beef Sustainability Assessment (NBSA) in October 2016. The objectives of this environmental and social assessment were to present existing sustainability efforts within the industry, implement a science-based monitoring framework, and communicate results of the study to various stakeholders. The assessment was conducted using the ISO 14040:2006 and ISO 14044:2006 standard requirements and has been reviewed by an external panel of experts. The CRSB has committed to updating this assessment every 5-7 years to monitor progress and improvement. This assessment helps to ensure that consumers have confidence in the Canada Beef brand and that Canada remains a competitive global leader in sustainable beef production.

A National Beef Sustainability Strategy accompanied the assessment and was the first step in developing a comprehensive approach to advancing initiatives that will further enhance the sustainability of the Canadian beef industry. An interim report was published in January 2020 and showed the progress that has been made in building a stronger and more united beef sustainability community and increasing awareness of sustainable beef production. The purpose of this current report is to update the 2016 NBSA and to discuss progress and fill gaps from the previous assessment using the most current data and methodologies available. The data collection was carried out in 2013/14 and 2021 for the publication years of NBSA 2016 and 2023, respectively.

From food safety to environmental protection, animal care to international trade, and antibiotic use to farm labour retention, a comprehensive and integrated approach is needed to foresee and mitigate risks, create opportunities in the industry, and build trust.

1.1.1 KEY STRATEGIC UPDATES

In addition to the elements included within the scope of the assessment from the 2016 NBSA, this updated project includes various new elements and analyses meant to add depth to the results. This includes dairy cattle production as a case study to the carbon footprint assessment to account for culled dairy cows and other dairy animals that enter the beef system. Next, the key topic of antimicrobial resistance (AMR) is included. Because of its importance, it is considered in both the environmental and social assessments, looking at how and why drugs and growth-enhancing technologies are used, and their potential implications on animal health and ecotoxicity. Finally, mental health is considered within the S-LCA because of the growing awareness of its importance throughout the industry.

1.2 Goals of the Study

1.2.1 Objectives

This project comes at an opportune time for the industry. This assessment will not only support the development of strategic goals for the beef industry, but it will also formulate recommendations to help them meet their 2030 goals and benchmark performance against past years. The data collection was carried out in 2013/14 and 2021 for the publication years of NBSA 2016 and 2023, respectively.

The **main objectives of this project** are to provide:

- A comprehensive update on the environmental, land use, and social impacts of beef production in Canada.
- The identification of key strengths and weaknesses that should be the focus of research, communication, policy, and other supply chain initiatives.
- Recommendations on action items and beneficial management practices (BMPs) to address these areas of concern or opportunity.

1.2.2 Intended Application and Audience

The intent behind conducting and publishing assessments such as these is to support the Canadian Roundtable for Sustainable Beef's (CRSB) vision of the Canadian beef value chain being a "global leader in environmental, social, and economic sustainability and part of a trusted and thriving food system." The findings of this study may be used to target and improve the beef production system, from environmental, social, and economic perspectives. This includes a wide range of environmental challenges, such as global warming, biodiversity, and water use, as well as social issues such as working conditions, health and safety, and animal care. Furthermore, identification of these hotspots can lead to meaningful recommendations and objectives for both future research and decision-making. The intended audience of this study is therefore members of the CRSB, which include representatives across the entire beef value chain, as well as the public and consumers interested in the environmental implications of their dietary choices.

Note that the National Beef Sustainability Assessment (NBSA) is not meant to compare beef production systems external to Canada. Furthermore, the study does not intend to substantiate comparative assertions to the public. Instead, it serves to provide a benchmark of the social, economic, and environmental impacts of the Canadian beef industry. The reproduction of any part of this report must be done with the written authorization of the CRSB. Hence, the study does not intend to directly support comparative assertions with respect to beef production external to Canada intended to be disclosed to the public.

1.3 Overview of the Assessment

The following section provides a general overview of the E-LCA, land use, and the S-LCA.

In this study, three main environmental areas of concern were assessed: global warming, resource use, and biodiversity and ecosystem quality (*see* Figure 1-1). Each indicator used to assess or quantify the risk associated with these issues combined qualitative and quantitative approaches and are contained within either the E-LCA or the LU assessments. In addition, four key social issues were considered in the S-LCA to identify positive contributions and potential risks using qualitative approaches: labour management, people's health and safety, animal care, and antimicrobial use.

1.3.1 Environmental Life Cycle Assessment (E-LCA)

Environmental life cycle assessment (E-LCA) is a commonly used approach for evaluating the environmental impacts of a product or service and is widely recognized by industries, governments, and the scientific community.

An E-LCA's major strength lies in its holistic approach, which includes all relevant environmental aspects of a product life cycle, from resource extraction (cradle) to its end-of-life (grave) or another relevant stage in its life cycle, such as the farm gate or the consumer's plate. E-LCA therefore ensures that major impact pathways are considered, and no trade-offs are omitted.

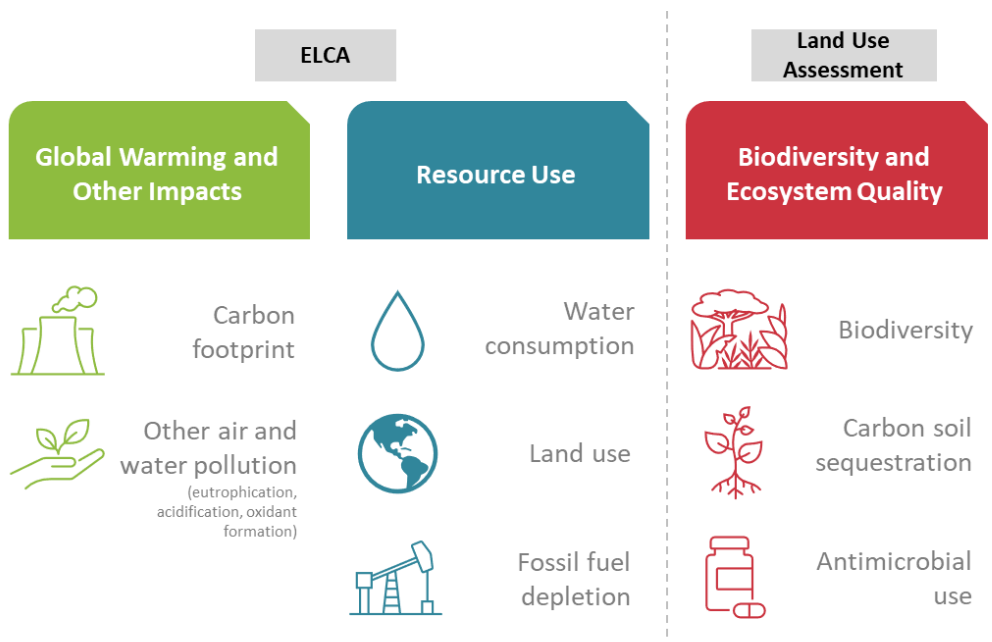


Figure 1-1: Environmental Issues Covered and Related Indicators Considered in the Environmental Performance Assessment.

The E-LCA followed the most rigorous methodology available. For example, in accordance with the LEAP guidelines, the methodology developed by the Intergovernmental Panel on Climate Change (IPCC, 2019) was used to evaluate manure emissions, as well as emissions from feed production. For the carbon footprint indicator, the conversion of different greenhouse gases in kilograms of CO_2 eq was based on the global warming potentials published in the Fifth and Sixth Assessment Reports of the IPCC (IPCC, 2013, 2021). Similarly, the water consumption indicator was calculated in accordance with the ISO 14046:2014 standard on water footprint (ISO, 2014).

1.3.2 Land Use (LU) Assessment and Other Indicators

While the E-LCA approach can provide the potential environmental impacts from land use to produce one kilogram of beef, a dedicated approach to ascertaining the complexity of land use impacts in Canada was needed. For this reason, the 2016 NBSA defined a "land use assessment" to focus on Canadian beef land use impacts related to four important areas of concern that are of growing interest to the industry: biodiversity, water risk, carbon soil sequestration, and antimicrobial use.

These assessments were done on a macro level, looking at a holistic view of the environmental impacts of the Canadian beef industry, not just its intensity. The land use assessment (LU) not only evaluated the total area of land used for the Canadian beef production but also included information on the location and the type of land use (pastures and croplands). The biodiversity assessment evaluated the contribution of the beef industry to land habitat capacity. The water assessment was divided into two parts in 2016: water consumption and water risk, using the Aqueduct tool. This report presents the update to these assessments and includes a carbon sequestration evaluation based on land management and land use changes with updated estimates of soil carbon stocks.

A fourth issue impacted by land use and treated as a separate indicator is added to this study in addition to the previous assessment: antimicrobial use. Research at Agriculture and Agri-Food Canada (AAFC) is currently ongoing regarding the occurrence of antimicrobials (AMs) and growth enhancing technologies (GETs) excreted by cattle into the environment, as well as their dissipation through different manure management practices and their potential endocrine disrupting effects (Larney & Jones, 2021). This study will take a qualitative approach to assessing the use rates of various AMs and GETs across the country and to discussing insights from the literature on how to handle environmental risks.

1.3.3 Social Life Cycle Assessment (S-LCA)

An S-LCA is a "technique that aims to assess the social and socioeconomic aspects of products and their potential positive and negative impacts along their life cycle" (UNEP Setac Life Cycle Initiative, 2009).[1] Similar to an E-LCA, an S-LCA evaluates the potential socioeconomic impacts of a product at different stages in its life cycle, from cradle to grave. But instead of measuring the potential impacts of physical processes, the approach can be used to assess the social performance of organizations to establish socioeconomic impacts with respect to the organization's main stakeholders (i.e., workers, the local community, business partners, etc.) and to different social issues (e.g., working conditions, local commitment to animal welfare and agri-environmental practices).

This approach offers a systemic assessment framework that combines quantitative and qualitative data. An S-LCA provides information on social and socio-economic aspects for decision-making, with the aim of improving the performance of an organization and ultimately the well-being of stakeholders.

In this project, the social impacts of Canadian beef farming and associated businesses was assessed according to four priority social issues for the Canadian beef industry. The selection of these four social issues and related themes was established through an iterative process in collaboration with CRSB and the Science Advisory Committee (SAC), and based on different sources, including the 2016 NBSA report, existing industry standards, the results of the on-farm data collection, interviews with industry representatives, and expert opinions (*see* Figure 1-2).

[1] By extension, S-LCA tool is also applicable to a service, a sector, or an organization.

Figure 1-2: Social Issues and Related Themes Considered in the Social Performance Assessment.

1.4 SCOPE OF THE STUDY

This section presents a general description of the environmental (E-LCA and land use assessments) and social assessments carried out in this study.

Establishing the scope is an important step of a life cycle assessment that involves describing and schematizing the processes and stages in the product system life cycle and identifying the main study assumptions and parameters, such as function(s) and functional unit(s) under study, system boundaries, data requirements, allocation procedures, indicators, and impact evaluation methods. From an S-LCA perspective, this step also involves mapping the value chains (upstream and downstream of beef producers) that constitute the system, identifying (by activity and region) the organizations to assess and defining the stakeholder categories and impact categories to consider in the assessment.

1.4.1 GENERAL SYSTEM DESCRIPTION & SYSTEM BOUNDARIES

The system boundaries determine the life cycle stages, processes, and flows considered in the LCA and include all activities relevant to meeting the objectives of the study. They are therefore necessary to perform the specified function.

The E-LCA study assesses the life cycle of the Canadian beef industry, from calf-fed animals and yearling grassers to the consumer. A separate case study was conducted to assess the beef industry when animals coming from the dairy sector are considered. Figure 1-3 presents the key life cycle stages (beef cattle production, dairy cattle production, slaughter and primary packing, secondary packing and processing, retail, and consumption) to be included in the system boundaries, as well as the main inputs, processes, and transport. Secondary meat processing and packaging were included within the study, meaning secondary packaging required to retail products that are then purchased by consumers. Additional transformation where raw beef is further processed into other final products (Bolognese sauce, sausage, lasagna, etc.) was excluded from the study. Furthermore, all beef meat co-products (e.g., hides, fats) and wastes (e.g., blood) produced during slaughter and processing were excluded from the study to maintain consistency with the 2016 assessment. Within each of the stages, the LCA considers all identifiable upstream inputs to provide a comprehensive view of the production system.

The system boundaries assess the life cycle of beef production from farming to consumption. Apart from the addition of dairy cattle production in the case of the E-LCA, the system boundaries of the 2023 NBSA were kept consistent with those of the 2016 assessment whenever possible.

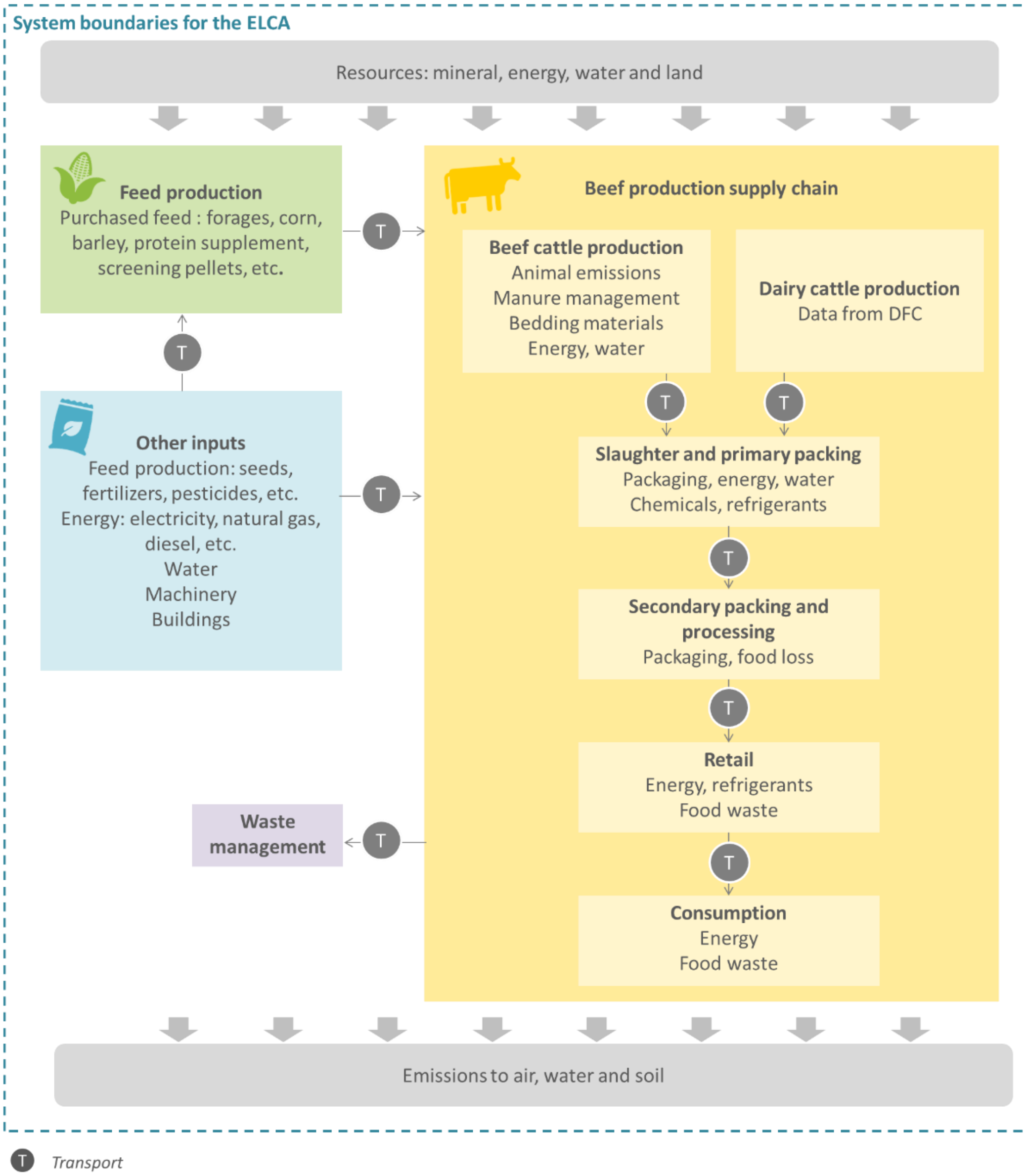


Figure 1-3: Boundaries of the cradle-to-farm gate Canadian beef production system modelled in the life cycle analysis.

As mentioned, dairy cattle were included in the scope of the E-LCA solely for the carbon footprint assessment. Dairy cattle production is part of the milk production system. The Dairy Farmers of Canada (DFC) updated the sector's LCA in 2018. Part of the milk production system is allocated to milk and another to meat. The latter part has been included as a separate scenario assessment in the 2023 NBSA. A separate scenario assessment was chosen to account for methodological differences between the DFC LCA and the current assessment on carbon footprint. It should be noted no other indicators are considered with respect to the inclusion of the dairy cattle. More details on the methodology applied for the inclusion of dairy are provided in Appendix B.1.

System boundaries associated with modelling of the Canadian beef production system varies throughout literature. The full description of the Canadian beef production system, including the farming practices, and the modeling pathway of the farming stage has been kept consistent with the previous assessment. In the previous NBSA, the model of the yearling-fed system, accounting for 55% of Canadian beef cattle production, included cow–calf operations, backgrounding, and finishing in a feedlot. However, backgrounding was divided into backgrounders and yearlings to differentiate between animals that spend more time on feed than pasture (backgrounders) and the animals that spend time more time on pasture than feed (yearlings) before reaching the finishing stage. Similarly, the calf-fed system included cow–calf operations and finishing in feedlots, with this model accounting for 45% of beef cattle production in Canada.

The product system differs however slightly between an S-LCA and an E-LCA. For simplification and access to data, the scope of an S-LCA product system usually includes only the most important and relevant value chains and organisations, whereas the product system in an E-LCA is more exhaustive. Hence, the definition of an S-LCA product system first requires identifying the organisations involved in each value chain included in the product's life cycle. In the 2016 assessment, cattle operations, processors, upstream and downstream value chain, associations of beef producers and processors, and national (legal and regulatory environment) organizations were considered.

For this assessment, the 2016 scope was revisited to provide more targeted, specific, as well as practical insights on the industry's performance in keeping with the objective of informing its sustainability strategy. To do so, the assessment is focused on activities that are taking place in Canada and specific to beef production, i.e., raising livestock (including the cow–calf, backgrounding, finishing stages) and packing operations. Therefore, upstream (e.g., input production and distribution) and downstream (e.g., retail and food services) operations and the market actors conducting them were not directly part of the assessment. That said, the social performance of the upstream and downstream business partners with respect to social issues (including transport companies, producer associations and veterinarians), is discussed with respect to how these issues are faced and managed by producers and packers.

1.4.2 Functional Unit and Reference Flows of E-LCA

Functional unit

Functional units are a key component to life cycle assessments (LCA). They are the unit according to which all impacts are calculated and reported across the life cycle of a product or system. Selection of an ideal unit varies depending on common practices in the field of study, the potential application of the results, and the necessity of comparison to other products. The function of the beef production system is to produce boneless beef meat to be packaged, delivered, and consumed. However, assessment of impacts across the value chain are relevant for the purpose of communication. Therefore, in this case, the functional units considered in the study were **1 kg of live weight**, **1 kg of beef carcass,** and **1 kg of boneless packaged beef product**, all produced in Canada (presented in Figure 1-4). In addition, a functional unit meant to be valuable to consumers was desired because they are one of the key audiences of this study. For this reason, **1 serving of beef** was selected to help consumers understand how weekly or daily consumption of beef affects their environmental footprint.

The main functional unit of 1 kg of live weight will be the primary focus of the report, but the additional functional units are added to enable a deeper understanding of the different stages of beef production and aid interpretation. A typical serving size of 100 g of boneless and consumed beef is therefore also included as a functional unit. Impacts were calculated for each functional unit based on both Western Canadian production and Eastern Canadian production, as well as a weighted average to gauge national performance. These functional units are depicted in the following figure.

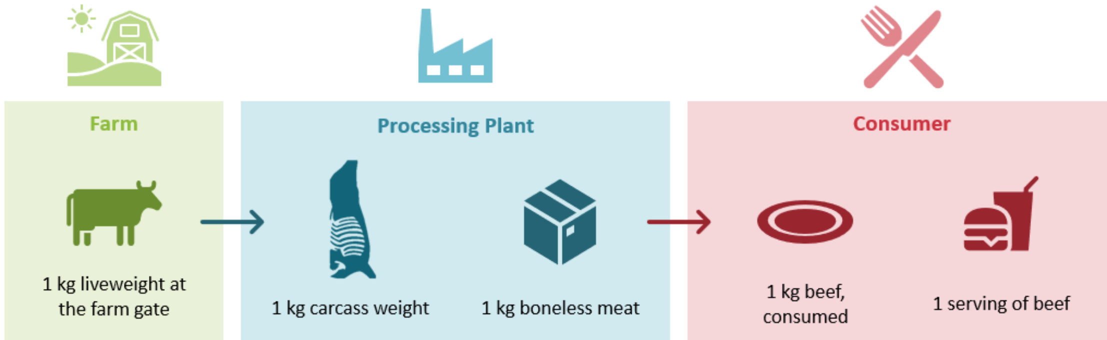


Figure 1-4: Functional units assessed in the study.

In this case, each of the functional units presented are mass-based. Additional product functions are not within the scope of the study. Furthermore, a mass-based functional unit, particularly based on live weight and carcass weight, is of interest to the CRSB as it fits within their communication goals. Moreover, the beef assessed in this study is meant to represent average Canadian production, including both intensive and extensive systems. Emphasis on other types of production, such as organic, are not within the scope of the study.

It should be noted that in the field of agri-food LCA, there is growing interest in nutrition-based functional units. These indices are a way of capturing nutrient density (Bianchi et al., 2020). Calories are another option. However, they are not always representative enough of the function of food products. For example, people do not eat certain foods just for the calories or energy, rather they eat food for a variety of other sociocultural and health-related factors. Therefore, a nutrient index which balances micro and macronutrients relevant to beef, such as protein, B12, riboflavin and so on, could help to better capture the function of beef. In existing research, however, nutrient indices have only been used to compare entire diets, for example, a comparison between a conventional and a vegetarian diet. They have yet to be created and applied for a single food product. Therefore, at this time, the study does not include the emerging functional unit methodology of nutrient indices, however, it should be revisited for future studies as the field develops.

Impacts of the meat production as a co-product of dairy production were not accounted for in the previous assessment. In the updated assessment, the impacts related to meat production from culled dairy animals were allocated to the beef production system. Further details of the allocation methodology are described in Appendix B.1.

Contrary to the E-LCA, this S-LCA follows a practice-based approach to provide a qualitative and evidence-based assessment of the performance of the Canadian beef industry. Consequently, and in-keeping with the 2016 assessment, results are not reported according to a functional unit or summed up across life cycle stages. Similarly, no reference flow is defined with respect to the functional unit.

System Description

The study aimed to capture a wide variety of production systems present in Canada. Primarily, calf-fed (45% of production) and yearling-fed (55% of production) systems are modelled. The calf-fed system includes heavier calves with end-weights of 575 lbs being sent immediately to finishing. They are typically ready for slaughter between 14–15 months of age. The yearling-fed system includes animals that are backgrounded and grassed in between the calf and finishing phases. To account for animals in the backgrounding phase that spend more time on feed or more time on pasture, they are modelled sequentially as both yearlings and backgrounders for the purpose of this study.

The system description including the start and end weights, the stage durations, and the average daily gains (ADG) (lbs/day) are shown in Table 1-1. To consider the full cycle of production, the previous NBSA methodology accounted for the impacts of the animal at the various stages of its growth (cows, the bulls and replacement animals that enabled the production of this finishing animal), which comprise the animal cohort.

Table 1-1: System descriptions for calf-fed and yearling-fed systems

2021

Calf-Fed System	45%	*From cow/calf to finishing directly.*					
	Start Weight (lbs)	**End Weight (lbs)**	**Duration (days)**	**ADG (lbs/day)**	**Stage**	On Pasture (days)	On Feed (days)
WEST	99	575	205	2.32	*Cow/Calf*	188	17
	575	1440	270	3.20	*Finishing*	0	270
EAST	99	575	200	2.38	*Cow/Calf*	166	34
	575	1450	270	3.24	*Finishing*	0	270

Yearling-Fed System	55%	*After cow/calf goes to backgrounding before finishing.*					
	Start Weight (lbs)	**End Weight (lbs)**	**Duration (days)**	**ADG (lbs/day)**	**Stage**	On Pasture (days)	On Feed (days)
WEST	99	500	205	1.96	*Cow/Calf*	188	17
	500	800	150	2.00	*Backgrounding*	38	113
	800	1000	100	2.00	*Yearling*	92	8
	1000	1500	140	3.57	*Finishing*	0	140
EAST	99	500	200	2.01	*Cow/Calf*	166	34
	500	800	150	2.00	*Backgrounding*	11	140
	800	1150	120	2.92	*Yearling*	58	62
	1150	1600	130	3.46	*Finishing*	0	130

In terms of the annual cohort being modelled, a similar methodology to NBSA 2016 is also applied here. The various subcategories of cattle defined for the purpose of this study could not be quantified through Statistics Canada, which uses more general categories. Therefore, a cohort multiplier was defined for each subcategory and multiplied by the annual total slaughter value reported by Statistics Canada. The basis of each cohort multiplier was based on the general categories. The main categories of cows, calves, backgrounders/yearlings, and finishers each had a base number of 1, as shown in the following image (*see* Figure 1-5). Then, depending on if males and females of the category were modelled, the numbers were divided into halves or quarters. From these base numbers, replacement rates, mortality rates, and other loss rates were included in the base number. For example, for calves with a mortality rate of 3.3% and a base value of 1, the cohort multiplier was the base number divided by one minus the mortality rate, giving a value of 1.034. Repeating this process for each cattle type provided a ratio of each type relative to the other in the cohort system. It captured and compounded the number of animals of each category required to produce one finishing animal and 0.13 culled cow based on individual mortality rates. Using these values, total slaughter numbers for each cattle subcategory could be obtained to quantify the overall annual impact of the total Canadian cattle cohort. The cohorts considered for both reference years of 2013/14 and 2021 are shown below.

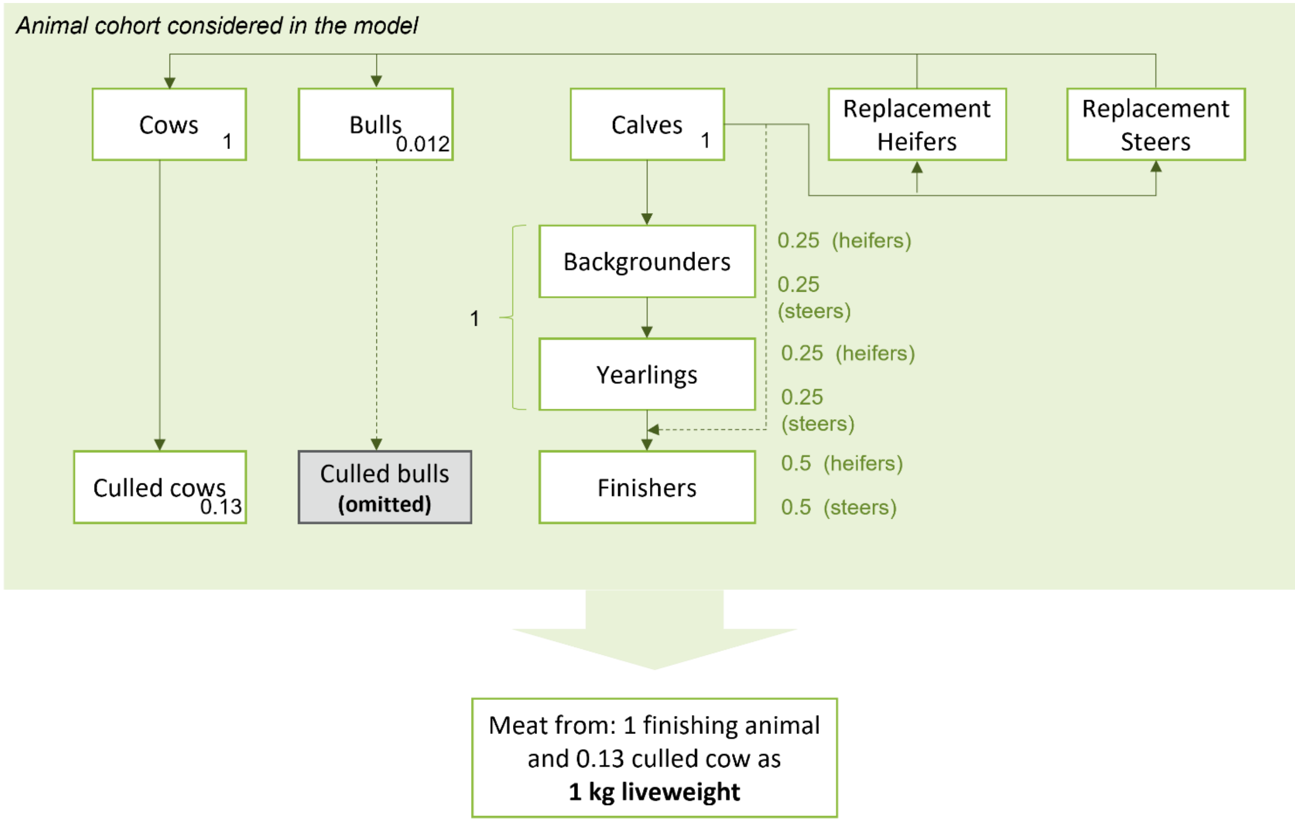


Figure 1-5: Cohort modelled to represent the Canadian cattle system in 2013/14 and 2021.

In order to model the various animal types, the base values shown in the figure above were multiplied by the numbers of total production days for that animal category, as shown in Table 1-1. This resulted in a cohort multiplier for each animal category and these values were the basis of all impact calculations. For feed, for example, cohort multipliers were multiplied by the ratio of time on feed to total time (on feed and pasture) and multiplied again by the daily emissions (or impacts) from the consumption of feed rations of that specific animal category. A similar process was followed keeping daily methane and manure-related impacts, daily water depletion, etc. Therefore, in general a daily equivalent impact was determined for each animal category and using the cohort and days described above, overall impacts over the life cycle of the animal until slaughter were determined. Then, in order to get the impact per 1 kg liveweight, the sum of impacts from each animal category was divided by the total liveweight exiting the cohort, specifically the weight of 1 finishing animal and 0.13 culled cow. Also, note that replacement rates do not affect the LCA model but are presented in Figure 1-5 only for visual representation and is an aggregate of the mortality rates.

The system considered in the S-LCA is focused on individual businesses operating at the production and processing stages. The S-LCA does not differentiate between production systems. That said, the on-farm survey presented the opportunity to document the certifications or production attributes participating producers were under (e.g., CRSB certified or VBP+ audited). This information was used to contextualize results and compare them to other datasets whenever appropriate. Also, given the national scope of the assessment and in-keeping with the 2016 NBSA, only the activities of federally inspected packing plants were considered in the assessment.

1.5 Temporal and Geographic Boundaries

The system boundaries presented in Figure 1-3 determine the life cycle stages, processes, and flows considered in the E-LCA and include all activities relevant to attaining the study objectives. The study is intended to represent the Canadian beef production in 2021. The collected data describes 2021, in agreement with the

Scientific Advisory Committee, considering the impact of COVID-19 on the value chain in 2020. The study assumptions are based on the equipment, processes, and market conditions of 2021. The first NBSA had 2013 as its historical reference year.

In addition, certain processes may generate emissions over a longer period than the reference years. For instance, fertilizer application in agricultural fields may lead to nitrous oxide (N_2O) being emitted to the air years after the causal application. For the purpose of this study, these emissions are considered as having been emitted during the year of activity.

Since the study represents beef produced in Canada, data collection and process modelling aim to be as representative of the national context as possible, considering the provincial specificities of beef production. For example, unit processes used in the modelling rely on an electricity grid chosen based on the location of the activity. This is also true of feed crop production, which was modeled on a regional level. However, less representative data have been used as estimates for parts of the supply chain that have little influence on the results. This is documented in the data quality assessment section (*see* Section 2.1.7).

As for the S-LCA, the assessment only covers activities taking place in Canada. Most primary data were collected to document practices in place in 2021. Only secondary data published after 2016 were considered in the analysis.

1.6 Data Collection

The data collection was carried out in 2013/14 and 2021 for the publication years of NBSA 2016 and 2023, respectively. In addition to the primary data, secondary data was also necessary to complete the assessment. In the case of the environmental life cycle and land use assessments, the majority of data used was secondary, either from literature or from consulting with experts. The primary data used pertained to areas where secondary data could not be obtained or validated. This included manure management practices, processing water requirements, and use of antibiotics and growth-enhancing technologies. For the most part, these values were obtained from the survey or taken from the previous assessment. In cases where values from the previous survey were used, interviews with experts were conducted to validate the values and ensure they were not outdated. All secondary data used in the E-LCA and LU assessment is either described in Section 1.6 or in Appendix D.

Regarding the S-LCA section, an iterative approach combining primary and secondary data was used for the assessment. Given the lack of databases that cover and record, on a regular and systematic basis, social issues at a sector or organization level that could be used to inform the assessment, this S-LCA relies to a large extent on primary data collected through interviews and surveys. Secondary data from industry standards, national and provincial databases, and existing literature were used to inform the primary data strategy (e.g., development of the on-farm survey, interview guides), but also to complement the assessment.

Specifically, the primary data collection strategy was comprised of 4 key activities:

- A Q-Sort was conducted among a diverse group of 39 purposively sampled beef industry stakeholders as part of the scoping report to prioritize sustainability issues in relation to one another (for more information about the Scoping Report, *see* Appendix C.1)[2].

[2] Of the 39 respondents involved in the scoping phase of the assessment, 22 were male (56%) and 17 were female (44%). Respondents identified as veterinarians (18%), human nutritionists (5%), ruminant animal nutritionists (5%), agricultural researchers (5%), retail employees (5%), processing plant employees (15%), farm employees (21%), agricultural business owners (15%), government employees (8%) and non-governmental organizations (3%). Seventy-nine per cent of respondents were from Western Canada (i.e., British Columbia, Alberta, Saskatchewan or Manitoba) and 21% were from Eastern Canada (i.e. Quebec, Ontario, Maritimes). Respondents 35 to 44 years of age (33%) were the largest age cohort, however, others were between 18 to 24 years (3%), 25 to 34 years (18%), 44 to 54 years (28%), 55 to 64 years (13%), or over 65 (1%).

- An on-farm survey was communicated to Canadian beef producers to document their practices with respect to social topics including labour relations, health and safety, stress management, community relations, animal welfare, animal health, management, and agri-environment. The survey included 65 questions, most of which were practice-based. The survey was available in French and English, and prizes were drawn among participating Canadian beef farmers to encourage their participation in the survey. The link to access the survey was shared with producers by CRSB via different media platforms (e.g., LinkedIn, Facebook and newsletters). A total of 333 Canadian beef producers from across the country completed the survey.
- Interviews were conducted among industry representatives and key informants. The objectives of these interviews were to document and validate current performance, challenges and opportunities facing the Canadian beef industry, to understand what major improvements took place in the industry over the past five years and to get insights on what the industry should or could be doing in the next five years. Each interview took about 60 minutes to complete. The interviewees were identified and contacted by the CRSB to participate. A total of 15 interviews were completed with representatives of producer associations (five interviews), CRSB members (six interviews) and packers (four interviews). The qualitative information from these interviews was used to complement the data available in the literature. Finally, five additional discussions took place to collect insights on particular issues.
- Lastly, two surveys were prepared for packers to document practices taking place at the facility-level. The information from these surveys was meant to complete the insights collected through the interviews. One survey was about animal care and the other about human resources management. A total of five surveys were completed by three individual companies (three surveys were completed on HR Management [covering four facilities] and one survey was completed on animal welfare. As for the on-farm survey, the CRSB oversaw inviting packers to participate.

For more information about the primary data collection activities, including the profile of survey respondents and interview participants, the survey and interview material, as well as an analysis of the limitations and caveats, see in Appendix D.4.

To limit the burden on producers and packers, particular attention was paid to focus the primary data collection on topics that could not be documented otherwise using secondary data. For instance, the French and English versions of the questionnaires were submitted, discussed, and approved by CRSB and industry experts. The final approval was done by the SAC members before the survey was launched. Three pretests also took place with companies at the production level. To ensure data quality, primary data values (e.g., survey results) were also cross-checked primary with secondary data sources (e.g., Statistics Canada). The quality and uncertainties relating to the data, as well as the consequences they have on the results of the E-LCA and the other assessments were discussed with CRS, SAC members and matter experts.

Secondary data mainly consisted of a literature review of recent peer-reviewed articles published after 2016, industry standards (e.g., VPB+, CRSB standards) and publications (i.e., reports, studies), websites and sustainability reports of CRSB members and industry associations as well as industry publications (e.g., newsletters, printed articles). In addition, results from other surveys conducted among Canadian beef farmers were considered to inform the assessment and compare results whenever appropriate (e.g., Western Canadian Cow-Calf Survey, Ontario Cow-Calf Production Survey, Atlantic Cow-Calf Production Survey, Northern Beef Study: Northern Ontario and Northern Québec Cow-Calf Production, etc.). This includes data from VBP+ and the most recent data from the Census of Agriculture 2021. These different sources are referred to in the assessment below (*see* Section 2.2).

1.7 Environmental Life Cycle Impact Assessment (LCIA) Methods and Indicators

The following section presents each environmental indicator reported in this study, as well as the general methodology applied. The results presented here includes those related to the data collection was carried out in 2013/14 and 2021 for the publication years of NBSA 2016 and 2023, respectively. Additional details pertaining to the methodology are presented in Appendix D.

The life cycle impact assessment (LCIA) classifies and combines each product system's input and output flows of materials, energy, and emissions by the type of impact their use or release has on the environment. These flows, which interact with the environment, are then evaluated for the potential effects they may have on different environmental issues. The method used in this assessment is a combination of ReCiPe Midpoint (H) 1.06 and IPCC 2021 GWP-100, including fossil, biogenic, and land transformation emissions.

The LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks. No data normalization was completed to avoid impact category comparisons. In addition, the indicators were not weighted, and all damage categories were considered separately to avoid aggregation, which can bias the interpretation of the results.

The indicators of relevance in this study are as follows:

- **Global warming (referred to as carbon footprint)**, as per IPCC 2021 (AR6). Further description of this indicator is available in Section 1.7.1.
- **Midpoint indicators** using the impact assessment methods described previously. This includes fossil fuel depletion, water consumption, agricultural land occupation, freshwater eutrophication, terrestrial acidification, and photochemical oxidant formation. These indicators were selected due to their relevance to the beef industry and to be consistent with the 2016 NBSA.

Furthermore, all indicators and impact assessment methods employed were chosen to be consistent with other environmental assessments of beef found in literature, the LEAP Guidelines, as well as to remain relevant to the study's geographic boundaries.

1.7.1 GLOBAL WARMING

Global warming is defined as by the IPCC (2018) as the "estimated increase in global mean surface temperature." Therefore, IPCC further defines GWP, or carbon dioxide equivalent (CO_2 eq), as the equivalent amount of carbon dioxide required to reach the same level of radiative forcing, or temperature increase, as the actual amount of greenhouse gases emitted. In this study, the carbon footprint is defined in terms of CO_2 eq per functional unit over a 100-year time period. For the 2021 results, the most recent version of the IPCC model, AR6, is used. In addition to this set of results, global warming potential (GWP-100) values using AR4 will also be provided to benchmark performance over the past 5 years.

In addition to the carbon footprint calculated with the GWP-100 factors, another factor of interest to evaluate the effect of GHGs on global warming is GWP*. This factor is one approach among others to better take into consideration the net warming effect of short-lived GHGs such as methane (Liu et al., 2021; Lynch et al., 2020). GWP-100 does not consider historical emissions. However, when dealing with emission rates (kilograms of CO_2 eq per year), historical emissions can have a significant impact on current warming effects on the climate. Therefore, the global warming indicator was evaluated using GWP* as well.

Three data points were calculated, using data from the National Inventory Report. In order to do so, as shown by the following equation, emissions data from six years was required, consisting of pairs of data 20-21 years apart. For this baseline assessment, data from the years 1990, 1996, 2000, 2010, 2016, and 2021 were used. It should be noted that the National Inventory Report does not calculate enteric emissions in the same way they were calculated in this report and that it does not follow an LCA approach in doing so.

The equation used to calculate the GWP* values in this study were based on the study by Liu et al. (2021), as shown below.

$$E_{CO2-we} = GWP_{CH4}(100) \times (4E_{CH4(t)} - 3.75E_{CH4(t-20)})$$

Where:

- $E_{CO2\text{-}we}$ = GWP* or the warming equivalent of biogenic methane emissions in terms of carbon dioxide equivalent.
- $GWP_{CH4}(100)$ = GWP(100) emission factor of 28, as per IPCC 5th Assessment Report (AR5).
- $E_{CH4(t)}$ = total biogenic methane emissions at time *t*. Obtained from the National Inventory Report (NIR) 2022 (ECCC, 2022).
- $E_{CH4(t-20)}$ = total biogenic methane emissions at time *t-20*. Obtained from NIR 2022 (ECCC, 2022).
- t-20 = a point in time 20 years prior to the initial time t.

1.7.2 Other Environmental Indicators

In this study, the chosen life cycle impact assessment (LCIA) method for all indicators is ReCiPe 2016 (except GWP), using the hierarchist perspective (Huijbregts et al., 2017). Impact modelling choices are based on scientific consensus in the hierarchist perspective, as opposed to the precautionary principle or minimal uncertainty. This is a recognized method in LCA practice. This version of ReCiPe is an update of its 2008 version which was a method recommended by the International Reference Life Cycle Data (ILCD) (EC, 2011).

Fossil Fuel Depletion

Fossil fuel depletion falls under the category of resource scarcity. Abiotic resources (e.g., non-living components present in the environment) are used in most processes involving energy production. These resources are subject to extinction if their extraction from the Earth's crust is done at a greater rate than that of their natural renewal. The extraction of coal, oil and natural gas for heating, transportation and electricity production contributes to the depletion of fossil fuels (fossil resource scarcity). It is given in terms of kilograms of oil equivalent.

Water Consumption

This is the quantity of water used that is not returned to the same water body from which it was withdrawn, in terms of litres. The methodology for building the water consumption inventory is explained in Appendix D. It is in line with the ISO 14046:2014 standard on water footprint.

Agricultural Land Occupation

This is the quantity of land used, in terms of loss of habitat and soil disturbance due to land occupation for agricultural purposes. It is typically the area and time integrated for one type of land use and reported as m^2.yr annual crop land. The land occupation flows of the ecoinvent databases with the same time reference were updated with the area occupied by beef production for each land use type. The midpoint characterization factors (in annual crop equivalents) were then applied to these calculated areas to estimate the land use occupation in m^2.yr annual crop land.

Freshwater Eutrophication

The eutrophication potential measures the enrichment of an aquatic ecosystem due to the release of nutrients (e.g. phosphates) resulting from natural or human activity (e.g., the discharge of wastewater into watercourses). In an aquatic environment, this activity results in the growth of algae which consume dissolved oxygen present in water when they degrade and thus affect species sensitive to the concentration of dissolved oxygen. The concentration of nutrients causing this impact is expressed in phosphorus equivalents (kilograms of P equivalent).

TERRESTRIAL ACIDIFICATION

Terrestrial acidification refers to the change in acidity (i.e., reduction in pH) in soil due to human activity. The increase in NH_3, NO_x, and SO_2 emissions generated by the transportation and manufacturing sectors are the main causes of this impact category. The acidification of land has multiple consequences: degradation of aquatic and terrestrial ecosystems, endangering numerous species and food security. The concentration of the gases responsible for the acidification is expressed in sulphur dioxide equivalents (kilograms of SO_2 equivalent).

PHOTOCHEMICAL OXIDANT FORMATION, HUMAN HEALTH & TERRESTRIAL ECOSYSTEMS

Potential impact can be caused by the release of substances that affect humans through acute toxicity, cancer-based toxicity, respiratory effects, increases in UV radiation, etc. Impacts can also occur to ecosystem quality. The overall impact of a system on ecosystem quality is assessed based on the substances' ability to cause each of various types of damages to wildlife species. Photochemical ozone formation is tropospheric ozone creation due to nitrogen oxides (NO_x) and volatile organic compounds (VOCs) emissions released during the combustion of fossil fuels and causing damages to lungs and to plants. It is measured in terms of kilograms of NO_x equivalent.

1.8 LAND USE ASSESSMENT METHODOLOGY

The land use assessment looked at environmentally critical factors beyond those captured by the environmental life cycle assessment. As a result, the LU evaluated four main areas: biodiversity, water risk, carbon soil sequestration (CSS), and antimicrobial use. The assessment of these four areas combined qualitative and quantitative approaches, typically pairing a literature review with publicly available or survey data. The indicators of relevance in this study are as follows:

- Biodiversity was assessed using the Wildlife Habitat Capacity on Index (WHCI) as well as the indicators of species intactness and species richness from the Alberta Biodiversity Monitoring Institute (ABMI). Further information on the biodiversity assessment and its indicators are given in Appendix D.
- Water risk was calculated using World Resource Institute (WRI) Aqueduct tool.
- Carbon soil sequestration was calculated using an update of the carbon stock (SOC) intensity of beef cattle production considering the removals and emissions associated with LMC and LUC in Western Canada. Further information on the carbon soil sequestration assessment is provided in Appendix D.
- Antimicrobial use was estimated based on survey responses. A literature review on ecotoxicity effects of residues was conducted for a high-level risk assessment.

For biodiversity, a combination of data from the Wildlife Habitat Capacity Index (WHCI) on agricultural land in Canada model developed by AAFC and the Alberta Biodiversity Monitoring Institute (ABMI) indicators were considered to understand species abundance and habitat capacity over time. The water risk assessment similarly used data from the World Resource Institute (WRI) Aqueduct tool to understand drought risk, water depletion, and interannual variability in relation to Canadian cattle production.

Next, the carbon soil sequestration potential was estimated due to land management change (LMC) and land use change (LUC) associated with Canadian beef production. It also included an update of the carbon stock data based on a literature review and a predictive SOC regression model developed by the AAFC Lethbridge Research Group on soil carbon sequestration that captures the total C stock through including variables of different agricultural soils and crop types. Details regarding each of these approaches, along with their limitations, are described further in Appendix D.

Finally, antimicrobial (AM) and growth-enhancing technology (GET) use and ecotoxicity concerns are intrinsically linked. The study considers AM and GET administration levels along with relevant literature, including emerging research by Canadian beef experts, to understand trade-offs between AM and GET use and environmental impacts. To address current practices regarding AM and GET use, questions were posed in the survey. These questions were meant to document current practices on the farm, however a more in-depth analysis on AM and GET use and its implications can be found in the Social LCA, Section 2.2.4. In addition to this qualitative portion of the assessment, it is important to keep in mind that the indirect influence of AM and GET use is captured in the quantitative portion of the assessment through the modelled durations on feed, mortality rates, and final weights, as discussed in the cohort discussion in Section 1.4.1.

1.9 Allocation, Cut-off Criteria and Exclusions

Allocation Rules

The E-LCA method considers products through the functions they fulfill. Therefore, multifunctional products and processes must be considered carefully. When a process yields multiple outputs with different functions, the impacts of the process can be allocated between the outputs, or the system boundaries can be expanded to include the life cycle of the next function (e.g., product).

The LEAP guidelines are compliant with the ISO 14044:2006 guidelines and provide guidance on allocation problems specific to the cattle industry.

The updated 2021 LCA model as well as the 2013/14 model used allocation methods in accordance with the ISO 14040:2006 and ISO 14044:2006 standards for environmental life cycle assessment and the LEAP guidelines for environmental performance of large ruminant supply chains. For co-products of biofuel and oilseed production, such as canola meal and corn distillers' grain, an economic allocation was used to allocate the impact between the different products. Because of their variable costs and small contribution (less than 5% of total feed), the default economic allocation model in ecoinvent was kept (not adapted to local values). For all co-products and wastes of beef production, 90% of impacts were allocated to the meat meaning 10% of the burden was allocated to co-products. Plastics and other wastes coming out of the slaughterhouse after the farm-gate were either recycled or landfilled. A cut-off approach to recycling was chosen and the rates of recycling are discussed further in Appendix D.

Cut-off Criteria and Exclusions

This LCA essentially used the same approach for cut-off criteria and exclusions as in the 2016 report. Mass flows with an aggregate contribution of less than 2% of inputs to a life cycle stage are omitted from the inventory analysis. It is believed that these criteria do not affect the final results. The literature review results were used to identify where this is relevant so that appropriate inputs were included in the study.

The following processes were excluded from the study:

- **Prescription drugs**: the production, use, and administration of prescription drugs. Their use is instead considered in the antimicrobial use portion of the land use assessment.
- **Plastic-wrapped haylage**: One kilogram of plastic used to wrap a 400 kg bale of haylage has a global warming impact equivalent to less than 1% of the carbon footprint of the bale of hay.
- **Organic farming**: Organic farming is considered an exception in the beef production industry. Although the survey data might include data from organic farms, because of their low number, the LCA model makes no distinction between organic and conventional farms (according to the 2021 Census of Agriculture, approximately 1.3% of Canadian beef production is certified organic). The results presented in this study are therefore representative of the average beef production in Canada.
- **Soil carbon**: In accordance with the latest IDF guidelines, the E-LCA model does not consider the potential benefit of carbon sequestration from soil management practices, forages, or pastures. Globally, agricultural soils represent a significant carbon pool and some practices (e.g., conservation tillage, conversion of annual crop land to grasslands and perennial crops) can increase the quantity of

carbon stored in soils. However, the process is complex, non-linear, and reversible. In addition, the link between a specific practice and a change in carbon stock can be difficult to demonstrate, and there is a lack of accepted methodology in the context of an LCA. Instead, the LU assessment considers the relative importance of this aspect based on recent scientific publications and research from AAFC Lethbridge.

- **Other components of feed**: Components with minor contributions (<1% by mass) to feed rations were neglected from the study. This includes mineral supplements as they generally do not contribute significantly to impacts. Because they make up less than 1% of daily dry matter intake, these were excluded from the study.
- **Wastes from slaughter**: As discussed previously, any wastes and co-products produced during slaughter and processing, such as fats, hides, hooves, etc., were excluded from the model.
- **Cohort**: Replacement animals and bulls represented in Figure 1-5 were excluded from the model based on the cut-off criteria assumptions.

In addition, production of capital goods, such as building and machinery, were included when information was readily available. The LEAP guidelines indicate that this inclusion is optional.

1.10 Sensitivity, Uncertainty and Scenario Analysis (E-LCA and LU)

Sensitivity Analysis

The parameters, methodological choices and assumptions used when modelling the systems present a certain degree of uncertainty and variability. It is important to evaluate whether the choice of parameters, methods, and assumptions significantly influences the study's conclusions and to what extent the findings are dependent upon certain sets of conditions. Following the ISO 14044:2006 standard, a series of sensitivity analyses are used to study the influence of the uncertainty and variability of modelling assumptions and data on the results and conclusions, thereby evaluating their robustness and reliability. Sensitivity analyses help in the interpretation phase to understand the uncertainty of results and identify limitations.

For this assessment, the majority of data was taken from direct sources, such as Statistics Canada, Canadian literature on beef production, and Canfax Research. In general, the same or improved sources from the previous assessment were considered. All data was validated by the Scientific Advisory Committee. However, in some cases, only expert judgement was available. This is the case for the end-weights of animals considered in this study. These values range greatly in application due to various conditions faced by producers and differences in animal types and rations. The values chosen fit within a 10% range of values found in the literature, therefore, for the sensitivity analysis, an increase and a decrease of end-weights by 10% was considered.

Uncertainty Analysis

There are two types of uncertainty related to the LCA model:

- Inventory data uncertainty;
- Characterization models uncertainty, which translate inventory into environmental impacts.

Inventory Data Uncertainty Analysis

A quantitative analysis of the uncertainty due to the variability of inventory data has been performed. This discussion is based on the outputs of the Monte Carlo analyses conducted with 1,000 iterations, or until stabilization of variability is reached. The results of Monte Carlo simulations are presented in Appendix E.1.

Characterization Model Uncertainty

In addition to the inventory data uncertainty described above, uncertainty related to the LCIA method, with respect to the characterization of the LCI results into mid-point indicators was considered. The uncertainty ranges associated with characterization factors at both levels vary from one mid-point to another. The accuracy of characterization factors depends on the ongoing research in the many scientific fields behind life cycle impact modelling, as well as on the integration of current findings within operational LCIA methods. This type of uncertainty is not yet well understood by the LCA community. The scientific consensus on this sensitive topic, as well as the grouping methodology, is still under revision to better assess these ranges of uncertainty.

Quantification of inventory uncertainties using Monte Carlo is presently considered sufficient to draw conclusions from obtained results.

SCENARIO ANALYSIS

In accordance with the previous NBSA study which considered a variety of "what if" scenarios designed to investigate parameters of special interest, the following scenarios have been included in the current study:

East vs. West Management Practices

The studied beef production practices were found to be different across Canada and had different impacts in the LCA results. Some of the common practices in Western Canada were extensive winter grazing/feeding (bale, swath, or stockpiled grazing) while winter confinement feeding predominated in Eastern Canada. Hence, the assessment was carried out with a regional distinction which accounted for a proper representation of the Canadian beef industry.

Calf-Fed vs. Yearling-Fed Systems

For this scenario, an entirely calf-fed and entirely yearling-fed system are considered based on Western production parameters. As mentioned previously, the baseline model includes 55% yearling-fed production and 45% calf-fed production. However, to understand how the varying production periods and grazing of backgrounders and yearlings affects impacts, this scenario analysis is included.

In addition to these scenarios which were part of the previous NBSA report, the current study also considers the inclusion of dairy for carbon footprint assessment.

1.11 Social LCA Methodology

The S-LCA methodology relies on the 'Guidelines for Social Life Cycle Assessment of Products and Organizations' (hereafter the Guidelines). Since its first edition in 2009 and last update in 2020, the Guidelines developed by the United Nations Environment Programme (UNEP), provide the general framework needed to conduct such an assessment. S-LCA is a practice-based approach that relies on quantitative and qualitative data and provides a qualitative assessment of the performance of organizations involved in a supply chain.

The Guidelines propose a classification of the main socially significant themes to assess, as well as a categorization of the main stakeholder categories potentially affected by the socioeconomic impacts induced by the activities and behaviours of the organisations involved in the product's life cycle. Six main impact categories are listed in the Guidelines, each being related to a number of impact subcategories, or specific issues of concern, which are "socially significant themes or attributes" to assess (UNEP, 2020, p. 22). These impact categories are human rights, working conditions, health and safety, cultural heritage, governance, and socioeconomic repercussions. As for the stakeholder categories, the Guidelines list the following six groups: workers, children, local communities, society, consumers, and value chain actors.

In addition to this general framework, the Guidelines also specify the steps to follow and the requirements to fulfill to conduct a rigorous and transparent assessment. However, the Guidelines are a work-in-progress towards the elaboration of a comprehensive assessment framework. For that reason, a specific assessment methodology was developed to conduct this S-LCA.

In keeping with the UNEP Guidelines (2009 and 2020) as well as with the 2016 NBSA report, the S-LCA methodology used in this project focuses on businesses' behaviours and the relationships they have with their stakeholders using a set of socioeconomic indicators related to a list of social issues, from working conditions and mental health, to animal welfare and health (that is, a Type 1 or Reference Scale approach). These indicators were then used to inform the positive contributions, as well as the potential risks induced by the Canadian beef industry's activities.

However, the methodology used in this project differs to some extent from the approach prescribed in the S-LCA guidelines as well as the one used in the 2016 NBSA report. The reason is that the primary intent of this social assessment was to inform a social sustainability roadmap by providing practical and action-oriented insights on the current performance of the industry, as well as recommendations to improve its performance over time. To that end, the assessment methodology departs from some of the steps and conceptual considerations described in the 2020 S-LCA Guidelines.

Specifically, three building blocks comprise the methodology used in this assessment (*see* Figure 1-6). Each is the result of an iterative and stepwise development process. Together, they provide an evidence-based assessment of the positive contributions as well as the potential risks (or hotspots) associated with beef production in Canada.

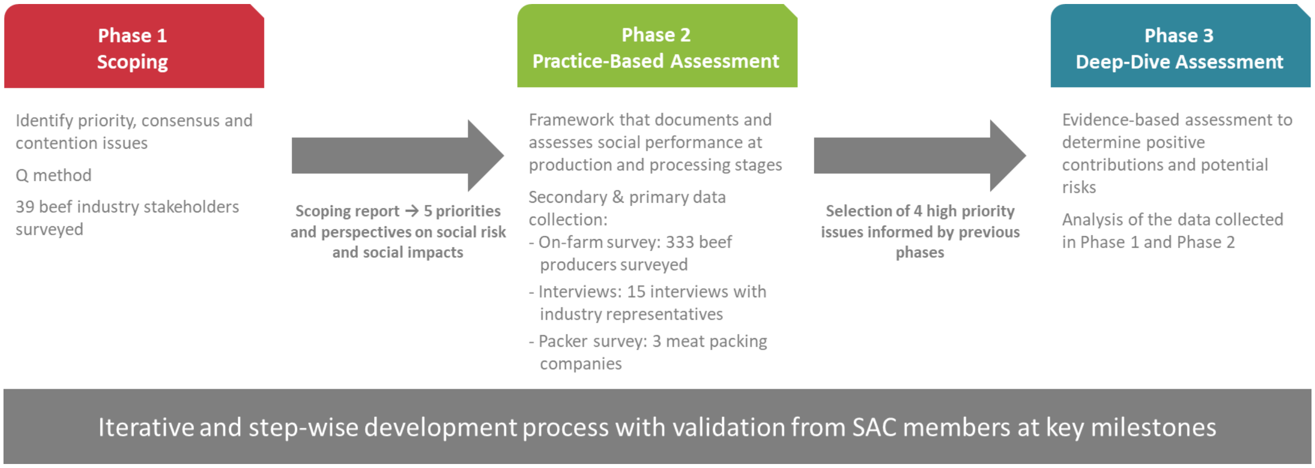


Figure 1-6: Three building blocks of the Social LCA Methodology.

THE SCOPING PHASE

First, a Scoping Phase was performed to identify priority, consensus, and contention issues within the current beef sustainability dialogue through a participatory approach to S-LCA. Using an approach called the Q method[3], a diverse group of 39 purposively sampled beef industry stakeholders were surveyed on different written statements about Canadian beef industry sustainability. These opinion groups provided five different sets of priorities and perspectives on social risk and social impacts within the Canadian beef industry. These viewpoints, which are described in detail in the Scoping Report (*see* Appendix C.1) outline what matters to beef industry stakeholders right now, how much it matters, why it matters, and to whom it matters.

THE PRACTICE-BASED ASSESSMENT

In conjunction with the Scoping Phase, a framework was developed to document and assess the social performance of Canadian beef farmers with respect to different social issues. In-keeping with the 2016 NBSA, this framework was designed to evaluate the degree of social responsibility of Canadian beef producers by using a set of socioeconomic indicators related to a list of social issues.

The list of indicators—which was developed alongside with the questions for the on-farm survey—was established based on different sources, including the 2016 NBSA indicators and results, as well as industry standards (including VBP+, the CRSB Standards and the Code of Practice for the Care and Handling of Beef Cattle). Expert opinions from CRSB representatives and SAC members were also instrumental in establishing and validating the framework. Results from the Scoping Report were also considered.

The framework is based on an evaluation scale that differentiates between risky, compliant, proactive, and committed behaviours. This practice-based approach allows to determine risks, but also positive contributions to society from a corporate social responsibility (CSR) perspective.

The complete list of indicators is available in Appendix F. Table 1-2 below provides an example of how each indicator is designed. The evaluation scale for each indicator was informed by Groupe AGÉCO's expertise and the discussions with experts from CRSB and SAC. This framework only applies to the beef production stage. However, not all indicators are reported using this standardized evaluation scale. For instance, perception-based indicators (e.g., Indicator 1.9 – Workload Dissatisfaction; how often is dissatisfaction with overall workload expressed by employees?) report the answers to the question asked using figures. This is to facilitate

[3] The Q-sort generates consensus items, contention items and distinct subgroups. The Q-sort can be used to standardize data between experts and non-vested groups, or to highlight differences.

interpretation and account for the fact that such perception-based results are not suited to be assessed using a normative evaluation scale.

Table 1-2: Template presenting how on-farm indicators are compiled

Indicator # and name		
Description		
Description of what the indicator is documenting based on the survey questions		
Evaluation		
Risky	A risky behaviour describes a situation where negative outcomes can be induced by a practice (or lack thereof)	% of farmers
Compliant	Refers to a normal and/or expected practice within a given context. It can refer to a legal requirement or the absence of a particular measure in situations where none is required	% of farmers
Proactive	Defines in-between situations where practices are going beyond basic expectations, but have not yet reached a committed behaviour	% of farmers
Committed	Is considered as the most responsible practice a leading business could take within the context of the assessment	% of farmers
Comments		
This section provides a detailed description of the results and informs on the number of respondents.		

As such, this framework differs from the one used in 2016, which in turns limits the capacity to compare results. However, this approach presented the opportunity to develop more specific indicators and to ask more targeted questions to assess issues and concerns at the farm level in greater detail.

To document the positive contributions and potential risks at the industry level, interviews were conducted among industry informants (*see* Section 1.6 on data collection)[4]. To do so, interview guides were designed to collect insights on the key risks, issues or opportunities facing Canadian beef farmers when it comes to sustainability, as well as on the informants' perspective on the current performance of the industry (or a sector in particular) with respect to different social issues (workforce/working conditions; animal health and welfare; food safety and biosecurity; environment; innovation and the adoption of new technologies). The interview guide was also meant to document if and how the industry could improve its performance with respect to these social issues. Copies of the interview guides are available in Appendix D.

Lastly, two questionnaires were developed to document practices at the packer plant level (*see* Section 1.61.6 on Data Collection). These questionnaires were developed to collect additional and more specific information on practices taking place in the sector. As for the on-farm survey, questions were designed based on the 2016 NBSA, existing industry standards and expert opinions. However, unlike the on-farm survey, no particular assessment framework was developed to assess results due to the small sample of respondents.

[4] This approach differs from the one used in 2016, where hotspots were documented in other stages of the value chain using a list of indicators informed mostly by secondary and not industry-specific data. Conducting interviews with a range of diverse informants was preferred to collect more practical and specific insights to inform the CRSB sustainability strategy. However, this approach limits the ability to compare results and provides a qualitative assessment, as opposed to a semi-quantitative one as in the 2016 NBSA.

The Deep-Dive Assessments

The results from the Scoping Phase and Practice-Based Assessment were then used to inform deep-dive assessments. The deep-dive assessments provide an evidence-based assessment of how, at the level of the Canadian beef industry, social issues of high priority are managed in a way that positively or negatively impact people (employees; farmers; communities) and animals.

Given the project's scope, only a limited number of deep-dive assessments could be conducted. To select the high priority ones, a list of criteria was established. Specifically, priority issues needed to (1) be relevant to the entire industry (i.e., relevant for both producers and packers), (2) allow the CRSB and its members to act on them, (3) be national in scope, (4) relate to material issues with respect to social sustainability, and (5) be impact-oriented, that is related to outcomes that can be measured and managed by the industry.

In collaboration with the SAC members, four priority issues were selected from a list informed by different sources, including the scoping report, the on-farm survey results, and the interviews[5]. Each is described in Table 1-3 below.

A key characteristic of the deep-dive assessments is that they provide an evidence-based assessment of the positive contributions as well as of the potential risks associated with the industry's activities by combining different approaches and types of data sources.

Specifically, the assessment of each priority issue is structured as follow:

- First, a **rationale** describes the reasons why the topic should be considered as a priority issue for the beef industry when it comes to social sustainability. These rationales provide a review of literature and leverage the information collected during the previous phases of the assessment to document the main pathways through which the Canadian beef industry is impacted by various drivers or is impacting its stakeholders by the operations taking place on farms or at the packing plant level[6]. These pathways provide the opportunity to investigate how practices taking place on farms or at the packing plant level can be related to positive or negative outcomes for people (including producers, employees, community members) or animals[7].
- Second, a **baseline** review of the 2016 NBSA hotspots related to the priority issue as well as the actions taken by the industry to address them since that time. This section is intended to contextualize the current assessment in the light of the 2016 NBSA results, and to account for the regulations in place and the industry's efforts (or lack thereof) with respect to the priority issue.
- Lastly, the **results** section provides a detailed analysis of the positive contributions as well as of the potential risks associated with the industry's activities with respect to the priority issue. This section looks specifically at practices in the Canadian beef industry that have been highlighted through

---

[5] As a consequence, not all the survey questions or answers to the interviews were used in the assessment, but only those that speak to the four selected priority issues.

[6] What the model provides is the foundation for the qualitative pathway analysis investigating how and why BMPs may lead to beneficial or adverse effects on stakeholders. The qualitative approach to pathway analysis provides nuanced descriptions and strategic insights into the urgency, severity, depth, breadth, gaps, and even potential outcomes related to practices.

[7] Operationalizing and quantifying the significance of the relationships between practices and outcomes (i.e., determining numerically the 'extent' of an impact) is challenged in S-LCA because very few pathways have been researched to determine direct correlation and causality between practice and impact. Furthermore, very few data exist to feasibly quantify these pathways in a standardized way. The characterization of impact pathways remains an area of dissent among attempts to standardize S-LCA or meet ISO 14044:2006 standards. Furthermore, not all pathways are unidirectional or static, meaning impacts can cycle and churn, accumulate, or increase or decrease in magnitude, frequency duration or direction at any time or place in any social unit or system (the individual, family, workplace, community, value chain, or society). For these reasons, not all impact pathways in social systems provide more value when quantified (Brymer et al., 2020 quoting; Sayre, 2004).

pathway analysis as having the potential to affect adverse or beneficial outcomes. This analysis is based on key observations, which capture the emerging strengths and risks coming out of the assessment.

In this way, the assessment attempts to deliver insight on *what* strengths and risks exist throughout the life cycle of the beef product, understanding *where, when, how* and perhaps most importantly, *why and to whom* impacts may occur.

Table 1-3 below identifies for each deep-dive assessment the stakeholder categories, key themes as well as the main indicators considered in the analysis or excluded from the scope of work. The decision to include or exclude specific stakeholder groups or themes was made in collaboration with the CRSB in-keeping with the system boundaries outlined above and information collected through the Scoping Phase and the Practice-Based Assessment.

Table 1-3: Overview of the Four Social Issues Considered for the Deep-Dive Assessment

LABOUR MANAGEMENT
What is it about? Labour management refers to the working conditions provided to the people working in the industry (including farm owners and family members) and the extent to which these conditions contribute to their overall well-being. Working conditions in this assessment cover a range of topics, from working time and remuneration to training. They build on labour rights and employment standards to also incorporate fairness and career development opportunities. Together with occupational health and safety (OHS), labour management plays a key role in creating a positive and attractive work environment for beef industry stakeholders.
Why is this social issue a priority? There are many job vacancies caused by a shortage of labour in the Canadian beef industry. Beef cattle producers and packers are facing the challenge of finding workers. This gap comes with economic and social costs related to the mental and physical health of business owners and workers and the industry's long-term viability.
Included in the assessment <u>Stakeholder groups (per sector)</u> Production: Farm owners; Employees, including temporary foreign workers (TFWs); Family labour (paid) Packers: Employees (including im/migrants and TFWs) <u>Key themes and related indicators</u> Workload: Recruitment and Retaining; Overtime; Workload Dissatisfaction; Consequences of Overload Labour relations: Onboarding Activities; Communication and Dispute Resolution Wages and benefits: Benefits Labour rights: Overtime; Benefits Equal opportunities/Discrimination: Diversity Management Professional development: Professional development; Language Training; Farm Management Training
Out of scope Retailers: employees [working hours]
PEOPLE'S HEALTH AND SAFETY
What is it about Health and safety at work concerns the promotion and maintenance of the highest degree of physical, mental, and social well-being and capabilities of all the individuals involved in business operations, including employees but also producers and the people living on the farm. A safe and healthy workplace can also contribute to the personal and professional development of the people active in the industry.
Why is this social issue a priority People's health and safety is one pathway affecting workers and owners as safety motivations and awareness manifest in policies and behaviours (practices) that result in increased or diminished serious, or fatal accidents or injuries. Additional OHS considerations exist with hiring temporary foreign workers (TFW).

Included in the assessment

Stakeholder groups (per sector)

Production: Farm owners; Employees (including TFW)
Packers: Business owners; Employees (including TFW)

Key themes and related indicators

Physical and Mental health: Stress Factors; Level of Disturbing Stress; Fatigue Management; COVID Management
Suicide: Stress Factors; Level of Disturbing Stress
Fatality Rate: Personal Protective Equipment (PPE); Fatigue Management
Rate of accidents/Injuries: First Aid; Emergency Procedures; Degree of Awareness and Preparation; Personal Protective Equipment (PPE)
OHS: COVID Management; Health and Safety Risk Assessment
Health and safety training: Prevention Activities; Health and Safety Training

Out of scope

Retailers: employees [OHS]; consumers [Food safety]

ANIMAL CARE

What is it about
Animal care is about animal health and welfare through activities that humans undertake as part of the beef supply chain. It is about providing for the physical and mental well-being of animals (cf. the Five freedoms), and meeting or exceeding consumer expectations.

Why is this social issue a priority
Animal care is instrumental to sustainable livestock businesses at the primary production and processing and retail stages. Animal care is also a central concern to citizens and consumers. Good animal care has the potential to affect animal well-being, human health, environmental health, and business viability.

Included in the assessment

Stakeholder groups (per sector)

Production: Animals; Farm owners; Employees
Packers: Animals; Business owners; Employees

Key themes and related indicators

Health Assessment: Health Assessments; Herd's Health Status; Health of Newly Arrived Cattle; Health Problem Assessment; Extreme Temperature
Training: Training on Animal Handling; Attendance to Training or Conference; Protocol for Needle Injections
Animal handling: Code of Practice; Weaning Strategy; Animal Care Innovation; Handling Techniques
Pain control: Pain Control Technique for Particular Procedures; Typical Pain Control Method Used
Stunning method: Code of Practice; Animal Care Innovation; Pain Control Technique for Particular Procedures
Euthanasia: Euthanasia; Code of Practice ; Pain Control Technique for Particular Procedures
Transportation: Animal Transportation; Code of Practice
Injuries: Code of Practice; Typical Pain Control Method Used; Herd's Health Status; Health Problem Assessment
Nutritional status: Herd's Nutritional Status
Record keeping: Record-Keeping

Out of scope

Retailers: society/consumers [AMU]

ANTIMICROBIAL USE

What is it about
Antimicrobials, which include antibiotics, antifungals, antivirals and antiparasitics, are instrumental for ensuring animal health in livestock agriculture. However, improper use can have adverse effects on animals, human health, and the environment.

Why is this social issue a priority
Although not a consumer-facing concern, it is a global issue affecting both human and animal health, as well as the environment. This topic is, for the most part, regulated in Canada and research results on AMU and AMR indicate that limited risks exist in the beef industry. However, practices and attitudes may not be evolving at the appropriate pace.

Included in the assessment

Stakeholder groups (per sector)

Production: Animals; Farm owners; Employees
Packers: Animals; Business owners; Employees

Key themes and related indicators

Training: Use of Antibiotics; Antimicrobial Alternatives
Record keeping: Use of Antibiotics
Antibiotic categories: Antibiotics Categories
Procedures/situations when using antimicrobials: Use of Antibiotics on Cow–Calf Operations; Use of Antibiotics on Backgrounding and Feedlot Operations

Out of scope
Retailers: Food safety; Human health
Consumers: Food safety; Human health

1.12 Other Methodological Considerations for the S-LCA

Given the qualitative nature of the deep-dive assessments, no particular weighting or contribution analysis was performed when interpreting results. For instance, results from the on-farm survey were not weighted according to the farm's size (e.g., number of head) and insights from the interviews are not treated differently depending on the organizations or the occupation of the interviewees. This approach was to build on documented evidence to inform the positive contributions of the industry as well as potential risks.

As with the E-LCA methodology, the S-LCA Guidelines also describe how sensitivity, uncertainty, and scenario analysis can be performed in an S-LCA. Given the qualitative approach used in this assessment and the project's goal and scope, none was performed.

Similarly, no allocation rule was used nor particular cut-off criteria considered to quantitatively include or exclude components from the analysis. In keeping with the project's goal and scope of informing a social assessment to provide practical and action-oriented insights on the current performance of the industry, all key decisions to include or exclude elements from the analysis were based on the concept of materiality. Information or items proving to be material were those considered relevant to the production and processing stages of the Canadian beef industry and that could be used to inform a social sustainability roadmap for the CRSB. This degree of significance was established throughout the project in collaboration with CRSB representatives and members of the SAC.

Uncertainty pertaining to data quality and results interpretation is accounted for in the deep-dive assessments. Limitations specifically associated with the primary data collection process (i.e., on-farm survey, packer surveys, interviews) are discussed in Appendix D.4.

Only the perspective of farm owners was documented with the on-farm survey due to the data collection strategy used (i.e., web-based surveys sent through the industry's mailing lists). It is an important limitation in the interpretation of the results, especially for the indicators related to labour management. This limitation was accounted for when conducting the analysis and identifying the key observations.

2. RESULTS

Results for the assessment are discussed throughout this section, starting with the environmental and land use assessments, followed by the social life cycle assessment.

2.1 ENVIRONMENTAL PERFORMANCE OF THE CANADIAN BEEF INDUSTRY

The following sections describe the results of the environmental life cycle and land use assessments for the environmental performance of the Canadian beef industry.

2.1.1 NATIONAL AND REGIONAL PERSPECTIVES

This section presents the results of the environmental life cycle assessment (LCA). Average national impact values are presented, along with the impacts for Western production (i.e., baseline) and Eastern production. Western production includes the weighted impacts of production for Alberta, British Columbia, Manitoba, and Saskatchewan, while Eastern production includes the weighted impacts of production for Ontario, and Quebec, and the Atlantic provinces. The national value is based on 84% of production occurring in the West and 16% in the East (Statistics Canada, 2022c). Impacts for the main functional unit of 1 kg live weight at the farm gate for all E-LCA indicators presented in Table 2-1.

Table 2-1: Impact results per 1 kg of live weight at the farm gate

Category	Indicator	Units	National	West	East
Global warming	Carbon footprint	kg CO_2 eq	10.4	10.5	9.8
Resource depletion	Fossil fuel depletion	kg oil eq	0.4	0.4	0.3
	Water consumption	L	657.3	761.5	89.9
Land use	Agricultural land occupation	m^2a annual crop eq	38.7	43.6	12.0
Water pollution	Freshwater eutrophication	g P eq	2.6	2.4	3.9
	Terrestrial acidification	g SO_2 eq	115.9	110.8	143.6
Air pollution	Photochemical oxidant formation, human health	g NOx eq	8.7	8.8	8.3
	Photochemical oxidant formation, terrestrial ecosystems	g Nox eq	8.8	8.9	8.3

A breakdown of each indicator by contributor is provided in the Sections 2.1.2 and 2.1.3 for the functional unit of 1 kg live weight for each Western and Eastern production.

RESULTS PER FU: 1 KG CARCASS

In addition to the functional unit of 1 kg live weight, 1 kg of carcass was also included to facilitate comparison with other studies. Carcass weight considers average dressing rates taken from Statistics Canada (2021), animal shrinkage, as well as transport from the farm to primary processing. Table 2-2 provides the impacts per 1 kg carcass weight for each indicator used in the E-LCA.

Table 2-2: Impact results for 1 kg of carcass at the slaughterhouse gate

Category	Indicator	Units	National	West	East
Global warming	Carbon footprint	kg CO_2 eq	17.3	17.5	16.3
Resource depletion	Fossil fuel depletion	kg oil eq	0.7	0.7	0.5
	Water consumption	L	1084.5	1256.5	148.3
Land use	Agricultural land occupation	m^2a annual crop eq	69.3	72.0	19.8
Water pollution	Freshwater eutrophication	g P eq	4.3	3.9	6.4
	Terrestrial acidification	g SO_2 eq	191.6	183.2	237.2
Air pollution	Photochemical oxidant formation, human health	g NOx eq	15.3	15.5	14.5
	Photochemical oxidant formation, terrestrial ecosystems	g NOx eq	15.3	15.5	14.5

In general, transport to primary processing represents a small percentage of the impacts compared to farming. Transport is negligible for all indicators except for the following, where the contribution is provided in the brackets: fossil fuel depletion (5.0%), ozone formation, human health (5.8%), and ozone formation, terrestrial ecosystems (5.7%). All other impacts are associated with animal production, as described in Sections 2.1.2 and 2.1.3.

Results per FU: 1 kg Boneless Beef, Processor's Gate

Similarly, impacts per 1 kg of bone-free meat at the processor's gate were also considered for comparative purposes. Table 2-3 provides the impacts per 1 kg bone-free meat at the processor's gate for each indicator used in the E-LCA.

Table 2-3: Impact results for 1 kg boneless beef at processor's gate

Category	Indicator	Units	National	West	East
Global warming	Carbon footprint	kg CO_2 eq	22.6	22.9	21.3
Resource depletion	Fossil fuel depletion	kg oil eq	1.1	1.1	0.8
	Water consumption	L	1385.4	1604.3	193.9
Land use	Agricultural land occupation	m^2a annual crop eq	81.3	91.6	25.3
Water pollution	Freshwater eutrophication	g P eq	5.6	5.1	8.3
	Terrestrial acidification	g SO_2 eq	257.2	246.5	315.3
Air pollution	Photochemical oxidant formation, human health	g NOx eq	26.9	27.1	25.9
	Photochemical oxidant formation, terrestrial ecosystems	g NOx eq	27.2	27.4	26.1

For this functional unit, impacts of beef production (on the farm), transport to primary processing, and primary processing (referred to as packing in NBSA 2016) are also considered. It should be noted that this primary processing is assumed to occur at the same slaughterhouse considered for the 1 kg carcass weight functional unit, meaning no additional transport is considered between these functional units. As with the 1 kg carcass functional unit, the majority of impacts come from the farming stage. A breakdown of each indicator by contributor is provided in Figure 2-1 and Figure 2-2 below for Western and Eastern production, respectively.

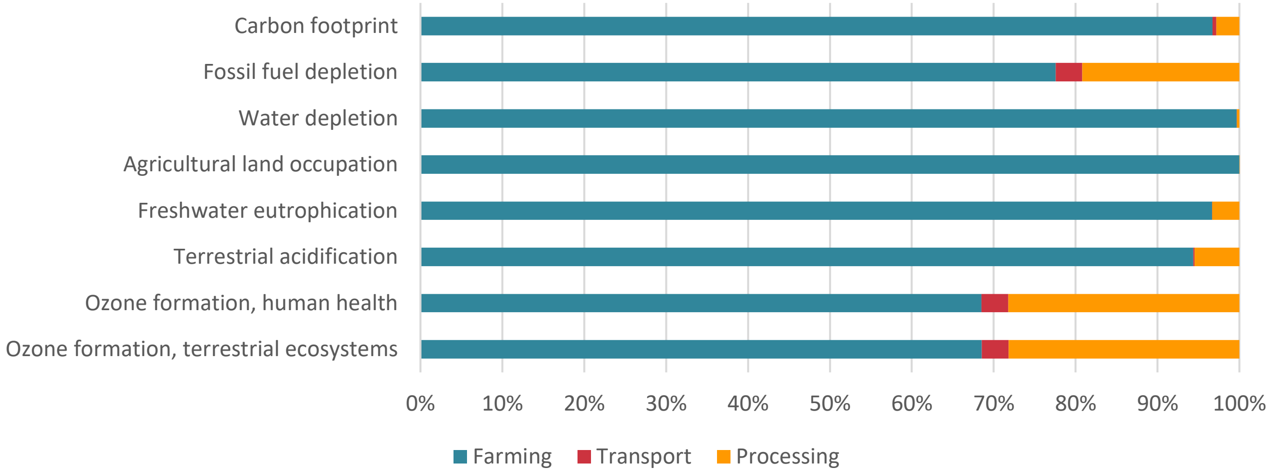


Figure 2-1: Contribution of impact to each indicator per kg of boneless meat at the processor's gate for Western production.

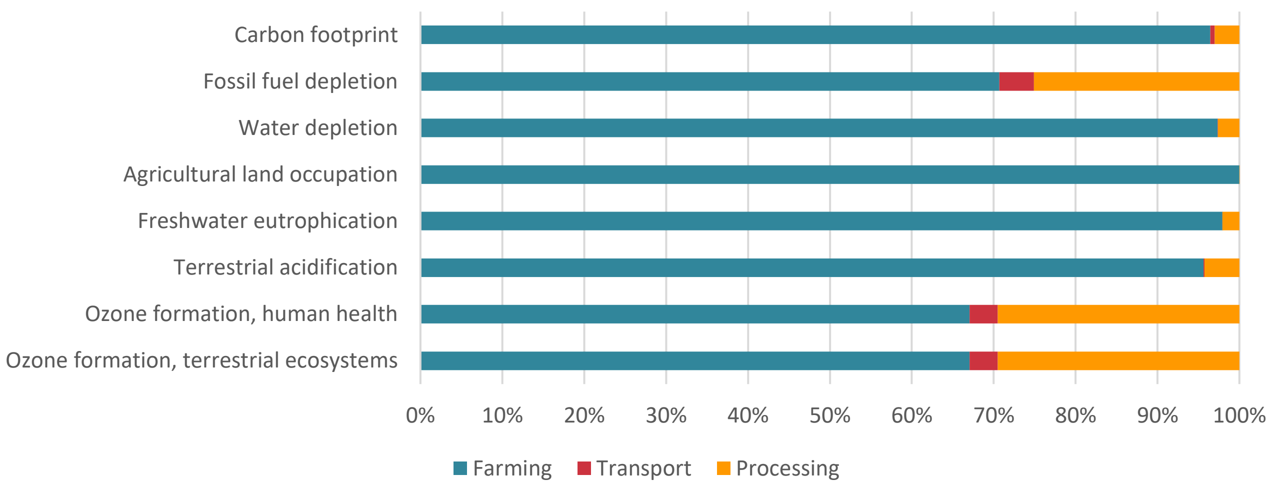


Figure 2-2: Contribution of impact to each indicator per kg of boneless meat at the processor's gate for Eastern production.

For both Western and Eastern production, the majority of indicators have minor contributions from the processing stage and negligible contributions from transport. However, fossil fuel depletion and ozone formation (both human health and terrestrial ecosystems) have substantial contributions from the processing stage. This is mainly coming from energy use for processing, which includes natural gas for heating, diesel, as well as electricity. As a result, energy consumption is responsible for 99% of fossil fuel depletion impacts at the processing stage and 92% of ozone formation (both human health and terrestrial ecosystem) impacts at the processing stage.

RESULTS PER FU: 1 KG BONELESS BEEF, CONSUMED

Next, impacts per serving of bone-free beef, including packaging, retail, delivery, and consumption were considered. Table 2-4 provides the impacts per 1 kg consumed bone-free meat for each indicator used in the E-LCA.

Table 2-4: Impact results for 1 kg boneless beef, consumed

Category	Indicator	Units	National	West	East
Global warming	Carbon footprint	kg CO_2 eq	32.8	33.1	31.2
Resource depletion	Fossil fuel depletion	kg oil eq	2.6	2.6	2.3
	Water consumption	L	1919.2	2192.3	432.7
Land use	Agricultural land occupation	m^2a annual crop eq	114.6	127.6	43.9
Water pollution	Freshwater eutrophication	g P eq	11.9	11.3	15.2
	Terrestrial acidification	g SO_2 eq	338.1	324.8	410.6
Air pollution	Photochemical oxidant formation, human health	g NOx eq	40.7	40.9	39.5
	Photochemical oxidant formation, terrestrial ecosystems	g NOx eq	40.7	40.9	39.5

A breakdown of each indicator by contributor is provided in Figure 2-3 and Figure 2-4 below for Western and Eastern production, respectively.

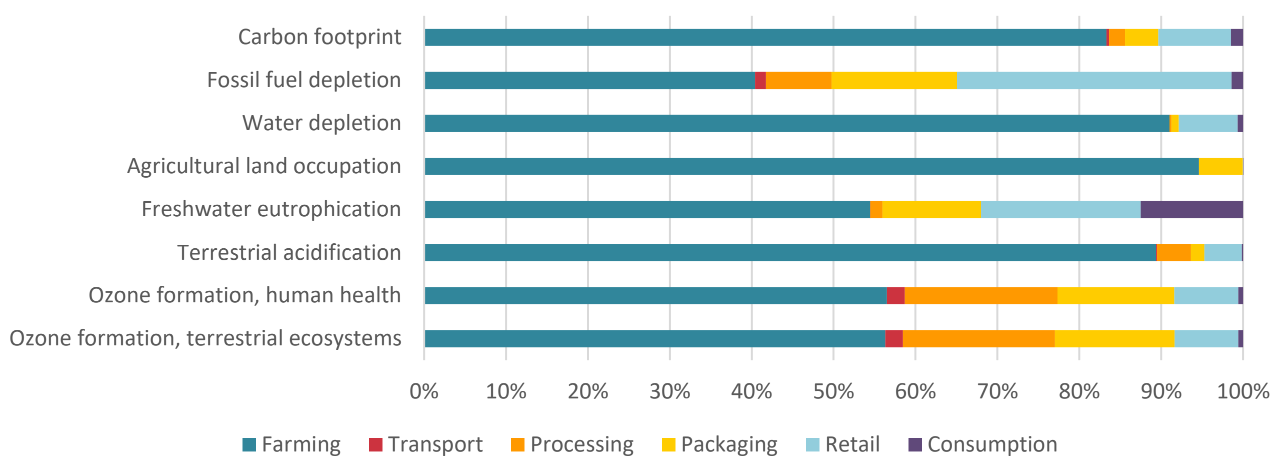


Figure 2-3: Contribution of impact to each indicator per kg of consumed meat, Western production.

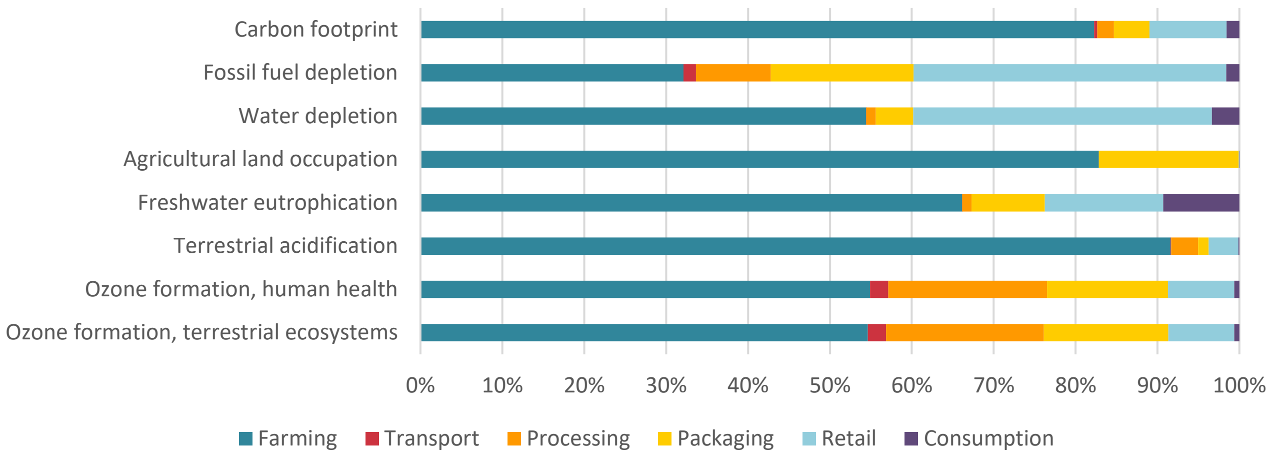


Figure 2-4: Contribution of impact to each indicator per kg of consumed meat, Eastern production.

As with the functional units of 1 kg carcass and 1 kg boneless meat at the processor's gate, the majority of impacts for most of the indicators are from the farming stage, for both Western and Eastern production. Three new stages are introduced for this functional unit, including (secondary) packaging, retail, and consumption. The impacts of consumption are generally negligible, while packaging and retail are more substantial in certain categories. However, there are a few exceptions for each of these statements. To examine these exceptions, a closer look at each stage introduced for this functional unit is provided as follows.

Packaging

The packaging stage includes additional processing and packaging to get the boneless meat from processor's gate to the retail and consumption stages. In general, losses occur at this stage due to trimming representing around 5% of the 1 kg boneless, consumed beef product. This is reflected in the model as a proportional increase in impacts from the farming stage as a larger portion of liveweight is required to produce 1 kg of packaged product when losses are considered. In the West, the majority of impacts caused by the secondary processing stage come from the packaging materials themselves, where packaging accounts for 1-15% of impacts. The impact categories with the highest contribution from packaging are ozone formation, terrestrial ecosystems (15%), ozone formation, human health (14%), and fossil fuel depletion (15%). A similar observation can be made in the East, where packaging accounts for 1-20% of impacts, with the highest contributions being in agricultural land occupation (20%) and fossil fuel depletion (17%). Across both regions, packaging has the least contribution to water depletion at 1% of impacts.

Retail

Similarly, retail also has a wide range of contributions to the various indicators. In the West, the contribution ranges between 0-34%, with the largest contributions being to fossil fuel depletion (34%) due to energy consumption and freshwater eutrophication (19%) due to landfilling of waste produced for electricity consumption, such as lignite ash from the mining of coal. In the East, the contribution of retail ranges between 0-36%, with the largest contributions being to fossil fuel depletion (38%) and water depletion (36%), both due to electricity production. As with the packaging stage, additional meat waste occurs at the retail stage, typically due to unsold products being landfilled after their expiration, further increasing impacts as more of the impacts of waste gets allocated to the meat.

Consumption

Finally, the consumption stage includes additional energy for basic cooking of the meat, as well as disposal of packaging materials and any meat waste that occurs at the consumer. This stage represents 0-1% of impacts across all impact categories, except for freshwater eutrophication, where consumption contributes to 13% of impacts in the West and 9% of impacts in the East. As with the other two stages, these potential impacts come from electricity consumption and meat wasted and landfilled at this stage, both contributing primarily to freshwater eutrophication through the introduction of excess phosphorus. With respect to electricity, landfilling of mining waste, such as lignite ash and coal, required for electricity production are the primary contributors to freshwater eutrophication.

Results per FU: 1 Serving Boneless Beef, Consumed

Finally, potential impacts per serving (100 g) of bone-free beef, including consumption were considered. On a per kg basis, these results are identical to those presented in the previous section but are scaled down to be relevant to consumers. Table 2-5 provides the impacts per serving of consumed bone-free meat for each indicator used in the E-LCA. See Figure 2-3 and Figure 2-4 for life cycle contributions.

Table 2-5: Impact results for 1 serving (100 g) of bone-free beef, consumed

Category	Indicator	Units	National	West	East
Global warming	Carbon footprint	kg CO_2 eq	3.3	3.3	3.1
Resource depletion	Fossil fuel depletion	kg oil eq	0.3	0.3	0.2
	Water consumption	L	191.9	219.2	43.3
Land use	Agricultural land occupation	m^2a annual crop eq	11.5	12.8	4.4
Water pollution	Freshwater eutrophication	g P eq	1.2	1.1	1.5
	Terrestrial acidification	g SO_2 eq	33.8	32.5	41.1
Air pollution	Photochemical oxidant formation, human health	g NOx eq	4.1	4.1	3.9
	Photochemical oxidant formation, terrestrial ecosystems	g NOx eq	4.1	4.2	4.0

2.1.2 Global Warming

Carbon Footprint

The carbon footprint of 1 kg of live weight at the farmgate based on Western and Eastern production is shown in Figure 2-5. In the West, a carbon footprint of 10.5 kg CO_2 eq/kg live weight was observed, while in the East, a carbon footprint of 9.8 kg CO_2 eq/kg live weight was observed.

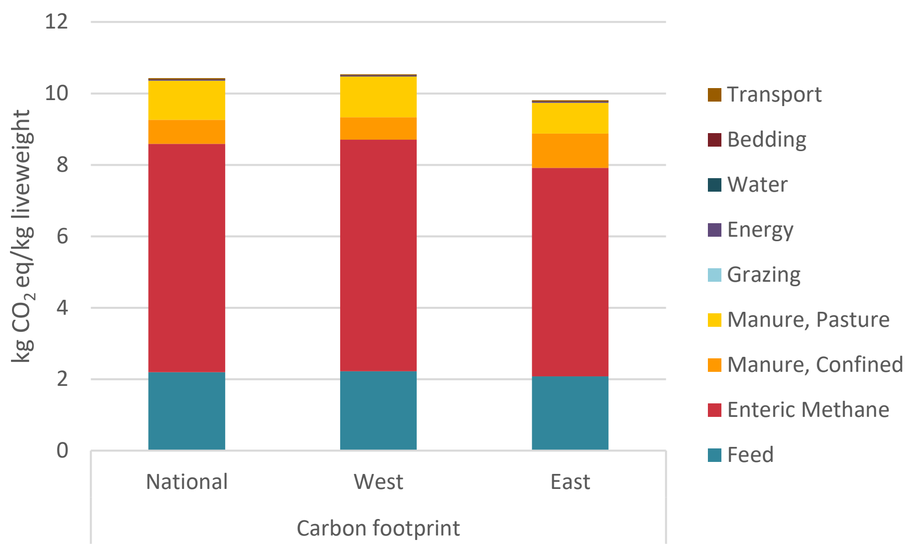


Figure 2-5: Contribution to carbon footprint nationally and for West and East.

The predominant contributors to carbon footprint are enteric methane (62% West, 60% East), manure management, both during confinement when manure is stored and during grazing when manure is applied to land (17% West, 19% East), and feed (21% both West and East). All other contributors, including transport of animals, bedding, water, energy, and grazing contribute to around 1% of the carbon footprint.

Enteric methane emissions results from enteric fermentation during digestion. In the West, the impact from enteric emissions is 6.5 kg CO_2 eq/kg liveweight, while in the East it is 5.8 kg CO_2/kg liveweight, each representing at least 60% of total impacts. Therefore, it is an important contributor to the carbon footprint of cattle production and is especially of concern for beef production around the world (Beauchemin et al., 2010; Chen et al., 2020; Persson et al., 2015) due to the higher global warming potential of methane compared to carbon dioxide. As described in Appendix D, enteric emission values are determined based on feed ration composition using equations defined in the Holos model (Little et al., 2008), IPCC (IPCC, 2019), and FAO LEAP guidelines (FAO, 2016) for ruminant production. In 2013/14, enteric emissions were also the biggest contributor to the carbon footprint, however, the impact caused by enteric fermentation per kg live weight is lower in 2021 by 9% in the West and 6% in the East due to changes in feed rations and shorter production periods (i.e. reduced time to slaughter). Regardless of this, the contribution from enteric emissions remains quite similar in relative magnitude, despite a difference in absolute value. The difference in absolute values can be explained by differences in the production systems. Specifically, heavier animals in the West (other than finishers) results in higher enteric emissions compared to the East due to the larger dry matter intake required, as explained in Appendix D.

Manure management is the next greatest contributor to the carbon footprint. As mentioned, manure, confined refers to emissions coming from manure storage while manure, pasture refers to emissions from manure during grazing. The contribution from manure management ranges between 17% in the West to 19% in the East. There was a difference in the contribution to emissions from manure storage and manure on pasture between the West and the East. In the West, the contribution from manure storage was 6% (0.63 kg CO_2 eq/kg liveweight) compared to 10% (0.96 kg CO_2 eq/kg liveweight). This is due to the fact that intensive production is more common in the East, shown by longer times on feed in confinement. Likewise, the contribution from manure on pasture is 11% in the West (1.1 kg CO_2 eq/kg liveweight), almost twice that of manure storage, due to the longer grazing periods in the West. In the East, contribution from manure on pasture is 9% (0.86 kg CO_2 eq/kg liveweight), much more similar in both absolute and relative value to manure storage in the East. Furthermore, the methane conversion factor, as defined by Little et al. (2008), is generally lower for pasture when compared to solid storage or deep bedding practices, further explaining the lower contribution from Western production.

Finally, feed was the third largest contributor to the carbon footprint. However, as shown above, feed rations indirectly contribute to enteric and manure-related emissions as well. In terms of other emissions incurred by feed rations, a large portion of emissions originate from the production of fertilizers used for crop production. Most of the emissions are CO_2 emissions originating from ammonia production for barley grain and silage production in the West and for corn grain and silage in the East. However, the production of other fertilizers, such as urea, as well as the use of diesel and other fossil-based energy on-farm are also contributors. Considering all feed-related inputs, the CO_2 emissions from feed production account for 57% of impacts in the West and 38% of impacts in the East. Differences in feed production impacts are generally the cause of the difference in carbon footprint between Western and Eastern production. In addition, the application of these fertilizers also results in emissions, which are typically N_2O emissions. These account for 59% (0.87 kg CO_2 eq/kg liveweight) of feed-related potential impacts in the East compared to 40% (0.89 kg CO_2 eq/kg liveweight) in the West, indicating higher fertilizer application rates for the crops being fed to beef cattle.

Since 2016, the hay production processes have been more accurately modelled and are specific to western and eastern production practices. Other crops, however, are still generic and not specific to beef producers. Since crop production does have a large impact, future assessments should include more informed models to better understand how on-farm practices affect crop-related emissions.

Inclusion of Dairy Sector

The beef cattle sector in Canada is intrinsically linked with the dairy sector through the transfer of animals across boundaries. As a case study, the inclusion of these dairy animals that end up in the beef production system are evaluated for the carbon footprint in this section.

The impacts of dairy produced in Canada were determined in the 2016 study by Dairy Farmers of Canada and allocation rules determined by IDF guidelines (2015) were considered to determine the impact of meat produced from dairy animals. Using these allocation rules, the portion of potential impacts from meat produced out of the dairy sector is a carbon footprint of 6.5 kg CO_2 eq/kg live weight beef nationally. Regionally, the carbon footprint of meat produced from the dairy sector is 6.0 kg CO_2 eq/kg liveweight in the West and 6.7 kg CO_2 eq/kg liveweight in the East. This includes dairy cows, calves, steers, and heifers that are produced in Canada and then slaughtered for beef. Furthermore, dairy steers are often imported from the United States to Western Canada. The impact of these imports is considered only in terms of transport of 1200 km by truck from the Pacific Northwest (Seattle) to Alberta (Calgary) in order to be consistent with other beef LCAs. It was then assumed that producing dairy-bred animals in the beef system does not vary significantly from beef-bred animals with respect to the carbon footprint.

It should be noted that the 6.5 kg CO_2 eq/kg live weight beef is lower than the carbon footprint observed for beef production, ranging between 9.8-10.5 kg CO_2 eq/kg live weight. This is because the majority of impacts from dairy production get allocated to milk, rather than to meat, which would be considered a co-product of the system.

In 2021, the amount of beef coming from the Canadian dairy sector, as well as imported dairy steers, was 17.2%, with the remaining 82.8% coming from the beef sector. This ratio varied slightly by region, with around 29.6% dairy beef in the East compared to 5.8% in the West.

The carbon footprint for 1 kg of live weight beef produced in Canada is shown in Figure 2-6 for the scenarios where dairy is included, as a case study, and excluded. As discussed in Appendix B, the carbon footprint for the case study on the inclusion of dairy was determined based on IPCC AR5 GWP-100 factors to match the IDF guidelines and the carbon footprint of dairy production in Canada.

At a national scale, the inclusion of dairy results in a carbon footprint of 9.8 kg CO_2 eq/kg live weight, compared to 10.4 kg CO_2 eq/kg live weight when it is excluded. When dairy is included in the West, the carbon footprint is 10.4 kg CO_2 eq/kg live weight, compared to 10.5 kg CO_2 eq/kg live weight when dairy is excluded. Similarly, when dairy is included in the East, the carbon footprint is 8.9 kg CO_2 eq/kg live weight, compared to 9.8 kg CO_2 eq/kg live weight when dairy is excluded.

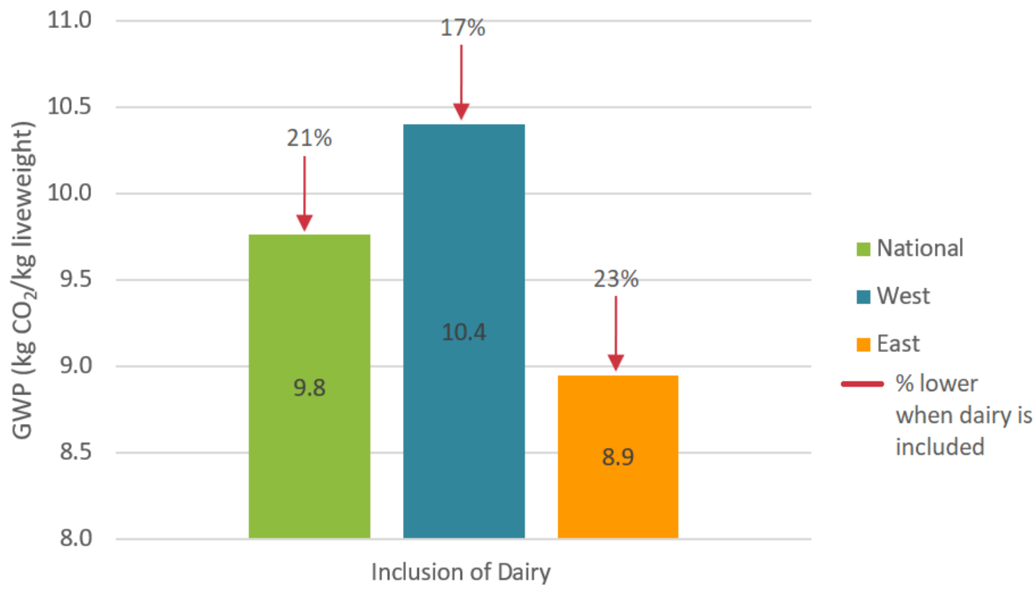


Figure 2-6: Carbon footprint (AR5) for National, Western, and Eastern production when dairy is included*.

*The difference in impacts when dairy is included is calculated based on the carbon footprint of beef production determined using the AR5 global warming potential factors. This was done in order to be consistent with the published data on the carbon footprint of Canadian dairy which was also calculated using AR5. As a result, the value for the beef carbon footprint used to determine the percentage difference in the above figure vary from the results presented in the main body of the report which use the AR6 global warming potential factors. The percentage difference is calculated between the AR5 values of with and without dairy.

In general, when beef coming from the dairy sector is included, the carbon footprint is slightly lower in both the West (1% lower) and the East (9% lower). This is due to the allocation of the majority of impacts of dairy cattle production to dairy or milk production. The remaining portion gets allocated to beef, meaning that beef coming from dairy animals is considered to have a lower carbon footprint than beef coming from beef animals. As mentioned, it was assumed that dairy-bred cattle that were imported and raised in the beef system likely do not have substantially higher carbon footprints than beef-bred cattle. In the East, a larger reduction in impact when dairy is included was observed compared to the West due to the larger portion of dairy animals being produced. Specifically, it found that 29.6% of beef in the East comes from dairy animals, while in the West, only 5.8% of beef comes from dairy animals. Another cause for the difference in Western and Eastern impacts is associated with the increased impact of imported dairy steers in the West. The transport of these animals adds an additional 0.0076 kg CO_2 eq/kg live weight in the West that is not associated with the East.

GWP*

In line with the direction of the Global Roundtable for Sustainable Beef (GRSB), results using the GWP* methodology (Allen & Hof, 2019; Liu et al., 2021; Lynch et al., 2020) were calculated in agreement with the SAC. This indicator was developed to address the growing interest for accounting of the net warming effect of short-lived climate forcer emissions (also called short-lived climate pollutants) especially methane, one of the GHGs that dominates the potential life cycle impacts of beef production on climate change.

Biogenic methane (CH_4) remains in the atmosphere for an average of 12 years before converting back to carbon dioxide (CO_2) through natural processes (Liu et al., 2021). This decomposition is equivalent to a methane sink. If methane emissions from a herd are reduced or the herd size itself is reduced, the methane sink from decomposing past emissions becomes dominant after a sufficient number of years (Del Prado et al., 2021; Liu et al., 2021; Lynch et al., 2020). According to Liu et al. (2021), an annual methane emission reduction of 1% during ten years would be sufficient for the California dairy industry to "approach" climate neutrality. Simulations from Del Prado et al. (2021) indicate that a methane emission increase below 0.8% (dairy sheep) or 1% (dairy goats) per year does not add warming to the atmosphere. Since GWP* is a relatively new indicator, it has not been extensively used in LCAs.

Results for GWP* are presented as a time series of data points. As mentioned previously, three data points consisting of a pair of data taken 20 years apart are used, including 1990 and 2010, 1996 and 2016, and 2000 and 2021. While 2020 could have been used, 2021 was selected to eliminate the possibility of skewed data as a result of the Covid-19 pandemic and to be more consistent with the reference year used throughout this study. Figure 2-7 below show the annual and cumulative emissions, respectively, based on biogenic methane from enteric emissions and manure management, while Table 2-6 shows the values used in these figures. GWP-100 results are presented in terms of Mt CO_2 eq, while GWP* results are presented in terms of Mt CO_2 warming equivalent (we).

Table 2-6: GWP* and GWP-100 values

Time (t-20)	Time (t)	Impacts	
		GWP-100	GWP*
1990	2010	26.2	23.2
1996	2016	24.9	18.0
2000	2021	26.6	-0.26

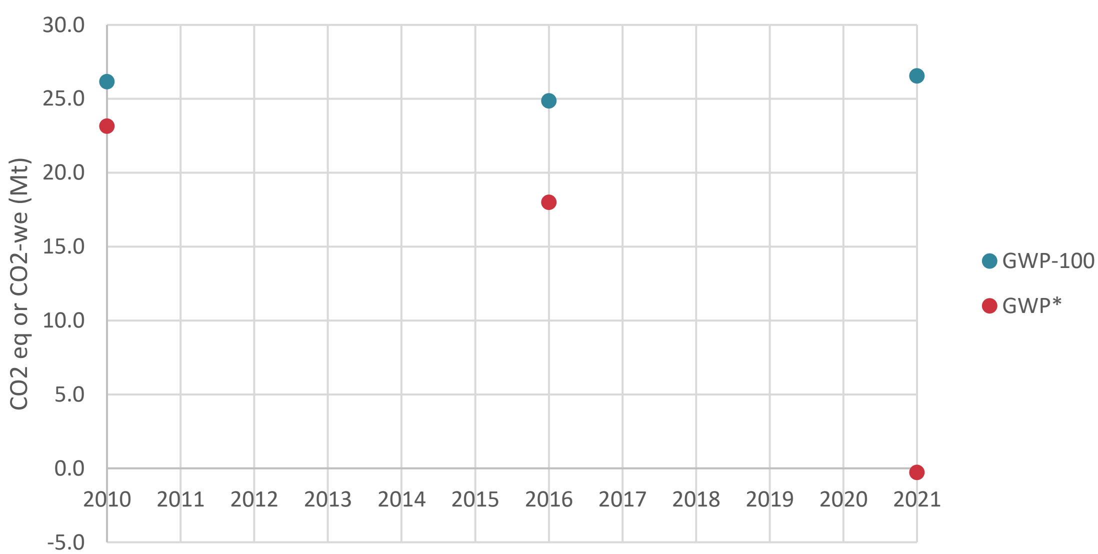


Figure 2-7: Annually calculated impacts from methane in terms of GWP-100 and GWP*.

Figure 2-7 shows the annually calculated impacts for both GWP and GWP* based on just biogenic methane, meaning enteric methane and methane from manure management. Relatively stable emissions are observed from 2010-2016. This is explained by relatively stable methane emissions from the beef cattle industry since 1990. Since 2016 however, a 16% smaller herd size and reduced biogenic methane emissions from efficiency improvements resulted in a carbon offset of around 0.26 Mt between 2000 and 2021, causing a negative GWP* value in 2021.

The results of the GWP* assessment should be considered with care. As mentioned, its methodology is still in development, as well as its interpretation. It should further be noted that GWP-100, used to calculate the carbon footprint described in previous sections considers future radiative forcing, which is consistent with how the other LCA indicators considered in this study are calculated. On the other hand, GWP* includes the effect of degradation of past emissions on warming to better match the temperature response of the climate. Consequently, it allocates the benefits of degraded methane from previous emitters to current emitters, which is not a typical approach in LCA. GWP* offsets should be understood and interpreted as short-term avoidance of peak warming, not as a substitute for understanding how current methane emissions affect warming, as GWP-100 does. In literature, it is highly recommended that both GWP and GWP* are reported side by side to account for this nuance. Furthermore, additional time-based dynamic emissions models could be considered in order to compare results.

2.1.3 Other Environmental Indicators

Fossil Fuel Depletion

The fossil fuel depletion potential of 1 kg of live weight at the farm gate based on Western and Eastern production is shown in Figure 2-8. In the West, a fossil fuel depletion potential of 0.4 kg oil eq/kg live weight was observed, while in the East, a fossil fuel depletion of 0.3 kg oil eq/kg live weight was observed.

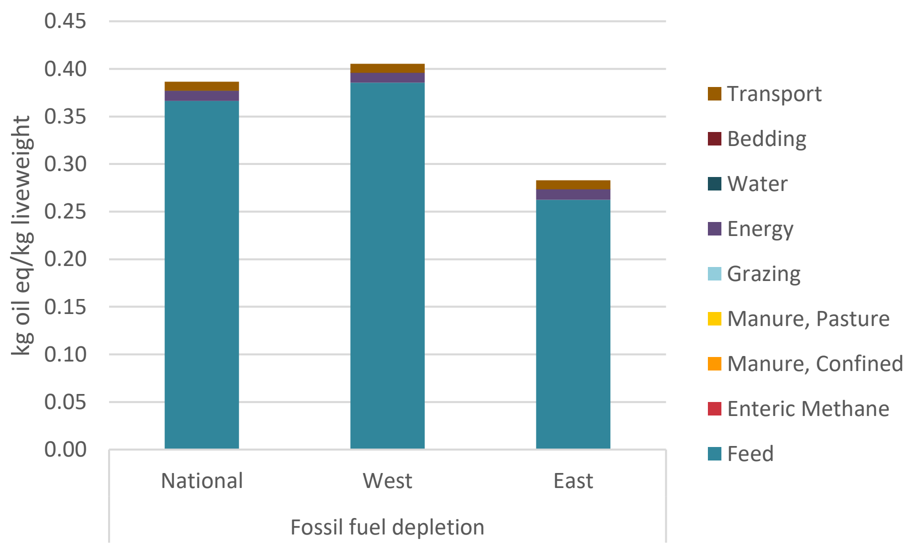
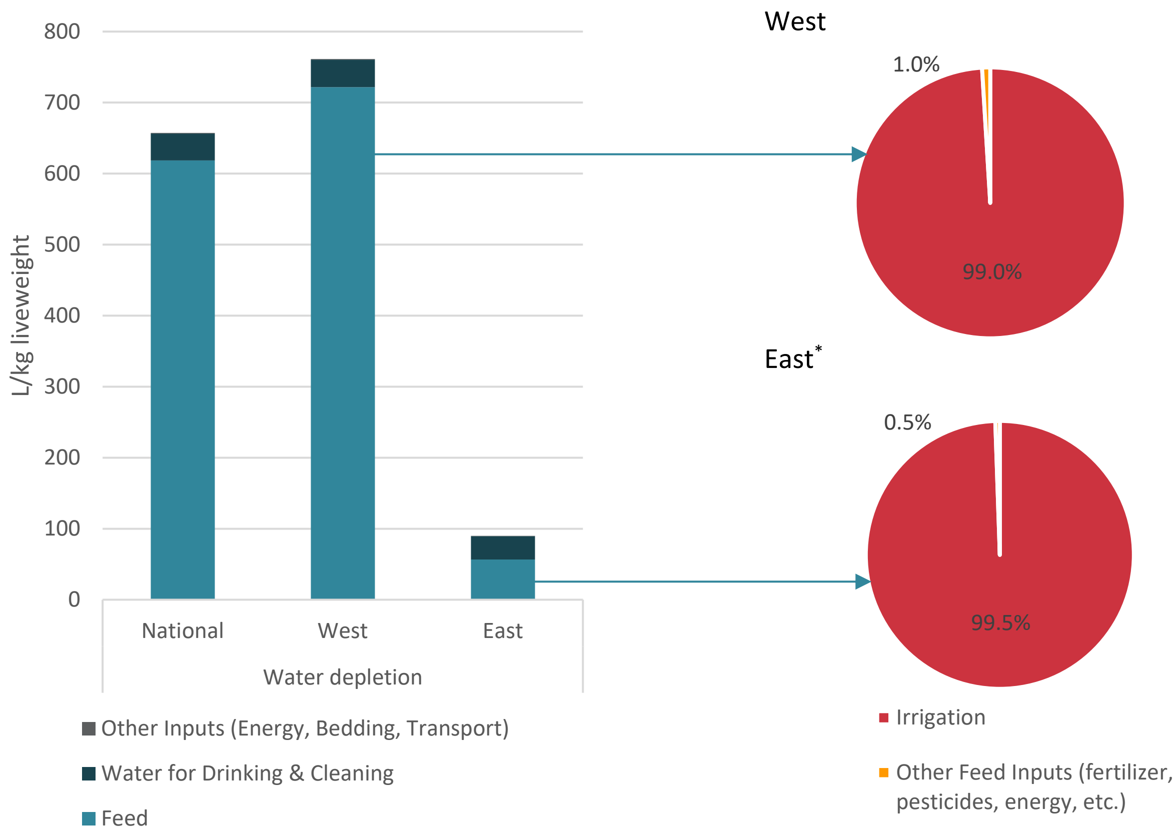


Figure 2-8: Contribution to fossil fuel depletion potential impacts nationally and for West and East.

Put in perspective, the values of 0.4 kg oil eq/kg live weight in the West and 0.3 kg oil eq/kg live weight in the East are equal to 16.7 MJ and 12.5 MJ, respectively. As shown in Figure 2-8, feed is the largest contributor to this impact. More precisely, indirect energy used to produce crops account for the majority of fossil fuel depletion (95% West, 93% East) since on-farm energy consumption is minor comparatively. Large fossil fuel depletion potential of barley production, compared to other crops used in feed rations, causes the difference between the West and the East. This is primarily due to the higher yields of corn produced in Canada compared to barley. Direct energy use is the second largest contributor, accounting for 3% in the West and 4% in the East. This is a result of the fossil-based energy sources typically used on farm, including natural gas and diesel. Finally, transport contributes to 2% of impacts in the West and 3% in the East.

Water Consumption

Ruminant production, including beef and dairy cattle, are known to be larger water consumers compared to other livestock. This is primarily due to the water required for feed production and is shown in relatively large water footprints (Legesse, Cordeiro, et al., 2018). Furthermore, water consumption for slaughter, processing, and packaging can be additional concerns for the industry. For Canadian beef, the water consumption potential of 1 kg of liveweight at the farm gate based on Western and Eastern production is shown in Figure 2-9. In the West, a water consumption of 762 L/kg live weight was observed, while in the East, a water consumption of 90 L/kg live weight was observed.



* Proportion of water used for irrigation compared to other inputs similar in West and East, but values differ due to higher precipitation levels in the East.

Figure 2-9: Contribution to water consumption potential impacts for National, West, and East (left) and contribution within feed-related water consumption (right).

Water consumption is one of the few indicators where a large difference was observed between Western and Eastern production. However, a higher precipitation level in Eastern Canada compared to Western Canada is the driver behind this. The value of 762 L per kg live weight in the West is justified due to the amount of irrigation required on field and forage crops in the Prairies, due to lower precipitation levels. However, the value itself is similar to numerous published studies on beef production in North America, since beef cattle production typically occurs on drier lands where crop production is not as feasible. Two notable studies on beef production in the United States have reported a water consumption ranging between 1214 L/kg live weight (Asem-Hiablie et al., 2019) and 1748 L/kg live weight (Capper, 2011).

On the other hand, a lower value of 90 L/kg live weight was observed in the East. Unlike Western production, less irrigation is used on grain crops due to higher precipitation levels. In fact, irrigation in the West accounts for over 90% of all irrigation in Canada, with almost 860,000 hectares of irrigated land according to the 2020 Agricultural Water Survey (Statistics Canada, 2021a). On the field and forage crops that make up the majority of feed rations, this difference is even larger with 100% of forage crop irrigation and 93% of field crop irrigation occurring in the West. It should be noted that a portion of forage crops that are irrigated are not fed to beef cattle, and rather are exported as "premium" products. This has been considered in the life cycle inventory of Canadian forage crops. Furthermore, precipitation rates are higher in the East compared to the West. For example, precipitation levels in Saskatchewan were lower than the average in the year 2021 by between 90-150 mm, while precipitation levels higher than average by 65-140 mm were common in southern Ontario (Statistics Canada, 2021b). While LCAs do not typically discuss the green water footprint related to the natural water cycle (precipitation, evapotranspiration, etc.), additional information on the green water footprint of Canadian beef has been researched by Legesse et al. (2018a). Regardless, the water consumption in the East is still primarily driven by irrigation. As shown in Figure 2-9, at least 99% of feed-related water use is associated with irrigation in both the East and the West. The remainder is associated with energy, fertilizer, and pesticide production.

It should be noted that in the previous NBSA, a substantially lower value was reported for the West. However, based on comparison from literature, it was clear that in NBSA 2016, some processes were underestimating the amount of water used, causing a lower than realistic value. As shown above, United States beef studies by Asem-Hiablie et al. (2019) and Capper (2011) reported values of 2558 L/kg boneless beef and 3682 L/kg boneless beef, respectively. Based on the same conversions used in this study, this equates to 1214 L/kg live weight and 1748 L/kg live weight, which are much more in-line with the newly reported 762 L/kg live weight in the West, than the previously reported 235 L/kg live weight. The larger values obtained from the United States beef studies indicate that higher irrigation rates might be applied compared to Canada. Furthermore, in 2013/14, the values reported for the West and East were more similar in terms of order of magnitude. However, the same irrigation values were applied in the East and West due to lack of data on hay production. This was a concern at the time given that irrigation practices vary greatly in the East, where very little irrigation occurs on grain crops, and the West, where irrigation is necessary given lower precipitation levels. The Hay LCI project (2018) revealed significant gaps between irrigation levels for hay in the East and the West, which is why there is a substantial difference between the values for the West and the East in the 2021 results, as well as between the 2021 results and the results of the earlier 2016 assessment.

This indicator does not consider green water. This is in line with the internationally recognized ISO 14046 standard on water footprint. The challenge with neglecting green water in the water footprint is that in regions where irrigation is required, the water consumption is much larger than in regions where enough naturally occurring precipitation exists. Indicators taking water scarcity more explicitly into account exist but were not part of the scope of the current study.

A limitation of this assessment is that water quality is not accounted for with the water consumption indicator. In the E-LCA, water-related indicators such as acidification and eutrophication are considered. However, other concerns like availability of water and competition among users is still not captured. This is where the water risk assessment can help shed light on the challenges faced by Canadian cattle producers.

AGRICULTURAL LAND OCCUPATION

The agricultural land occupation of 1 kg of live weight at the farm gate based on Western and Eastern production is shown in Figure 2-10. In the West, a land use of 43.6 m^2a annual crop eq/kg live weight was observed, while in the East, a land use of 12.0 m^2a annual crop eq/kg live weight was observed. It should be noted that this land use is over the lifetime of the animal.

Other beef LCAs typically report land use in terms of m^2a (annual crop equivalent), which represents annual crop land use. In this study, these units are applied based on land use (area) data that was collected for grazing and based on feed requirements. The land occupation flows of the ecoinvent databases with the relevant time reference were updated with the area occupied by beef production for each land use type. The midpoint characterization factors (in annual crop equivalents) were then applied to these calculated areas to estimate the land use occupation in m^2/yr annual crop land. For annual crops, meaning any land used for production of feed rations, a CF of 1 was applied, while for grazing land, a CF of 0.55 was applied (Huijbregts et al., 2017). It should be noted that in NBSA 2016, the values were reported in terms of actual land use, m^2.

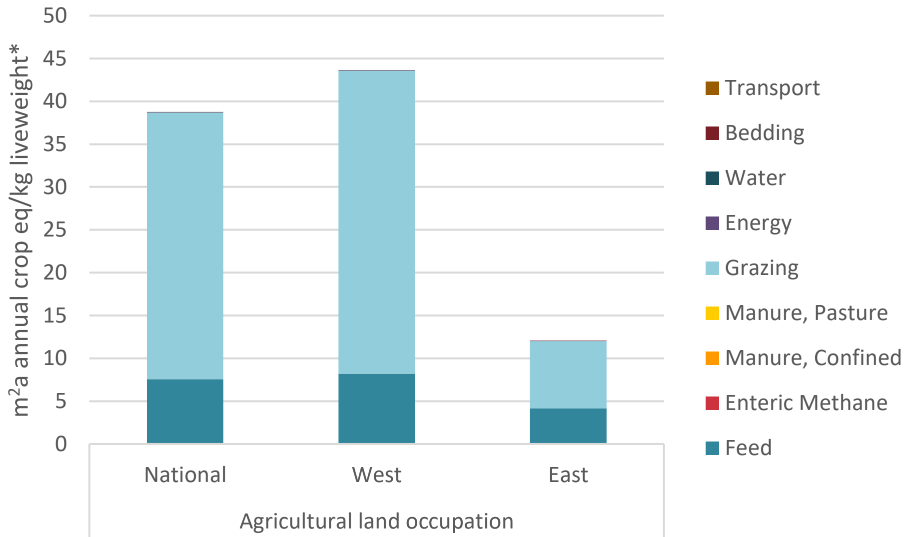


Figure 2-10 : Contribution to agricultural land occupation for West and East.
*Unit of measurement: m^2a annual crop land eq

Agricultural land occupation is the other indicator, along with water consumption and fossil fuel depletion, where a large difference between Western and Eastern production is found. In both cases, the contribution from land used for grazing (89% West, 77% East) is substantially higher than land used for feed production (11% West, 23% East). The values themselves are different, however. In the West, 35.4 m^2a annual crop eq/kg live weight is used for grazing, while only 7.9 m^2a annual crop eq/kg live weight is used in the East due to the larger use of extensive production in the West where available grazing lands exist. As noted earlier, the higher precipitation in Eastern Canada also improved pasture productivity compared to Western Canada. More intensive production in the East means that less land is required for grazing, but proportionately more land is required for feed production compared to the West, as shown in Figure 2-10. It should also be noted that several factors influence the split between intensive and extensive production, including the annual cohort size in the West and the East, the number of yearlings and backgrounders, and the availability of grazing land.

The potential land required for feed production, including the production of other feed-related inputs, such as energy, pesticides, and fertilizer, also varies between the West and the East. In the West, 8.2 m^2a annual crop eq/kg live weight is used for feed production, while in the East, 4.2 m^2a annual crop eq/kg live weight is used. This is due to the regional differences in the feed rations themselves, as well as the differing yields between the crops used for feed in the West and the East. For example, the national average crop yield based on the 2021 Census for barley was 0.36 kg/m^2, compared to 0.95 kg/m^2 for corn. The lower yield of barley, the primary feed component in the West due to its drought tolerance, accounts for the higher potential land use for feed production in the West. It should be noted that the difference is not related to the amount of feed fed in the regions since similar amounts are fed within each production stage, as indicated by the mid-weights listed in Appendix D.

The values obtained from this assessment are within the range of other published studies. The study by Asem-Hiablie et al. (2019) on the United States beef system reported a value of 47.4 m^2a/kg boneless beef, or 22.6 m^2a/kg live weight, similar to the value of Eastern beef production. The lower agricultural land occupation of this United States study and of Eastern Canadian production are explained by more intensive production patterns facilitated by higher precipitation, with less grazing than the extensive production systems in place in the West. Therefore, a study on Canadian beef production by Basarab et al. (2012) reported a value of 43.5 m^2a/kg live weight, similar to that of Western beef production, showing how extensive production systems can results in larger land occupations.

An understanding of the amount of land used Is important, but it is not the only relevant factor associated with land use. Therefore, additional impacts coming out of agricultural land occupation, including on biodiversity and carbon-soil sequestration, were also examined in this study. A deeper look at land use and its implications is therefore provided in Section 2.1.4.

Freshwater Eutrophication

Excess phosphate in aquatic environments can result in negative impacts on both aquatic and terrestrial life. The freshwater eutrophication indicator considers the amount of potential phosphorus, in the phosphate form in particular, emitted to water.

The freshwater eutrophication potential of 1 kg of live weight at the farm gate based on Western and Eastern production is shown in Figure 2-11. In the West, a freshwater eutrophication of 2.4 g P eq/kg live weight was observed, while in the East, a freshwater eutrophication of 3.9 g P eq/kg live weight was observed.

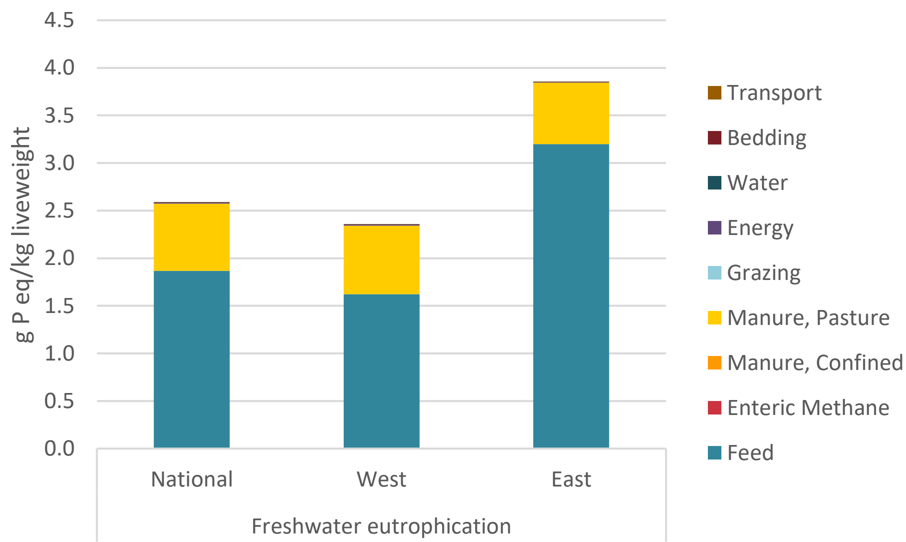


Figure 2-11: Contribution to freshwater eutrophication potential for West and East.

There is a substantial difference between the freshwater eutrophication potential in the West and in the East. The breakdown of contributions is the same, however. The majority of impacts are from feed production (69% West, 83% East), with the remainder from manure on pasture (31% West, 17% East). Manure management during confinement is not a contributor to this impact because it was assumed that phosphorus losses to freshwater only occur in pasture, as described in Appendix D.

In terms of feed production, the majority of impacts in both the East and the West originate from hay production practices. These processes have been studied and modelled in greater detail than in the NBSA 2016 model. Within the hay processes, use of fertilizers and pesticides, particularly phosphorus-based ones, are the greatest contributor to impacts. Soil management practices, such as tillage and cover, as well as erosion are additional factors affecting the amount of phosphorus leaching to freshwater. The average outcome of these factors was accounted for in each provincial hay process, which indicates that phosphorus leaching occurs at higher rates in the East compared to the West.

In the 2010 study by Alberta Agriculture and Rural Development on beef production, the eutrophication potential was found to be 3.89 g PO_4 eq/kg live weight (AARD, 2010), which is equivalent to 1.3 g P eq/kg live weight. This is slightly lower than the values of 2.4 g P eq/kg live weight (West) and 3.9 g P eq/kg live weight

(East) found here. At the time, the AARD study considered real data to model their crop production processes, while this study applies crop production data generic to Canada as a whole, except for hay production. Therefore, it is possible that there is an overestimation of P leaching on crops based on generic fertilization rates. Future studies could eliminate this uncertainty by modelling province-specific crop production for key crops, including barley, corn, and wheat.

Terrestrial Acidification

The terrestrial acidification potential of 1 kg of live weight at the farm gate based on Western and Eastern production is shown in Figure 2-12. In the West, a terrestrial acidification of 110.8 g SO_2 eq/kg live weight was observed, while in the East, a terrestrial acidification of 143.6 g SO_2 eq/kg live weight was observed.

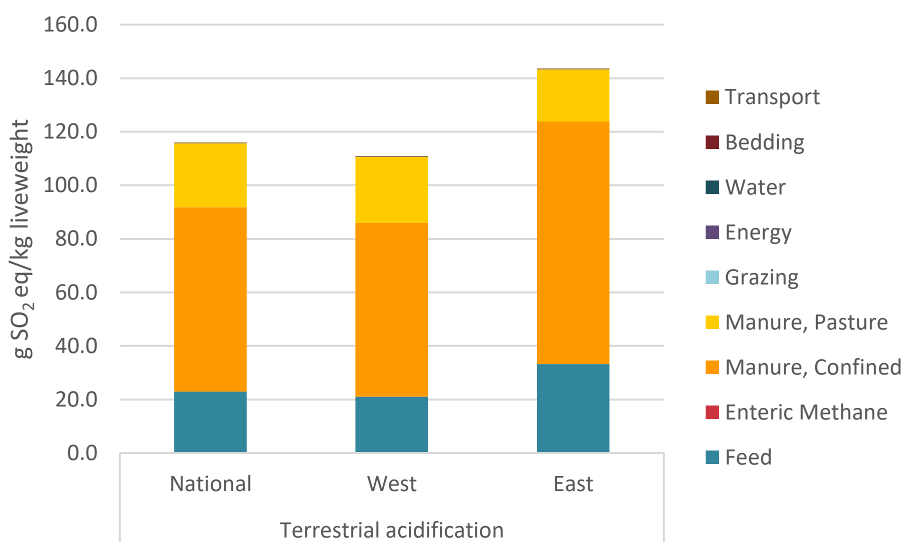


Figure 2-12: Contribution to terrestrial acidification potential for West and East.

A negligible difference between terrestrial acidification potential in the West and the East was observed. The impact is primarily driven by three contributors: manure management during confinement (59% West, 63% East), feed production (19% West, 23% East), and manure on pasture (22% West, 14% East).

In general, emissions from manure during confinement are higher than manure on pasture. This is true for methane, nitrous oxide, and ammonia because the emission factors for manure storage (including deep bedding and solid storage) are all typically higher than that of the emission factor on pasture, as described in Appendix D. However, it should be noted that ammonia emissions to air are the primary driver for terrestrial acidification potential. Slightly higher emissions are incurred in the East since animals typically spend more time in confinement when compared to the West. This difference in housing practices between Eastern and Western Canada is related to precipitation, as noted elsewhere. As a result, the contribution from manure during confinement is larger in the East, while the contributions from manure on pasture and feed are equal across both regions.

The values for terrestrial acidification range widely in literature, however the value found in this study does fit within this range. The study by Asem-Hiablie et al. (2019) reported an acidification potential of 726 g SO_2 eq/kg boneless beef, which is equivalent to 346 g SO_2 eq/kg live weight. This is higher than the values reported in this study. On the other hand, the AARD report (2010) published an acidification potential of 23 g SO_2 eq/kg live weight, which is lower. Different characterization methods and varying datasets could be the cause for this large range.

PHOTOCHEMICAL OXIDANT FORMATION: HUMAN HEALTH & TERRESTRIAL ECOSYSTEMS

Photochemical oxidant or smog formation is quantified by two different midpoint indicators, one representing human health effects and the other representing terrestrial ecosystem effects. The ozone formation potential of 1 kg of live weight at the farm gate based on Western and Eastern production is shown in Figure 2-13. In the West, an ozone formation of 8.8 g NO_x eq/kg live weight (human health) and 8.9 g NO_x eq/kg live weight (terrestrial ecosystems) was observed, while in the East, an ozone formation of 8.3 g NO_x eq/kg live weight (human health) and 8.3 g NO_x eq/kg live weight (terrestrial ecosystems) was observed.

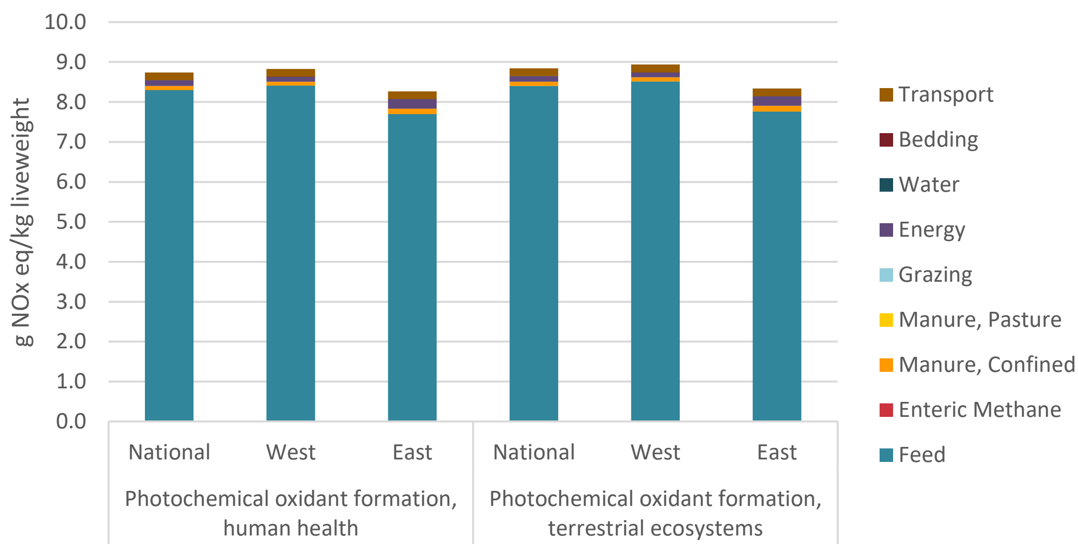


Figure 2-13: Contribution to photochemical oxidant formation potential for West and East.

For both midpoint indicators, feed rations contribute to the majority of impacts in the West (95%) and East (93%). As in NBSA 2016, the larger contributors within feed rations are barley, wheat, corn, due to chemical inputs, such as fertilizers and pesticides, along with diesel use for crop production. Other on-farm practices, such as tillage and combine harvesting also represent non-negligible portions of the impact from feed rations. All other inputs have a negligible contribution to this impact.

2.1.4 BIODIVERSITY AND ECOSYSTEM QUALITY

BIODIVERSITY OVERVIEW

The relationship between wildlife and intensive agriculture is a complicated one. Efforts must be taken to ensure that existing biodiversity is adequately preserved and that further biodiversity losses are prevented. For the beef industry, biodiversity is a growing topic of discussion both inside and outside of academia. Grazing and biodiversity are connected topics, and this is where the beef industry plays a role, however there are many trade-offs to consider.

The consensus in literature is that well managed grazing practices can help to increase species richness depending on the land cover type and existing vegetation being grazed (Gao & Carmel, 2020; Pulungan et al., 2019; Velado-Alonso et al., 2020). Gao & Carmel (2020) focus on the increase in plant richness that occurs in wet grasslands, while Velado-Alonso et al. (2020) emphasize the importance of amphibian biodiversity as well. Furthermore, proper grazing can also reduce the occurrence of erosion and nutrient leaching as well (Kleppel, 2020). Properly managed grazing can also reduce the presence of non-native plant species and invasive species, which in turn can allow more native vegetation to be restored (Barry & Huntsinger, 2021). One of the mechanisms by which biodiversity increases is through the trampling that occurs because of cattle presence. This trampling, when paired with periods of "rest" without grazing, can encourage soil recovery and other natural cycles that support plant and insect biodiversity (Bailey et al., 2019; Manning et al., 2015). It is important to note that this period of rest between grazing cycles is essential for increasing biodiversity because of the physical damage trampling can cause otherwise.

As mentioned, there are trade-offs to consider. While increased biodiversity is possible with grazing, it has also been found that higher biodiversity of livestock, meaning greater breed richness in cattle, typically leads to higher biodiversity in wildlife (Velado-Alonso et al., 2020). The same study found that, on the other hand, introduction of sheep led to lower biodiversity. While there are many positive interactions between grazing and biodiversity, there are some challenges that must be kept in mind.

In terms of risks to biodiversity posed by the beef industry, improper grazing is a topic of concern in literature. As shown previously, in general, grazing positively affects species composition. It supports the gradual increase and maintenance of biodiversity. However, some species are disproportionately affected compared to others. In fact, over half are negatively affected including many birds, mammals, and bee species, despite the sizable fraction that reaps some benefits (Pozo et al., 2021). In particular, herbivorous mammals suffer because they are competing for space and fenced off farmlands disturb their migratory patterns (Pozo et al., 2021). Furthermore, poor grazing management also leads to risks of trampling, overconsumption, and habitat destruction (Barry & Huntsinger, 2021; Thapa-Magar et al., 2020). In terms of risks for cattle production, increased biodiversity of certain plant types can have a negative influence on cattle growth (Angerer et al., 2021). Kleppel (2020) mirrored this finding by pointing out that the level forage quality is a key trade off parameter when considering the duration of grazing periods and the use of feed rations. Despite these findings, there is very little consensus on which factors affect biodiversity and to what extent (Lebbink et al., 2021). Lebbink et al. (2021) also indicated that the specific conditions under which grazing must be undertaken to positively affect biodiversity are not fully understood, which could pose risks for native species. Furthermore, based on the studies reviewed here, there is also a lack of consensus on how to measure and report biodiversity with respect to cattle production making it very difficult to compare studies and production systems. With these benefits and risks in mind, the performance of the Canadian beef sector with respect to biodiversity can be better understood.

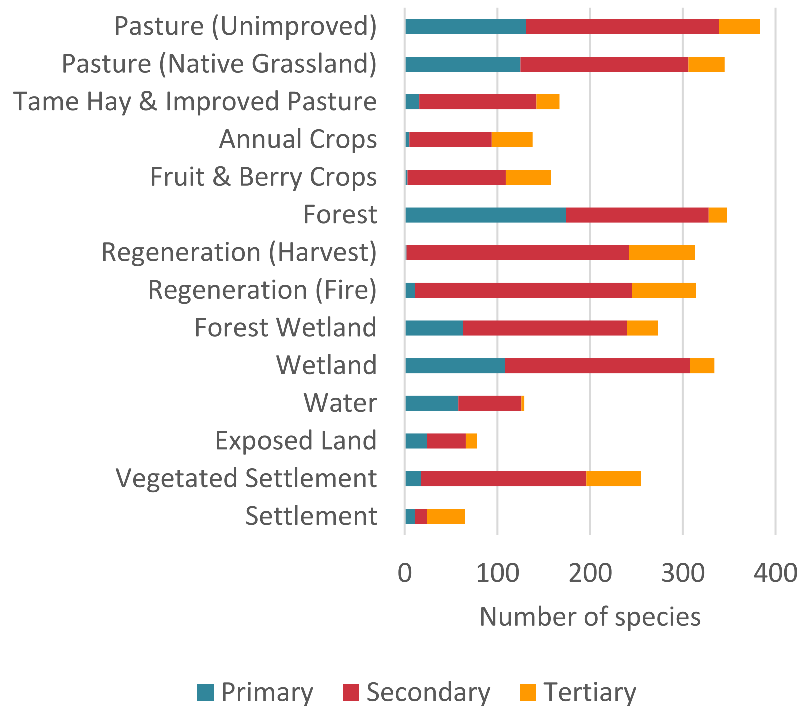
POTENTIAL WILDLIFE HABITAT CAPACITY ON AGRICULTURAL LAND ASSOCIATED WITH THE BEEF CATTLE INDUSTRY

As mentioned, the Potential Wildlife Habitat Capacity Index (WHCI) on Agricultural Land in Canada Agri-Environmental Indicator was developed by AAFC to provide a multi-species assessment of broad-scale trends in the capacity of the Canadian agricultural landscape to provide reproductive and feeding habitat for populations of terrestrial vertebrates. Calculation methodology relates species found within the agricultural landscape with natural, semi-natural, agricultural and urban land cover used as primary, secondary or tertiary reproductive and feeding habitat.

To understand the relationship between beef cattle industry and wildlife habitat capacity, an agri-environmental indicator was developed focusing on the agricultural land cover portion (cropland and pastureland including native grassland) of the broader landscape ($WHCI^A$). Applying proportions of agricultural cover types used by the beef cattle industry allowed calculation of a beef-specific Wildlife Habitat Capacity Index ($WHCI^B$). Harmonized methodologies between $WHCI^A$ and $WHCI^B$ allowed assessment of the proportion of total overall wildlife habitat associated with the cattle industry. The results are presented for 2021 as follows.

Wildlife

Nationally, there are 545 species of terrestrial vertebrates (332 birds, 134 mammals, 41 amphibians and 38 reptiles) that use land within the agricultural extent in Canada for reproduction and feeding. Figure 2-14 shows the number of terrestrial vertebrate species associated with each land cover type in the Canadian agricultural extent and whether it provided primary, secondary or tertiary habitat for breeding and feeding purposes, respectively.



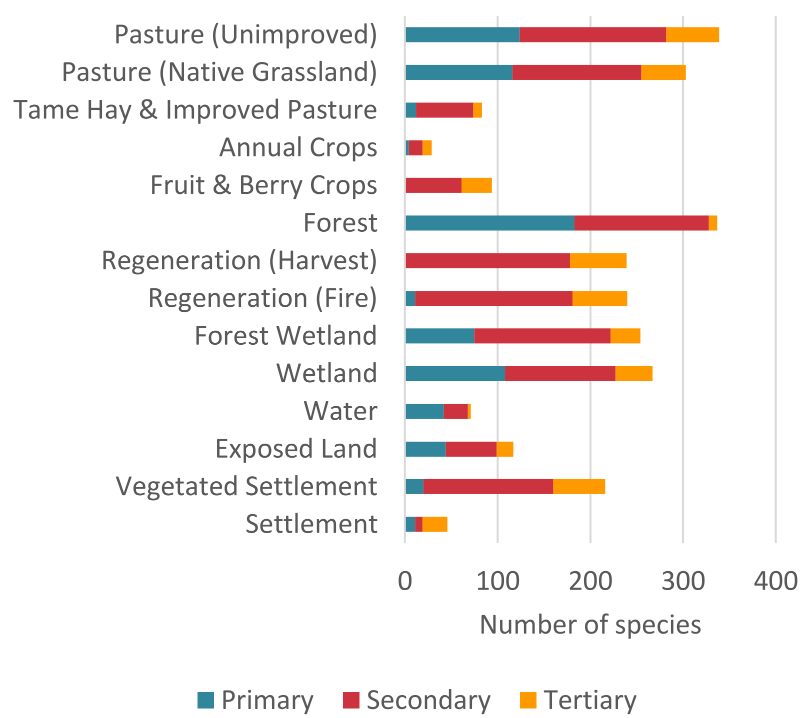


Figure 2-14: The number of terrestrial vertebrate species using cover types for primary, secondary, and tertiary feeding (top) and reproductive habitat (bottom).

Note: The data shown in these figures is representative of the year 2016 as part of the underlying WHCI dataset.

Natural and semi-natural land cover (Woodland, Wooded Wetland, Wetland, Water, Managed Grassland and Unimproved Pasture) provided primary breeding and feeding habitat for many species. These cover types are extremely important for wildlife, providing both primary reproductive and feeding habitat for the vast majority of species (71.92%) and met habitat requirements for 93.94% of species when both primary and secondary habitat was considered. Many species used Regenerating Woodland following harvest or fire as secondary/tertiary habitat for reproduction and feeding but it offered little in the way of primary habitat. Cropland cover types were used by relatively few species compared to natural and semi-natural cover types. Only 2.93% of species used Cropland cover types (Annual, Perennial, Fruits and Berries) as primary reproductive habitat which increased to 21.28% when both primary and secondary habitat use was considered. Annual Cropland provided primary reproductive habitat for just 0.73% of species (3.48% of species for primary and secondary habitat) while Perennial cover offered primary habitat to 2.20% of species (13.57% of species for primary and secondary habitat). The inability of Cropland alone to fulfill habitat requirements for the vast majority of wildlife species highlights the importance of natural and semi-natural cover types in Canadian agricultural landscapes.

Land Cover and Beef Cattle Rations (2013/14-2021)

Cover types associated with the beef cattle industry were Oats, Barley, Triticale, Corn, Wheat, Unimproved Pasture, Improved Pasture, Grass and Hay, and Native Pasture. Table 2-7 shows National and Provincial/Regional proportions of each cover type in the agricultural extent in 2021 and percent change since 2013/14[8].

Table 2-7: National and provincial percentages of agricultural land in Canada in Cropland and Pastureland for 2013/14 and 2021

		% Cropland within Agricultural Footprint									% Pastures within Agricultural Footprint		
		Fruit and Berry	*Nursery*	*Other Annual Crops*	*Corn*	*Barley*	*Grass & Hay*	*Oats*	*Wheat*	*Triticale*	*Unimproved*	*Improved*	*Native Grassland*
Atlantic	2013/14	9.06%	0.08%	19.10%	5.44%	6.63%	35.32%	3.32%	4.31%	0.00%	8.90%	7.84%	0.00%
	2021	9.05%	0.07%	19.70%	6.70%	7.04%	35.62%	3.92%	4.70%	0.01%	6.99%	6.21%	0.00%
Quebec	2013/14	2.02%	0.14%	22.58%	22.13%	2.49%	31.46%	4.03%	4.40%	0.04%	5.43%	5.28%	0.00%
	2021	2.28%	0.12%	24.89%	22.08%	1.83%	32.62%	3.35%	4.61%	0.04%	3.95%	4.24%	0.00%
Ontario	2013/14	0.50%	0.21%	32.79%	23.78%	1.00%	16.71%	0.80%	11.63%	0.03%	7.58%	4.98%	0.00%
	2021	0.48%	0.19%	33.35%	24.69%	0.68%	17.04%	0.84%	12.50%	0.05%	6.21%	3.97%	0.00%
Manitoba	2013/14	0.00%	0.01%	37.76%	3.23%	2.77%	10.70%	2.95%	19.93%	0.00%	13.63%	6.18%	2.84%
	2021	0.00%	0.01%	38.92%	4.11%	2.89%	9.50%	5.12%	19.99%	0.02%	11.23%	5.38%	2.83%

[8] The feed rations considered in the biodiversity assessment are based on data from 2013/14. However, the underlying data in the benchmarked model is based on 2016, including number of species and habitat use. Subsequent figures will therefore refer to 2016 as the benchmarked year.

Saskatchewan	2013/14	0.00%	0.00%	38.34%	0.21%	4.34%	6.69%	2.60%	20.59%	0.11%	3.73%	8.36%	15.02%
	2021	0.00%	0.00%	36.30%	0.20%	6.43%	5.71%	3.02%	20.91%	0.12%	3.85%	8.44%	15.01%
Alberta	2013/14	0.00%	0.01%	20.06%	0.48%	6.86%	8.81%	1.65%	14.09%	0.10%	12.69%	10.90%	24.33%
	2021	0.00%	0.01%	19.96%	0.51%	8.00%	8.33%	1.79%	14.01%	0.11%	12.31%	10.63%	24.32%
British Columbia	2013/14	1.04%	0.15%	3.32%	0.73%	0.95%	14.96%	1.12%	1.78%	0.02%	41.59%	8.46%	25.86%
	2021	1.38%	0.12%	4.02%	0.97%	1.48%	16.70%	1.62%	1.28%	0.01%	37.86%	8.72%	25.86%
Canada	2013/14	0.26%	0.03%	30.51%	3.56%	4.57%	10.14%	2.23%	16.50%	0.08%	8.78%	8.51%	14.82%
	2021	0.27%	0.03%	29.90%	3.74%	5.79%	9.56%	2.67%	16.70%	0.09%	8.19%	8.24%	14.82%

The distribution of Native Grasslands is restricted to the Prairie Ecozone and parts of British Columbia where it provides important habitat for many species. Despite its limited distribution, native grasslands comprised 14.82% of agricultural land in Canada. The share of Native Grasslands contracted across its range with Alberta, Saskatchewan and Manitoba each experiencing a -0.01% decline from 2016 to 2021. Nationally, the share of Native Grassland declined by -0.0007% over this time period. The National share of Unimproved Pasture declined by -0.59%. There was a similar pattern of decline Provincially with exception of a slight increase in the proportion of Unimproved Pasture in Saskatchewan. Nationally, Improved Pasture declined by -0.27%. Unimproved Pasture declined in all Provinces with the exception of Saskatchewan and British Columbia. Nationally, the share of Grass and Hay declined by -0.58%. Grass and Hay decreased in each Province with the exceptions of Saskatchewan and British Columbia. The National proportion of Annual Crops associated with the beef cattle industry (Corn, Barley, Oats, Wheat and Triticale) increased while Other Annual Crops declined.

There were significant changes in proportion of land cover allocated to the beef cattle industry from 2013/14 to 2021, as shown in Table 2-8. This is based on the feed rations described in Appendix D.2. Most notable is the increase in the proportion of improved pasture, unimproved pasture and native grassland allocated to the beef cattle industry in Alberta, Manitoba, Ontario, Quebec and the Atlantic Region and the slight declines in Saskatchewan and British Columbia. The allocations of Annual Crop types to the beef cattle industry were highly variable among reporting years.

Table 2-8: Proportion of total cover types allocated to the beef cattle industry, based on feed rations

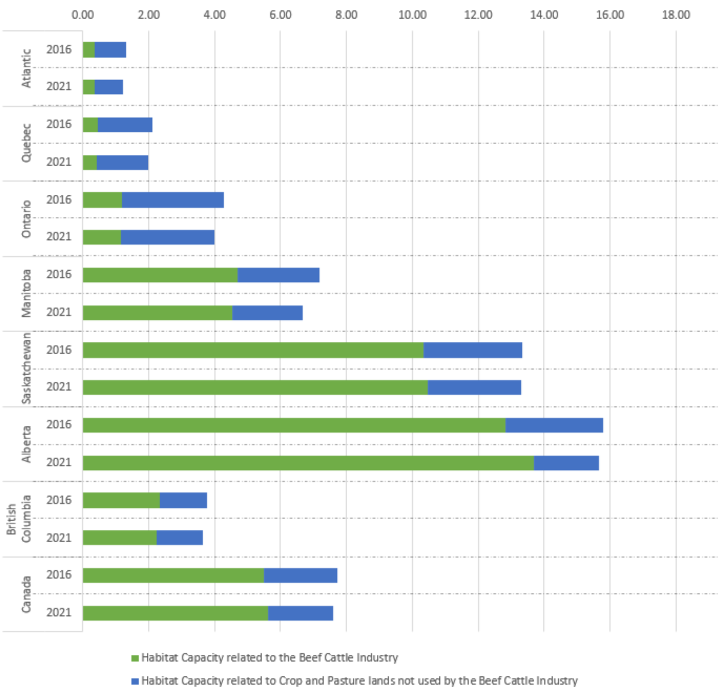
	Year	Oats	Barley	Triticale	Corn	Wheat	Unimproved Pasture	Improved Pasture	Grass & Hay	Native Grassland
BC	2013/14	39%	24%	39%	4%	36%	65%	65%	24%	65%
	2021	65%	17%	0%	7%	28%	64%	64%	32%	64%
AB	2013/14	35%	23%	34%	4%	32%	90%	90%	26%	90%
	2021	31%	19%	0%	9%	29%	97%	97%	36%	97%
SK	2013/14	35%	23%	45%	4%	41%	97%	97%	30%	97%
	2021	29%	17%	0%	13%	36%	96%	96%	67%	96%
MB	2013/14	33%	21%	58%	4%	33%	92%	92%	24%	92%
	2021	28%	16%	0%	9%	28%	96%	96%	46%	96%
ON	2013/14	38%	24%	0%	9%	20%	55%	55%	17%	-
	2021	34%	30%	0%	6%	19%	66%	66%	15%	-
QC	2013/14	41%	23%	0%	9%	33%	39%	39%	18%	-
	2021	41%	32%	0%	6%	32%	57%	57%	14%	-
ATL	2013/14	41%	24%	0%	11%	32%	48%	48%	18%	-
	2021	39%	31%	0%	7%	27%	63%	63%	15%	-

From 2013/14 to 2021 there were cover type changes that impacted the overall WHCI that were not directly associated with the beef cattle industry. Nationally, important wildlife habitat such as wetlands and wooded wetlands declined slightly while woodland saw a slight increase. Increase in the proportion of woodland in the agricultural extent was associated successional transition of regenerating woodland (<20 years) to woodland (>20 years). Nationally, the share of total Annual Cropland increased by 0.50% while the proportion of settlements expanded slightly (0.04%).

Wildlife Habitat Capacity Index (WHCI)

National reproductive WHCI^{A} on agricultural land decreased from 7.74 to 7.61 from 2016[9] to 2021, as shown in Figure 2-15. This overall decline was attributable to loss of important natural and semi-natural land cover (native grassland, unimproved pasture and improved pasture) and tame hay combined with increases in cover types of significantly lesser value to wildlife (annual cropland). WHCI^{A} declined in each Province.

[9] Feed rations data used in the 2016 benchmark are representative of 2013/14, however all underlying habitat data is representative of 2016.

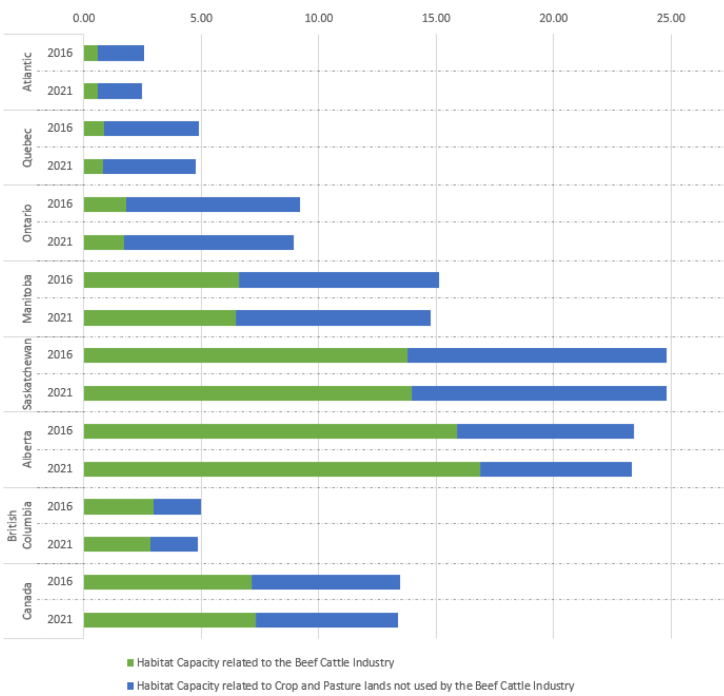


Habitat Capacity on Cropland and Pastureland (WHCI[A])	Habitat Capacity on Land associated with the Beef Cattle Industry (WHCI[B])	% of Cropland and Pastureland Habitat Capacity associated with the Beef Industry
1.32	0.37	28.14%
1.23	0.37	30.39%
2.12	0.46	21.52%
1.99	0.44	22.07%
4.27	1.20	28.22%
4.00	1.15	28.83%
7.17	4.69	65.41%
6.68	4.53	67.81%
13.33	10.35	77.61%
13.32	10.45	78.48%
15.78	12.83	81.31%
15.65	13.69	87.48%
3.77	2.35	62.30%
3.66	2.24	61.24%
7.74	5.48	70.81%
7.61	5.63	73.93%

Figure 2-15: Reproductive Wildlife Habitat Capacity Index (WHCI) on agricultural land in Canada.
Green bar is the WHCI associated with the beef cattle industry (WHCI[B]). Numbers at end of bar indicate overall WHCI. Note that for the benchmarking year of 2016, the underlying biodiversity data is representative of the year 2016, while the feed rations applied to determine land over types is representative of the years 2013/14.

In the Atlantic Region, successional woodland transition was greater than harvest resulting in a net increase in this high value cover type which contributed to a slightly higher WHCI. In Quebec and Ontario, the main drivers of slight WHCI decline were loss of improved and unimproved pasture and wetland and increases annual cropland and settlements. In Manitoba and Alberta WHCI decline resulted from loss of native grassland, unimproved pasture, improved pasture, and wetland and increase of annual cropland and settlement. Slight increase in WHCI in Saskatchewan was attributable to a greater share of unimproved and improved pasture. Despite slight overall increase in Saskatchewan, the loss of high value natural land cover (native grassland, wetland, woodland) negatively impacted WHCI. WHCI decline in British Columbia resulted from reduction of unimproved pasture, improved pasture and increased share of annual cropland and settlement.

National feeding WHCI[A] decreased from 13.49 to 13.38 from 2013/14 to 2021, as shown in Figure 2-16. Drivers of feeding WHCI decline were similar to that of reproductive WHCI. Drivers of feeding WHCI[A] decline were similar to that of reproductive WHCI[A]. Feeding WHCI[A] declined in each province with the exception of Saskatchewan where it remained stable.



Habitat Capacity on Cropland and Pastureland (WHCI^A)	Habitat Capacity on Land associated with the Beef Cattle Industry (WHCI^B)	% of Cropland and Pastureland Habitat Capacity associated with the Beef Industry
2.55	0.61	23.74%
2.48	0.61	24.42%
4.91	0.86	17.57%
4.79	0.80	16.66%
9.19	1.82	19.78%
8.94	1.71	19.17%
15.13	6.60	43.66%
14.76	6.47	43.82%
24.84	13.77	55.44%
24.84	13.95	56.15%
23.42	15.89	67.86%
23.32	16.89	72.45%
4.97	2.96	59.50%
4.86	2.85	58.50%
13.49	7.16	53.10%
13.38	7.34	54.83%

Figure 2-16: Feeding Wildlife Habitat Capacity Index (WHCI) on agricultural land in Canada. Green bar is the WHCI associated with the beef cattle industry (WHCI^B). Numbers at end of bar indicate overall WHCI. Note that for the benchmarking year of 2016, the underlying biodiversity data is representative of the year 2016, while the feed rations applied to determine land over types is representative of the years 2013/14.

Wildlife Habitat Capacity Index: Beef Cattle Industry (WHCI^B)

National reproductive WHCI^B increased slightly from 5.48 to 5.63 from 2016 to 2021 (Figure 2-15). Over this time period the national share of overall WHCI^B increased from 70.8% to 73.9% of total WHCI^A on agricultural land. In the Prairie Provinces, WHCI^B comprised a higher proportional of total WHCI^A compared to the rest of Canada. This is due in part to the relationship of native grasslands and cattle. In 2021, the share of WHCI^B in Saskatchewan, Alberta and Manitoba was 78.2%, 87.5% and 67.8% of total WHCI^A, respectively. Increased reproductive WHCI^B on agricultural land is attributable to a greater share of natural and semi-natural cover types (Native Grassland, Unimproved Pasture and Improved Pasture) allocated to the beef cattle industry in 2021 compared to 2016, not an increase in these important land cover types. Over this period, declines in Native Grassland, Unimproved Pasture and Improved Pasture highlights a trend that negatively impacts wildlife and biodiversity in the Canadian agricultural landscape. Reproductive WHCI^B declined in Quebec, Ontario, Manitoba and British Columbia, was stable in the Atlantic and Increased in Saskatchewan and Alberta.

National feeding WHCI^B increased slightly from 7.16 to 7.34 from 2016 to 2021 (Figure 2-16). Over this time period the share of WHCI^B increased from 53.10% to 54.83% of overall WHCI^A. The increase in feeding WHCI^B followed similar patterns as reproductive WHCI^B. Specifically, increased allocation of high value cover types to the beef cattle industry more than offsetting decline in those land covers. Feeding WHCI^B was stable in the Atlantic Region, decreased in Quebec, Ontario, Manitoba and British Columbia and increased in Saskatchewan and Alberta.

Assessment Based on Alberta Biodiversity Monitoring Institute (ABMI)

The method followed by the Alberta Biodiversity Monitoring Institute (ABMI) differs from the WHCI model and presents various indicators reflecting biodiversity across the province of Alberta. Unlike WHCI, the ABMI model is not beef cattle specific, meaning that causal relationships between beef production and the biodiversity indicators provided by ABMI cannot be drawn. However, it can provide high-level insights regarding biodiversity changes in Alberta compared to pre-European conditions. Additionally, while the WHCI model considers agricultural land specifically, the ABMI model considers numerous land uses, including for infrastructure, which, again, is not specific to the beef industry. Therefore, this assessment should not be used as a standalone for understanding biodiversity impacts by beef cattle in Canada, it should be used in addition to the WHCI analysis described previously, which considers land use and crop areas directly based on feed rations used by the beef industry. A high-level, qualitative understanding gained from ABMI is provided in this section.

The two indicators taken from the ABMI model for this assessment are species intactness and species richness. These indicators are defined as shown in Table 2-9.

Table 2-9: Definition of ABMI indicators considered in this study

Indicator	Definition (ABMI, 2021)
Species Intactness	Comparison of predicted species abundance in a given region with the predicted species abundance in that same region assuming a zero human footprint.
Species Richness	Absolute value of the number of native species in a given region.

Species intactness and species richness across Alberta as determined by the ABMI model are provided in Figure 2-17.

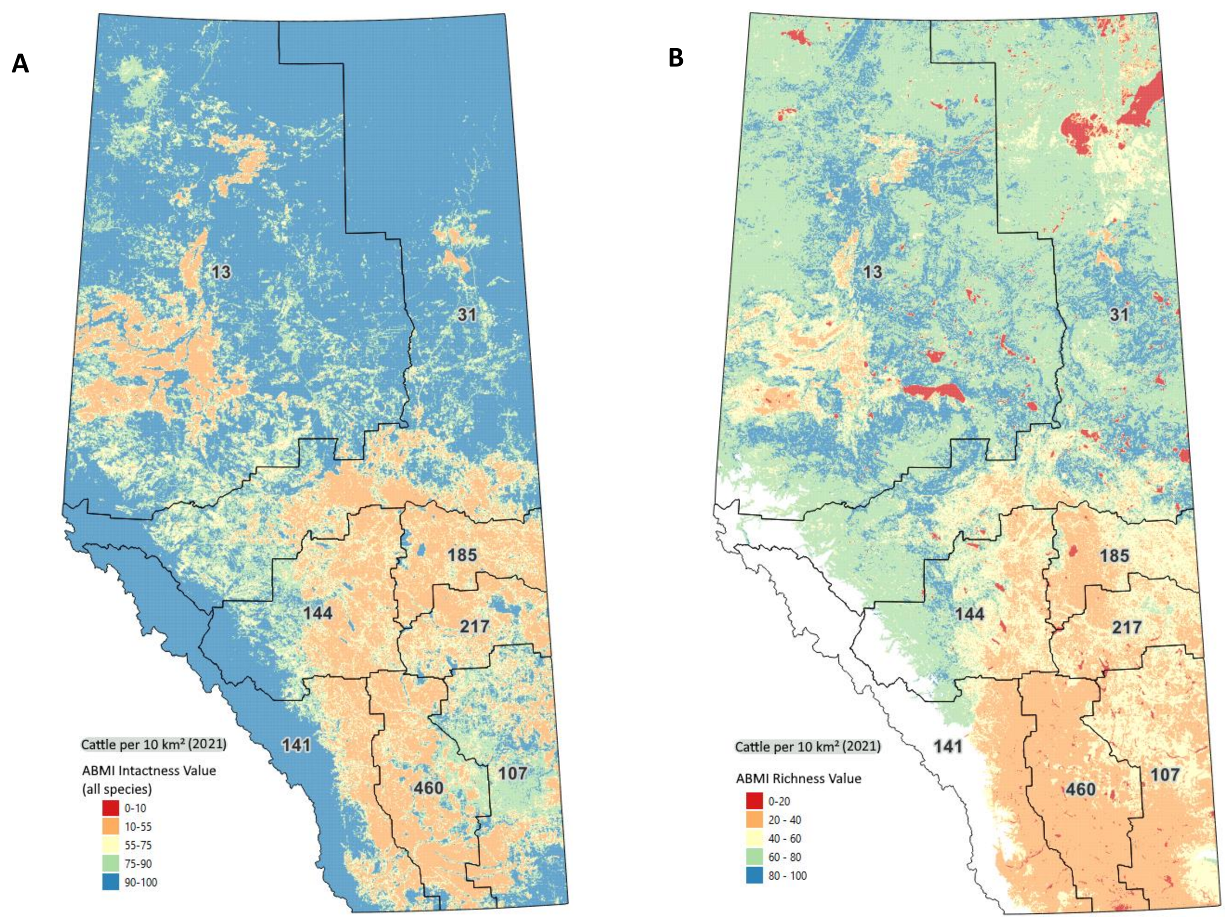


Figure 2-17: Species intactness (A) and species richness (B) based on ABMI model, with cattle per 10 km^2 in census districts.

The indicators shown in Figure 2-17(A) and (B) represent species intactness and species richness, respectively. As mentioned, species intactness describes how species abundance has diverged since human disturbance. Figure 2-17(A) indicates most of the species loss has occurred in the southern part of the province, where the majority of cattle production happens to occur. A similar trend is shown in Figure 2-17(B), which shows the species richness in the region. This makes sense given the human population, infrastructure, and crop production that are also present in this part of the province. Therefore, while the ABMI model cannot draw a connection between cattle production and species loss, it can conclude that the dense and agriculture-heavy lands in Alberta are subject to species loss. Despite this, the WHCI assessment and the studies by Gao & Carmel (2020), Pulungan et al. (2019) and Velado-Alonso et al. (2020) all point out that cattle grazing is a key element in increasing and maintaining species richness. This reiterates the value of proper grazing management in these regions to maintain the remaining species intactness and species richness. Furthermore, the majority of the land shown in southern Alberta with species intactness in the 80-100 range typically coincide with cow/calf operations.

It should be noted that species richness is not always a positive indication when it comes to biodiversity. This indicator as defined by the ABMI model does not differentiate between natural and unnatural levels of particular species in a region. This means that it may overcompensate for species which are at levels harmful to biodiversity in general. For example, the coyote population in Alberta is increasing, which is captured in Figure 2-17(B). However, an increased coyote population is detrimental to other wildlife (Kilgo et al., 2014) and overpopulation is not accounted for by this indicator.

Recommendations

To manage biodiversity risks, various recommendations have been highlighted in literature. Based on the finding from Lebbink et al. (2021), more consensus on biodiversity measurement and monitoring are necessary. From an animal agriculture perspective, there should also be a clearer understanding of which indicators are most relevant. Velado-Alonso et al. (2020) also point out that integration of the spatial relationships between wildlife and agriculture are necessary to better understand the effects on biodiversity. Some authors also highlighted the importance of including socio-economic factors in any biodiversity assessment to gain a more holistic view (Pozo et al., 2021; Velado-Alonso et al., 2020; Vrasdonk et al., 2019). Furthermore, as found in numerous studies, proper grazing management is necessary in order to balance the trade-offs between nutrient availability for supporting cattle growth, reproductive performance, species richness, and for reducing invasive species and overgrazing (Angerer et al., 2021; Kleppel, 2020). Some measures to support proper grazing management include: rotational grazing programs which allow native vegetation to grow back, manual replanting initiatives, and designated grazing and no-grazing areas (Dominati et al., 2021; McDonald et al., 2019). Finally, the last recommendation to support biodiversity on grazing land is the development of effective monitoring and reporting strategies to ensure that targets are being met (Bailey et al., 2019; Lebbink et al., 2021; L. Wang et al., 2019). With respect to the Canadian cattle sector, some of these recommendations are more relevant than others.

Through the WHCI assessment, it was found that certain factors associated with beef cattle feeding have a more positive influence on biodiversity than others. In general, higher habitat capacity was found on land cover types used by beef cattle for grazing, rather than annual crops using to produce feed rations. This indicates that grazing lands are biologically diverse regions and that the presence of beef cattle is an important factor to consider. This assessment indicated that increased $WHCI^B$ was observed where greater proportions of grazing lands were allocated to beef cattle and that reductions in $WHCI^B$ generally occurred where more land was allocated to annual crop cover types reducing natural and semi-natural cover types. This implies that there is a strong link between biodiversity and grazing practices. Therefore, best management practices must be kept in place to ensure that grazing does not negatively affect wildlife and continues to support wildlife for feeding and breeding purposes.

In terms of the ABMI model, as discussed, the results were not specific to the beef cattle industry and therefore causal relationships could not be defined. Furthermore, the analysis itself is meant to supplement the main analysis which uses the WHCI model as its basis. Therefore, it is recommended that future assessments consider emerging research from ABMI which considers feed rations in Alberta and are designed to be beef specific.

WATER RISK

Agriculture is a major consumer of freshwater in Canada and globally. According to a study by Gerbens-Leenes et al. (2013), 92% of the global freshwater footprint is agriculture. Of this 92%, one third is associated with animal agriculture. Water consumption by the animals themselves is a small portion of water used by the beef industry. Optimizing drinking water quantities based on feed water quantity is one way of managing this (Doreau et al., 2021), which could be especially important during dry seasons and droughts. Another minor concern is the water required for sanitation and manure management. While the impact of animal water consumption and manure management can be exacerbated by allowing ruminants to access sensitive bodies of water and poor runoff management (Getahun Legesse, Kroebel, et al., 2018), the largest concern is by far water consumed for irrigation of crops. Methods of increasing irrigation efficiency can be taken to reduce this risk. For example, selection of crops that mature early with similar yields to traditional crops can help to reduce overall water requirements (Doreau et al., 2021).

The purpose of the water risk assessment is to highlight various issues and challenges associated with water use, beyond just consumption quantity. It is meant to address water conservation, competition among users in a region, and risk of drought or flood. It should be noted that beef cattle production typically occurs on drier lands, where crop production is not as feasible. As a result, it should be expected that areas of high beef cattle production do show risks of drought and competition between users.

As discussed, the water risk assessment combined indicators from the WRI Aqueduct tool and the national cattle inventory to highlight regions of elevated risk across the country. The three indicators of interest are baseline water depletion, interannual variability, and drought risk, which are defined as follows.

Table 2-10: Description of the Aqueduct indicators examined in this study

Updated Indicator	Description (Aqueduct, 2019)
Baseline Water Depletion	Annual *water withdrawals* divided by *mean available blue water* to indicate level of competition. Higher temporal resolution available since NBSA 2016. *Hazard* associated with water consumption is assessed.
Drought Risk	Multiplies *hazard* (areas with historically low precipitation), *exposure* (populations/crops) and *vulnerability* (social, economic, and infrastructure indicators).
Interannual Variability	Coefficient of variation of annual *total blue water* to provide unpredictability of supply. Higher temporal resolution available since NBSA 2016. *Hazard* associated with water availability is assessed.

It is important to note that because the Aqueduct tool does not consider cattle industry-specific factors in its model, a causal relationship between cattle numbers and water risk cannot be defined. Instead, the intent of this analysis is to highlight areas of high risk to help producers prepare for future water-related challenges and to highlight certain infrastructure components that may reduce the water risk in certain regions.

Baseline Water Depletion

Baseline water depletion in the reference year of 2021 is shown in the following figure.

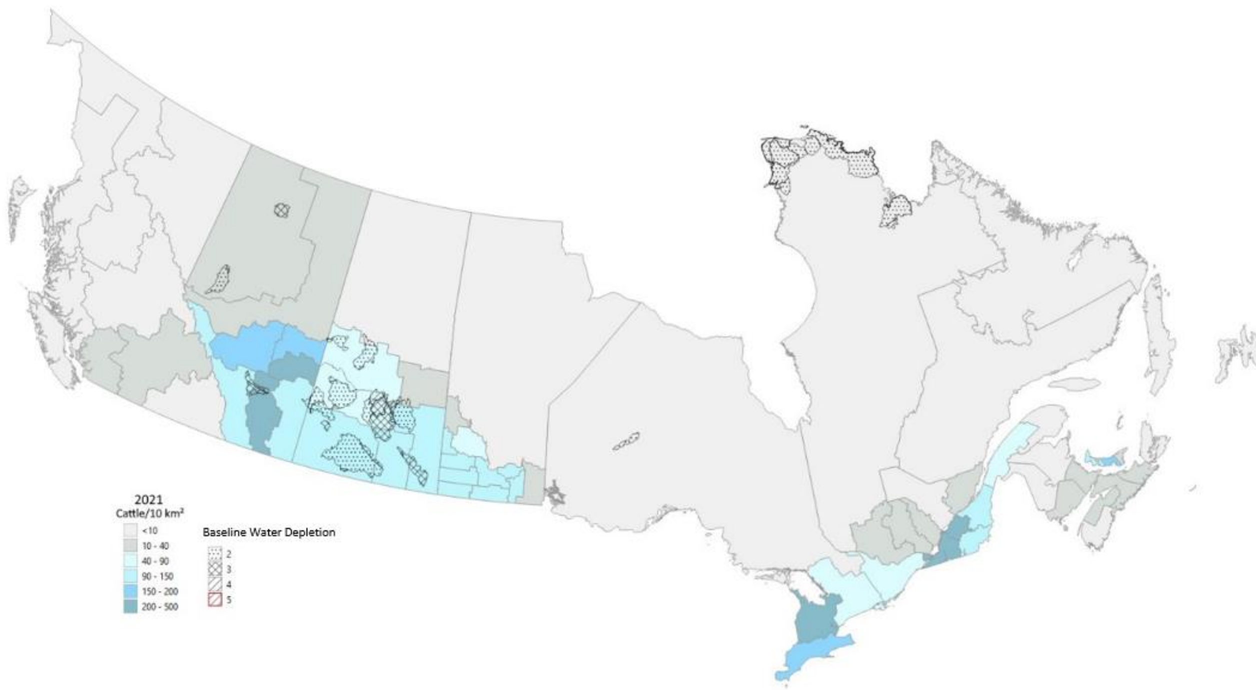


Figure 2-18: Baseline water depletion (2021) with cattle inventory.

In general, the majority of baseline water depletion related risks occur in southern Saskatchewan and in smaller pockets in Alberta. In Saskatchewan especially, higher cattle intensities typically coincide with areas with higher risk of water depletion. Since baseline water depletion represents the ratio between water use and water availability, this mirrors current challenges faced by farmers in the Prairies during the height of dry spells and droughts throughout the region. During dry periods, there is likely to be a lot of competition among users in southern Saskatchewan. On the other hand, in Ontario and Quebec, though high cattle densities exist, there are fewer concerns of water depletion risks due to proximity to numerous water bodies.

Differing climates in these regions could also account for the lower risk of baseline water depletion. Precipitation levels in eastern Canada are typically much higher than that of the Prairies, explaining why there is less competition among users in Ontario and Quebec (Statistics Canada, 2019). Therefore, for cattle producers in Saskatchewan, competition among users is a concern. Furthermore, precipitation levels in the highlighted regions of Saskatchewan were lower than the average in the year 2021 by between 90-150 mm, further exacerbating baseline water depletion risk in this region, while precipitation levels higher than average by 65-140 mm were common in southern Ontario (Statistics Canada, 2021b). This means that producers in high-risk regions where lower than average precipitation is a recurring pattern must develop contingency plans or implement water saving measures to prepare for inevitable dry spells.

Drought Risk

Related to baseline water depletion, drought risk in the reference year of 2021 is shown in the following figure.

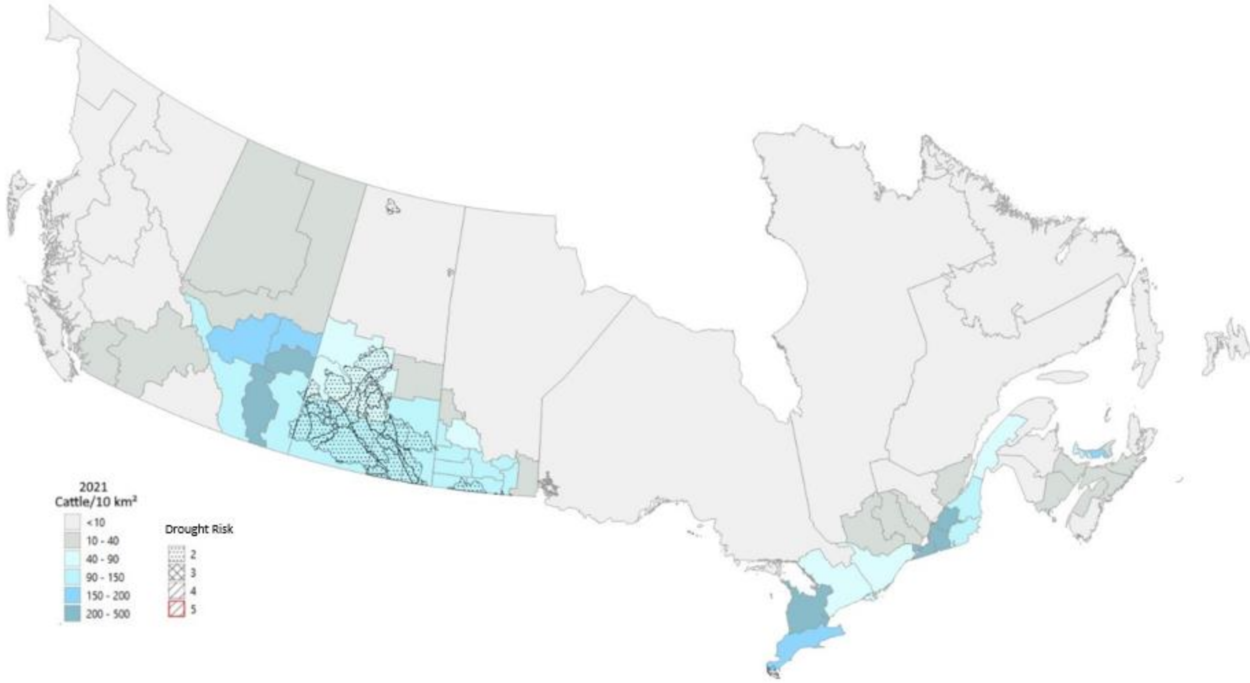


Figure 2-19: Drought risk (2021) with cattle inventory.

As with baseline water depletion, the region showing the greatest sensitivity to droughts is southern Saskatchewan. The majority of drought risk in Saskatchewan coincides with the areas of heavy cattle production. This is a challenge for both cattle farming and crop farming, specifically for crops with large irrigation requirements. As discussed previously, this mirrors what has been observed in recent years with respect to higher rates of drought in the Prairies. Risks in other regions on Canada where high cattle densities exist, like Alberta, Ontario, and Quebec, have much smaller risk of drought compared to Saskatchewan and Manitoba.

It is worth noting that there are many limitations to the water risk assessment. Notably, the subjectiveness of each indicator and the vagueness around how certain parameters are calculated are concerns. For example, for the drought risk indicator, there is uncertainty regarding which infrastructure, social, and economic factors were used to assess vulnerability. Moreover, while the implementation of drought infrastructure could reduce the related risks depicted in this section, because the assessment was not beef specific, it fails to capture unintended consequences for the beef industry. For example, drought infrastructure, especially for irrigation, encourages the conversion of grazing or pastureland to cropland. This can have consequences in other environmental concerns associated with land use. As discussed in the biodiversity and carbon soil sequestration discussions, cropland has both lower habitat capacity for species and lower sequestration rates at large depths. More area associated with crops could result in less biodiversity and carbon soil sequestration associated with the beef industry and its practices. Therefore, management of drought risks could be shifted towards importing of crops, rather than irrigation so that the focus could be providing drinking and facility cleaning water.

Furthermore, vulnerability is not captured in all the indicators making them inconsistent between each other. Additionally, the scale at which the results are meant to be applied is large, meaning that local-scale conclusions may not be sound. Finally, while the models and methodologies applied by the Aqueduct tool were validated, the results were not (Hofste et al., 2019). Given the high-level analysis presented here and the limitations discussed previously, a more sophisticated and tailored approach may be necessary to gain in-depth insights into the water risks faced by the Canadian beef cattle industry. This includes, but is not limited to, consideration of water supply, management practices, precipitation changes, and water efficiency measures.

Interannual Variability

Interannual variability in the reference year of 2021 is shown in the following figure.

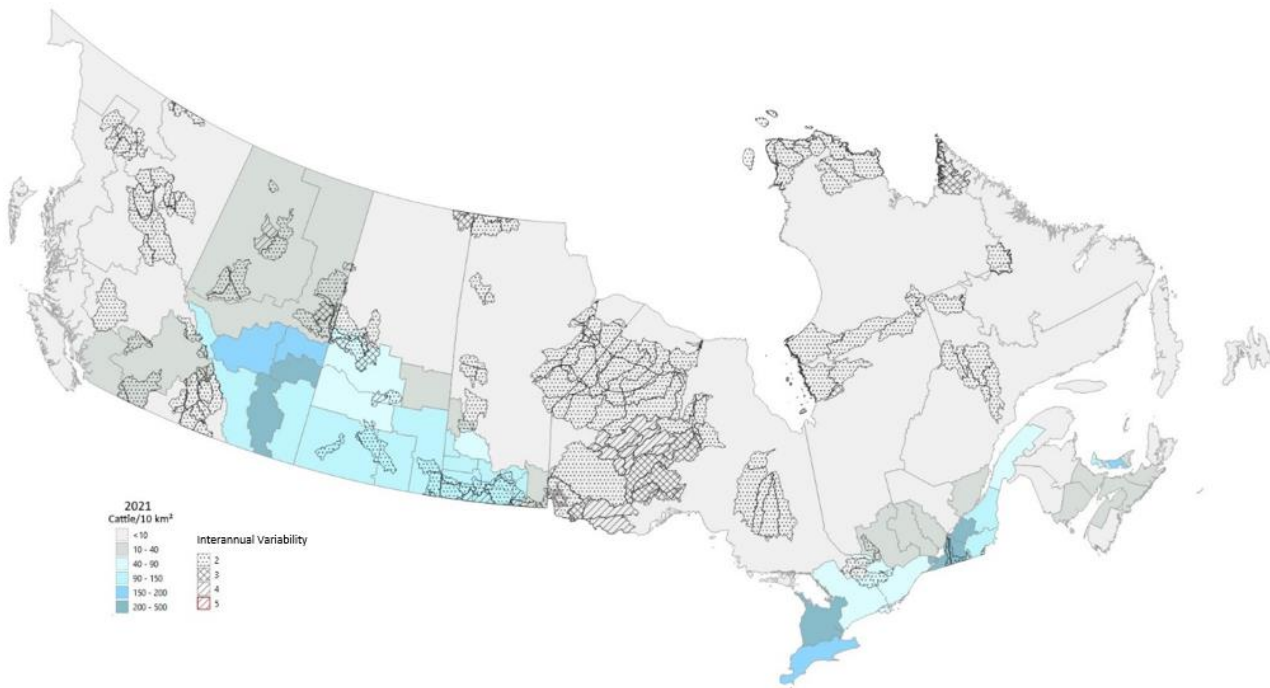


Figure 2-20: Interannual variability (2021) with cattle inventory.

Unlike baseline water depletion and drought risk, much more risk of interannual variability is present across the country. Higher values of interannual variability, which ranges between 2 and 5, as shown in Figure 2-20, indicate larger discrepancies between water supply. Large regions of land show the potential of low-level risks (Level 2) and some higher-level risks (Level 4) of variability, particularly in northern Ontario, southern Manitoba, and Saskatchewan. In this case, regions with lower densities of cattle are more likely to be affected by variability, which is a concern for small-scale farmers already facing financial and environmental challenges or looking to scale up. However, higher cattle density regions in southern Manitoba do happen to coincide with higher risks of variability (Level 4), therefore along with concerns of water depletion, farmers in this region may expect changes in water availability over the coming years.

Finally, each of the indicators discussed in this section, Baseline Water Depletion, Drought Risk, and Interannual Variability, can be combined to get a composite water risk score. This value takes an evenly weighted average of each indicator and describes the percentage of total beef cattle included within this risk category. Values for 2021 and 2013/14 are shown in Table 2-11. It should be noted that since the indicators within the Aqueduct model are different than they were in the 2016 NBSA, an updated composite risk score for 2013/14 is provided for benchmarking purposes, which may not match the value shown in the previous report.

Table 2-11: Distribution of composite risk score by number of cattle, for 2021 and 2013/14

Composite Risk Score	% Total Beef Cattle	
	2013/14 (Benchmark)	2021
Low to medium (0-1)	43.4%	50.7%
Medium to high (2-3)	23.3%	20.3%
High (4)	24.7%	21.6%
Extremely high (5)	8.5%	7.5%

As shown in Table 2-11, for the composite risk scores ranging from medium to extremely high (scores 2-5), the percentage of beef cattle affected are quite similar between 2013/14 and 2021, with the 2021 values often between 1-3% lower. As a result, the percentage of beef cattle facing low to medium (scores 0-1) water risks is 7% higher in 2021 than it was in 2013/14. This indicates that most cattle production in Canada does not coincide with areas of high risk and that this is truer in 2021 than it was in 2013/14. As discussed previously, while a direct causal relationship between water risk and cattle numbers cannot be drawn based on this analysis, some factors could be causing this. For example, better infrastructure for handling droughts could be in place now given the importance of the agriculture sector in the Prairies where the majority of beef cattle production occurs and the increasing frequency of droughts in these regions. Future assessments could consider the validity of this possibility by further examining water-related resources and water use by the beef cattle sector.

It is worth noting that there are many limitations to the water risk assessment. Notably, the subjectiveness of each indicator and the vagueness around how certain parameters are calculated are concerns. For example, for the drought risk indicator, there is uncertainty regarding which infrastructure, social, and economic factors were used to assess vulnerability. Furthermore, vulnerability is not captured in all the indicators making comparison inconsistent. Additionally, the scale at which the results are meant to be applied is large, meaning that local-scale conclusions may not be sound. Finally, while the models and methodologies applied by the Aqueduct tool were validated, the results were not (Hofste et al., 2019). Given the high-level analysis presented here and the limitations discussed previously, a more sophisticated and tailored approach may be necessary to gain in-depth insights into the water risks faced by the Canadian beef cattle industry. This includes, but is not limited to, consideration of water supply, management practices, precipitation changes, and water efficiency measures.

Carbon Soil Sequestration

Carbon soil sequestration is a process in which CO_2 is removed from the atmosphere and stored in the soil carbon pool and is primarily mediated by plants through photosynthesis, with carbon stored in the form of SOC (Ontl & Schulte, 2012). There is uncertainty with estimations of the soil carbon sequestration potential of agricultural management practices and these estimates are often dependent on site-specific factors such as soil type, geography, land use history, and weather. While there is evidence of climate change mitigation benefits, they are usually not guaranteed from the use of common practices implemented to sequester carbon (such as cover cropping, conservation tillage, no-till, and rotational grazing). However, these practices can improve soil health and increase farm resilience to climate change.

Amidst the growing interest in soil health, there is a particular focus on the potential for agricultural soils to sequester atmospheric carbon and thereby contribute to the mitigation of climate change. Carbon sequestration in the agriculture sector refers to the process in which carbon dioxide is removed from the atmosphere and stored in the soil carbon pool. This process is primarily mediated by plants through photosynthesis, with carbon stored in the form of soil organic carbon (Ontl & Schulte, 2012). Large-scale policies and initiatives have further developed this interest in agricultural soil carbon sequestration. This includes the "4 per 1000 Initiative" for increasing soil organic carbon stocks, also known as "4 per mille" or "4‰," which was launched by the French Ministry of Agriculture in 2015 for the 21st Conference of Parties of the United Nations Framework Convention on Climate Change (UNFCCC). This initiative aspires to increase global soil organic carbon stocks by 0.4% per year to offset the global emissions of greenhouse gases by anthropogenic sources.

There is a lack of consensus in the scientific literature around carbon sequestration rates in northern temperate grasslands that are grazed due to the inability to capture the full range of conditions found across grasslands and differences in methodologies. As a result, carbon sequestration rates have been linked with increases, decreases, and no change in soil carbon. Common grazing management practices that could increase carbon sequestration include stocking rate management, rotational, planned, or adaptive grazing, and enclosure of grassland from livestock grazing.

The quantification of the relationship between land use change and carbon storage is of great significance to evaluate carbon sequestration. Land use changes (Ostle et al., 2009) have been directly related to measured soil organic carbon content of different land use types, soil types, and slope types (Wasige et al., 2014). These changes in carbon stocks can occur either due to change in management practices—i.e., land management change (LMC), or on land converted to a new land use—i.e., land use change (LUC). This study accounts for emissions from direct land use changes which occur at the location of the studied production, in this case, specific to beef production system in Canada, and excludes all indirect emissions which are consequent to the studied production practice, but not at the source of the location of the activities that cause the change (ISO 14067:2013).

Grasslands represent the largest land resource in the world, occupying 40% of the earth's land surface (W. Wang & Fang, 2009) and storing over 10% of terrestrial biomass carbonI) and nearly 30% of the global soil organic carbon (SOC) stock (Scurlock & Hall, 1998). Livestock grazing intensity along with management practices have been found to be the key drivers of carbon sequestration based on climate region and grassland type. Grazing intensity has been shown to modify soil structure, function, and capacity to store soil carbon (SOC) and could significantly change grassland C stocks (Cui et al., 2005). As well, stocking rates (light to moderate carrying capacity) with adequate and uniform livestock distribution have been recommended on the Canadian prairie grasslands to support grasslands to recover back to a healthy condition after severe deterioration. Another effective way to maintain grassland health is deferring grazing during sensitive or vulnerable periods, which allows for more shoot and root reproduction, particularly during drought cycles. In addition, a periodic moratorium from grazing could lead to restoration and would maintain grasslands in a healthy state. One of the key focuses of the Canadian beef production system continues to be supporting carbon sequestration on grazing land through increasing information around range health and grazing management. Grazing management practices, particularly that of Adaptive Multi Paddock (AMP) grazing which is an acutely refined version of rotational grazing, have been shown to affect productivity and SOC levels of grazing lands by increased post-grazing plant recovery and by promoting biodiversity through encouraged growth of desirable plant species (A W Alemu et al., 2017; Boyce, 2019). Indeed, the Census of Agriculture (2021) has indicated that these practices are quite common among ranchers in Canada with over 40% of farms reporting to carry out rotational grazing, in the Canadian beef production system. Moreover, management practices related to crop and forage management have the highest rates of adoption with crop residues baled on 31.6% of farms, and 28.6% on farms manage lands as no-till (Canfax Research, 2021).

A high-level evaluation of the carbon stock impact of cattle farming, from a land use perspective, both at the provincial and national levels is presented in Figure 2-21. It includes an analysis of the provincial breakdown of the aggregated agricultural land used for beef cattle production versus other agricultural uses, and their respective stock of carbon contributions. The carbon stock contribution is based on the contribution of each agricultural land cover referenced in the Census of Agriculture 2011, with their associated average stock of carbon intensity value (kg C/ha) (*see* Table D-34), split by their use for beef cattle production or other agricultural uses. The analysis demonstrates that beef cattle production uses 40% of the agricultural land occupied or 63.1 million acres (Ma) (25.6 million hectares, Mha) of the Canadian agricultural land base, with a significant portion of that being in Western Canada (Figure 2-22). Beef cattle production in cropland used for cattle feed production (e.g., barley, corn, oat, and wheat) represents less than 9% of cropland (Figure 2-22) in Canada. On the other hand, the land used for beef production represents 39% of the agricultural land carbon stock (Mt) across Canada ((Figure 2-22), highlighting that the average carbon stock intensity is relatively similar in croplands and pastures (*see* Table D-33) at the national level. In order to maintain consistencies with the previous assessment and common carbon inventories, the carbon stocks were estimated for soil depth of 30 cm, however, previous studies (Ward et al., 2016) have highlighted the considerable amounts of carbon in sub-surface soil below 30 cm, which is missed by standard carbon inventories. Moreover, it is reported that the substantial carbon stocks at depth in grassland soils are sensitive to management. This will have considerable relevance, given the extent of land cover and large stocks of carbon held in temperate managed grasslands and implications for the future management of grasslands for carbon storage and climate mitigation. For cropland, soil sampling at higher soil depths than 30 cm have a lower implication considering that the majority of the land for beef production is located in western Canada where tillage is generally not deeper than 15 cm, which limits the zone of influence on soil carbon dynamics to shallower depths than conventional tilled soils of Eastern Canada (VandenBygaart et al., 2010).

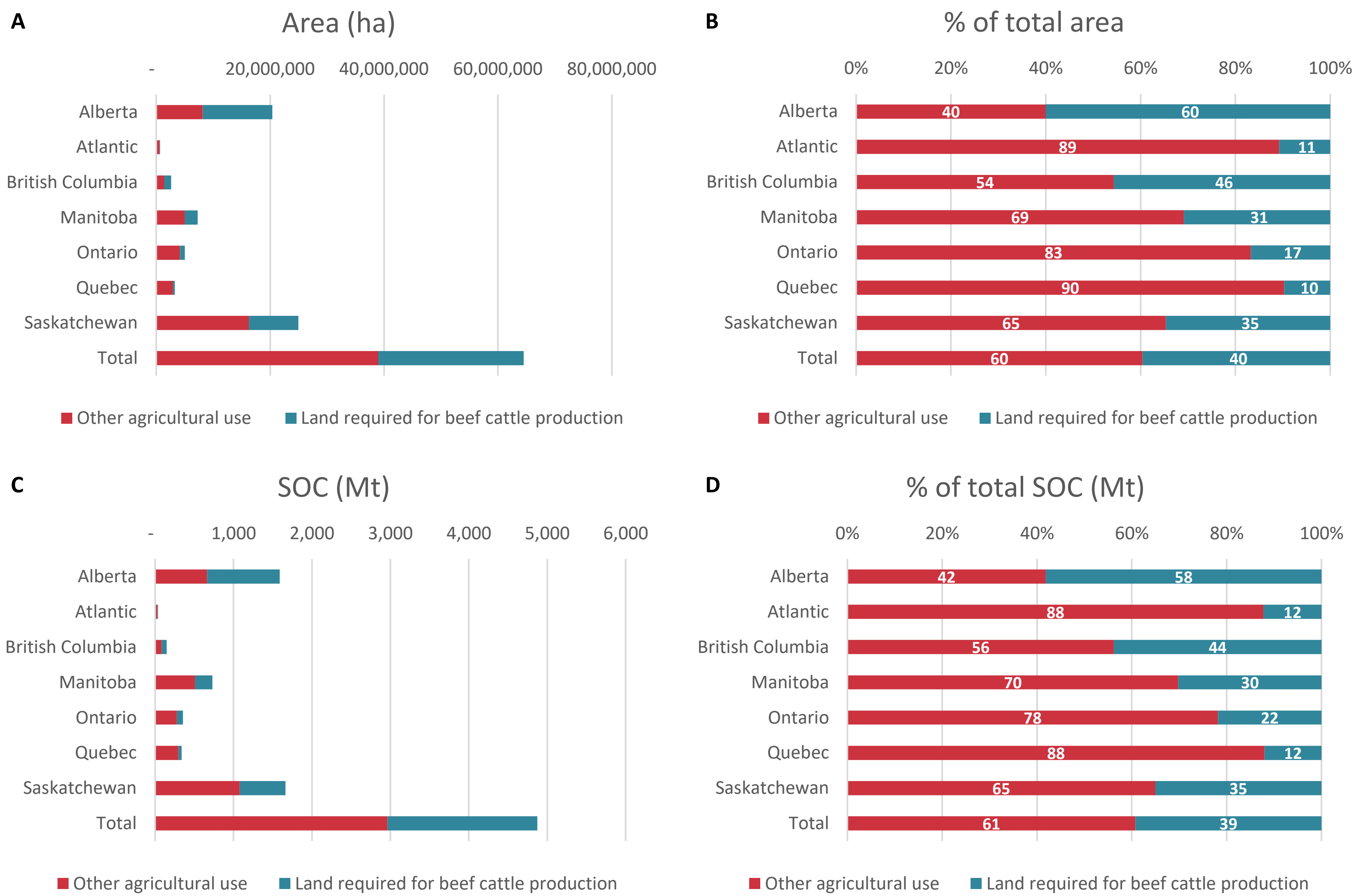


Figure 2-21: Land used for beef cattle production and other agricultural areas and corresponding stock of carbon (SOC) values for provinces in Canada. (A) Area (ha); (B) % of total area (ha); (C) SOC (Mt); (D) % of total SOC (Mt).

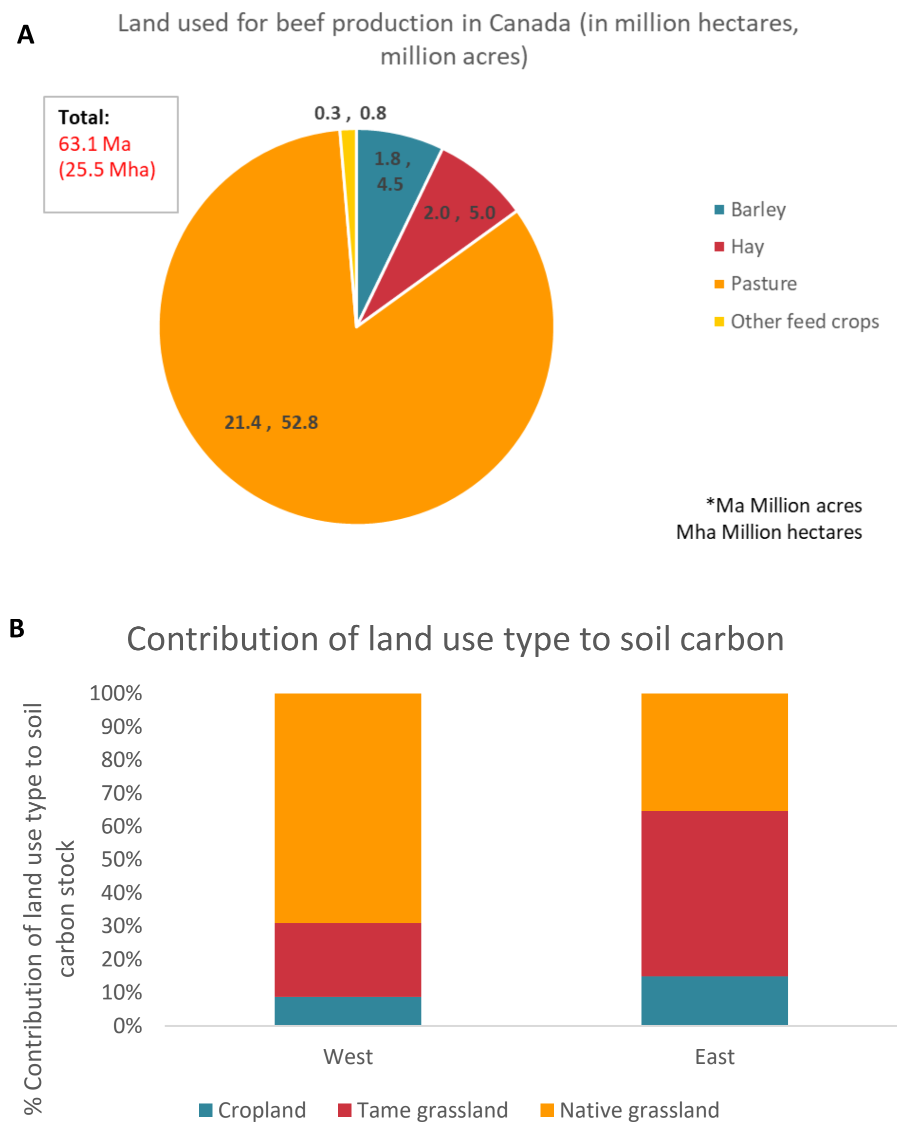


Figure 2-22: Relationship between land use and carbon stock for beef cattle production in Canada in 2021: (A) land used (in million hectares, million acres) for beef cattle production; (B) contribution of land cover type to total carbon stock

The average GHG emissions and removals issuing from LMC and LUC of canola for the year 2006 presented in Table D-33 were applied to the rations fed to cattle and to the pasture areas. This resulted in the average GHG emissions and removals issuing from LMC and LUC associated with Western Canada beef meat production (kg CO_2 eq/kg of live weight) presented in Figure 2-23. In Western Canada, the GHG emissions associated with beef meat production, excluding the effects of land use and land management change, are estimated to be 10.5 kg CO_2 eq/kg of live weight as discussed in Section 2.1.1. With the accounting of removals and emissions associated with LMC and LUC with this carbon soil sequestration assessment, the net carbon footprint of Western Canada beef production is reduced to 9.9 kg CO_2 eq/kg of live weight and in turn, indicating a similar influence of LUC and LMC on the carbon footprint as in 2013/14.

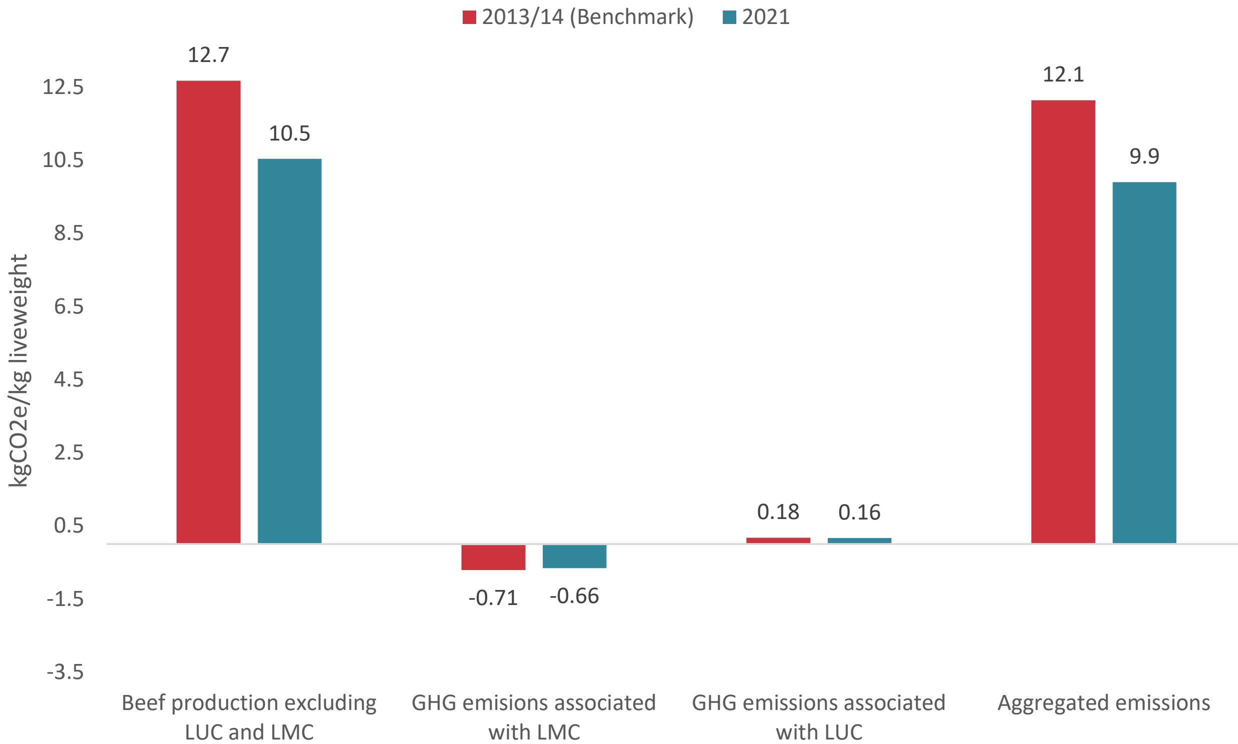


Figure 2-23: Greenhouse gas emissions and removals associated with Western Canadian beef meat production per kg of live weight in 2021 and 2013/14 (Benchmark).

In this analysis, LUC have a relatively minor impact on GHG emissions (Figure 2-23) based on the assumptions of the 2013/14 assessment of modelling the impacts and benefits of LMC and LUC for crops, forages, and grass from improved pasture on the average GHG emissions and removals issuing from LMC and LUC of canola for the year 2006. This would hold true considering the decrease in forest land conversion, while improved land management practices have a greater contribution in enabling the reduction of GHG emissions in soil carbon sequestration. However, a limitation of this analysis is that the modelling of C sequestration was based on canola only, consistent with the previous assessment in 2013/14, and does not consider associated emissions (or sequestration) of soil carbon through LUC from cropland into pastureland, is a strong limitation. On the other hand, land use change has been found to have a more lasting effect on carbon soil sequestration (and biodiversity) in the Canadian context with higher sequestration rates after conversion of cropland into pastureland compared to improved grazing practices (including lower stocking rates, seasonal grazing and rotational or short-duration grazing) (Alemu et al., 2019).

The overall soil organic carbon stock in Canadian agricultural lands has seen an overall minor increase since the last assessment to about 4,875 million tonnes of organic carbon to 30 cm, while land occupied for beef production represents 1,914 million tonnes. The effects of LUC and LMC were compared to current carbon stocks to evaluate the carbon sequestration potential of the Canadian beef production. This was done by evaluating the soil organic carbon stocks per hectare in Canadian soils (Table D-34) to the crop, native and tame pasture areas (Figure 2-23) required to produce one kilogram of live weight of beef. The average carbon sequestered by cattle in Canada was estimated to be an equivalent of 2.1 tonnes of CO_2 per kg live weight and represents a sequestration rate of 0.28 tonne of carbon per hectare per year. This is consistent with literature estimates of impacts of grazing management on soil carbon with reported soil C sequestration rates ranging from 0–28 – 0.87 t C/ha/y based on LMC and LUC respectively (Conant et al., 2017).

Recommendations

Grasslands represent the largest land resource in the world and they occupy 40% of the earth's land surface. They are estimated to store nearly 30% of the global SOC stock (Wang et al., 2014). This is consistent with the findings of this study; native grasslands, specific to the use of beef production, contain over 40% and 66% more total carbon (Mt) at 30 cm depth than cropland and tame pastures, respectively, which is represented in Figure 2-22(B). Restoration and maintenance of native prairie grasslands can also provide an opportunity to mitigate greenhouse gas (GHG) emissions through carbon soil sequestration (Alemu et al., 2019). Recent research in carbon soil sequestration have indicated that Canadian natural grazing grasslands are likely acting as a carbon sink under current management regimes, but the potential of sequestration is believed to be finite and has likely reached its saturation point in recent years (Wang et al., 2014). Improved grassland management practices that increase net accumulation of carbon in grasslands are needed for their potential to minimize the rising concentration of atmospheric carbon dioxide. Sustainability projects, as outlined in the previous NBSA, should continue to focus on enhancing the general understanding of rangeland management practices, in particular, how livestock grazing regulates carbon soil storage and sequestration in northern temperate grasslands. Native rangelands and unimproved pasture provide the highest capacity to sustain soil carbon for Canadian beef production in agricultural areas. Conservation of grassland species largely depends on sustainable cattle grazing practices. The beef industry can also play a valuable role in maintaining or improving the health of native and tame perennial rangeland and thus can improve ecological services and wildlife habitat.

ANTIMICROBIAL AND GROWTH-ENHANCING TECHNOLOGY USE

An additional and growing concern for the Canadian cattle sector is the use and management of antimicrobials (Ams) and growth-enhancing technologies (GETs) because of their potential ecotoxicological impacts. More details regarding the social implications of this is discussed in Section 2.2.4, therefore this section will focus on the use of specific Ams and GETs highlighted in literature for their potential risks.

Many Ams are approved for use in cattle. The Government of Canada classifies antimicrobial drugs by importance to human medicine, with **Category I** being very high importance (fluoroquinolones), **Category II** being high importance (for example, the macrolide named tylosin), **Category III** being medium importance (tetracyclines, phenicols, sulfamethazine), and **Category IV** being low importance, often not for human use (ionophores like monensin) (Health Canada, 2009). Based on current research, chlortetracycline & tetracycline, sulfamethazine, tylosin (type of macrolide), and monensin are the ones requiring the most extra care and considering when being administered to cattle. Some resistance to antibiotics and ecotoxicity concerns have been outlined through academic research. Specifically, resistance to tetracycline and macrolides are common in cattle manure, feedlot wastewater and pasture (Zaheer et al., 2020). Overall, many researchers have indicated that resistance to tetracyclines is the greatest concern, especially in *E. coli* present in meat (Aust et al., 2008; Nekouei et al., 2018; Zaheer et al., 2020). However, one of the outcomes of the BCRC 2013–2018 report (BCRC, 2019a) about responsible AMU shows that antimicrobial resistance (AMR) found in bacteria associated with beef is very low and has not increased over time. Other research has shown that chlortetracycline, sulfamethazine, and tylosin can be present in run off water during rain fall events, but could be captured in catch basins (Sura et al., 2015). Therefore, installation of catch basins at feedlots could prevent runoff and subsequent contamination. This is especially important for sulfamethazine because it has found to be detectable up to one year after administration (Aust et al., 2008). Finally, the low importance ionophore antibiotic monensin is another commonly used AM. This is a feedlot additive used to improve feed efficiency, which can also reduce enteric methane production (Owens et al., 2020).

According to the survey, the portion of respondents using these Ams, by category, are as follows.

Table 2-12: AM use in Western and Eastern Canada, according to 2021 survey

Category and Relevant AM	Use in Western Canada (%*)	Use in Eastern Canada (%*)
Category I E.g., Fluoroquinolones	15.9%	8.3%
Category II E.g., Macrolides, such as tylosin	49.8%	13.7%
Category III E.g., Tetracyclines, sulfamethazine	56.7%	16.6%
Category IV E.g., Ionophores, such as monensin	26.2%	6.1%

* Percentages represent the portion of survey respondents using drugs within the specified category. It should be noted that the majority of survey respondents were VBP+ producers, implying that this distribution of AM use may not be representative of the overall industry. This is explained further in Section 2.2.4. Further separation of responses by production type (i.e., feedlot, cow/calf, etc.) were not available and is a limitation of this data.

The implications of the survey responses vary depending on AM category. While none of the Category I Ams are cited in literature as being a concern for antimicrobial resistance or ecotoxicity, it is still important to note that 25% of the survey respondents indicated their use of these compounds, with the highest proportion of users (31%) located in Alberta and in the Prairies in general (54%). On the other hand, macrolides such as tylosin, which are part of Category II, were used by 64% of the survey respondents, of which 71% of use occurs in the Prairies. As stated previously, according to Zaheer et al. (2020), resistance to macrolides were common in bacteria found in cattle manure, feedlot wastewater, and soil. That being said, macrolides are rarely used in grazing cattle making their exposure to water bodies rare (Waldner et al., 2019). Next, Category IiI Ams, such as tetracyclines and sulfamethazine, had the highest use rate of all Ams at 74% of respondents, with 56.7% in the west and 16.6% in the east. As discussed, sulfamethazine is a key concern within this category due to its long detection period and ecotoxicological effects on aquatic environments, resulting in the need for catch basin installation in feedlots (Aust et al., 2008). Finally, Category iV Ams, including monensin, were used by 33% respondents. While monensin is an ionophore and can be used as an antimicrobial for veterinary use, it is primarily used by cattle producers as a feed additive to increase feed efficiency and reduce enteric methane formation. As mentioned previously, according to Owens et al. (2020), due to its chemical stability it can remain at levels harmful to aquatic life for a long period of time. Monensin has been used for decades by the beef industry, implying that management practices have been honed. This is explored further in the social life cycle assessment, in Section 2.2.4. As a result, an adequate assessment of risk cannot be made, which is one of the limitations of the survey conducted for this study.

In the feedlot sector, growth-enhancing technologies are also used, such as hormones, ionophores, and β-adrenergic agonists. The GETs of interest are trenbolone acetate (TBA), melengesterol acetate (MGA), and β-adrenergic agonist ractopamine (RAC). Both TBA and MGA have little mobility in the environmental (Challis et al., 2021), meaning they are unlikely to affect the ecosystem and other aquatic life. They still could be a concern in high-cattle population cases due to their local concentration, however they are generally not detectable in manure after treatment periods due to their short half-lives (Aboagye et al., 2021). However, RAC has both aquatic and airborne mobility and 100% detection rate in manure (both solid and liquid) even 37 days after treatment (Challis et al., 2021). The order of magnitude that RAC was found at was 3-4 times higher than that of TBA and MGA, which is a level known to cause behavioural changes in certain species of fish if similar concentrations are achieved in aquatic environments (Challis et al., 2021). According to the survey, the portion of respondents reporting the use of β-adrenergic agonists, such as RAC, is at 4% in the West and 3% in the East. Therefore, it is recommended that the rate of RAC in wastewater from feedlots be further investigated. Since treatment periods often rotate, there may not be a sufficient time period before manure can be applied unless stockpiles are kept separate, despite the majority of survey respondents stating a time-period of one month or more (45%) or that land application did not occur (38%). Further consideration is needed for land application of fresh manure and for manure storage. In general, the increased use of ractopamine could signal a potential challenge for the industry due to its aquatic and airborne mobility.

While manure management practices are important to ensure lowest detection rates before application to land, there are some other steps that producers can take as well. This includes following veterinary protocols on drug use and withdrawal periods, limiting direct access to animals to water bodies, and correct disposal of expired drugs (Forrest et al., 2011). However, further research is needed on implementation of these best practices and the level of risk that can be avoided by following them. Specifically, future NBSAs should rely more heavily on independent AMU data that can be accurately reported by sector. Furthermore, details regarding administration practices could also be considered in future assessments. Additional aspects pertaining to AM and GET use, including adherence to veterinary protocol and use rates at the feedlot versus other production stages are described in Section 2.2.4.

2.1.5 Benchmarking the Performance of the Canadian Beef Industry

An objective of this study was to benchmark performance of the Canadian cattle industry between 2013/14 and 2021. To do so, data from 2013/14 was used in the updated 2021 model. This means that updated processes for feed production, energy, and other materials were used with 2013/14 production data. Additionally, the 2021 impact assessment methodology was applied, meaning that the latest indicators, including GWP (IPCC, 2019) were applied. As a result, a new set of results for 2013/14 was generated to compare to 2021 on an equal basis. As with the main contribution analysis, 1 kg of live weight was chosen as the basis for benchmarking due to its relevance to the CRSB.

Environmental LCA Indicators

Several differences exist between the 2013/14 system and the 2021 system. The most impactful ones include the production periods, including time on pasture and in confinement, the annual cohort, irrigation levels, and feed rations, which subsequently affect enteric and manure-related emissions. In general, a minor reduction was observed across all indicators, other than terrestrial acidification. The effect these changes have on the environmental performance of the industry is illustrated in Figure 2-24.

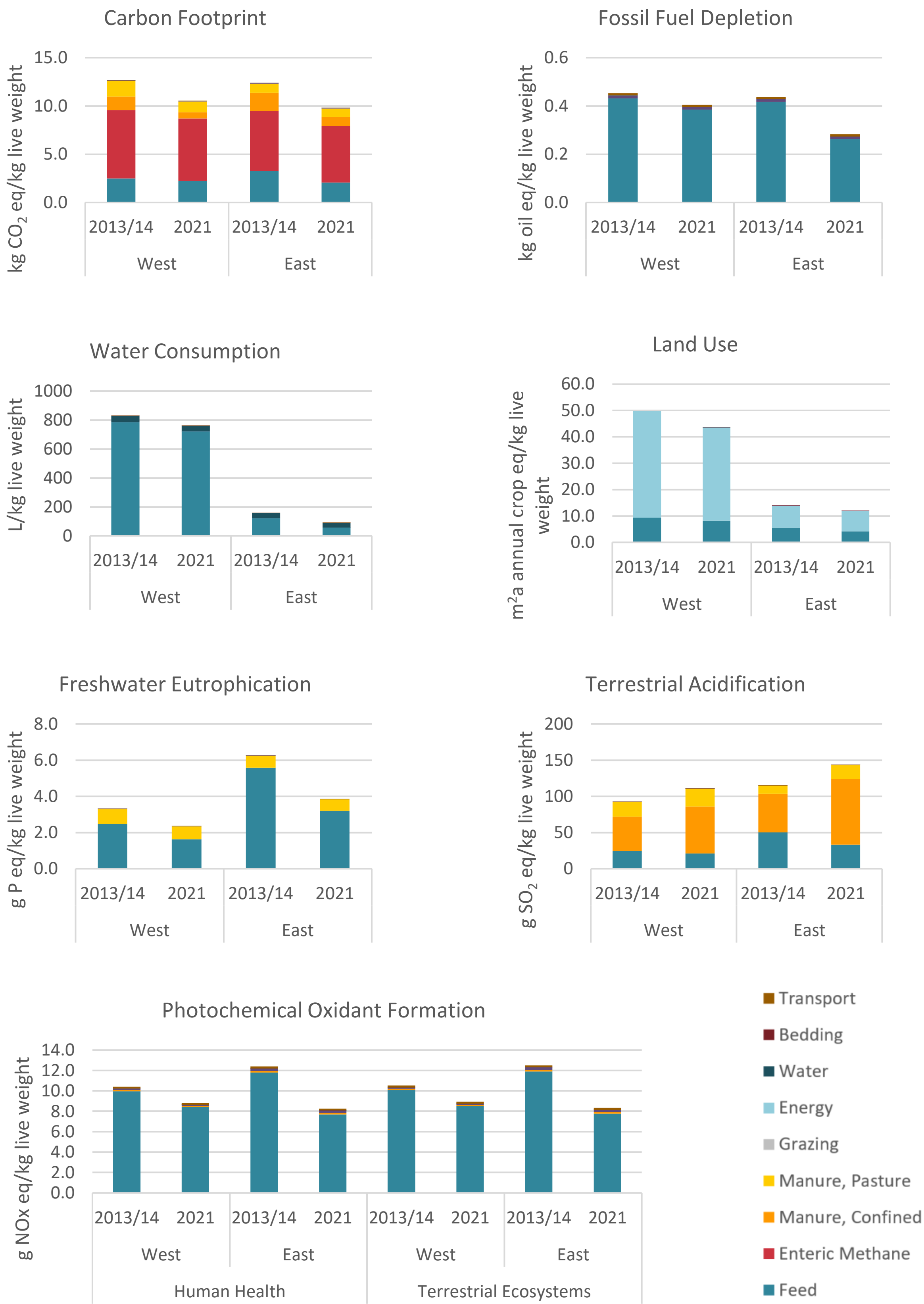


Figure 2-24: Comparison of environmental impacts between 2013/14 and 2021 up to the farm gate.

Table 2-13: Environmental impacts in 2013/14 and 2021 per kg live weight beef

Category	Indicator	Units	National		West		East	
			2013/14	2021	2013/14	2021	2013/14	2021
Global warming	Carbon footprint	kg CO_2 eq	12.6	10.4	12.7	10.5	12.4	9.8
Resource depletion	Fossil fuel depletion	kg oil eq	0.4	0.4	0.5	0.4	0.4	0.3
	Water consumption	L	654.7	657.3	829.3	761.5	157.5	89.9
Land use	Agricultural land occupation	m^2a annual crop eq	40.5	38.7	49.8	43.6	13.9	12.0
Water pollution	Freshwater eutrophication	g P eq	4.1	2.6	3.3	2.4	6.3	3.9
	Terrestrial acidification	g SO_2 eq	98.4	115.9	92.5	110.8	115.3	143.6
Air pollution	Photochemical oxidant formation, human health	g NOx eq	10.9	8.7	10.4	8.8	12.4	8.3
	Photochemical oxidant formation, terrestrial ecosystems	g NOx eq	11.0	8.8	10.5	8.9	12.5	8.3

Carbon Footprint

In terms of the carbon footprint, a 17% reduction in the West and a 21% reduction in the East was observed between 2013/14 and 2021. As shown in Table 2-13, the carbon footprint per kg of live weight beef decreased from 12.7 to 10.5 kg CO_2 eq in the West and 12.4 to 9.8 kg CO_2 eq in the East. As a result, the national average decreased from 12.6 to 10.4 kg CO_2 eq/kg live weight.

As shown in Figure 2-24, the major drivers for the carbon footprint are enteric emissions, feed rations, emissions from manure during confinement, and finally manure on pasture. In terms of enteric emissions, there was a proportionate increase between 2013/14 and 2021 from 56% to 62% of the carbon footprint in the West (as well as 50% to 59% in the East). This is the result of higher body weights and higher dry matter intake, which lead to proportionately higher enteric methane emissions, despite an overall decrease in emissions. Then, in terms of feed rations, as mentioned, the higher dry matter intake generally results in higher enteric methane emissions. However, shorter durations of production, including confinement, balance out this increase. Finally, emissions from manure both during confinement and on pasture both decreased due to shorter production periods. Overall, changes to production patterns and increased efficiencies in feed to gain result in lower emissions, thereby reducing the carbon footprint between 2013/14 and 2021.

Fossil Fuel Depletion

Referring back to Figure 2-24, fossil fuel depletion potential was reduced by 0.1 kg oil eq/kg live weight between 2013/14 and 2021 in both the West and the East. The difference in values for both the West and the East was around 0.1 kg oil eq, which is a minor difference associated with feed production. These changes can be attributed to changes in feed rations. In particular, barley and corn production account for the majority of fossil fuel depletion. A reduction in the number of days on feed by 9 days in the West and 53 days in the East, thereby reducing the amount of feed consumed, can therefore explain the decrease. It should further be noted that this reduction in days is partially created due to the shift in yearling-fed (59% in 2013/14, 55% in 2021) and calf-fed (41% in 2013/14, 45% in 2021) production.

Water Consumption

Water consumption values were slightly reduced between 2013/14 and 2021 by 68 L in both the West and the East. Increased feed efficiency is likely the cause of this reduction because irrigation levels and water consumption for drinking and cleaning remained relatively consistent between the years. Instead, improvements to feed conversion ratio and average daily gain reduce the overall water consumption required to feed the cattle.

While the 68 L reduction in water consumption appears to be minor, it should be noted that Canadian beef production is already more water efficient than beef produced elsewhere. In particular, the two United States studies mentioned previously by Asem-Hiablie et al. (2019) and Capper (2011) reported values of 1214 L/kg live weight and 1748 L/kg live weight. Increased irrigation efficiency in Canada likely explains the large difference, especially in the East where very little irrigation is applied.

Furthermore, the water use from farm-gate to processor's gate is another area where higher efficiency was observed. For example, the same United States studies listed above report a water consumption between 2558 L/kg boneless beef and 3682 L/kg boneless beef (Asem-Hiablie et al., 2019; Capper, 2011). In 2021 in the West, a value of 1679 L/kg boneless beef was reported, while in 2013/14 the water consumption was lower, at 1368 L/kg boneless beef. Therefore, further reductions in water consumption should be focused on the processing stage where a reduction was not observed. Water used for processing itself represents less than 0.5% of total water consumption, as shown in Figure 2-1. The vast majority is from farming due to the ratio between live weight and processed beef. Therefore, to reduce water consumption beyond the farm-gate, reduction of meat waste throughout the value chain is required.

Land Use

In the case of agricultural land occupation, a decrease was observed across both regions. In the West, a decrease of 6.15 m^2a annual crop eq/kg live weight was observed, while in the East, a decrease of 1.89 m^2a annual crop eq/kg live weight was observed. The average grazing area per head per day increased by around 12% in the West since 2013/14. However, the reduction in land use can be attributed to two parameters: crop yields and cohort size. As shown in Figure 2-24, most of land use is driven by grazing. Therefore, changes in crop yields likely had a minor effect on the land requirements. In terms of cohort size, the number of grazing animals and the time on pasture both have an impact on the total grazing land requirements. In general, the time on pasture in the West has decreased from 383 days on pasture in 2013/14 to 318 days on pasture in 2021. A similar reduction from 280 days to 234 days was observed in the East as well. It should be noted that these days occur over the entire production period, which is why a value greater than the length of one year was modelled. As a result, less grazing land is required during the production period. Additionally, lower mortality rates mean that the ratio of grazing animals to non-grazing animals required to produce the functional unit is lower in 2021 than it was 2013/14. The cumulative result of these changes is a slight reduction in overall land use.

It should be noted that lower land use by beef cattle production could have potentially detrimental effects on both biodiversity and carbon soil sequestration. As discussed in Section 2.1.4, land use is intrinsically tied to biodiversity levels, particularly on grazing land. There is a positive correlation between beef cattle on grazing land and higher levels of habitat capacity, both for feeding and reproductive purposes. Less grazing by beef cattle could indicate lower levels of biodiversity. Similarly, grazing is useful for sequestering carbon within soil. Lower land used for grazing could therefore reduce sequestration levels as well.

Freshwater Eutrophication

Minor decreases in freshwater eutrophication potential are observed for both the West and the East between 2013/14 and 2021. This equates to a decrease of 1 g P eq/kg live weight in the West and 2.4 g P eq/kg live weight in the East. These changes can be attributed to changes in feed rations.

Terrestrial Acidification

Terrestrial acidification potential is the only impact that increased between 2013/14 and 2021. In the West, the impact increased by around 18 g SO_2 eq/kg live weight, while in the East, it increased by around 28 g SO_2 eq/kg live weight. In general, these increases can be attributed to changes in the emissions from manure during confinement. These emissions are directly related to feed ration composition, particularly ammonia emissions from manure. The amount of ammonia excreted per day is determined by the amount of crude protein (CP) in feed. Since 2013/14, the average CP level of feed increased from 12% to 16% in both the West and East. As a result, the amount of ammonia emissions has also increased, thereby causing a 20% increase in terrestrial acidification potential.

Photochemical Oxidant Formation

In terms of photochemical oxidant formation, for both human health and terrestrial ecosystems, very minor reduction in impacts was observed. In the West, a negligible change was observed of around 1.6 g NO_x eq/kg live weight, while in the East a difference of around 4.1 g NO_x eq/kg live weight was observed. Both changes are due to slight differences in the amounts of certain feed components used, particularly barley, corn, and wheat.

Inclusion of Dairy

In addition, benchmarking on the inclusion of dairy is shown in Figure 2-25. In 2013/14, the amount of beef coming from the dairy sector was 17.9% and the remaining 82.1% came from the beef sector. This ratio is almost identical to that of 2021, however the ratio within the regions was slightly different. In the West, only 1.8% of beef came from dairy which is lower than 2021. On the other hand, 31.3% of beef came from the dairy sector in the East, which is higher than in 2021.

The impact of beef produced in Canada when Dairy animals are included was 10.4 and 8.9 kg CO_2 eq/kg live weight in the West and East, respectively, in 2021. In 2013/14, the carbon footprint was 12.7 kg CO_2 eq/kg live weight in the West and 10.7 kg CO_2 eq/kg live weight in the East. At a national scale, this was a reduction (15%) from 11.5 kg CO_2 eq/kg live weight in 2013/14 to 9.8 kg CO_2 eq/kg live weight in 2021.

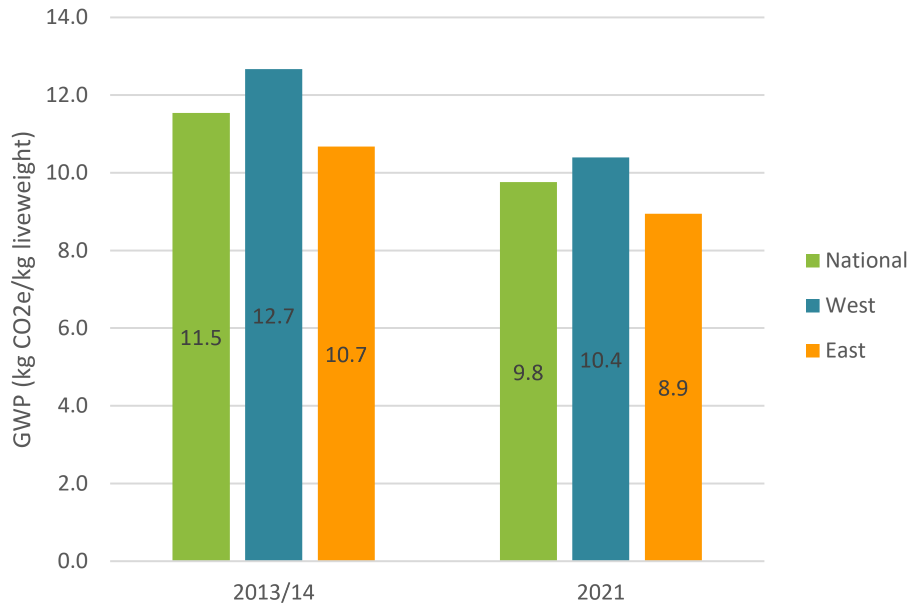


Figure 2-25: Carbon footprint for West and East when dairy is included, benchmarked between 2013/14 and 2021.

As seen in Figure 2-25, the carbon footprint values decreased by 18% in the West and 16% in the East. The reduced impact can be associated with two factors. The first is the reduction in the carbon footprint of beef produced in both the West and the East, as described in the previous section. The 16-18% reduction is consistent with the reduction of the carbon footprint seen with beef excluding dairy, which ranged between 16-20%. The second factor is the number of imports. In 2013/14, a substantially lower number of animals were imported compared to 2021. Higher imports mean more impacts are allocated to the production system where the animals originated. In this case, as discussed previously, the impacts of raising dairy cattle as beef is considered, however all impacts prior to their entrance to Canada (rearing, weaning, etc.) are allocated to the production system of origin. Beyond this, only transport into Canada is considered. As a result, a higher portion of the impacts of raising dairy cattle for beef were allocated to the Canadian production system in 2013/14, resulting in a higher impact compared to 2021.

This increase in imports in 2021 has to do with changing market conditions both in the United States and in Canada. In the past, Canada typically exported feeder cattle, however, as the United States herd expanded, it became more profitable to import feeders in 2017, including dairy calves. Newly attractive prices combined with a feed-cost advantage meant fewer exports from Canada. Furthermore, according to Canfax (Canfax Research, 2021), in 2018-2019, some United States packers stopped processing fed dairy steers, causing their export and subsequent feeding and processing to occur in Canada.

A limitation of this benchmark is that the value for carbon footprint of beef from the dairy sector was assumed to be consistent between 2013/14 and 2021 due to lack of more recent data at the time of this study.

2.1.6 Sensitivity and Scenario Analyses

Scenario Analysis: Calf-Fed vs Yearling-Fed Systems

The Canadian cattle production system considered in this study is a combination of both calf-fed (45%) and yearling-fed (55%) production systems. A scenario analysis where the implications of fully yearling-fed production or fully calf-fed production, based on Western production parameters, was also considered.

As described in Section 1.4.1, calf-fed production sends calves with heavier weaning weights directly to finishing, while yearling-fed systems including backgrounding and grazing prior to finishing. As a result, calf-fed animals are modelled with a shorter production period overall, but a proportionately longer finishing period. In general, these differences between production systems are balanced out. Differences range between 22-26% higher impacts for the yearling-fed system, across all indicators. This is pictured in Figure 2-26.

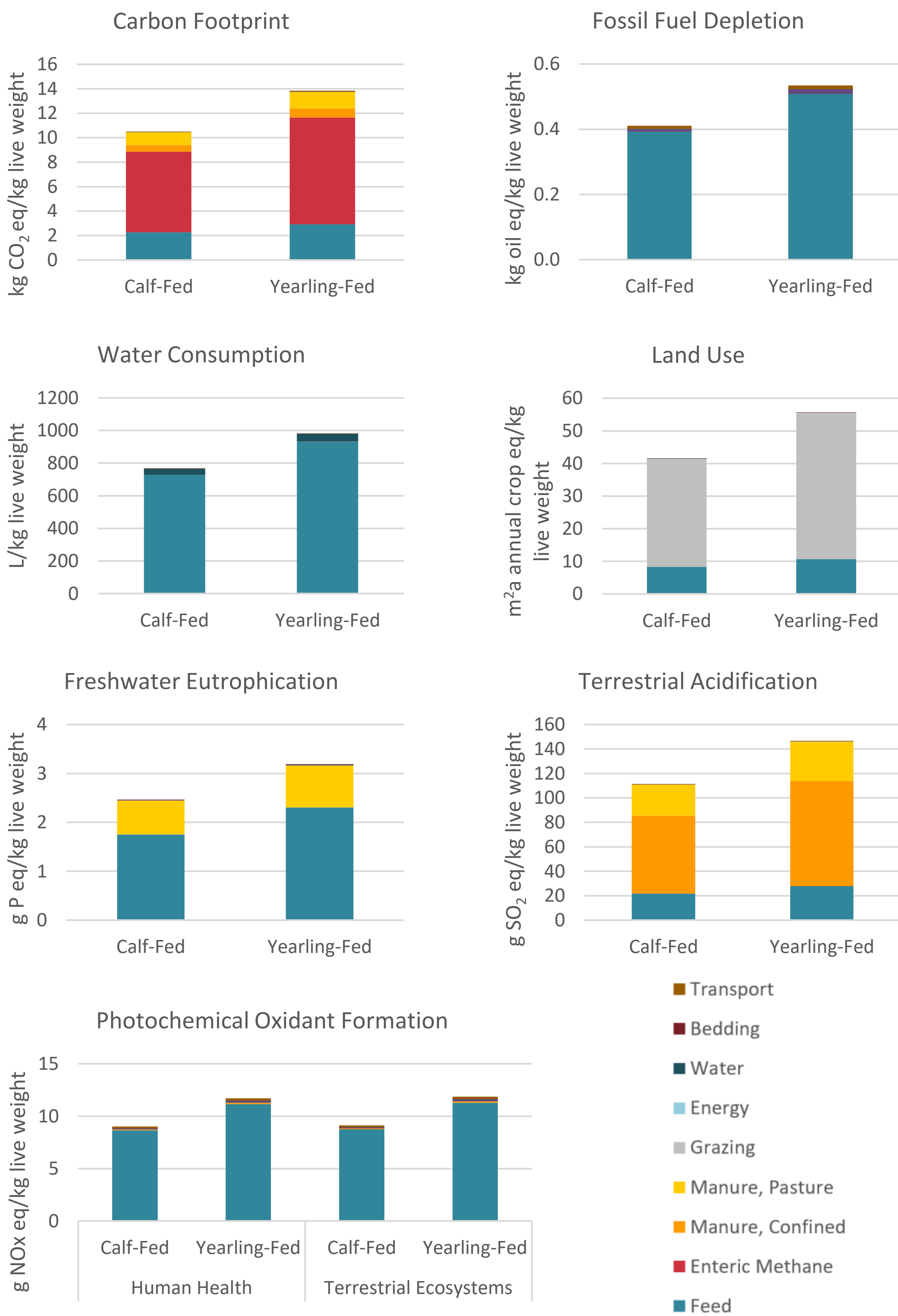


Figure 2-26: Comparison of environmental impacts of calf-fed vs yearling-fed scenarios.

Table 2-14: Environmental impacts per 1 kg live weight for calf-fed and yearling-fed scenarios

Category	Indicator	Units	Calf-Fed	Yearling-Fed
Global warming	Carbon footprint	kg CO_2 eq	10.5	13.8
Resource depletion	Fossil fuel depletion	kg oil eq	0.4	0.5
	Water consumption	L	766.7	980.1
Land use	Agricultural land occupation	m^2a annual crop eq	41.5	55.6
Water pollution	Freshwater eutrophication	g P eq	2.5	3.2
	Terrestrial acidification	g SO_2 eq	111.1	146.4
Air pollution	Photochemical oxidant formation, human health	g NOx eq	9.0	11.7
	Photochemical oxidant formation, terrestrial ecosystems	g NOx eq	9.1	11.9

Carbon Footprint

Per 1 kg of live weight beef, a calf-fed production system results in a carbon footprint of 10.5 kg CO_2 eq, while the yearling-fed system results in a carbon footprint of 13.8 kg CO_2 eq. This is a difference of 24%. As shown in Figure 2-26, the relative values of each contributor are equal for both production systems, but the values themselves are larger for the yearling-fed system. This is due to the longer production period for the animal, resulting in more enteric and manure-related emissions. Furthermore, despite shorter finishing times for the yearling-fed system, additional time in confinement occurs during backgrounding, which is why the impact of feed is also larger for the yearling-fed production system.

Fossil Fuel Depletion

Per 1 kg of live weight beef, a calf-production system has a potential fossil fuel depletion of 0.4 kg oil eq, while a yearling-fed system results in 0.5 kg oil eq. Both values are similar in terms of order of magnitude. Feed production is the major driver for both production systems. In general, this is a minor difference driven primarily by longer production period in the yearling-fed scenario.

Water Consumption

An additional 200 L of water are required to produce a kg of live weight beef in the yearling-fed system compared to the calf-fed. The calf-fed production system requires 767 L/kg live weight, while the yearling-fed system requires 980 L/kg live weight. As with fossil fuel depletion, feed production is the primary contributor to water consumption across both production systems. Again, the longer production period of the yearling-fed system, including the confinement period during backgrounding, accounts for this difference.

Land Use

The calf-fed system requires 41.5 m^2a annual crop eq/kg live weight, while the yearling-fed system requires 55.6 m^2a annual crop eq/kg live weight. As shown in Figure 2-26, the contribution of land use from feed production is very similar across both production systems, but the land required for grazing is much higher for yearling-fed production. This is an expected difference given the additional grazing periods introduced by backgrounding and grazing in the yearling-fed system.

Freshwater Eutrophication

Per 1 kg of live weight beef, the calf-production system and yearling-fed system result in a freshwater eutrophication potential of 2.5 g P eq and 3.2 g P eq, respectively. This difference is driven primarily by feed production and manure on pasture, both of which occur during longer periods in the yearling-fed system.

Terrestrial Acidification

A slightly larger relative difference is found for terrestrial acidification potential, with an impact of 111 g SO_2 eq/kg live weight for the calf-fed system and 146 g SO_2 eq/kg live weight for the yearling-fed system. As with the carbon footprint, the relative contributions of feed production, manure on pasture, and manure during confinement is consistent across both production systems. However, the values themselves are larger for the yearling-fed system, again due to the longer production periods required.

Photochemical Oxidant Formation

Finally, in terms of photochemical oxidant formation, for both the human health and terrestrial ecosystems indicators, minor differences are observed between the calf-fed and yearling-fed systems. An impact of 9 (calf-fed) and 12 (yearling-fed) g NO_x/kg live weight are observed for both human health and terrestrial ecosystems. This has to do with the longer production period.

SENSITIVITY ANALYSIS: END-WEIGHTS OF ANIMALS

Sensitivity of the end-weights of animals within each category were tested. This effectively increases in the feed efficiency of each animal category. In the baseline, the end-weights were defined based on expert judgement of typical end-weights in the West and East. However, there are likely to be producers with animals weighing different amounts than modelled here. Furthermore, as discussed in Appendix D, end-weights defined by experts were cross-referenced with literature compiled by Canfax Research on cattle weights and their changes over many years. The values applied in the model were all within a range of 10% of the values found in literature. Therefore, a sensitivity analysis was conducted by increasing and decreasing the end-weights by 10%. The results are presented in Figure 2-27 for Western production and Figure 2-28 for Eastern production.

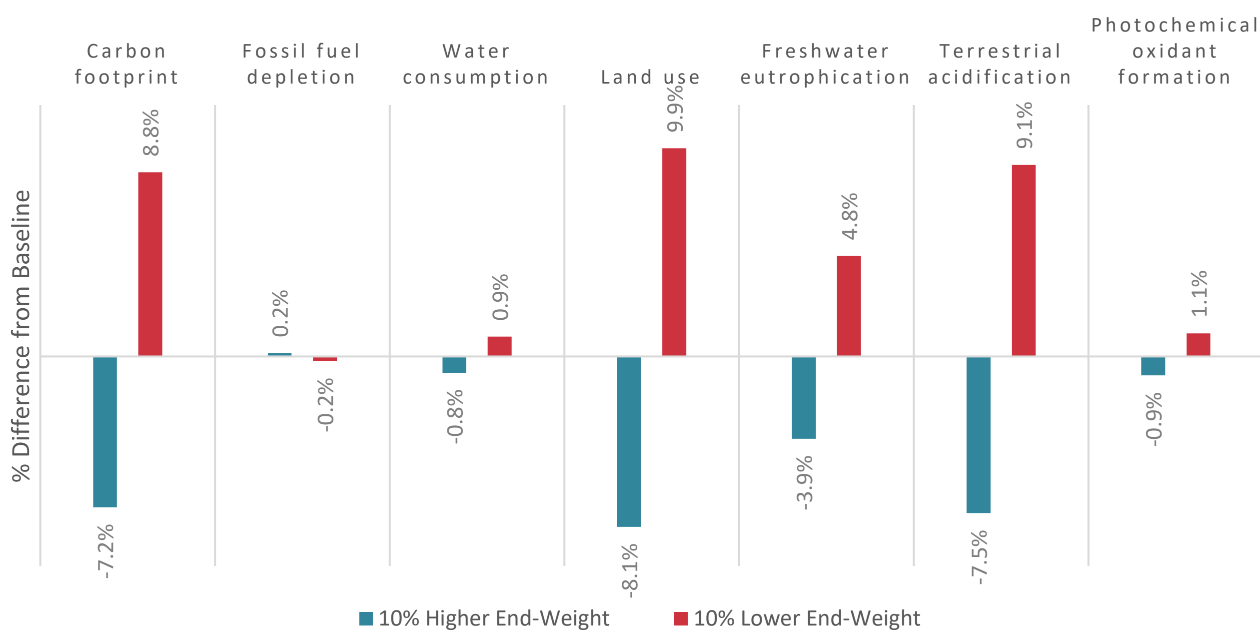


Figure 2-27: Sensitivity analysis on end-weights, percentage difference for 1 kg live weight, West.

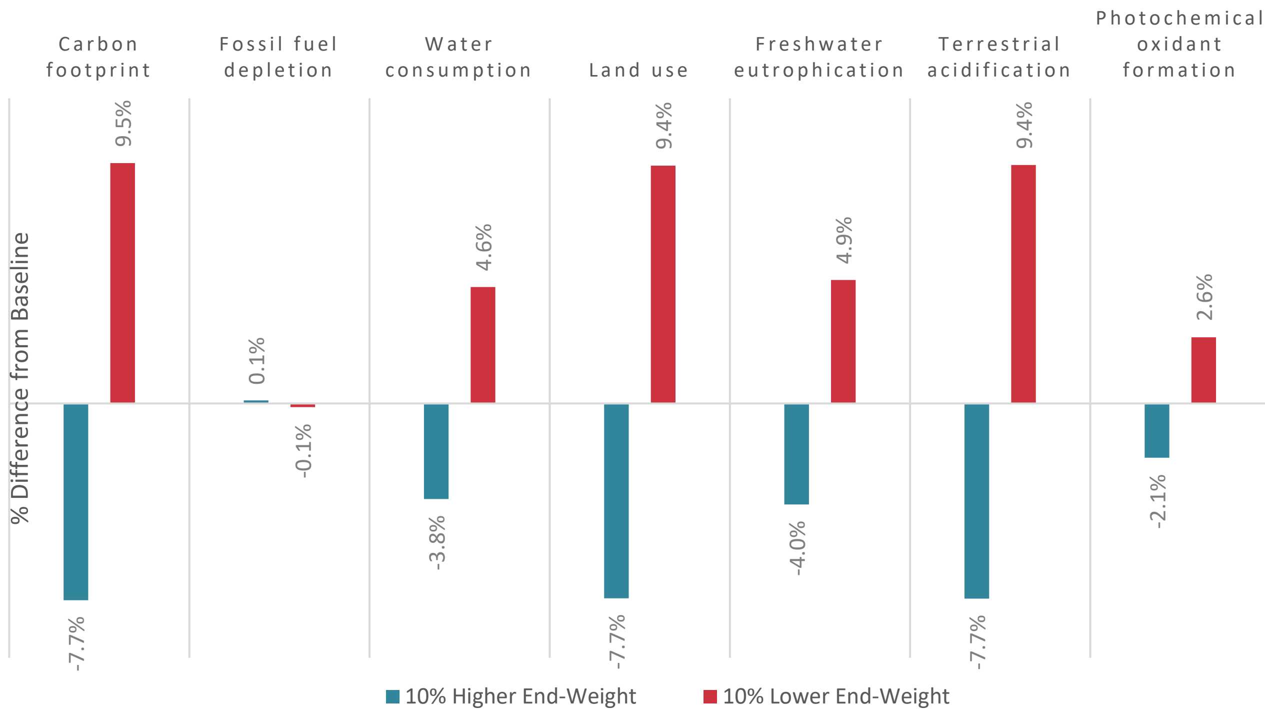


Figure 2-28: Sensitivity analysis on end-weights, percentage difference for 1 kg live weight, East.

In general, a 10% increase in end-weight resulted in impact values lower than the baseline. The reduction ranged between 0.2-8.1% in the West and 0.1-7.7% in the East. The largest reductions were seen for carbon footprint, land use, and terrestrial acidification. The least sensitive indicators were fossil fuel depletion and photochemical oxidant formation. The reduction is signalled by higher efficiency of the system with larger end-weights but equivalent production periods as the baseline. On the other hand, a 10% decrease in end-weight caused an increase in impacts compared to the baseline. These increases were in similar ranges as the decreases caused by a lower end-weight (0.9-9.9% in the West, 0.1-9.5% in the East) and have to do with lower efficiency caused by higher weights for the same production periods.

While the difference from the baseline is nearly as high as 10% for carbon footprint, land use, and terrestrial acidification, there is not a lot of sensitivity introduced for the other indicators. However, because there was some influence on water consumption, further refinement of end-weights by region could be useful in future assessments.

Additional sensitivity analyses were conducted in NBSA 2016 on the allocation of meat by-products, as well as the nitrogen leaching fraction assumed for stored manure. Sensitivity analysis on the allocation of by-products indicated high sensitivity to the allocation. The baseline assessment uses economic allocation, ensuring that the largest portion of impacts are allocated to the main meat product, while mass-based allocation would distribute equal impacts on a per kg basis. As a result, overall potential impacts would be smaller when using mass-based allocation. On the other hand, sensitivity analysis on the nitrogen leaching fraction showed very little sensitivity to the indicators considered in this assessment (<1% difference). Since these aspects of the model have not been changed since the previous assessment, their results are still valid and sensitivity analysis was not conducted again.

2.1.7 DATA QUALITY AND UNCERTAINTY

DATA QUALITY

Data sources are assessed on the basis of time-related coverage, geographical coverage, technology coverage, precision, completeness, representativeness, consistency, reproducibility, source description and uncertainty of the information as prescribed in ISO 14044. The pedigree matrix (B P Weidema et al., 2013) for rating inventory data was used in this study as a guide to evaluate data quality and conduct a quantitative uncertainty analysis. The matrix used in this study is presented in Table E-1 with details of the data quality assessment methodology in Appendix E.1. Quality assessment of the activity data as well as of the applied secondary LCIs were carried out. Activity data quality were assessed for both reliability and representativeness, while only representativeness was assessed for LCIs, based on the assumption made in the previous assessment of not to perform an assessment of already reviewed LCIs.

The data quality evaluation is presented in Table 2-15. The importance of data on the potential life cycle impacts was also evaluated based on contribution analysis and sensitivity analyses. In the framework of this LCA, data with high importance means that its relative contribution to the potential impacts for more than one indicator was the highest. Data with moderate importance means that its relative contribution to the potential impacts was among the highest for at least one indicator. Data with low importance means that its relative contribution to the potential impacts was never among the highest.

Primary data: This analysis shows that, the primary data quality is considered to be highly reliable and complete. They are also representative of the temporal, geographical and technological contexts. Processes with high and moderate importance in terms of environmental impacts are all modelled using primary data which make data uncertainties less significant. These primary data were as current as possible since they were collected for the most recent year of operation (2020 or 2021).

Secondary data: For, secondary data were used mainly for the processing, packaging, retail and consumption stages and their reliability and representativeness were deemed to be good.

Many processes from the ecoinvent v3.8 have been adapted to improve the scores these secondary data. More details on how the ecoinvent datasets used were adapted are in Appendix D.2.However, it is important to note that this is a mixed data quality dataset wherein certain parameters, such as, mortality rates, feed, meat waste (retail and consumption stages) were modelled based on reliable secondary data while enteric emissions are from primary sources based on NBSA 2016.

Table 2-15: Data quality assessment and importance of data contribution to life cycle impacts of Canadian beef production in 2021

Data	Source[1]	Impor-tance[2]	Indicator score[3]					Dataset quality assessment [4]
			Reliability	Completeness	Temporal correlation	Geographical correlation	Further technological correlation	
Farming								
Mortality rates	2		2	1	1	2	1	NA
"Animal stage" duration	1		2	1	1	2	1	NA
Animal weight	1		2	1	1	2	1	NA
On-farm energy consumption	1		1	2	2	2	1	
Water consumption	1		1	2	2	2	1	
Land used by animals	2		1	1	1	2	1	NA
Feed	2		2	2	1	2	1	NA
Enteric emissions[5]	1		1	1	1	2	1	
Manure management	2		1	1	1	2	1	
Transport								
Animal transportation	1		3	2	2	2	1	
Processing								
Material consumption	1		2	2	2	2	1	
Meat waste	1		2	2	2	2	1	
Packaging								
Energy consumption	1		1	2	2	2	1	
Water consumption	1		1	2	2	2	1	
Material consumption	1		1	2	2	2	1	
Retail								
Meat waste	2		2	2	2	2	1	
Energy and refrigerant consumption	2		3	2	2	2	1	
Consumption								
Meat waste	2		2	2	2	2	1	
Energy and refrigerant consumption	2		2	2	2	2	1	

[1] **Source:** 1 – specific (primary) data; 2 – generic (secondary) data. [2] **Importance:** High – max. contribution between >50%; Moderate – max. contribution between 10%-50%; Green – max. contribution <10%. [3] **Indicator scores (1 to 5):** *see* Table E-1 in Appendix E.1. [4] **Dataset quality:** Low quality; Acceptable quality; High quality; see Appendix D.2. for the datasets used.
[5]Importance exception: Enteric emissions were assigned higher importance based on their relative importance with respect to their contribution to the overall beef production system. However, it is noted that from a LCA perspective, its contribution towards all other indicators is moderate.

UNCERTAINTY ANALYSIS

Uncertainty on the LCI parameters is established by the creators of the LCI (ecoinvent). In most cases it follows a log-normal distribution and standard deviation is calculated according to the pedigree matrix (https://www.presustainability.com/improved-pedigree-matrix-approach-for-ecoinvent). The results of Monte Carlo simulations are presented in Appendix E.1. The uncertainty included in the Monte Carlo simulations came from the base uncertainty and included the model results used to calculate the background LCI data values. These are estimates of the variability in values for data from different types of processes or sectors, such as transportation, energy carriers, and emissions.

2.2 SOCIAL PERFORMANCE OF THE CANADIAN BEEF INDUSTRY

The following sections describe the results of the social life cycle assessment for the social performance of the Canadian beef industry for the four priority social issues: Labour Management, People's Health and Safety, Animal Care, and Antimicrobial Use.

2.2.1 LABOUR MANAGEMENT

Labour management refers to the working conditions provided to the people working in the industry (including farm owners and family members) and the extent to which these conditions contribute to their overall well-being. Working conditions covered in this assessment range from working time and remuneration to training. They build on labour rights and employment standards to also incorporate fairness and career development opportunities. Together with occupational health and safety (OHS), labour management plays a key role in creating a positive and attractive work environment for beef industry stakeholders.

RATIONALE: WHY IS THIS ISSUE A PRIORITY WHEN IT COMES TO SOCIAL SUSTAINABILITY?

Job availability is a tremendous opportunity for social well-being in Canada. From the positive and stabilizing effects for society to the detrimental experience of unemployment, "both the availability of jobs and the earnings they pay are relevant for well-being" (OECD, 2011). However, while the Canadian beef industry forecasts until 2030 predict production growth and more available jobs, there will also be fewer workers (CAHRC, 2018).

Job availability is currently unmet by labour availability in the Canadian beef industry, with beef industry stakeholders facing increasing challenges in finding workers (CAHRC, 2018). This gap comes with financial and economic costs (CAHRC, 2018). Social costs may also result from the potential increase in demand on workers to achieve greater outputs. This deep dive into labour management focuses on the potential for these social issues to impacts human health and healthy, sustainable workplaces and communities.

- Labour availability may be outside the control of any one operation, but value chain actors can encourage socially responsible labour management practices in their organization to address the issue of labour availability. From the ISO 26000:2010 perspective, the benefits of socially responsible labour practices for organizations include:
  - a positive impact on "an organization's ability to recruit, motivate and retain its employees"
  - "enhancing employee loyalty, involvement, participation, and morale"
  - "improving the safety and health of both female and male workers"
  - influence the organization's reputation, further promoting recruitment and retention (ISO, 2010)

These outcomes are desirable for the sustainability of the Canadian beef industry. Stakeholders involved in scoping this assessment prioritized recruitment, training, and retention of new local employees and temporary foreign workers as topics that matter most for sustainability (*see* Appendix C.1). Furthermore, they prioritized labour management as a "fast-growing" and "immediate" challenge, particularly around the physical harm that may occur from a lack of labour, including stress, burnout, or depression (among other potential priorities (*see* Appendix C.1). In one respondent's words: "Labour shortages and extreme job demand have real mental and physical health repercussions on employees and management and threaten the longevity and sustainability of the industry" (*see* Appendix C.1). These insights and more were gathered as part of the goal and scoping phase of the social life cycle assessment (S-LCA) and were considered as part of the criteria that informed the choice to assess labour management here as a priority social issue.

Table 2-16: Assessed Labour Management Related Themes

Related themes	At packing plants	On farms
Onboarding Activities	√	√
Professional Development Opportunities	√	√
Communication and Dispute Resolution		√
Benefits	√ (incl. salaries)	√
Diversity Management	√	√
Language Training		√
Recruitment and Retention	√	√
Overtime		√
Workload dissatisfaction		√
Consequences of Overload		√
Succession/Transition		√

Indicators for these themes are provided in Appendix F.

Impact Pathways

Evidence of stressors and potential impacts along the beef value chain are defined by stakeholders and the broader literature on sustainability. In some cases, the interrelations are known and have been characterized scientifically by recent studies. In other cases, the interrelations are theoretical possibilities that have not yet been characterized through an examination of cause and effect. The impact pathways section takes a first step toward gathering the breadth of potential stressors and potential impacts together to highlight the potential for social consequences (good or bad) in the context of agriculture. The current state of knowledge about how stressors may interrelate or manifest in mid-point or endpoint impacts varies. The pathway analysis section below will show that as it describes these interrelations as complex and multi-directional. Furthermore, the interrelations are not always predictable, or uniform, because they are defined by relationships between people within an organization or between organizations within the value chain. The aim of the impact pathway section is to provide the reader with an awareness of the potential for impact pathways to activate along the beef value chain.

Pathway 1.1 – Workloads may impact the personal health of workers.

Labour management practices can create or contribute to conditions leading to overwork and chronic stress (Cedillo et al., 2019). Workloads are one of the top 3 most common farm stressors. Prior to the pandemic, nearly three in four farmers (72%) reported moderate to high stress from workloads (FMC & Wilton Consulting Group, 2020, p. 30).

In 2021 a similar number of farmers (76%) reported perceived stress levels as moderate to high (Jones-Bitton et al., 2022). Moderate to severe stress in some cases can be characterized as burnout. Burnout is the third of four levels of stress response described by Sabongui (2018) as a potentially harmful level of deteriorating mental or physical health (FCC, 2020). Burnout has implications on mental health (FMC & Wilton Consulting Group, 2020, p. 16). Stressful periods affect the mental and physical health of employees and operators and may create chronic conditions such as depression, anxiety, skin issues, heart issues, immune issues, digestive, and reproductive issues (FCC, 2020, p. 18; Jones-Bitton et al., 2019). In severe cases, decision-making abilities may become paralyzed, and may cause far more serious outcomes (FCC, 2020). Compared to the general population "farmers had significantly higher scores on all 3 subscales of the Maslach burnout inventory" in 2021 (Jones-Bitton et al., 2022). Burnout has consequences on personal health.

Pathway 1.2 –Stress affects business management and relationships and vice-versa.

In addition to direct personal health outcomes, stress may impair decision-making and lead to an inability to concentrate on business management planning (FCC, 2020) . What is more, business management planning and activities are often key to reducing stress (FCC, 2020). The interrelationship between stress and decision-making is cyclical. Similarly, the interrelationship between stress and tiredness and relationships is cyclical, with relationships being another key to managing stress in return (FCC, 2020). Women and younger farmers may be more vulnerable to stress, but may also be more willing to seek out help (FCC, 2020). The effects and magnitude of stress vary among the demographic of operators and their families. Managing workloads may reduce stress as time available for family and friends, engagement in leisure activities, or access to support are all key for moderating stress (FMC & Wilton Consulting Group, 2020, p. 17). Reducing workloads may create more time for business management activities.

Pathway 1.3 – Working conditions affect labour performance.

Working conditions "can increase job satisfaction and commitment," (Cedillo et al., 2019) or conversely, job dissatisfaction, absenteeism, and negative presenteeism due to burnout (FMC & Wilton Consulting Group, 2020; Jones-Bitton et al., 2019). Conditions that foster "tiredness and stress can lead to poor performance that has nothing to do with ability" (FCC, 2020). Job dissatisfaction may result in voluntary turnover (Estrada, 2016) that present individual and/or social opportunity costs to the industry including recruitment and training costs (Aljoe, 2019). Recruitment and training issues were flagged as a priority issue for one group of stakeholders in scoping.

Labour management practices have been shown to contribute to the adverse experience of employees and employers in Canadian agriculture, but not all labour management practices lead to adverse effects. Socially responsible labour practices present a significant opportunity for just and favourable conditions of work that complement the quality of life that can be offered by employment. Figure 2-29 is a visual attempt to summarize this social issue through a pathways approach.

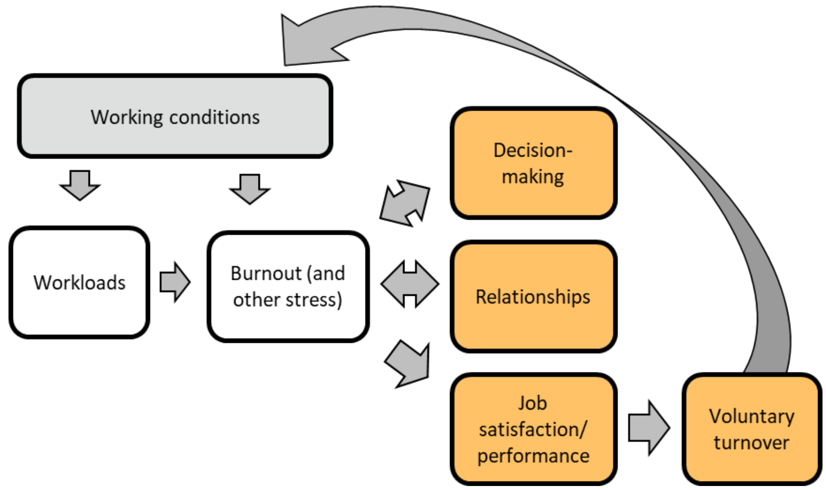


Figure 2-29: Potential pathways of effect in agricultural labour practices.

The arrows represent the potential for single-or multi-directional pathways or linkages. The grey fill indicates the stressor following a pathway. White fill boxes represent the mid-point affects and orange fill boxes represent the potential beneficial or adverse outcomes from the stressor.

BASELINE: WHAT WERE THE DOCUMENTED HOTSPOTS IN 2013/14 AND WHAT HAS THE INDUSTRY ACCOMPLISHED SINCE THEN?

The NBSA 2016, based on the reference years of 2013/14, showed very low to low risks for most indicators related to working conditions. Farmers and packers scored well on hourly wages and health and safety training and prevention. The 2013/14 S-LCA revealed three social hotspots along the Canadian beef production value chain that were directly linked to working conditions and labour management (CRSB, 2016b). These include:

The rights of temporary foreign workers at the national 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 to 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, which was the indicator used to evaluate legal rights in NBSA 2016.

The wage of workers at the distribution level: The wages 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 salaries[10].

The workload at the beef producer level: 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.

Based on the 2016 NBSA results, the CRSB has established, as part of the National Beef Sustainability Strategy, the goal of promoting farm safety and responsible working conditions (CRSB, 2021b). While no action items specifically address labour management, there is a recognition that the rights of temporary foreign workers, wages for retail and food-service workers, and workload for farmers and ranchers are areas for improvement (CRSB, 2021b).

[10] This specific risk was not included in the current assessment, which focuses on activities taking place at the production and processing levels. In addition, the indicator used in NBSA 2016 was based on 2011 data, which were last updated in 2015.

Since 2016, efforts have been made at the industry level with respect to these hotspots. Most are associated with initiatives aiming to address labour needs at the farm and packer levels by collaborating with federal agencies to facilitate access to temporary foreign workers[11].

With less seasonality and less variability in hours than other sectors, the Canadian beef sector primarily relies on domestic labour, with only 0.7% of the workforce being made up of foreign workers. This is much lower than the Canadian agricultural average of 12% (CAHRC, 2021). Nonetheless labour shortages are affecting the industry, at both production and packing levels. According to the CAHRC Commodity Dashboard, the current labour gap in the beef sector for 2022 is 5,856 jobs and this estimate is expected to reach about 14,000 by 2029 (CAHRC, n.d.). A study published by Food Processing Skills Canada (FPSC) in 2019 indicated that eight of the fourteen regions studied in-depth were facing very tight labour markets and concluded that the situation is projected to worsen under status quo conditions (Food Processing Skills Canada, 2019)[12].

COVID-19 also had a significant impact on meat processing plants across Canada. Many had to slow operations, and in some cases, shut down temporarily, to contend with outbreaks among workers[13]. With respect to labour management, this particularly impacted vulnerable worker groups, including racial minorities, as well as immigrants, migrants, and refugee workers who make up 18% of the workforce in meat packing plants in Alberta, where approximately 70% of meat production occurs (Bragg, 2021).

In comparison, COVID-19 caused no significant labour disruptions at the feedlot and cow–calf operation levels (Rude, 2021). However, labour shortages do affect producers as well as their network of auction barns, feed mills and associated transportation services[14].

The labour shortage facing the overall industry amplifies the issue of workload and its associated repercussions on people and businesses[15]. This situation also reinforces the need for adopting labour management practices that focus on recruiting, training, and retaining domestic and foreign workers in the Canadian beef industry.

---

[11] For instance, since the end of 2019, Service Canada began accepting Labour Market Impact Assessment (LMIA) applications with a two-year employment duration for positions in meat processing (Government of Canada, 2022). The LMIA Pilot was developed to support a temporary foreign worker employee's application for permanent residence and was tied to the Agri-food Immigration Pilot (Food and Beverage Canada, n.d.). To address the shortage of butchers, a three-year agri-food immigration pilot project to bring full-time, non-seasonal agriculture workers to Canada was also announced in 2019. The Canadian Meat Council has asked for 2,750 immigration spots (CRSB, 2020a). In December 2021, eleven industry associations also presented an initial proposal for an Emergency Foreign Workers Program to develop a short-term strategy to address the food and beverage manufacturing sectors labour needs (Food and Beverage Canada, n.d.). More recently, CAHRC, together with its partners, the Canadian Federation of Agriculture (CFA) and Food and Beverage Canada (FBC-ABC), have announced the launch of the National Workforce Strategic Plan for Agriculture and Food and Beverage Manufacturing (CAHRC, 2022).

[12] Specifically, the study suggests there will be a need to hire a net of nearly 2,275 additional new workers over the next three years to meet expansion and workforce retirements. Replacement demands (deaths and retirements) alone are expected to total 5,500 between 2017 and 2030. Taking account of both replacement and expansion demands, the industry will likely need to hire just over 10,400 new workers, or (77%) of the current workforce over the next 13 years (Food Processing Skills Canada, 2019).

[13] In terms of Canadian beef packers, Cargill's High River Alberta plant was responsible for the single largest COVID-19 outbreak (almost 900 employees were infected) for North American meat packers. At the JBS Brooks Alberta plant, more than 500 of the 2,600 employees contracted COVID-19 (Ross, 2020 cited in; Rude, 2021).

[14] The trucking industry is also facing a labour shortage and, since it plays a major role in the beef sector, it has an important impact on the rest of the supply chain (Canadian Trucking Alliance, 2022; Toor & Hamit-Haggar, 2021)

[15] According to workplace psychologist Jennifer Newman, working extended hours can induce a lot more than just fatigue. It can lead to workplace injuries and constantly working long hours increases the chances of being diagnosed with a chronic illness later in life (CBC News, 2017). Long hours working on the land, away from people and community supports, can lead to feelings of isolation and loneliness which adds to their stress. A meta-analysis conducted by Wong et al. (2019) synthesised the data from studies undertaken during the 1998 to 2018 period on the effects of working long hours on the occupational health of employees. Their main result is that: "[…] long working hours were shown to adversely affect the occupational health of workers and that the management on safeguarding the occupational health of workers working long hours should be reinforced."

RESULTS: WHAT IS THE CURRENT SITUATION OF THE INDUSTRY WITH RESPECT TO THIS SOCIAL ISSUE?

Results from the assessment led to three key observations regarding the strengths and risks associated with labour management in the Canadian beef industry. Evidence supporting each of these key observations are provided below.

Table 2-17: Key Observations

Key observation #1 Labour availability, recruitment, and retention are creating workload levels with potential negative repercussions on people working in the industry	
Documented strengths	There is a broad awareness and recognition that labour management is a critical area requiring additional attention from everyone within the industry
Documented risks	Each sector of the industry is facing risks related to labour management, but cow–calf operations are perceived as being particularly vulnerable due to a lack of resources to compete with other sectors and industries
Key observation #2 There is a recognition that sound labour management practices are needed to address workload levels and efforts are being made by individual businesses, both at the farm and packing plant levels	
Documented strengths	Many farm operations with hired labour have adopted practices to support on-boarding (e.g., initial training, discussion about workers' rights and responsibilities) and to promote professional development of employees (e.g., involving employees in decision-making, providing skill development opportunities)
Documented risks	Very few farms have implemented measures to support communication and dispute resolution with employees The adoption rate of practices having the potential to limit the negative repercussions overtime may have on employees remains low at the farm level (e.g., providing regular breaks, adjusting working hours not to affect the employees' health and safety, compensating additional hours worked) Recent research shows that im/migrant workers at packing plants may face particular risks with respect to their working conditions
Key observation #3 Farm and packing plant businesses need to consider innovative approaches to deal with workload levels and ensure job satisfaction for the people working in the industry	
Documented strengths	There is a strong and growing recognition within the industry of the value of hired labour and of the importance of finding innovative ways to mitigate the labour shortage situation and its consequences
Documented risks	Important economic barrier limiting the adoption of innovations and new technologies to lower staff requirements at the farm, and to some extent, at the packing level Improved communication between employers and employees is an area where additional efforts are needed with respect to labour management

Key observation #1 – Labour availability, recruitment and retention are inducing workload levels with potential negative repercussions on people working in the industry

Beef farmers are increasingly challenged to find labour. The CAHRC Commodity Dashboard shows that in 2017, 49% of Canadian beef farmers were unable to find needed workers based on results of an employer survey (CAHRC, n.d.). This observation is consistent with the results of the on-farm survey conducted as part of this assessment (*see* Figure 2-30). Specifically, about 45% of respondents who employ hired labour indicated that the challenge of recruiting employees has increased to a large extent compared to five years ago. A similar proportion of respondents also indicated that labour retention is increasingly challenging (44%) (Indicator 1.7).

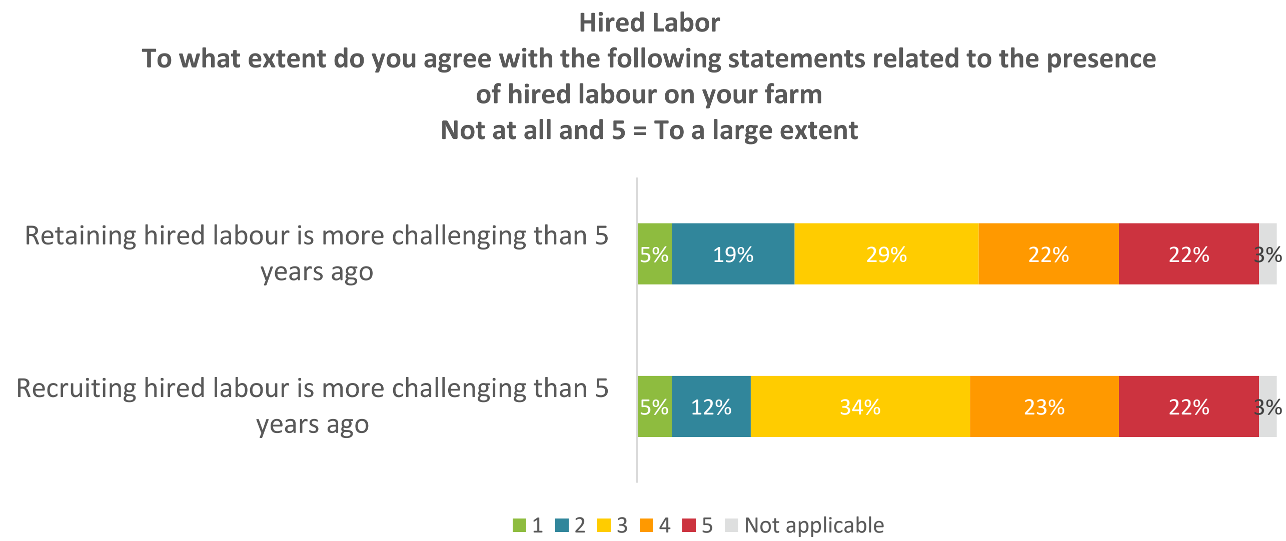


Figure 2-30: Retention and Retaining.

Results from the survey do not allow for the empirical establishment of a correlation or causality between the challenges of recruiting and retaining hired labour, and the level of workload on farms. However, there is evidence of dissatisfaction with workload and adverse mental and physical effects. When asked how often dissatisfaction with overall workload is expressed by employees, 56% of respondents said rarely or never, but 44% indicated that some degree of dissatisfaction is communicated by employees (with 24% saying often to very often) (Indicator 1.9).

Similarly, most producers said that negative health outcomes, such as absenteeism (56%), stress injuries (42%), physical injury (60%), and stress leave (70%), never or rarely occur on the farm as a direct result of working too much (Indicator 1.10). Yet, the proportion of farmers who said they or their employees experience these negative health outcomes as a direct consequence of workload on their farm remains substantial, especially with respect to stress injuries, with 29% saying often to very often. Results are based on the producers' perspectives and opinions. Farm employees were not asked to complete this assessment, which is one limitation of the approach used.

Workload appears to be a primary source of stress in the beef industry. For instance, workload pressures from the beef operation are considered a major stress factor for 45% of beef producers who completed the survey. The ability to recruit and retain employees is also identified as a stressor affecting about 40% of respondents (Indicator 2.8).

The interviews with industry informants indicated that the overall challenge of labour management is experienced differently depending on the sector and the size of the operation. For feedlots and packers, they are more directly facing issues related to recruitment and retention. At the cow–calf level, interviewees expressed concern with respect to the ability of operators to address labour management related issues. In fact, the cow-calf sector seems particularly vulnerable on the labour side due to operation size or capacity.

While many appear to be doing their best according to informants, they are fighting an up-hill battle when it comes to labour recruitment and retention. They cannot afford to compete with other industries to attract good employees[16]. Overall, the workload induced by labour shortages and its repercussions on people's health is one common denominator for many businesses across the industry.

Quotes from the interviews

"Cow-calf producers try their best to provide a positive work environment. They should be commended for their efforts. However, results are disappointing" (Respondent 1)

"They are small employers; they can't afford attract / retain workers; competition is strong" (Respondent 1)

"There are significant differences between cow-calf and feedlot. Feedlots pay good wages to employees (more than for nurses!). Cow-calf operations offer poor pay. They are not very competitive" (Respondent 4)

"Many farms are trying to be good employers, but most of them are small-capacity" (Respondent 9)

"Producers pay what they can afford, but this is not enough in comparison to what other sectors offer. They get 'second-tier' workforce, including from family" (Respondent 10)

The concerns regarding the vulnerability of cow–calf operations with respect to labour management are also associated with the challenge of farm transfer. Many interviewees pointed out that it is difficult for cow–calf producers to keep children on the farm. The occupation may not be sufficiently marketed towards the younger generation. Among the concerns mentioned are financial issues (e.g., relatively low returns in comparison to other productions), barriers to entry (e.g., land values, regulations, urban sprawl), hardship of the occupation (e.g., exposure to the weather, long working hours), and the perception they have of the sector (e.g., traditional sector with little innovation). However, whether these concerns are real and affect the sector's ability to engage the younger generation was not documented as part of this assessment[17].

[16] Wages paid to farm workers were not documented in the on-farm survey. In Canada, the application of minimum wage requirements to farm workers varies by province. However, wages paid to farm workers are usually higher than the minimum wage (CRSC, 2020d). For instance, in 2021, the median wage for full-time and part-time farm workers was higher in every province than the current minimum wage (as of 2021) (Loans Canada, 2021). That said, agricultural median wages are on average 27% lower than the average provincial median wages (Statistics Canada, 2022b).

[17] It worth noting that while generational issues were mentioned during interviews, no references were made to gender equality within the industry, either at the farm or at the packing plant level. This theme was not documented per se in this assessment. However, data from Statistic Canada show that the average hourly wage of women (full-time job) is lower than that of men by 11% in agriculture and 15% in manufacturing in 2021; 13% and 18%, respectively, if we consider the median wage. By occupation (for full-time jobs), workers in natural resources, agriculture, and related production: the difference in 2021 is 16% for average wage, 14% for median wage. For the labourers in processing, manufacturing and utilities: the difference in 2021 is 14% for average wage and 11% for median wage (Statistics Canada, 2022a). This is a particular area that could receive further scrutiny in later research.

Quotes from the interviews

"Transition planning is huge challenge for the industry and individual farms. It is difficult to keep kids on the farm" (Respondent 1)

"The biggest risks are facing the cow-calf sector; risk of losing a segment of the industry; people are tired and leaving the industry; do not want to fight an up-hill battle" (Respondent 9)

"I am questioning whether many producers will have their children replace them" (Respondent 9)

"On the cow-calf side, they [producers] tend to be a bit older, and will reach the retirement age soon; risk-wise, they need to make sure there are people that are being brought to the manager role" (Respondent 17)

"We need to look for new models for succession (e.g., including employees; new immigrants). We are facing a demographic issue" (Respondent 2)

"There is an unwillingness to take over due to year-long commitment and public trust concerns" (Respondent 7)

"The intergenerational problem is not that kids are not there, but they struggle to access the financing" (Respondent 8)

"The average age of producers is key risk and there is a lack of financial incentives for younger folk to jump in" (Respondent 11)

Results from the 2021 Census seem to confirm the challenge facing Canadian beef farms with respect to farm succession. First, Census data shows that full-time producers (those working more than 30 hours per week) of 55 years of age and over account for 60% of the population (Census; Table 1). In addition, 66% of the 60,697 reporting farms indicated that no written succession plan is in place or even discussed (Census; Table 13). Within this group, 54% of farms have an operator 55 years of age or older. This trend is similar across the types of cattle operations (cow–calf, stocker, and finishing)[18].

In comparison, feedlot operations are perceived as being more competitive in dealing with labour management issues. Many have human resources in place. They are also more likely to rely on temporary foreign workers TFWs, which involves having to comply with labour regulations. Still, as one interviewee said, "feedlot producers are facing an extremely challenging situation. […] They offer very competitive working conditions, but they can't draw or attract domestic labour. […] The return on investment (ROI) of their efforts is very low" (Respondent 1).

Similar observations apply with respect to packers when it comes to labour management. On the one hand, difficulty of recruiting was identified by all three surveyed companies as being part of their biggest HR challenge, followed by staff retention for entry-level positions (67%) (PackerQ1). On the other hand, many interviewees mentioned that packing plant employees are "doing jobs most Canadians wouldn't do" (Respondent 6; Respondent 14; Respondent 1; Respondent 17). Representatives of packing plants also noted that a key risk for the sector is "not paying and treating people very well" (Respondent 12) in a context where employees are working in "a close quarter work environment" (Respondent 15) to perform an "assembly line type of operation" that requires "manually intensive labour" (Respondent 13). It is "all about speed; people are forgotten" said one of the interviewees (Respondent 6). As a result, "people are overworked" (Respondent 12) and labour management is perceived as "the greatest risk" (Respondent 13) for the sector. Therefore, reliance on TFWs is instrumental from the packer's perspective even though barriers exist to their recruitment and integration.

[18] Additionally, there is a clear distinction according to farm sizes. With the group reporting having no written succession plan in place, or even discussed, 88% of them are farms with under 250 head of cattle.

The difficulty to attract the younger generation into the industry was also mentioned as a challenge facing packers (Respondent 13). As one interviewee put it, the "younger generation is looking for more alignment between their work and personal life. If they don't find this consistency, they'll move on" (Respondent 14).

Overall, there was a clear recognition among interviewees that while efforts are already made, improvements are still needed at the packing plant level with respect to labour management.

Key observation #2 – There is a recognition that sound labour management practices are needed to address workload levels and efforts are being made by individual businesses, both at the farm and packing plant levels

While labour availability is outside the control of any one operation, the adoption of labour management practices that focus on recruiting, training, and retaining domestic and foreign workers is instrumental to the future of the Canadian beef industry.

In Canada, labour relations and working conditions of hired labour is regulated to a large extent. Specifically, the employment standards legislation in each province and territory sets out the minimum legal requirements that an employer must follow within areas such as minimum wage, statutory holidays, vacation and leaves, notice of termination and severance pay, and many more obligations (ADP Canada, n.d.). However, the extent to which these provisions apply to farm workers varies by province (CRSC, 2020d). Temporary foreign workers hired through federal programs (e.g., Temporary Foreign Worker Program, Seasonal Agricultural Worker Program) are also entitled to the rights and freedoms guaranteed in the Canadian Charter of Rights and Freedoms as well as at least the same provisions as locally hired labour (CRSC, 2020b, 2020d).

To attract and retain employees, businesses often need to adopt practices that go beyond legal requirements. This is particularly the case given the current labour shortage facing the Canadian beef industry.

Survey results at the farm level show that many operations with hired labour have adopted practices to support on-boarding and promote professional development of employees. Specifically:

- 95% of respondents perform at least one or two on-boarding activities upon hiring, including discussing the workers' rights and responsibilities (50% of respondents), providing initial training (54% of respondents), or organizing welcoming activities (e.g., introduction of the company, immediate supervisors) (33% of respondents) (Indicator 1.1).
- 95% of respondents also perform activities related to professional development, including involving employees in decision-making and in fostering new ideas (58% of respondents), having meetings to discuss positive actions and irritants with employees in a timely manner (51%), conducting regular staff meetings (48% of respondents), providing skills development opportunities to employees (43% of respondents), carrying out employee performance evaluations on a regular basis (35% of respondents), or providing workers with advancement opportunities (32% of respondents) (Indicator 1.2).

Similarly, a clear majority of respondents (92%) offer their employees at least 1 benefit, the most common being bonuses (45% of respondents), health insurance (42% of respondents), disability insurance (41% of respondents), and in-kind donations (42% of respondents). Other typical benefits include paid sick days (34% of respondents), life insurance (23%), paid vacations (25%), pension plan contribution (18%) and parental leave (15%) (Indicator 1.4)[19]. Providing benefits was identified by some interviewees as being a key tool in a producer's toolbox to standout as an employer (Respondent 2; Respondent 6; Respondent 16).

While these results are positive overall, room for improvement exists when looking at individual practices. For instance, establishing clear site rules, procedures, and expectations with employees are essential to ensure that everyone working on the farm understands what is expected of them and that managers and supervisors are fair and consistent in their approaches. Yet, about half of respondents said they do not provide a contract or establish a clear relationship understood by the employee (52%) or discuss the workers' rights and responsibilities upon hiring (50%). Also, 31% of respondents said they do not keep an up-to-date record of hours of work, wages, and all deductions (Indicator 1.1)[20]. The total number of employees, their employment status or profile (e.g., full-time vs. part-time or seasonal; family vs. non-family labour; domestic vs. foreign workers) and other reasons could explain why these practices are not used more widely on some farms[21].Yet they remain practices which are highly recommended for adoption, both from labour management and sustainability standpoints (CRSC, 2020d).

The same observation applies with respect to professional development activities. Results from the survey indicate there is room for improvement when looking at individual practices (Indicator 1.2). Some, including involving employees in decision-making, fostering new ideas, and conducting regular staff meeting, can be easy to implement and have a substantial impact. In fact, enabling communication between employees (including farmers) was identified by one interviewee as a key success factor to foster a positive and purposeful work environment (Respondent 16).

However, survey results show that only 47% of respondents make sure that all important communications (e.g., work contract, safety procedures) take language into account and are developed in ways that are understood by all workers (Indicator 1.3). In fact, more than half of respondents (53%) have **no particular measures in place to deal with communication and dispute resolution on farm**. This situation can be considered as a **potential risk** at the farm level.

When it comes to labour management practices, **another key risk is related to overtime management and workweek length**. In NBSA 2016, this issue was identified as one of the key risks based on the average number of hours worked per week during the peak season and the number of weeks per year during which workers worked more than 48 hours per week. The agri-food sector, including beef production, can require a higher workload than what is commonly observed in other industries (CRSB, 2016a). Also, the extent to which employment standards for working hours and overtime applies to farm workers varies by province, with farm

---

[19] This result compares to the one measured in NBSA 2016, where 89% of respondents said they offer at least one of the nine social benefits listed by the ILO (e.g., medical care, sickness benefit, unemployment benefit, old age benefit, employment injury benefit, family benefit, maternity/paternity benefit, invalidity benefit, survivor's benefit), the most common being unemployment benefit (37% of respondents), employment injury benefit (33%), old-age benefit (30%) and medical care (26%).

[20] Maintaining employee records is required by all provinces in Canada, but the types of information employers are required to record and keep vary from one province to the next. Employers have to keep pay records which usually include the employee's name, rate/hour and amounts of mandatory deductions such as income tax, Canada Pension Plan and Employment Insurance. The survey question did not differentiate between mandatory and voluntary record keeping.

[21] As a comparison, a survey conducted by the CRSC in 2017 shows that 26.2% of Canadian grain farmers responded "rarely" or "never" to the question "Do you keep up-to-date employment records to provide an accurate overview of all employees (including seasonal workers and subcontracted workers), including contact information and salaries?" (CRSC, 2020a).

workers usually being excluded. For these reasons, this assessment looked at the practices used by farmers to limit the potential negative repercussions may have on employees' overtime.

Results from the on-farm survey provide evidence that risks remain with respect to this issue. Specifically, when asked how they manage the hours worked by employees on their farm, 55% of respondents said they are given regular breaks, 53% said they make sure that hours worked do not affect the employees' health and safety, 53% said workers receive equal compensation when working additional hours (e.g., time in lieu, meals), and 49% said that workers can decline without consequence when asked to work additional hours. Moreover, 60% said that they have an agreement between the employees and themselves stating expectations about hours worked (including overtime) (Indicator 1.8).

Taken individually, the degree of adoption of these practices does not indicate to a major risk, even though improvement could be made. However, the results are more concerning when taken together, as 76% of respondents declared that one or more of the key practices are not met (e.g., employees working on their farm cannot decline without consequence when asked to work additional hours, are not given regular breaks, and that farmers do not make sure that hours worked do not affect their employees' health and safety).

The topic of work schedule and overtime is a complex one in an agricultural setting. Also, these results are based on a self-assessment and do not fully capture the context in which work hours are managed on these farms and the extent to which this situation is detrimental to employees. Farm workers were not asked their opinion and more than half of producers said they never or rarely hear dissatisfaction with overall workload from their employees (Indicator 1.9). That being said, this indicator documents practices that are strongly recommended to limit the risk for working hours to have negative repercussions on employees and results point to a risk that should be accounted for by industry (AgriShield, n.d.).

Some labour management practices were also documented at the packing plant level. Due to the small sample of respondents, results cannot be considered as typical of the situation in place in that sector. But they tend to show that efforts are being made to create conditions to recruit and retain workers. For instance, all respondents said they have a corporate policy handbook or a document containing information on applicable labour practices, an onboarding policy for new employees, a non-discriminatory recruitment policy, a formal prohibition against all forms of abuse and intimidation within the organization, as well as mechanisms for employees to report abuse by a colleague or supervisor (PackerQ2).

Employment benefits, salary, and employment stability are also identified by these companies as factors that help them attract and retain employees in their companies (PackerQ3). In addition, various actions were implemented in the last three years to retain their production employees and supervisors, including offering competitive salaries, faster salary progression, and attractive employee benefits, as well as providing advancement opportunities (PackerQ3). A plan and record of all training (mandatory, job training, team leadership, etc.) are also in place in all four participating facilities. These results are similar to those of a study conducted in 2021 by the *Comité Sectoriel de main-d'oeuvre en transformation alimentaire* (CMOSTA) to update the Quebec industry's profile with respect to labour management (CSMOTA, 2021)[22].

These results are also consistent with what the business representatives said about the level of efforts made to provide competitive working conditions to their employees, as different approaches and practices were said to be in place or being explored to attract and retain employees, including enhancing working conditions (e.g., wages, work schedules, benefits, training). According to informants not directly involved in the sector, packers "are doing what they can to ensure they are offering good working conditions. Things are improving to recruit and retain" (Respondent 17). "The industry is in a better place than before" (Respondent 11).

[22] This study was conducted in Quebec in Spring 2021 and the results are based on an online survey with 102 respondents from various sectors from the processing industry. Results are therefore not specific to the beef packing sector.

When it comes to labour management, it is also critical to account for how the industry accommodates workers from diverse backgrounds, including im/migrant workers. In Canada, temporary foreign workers, along with recent immigrants and refugees, make up 13% of the meat-packing workforce (Food Processing Skills Canada, 2019). All participating packing companies reported hiring immigrants (i.e., people born outside of Canada) and/or temporary foreign workers (PackerQ5).

When asked about the extent to which efforts were made to support their integration, companies strongly agreed that "awareness is raised by the employer to avoid cultural bias" (average of 9.5 on a 1 to 10 evaluation scale) and that "support was received from of an organization specialized in the integration of immigrant workers or TFWs" (average of 10 out of 10) (PackerQ6). Lower and various levels of agreement were measured with respect to other aspects of their integration (e.g., English/French-building activities are offered to workers; internal team-building activities are organized; hiring instructions and training are available in languages other than English or French).

During interviews, company representatives did not consider the integration of im/migrant workers as a particular issue, or risk, but more as a challenge that requires additional efforts.

Quotes from the interviews

"The sector is good at integrating a diverse population into the workforce" (Respondent 15)

"We need to be more attractive to immigrants and temporary foreign workers" (Respondent 1)

"Temporary foreign workers are a must, but they are difficult to recruit due to programs limitations" (Respondent 13)

"We have opportunities globally to bring skilled individuals willing to do that work [at packing plants]. Why [are we] being concerned about immigration? Someone has to do this work; who wants to do that job? It is about sustainability as well." (Respondent 14)

However, recent research about employment conditions of workers in Alberta's meatpacking industry during the COVID-19 pandemic sheds a different light on the situation of im/migrant workers (Bragg, 2021). Based on survey results and interviews with im/migrants and refugee workers in the Alberta meatpacking industry, the research indicates that "Canada's temporary labour migration programs exacerbate the vulnerability facing migrant workers in meat processing" and that "workers who enter Canada through this migration pathway are reluctant to voice concerns about their work conditions due to fear of reprisal and/or job loss." With respect to labour management, the study notes that "some workers reported experiencing extreme stress from their work environment. Sometimes this stress was caused by conditions workers described as abusive. Some participants described abusive supervisors or experiencing bullying and/or harassment at work. Several survey respondents described having requests for bathroom breaks ignored or delayed. Many participants described problems with compensation" (Bragg, 2021).

Such findings would confirm the existence of a **risk to the rights of im/migrant workers** at packing plant level, beyond what was identified in NBSA 2016. These results, which cannot be corroborated given the scope of the study (e.g., no im/migrant workers were questioned or interviewed), should receive further scrutiny by the industry in the future.

At the farm level, im/migrant workers and temporary foreign workers are mostly found in feedlot operations. No particular concerns were expressed during the interviews with respect to their presence on farm. In fact, some interviewees consider im/migrants as a group of individuals who should be part of new models for farm succession (Respondent 9; Respondent 2). The on-farm survey indicates that around 70% of producers who hire workers with diverse backgrounds have received training in diversity management or have been informed about the cultural differences, as well as offer language training to their employees (e.g., English as a second language, ESL classes).

Key observation #3 – Businesses need to consider innovative approaches to deal with workload levels and ensure job satisfaction for the people working in the industry

According to the industry informants who participated in the interviews, there are no unique solution individual businesses can rely on to address the workload issue and its repercussions induced by labour shortage in the Canadian beef industry. However, the interviews presented the opportunity to identify key considerations the industry should account for in mitigating this situation and its consequences.

Specifically, the interviews show that there is a strong and growing recognition within the industry of the importance and value of hired labour.

<u>Quotes from the interviews</u>

"Need to be responsible to the people; they are not [taken] for granted" (Respondent 12)

"If there is no labour, there is no industry; no one can ignore that there is a labour issue, we all need to have all hands on deck. We need to address this issue. Especially at the packer level. […] This is a foundational issue." (Respondent 1)

"We haven't recognized or protected them [i.e., workers] well-enough, especially at the packing level" (Respondent 6)

"There is no room for inappropriate behaviors [with respect to on-farm labour]; it needs to become a 'casual' discussion" (Respondent 3)

"There is a need recognition for the people working in the supply chain. Especially after the pandemic. That sector is hard work. Most people wouldn't stand [it for] long" (Respondent 11)

"People welfare [should be a priority], keeping people in the industry, and demonstrating to them they are important and are treated fairly" (Respondent 13)

"People should be central to your business plan! When you plan things well, there will be a return, including financially. You should spend the same time [i.e., on people] you must spend on other business aspects (e.g., feed management)" (Respondent 17)

Yet, many interviewees also noted that part of the challenge facing the industry with respect to labour management is related to the expectations employers have regarding hired labour. This is particularly the case at the farm level. In fact, dissatisfaction with labour management would come from owner-operators expecting too much from hired labour, as compared to their own involvement in the operation. As some interviewees suggest, this situation also has implications with respect to farm succession.

Quotes from the interviews

"[Producers need to] lose a notch in regards to the expectation of delivery (hours of work, contribution); producers expect employees to work as hard for similar conditions. Producers don't always understand why employees should receive a raise, while they don't. The answer: producers own their operation, and their assets increase in value overtime. Expectations towards farm employees have to be reviewed" (Respondent 10)

"The crucial part about bringing people on board, is managing the culture and communication part. So maybe the hard work isn't that hard… if it is properly explained. You need to make employees understand what they do" (Respondent 16)

"Farm leaders are not trained to manage people. They manage by 'fear'. Under-trained leadership." (Respondent 8)

"There will always be rushes and expectations (owner-operators set the bar high)" (Respondent 2)

"Human resources have always been considered a bit more fluffy. Younger guys will change this" (Respondent 3)

"Producers will say they are doing OK, but it is not always reasonable. Unclear how they threat themselves and family labour" (Respondent 5)

"Why would your kids wouldn't like to stay working on the farm? Because you are not running it as a business" (Respondent 17)

"If there is more innovation, then the kids are more interested in returning and working in this improvement-oriented mindset" (Respondent 9)

As noted above, improved communications between employers and employees needs additional efforts with respect to labour management. For many interviewees, this also includes better communicating the unique opportunities the industry has to offer both at the farm (e.g., rewarding job environments; opportunities to learn and grow, below-average seasonality and variability in hours create a more stable, attractive workplace; the work is less physical than average for jobs in agriculture) and packing plant (e.g., work-life balance, career development opportunities, guaranteed work with competitive benefits) levels.

But other initiatives can also be explored by businesses, including participating in training with respect to labour management. Results from the on-farm survey show that 26% of farms with hired labour have had at least a manager who attended a conference or a training session either online or in person over the past 3 years on the topic of human resources management (Indicator 1.11). This result is relatively low but access to training opportunities also need to be accounted for. As one interviewee noted, "training would benefit farmers and employees, but there are not enough training opportunities for farmers to learn and transfer that knowledge to their employees" (Respondent 16). With respect to packers, all participating companies declared having a structured plan for ongoing employee training (PackerQ15).

Adopting innovations and new technologies can also be an effective way to lower staff requirements. For instance, based on Statistics Canada and FMS data, the CRSB's Interim Progress Report estimated that in 2017, 10% of beef operations had adopted improved technology with lower staff requirements, 7% restructured farm operations to reduce or eliminate certain types of farm functions, and 2% used other methods to manage labour requirements (CRSB, 2020a). At packing plants, automation and other technologies (including artificial intelligence) were also identified by interviewees as ways to improve productivity, create safer work environments, and lower staff requirements (Respondent 13; Respondent 15; Respondent 12). However, significant barriers exist, including the large investments needed. In addition, some technologies may not reduce the number of workers needed, but instead shift the type of skillsets needed and create a more innovative and inviting environment that supports more effective recruitment (Respondent 17).

Innovation can also go beyond the adoption of specific technologies or methods. It can also be a mindset or attitude which can benefit businesses and cattle operations, particularly with respect to labour management.

On one hand, it can help address challenges by considering alternatives approaches[23]. On the other hand, an innovative workplace is more likely to attract and retain employees, particularly younger ones (Respondent 9; Respondent 16). However, industry informants have very polarized views about the attitude beef farmers have towards innovation, some seeing them as very innovative and others as being too little, for various reasons. The way the concept of "innovation" is defined likely plays a key role in how the performance of producers is perceived in this particular domain[24].

2.2.2 People's Health & Safety

Health and safety at work concerns the promotion and maintenance of the highest degree of physical, mental, and social well-being and capabilities of all the individuals involved in business operations, including employees but also producers and the people living on the farm. A safe and healthy workplace can also contribute to the personal and professional development of the people active in the industry. Good labour relations and clear working conditions are also part of a healthy work environment as they contribute to creating a satisfactory working environment.

Rationale: why is this issue a priority when it comes to social sustainability?

The Canadian beef industry offers a range of employment opportunities that pose both risks and rewards related to health and safety. On one hand, workers may benefit from positive health outcomes[25] (Bendixsen, 2020) and reconnect with a sense of "place and purpose" (Brymer et al., 2020, p. 12). Opportunities for the undereducated and inexperienced allow diverse workers to participate meaningfully in society or to jumpstart a personal career. On the other hand, hazards exist in some roles along the value chain, presenting the potential for serious adverse outcomes from injury, disease, or death[26]. Both risk and reward present implications for well-being, a central principle of sustainable development goals. The focus of this deep dive into people's health and safety is the potential social impacts to human health from workplace hazards in the Canadian beef industry, and the health and safety practices through which serious adverse outcomes may be prevented.

- Health and safety are basic legal protections for employed and self-employed workers (*see* Section Baseline), but the Canadian beef industry faces unique challenges regarding people's health and safety in the workplace. These challenges include serious but manageable hazards, heavy workloads (*see*

---

[23] As one interviewee mentioned: "Common schedule is 11 days on, 2/3 days off. 11 days are a lot. Why not changing that? Having full-time positions; why not part-time / seasonal positions? There are different ways to access labour pools" (Respondent 16)

[24] For instance, VPB+ documents what innovations and technologies producers have implemented on their operations. Data show that 75% of certified producers answered they are aware of areas within the operation that improvements can be made, have implemented innovation measures, and plan to do so in the future. Only 13% of certified producers answered they have a written plan with timetable of implementation of a series of innovations, reviewed and analysed innovations that have been implemented (VBP+, 2022).

[25] Benefits include the formation of strong family supports through shared tasks, enhanced cognitive ability and lower levels of anxiety through working outside, and reductions in inflammatory disorders, allergies, and asthma (Bendixsen, 2020).

[26] Hazards are well documented and include diseases and disorders, dangerous materials handling, ergonomic hazards from standing or sitting long hours (ISO, 2010) repetitive work tasks, noise, high or low temperatures (AWCBC, 2022), heavy machinery, falls, asphyxiation (CASA CAIR, 2016), working at fast paces, with sharp tools, underreporting of incidents, and the unpredictability of working with sentient animals (Richardson, 2021). In agriculture, mechanical and livestock-related injuries are the most common mechanisms of fatal injury (CASA CAIR, 2016; FCC Market Insights, 2020). In the manufacturing, processing and packaging sector in Alberta, where three quarters of beef cattle in Canada are processed, sprains, strains, tears, and wounds are common sources of injury, with disease and workplace incidents the leading cause of fatality in the sector in 2019 (latest) (Government of Alberta, 2021a). Research has suggested a psychological toll associated with the slaughter of animals (Richardson, 2021). Psychological hazards for farmers include stress from unpredictable weather, animal disease, economic pressure, overwork, burden of bureaucracy, media criticism, and social isolation (Jones-Bitton et al., 2019), conflicts with family, and farm transition planning (FMC & Wilton Consulting Group, 2020).

Section 2.2.1 Labour Management), and a workforce and periphery that include vulnerable groups that regulations may not protect. Given these challenges, a socially responsible approach to health and safety can help fill in the gaps. From the ISO 26000 social responsibility perspective, workplace health and safety:

> "Concerns the promotion and maintenance of the highest degree of physical, mental and social well-being of workers and prevention of harm to health caused by working conditions. It also relates to the protection of workers from risks to health and the adaptation of the occupational environment to the physiological and psychological needs of workers" (ISO, 2010, p. 38).

In Canada, employers and employees both have roles in effective health and safety.

Farm and processing employees engaged in scoping this assessment indicated that *training for safe work* and *safe cattle handling practices that minimize stress and physical harm from stress or injury* were issues that mattered most for beef industry sustainability (*see* Appendix C.1). This spotlight from stakeholders, combined with the knowledge that the physically challenging and risky occupations that exist within the industry confirms particular attention needs to be paid to people's health and safety.

Furthermore, the industry employs or operates in proximity to vulnerable groups, including people over 60, im/migrants, minorities, and children. Farmers over the age of 60 experience higher proportions of agriculture-related fatalities (CASA CAIR, 2020). As the average age of the farmer has increased to 57 years of age over the last two decades, the potential for fatalities from work-related injuries could increase. Temporary foreign workers and or im/migrants may lack access to information, face language barriers, can be isolated, or face constraints exercising basic workplace rights under the bureaucracy of immigration (Cedillo et al., 2019). Women are likely to report higher stress levels, but are also more likely to take action than men (FMC & Wilton Consulting Group, 2020), with men comprising the majority of injuries and fatalities over the last five years (CASA CAIR, 2016)[27]. Youth on farms are vulnerable as well, primarily from proximity to impacts with heavy machinery (Drozdowski, 2021). The fatality rate for children on farms over the 26-year period between 1990 and 2015, has remained relatively constant with a slight increase of 0.2% per year (CASA CAIR, 2020). Most of these fatalities were children under the age of 5 years old.

In practical terms, an effective health and safety protocol starts with hazard awareness that translates into actions and maintenance, leading to fewer accidents, injuries, and fatalities. Socially responsible practices include, but are not limited to, the following (CCOHS, 2022a, 2022c; ISO, 2010):

- Hazard identification
- Controls (elimination, substitution, engineered controls, administrative controls, personal protective equipment)
- Recognizing the needs of a diverse workforce
- Training
- Monitoring
- Adaptations
- Accountability
- Communication

[27] The latest Census of agriculture survey found that in 2021, 79 795 women counted themselves as female farm operators, which represents 30.4% of total farm operators (Statistics Canada, 2021d).

Many of these practices were considered in the practice-based assessment, both at the farm and processor's levels (*see* Table 2-18). Indicators for these themes are provided in Appendix F.

Table 2-18: People's Health and Safety Related Themes

Related themes	Processors	Farms
Awareness	√	√
Risk Assessments and follow-up actions		√
Safety prevention information sessions or training, preparation	√	√
Job/site specific health and safety training (e.g., livestock handling)	√	√
First aid	√	√
Emergency responses		√
Personal Protective Equipment (PPE)	√	√
Stress factors		√
Levels of disturbing stress		√
Fatigue management		√
Covid management	√	√
Communication		√
Environmental controls (e.g., noise, air filtration)	√	

IMPACT PATHWAYS

Evidence of stressors and potential impacts along the beef value chain are defined by stakeholders and the sustainability literature. In some cases, the interrelations are known and have been characterized scientifically by recent studies. In other cases, the interrelations are theoretical possibilities that have not yet been characterized through an examination of cause and effect. The impact pathways section takes a first step toward gathering the breadth of potential stressors and potential impacts together to highlight the potential for social consequences (good or bad) in the context of agriculture. The current state of knowledge about how stressors may interrelate or manifest in mid-point or endpoint impacts varies. The pathway analysis section below will show that as it describes these interrelations as complex and multi-directional. Furthermore, the interrelations are not always predictable, or uniform, because they are defined by relationships between people within an organization or between organizations within the value chain. The aim of impact pathway section is to provide the reader with an awareness of the potential for impact pathways to activate along the beef value chain.

Pathway 2.1. Health and safety awareness and motivations affect workplace safety practices on farms

When awareness is met by a motivation to learn it can be translated into practice (Gooch, 2012). Knowledge is awareness, and motivation is commonly understood as a complex set of physical and mental processes that explain behaviour. Many theories exist to explain motivation (Cook & Artino, 2016), and there are many ways to motivate people. People can be motivated by tangibles, like remuneration, or intangibles, like praise or punishment (Johnson & Lascano, 2014). A lack of awareness or a lack of motivation can affect the existence or quality of a practice or behaviour.

Recent findings suggest that Canadian farmers are positively motivated to improve safety, but those motivations are not necessarily reflected in safety behaviours (FCC Market Insights, 2020), highlighting a potential barrier along the pathway to best practice on farm. Awareness could be one reason, but ability could be another. Time and cost have recently been perceived as predominant barriers to health and safety practices on farms, and are perceived as larger constraints by younger farmers than older ones (FCC Market Insights, 2020). Many safety practices, however, require very little investment, but rather a slight change in habit. 'Old habits' were cited as another predominant barrier, pointing to a potential motivation issue, *for some*. Nearly one-quarter (24%) of agricultural producers who reported having had an injury or close call within the last year, were "more likely to see health and safety risks and less likely to think the work on their operations was done safely... despite this, they are less motivated to improve safety on their operation than producers who have not had an incident, and not any more likely to have accessed safety information or to have a safety plan in place" (FCC Market Insights, 2020). Motivation is a social and mental process influenced by an individual's physical and mental health, mindset, and surrounding social environment (Cook & Artino, 2016). These influences may present key drivers to expanding a culture of safety in the industry.

Pathway 2.2. Stress factors can affect decision-making and lead to accidents or perpetuate safety risk for people, animals, and society.

"High stress among farmers is associated with increased risk of farm injury" (Jones-Bitton et al., 2019) with stressed individuals suffering a reduced "ability to focus and make decisions, and this can cause accidents on farms," especially during periods with high workloads (FMC & Wilton Consulting Group, 2020). Stress among farmers is high and increasing. In 2021, a follow-up survey of Canadian farmers declared "the mental health of farmers in Canada is worse than it was five years ago," with moderate to severe anxiety 15% higher than the normal population and moderate to severe depressive disorder 26% higher than the normal population (Jones-Bitton et al., 2022). At the time of the initial survey, 40% of farmers were uneasy seeking professional help, which may help explain the decline in mental health over time (FCC, 2020). High levels of stress can affect individual well-being in many ways and most severely in the tragic case of suicide. "On farms and ranches across the country, struggles are taking their toll, leading to anxiety, depression, post-traumatic disorder, and even suicide" (CCOHS, 2019). Social well-being may be impacted in the tragic case of preventable accidents involving vulnerable groups. Furthermore, "high stress and strains on mental health have been found to impact farm animal welfare (FMC & Wilton Consulting Group, 2020).

Regarding workers at processing plants, there is evidence of a psychological toll associated with being a processing plant worker in the meat industry with reverberating effects to animals and society (Richardson, 2021). There is a recognition, however, that the literature lacks rigour for "meaningful assertions regarding the underlying mechanisms that facilitate poor mental health outcomes for the [processing plant] workers" (Slade & Alleyne, 2021), especially for Canada, identifying opportunities for research. For more information on animal welfare, *see* Section 2.2.3. While these pathways can lead to severe adverse outcomes, mitigating stressors and mid-point impacts (e.g., awareness and motivation, and stress factors like high workloads, working in isolation) as well as having safe work protocols and practices may result in fewer serious, fatal, and fatigue-related injuries. Indeed, consistent health and safety practices and protocols can play an important role to support safe-work when decision-making or focus is under stress. Figure 2-31 attempts to visually summarize this social issue through a pathways approach.

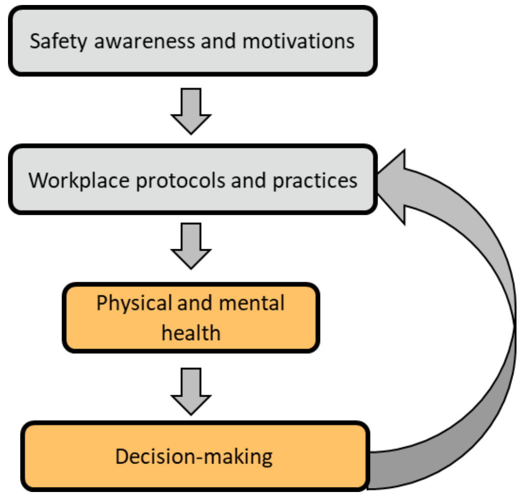


Figure 2-31: Potential pathways of effect in agricultural health and safety.

The arrows represent the potential for single-or multi-directional pathways or linkages as described in the literature. The grey fill indicates the stressor following a pathway. White boxes represent the mid-point affects and orange boxes represent the potential beneficial or adverse outcomes from the stressor.

BASELINE: WHAT WERE THE DOCUMENTED HOTSPOTS IN 2013/14 AND WHAT HAS THE INDUSTRY ACCOMPLISHED SINCE THEN?

In Canada, health and safety legislation has been enacted in the federal jurisdiction and in every province and territory. Three primary rights are conferred through this legislation on employees. First, employees have the right to participate in health and safety decisions at their workplace. Second, employees have the right to refuse work without penalty if they have an honest and reasonable belief that the work is hazardous. Finally, employees have the right to be informed of health and safety hazards in the workplace (Cedillo et al., 2019; quoted in Richardson, 2021).

Practically, this means that workers in Canada are entitled to basic rights, including the right to be informed of any foreseeable health or safety risks in the workplace, as well as to have access to the necessary training, protective equipment, and supervision to perform their work safely. In turn, workers are responsible for collaborating with their employers to identify and eliminate hazards and adopt the safety practices prescribed by legislation and implemented in their workplace (CRSC, 2020c).

Even though employees are entitled to a safe workplace in Canada, owner operators as well as farm workers may be excluded from parts of occupational health and safety legislation. For example, in some provinces, employers are not required to provide workers' compensation to agricultural workers who are injured at work but may elect to do so[28]. Temporary or seasonal agricultural workers from outside Canada are eligible for workers' compensation on the same basis as Canadian farm workers.

[28] For instance, in Saskatchewan, *The Occupational Health and Safety Regulations, 1996* (Government of Saskatchewan, 1996) requires the training of all hired workers. It requires training when a worker begins work at a place of employment or is moved from one work activity or worksite to another that differs with respect to hazards, facilities, or procedures. In Quebec, employees are entitled to training, information and counselling services in matters of occupational health and safety, especially in relation to his work and his work environment, and to receive appropriate instruction, training and supervision under the *Act Respecting Occupational Health and Safety* (Government of Quebec, 2022). In Manitoba, under the *Workplace Safety And Health Act* every employer shall provide to all his workers such information, instruction, training, supervision and facilities to ensure, so far as is reasonably practicable, the safety, health and welfare at work of all his workers (Government of Manitoba, 2022).

Given this legislative background, the NBSA 2016 showed low to very low risks based on the survey results of farm owners and packers (CRSB, 2016a)[29]. However, the assessment also noted that these risks could be underestimated considering that the agricultural sector is the fourth most dangerous industry in which to work in Canada and that meat-packing plant activities and equipment present diverse potential hazards for workers (Grant, 2017).

For this reason, the Canadian Beef Advisors have established a people health and safety goal for 2030 as part of the National Beef Strategy (CRSB, 2016b). Specifically, three goals have been set with respect to OHS, namely to (1) create a culture of safety across the beef supply chain; (2) reduce serious, fatal, and fatigue-related incidents by 1.5% per year; and (3) support education, awareness, and improvements in farm and ranch safety (CRSB, 2021b).

The baseline was established according to data provided by the Canadian Agricultural Injury Reporting (CAIR) program for the period going from 1990 to 2012 (CASA CAIR, 2016; CRSB, 2021c). More recent data is not available at the national level to determine if, and the extent to which, a decrease in the number of incidents can be observed on Canadian beef farms. However, efforts are being made by the industry in collaboration with various organizations, including provincial agricultural safety boards, the Canadian Agricultural Safety Association (CASA), and provincial agricultural safety groups to provide training and resources to farmers[30].

The COVID-19 pandemic had a significant impact on the Canadian meat-packing industry and exacerbated existing occupational hazards (Richardson, 2021)[31]. Different factors were identified for explaining this situation[32], and some are specific to the sector's activities. For instance, the work environment in packing plants typically involves standing elbow-to-elbow in an assembly line type of work, which facilitates transmission from worker to worker. In addition, packing plants are typically located in rural communities where carpooling is commonly used by workers to get to work, a factor also increasing the risk of transmission. On the other hand, packing plants operate in a system which incentivizes companies to operate at as high a capacity as possible. In this context, adjustments were made to try to prevent additional COVID-19 outbreaks (e.g., introduction of safety screens, barriers, physical-distancing protocols, restrictions on carpooling, and other measures), but consideration was also given to limit the impact on the line speed and capacity utilization (Rude, 2021)[33]. As noted by Bragg (Bragg, 2021), this situation has particularly impacted racialized, immigrant, migrant, and refugee workers who make up a significant proportion of the workforce in the meat-packing industry in Alberta[34].

---

[29] The social assessment also revealed a hotspot with respect to OHS at the upstream value chain actors' level (e.g., seeds, grains, fertilizers, feed, salt, and mineral). This hotspot was based on secondary data measured at the national level and compared to the sectorial rate of injuries (per 100,000 workers employed in 2008) to the country average rate of injury (in 2008). This part of the value chain is outside the scope of this assessment, which focuses on beef production and processing activities taking place in Canada.

[30] There are provincial sources which list injuries, illnesses, and traumas that occur within the agricultural sector (although they are not specific to beef) and they also provide preventative measures to mitigate such incidents (Government of Alberta, 2021b; INSPQ, 2022; Saskatchewan Workers' Compensation Board, n.d.; WorkSafeBC, n.d.).

[31] One of the largest recorded COVID-19 outbreaks in North America occurred at Cargill Foods' beef processing plant in High River, Alberta.

[32] See Foster and Barnetson for an analysis of the outbreaks that took place in two meat-packing plants in southern Alberta. They identify three key reasons why these outbreaks happened. All of them point to the specific role (and shortcomings) of the Alberta's occupational health and safety (OHS) system (Foster & Barnetson, 2020).

[33] In her analysis of how production line of speeds in Canadian meat and poultry processing facilities impact on worker safety and animal welfare, Richardson concludes that "The reality is that livestock, workers, and meat products all interact along the assembly line and are impacted by its speed. It is imperative to take seriously the interconnectedness among all three and the social impacts of the acceleration of production on the well-being of humans and the welfare of animals that meet on the kill floor." (Richardson, 2021).

[34] In her report, Bragg notes that "While COVID-19 represents an extreme example of the risks im/migrant and refugee workers face in the meatpacking industry, workers report conditions characterized by high levels of risk, high probability of injury, difficulty navigating support and fear of reprisal and/or job loss." (Bragg, 2021).

The COVID-19 pandemic also amplified the level of stress facing everyone working within the industry. Mental health-related stressors represent a growing area of concern in the agri-food industry. At the farm level, recent publications examined the prevalence of anxiety and depression among Canadian farmers and documented poor mental health among farmers, which can result in an increase in suicide in rural and farming communities (Hagen et al., 2021; Jones-Bitton et al., 2019). Similar concerns have been documented at the meat-packing industry level as well[35].

RESULTS: WHAT IS THE CURRENT SITUATION OF THE INDUSTRY WITH RESPECT TO THIS SOCIAL ISSUE?

Results from the assessment led to two key observations regarding the Canadian beef industry's situation with respect to people's health and safety. Evidence supporting each of these key observations are provided below.

Table 2-19: Key observations

Key observation #1 Room for improvement remains with respect to the adoption of practices to prevent incidents, particularly on farms.	
Documented strengths	There is a high degree of awareness and preparation with respect to people's health and safety in Canadian beef packing plants and on farm according to packers and producers
Documented risks	The adoption rate of many people's health and safety practices remain low on Canadian beef farms, including on those with hired labour. Particular focus is needed with respect to training and the use of personal protective equipment (PPE) Given the physical and mental strains of working in packing plants, the occupational health and safety (OHS) programs are all the more important and a high priority, especially for at-risk populations
Key observation #2 Producers experience disturbing stress as a result of their on-farm occupation even though most farmers adopt practices to manage their physical and mental fatigue.	
Documented strengths	Mental health is less of a taboo in the sector than in past years and more resources are available to support farmers The vast majority of producers reported following one or more practices to manage physical and mental fatigue
Documented risks	About half of participating producers indicated that they feel, to a large degree, a disturbing amount of stress resulting in physiological changes such as sleep loss, changes in appetite, body/headaches, etc. due to their on-farm occupation.

Key observation #1 – Room for improvement remains with respect to the adoption of practices to prevent incidents, particularly on farms.

Producers and workers are responsible for knowing and applying best farm safety management practices and for ensuring the safety of everyone who lives or works on the farm. The creation of safe and healthy workplaces

[35] In her report, Richardson notes that "Research demonstrates the psychological toll of slaughtering animals, including studies that connect this employment to increased rates of domestic violence, substance abuse, and post-traumatic stress disorder." (Richardson, 2021). See Khara (Khara, 2020) for a detailed overview of some of the physical, but also psychological hazards slaughterhouse employees are facing.

can help avoid incidents that can negatively impact people directly involved in production activities (e.g., hired employees, farmers), but also those living on farms (e.g., family members).

Occupational health and safety (OHS) typically comprises procedures and programs that ensure the operation is a safe and healthy place to work. This entails minimizing workplace injuries and illnesses through information and training, and the adoption of best practices by farmers, managers, employees and everyone else living on the farm (AgriShield, n.d.).

The on-farm survey was the opportunity to document different practices used by farmers to prevent, minimize, or mitigate the consequences of work injuries. Questions were asked to all farmers, irrespective of the presence of hired labour on farms.

Overall, participating producers consider that there is a high degree of awareness and preparation with respect to OHS on their farm (Indicator 2.7). Specifically, about 75% of respondents strongly or fully agree that (1) everyone working and/or living on the farm are knowledgeable about the health and safety risks associated with their job function or presence on the farm in a way that can be easily understood; (2) efforts are undertaken to address high-risk areas on the farm after accidents occur; (3) efforts are undertaken to look for and address high-risk areas on the farm before accidents occur; (4) that everyone working and/or living on the farm understands the safety procedures in place; and (5) workers (either paid and/or non-paid, e.g., family) are trained and prepared to safely complete their tasks. In other words, only about 25% of producers consider that increased awareness and preparation is required to some degree. This result is consistent with recent findings from the FCC Ag Safety Study (FCC Market Insights, 2020).

As with the other outcome-based indicators from the survey, this result is based on a self-assessment from the farm owner's standpoint. Consequently, this result does not fully capture the situation taking place on the farm or being experienced by the impacted individuals. Still, on-farm safety was not found to be a top concern from the key informants who were interviewed as part of this assessment. When asked about the key risks facing the industry or questioned about its performance with respect to labour (including OHS), only few mentioned the topic. In fact, two interviewees listed OHS as an example of an area where efforts have been made and for which improvements could be seen (Respondent 2; Respondent 5), whereas two others noted that "safety issues [are] overlooked" (Respondent 10; Respondent 16) due to the lack of training and the "colourful" profile of some of the individuals working on farms who tend to "push people around to get the job done" (Respondent 16).

While very few comments were explicitly made with respect to OHS during the interviews, it is not to say this topic was not perceived by the interviewees as being of significance for beef producers. In fact, ensuring on-farm safety was an implicit expectation or basic requirement for most informants when talking about people and sustainability in general. As discussed in Section 2.2.1 on Labour Management section, other more pressing people-related risks captured the attention of key informants during the interviews.

In the absence of recent data on the work incident rate, it is not possible to determine whether OHS-related risks are effectively addressed on Canadian beef farms. However, results from the on-farm survey show that the adoption rate of many OHS practices remain low on Canadian beef farms, including on those with hired labour.

Specifically, only 32% of respondents said that a health and safety risk assessment covering all activities on the farm site have been carried out over the last 5 years and that measures have subsequently been taken to reduce the risk of injuries. About half of the producers who have not completed such assessment have hired employees on their farm (Indicator 2.1). Similarly, only 42% of respondents indicated that at least one person on the operation (including owners) participated in health and safety prevention activities, information sessions or training (on-site or off-site) in the past 3 years. About of third of those who haven't hired labour on their farm (Indicator 2.2).

This proportion is lower when it comes to health and safety training: only 26% of participating producers declared that everyone working on the farm (including owners) participates in health and safety training (on-site or off-site) on a regular basis or prior to new work activities for the job tasks that apply to them (e.g., cattle handling, farming, feeding). Again, hired labour can be found on half of the farms where no training is provided (Indicator 2.3). Yet, training of new employees is a good business practice and an important area of risk management on any farm (Government of Alberta, 2018). In Canada all employees are also entitled to basic occupational health and safety rights, including to be informed of any foreseeable health or safety risks in the workplace, as well as to have access to the necessary training and supervision to perform their work safely. Therefore, **the documented performance at the farm level could be considered a risk for which improvements would be needed**.

Uptake is slightly higher with respect to first aid, with 43% of farmers saying at least one person on the farm (including owners) holds a valid and up-to-date first aid certificate (Indicator 2.4). All Canadian jurisdictions have a requirement for the workplace to provide at least some level of first aid. The type of first aid equipment and training required depends on the number of employees, the types of hazards present in the workplace, the travel distance to a hospital/availability of professional medical assistance (CCOHS, 2022b)[36].

In preparation for an emergency situation, all employees should receive and understand clear emergency procedures and instructions. When asked if, in case of an accident, producers have a well-defined procedure (or protocol) known by everyone (all employees and farm owners), 70% of producers answered 'Yes' (Indicator 2.5). However, only 26% have this procedure in a written form, the others (44%) communicating it verbally. The proportion of farms with written procedures in place is higher with the presence of hired labour (46%). Still, about 30% of producers declared not having such procedure in place. This result goes down to 19% on farms with hired labour.

A potential risk also exists with respect to the use of personal protective equipment (PPE). Working on a beef farm can involve different hazards. For that reason, it is important to minimize the risks of incidents and provide PPE when necessary. However, only 43% of respondents declared that the proper PPE is freely provided to everyone working on the farm, 36% that PPE is maintained regularly, and 22% that they enforce the use of PPE. Overall, 91% of producers declared one or more of these three practices are not met (Indicator 2.6).

Each piece of PPE has a specific use depending on the work environment, the work conditions, and the activity being performed. The survey did not specifically question producers on the context in which particular PPE is used (or not)[37]. Consequently, results may not fully capture the situation on the farm when it comes to the daily use of PPE by farmers and their employees. That said, in Canada, employers are responsible for selecting, providing (to everyone, including owners, employees, family members, visitors) and fitting of appropriate PPE for the hazardous exposures in the workplace. Employers are also responsible for providing and enforcing the use of personal protective equipment in the workplace[38]. Given this, **the use of PPE should be considered a risk at the farm level and an area where improvements should be made**.

---

[36] For example, in Saskatchewan, first aid kit requirements are outlined in *The Occupational Health and Safety Regulations, 1996* and farmers must also provide orientation to the location of first aid supplies to farm workers (i.e. hired labour) (Government of Saskatchewan, 1996).

[37] In comparison, the survey conducted in 2017 by the CRSC among Canadian grain producers asked specifically about the use of PPE in the context of handling crop protection products. Result showed that 79% of respondents always or usually provide PPE for handling crop protection products (CRSC, 2020c).Result showed that 79% of respondents always or usually provide PPE for handling crop protection products (CRSC, 2020c).

[38] For instance, in Quebec, the *Act Respecting Occupational Health and Safety* and Regulation respecting occupational health and safety require employers to supply safety equipment and see that it is kept in good condition, as well as to provide the worker, free of charge, with all the individual protective health and safety devices or equipment and require that the worker use these devices and

These results from the on-farm survey on the adoption of health and safety practices contrast with those at packing plants. All four participating facilities declared having implemented typical health and safety measures, including the establishment of a Joint Occupational Health and Safety Committee, the development of internal health and safety regulations and policies, the conduct of site inspections (by an internal OHS official or other), the implementation of prevention programs (including machine maintenance), of procedures for work-related accidents, and of accident investigation and analysis (by an internal OHS officer or other), as well as performing job rotation and ensuring the use of PPE (PackerQ9). Similar results are found with respect to health and safety training. Over the last two years, all four participating facilities declared having trained their production employees on first aid, forklift operator, WHMIS (Workplace Hazardous Materials Information System), and lockout procedures (PackerQ10). Such results are to be expected as many of these practices are required by regulations or are otherwise common practice for this type and size of operation.

All participating packing plants also declared that measures to improve the physical work environment (noise and odour reduction, temperature control, air filtration, etc.) have been implemented (PackerQ11). In fact, as for farmers, OHS was not identified as a key risk area for packers; when asked how they would rate their company's health and safety practices, an average score of 8.7 was estimated on a 1 to 10 evaluation scale (1 being "much work remains to be done" and 10 being "the situation is exemplary") (PackerQ12). All of them also considered themselves "very satisfied" with respect to the adjustments made at the plant as an employer in the overall context of the COVID-19 pandemic (PackerQ13). Such result contrasts with the evidence of health and safety issues documented at packing plants with respect to how the COVID-19 pandemic was managed (cf. above). Diverging views and perceptions remain on this matter, even between key informants interviewed as part of this assessment[39].

Key observation #2 – Producers experience disturbing stress as a result of their on-farm occupation even though most farmers adopt practices to manage their physical and mental fatigue

Farming can be a very tiring and stressful occupation. Stress and fatigue can cloud judgment and can result in on-farm accidents. As also discussed in Section 2.2.1 on Labour Management, many Canadian beef farmers reported that negative work-related outcomes (e.g., absenteeism, stress injuries, physical injuries, stress leave) frequently occur on the farm as a direct result of working too much (Indicator 1.10).

The on-farm survey was also the opportunity to question farmers about the level of stress they are experiencing as part of their occupation.

One key result is that over 75% of producers who completed the survey indicated that they feel to some degree disturbing stress, resulting in physiological changes such as sleep loss, changes in appetite, body/headaches,

equipment in the course of work. The regulation also requires the worker to wear or use, as the case may be, the individual or collective protective means and equipment required under the Regulation (Government of Quebec, 2022). According to the *Occupational Health and Safety Act* in Ontario, an employer shall provide the equipment, materials and protective devices as prescribed, ensure they are maintained in good condition and ensure they are used as prescribed (Government of Ontario, 2022). In Manitoba, under *Workplace Safety and Health Regulation* employers must ensure that workers who may be exposed to any remaining uncontrolled risk use personal protective equipment that meets the requirements. Employers must also provide a worker, at no cost, the equipment appropriate for the risks associated with the workplace and the work. They must also ensure that a worker wears and uses personal protective equipment when required and in the event of an emergency in the workplace, including a spill or discharge of a hazardous substance (Government of Manitoba, 2022). *The Saskatchewan Employment Act* covers the health and safety of both farmers and farm employees. Under the Act, a farmer or farm operator who employs farm employees must supply personal protective equipment (PPE) and instruct the worker about the requirement to wear PPE and how to correctly use and maintain it (Government of Saskatchewan, 2013).

[39] Some mentioned that external factors (e.g., carpooling) explain, for the most part, the outbreaks (Respondent 17; Respondent 13), while others consider that poor response and performance at packing plants are the key reasons for this situation (Respondent 15). That said, all agree that public perception of the sector suffered from this situation.

etc. because of their on-farm occupation (*see* Figure 2-32). In fact, 47% of respondents said they experience such situations to a large extent (Indicator 2.9).

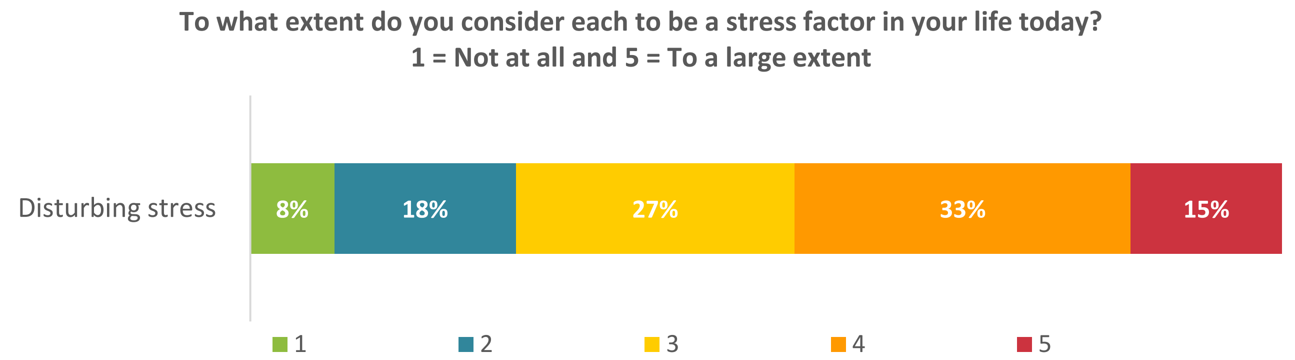


Figure 2-32: Disturbing stress.

The survey was meant to question farmers about the extent to which producers consider different stressors to be a stress factor in their life today (Figure 2-33). Results show that workload pressures from the beef operation, financial pressures from the beef operation (e.g., cashflow, debt repayment), the unpredictability of the agriculture industry (e.g., weather, market prices), as well as public trust in Canadian agricultural production are among the stressors affecting farmers the most overall (Indicator 2.8). The results are consistent with those of recent research projects on workplace stressors in the agri-food sector.

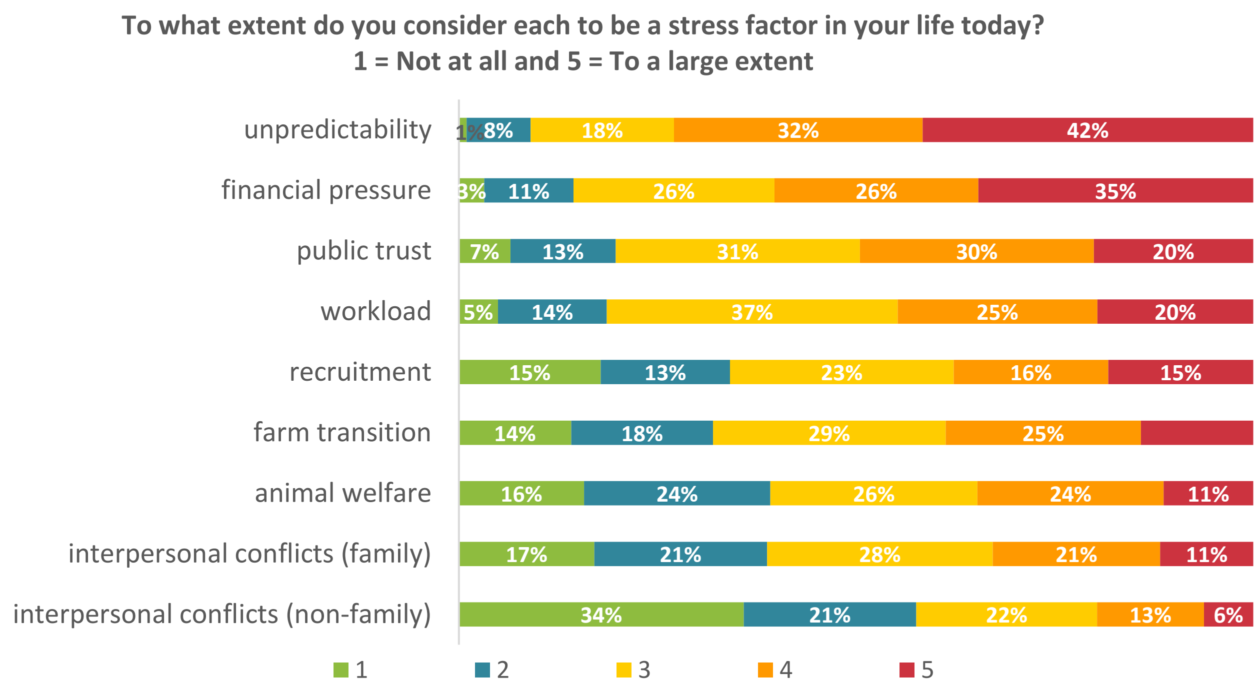


Figure 2-33: Stress factor.

On a more positive note, the vast majority of producers (96%) reported following one or more practices to manage physical and mental fatigue and over 60% are using three or more (Indicator 2.10). Specifically, about half of respondents declared that they adopt a healthy diet and exercise regularly (52%), schedule time for family (51%) or take time to talk about the causes of stress, especially to family and friends (46%). A slightly lower proportion said they limit alcohol consumption and avoid drug use (42%). About a third indicated they get physical therapy when needed (35%), take time off and holidays whenever possible (35%), schedule regular medical check-ups and health assessments (32%), or establish personal goals such as a bucket list (30%). In addition, 15% said they seek external resources (e.g., Farmer Specific Crisis Lines, Sentinel Program; In the Know, counselors, mediators, pastors, etc.) when needed. However, these are measures already taken by farmers who are nonetheless experiencing disturbing stress resulting in physiological consequences. Consequently, additional or alternative measures may be needed to prevent, mitigate, or cope with the different stress factors farmers are facing.

A few interviewees referred to mental health as an area of concern, for which efforts have been made at the production level in collaboration with provincial organizations (Respondent 3; Respondent 2; Respondent 5). The Beef Farmers of Ontario's dedicated webpage on the theme of "wellness" was identified as exemplifying that mental health was now less of a taboo among producers in general and the younger ones in particular (Beef Farmers of Ontario, n.d.).

The topic of mental health was not documented with the same level of detail at the packing plant level or discussed as such by interviewees when talking about the sector's risks and performance with respect to people's health and safety. That said, all three processors indicated in the survey that training on mental health was provided to their production employees (PackerQ10). They also noted that the COVID-19 pandemic had a significant impact on the work environment and their employees' mental health and anxiety levels (an average score of 8.3 on a 1 to 10 evaluation scale) (PackerQ13).

2.2.3 ANIMAL CARE

Animal care concerns animal health and welfare through activities that humans undertake as part of the beef supply chain. It is about providing for the physical and mental well-being of animals (cf. the Five Freedoms[40]), and meeting or exceeding consumer expectations.

RATIONALE: WHY IS THIS ISSUE A PRIORITY WHEN IT COMES TO SOCIAL SUSTAINABILITY?

Animal care concerns the treatment an animal receives whereas animal welfare refers to the scientifically assessed state an animal is in, with respect to health, comfort, nutrition, safety, behaviour, and mental states of fear, pain and distress (CAST, 2018; Thompson, 2015). Animal care is a human practice that affects animal welfare (Zulkifli, 2013), with the possibility of affecting other aspects of society both positively and negatively. The human-animal relationship makes animal welfare a common component of social sustainability research (Arvidsson Segerkvist et al., 2021). With mounting evidence that "human and animal welfare are connected," Gosnell et al. (2021, p. 19) urge industry sustainability frameworks to "better attend to human welfare alongside animal welfare" (2021, p. 19) and to consider both human and animal welfare in relation to one another (Gosnell et al., 2021, p. 18). The focus of this deep dive is how animal care practices may impact animal welfare and social sustainability, namely human health, and healthy, sustainable workplaces, and communities.

Assessing animal care is a multifaceted approach involving a measured assessment of animal welfare toward risks of good or harm, followed by ethical judgement (Broom 1991 p. 4168 in Bock & Buller, 2013) toward "what level of risk is acceptable" (CAST, 2018, p. 6). Acceptable risk, or 'good' welfare, and who is responsible for it, has been a moving target through history and changes as human values shift over time (Bassi et al., 2019; Bock & Buller, 2013; CAST, 2018; Fraser, 1995, 2008; Rushen, 2003). These shifts direct animal welfare research and innovation to define measures based on what can and should be assessed (Lund 2006 in Bassi et al., 2019; Bock & Buller, 2013). Due to this process, "tension" between practice and ethics (CAST, 2018) is "endlessly

[40] The Five Freedoms is one of the original animal welfare concepts and includes freedom from malnutrition, discomfort, disease, fear or distress, and freedom to express normal behaviour (American Humane, 2016). It is the term used in the various documents consulted and in the report, but the more modern animal welfare concept is now called the Five Domains. It includes nutrition, environment, health, behavior, and mental state (World Animal Protection, 2021).

evolving" (Bassi et al., 2019, p. 337). During the scoping phase of this assessment, stakeholders prioritized animal welfare for the purpose of enriching animal lives while recognizing the benefits of productivity as important for beef industry sustainability (*see* Appendix C.1). For these reasons, animal care merits particular attention as an area of focus in this assessment.

Today's standards suggest that animal care should produce a good quality of life for the animal, at or beyond a legal standard, in which all vital needs and most wants of the animal are met (Moya, 2020). Animal care involves eliminating or mitigating negative states, like stress, and encouraging positive states like key natural behaviours (CAST, 2018, p. 3). The Five Freedoms, though with their own limitations (Bassi et al., 2019; Mellor, 2016), are an internationally recognized set of principles used in most audits globally to account for good animal welfare. The Five Freedoms include freedom from malnutrition, discomfort, disease, fear or distress, and freedom to express normal behaviour (American Humane, 2016). The Domains apply to live animals found throughout the Canadian beef supply chain, including on farms, during transport, at auction, and prior to slaughter at processing plants. The principles underscoring the Five Freedoms are transformed into practice through the *Code of Practice for the Care and Handling of Beef Cattle* (2013), i.e., the Beef Code.

The Beef Code provides guidelines for nutrition, housing, husbandry, and euthanasia practices and is used as the standard to evaluate sustainable animal care practices in this assessment. The Beef Code is a written best practice document based on science, transparency, stakeholder engagement, continuous improvement, clarity, and practicality. The Beef Code provides significant focus on preventative care practices. Practices assessed here include those listed in the Table 2-20.

Table 2-20: Animal Care Assessed Related Themes

Related themes	Processors	Farms
Health Assessments		√
Herd Health Status		√
Health of Newly Arrive Cattle		√
Record-keeping		√
Protocol for Needle Injections		√
Herd's Nutritional Status		√
Code of Practice		√
Animal Transportation	√	√
Pain Control Technique for Particular Procedures	√	√
Typical Pain Control Method Used	√	√
Weaning Strategy		√
Training on Animal Handling	√	√
Attendance to Training or Conference		√
Animal Care Innovation		√
Euthanasia		√
Health Problem Assessment		√
Handling Techniques		√
Extreme Temperature		√

Practice selection also aligns with CRSB Sustainability Indicators for Animal Health and Welfare (CRSB, 2020b, 2020c). Not all animal care practices have been assessed as part of this study, but the assessment does investigate known risks in Canada (NBSA 2016; *see* Appendix C.1) and the United States, including handling, transport, and pain management (CAST, 2018). Non-therapeutic antimicrobial use (and ionophore use) are also "hot-button" animal care practices concerned with providing freedom from disease and discomfort (CAST, 2018, p. 5) (*see* Appendix C.1). Antimicrobial use is addressed in this assessment with its own section entirely (*see* Section 2.2.4).

This assessment will focus on the social sustainability aspects of animal care knowing that animal care is a multi-disciplinary topic at the nexus of three pillars of sustainability (social, environmental, and economic) (CAST, 2018). Under social sustainability, "animals' lives are part of the social system of the ranch" and "the well-being of people and animals are linked" (Losada-Espinosa et al. 2020 in Gosnell et al., 2021, p. 7). Meta-analysis shows that animal welfare assessments often pair in social and/or environmental assessments concerning public goods including human health and environmental sustainability (Bock and Buller 2013 in Bassi et al., 2019, p. 337). Even during the scoping phase of this assessment, stakeholders for whom animal care mattered most also believed that air, soil, water, and land are sustainability priorities. Stewardship and animal care were viewed as a source of pride and positive mental health in the Canadian beef industry (*see* Appendix C.1).

Economic studies on the productivity and profitability of animal care practices are increasing (CAST, 2018) as many animal care practices are thought to produce better beef products (CAST, 2018 p. 11, Gosnell et al., 2021 p. 9) with cascading effects to supply and demand, consumers and producers, society, the economy, and the environment at multiple scales. Texas A&M has undertaken synthesis work with animal care as part of the triple bottom line in animal production (Lacewell, 2018). Despite the fact farm animals are often raised on private lands by private individuals and businesses, animal welfare appears to remain an issue of "societal choice" (Bock & Buller, 2013) and an "important social issue" (CAST, 2018) because the scientific, economic, and environmental outcomes of animal care practices are underpinned by social ethics.

IMPACT PATHWAYS

Evidence of stressors and potential impacts along the beef value chain are defined by stakeholders and the sustainability literature. In some cases, the interrelations are known and have been characterized scientifically by recent studies. In other cases, the interrelations are theoretical possibilities that have not yet been characterized through an examination of cause and effect. The impact pathways section takes a first step toward gathering the breadth of potential stressors and potential impacts together to highlight the potential for social consequences (good or bad) in the context of agriculture. The current state of knowledge about how stressors may interrelate or manifest in mid-point or endpoint impacts varies. The pathway analysis section below will show that as it describes these interrelations as complex and multi-directional. Furthermore, the interrelations are not always predictable, or uniform, because they are defined by relationships between people within an organization or between organizations within the value chain. The aim of impact pathway section is to provide the reader with an awareness of the potential for impact pathways to activate along the beef value chain.

Pathway 3.1 – Working conditions may affect animal care

Working conditions impact the environment in which animal care occurs. Physically or mentally hazardous working conditions (*see* Section 2.2.1, Labour Management and Section 2.2.2, People's Health and Safety) may negatively impact animal welfare (CCOHS, 2019; Richardson, 2021). At meat processing plants in Canada, for example, Richardson (2021) argues that the food safety focus regulating line speeds may leave some grey area with respect to human or animal welfare at these work sites (Richardson, 2021, p. 101). Wherever working conditions may affect the mental health of workers, "high stress and strains on mental health have been found to impact farm animal welfare" (FMC & Wilton Consulting Group, 2020). Working conditions can affect cattle handling practices, with heavy workloads and accidents creating stress-inducing work environments on cattle farms, which may influence decision-making (*see* Section 2.2.1, Labour Management and Section 2.2.2, People's Health and Safety) and adoption of improved cattle handling practices (Ceballos et al., 2018). Working conditions that facilitate anxious animals create problems for handlers, who may experience decreasing job satisfaction, motivation, commitment and self-esteem in efforts to work harmoniously with animals (Ceballos et al., 2018). A tired, aggressive, or anxious handler can interact with the animal's senses, which can lead to an aggressive or anxious animal, creating opportunities for frustration or force (Ellingsen et al., 2014; Fukasawa et al., 2017).

Other working conditions that may affect animal welfare include the presence or absence of infrastructure or the ability to implement a proposed innovation given available resources or logistics (e.g., land, labour or capital) (Bassi et al., 2019). These limitations may affect one work site, or the entire supply chain. For example, the closing of regional facilities that mean cattle must be transported farther have the potential to directly affect animal welfare (Richardson, 2021) in many ways (BCRC, 2022a).

Pathway 3.2 – Animal handling training, experience, or mentorship may affect rates of animal stress and injury and decrease human fatalities on farms

Animal handling in the Canadian beef industry is a practice where change may "have drastic farm animal welfare benefits" (Bassi et al., 2019, p. 347), reducing unnecessary pain and stress in animals (Moggy et al., 2017a, 2017b, 2017c). There is tremendous potential to mitigate human–livestock impacts that are among the leading causes of injury-related fatalities to people on farms (CASA CAIR, 2016) and unreported in the processing sector.

As noted in scoping (*see* Appendix C.1), training workers about the Beef Code and implementing the required and recommended practices was a priority for Canadian beef industry stakeholders. Safe cattle handling is addressed on page 19 of the Beef Code, but there may be issues of uptake regarding this practice (Moggy et al., 2017c). The learning process (e.g., through observation or access to training resources) is a key driver of on-farm practice adoption (Kuehne et al., 2017). Traditional knowledge is a key mode of knowledge transfer among Western Canadian cattle producers (Bassi et al., 2019), with many traditions pre-dating the Beef Code. In-community learning and animal handling, experts encourage the evolution toward low-stress animal handling on-site (Bassi et al., 2019).

If knowledge is the first ingredient in effective animal handling, then skill and focus are the second and third. A lack of available labour (*see* Section 2.2.1, Labour Management) may present challenges to selecting the right personnel. The Beef Code states, "the selection and training of personnel are the most important factors in ensuring that cattle will be managed humanely" (NFACC, 2013, p. 5). This goes beyond finding labour with previous experience and should account for the personalities and attitudes of the handlers: "handlers who had negative beliefs about animals were more likely to behave negatively with them" (Losada-Espinosa et al. 2020 in Gosnell et al., 2021, p. 7 and 74), whereas positive attitudes and calm body language promote positive interactions with animals. Effective animal handling training, experience, or mentorship lowers risk of injury to animals and workers (NFACC, 2013, p. 1).

Pathway 3.3 – Animal care practices that affect animal welfare may also affect productivity or profitability, and human mental health

Animal care practices that affect animal welfare may have reverberating effects on cattle productivity, profitability, and workers. An impressive body of research into animal welfare in Canada has furthered the pursuit of animal care practices toward the Five Freedoms (CAST, 2018). As the science assessing animal welfare expands, supporting the practices that are productive and profitable has become a growing area of economic interest (CAST, 2018). Results from that work would contribute to foundational knowledge of the economic pillar of sustainability at the family, business, community, and global scale. Which practices are profitable, which are not, and which markets are willing to pay are areas of consideration.

Pain control is one animal care practice that is useful for demonstrating the pathway of effect from animal care practices that promote the Five Freedoms to the potential for improved human mental health. Using the growing body of research in pain management and their own observations, farm owners and workers know that animals may experience pain, distress or discomfort through some necessary aspects of animal husbandry, including surgeries, castration, dehorning, and branding (Moggy et al., 2017a). The trend toward using pain control increased in Western Canadian cow–calf producers from 2014 to 2017 (WCCCS, 2018), with observations that animals are recovering quicker (Furber, 2017). According to a growing number of producer's, "it's a feel-good thing for us, too," knowing that calves are eating and behaving normally, and getting back to their mothers faster (Furber, 2017). This notion of producers 'feeling good' when their cattle do is an increasingly explored theme (Bassi et al., 2019, p. 344). Healthy, sustainable workplaces and communities rely on healthy animals, workers, and businesses.

Pathway 3.4 – Through public trust, consumers and producers affect animal care.

Workers may feel 'top-down' pressure from employers while experiencing 'bottom-up' pressure from the consumer, either directly or indirectly who have ethical objections to beef production. These ethical issues have been broken down into three categories: (1) the welfare of an animal concerning its use in food production; (2) whether animals should be used in food production at all; and (3) whether animals are owed a certain standard of care based on the services they provide to humans. Where most consumers in Canada and abroad stand with respect to ethics, "is critical to understanding and reconciling differing perspectives about animal care and use" (CAST, 2018, p. 3).

Media are a key source of public trust, to varying degrees. The potential for negative mental health effects to arise from negative media, however, is disturbing: "Public trust in Canadian agriculture was a moderate to large source of stress" reported by producers, and can reduce pride of or confidence in their work (FMC & Wilton Consulting Group, 2020). Producers have described disease outbreaks or activist intrusions in their own words as "traumatic events that can have a huge impact on the farm family" (FMC & Wilton Consulting Group, 2020, p. 33). Public trust can be earned based on the quality of the product produced (Moggy et al., 2017c, p. 967) and the story behind how it was produced (Gosnell et al., 2021). That journey involves the whole supply chain working in tandem, and since trust is a two way street, when violated, it can put road blocks toward animal care, transparency, and communication (CAST, 2018, p. 3). Trust is a two-way street that when violated can put up road blocks toward. For producers, trust can be violated as well and impede sustainability goals. Gosnell et al. (2021) use the term a "socially unsustainable rancher" to refer to one that feels victimized, isolated, and affected by influences beyond their control. These conditions lead to anger, vulnerability, complaints, and trouble adapting (p. 8) and are altogether opposite of clarity, strength, problem-solving and resilience.

As the science of animal welfare expands, so too do the science-based recommendations to improve animal care (CAST, 2018) which is good news for cattle, producers, and businesses who mutually benefit from improved welfare. Adoption of animal care practices will either follow from regulation or from trusted networks for learning and relative advantage (that according to Kuehne et al., 2017, are primarily a factor reducing risk and cost(Kuehne et al., 2017). Communicating the science is critical but understanding the real and perceived constraints faced by producers and the ethical bias of the consumer is essential for ongoing and meaningful dialogue. Figure 2-34 is a visual attempt to summarize this priority area through a pathways approach.

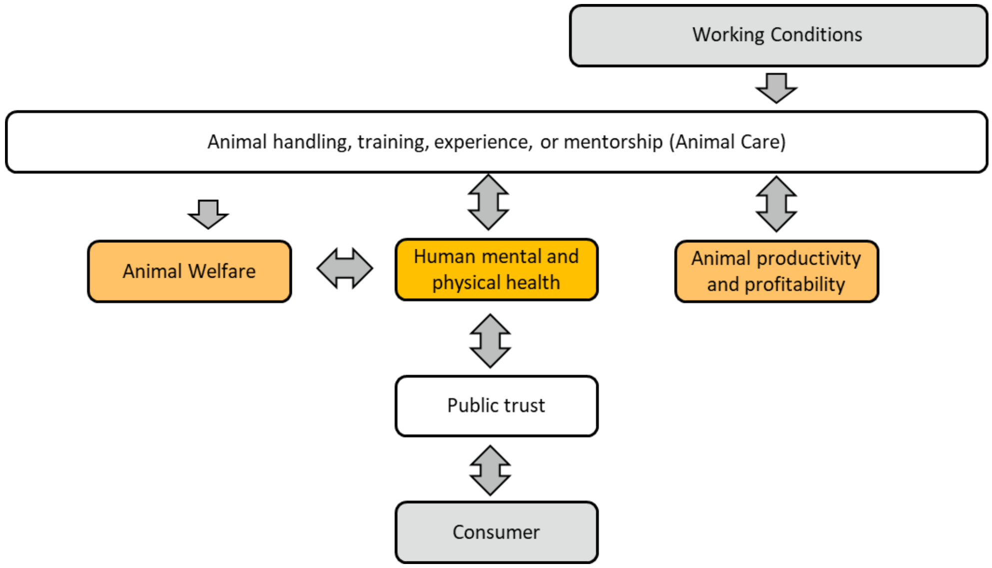


Figure 2-34: Potential pathways of effect in agricultural animal care.

The arrows represent the potential for single-or multi-directional pathways or linkages as described in the literature. The grey fill indicates the stressor following a pathway. White fill boxes represent the mid-point affects and orange fill boxes represent the potential beneficial or adverse outcomes from the stressor.

BASELINE: WHAT WERE THE DOCUMENTED HOTSPOTS IN 2013/14 AND WHAT HAS THE INDUSTRY ACCOMPLISHED SINCE THEN?

Promoting excellence in animal care is one of the goals of the National Beef Sustainability Strategy. To achieve this objective, the industry can build on federal and provincial regulations[41] as well as on industry standards, such as the Code of Practice for the Care and Handling of Beef Cattle (Beef Code)[42], Verified Beef Production Plus (VBP+), and CRSB Sustainability standards.

In particular, the Beef Code is a key component on which Canada's beef industry animal care efforts are based[43]. It outlines required and recommended practices for animal care in Canada. The current version of the Beef Code was released in 2013 and a new version is expected to be published in April 2023 (Canadian Cattle

---

[41] In Canada, the Criminal Code of Canada prohibits anyone from willfully causing animals to suffer from neglect, pain, or injury. That said, provincial legislation is typically responsible for protecting animals on farms, whereas federal legislation is responsible for protecting animals in transport and at slaughter in federally inspected abattoirs (BC SPCA, n.d.). All provinces and territories have laws in respect to animal welfare. A complete description of the provinces and territories roles with respect to animal welfare is accessible on the Canadian Food Inspection Agency's (CFIA) website (Canadian Food Inspection Agency, 2021). Legislation also exists with respect to animal health. For instance, at the federal level the *Health of Animals Regulations*, under the authority of the *Health of Animals Act*, are intended to protect animals and animal health. Specifically, they provide for the control of diseases and toxic substances that may affect terrestrial and aquatic animals or that may be transmitted by animals to persons (CFIA, 2015; Government of Canada, 2019).

[42] In some provinces (e.g., British-Columbia, Newfoundland & Labrador, Manitoba, New-Brunswick, Prince Edward Island and Saskatchewan) the laws will explicitly reference the Codes of Practice for the care and handling of farm animals developed by the National Farm Animal Care Council (NFACC) (BC SPCA, n.d.). That said, "All provinces may use the Codes of Practice as a reference for acceptable care, regardless of whether or not they are referenced in provincial acts. These Codes may be used in a court of law ([…] personal communication; Jackie Wepruk, National Farm Animal Care Council, 2016). The COPB, therefore, is an important document that beef producers should be aware of when making on-farm management decisions" (Moggy et al., 2017c).

[43] For instance, it forms the foundation for Animal Health & Welfare indicators in the CRSB's Sustainable Beef Production Standard. It is also part of the National Beef Sustainability Strategy, under the Goal 'Promote excellence in animal care'.

Association, n.d.). Animal care standards are also in place for transportation[44] and at the packing plant level, where first-, second-, and third-party audits can take place to ensure high standards are implemented in this area.

The CRSB is Id, as part of the National Beef Strategy, to one of the 2030 goals which is to ensure the Five Freedoms of animal well-being by (1) increasing reproductive efficiency (from 85% to 92%); (2) utilizing practices that support animal welfare such as breed selection, polled animals and pain relief; and (3) establishing and using a surveillance systems to monitor animal care practices across Canada (CRSB, 2021a).

These objectives were established in part based on the results of the 2016 NBSA which showed low risks with respect to animal health and welfare, a result attributed to the industry's investment in developing and disseminating the Beef Code (CRSB, 2016a, 2016b). Only a moderate risk was identified with respect to the use of pain control for branding, based on the limited use by farmers of pain control techniques (CRSB, 2016a).

To improve and promote excellence in animal care, the industry has been actively addressing all the action items on animal care. For instance, the CRSB and NFACC are members of each other's organizations, facilitating communication and support activities around animal care. Promoting awareness and implementation of the Beef Code is also ongoing. Research and innovation also play a key role with respect to animal care. The 2021 Canadian Beef Research and Technology Transfer Strategy has outlined five Animal Health and Welfare research outcomes, namely (1) cost-effective improvements in nutritional and overall management; (2) develop and promote the adoption of cost-effective management practices and technologies that reduce the need for and preserve the effectiveness of antibiotics; (3) effective surveillance of production-limiting diseases, production practices, antimicrobial use and antimicrobial resistance; (4) improved prevention and mitigation of animal disease issues; and (5) improved prevention and mitigation of animal welfare issues (BCRC, 2021). This attention resulted in the publication of many articles in producer magazines.

Despite these efforts, animal care remains a priority social issue for Canadian citizens and consumers. For instance, the Canadian Center for Food Integrity (CFFI) notes in its 2021 Public Trust Research report (CFFI, 2021) that declining numbers were measured with respect to three important metrics, including the one on "those who feel Canadian meat is derived from humanely treated animals." Such results demonstrate the need for and importance of maintaining continuous efforts in this area, as animal care standards and expectations are always evolving.

RESULTS: WHAT IS THE CURRENT SITUATION OF THE INDUSTRY WITH RESPECT TO THIS SOCIAL ISSUE?

Results from the assessment lead to two key observations regarding the Canadian beef industry's situation with respect to animal care. Evidence supporting each of these key observations are provided below.

[44] A 'Code of Practice for the Care and Handling of Farm Animals: Transportation' developed by NFACC is also available. The current version was released in 2001. It is currently under revision. The update version should be made available in the Spring of 2023 (NFACC, n.d.). The Canadian Livestock Transport (CLT) is another certification program for transporters focusing on key topics such as animal welfare, fitness for transport, animal behaviour and handling. The CFIA also dictates the portion relevant to the regulations for animal transportation.

Table 2-21: Key observations

Key observation #1 Animal care is a topic that received particular attention within the Canadian beef industry over the years, with tangible and positive results, even though areas for improvement remain with respect to certain on-farm practices	
Documented strengths	Most producers consider the overall animal health's status of their herds as being stable or to have improved over the last three years There is a widespread recognition within the industry that healthy animals and welfare are instrumental in ensuring beef operations' financial viability over time
Documented risks	The adoption rate of practices identified in the 2016 NBSA or as part of the CRSB's sustainability strategy, including the uptake and implementation of the Beef Code and the adoption of low-pain/low-stress techniques during typical procedures (e.g., castration) could still be increased Specific areas that require additional scrutiny include animal transportation (on and off-farm), the management of newly arrived cattle on the farm or how needle injections are performed
Key observation #2 Increased coordination and communication across businesses, sectors, and industries may be needed to ensure animal care throughout the cattle's life cycle	
Documented strengths	The existence of federal regulations and industry standards help ensuring that animal care is achieved and maintained throughout the animals' life cycle
Documented risks	Coordination across businesses and supply chain stages is likely suboptimal to fully secure animal care throughout the animal's life cycle

Key observation #1 – Animal care is a topic that received particular attention within the Canadian beef industry over the years, with tangible and positive results, even though areas for improvement remain with respect to certain on-farm practices

Animal care is the sustainability-related area for which the Canadian beef industry performs the best according to the majority of the interviewees who participated in this assessment[45]. A positive performance that would be the direct result of "real, concerted and concentrated efforts" of the industry members (Respondent 1).

[45] Interviewees were asked to rank (and score) Five Freedoms of sustainability (i.e., workforce & working conditions; animal health & welfare; food safety & biosecurity; environment; innovation & the adoption of new technologies). All but one of the informants who answered this question ranked this theme first and/or scored this theme 8 or higher (on a 1 to 10 evaluation scale).

Quotes from the interviews

"The amount of individual care provided to animals is outstanding" (Respondent 2)

"This is the one where the most improvements took place" (Respondent 3)

"The area where the sector is doing the best" (Respondent 6)

"Best kept secret; animals are being taken care of […]. Practices are solid, but misunderstood or unknown" (Respondent 10)

"Industry wide compliance for animal health and welfare, no complaints. Overall good industry wide performance" (Respondent 15)

The existence of regulations and implementation of the Beef Code are considered instrumental in this achievement (Respondent 5; Respondent 8; Respondent 6; Respondent 9). But other reasons would also explain this overall impression, including a broad realization among farmers that raising "healthy, happy animals" directly impacts the bottom-line while also building and maintaining public trust (Respondent 1; Respondent 3; Respondent 5; Respondent 13). Consequently, it is now "[…] more socially acceptable to talk about it [animal care]" (Respondent 3) and "Those who do not take action are accounted responsible" (Respondent 1).

Some interviewees did note that continued efforts and more specific training are required to ensure that awareness remains high, and that on-farm practices meet the evolving requirements either from the Beef Code or regulations. Animal transportation and vaccination are two specific areas mentioned by interviewees in this respect (Respondent 4; Respondent 5; Respondent 15). The relatively large number of small, part-time farmers (or 'hobby farms') in the sector was also identified as a potential concern with respect to animal care based on the assumption that this group of producers may not have the same incentives "to achieve the same results" (Respondent 2; Respondent 5).

Limited information was available to document practices at the packing plant level[46]. That said, discussions with company representatives and experts did not lead to the identification of major risks due to compliance with regulations and the conduct of regular inspection and audits[47] at the packing plant level, except maybe for a potential risk associated with labour shortages[48]. That said, increased transparency and accountability on compliance levels and how reported issues are being managed at packing plants could be desirable to build trust[49].

[46] Only one of the packing companies that were asked to complete a survey on animal care did participate. As a consequence, this information cannot be used in the assessment.

[47] First-, second- and third-party audits all play a role in ensuring that high standards are achieved with respect to animal care. Unfortunately, little information is made available on the type, frequency, and results of the audits taken place in packing plants.

[48] As one of the representatives indicated, "they [employees] are paid so low, they [farmers and packers] get less skilled people with the wrong attitude [with respect to animal care]" (Respondent 12).

[49] Packers do report on their website about their commitments on animal care. For instance, JBS refers to their animal welfare programs aligned with the Five Freedoms (JBS USA, 2021). One of JBS' 2020 Sustainability Targets was to achieve 90% or better on their own animal welfare scorecard (JBS Canada, 2020). Each business unit also has a Corporate Animal Welfare Manager who reports to the Head of Food Safety and Quality Assurance. The Animal Welfare Manager is a Professional Animal Auditor Certification Organization (PAACO)-trained humane handling specialist (JBS USA, 2021). Similarly, Cargill communicates on its website its 'philosophy' to meet or exceed the Five Freedoms and their commitment to have a zero-tolerance policy on animal abuse (Cargill, n.d.).Their global animal welfare approach includes initiatives that promote continuous engagement and the development of a positive animal welfare culture, as well as accountability for animal well-being throughout an animal's life. Harmony Beef also refers to their animal handling audits to ensure animals are humanely raised. The company has its own animal welfare standards (Harmony Beef, n.d.). As for Artisan Farms, they declare maintaining the highest standards for ethical animal welfare at all its farms.

Animal health, welfare, and beef production management practices are strongly linked. For this reason, the topic of animal care was central to the on-farm survey used in this assessment. Different areas and practices were considered to account for the multi-faceted nature of this topic. The information collected is meant to complement other surveys conducted by the industry, including the Western Canadian Cow–Calf Survey (Moggy et al., 2017c), the Maritime's Beef Council 2017 Atlantic Cow–Calf Production Survey (Maritime Beef Council, 2018), the Ontario Cow–Calf Production Survey (OCC, 2018), Northern Ontario and Northern Québec Cow–Calf Production Study (Lamothe, 2018), the BCRC's study on the Adoption Rates of Recommended Practices by Cow–Calf Operators in Canada (BCRC, 2019b), and OMAFRA's survey on Ontario feedlot practices (Beef Farmers of Ontario, 2021).

When it comes to animal health, most producers who participated in the survey considered the overall health status of their herds to be stable or to have improved over the last three years (Indicator 3.16)[50]. Most producers (94%) also indicated that cattle are typically assessed for **health problems** at least on a weekly basis (Indicator 3.2). About 70% mentioned having a herd health management plan in place for disease prevention, diagnosis, and treatment. A similar proportion reported having a vaccination program developed in consultation with a veterinarian (Indicator 3.1). All producers also declared evaluating their herd's nutritional status, with most (80%) using two or more methods to do so (Indicator 3.6). While it is not possible, based on this information, to determine the actual health status of cattle, no particular risk can be identified based on these results.

Biosecurity is another key aspect related to animal health. One key biosecurity risk documented through the on-farm survey was about the health management of newly arrived cattle on farm. Four specific practices to prevent and assess health issues were considered (Indicator 3.3). Results show that 70% of producers monitor the behaviour of newly arrived cattle for the detection of illness and 62% quarantine newly arrived cattle or make sure they do not co-mingle with the rest of the herd, as appropriate. Approximately half said that a disease prevention strategy was in place to manage the risk of bovine respiratory disease (BRD) for newly arrived cattle (48%) or that they communicate with vendors to check the health history of newly arrived cattle (53%)[51]. While these results are limited, they do not suggest that biosecurity is a risk for the Canadian beef sector. However, it could be considered as one area where improvements may be needed, given one of the interviewees indicated "beef [producers] are not doing great in regard to biosecurity [compared to other livestock producers]. More awareness is needed" (Respondent 4).

One key indicator documented through the survey was about the review and **implementation of the Beef Code** on-farm. Specifically, farmers were asked if, on the farm, a manager or any other cattle handler have read/reviewed the 2013 Code of Practice for the Care and Handling of Beef Cattle (Indicator 3.7). To this question, 74% of respondents answered 'Yes'. Among those, 47% reported that they made follow-up improvements to their facilities, 35% to their husbandry and handling practices, 32% to their disease detection techniques, and 28% to their training approach. Only 8% of respondents who said they had read the Beef Code indicated that no adjustments were needed following reviewing the document.

[50] For instance, 75% of producers strongly or fully agreed that "The mortality rate is stable or has decreased over the last 3 year." A similar proportion indicated that "The respiratory disease treatment rate is stable or has decreased over the last 3 years" (73%) and that "The digestive disease (e.g., bloat, acidosis, diarrhea) treatment rate is stable or has decreased over the last 3 years" (75%). However, such results need to be interpretated with caution, as they do not necessarily mean the health situation is better per se. It could also mean that producers are treating animals less.

[51] The degree of communication (or lack thereof) between the different stages of the supply chain (cow–calf, feedlot, packer) was a recurring concern during the interviewees conducted with industry professionals. This concern was not specific to one particular theme (e.g., biosecurity), but was mostly referring to the lack of coordination and transparency when it comes to conveying market signals throughout the supply chain. Many interviewees pointed out that "Producers are not involved enough in the supply chain" (Respondent 2; Respondent 4; Respondent 6; Respondent 10), which in turn makes them less responsive to customers' and consumers' expectations.

In the 2016 NBSA, over 80% of respondents indicated having read the Beef Code (CRSB, 2016a, p. 164)[52]. However, results cannot be readily compared due to differences in how the question was formulated and the profile of respondents in both assessments. That said, this represents an increase in producer awareness of the Beef Code compared to a survey conducted shortly after the 2013 Code was first released, in which half of the 94 respondents within their sample had not read the Beef Code (Moggy et al., 2017c)[53]. The upcoming publication of the revised Beef Code in 2023 would be an opportunity to further communicate about the Beef Code among farmers.

Other more specific practices related to animal care were also documented through the on-farm survey, including on the use of **pain control** techniques typically used to perform certain procedures, such as dehorning (or disbudding), castration, and branding. Painful procedures are a necessary part of the beef business, however, producers today have new tools to manage pain and they are using them. According to research, nearly half of producers across Canada were using pain mitigation by 2017 some or all of the time, depending on the age and method used (BCRC, 2019b; CRSB, 2020a).

Overall, results indicate that about half of producers who perform these procedures use pain control techniques, with a higher uptake in the case of dehorning/disbudding (54%) than with castration (48%) and branding (44%) (Indicator 3.9). Among those who do not, many indicated it is due to the age of the animals or methods used, as per the Beef Code guidance. Few producers (12%) indicated not using any specific pain control techniques, except for branding for which 33% of producers reported using no pain control which could be explained by the limited number of product available for branding. Interestingly, about 85% of respondents indicated that the typical pain control techniques used on the farm are per the Beef Code's requirement (55%) or go above and beyond the Beef Code's requirements (29%) (Indicator 3.10)[54].

These results represent increases in producer adoption since the survey of Moggy et al. (2017a) conducted shortly after the Code was released, at which point a majority of farms did not use pain mitigation strategies either for castration (90%), dehorning (85%), or branding (4%)[55,56]. In comparison, the profile of producers having completed the on-farm survey for this assessment is characterized by the high proportion of farmers certified under the CRSB or VBP+ standards, which are more likely to adopt these practices[57]. For instance,

---

[52] Specifically, 14% of respondents declared not having read the Beef Code. Of those who did, 24% said they have implemented part of the basic requirements, 57% that basic requirements were fully implemented and 5% that some or all recommended practices were implemented (in addition to having fully implemented basic requirements). Some SAC members also commented on this result, which is higher than what they would have expected.

[53] According to industry experts, this important increase can be explained by the fact that the 2013 Code was the first revision since the original Code that was developed in 1991. Due to industry evolution, that first Code was out of date before work on the revised 2013 edition began. Consequently, the 1991 version really had not been recommended as an industry standard for years, and producer / industry awareness was correspondingly low. The revised Code came out sometime in 2013 so the research conducted shortly after do not represent the increase in awareness that occurred since then (Respondent 18).

[54] In comparison, 74% of respondents indicated having read the Beef Code (Indicator 3.7). This sort of inconsistency is typical of on-farm surveys where farmers self-assess their practices based on their understanding of the questions.

[55] This study was part of the Western Canadian Cow-Calf Surveillance Network (WCCCSN), a 5-year longitudinal project that entailed repeated surveying and biological sampling of herds across 3 provinces (Manitoba, Saskatchewan, Alberta).

[56] Similar results are observed in the 2017 Western Canadian Cow-Calf Survey, where 14% of producers declared using pain control depending on age and method in case of dehorning, and 15% in the case of castration (WCCCS, 2018). The Atlantic Cow-Calf Survey (2018) also shows that 90% of the time pain control is not used during castration; the result was 50/50 whether or not it would be used with respect to dehorning. According to industry experts, there has been a considerable increase in the number of effective pain drugs available (and practical) for on farm use (as well as both producer and veterinary awareness of their existence) since 2013. That is partly why adoption has gone up. (Respondent 18)

[57] 43% of respondents to the on-farm survey indicated being certified under CRSB or VBP+ standards. See Section 1.6 on Data Collection.

among the 295 VBP+ certified producers (as of May 2022)[58], 85% use pain mitigation when performing branding, 97% when castrating, and 98% when dehorning (VBP+, 2022)[59]. These results show the use of pain control techniques can be improved, especially among "conventional" producers.

The adoption of a low-stress **weaning** strategy (e.g., two-stage, nose paddle, fence-line separation, natural) is another important aspect with respect to animal care. In the on-farm survey, producers were asked how frequently such a strategy was being used. 45% of respondents indicated 'routinely' and 25% 'occasionally', meaning that 30% of producers with calves are 'rarely or never' using such an approach (Indicator 3.11). Recent studies indicate that abrupt weaning or abrupt separation remains the most popular weaning method (with adoption rates varying between 50–70%, depending on the study), in spite of the recommended practice to implement low-stress weaning (BCRC, 2019b; Moggy et al., 2017b). As for the use of pain mitigation measures, this observation contrasts with the results from the VBP+ dataset which shows that over 80% of certified producers are using low-stress techniques during weaning (VBP+, 2022)[60].

Handling is known to cause stress in cattle, as demonstrated by behavioral indicators (Woiwode et al., 2016 as cited in Moggy et al., 2017b). Two questions were asked in the on-farm survey with respect to handling. The first one documented if and how animal handlers are trained on cattle behaviour and quiet animal handling (Indicator 3.12). Results show that 97% of respondents train animal handlers. The most typical method is "Generational/spoken knowledge transfer," used by 69% of respondents. More structured training activities, such as taking courses, watching videos, and job shadowing are less frequently used (about 30% of respondents). The use of written documents (16% of respondents) and on-site training by consultants/animal welfare specialists (20%) or veterinarians (18%) are the least-used learning methods.

The second question documented the extent to which producers are practising the following handling techniques (Indicator 3.17):

- Handling techniques and positioning are adjusted according to the individual animal's flight zone response
- Handling tools (e.g., flags, plastic paddles, rattles) are used to direct animal movement quietly
- Cattle handling techniques are evaluated regularly and improved as needed
- Handling events (e.g., falling, stumbling, hesitation, or tripping) are monitored and changes in lighting, noise levels, equipment, handling methods, or environment are made as needed

Overall, most of respondents (70% or more) indicated that these techniques were very often or always used on sites. Relatively few respondents answered that these techniques were never or very rarely used (12% in the case of handling tools and 6 to 7% for the other practices).

These results cannot be readily compared to the VBP+ results, but a similar trend exists when it comes to how cattle are handled for processing, calving or pasture movement, with 91% of certified producers having adopted low-stress handling techniques (VBP+, 2022)[61]. No other publication was found which compares these results with the practices in place on conventional farms.

Euthanasia is a critical dimension of animal care, and the knowledge or use of criteria, equipment, and proper procedures are important to provide a humane death with minimal distress or suffering. In the on-farm survey, 62% of producers indicated they were using protocols for the identification, care, treatment, and possible

[58] The dataset represents 20% of the total number of certified producers (collected from the electronics system).

[59] Results are based on the percentage of producers having achieved the Level 2 or 3 for these criteria.

[60] Results are based on the percentage of producers having achieved the Level 2 or 3 for these criteria.

[61] Results are based on the percentage of producers having achieved the Level 2 or 3 for these criteria.

euthanasia of sick or injured animals (Indicator 3.1). They were also asked how they assess and determine when to euthanize an animal (Indicator 3.15). All respondents indicated referring at least to one criterion, the most common of which being 'when the animal is unlikely to recover' (73%), 'when the animals have chronic, severe, or debilitating pain and distress' (69%)[62], 'when the animal fails to respond to treatment and recovery protocols' (64%), and 'when the animal is unable to get to or consume feed and water' (58%). Veterinary advice is used by 57% of respondents. Only 8% of respondents reported the use of a decision-making tool, which can be explained by the lack of tools or standardized approaches that could be used by farmers and veterinarians alike (Respondent 18). The on-farm survey did not document how euthanasia is performed or if and how death is confirmed by producers. But according to (Moggy et al., 2017b), this is an area that should be a focus for future extension efforts.

Three other animal-care related situations were documented in the on-farm survey: the management of needle injections, animal transportation, and the measures taken to deal with extreme temperature events. Needle injections is an important topic that relates to animal care, but also animal health and meat quality[63]. Specifically, producers were asked what protocol (or standard operating procedure) is in place for **needle injections** (when applicable). Seven different practices were suggested, and all respondents selected at least one of them (Indicator 3.5). When looking at each practice individually, results show that:

- 85% injected vaccines according to label instructions;
- 79% replaced needles regularly;
- 74% regularly clean injection equipment;
- 67% use proper restraint (based on the situation);
- 52% complete records check for broken needles.

In addition, employees were trained as to the proper location of the injection on 63% of participating operations. Only 39% of respondents indicated using remote delivery devices only when animals cannot be easily/safely captured, meaning that such devices may be used in other situations.

Based on this information it is not possible to identify specific risks when it comes to needle injections. However, it could be considered an area where improvements would be beneficial, notably with respect to the compliance level with label instructions, recognizing that labels are complex to read and interpret.

Animal transportation is another critical area that can impact animal care, animal health and meat quality[64]. Typically beef cattle are transported at least once and up to five or more times during their lifetime[65] and their welfare will be influenced by typical factors including the 'microclimate' inside of the trailer, the loading density, the duration of transport, the quality of transport, and animal behaviour (Schuetze et al., 2017; Schwartzkopf-Genswein et al., 2012).

---

[62] These results for these two criteria are similar to those measured in (Moggy et al., 2017b).

[63] The National Beef Quality Audit (National Beef Quality Audit, 2018) suggests that increased use of treating cattle with dart guns may be responsible for the increase in injuries in non-fed cattle from 2010-11 to 2016-17. There was also an increase in injuries in different areas of the carcass (e.g., shoulder) compared to previous years. There is an opportunity to promote best practices for dart gun use by livestock producers as well as continue efforts aimed at injection best practices (BCRC, 2019b).

[64] For instance, in the latest National Beef Quality Audits done in Canada (2016-2017), economic losses from bruising ($1.90/head) were measured, leading to recommendations that the industry must improve handling and transport techniques (National Beef Quality Audit, 2018; Schwartzkopf-Genswein et al., 2012).

[65] This may include transportation from their ranch of origin to either a different location within the same farm or sold through auctions or directly to feedlots for growing (backgrounding) where they may be transported to fattening (finishing lots) and finally to processing plants for harvest (Schwartzkopf-Genswein et al., 2012).

The Beef Code includes a section on transportation decision making and un/loading. Legislation also exists. Revisions to the federal Transport of Animals Regulations (Part XII of the Health of Animals Regulations) came into effect in February of 2020 with four major changes focusing on categorizing animals fit for transport, record keeping for transporters, required feed, water and rest times and contingency planning (BCRC, 2022d). In-keeping with the Beef Code, the questions in the on-farm survey focused on some key practices with respect to animal transportation on or off the farm (when applicable), namely (Indicator 3.8):

- The presence of a farm representative (e.g., owner, worker) on site to observe the loading/unloading process;
- The ability of the persons making shipping decisions to understand what is not acceptable when loading and transporting cattle;
- The verification that loading and unloading equipment, chutes or conveyances are free of hazards to minimize the risk of injury.

Results show that about 80% of respondents said that they always have a farm representative on site (82%), that the people making shipping decisions understand what is acceptable (78%), or that loading and unloading equipment, chutes or conveyances are checked to make sure they are free of hazards (78%). Taken individually, the degree of adoption of these practices does not point to a major risk, even though improvement would be expected. However, the result is more concerning when taken together, as 40% of respondents declared one or more of the three practices are not met (e.g., presence of a farm representative; ability of the people making shipping decisions to understand what is not acceptable when loading and transporting cattle; verification that loading and unloading equipment, chutes or conveyances are free of hazards). According to these results, **this situation related to animal transportation could be considered as a risk for the sector**[66].

One last animal care consideration in the on-farm survey was about measures taken to support cattle during extreme temperatures (both high and low), such as improved shelter or adjusted feeding. Due to climate change, farmers are facing increased climate-related risks associated with weather events and climatic conditions, such as an increase in the frequency and intensity of extreme weather events, increased precipitation, generally warmer temperatures, and more frequent and longer heatwaves, which can affect agricultural production on a local and regional scale. Results from the survey indicate that 88% of farmers have been taking measures over the last 3 years to support cattle in that respect, while 7% declared that no changes were needed (Indicator 3.18). Producers were not asked to identify what these measures are.

How farmers adapt to a changing climate and its consequences on animal health and other aspects of the operation (e.g., grazing, pest control) present an area that may benefit from further research given the short-, mid- and long-term consequences it may have on Canadian beef farms. As one of the interviewees put it, "We need to be aware that farming in 30 years from now will be different [due to climate change]—are the BMPs promoted today the right ones for the future?" (Respondent 7).

From this perspective, promoting innovation and continuous learning at the farm level is instrumental. With respect to animal care, the on-farm survey shows that about 40% of participating farms had at least one manager attending a conference or a training session either online or in person over the past 3 years on topics related to animal health or care (e.g., animal welfare, biosecurity) (Indicator 3.13). That said, over 85% indicated having adopted or tried innovations related to animal care in the last three years, including with respect to feed & nutrition (59%), animal welfare practices (50%), animal health (50%) or genetics (34%)

[66] In addition, one of the experts interviewed as part of this assessment indicated that "some feedlots are pushing the limits when it comes to what animals are unfit (or not) for slaughterhouse." (Respondent 19). The absence (or lack of) of standardized approach to assess the cattle health status can lead to a certain degree of interpretation by individual farmers or employees.

(Indicator 3.14). Over 30% of respondents also indicated a willingness to make improvements with respect to animal care over the next 3 years across the operation.

Key observation #2 – Increased coordination and communication across businesses, sectors and industries may be needed to ensure animal care throughout the animal's life cycle

Ensuring animal care is a shared responsibility across businesses, sectors, and other stakeholders. Many market actors, including cow-calf producers, feedlots, auction markets, packers, and transport companies, handle an animal throughout its life.

The original focus of this assessment was to document the practices used by farmers and packers contributing to animal care. However, interviews and discussions with experts led to the identification of potential concerns with respect to 'transition points' when cattle are transitioning within and across the different management or ownership stages of the supply chain. Ensuring animal care through these transitions requires strong collaboration and coordination among businesses, which may not always be assured based on the gathered information.

As noted above, the lack of (or insufficient) coordination and communication within the industry was a recurring theme during the interviews with key informants[67]. But beyond this overall impression, specific areas were identified where increased coordination would be required to bridge gaps and mitigate risks with respect to animal care.

A first area is about **communication between cow-calf producers and feedlots** about the health status of their animals. In the on-farm survey, 53% of producers indicated that communications are made with vendors to check the medical history of newly arrived cattle (Indicator 3.3). In fact, experts interviewed during this assessment suggested that the lack of coordination between producers may lead to suboptimal practices with respect to vaccination and the use of antimicrobials (Respondent 18).

Another of these areas relates to **animal transportation**. A few interviewees identified this area as requiring particular attention and training (Respondent 4; Respondent 10; Respondent 15). As mentioned above, federal regulations are in place that set basic requirements with respect to animal transportation (dictated by the CFIA) and a Transportation Code is also made available by the NFACC. However, how transportation is managed can vary significantly depending on the situation[68], including with respect to the industry standards trucking companies have to comply with[69]. Knowing the importance of proper transportation to animal care, documenting how animal transportation is managed between producers, trucking companies. and packers (e.g., are the hauling truckers certified under an animal care program and how often are they audited?) is an area that should be further researched to determine whether there are particular risks that should be addressed.

How animals are managed and handled in **auction markets** was also identified as an important information gap. Auction markets are commonly known as a central gathering point for livestock where they are sold on

[67] This characteristic of the industry has been identified back in 2012 in a report published by the Canadian Agri-Food Policy Institute (CAPI), which referred to the "cowboy mentality" to describe the high level of business independence that contributes to minimal collaboration between businesses (CAPI, 2012).

[68] In Western Canada, packers are generally the ones in charge of scheduling transportation, either by contracting companies (or independent truckers) or by using their own fleet. But feedlot may have their own trucks (Respondent 19).

[69] For instance, Cargill indicates on their website that transporters delivering cattle to Canadian plants adhere to the Canadian Code of Practice for the Care and Handling of Farm Animals for Transportation (Cargill, n.d.). In the on-farm survey farmers were also asked if transporters transporting on or off their farm animals were certified by the Canadian Livestock Transport (CLT) program. About 20% answered "yes" (Indicator 3.8). However, producers have limited control on this decision. No information is available on the degree to which trucking companies are certified under CLT or other industry standards in Canada.

commission (Van Metre et al., 2009 quoted from Heuston, 2017, p. 21). These market actors play a key role in the industry and have legal obligations with respect to animal care. Specifically, once cattle are unloaded at an auction , they become the responsibility of that entity which must deal with the proper culling or end of life strategies for either compromised or unfit cattle (e.g., be sold, refused prior to unloading, returned to the owner, or euthanized on-site with or without salvage of the carcass) (Heuston, 2017). However, as Heuston describes in her thesis, auction markets "are conflicted with the appropriate way of discouraging the transportation of compromised cattle without risking the welfare of the animal or impacting the economic viability of their business"(Heuston, 2017, p. 22)[70].

According to the author, "the cattle industry is doing [a] reasonable job managing these cattle [in compromised and unfit conditions] as evidenced by the relatively low prevalence of compromised and unfit cattle upon arrival" (Heuston, 2017, p. 94). That said, this is an area where additional information would be required to ensure that best practices are in place and that sufficient communication exists between producers, auction market managers and packers to reduce unnecessary suffering of cattle being transported for sale or slaughter (e.g., how are welfare issues handled between farmers and auction markets or packers when comprised or unfit animals are received on site?).

The growing importance of **dairy beef** entering the cattle beef industry was a third area identified in this assessment where data gaps exist, and for which increased coordination between market players would be required. According to experts (Respondent 18), these animals may 'fall between the cracks' between what is required in the Beef Code and the Dairy Code, as they may not be considered as belonging to either group. Recent publications suggest the existence of potential concerns and issues with respect to the health and welfare status of dairy cows (culls or calves) entering the beef supply chain in Canada (Creutzinger et al., 2021). Given this, particular attention should be given to this emerging trend to limit the consequences to animals and the risks to the dairy and beef industries alike.

2.2.4 ANTIMICROBIAL USE

Antimicrobials, which include antibiotics, antifungals, antivirals and antiparasitics, are instrumental for ensuring animal health in livestock agriculture. However, improper use can have adverse effects on animals, human health, and the environment.

RATIONALE: WHY IS THIS ISSUE A PRIORITY WHEN IT COMES TO SOCIAL SUSTAINABILITY?

Responsible antimicrobial use and expert consultation are sustainability practices defined by the Canadian Roundtable for Sustainable Beef (CRSB). To be sustainable, antimicrobial use would meet "the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987, p. 16). Antimicrobials are medicines for treating infections, including antibiotics, antifungals, antivirals, and antiparasitic drugs (WHO, 2021). They are used for crops, aquaculture, pets, livestock, and human healthcare, hygiene products, and as household cleaners (Cameron & McAllister, 2016; Davies & Davies, 2010). Antimicrobials are "important tools for maintaining human and animal health" (Hannon et al., 2020) with a broad range of applications and effectiveness against common infections (WHO, 2021).

[70] Specifically, the author describes the situation as follow: "If an auction market owner refuses cattle from a given producer, they are at risk of losing business from that producer in the future. If the animal is refused by the auction and sent back to the producer that animal may not be able to withstand transportation without undue suffering. However, if an auction market accepts a compromised animal, that animal is at risk of not being able to withstand subsequent transportation events after the sale without causing undue suffering. This is a point where economics, efficiency, and welfare have trouble converging due to lack of understanding of transportation regulations." (Heuston, 2017, p. 22).

Microbial genes resistant to antimicrobials used in food animals, plants and humans have emerged in recent decades to challenge the effectiveness of antimicrobials to treat health problems. Antimicrobial use in livestock production has since been in the spotlight (Hannon et al., 2020). The focus of this deep dive is on the potential social impacts on cattle health, and healthy sustainable workplaces and communities from antimicrobial use and antimicrobial resistance in the Canadian beef industry, specifically pertaining to antibiotics.

Antimicrobial resistance may make antimicrobial treatments ineffective with consequences ranging from increased healthcare costs to scenarios where untreatable infections result in death to humans and animals (Booker, 2020; WHO, 2021). Globally, "the most striking examples, and probably the most costly in terms of morbidity and mortality, concern bacteria" (Davies & Davies, 2010). In Canada, about one-quarter of a million lives are projected to be lost by 2050 if today's levels of first-line antimicrobials remain at today's level of resistance (CCA, 2019). The impacts may include the following:

> Human health consequences include: (1) infections that would not have otherwise occurred and (2) increased frequency of treatment failures and increased severity of infection. Increased severity of infection includes longer duration of illness, increased frequency of bloodstream infections, increased hospitalization and increased mortality (Angulo et al., 2004).

Unsurprisingly, beef cattle are vulnerable to these same health consequences.

Resistant bacteria can occur in humans, animals, plants, and throughout the natural environment, arise through everyday genetic mutation in the environment, and can be transferred between people, and between people and animals. In both humans and animals, the main drivers of resistance are thought to be overuse of antibiotics related to a lack of access to clean water, sanitation, and hygiene, and especially a *lack of disease prevention*. The concept of One Health is underpinned by a recognition of the interconnectedness between humans, animals, and the environment. It is One Health's stance to fight antimicrobial resistance in people and animals (CDC, 2022) whereas the Global Roundtable for Sustainable Beef's statement on antimicrobial stewardship seeks "to minimize the development of antimicrobial resistance" (GRSB, 2018). Both consider antimicrobial resistance negative to the well-being of the industry.

A secondary problem is the lack of knowledge around the "complexity of processes that contribute to emergence and dissemination of resistance" (Davies & Davies, 2010). Understanding how livestock operations contribute to antimicrobial resistance is a bit blurry at the gene scale (Cameron & McAllister, 2016) even as the science progresses and outcomes on farms and communities in Canada are increasingly coming into focus (Cameron & McAllister, 2016).

Beef value chain partners have a role to play in the responsible use of antimicrobials or stewardship. In addition to participating in innovative, on-site research (for example Andrés-Lasheras et al., 2021; Beukers et al., 2018; Cormier et al., 2020; Hannon et al., 2020), value chain actors can implement best practices to prevent disease or the potential for disease transmission. Key stewardship or responsible use practices include having a valid Veterinary Client-Patient Relationship (VCPR), accurate diagnosis, herd health management plans, record keeping, following label directions, low stress management (i.e. strategies to reduce the impacts of weaning, pain, handling, transport, change of feed and comingling), use of antimicrobial alternatives, preventative vaccinations and environmental controls, including animal housing and handling, training for administering personnel, pain mitigation for painful management procedures, record-keeping, and having a general understanding of category I, II, and III antimicrobials and ionophores (category IV) (BCRC, 2022c; GRSB, 2018). These practices span the supply chain throughout the animal's whole life on the ranch, at the auction markets and assemblies, at backgrounding operations, at feedlots and before processing, and among associations (BCRC, 2022c; GRSB, 2018).

Antimicrobial use and resistance were identified as areas that matter most to beef industry sustainability among stakeholders involved in scoping (*see* Appendix C.1). Stakeholders identified that the continued, responsible use of antimicrobials in beef cattle production is important to reduce morbidity and mortality, thereby supporting continued animal productivity and food security. Antimicrobial resistance also mattered, and each stakeholder group reported a slightly different priority on why resistance was a concern: (1) resistance was a concern for cattle health within intensive animal housing units; (2) for cattle health and productivity; and (3) for effectiveness of antimicrobial treatments in human and animal medicine. These perspectives bring generic and Canadian context-specific categories into the assessment. The top-down and bottom-up approach to assessment (*see* Section 1.11) is not unlike the two-layer approach to S-LCA described by Dreyer et al. (2006). To assess antimicrobial use, the S-LCA took account of antibiotics (antimicrobials used for bacteria) as defined in Table 2-22 below.

Table 2-22: AMU Related Themes

Related themes	Processors	Farms
Use of Antibiotics	N/A	√
Preventative practices	N/A	√
Antimicrobial Alternatives	N/A	√
Use of Antibiotics on Cow-calf Operations	N/A	√
Use of Antibiotics on Backgrounding Operations	N/A	√
Antibiotic Categories Used	N/A	√

The potential for antimicrobial use practices to impact people and businesses is "related to the conduct of companies engaged in the social life cycle" (Dreyer et al., 2006). Antimicrobial use can be considered a group of practices or as a stressor along a cause-effect chain. The practices have an unquantified mid-point impact, that is antimicrobial resistance[71], which has 'end-point' effects on stakeholders, in this case, animals, farm owners, and employees. A stressor or an impact is not normatively good or bad but is something materially affecting an outcome.

The literature discusses three prominent pathways of resistance. The first two, environment and consumption[72], fall outside of the scope of the social assessment (*see* Section 1.2, Goals of the Study and Section 1.4, Scope of the Study). The focus of this social assessment is on a third pathway, the responsible use pathway, which outlines responsible antimicrobial use as a starting point for managing impacts to cattle, through disease and stress and impacts to businesses and employees through profitability and employee morale. The likelihood of a positive or negative outcome hinges on the current state of responsible antimicrobial use practices assessed and presented in the results section to follow.

Impact Pathways

Evidence of stressors and potential impacts along the beef value chain are defined by stakeholders and the sustainability literature. In some cases, the interrelations are known and have been characterized scientifically

[71] See also Weidema (2018). Presentation: Towards a taxonomy for social impact pathway indicators Bo P. Weidema (Bo P. Weidema, 2018).

[72] The environmental pathway concerns practices such as manure management and surface water management and the potential for resistance gene emergence and transmission to affect human and animal health. The environmental vectors and practices are assessed as part of the Environmental Assessment. The consumption pathway concerns the use of antimicrobials and the potential for human resistance to develop through exposure to antimicrobial resistant bacteria from consumable products. Potential impacts to human health through the consumption pathway could also include impacts from food/water borne illness. The consumption pathway was scoped out of the assessment due to the robust regulations around food safety and environmental management in Canada (see Section 1.2, Goals of the Study and 1.4, Scope of the Study).

by recent studies. In other cases, the interrelations are theoretical possibilities that have not yet been characterized through an examination of cause and effect. The impact pathways section takes a first step toward gathering the breadth of potential stressors and potential impacts together to highlight the potential for social consequences (good or bad) in the context of agriculture. The current state of knowledge about how stressors may interrelate or manifest in mid-point or endpoint impacts varies. The pathway analysis section below will show that as it describes these interrelations as complex and multi-directional. Furthermore, the interrelations are not always predictable, or uniform, because they are defined by relationships between people within an organization or between organizations within the value chain. The aim of impact pathway section is to provide the reader with an awareness of the potential for impact pathways to activate along the beef value chain.

Pathway 4.1 – Responsible antimicrobial use in beef cattle production affects animal welfare, profitability and employee morale

Different categories of antimicrobials are used to treat a range of unwanted animal health issues, including widespread and potentially terminal cases of respiratory disease and foot ailments. Antimicrobials are important for animal welfare, "ensuring good health at individual and herd levels" (Lhermie et al., 2019). Within the beef industry, animal care is the responsibility of beef industry workers and service providers. Diseases on farms affect both animal welfare and on-farm profitability through herd performance, namely production efficiency, morbidity, mortality (Cameron & McAllister, 2016) or added costs for treating chronic illness in beef cattle (Booker, 2020).

Bovine Respiratory Disease (BRD) is responsible for close to half of the morbidity and the majority of mortality in North American feedlot cattle (Andrés-Lasheras et al., 2021). The cost to farm owners in North America from BRD alone is estimated at US$3 billion per year (Andrés-Lasheras et al., 2021) making BRD a major target for antimicrobial use (Cameron & McAllister, 2016). From this one disease, "direct impacts include costs to manage chronically ill animals, including those associated with BRD relapse treatment; reduced returns from animals sent for salvage slaughter, loss of the initial investment to purchase the animal and feed and other accumulated expenses to death, and costs associated with carcass disposal" (Booker, 2020, p. 172). A higher prevalence of disease will increase labour and treatment costs (Lhermie, Verteramo Chiu, et al., 2019).

Sick animals require more attention to meet welfare standards (Booker, 2020, p. 173) at all stages of the supply chain. If animals do not respond to treatments initially, there is higher risk that the animal will develop chronic problems or die (Booker, 2020, p. 173). When employees attempt treatments that fail and result in death, it "often has a negative effect on employee morale," requiring additional employee support to mitigate the effects (Booker, 2020, p. 173). Furthermore, there may be a cumulative effect as resistance requires potentially more antimicrobials for treatment, which can lead to "the potential for harmful exacerbation of antimicrobial resistance" (Booker, 2020, pp. 173–174).

Antimicrobial use in cattle treated for BRD and the impact on resistance development are imperfectly understood (Booker, 2020, p. 173). What is known is the presence and virulence of infectious pathogens can impact profitability, animal welfare, and the people who work with animals. A precautionary approach is emerging among the recommendations for good antimicrobial stewardship as studies emerge to further characterize the pathways between use and resistance. Figure 2-35 is a visual attempt to summarize this social issue through a pathways approach.

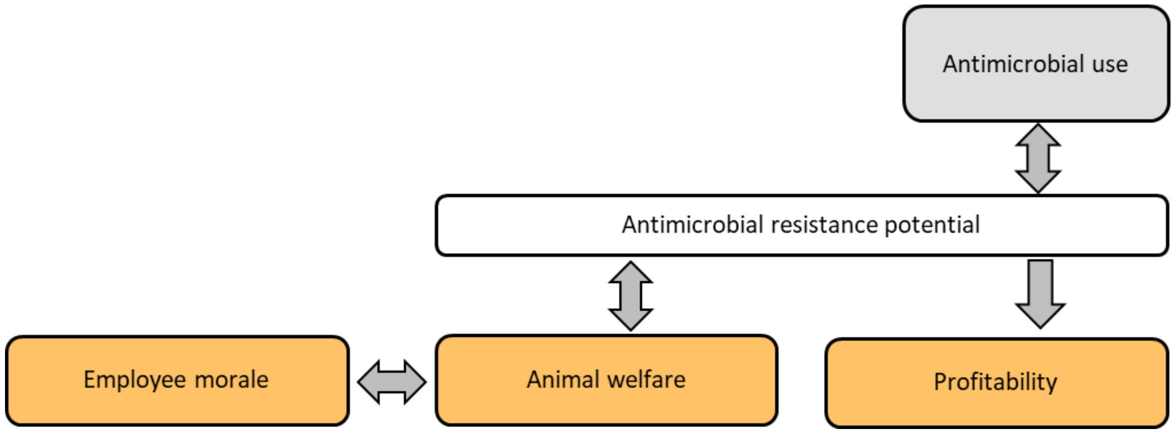


Figure 2-35: Potential pathways of effect in agricultural antimicrobial use.

The arrows represent the potential for single-or multi-directional pathways or linkages. The grey fill indicates the stressor following a pathway. White fill boxes represent the mid-point affects and orange fill boxes represent the potential beneficial or adverse outcomes from the stressor.

BASELINE: WHAT WERE THE DOCUMENTED HOTSPOTS IN 2013/14 AND WHAT HAS THE INDUSTRY ACCOMPLISHED SINCE THEN?

In the 2016 NBSA, some of the impacts due to antibiotic use could not be assessed through the LCA methodology (e.g., development of antimicrobial resistant microorganisms in beef production systems, impacts of antibiotics potentially released into the environment on human and ecosystem health, toxicity impacts). However, indirect effects of the use of antibiotics were considered in the study. To do so, the assessment considered preconditioning and VBP+ uptake as indicators. Based on survey results, the report found the potential for antimicrobial misuse to be a very low to low risk in Canada due to the uptake of beneficial management practices, training and measuring and monitoring (CRSB, 2016a, 2016b)[73].

Besides, in Canada, all veterinary drugs are regulated at the federal level by the Food and Drugs Act and Regulations (BCRC, 2018a; BCRC & Alberta Beef Producers, 2018). In particular, since December 1, 2018, federal regulations require that all Canadian livestock producers have a prescription from a licensed veterinarian with whom they have a valid VCPR before they can access medically important antibiotics for use in livestock, and medically important antibiotics cannot be used to improve growth or feed efficiency (BCRC & Alberta Beef Producers, 2018)[74]. At the processing level, processors are overseen by the Canadian Food Inspection Agency (CFIA) regarding food safety issues through the *Safe Food for Canadians Act* and its regulations (BCRC, 2018a).

[73] In this updated assessment, a further look at AMU in the industry and its effects on ecotoxicity is explored in Section 2.1.4.

[74] In addition, mandatory reporting of antimicrobial drug (AMD) distribution for sale for animal use is required and all MIAs have been moved to the prescription drug list. Regulation now prevents the importation of MIAs for own-use, requires that imported active pharmaceutical ingredients are only in approved forms from registered production facilities, and bans the use of MIAs for strictly growth promotion (Hannon et al., 2020).

Recognizing the importance of antimicrobial stewardship both for continued effectiveness of use and to address consumer concerns (CRSB, 2016b), the industry has been responding with regulatory changes, investments in research and surveillance, and communication to producers and consumers.

Specifically, the Canadian Beef Advisors established one of the 2030 goals of the National Beef Strategy which is to ensure preservation of existing and future antimicrobial effectiveness to support human and animal health by (1) the continuous development, monitoring, and dissemination of best practices for antimicrobial use; (2) the quantification and description of baseline antibiotic use practices in Canadian feedlot production; and (3) the determination and monitoring of antibiotic resistance profiles in bacteria of concern in feedlot cattle (CRSB, 2021a).

Programs and practices have been implemented to address this issue, such as the VBP+ program, which focuses on appropriate and responsible use of antimicrobials as well as establishing and maintaining a VCPR. The industry is also tracking overall resistance levels of isolates measured, which remain low in general (CRSB, 2020a).

Research also plays a critical role in the industry's ability to reduce medically important antimicrobial use. The National Beef Antimicrobial Research Strategy, published in May 2016, identifies three priority research outcomes for the Canadian beef industry: antimicrobial resistance, antimicrobial use, and antibiotic alternatives. The CRSB is committed to monitoring the associated research activities to inform its stakeholders of scientific advances in the field and continue building awareness around antimicrobials (CRSB, 2020a).

One of the outcomes from the BCRC 2013–2018 report (BCRC, 2019a) about responsible AMU shows that antimicrobial resistance (AMR) found in bacteria associated with beef is very low and has not increased over time. However, continued research on antimicrobial resistance is needed to monitor the issue, as well as to study whether antimicrobial use in a feedlot may lead to 'downstream' resistance in the environment and humans[75].

To do so, collaborative initiatives involving the Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS), Agriculture and Agri-Food Canada (AAFC) and the beef industry have been taking place to monitor AMU and AMR in commercial feedlot settings. That said, on-farm surveillance for beef cattle came more slowly due to resource limitations for the CIPARS program within the Public Health Agency of Canada (BCRC, 2019c). Building on past and ongoing CIPARS efforts, a project started in April 2019 is focused on providing unified approaches to monitoring trends over time in AMU and AMR in the feedlot sector[76] as well as veterinary antimicrobial dispensing data (CRSB, 2020a). Preliminary results show that except for a single resistant isolate, no resistance to antimicrobials of Very High Importance in Human Medicine (i.e., Category I antimicrobials) was detected during the first year of surveillance. However, some resistance was identified in other categories of antimicrobials (Gow et al., 2021). Such results emphasize the need to continue monitoring AMU and AMR, and to promote the adoption of practices that optimize the use of antimicrobials on Canadian beef farms.

---

[75] Examples of projects include one organized by Alberta Cattle Feeders Association to support a surveillance research system to collect AMU and AMR data from Alberta/Canadian feedlot cattle operations and disseminate this information to key stakeholders, including industry, feedlot producers, veterinarians, and federal/provincial governments, to help demonstrate antimicrobial stewardship, improve treatment decisions, reduce unnecessary or inappropriate AMU, and reduce the potential development of AMR (BCRC, 2019c; RDAR, 2021). Another project supported through the Beef Science Cluster has examined the risk that antimicrobial residues, resistant bacteria, or resistance genes can travel from feedlot environments to human environments, through manure, soil, and water. This study found that composting manure is an effective way to dissipate antimicrobial residues and resistance genes (BCRC, 2018b).

[76] Surveillance is in place at the feedlot level, in particular with respect to AMR. However, less information is available at the cow-calf level.

RESULTS: WHAT IS THE CURRENT SITUATION OF THE INDUSTRY WITH RESPECT TO THIS SOCIAL ISSUE?

Results from the assessment lead to two key observations with related strengths and risks associated with the Canadian beef industry's situation with respect to antimicrobial use. Evidence supporting each of these key observations are provided below.

Table 2-23: Key Observations

Key observation #1 AMU is a complex topic and different perceptions exist as to the current situation taking place in the Canadian beef industry	
Documented strengths	The presence of regulations at the federal level provides confidence that producers are doing the right things with respect to AMU
Documented risks	There are a variety of opinions and perceptions within the industry related to the performance of Canadian beef producers with respect to AMU that may not be fully informed by an objective assessment of the actual situation
Key observation #2 Ensuring the optimal management of AMU requires well-informed on-farm decisions and evidence suggests access to additional resources would be needed at the farm level	
Documented strengths	Most producers have adopted practices supporting the optimal management of AMU, including the establishment of VCPR
Documented risks	On-farm survey results indicate that room for improvement still exists with respect to the adoption of management practices, leading to potential risks with respect to optimal use of antimicrobials on farm

Key observation #1 – AMU is a complex topic and different perceptions exist as to the current situation taking place in the Canadian beef industry

By far, the topic of AMU is the one for which the industry informants interviewed as part of this assessment expressed the most varied opinions as to the industry's performance. For some, producers are doing well overall, mainly due to regulations and the existence of industry standards (Respondent 1, Respondent 4, Respondent 5, Respondent 7, Respondent 10). As one interviewee indicated, "As long as producers comply with withdrawal time and transportation regulations, all is good" (Respondent 10). In fact, part of the issue with AMU would be with respect to the communication to consumers.

<u>Quotes from the interviews</u>

"Producers are criticized regarding the use of antimicrobials, but what is the difference with people's health?" (Respondent 10)

"Farmers have no financial reasons of not using these products [antimicrobials] properly; consumers do not understand how high the standards are in Canada about the practices in place. It is more about telling the story" (Respondent 7)

"We need to continue to educate consumers on AMU" (Respondent 1)

That said, the same individuals, as well as many other interviewees, also expressed various concerns about how antimicrobials were used on farms. Some of these concerns relate to the cultural barrier and the shift that is still needed to change practices on-farm following changes to regulations.

Quotes from the interviews

"A good share of producers are not using medications the way they should. The thing is, regulations go against their culture / perception. They are pushing the boundaries on what people think they are doing" (Respondent 8)

"It is about a cultural shift" (Respondent 9)

"The only falling down is between diagnostic and treatment; treating things that do not require antimicrobials" (Respondent 2).

Some issues also seem to exist with respect to the level of education, training, and oversight on-farm. As one interviewee mentioned, "things slip" on large operations when it comes to injection techniques (Respondent 1).

However, these comments are based on perceptions, which can widely vary from one individual to another. For instance, one interviewee noted that a "better job could be made with respect to withdrawal time" (Respondent 1), while another mentioned that producers are "doing a great job" on this front (Respondent 2). The use of expressions such as 'a good share', 'some', 'many', etc. with no specific references to particular sources to characterize the extent to which these situations or behaviours are taking place also speaks to fact that these opinions may be informed by perceptions or piecemeal information. In fact, one of the interviewees answered that with respect to AMU, "I would have said that they [producers] are doing well… but ever since the COVID hit, I realize that people do not make the difference between a virus, an infection, and a parasite… so based on this observation, we do not understand how to use antimicrobials and the way they operate. Now I wonder the extent to which producers actually follow prescriptive advice?" (Respondent 6).

Such observations from key industry informants tend to show that the level of knowledge and understanding of the current situation taking place on-farm and at the industry level with respect to AMU and AMR may be insufficient. In which case, this could pose risks to the industry, as these perceptions or beliefs—whether positive or negative—may influence how decisions are made and messages communicated.

Key observation #2 – Ensuring the optimal management of AMU requires well-informed on-farm decisions and evidence suggests access to additional resources would be needed at the farm level

As noted above, federal regulations require all Canadian livestock producers, including beef farmers, to have a prescription from a licensed veterinarian with whom they have a valid VCPR before they can access medically important antibiotics (MIA) for use in livestock. Such practices are meant to ensure proper antimicrobial stewardship by allowing veterinarians to make clinical assessments and recommendations regarding the health of the animals and the need for medical treatment, and to arrange for follow-up evaluation. The objective is to determine whether using an antibiotic is the best course of treatment and, if so, to select the most appropriate drug, dose, duration, and route of administration to optimize treatment while minimizing the risk of resistance (Smith Thomas, 2017).

Preventing illness to reduce the need to use antimicrobials through proper preconditioning, low-stress weaning, vaccination (*see* Side-Box 1), nutrition and other practices supporting animal health and care should remain a primary objective for producers (see Section 2.2.3, Animal Care). However, antimicrobials remain a critical animal health tool and appropriate treatments made under the supervision of veterinarians may be required to contribute to animal health and care.

SIDE-BOX 1: VACCINE USAGE IN CANADIAN HERDS

Vaccination has been a proven tool for disease prevention for many years and it is an alternative to minimize the use of antimicrobials and antimicrobial resistance (BCRC, 2022b; Waldner, Parker, & Campbell, 2019). Even if they cannot provide absolute protection, vaccines can be a primary component of farmers' herd health programs and an effective tool for preventing the introduction and spread of many infectious diseases often treated with antimicrobials in cow–calf operations (e.g., respiratory disease and diarrhea in calves before weaning, respiratory disease in calves after weaning, and lameness in cows and bulls) (BCRC, 2022b; Waldner, Parker, & Campbell, 2019). Combined with other management components (e.g., biosecurity, nutrition and environmental management), having a vaccine program/protocol implemented in collaboration with a veterinarian and adapted to each herd is imperative (BCRC, 2022b; Lamothe, 2018). There are a wide variety of vaccines available for beef cattle and depending on the severity risk of disease, geographic differences in disease occurrence, exposure to other herds and the management system, the vaccination program could vary significantly (BCRC, 2022b; Lamothe, 2018).

According to multiple research studies conducted recently, the vast majority of producers do vaccinate their animals. In fact, 95% of western producers (WCCCS, 2018), 88% of Ontario cow–calf producers (OCC, 2018), and 73% of Atlantic cow-calf producers (Maritime Beef Council, 2018) answered they do vaccinate for at least one disease or condition. The Northern Beef Study also obtained similar results, with only 12% and 7% of respondents from Ontario and Quebec, respectively, reporting they don't vaccinate their cattle (Lamothe, 2018). For calves, the situation is more or less identical with 88% and 94% of respondents in Ontario and Quebec, respectively (Lamothe, 2018), and 80–90% of Western producers (WCCCS, 2018) reporting vaccinating their calves. These results demonstrate much higher rates of vaccine uptake than previous studies (Waldner, Parker, & Campbell, 2019). Furthermore, while producers followed different vaccination programs, multiple studies mention that the majority of producers vaccinate bulls, cows, heifers and calves against many of the common clostridial, respiratory and reproductive diseases (OCC, 2018; Waldner et al., 2013; Waldner, Parker, & Campbell, 2019; WCCCS, 2018).

While there has been improvement in usage of reproductive and respiratory viral vaccines since previous studies, there is still a need to increase producers' awareness regarding the use of vaccines to prevent spread of infectious diseases. Current information is needed by veterinarians and the beef industry to identify opportunities for improvements in infection prevention and control, and to provide benchmarks to motivate change in producers who have not yet adopted common vaccination practices (Waldner, Parker, & Campbell, 2019). Waldner, et al. also identify areas were more research is needed (e.g., to examine the cost-effectiveness of existing vaccines or to develop improved and affordable vaccines) (Waldner, Parker, & Campbell, 2019)[77].

Given the importance of this issue and the limited information collected during the 2016 NBSA, particular attention was paid during the preparation of the on-farm survey to effectively document the practices in place with respect to the use of antimicrobials which, in the context of the assessment, exclude ionophores (BCRC, 2022c)[78].

However, while interesting insights have been documented, some results have also been challenged by industry experts with respect to the situations in which antimicrobials are used on cow–calf or feedlot

[77] For example, two areas reported by Waldner et al. (2019), in which antimicrobials are commonly used, but vaccine uptake is limited, are foot rot in adult cows and diarrhea in calves (Waldner, Parker, & Campbell, 2019).

[78] Most antimicrobials used in Canadian beef production are ionophores, which are not considered to be medically important by the World Health Organization (BCRC, 2022c). Questions about antimicrobials in the on-farm survey clearly indicated that ionophores were not to be accounted for in the answers.

operations[79]. Furthermore, the complexity of this topic and the risk of confusion and misunderstanding of the questions makes it challenging to document through an online survey[80]. For this reason, results presented in this section focus on the management practices pertaining to AMU.

The context in which antimicrobials are used on farms is one of the key factors to consider with respect to AMU. When asked about the practices in place when using antimicrobials (excluding ionophores), 79% of respondents using antimicrobials[81] declared that 'veterinary and/or label instructions on how to administer the product are systematically followed'. Almost two thirds also said that the 'effectiveness of the treatment is always monitored' (63%), that 'antimicrobials are always selected in collaboration with a veterinarian' (60%), that 'records of antimicrobial use are kept' (59%), or that 'a diagnosis is always performed prior to using any antimicrobials' (57%) (Indicator 4.1). The on-farm survey results also indicate that 81% of respondents have a VCPR (Indicator 3.1). Only 13% of producers said they have tried or adopted novel alternatives to replace antimicrobials in the last three years (e.g., bacteriophage, phenolics, organic acids) (Indicator 4. 2). That said, other management strategies, including those aiming at reducing stressors which is a key factor resulting in immune suppression ultimately leading to increased risk of respiratory disease, are to be considered (*see* Section 3.1.7).

While these percentages are relatively high[82], even higher uptake would be desirable to ensure that an optimal management of AMU is achieved on-farm. While it is not possible based on these results to determine whether producers are practising appropriate use of antimicrobials with their animals, the management practices documented would indicate that **risks exist with respect to optimal use of antimicrobials on farm**.

---

[79] Personal communication with Respondent 18. For instance, the on-farm survey results suggest that about 25% of cow–calf producers are using antimicrobials (excluding ionophores) in a preventive way for cows and calves on grass (pre-weaning). Such results would contrast with those from other more specific research on these practices, knowing that well-fed calves on grass face low health risk that would require the preventive use of antimicrobials. Besides, preliminary results from an on-going research project involving field level data collection on 175 cow-calf operations across the country would show that antimicrobials are used in most herds (e.g., 88% of herds with pre-weaning calves), but only small proportions of animals are actually treated (e.g., less than 5% in the case of pre-weaning calves). A similar trend is observed with post-weaning calves (i.e., 60% of herds, less than 5% of animals being treated) and cows (e.g., 91% of herds, less than 5% of animals). These results, which are not yet published, would suggest that while nearly all herds use antimicrobials, very few animals actually receive them. Similarly, medically important antimicrobials were used for disease prevention in calves before weaning (14% of herds), cows (1.4% of herds) but not bulls (0% of herds).

[80] See (Hannon et al., 2020) for a review of some of the challenges and lessons learned from large-scale Canadian feedlot cattle AMU projects, including with respect to data collection.

[81] 15% of respondents answered 'Not applicable (I am not using antimicrobials)'.

[82] In fact, these results are higher than what industry experts expected (Respondent 18). This may be due to the high response rate from VBP+ and CRSB certified producers. For instance, Based the VBP+ database, 96% of VBP+ certified producers have a valid VCPR in place (VBP+, 2022). That said, 97% of the 75 producers who participated to the 2016 NBSA also reported having such relationship in place (CRSB, 2016a).

3. CONCLUSION

In the following section we present a summary of the key findings of the environmental, land use and social life cycle assessments (Section 3.1), implications of these results (Section 3.2) in the context of the targeted audience and in meeting the objectives of the study and finally, recommendations for next steps (Section 3.3) based on the results presented previously for the E-LCA, land use assessment and S-LCA, that will inform the strategy of the Canadian beef industry from a sustainability perspective.

3.1 SUMMARY OF KEY RESULTS

The following sections summarize the key findings from the study, along with their implications to the Canadian cattle sector. From the E-LCA and LU, key findings are divided into the three main categories identified in Figure 1-1, including global warming, resource use, and biodiversity and ecosystem quality. Following this, benchmarking on overall environmental performance is provided. From the S-LCA, implications with respect to the four deep-dive topics of labour management, people's health and safety, animal care, and antimicrobial use are discussed.

3.1.1 GLOBAL WARMING

A carbon footprint of 10.5 kg CO_2 eq/kg live weight was observed in the West, while in the East, a slightly lower value of 9.8 kg CO_2 eq/kg live weight was observed. Across both regions, the predominant contributors are enteric fermentation (62% West, 60% East), manure management, both during confinement when manure is stored and during grazing when manure is applied to land (17% West, 19% East), and feed rations (21% West, 21% East). Values were generally comparable to that of other beef production systems, with slightly lower values in the Canadian system caused by differences in Canadian production.

The proportion of enteric emissions of the overall carbon footprint generally increased since 2013/14 because dry matter intake also increased, despite an overall decrease in the enteric emissions themselves. Larger end-weights of the animals meant that DMI increased, directly affecting the amount of enteric methane produced per head per day compared to 2013/14. However, because production periods were also reduced, fewer emissions are released across the production period meaning that enteric emissions were lowered per kg live weight over the past 5 years. A similar decrease was seen in manure-related emissions as well due to shorter production periods. Feed rations were the third largest contributor to the carbon footprint in both the West and the East, primarily due to nitrogen fertilizer production and application.

A separate assessment was conducted to determine how the global warming impacts of beef production in Canada changes when the flow of dairy animals into the beef system is considered. The inclusion of dairy caused a 1–9% decrease in GHG emissions to 10.4 kg CO_2 eq/kg live weight in the West and 8.9 kg CO_2 eq/kg live weight in the East. The majority of impacts of dairy production is allocated to milk products, resulting in a lower attribution to beef. As a result, the carbon footprint is lowered when dairy beef is considered. This is why there is a more substantial reduction to the carbon footprint of Eastern production compared to Western. On the other hand, the lower proportion of beef coming from dairy animals and higher imports to the West result in the higher carbon footprint of Western production compared to Eastern. Between 2013/14 and 2021, the carbon footprint when dairy is included decreased due to the larger number of animals being imported in 2021. As a result, more impacts are allocated to the system of origin which is the United States beef system.

According to GWP*, which is not an LCA approach, the degradation of the sector's past methane emissions is currently dominant over the current sector emissions. This is due to decreasing methane emissions in the last 20 years, caused both by a reduced herd and increased efficiency in production. Therefore, the overall effect on the climate is a net cooling equivalent to 0.26 Mt CO_2 in 2021. Further reduction in emissions or herd size could continue the downward trajectory, perpetuating the cooling effect introduced by reduced biogenic emissions.

3.1.2 Other Environmental Indicators

The other E-LCA indicators considered in this study are fossil fuel depletion, water consumption, agricultural land use, freshwater eutrophication, terrestrial acidification, and photochemical oxidant formation. In general, values comparable to earlier beef life cycle assessments were found for each indicator. Some indicators varied slightly, but differences in Canadian production practices can explain these variations.

For some indicators, a lower impact was observed in the East compared to the West. In terms of fossil fuel depletion, 0.4 kg oil eq/kg live weight was observed in the West, while 0.3 kg oil eq/kg live weight was observed in the East. The difference in values between regions can be explained by differences in energy sources and quantity used to produce crops for feed rations, as well as differences in crop yields.

Similarly, a water consumption potential of 762 L/kg live weight was observed in the West, while a lower value of 90 L/kg live weight was observed in the East. The water consumption for Western production is comparable to the values found in literature for United States beef production that range between 1214-1748 L. A slightly more efficient use of water for irrigation in the Prairies can explain this difference. On the other hand, the considerably lower value in the East is due to non-existent irrigation on most crops.

Land use was another area where differences in production practices in the West and East create a substantial difference. In the West, a land use of 43.6 m^2a annual crop eq/kg live weight was observed, while in the East, a land use of 12.0 m^2a annual crop eq/kg live weight was observed. Extensive production practices dominate Western production, which means more land is required for backgrounding and grazing animals. In the East, more intensive production means that less land is required overall, however more land for feed production is used. As mentioned, this can have negative consequences for biodiversity and carbon soil sequestration due to the positive correlations between grazing and both habitat capacity and soil organic carbon levels.

The final three indicators of freshwater eutrophication (2.4 g P eq/kg live weight West, 3.9 g P eq/kg live weight East), terrestrial acidification (111 g SO_2 eq/kg live weight West, 144 g SO_2 eq/kg live weight East), and photochemical oxidant formation (8.8-8.9 g NO_x eq/kg live weight West, 8.3 g NO_x eq/kg live weight East) had minor differences between Western and Eastern production. Most values were comparable to literature, with differences in feed production practices, including fertilization and tillage, and manure management accounting for variations from literature and between regions.

3.1.3 Biodiversity and Ecosystem Quality

Biodiversity

The Potential Wildlife Habitat Capacity Index (WHCI) on Agricultural Land in Canada Agri-Environmental Indicator was developed by AAFC to provide a multi-species assessment of broad-scale trends in the capacity of the Canadian agricultural landscape to provide reproductive and feeding habitat for populations of terrestrial vertebrates. Cover types associated with the beef cattle industry were Oats, Barley, Triticale, Corn, Wheat, Unimproved Pasture, Improved Pasture, Grass and Hay, and Native Pasture. National reproductive WHCI decreased from 35.3 to 35.2 from 2016 to 2021. This overall decline was attributable to loss of important natural and semi-natural land cover (wetland, native grassland, unimproved pasture and improved pasture) combined with increases in cover types of significantly lesser value to wildlife (annual cropland and settlements). Specific to the beef sector, habitat capacity increased slightly from 5.5 to 5.6 from 2016 to 2021. The use of high biodiversity-value Native Grassland along with Unimproved pasture accounted for higher beef-specific habitat capacity in the Prairies. Increased reproductive and feeding habitat capacity is attributable to a greater share of natural and semi-natural cover types (Native Grassland, Unimproved Pasture and Improved Pasture) allocated to the beef cattle industry in 2021 compared to 2016.

In terms of the ABMI model, the results were not specific to the beef cattle industry and therefore causal relationships could not be defined. The indicators of represent species intactness and species richness were examined, both of which showed that species abundance has diverged since human disturbance, notably where the majority of cattle production happens to occur. This makes sense given the human population, infrastructure, and crop production that are also present in this part of the province. While the ABMI model cannot draw a connection between cattle production and species loss, it can conclude that the dense and agriculture-heavy lands in Alberta are subject to species loss. Furthermore, the analysis itself is meant to supplement the main analysis which uses the WHCI model as its basis. Therefore, it is recommended that future assessments consider emerging research from ABMI which considers feed rations in Alberta and are designed to be beef specific.

Water Risk

In addition to the assessment on water consumption, other water-related risks were considered. Three water risk indicators of baseline water depletion, drought risk, and interannual variability were examined with respect to cattle density. In general, the highest risks coincided with areas of high cattle density in the Prairies. Saskatchewan, parts of Alberta, and southern Manitoba are especially at risk.

In terms of baseline water depletion, annual water withdrawals are divided by available water to determine the level of competition among users in the region. The majority of baseline water depletion related risks occur in southern Saskatchewan and in smaller pockets in Alberta. Competition among users, including other agricultural sectors, is likely to be high in Saskatchewan during periods when irrigation is required.

Drought risk considers the hazards associated with low precipitation, exposure in terms of population and crops, and vulnerability with respect to drought infrastructure and economic factors. Again, the majority of drought risk was observed in southern Saskatchewan. While droughts are also a common occurrence in Alberta, presence of irrigation infrastructure in the province and growing investments into drought relief mean that the risk is not as elevated as it is for Saskatchewan. However, a limitation of this indicator is the lack of clarity surrounding which infrastructure components are included and the weighting given to social, economic, and infrastructure categories in general.

Finally, interannual variability considers the coefficient of variation of total blue water supply to determine unpredictability in the local supply. A risk of interannual variability is present across the country, however, most of it does not coincide with areas of high cattle concentration. Southern Manitoba is an exception, so producers in this region may face a growing number of water-related problems in the coming years.

It is worth noting that a more sophisticated and tailored approach may be necessary to gain in-depth insights into the water risks faced by the Canadian beef cattle industry. This includes, but is not limited to, consideration of water supply, management practices, precipitation changes, and water efficiency measures.

Carbon Soil Sequestration

The carbon soil sequestration approach evaluated carbon emissions or storage due to land management change (LMC) and land use change (LUC) associated with Canadian beef production. In this update, the carbon stock values were updated and refined with regionalized values for east and west. However, similar values of carbon stock for croplands and tame pasture are considered due to data limitations at this time. In future updates of the assessment, it is expected that a refined vision of carbon sequestration could be obtained with regionalised data and specific carbon stock change per crop, to better understand the contribution of the beef industry.

The carbon footprint of 10.5 kg CO_2 eq/kg live weight calculated in the baseline for the west is lowered to 9.9 kg CO_2 eq/kg live weight when considering carbon soil sequestration, which is lowered by 15% since

2013/14. The analysis demonstrates that beef cattle production represents 40% of the total agricultural land occupied as well as total carbon stock across Canada, highlighting that the average carbon stock intensity is relatively similar in croplands and pastures. The average carbon sequestered by cattle per kilogram of live weight in Canada was estimated to be an equivalent of 2.1 tonnes of CO_2 per kilogram of live weight to a 30 cm depth and represents 0.28 tonnes of carbon per hectare per year.

Of the land used for beef production, native grasslands contain over 40% and 66% more total soil carbon (Mt) at 30 cm depth than cropland and tame pastures, respectively. This is a reflection of the much greater acres of native grasslands used for beef production (see Figure 2-22). Restoration and maintenance of native prairie grasslands can also provide an opportunity to mitigate greenhouse gas (GHG) emissions through soil organic carbon (SOC) sequestration.

ANTIMICROBIAL AND GROWTH-ENHANCING TECHNOLOGY USE

Finally, an additional aspect considered was the potential environmental risks invoked by antimicrobial (AM) and growth-enhancing technology (GET) use. A qualitative, high-level assessment was made of current AM/GET use practices and potential environmental risks that could arise. In terms of Ams, the majority of administered drugs were designated Category II and III. Certain drugs in these categories, such as macrolides, tetracyclines, and sulfamethazine, do pose environmental risks due to long detection periods and mobility in water. Appropriate use of catch-basins can prevent run-off from feedlots. The use of Category IV Ams is another area of concern due to the use of ionophores, specifically monensin. However, the findings of the assessment were inconclusive due to the wide range of drugs within this category. On the other hand, the main GET of concern is ractopamine (RAC) due to its aquatic and airborne mobility long after treatment periods. A small portion of producers in the West do administer RAC in feedlots, which could be an environmental concern even at relatively low concentrations. As with Ams, catch basins and proper manure management practices can be employed to reduce this risk. Continued efforts to encourage the collection of on-farm AMU data through the Canadian Integrated Program for Antimicrobial Resistance Surveillance can help provide valuable objective information regarding AMU practices in the beef industry.

3.1.4 BENCHMARKING THE PERFORMANCE OF THE CANADIAN BEEF INDUSTRY

A comparison between the environmental impacts of production in 2021 and 2013/14 was conducted to understand the trajectory of the Canadian beef sector and to highlight both areas where large improvements have been made and areas where further action is needed. The percentage change from 2013/14 to 2021 for each E-LCA indicator examined in this study is shown in Figure 3-1. It should be noted that the data in the following figure includes beef production and excludes dairy production.

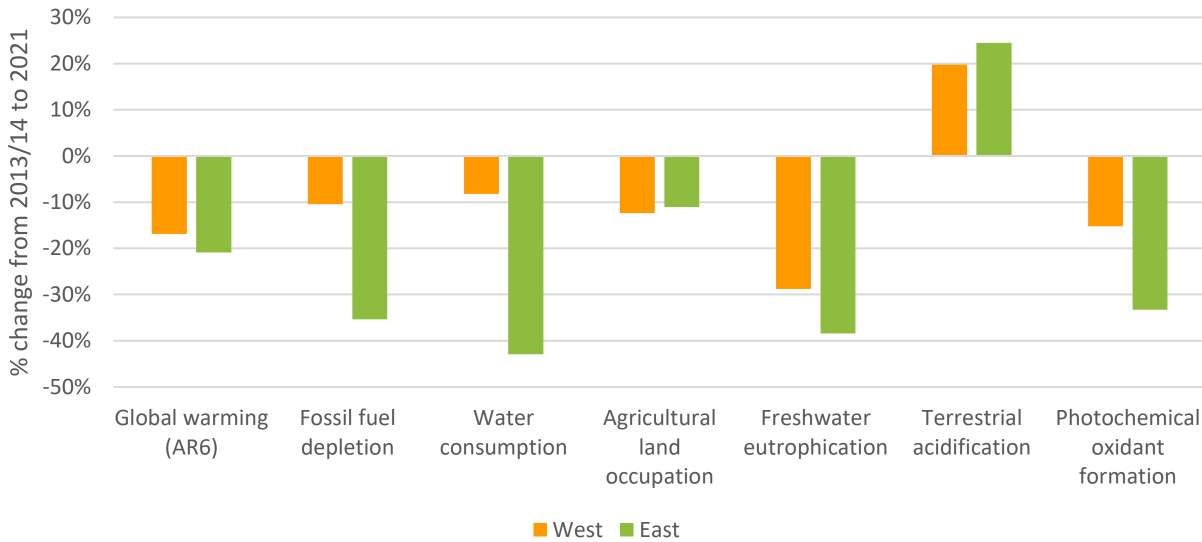


Figure 3-1: Percentage change from 2013/14 to 2021 for E-LCA indicators up to the farm gate.

In general, a reduction was observed across all indicators, other than terrestrial acidification, where an increase in impacts was observed. These differences are related to numerous changes to the beef production system from 2013/14 to 2021. The most impactful changes include the changes to production periods, including time on pasture and in confinement, the annual cohort, irrigation levels, and feed rations, which subsequently affect enteric and manure-related emissions.

Starting with the carbon footprint, as discussed previously, higher body weights and higher dry matter intake, led to proportionately higher enteric methane emissions, despite an overall decrease in emissions. However, shorter durations of production, including confinement, balance out this increase. These shorter production periods also led to reduced fossil fuel depletion, freshwater eutrophication, and photochemical oxidant formation. Slightly different feed rations can also account for these changes.

In terms of water consumption, a reduction was observed between 2013/14 and 2021 in both the West and the East by 68 L per kilogram of live weight. Increased feed efficiency is likely the cause of this reduction because irrigation levels and water consumption for drinking and cleaning remained relatively consistent between the years. Similarly, for land use, impacts were reduced 6.15 m^2a annual crop eq/kg live weight in the West and 1.89 m^2a annual crop eq/kg live weight in the East from 2013/14 to 2021. In general, the time on pasture over the entire production period in the West decreased from 383 days on pasture in 2013/14 to 318 days on pasture in 2021. A similar reduction from 280 days to 234 days was observed in the East as well. As a result, less grazing land is required during the production period. Additionally, lower mortality rates mean the ratio of grazing animals to non-grazing animals required to produce the functional unit is lower in 2021 than it was 2013/14. The cumulative result of these changes is a slight reduction in overall land use.

Finally, terrestrial acidification is the only indicator where an increase was observed between 2013/14 and 2021. The magnitude of this increased ranged from 18 g SO_2 eq/kg live weight in the West to 28 g SO_2 eq/kg live weight in the East. These impacts primarily come from manure-related ammonia emissions during confinement, which is determined by the amount of crude protein (CP) in feed. Since 2013/14, the average CP level of feed increased from 12% to 16% in both the West and East. As a result, the amount of ammonia emissions has also increased, thereby causing this increase in terrestrial acidification. It should be noted that the crude protein levels in feed are within the appropriate range, but higher protein levels could also explain the efficiency increases that reduced Impacts in other categories, including the carbon footprint. Therefore, this is a key trade-off for the industry to consider.

From a broad perspective, benchmarking has revealed a generally positive trajectory for the Canadian beef sector. The majority of indicators have seen a reduction due to increased efficiency in production signalled by higher end-weights and shorter production periods. However, there are trade-offs to consider as feed rations change to accommodate these changing efficiencies, particularly for terrestrial acidification.

3.1.5 LABOUR MANAGEMENT

Promoting responsible working conditions throughout the Canadian beef industry is instrumental to sustaining operations and contributing to the mental, emotional, and physical health of the individuals working at each stage of the value chain. This objective is becoming ever more acute and challenging due to labour shortages affecting the overall agri-food industry in Canada.

The overall challenge of labour management is experienced differently depending on the sector and the size of the operation. Whereas feedlots and packers are more directly facing issues related to recruitment and retention, cow–calf operations must consider this challenge in the context of farm succession.

The interviews conducted during the assessment show that there is a strong recognition within the industry of the importance and value of hired labour. However, labour management is also an area where improvements are, admittedly, needed with respect to sustainability.

While labour availability is outside the control of any one operation, the adoption of labour practices that focus on recruiting, training, and retaining domestic and foreign workers is instrumental to the future of the Canadian beef industry. Results from the assessment identify some of the areas where such efforts are made, as well as where challenges remain.

Specifically, three key observations come out of this assessment. First, results suggest that labour availability, recruitment and retention are inducing workload levels with potential negative repercussions on people working in the industry. While there is a broad awareness and recognition that labour management is a critical area requiring additional attention from everyone within the industry, each sector of the industry is facing risks related to labour management, with cow–calf operations being perceived as being particularly vulnerable.

Second, there is a recognition that sound labour management practices are needed to address workload levels and efforts are being made by individual businesses, both at the farm and packing plant levels. Specifically, on-farm survey results show that many farm operations with hired labour have adopted practices to support on-boarding (e.g., initial training, discussion about workers' rights and responsibilities) and to promote professional development of employees (e.g., involving employees in decision-making, providing skill development opportunities). However, very few farms have implemented measures to support communication and dispute resolution with employees, and the adoption rate of practices having the potential to limit the negative repercussions overtime may have on employees remains low at the farm level. In addition, recent research shows that im/migrant workers at packing plants may face particular risks with respect to their working conditions.

Lastly, the assessment suggests that farm and packing plant businesses need to consider innovative approaches to deal with workload levels and ensure job satisfaction for the people working in the industry. The strong and growing recognition within the industry of the importance and value of hired labour would benefit from improved communications between employers and employees with respect to labour management.

3.1.6 PEOPLE'S HEALTH AND SAFETY

Creating a culture of safety across the beef supply chain and reducing incidents through the support for education, awareness and improvements on farm and ranch safety are among the National Beef Strategy 2030 goals. Focusing on establishing healthy work environments is also critical in the industry's efforts to recruit and retain hired employees.

To achieve that goal, the industry can build on federal and provincial health and safety legislations that entitle all workers to basic occupational health and safety rights. However, raising livestock as well as packing and processing meat, are risky occupations. Promoting and adopting safety-oriented behaviours at each stage of the value chain remains an ongoing challenge, notably with respect to heavy workload, labour shortage, and high turnover rates. The COVID-19 pandemic also presented new risks to workers, especially at the packing-plant level.

The assessment shows that efforts are made by producers and packers to manage safety risks at the workplace. However, health and safety is also identified as an area that can be overlooked and where more dedicated efforts are needed, especially regarding training.

Specifically, results show that while efforts are made to manage people's health and safety hazards at the workplace, room for improvement remains with respect to the adoption of practices to prevent incidents, particularly on farms. In fact, there is a high degree of awareness and preparation with respect to people's health and safety in Canadian beef packing plants and on farm according to packers and producers. However, the adoption rate of many key practices remains low on Canadian beef farms, including on those with hired labour. Particular focus is needed with respect to training and the use of personal protective equipment (PPE). Also, given the physical and mental strains of working in packing plants, the occupational health and safety (OHS) programs are all the more important and a high priority, especially for at-risk populations.

Mental health is a growing concern in the Canadian farming community and received particular attention in this assessment. Results from the on-farm survey highlight that a significant proportion of producers experience disturbing stress due to their on-farm occupation. Unpredictability, financial pressure, public trust, and workload-related issues are among the main stressors inducing this situation. On the flip side, most farmers are adopting practices to manage their physical and mental fatigue. Increased awareness, particularly from the younger generation, also makes this issue less of a taboo.

3.1.7 ANIMAL CARE

Promoting excellence in animal care is one of CRSB's sustainability goals. To achieve this objective, the industry builds on federal and provincial regulations, on industry standards, such as the Code of Practice for the Care and Handling of Beef Cattle (Beef Code), the Verified Beef Production Plus (VBP+), the CRSB Sustainability standards, and on concerted efforts at the industry level. Third party audits taking place at packing plants also contribute to maintaining high standards in this area.

Animal care is instrumental to sustainable livestock businesses at the primary production and processing stages. In 2013/14, the assessment showed very low and low risks to animal welfare throughout the entire value chain. Building on this result, the current assessment looked more closely at some on-farm practices related to animal care to update and expand the review of producers' performance in this area.

Results led to two key observations. First, animal care is a topic that received particular attention within the Canadian beef industry over the years, with tangible and positive results. For instance, most producers consider the overall animal health's status of their herds as being stable or to have improved over the last three years, and there is a widespread recognition within the industry that healthy animals and welfare are instrumental in ensuring beef operations' financial viability over time. However, areas for improvement remain with respect to certain on-farm practices. In particular, the adoption rate of practices identified in the 2016 NBSA or as part of the CRSB's sustainability strategy, including the uptake and implementation of the Beef Code and the adoption of low-pain/low-stress techniques during typical procedures (e.g., castration) could still be increased. In addition, specific areas would require additional scrutiny, including animal transportation (on and off-farm), the management of newly arrived cattle on the farm, and how needle injections are performed.

Also, increased coordination and communication across businesses, sectors, and industries may be needed to ensure animal care throughout the cattle's life cycle. Specifically, the existence of federal regulations and industry standards help ensuring that animal care is achieved and maintained throughout the animals' life cycle. However, results suggest that coordination across businesses and supply chain stages is likely suboptimal to fully secure animal care throughout the animal's life cycle.

3.1.8 ANTIMICROBIAL USE

Available research results on antimicrobial use (AMU) and antimicrobial resistance (AMR) indicate that limited risks exist in the beef industry. The industry recognizes that responsible AMU is critically important to preserving their effectiveness over time and to protect animal and human health.

Supporting the further development, monitoring and dissemination of best practices regarding AMU is one of the 10 key continuous improvement goals of the CRSB's National Beef Sustainability Strategy. To attain that goal, the industry can build on research activities on AMU, AMR and antimicrobial alternatives, as well as on-farm AMU and AMR surveillance networks and programs.

Protecting the health of animals through optimal nutritional, health, weaning management, marketing, and biosecurity practices is key to antimicrobial stewardship. However, results from interviews with key informants and from the on-farm survey have identified opportunities for further improvements in that area (cf. Animal Care section).

AMU is a complex topic and different perceptions exist as to the current situation taking place in the Canadian beef industry. On the one hand, the presence of regulations at the federal level provides confidence that producers are doing the right things with respect to AMU. On the other hand, there is a variety of opinions and perceptions within the industry related to the performance of Canadian beef producers with respect to AMU that may not be fully informed by an objective assessment of the actual situation. This could pose risks to the industry, as these perceptions or beliefs—whether positive or negative—may influence how decisions are made and messages communicated.

Practically, ensuring the optimal management of AMU requires well-informed on-farm decisions and evidence suggests access to additional resources would be needed at the farm level. Survey results suggest that most producers have adopted practices supporting the optimal management of AMU, including the establishment of VCPR. That said, results also indicate that room for improvement exists with respect to the adoption of management practices, leading to potential risks with respect to optimal use of antimicrobials on farm. However, real barriers to antimicrobial stewardship exist, including access to veterinarians in some regions.

3.2 IMPLICATION OF RESULTS

The purpose of this current report is to update the baseline National Beef Sustainability Assessment published in 2016, benchmarking and providing a comprehensive update of the overall performance of the Canadian beef industry from environmental, social, and economic perspectives, presented in Section 3.1. The NBSA results comprise one of the main tools that the CRSB uses in developing messaging for their Environmental and Social Pillars and to inform the action items that will advance the journey of sustainability within the Canadian beef industry. This update will play a key role in developing a comprehensive approach to advancing initiatives that will further enhance the sustainability of the Canadian beef industry. An additional objective was to discuss progress and fill gaps from the previous assessment using the most current data and methodologies available.

The results of this current update to the NBSA also identifies key strengths and weaknesses that should be the focus of research, communication, policy, and other supply chain initiatives that the CRSB will be using to focus on areas that need attention over the coming years in order to meet the goals set out in the strategy.

STRENGTHS:

This updated project includes various new elements and analyses that are an enhancement to the baseline assessment carried out in 2016. Some the key strengths of this update, including those which address weaknesses from the previous assessment were:

- **New elements:** Inclusion of new elements and their analysis that were either identified as future recommendations in the previous assessment or have developed into key social issues for the beef industry in recent years. This included adding a case study of dairy cattle production to the carbon footprint assessment, antimicrobial resistance (AMR) due its potential implications on animal health and ecotoxicity and hence is considered both in the environmental and social assessments, and GWP* to address the growing interest for accounting of the net warming effect of short-lived climate forcer emissions.
  - GWP* was specifically developed for this assessment since methane, a short-lived climate pollutant, is one of the GHGs that dominates the potential life cycle impacts of beef production on climate change. This area of research is novel but also of importance in the context of the sector. The results of this analysis comprise a first attempt at understanding the implications of this indicator for the Canadian beef industry while also providing clarity on the application of GWP* to report impacts of its carbon footprint.
  - Through the inclusion of a more thorough assessment of AMU, we have a better understanding of responsible AMU, that plays a critical role in animal and human health. The results of this analysis will provide support for further development, monitoring and dissemination of best practices regarding AMU which is one of key highlights of the CRSB's National Beef Sustainability Strategy.
- **Regionalized data:** The current assessment made a conscious effort to improve the regional representation of the environmental performance of the Canadian beef production systems. In addition to carrying out a scenario analysis from a comparative perspective between the production systems in the East and West of Canada, the key indicators of water consumption in the E-LCA now include an improved representation of irrigation and carbon stocks for carbon soil sequestration in the land use assessment and were updated with datasets specific to the East and West to better understand the contribution of the beef industry.
- **Benchmarking:** Another aspect that has implications on the strengths of the findings of this work is related to the special efforts taken in benchmarking of the 2016 model for both the E-LCA and LU methodologies, as well as improvements to key parameters. This included recalculation of these parameters, e.g., feed rations, cohort model, irrigation data, and crop-specific data (Canfax Hay LCI project) that impacted the final results.
- **S-LCA approach:** The update of the social impacts of Canadian beef production was improved through the application of practical, targeted, and detailed assessment of specific topics that were developed by including a combination of several layers of approaches for data collection that included a scoping report, an on-farm and packer's survey, as well as the inclusion of pathways for impact assessment.
- **Collaboration:** The development of the NBSA is a unique case study of stakeholder engagement in agricultural sustainability projects wherein a diverse and interdisciplinary group of experts is involved

in providing technical guidance via the Scientific Advisory Committee and are invested in advancing the journey of sustainability within the Canadian beef industry.

WEAKNESSES:

The following are some key weaknesses of the findings that should be the focus of research and intentional deliberation in the next update:

- **Specificity to beef:** Certain elements of the environmental assessment included methodologies and approaches that were not specific to the Canadian beef industry. This included the water risk and biodiversity analyses in the land use assessment. This presents a limitation to derive a causal relationship between the results of these sections directly to activities of the beef industry.
- **Data limitations:** While efforts were made to achieve high-quality data throughout the assessment, the results of this update were also limited by data availability. This includes specific areas of carbon soil sequestration where crop and region-specific data could improve the implications for the beef industry. The beef cohort described in the assessment is improved since 2013/14 via discussions with experts, however, there remain discrepancies between the model and industry knowledge. The analysis of food waste, which is a focus of CRSB's strategy, did not have any improvements in this update mainly owing to data limitations related to confidentiality concerns within the processing sector. Additionally, phosphorus run-off estimates from manure were based on outdated data from Statistics Canada and are rough estimates based on body weight alone which did not account for diet, and would be an area of improvement for the next update. Hence, our overall recommendation to CRSB and its stakeholders is to develop a systematic data collection process in preparation for the next update to collect data for parameters (e.g., feed ration, soil carbon stock) that have the most significant contribution to the risks in the sustainability assessment, and to prioritize collaboration between different producer groups to optimize data collection.
- **Methodology:** The methodological weaknesses of this current update include those applied to AMU in the environmental assessment. The qualitative approach used surveyed which asked aMs were used, but not volumes of aMs used, or percentage of animals treated. Furthermore, it did not distinguish AMU practices between extensive (cow-calf) and intensive (feedlot) forms of production. Future sustainability updates would benefit from a more inclusive methodology based on discussions from industry experts to provide a link between AMU and ecosystem toxicity that can be included in the E-LCA.
- **Consumer concerns:** NBSA has never taken other production types (organic, grass-fed etc.) into account because of their small contribution to total production volume, however, these could be done as case studies given the misinformation among consumers about the relative environmental benefits of different beef production systems.
- **S-LCA:** In this update of the social performance of Canadian beef production, assessment took a bottom-up perspective and followed an iterative process. The implications are that the methodology departs to some extent from the prescribed methodology described in the S-LCA Guidelines. Moreover, the assessment covered a limited scope (e.g., respondents to questionnaires and interviews included employers, managers, industry experts, associations, etc. – but excluded employees), and results could not be readily compared to those from the 2016 NBSA and Implications of doing so include a limited.

Finally, the findings of the current report are used to discuss recommendations on action items and beneficial management practices (BMPs) to address these areas of concern or opportunity (see Section 3.3).

3.3 Recommendations and Next Steps

Recommendations developed through the findings from this study are presented in this section.

3.3.1 Environmental LCA

The E-LCA focused on several indicators and evaluated the results from a regional perspective which considered the distinct production systems in the East and West of Canada. In addition, scenarios involving calf-fed and yearling-fed production were considered. The results indicated various hotspots of concern, all of which were consistent with the previous assessment. Additionally, the update was improved by the inclusion of dairy cattle production, antimicrobial resistance (AMR) and the effect of GHGs on global warming through GWP*. As a result, the following recommendations can be made:

- Feed rations remain the most significant hotspot across numerous indicators. This includes fossil fuel depletion due to energy required for crop production, water consumption due to irrigation needs in the West, and freshwater eutrophication and photochemical oxidant formation due to fertilizer and pesticide use. In addition, nutrient quantities in the feed affect enteric emissions, which is the largest contributor to the carbon footprint of the beef industry, alongside of manure-related emissions. Optimization of both feed quantities and nutrients within rations to make feed-to-gain ratios more efficient and reduce emissions would result in lowering the contribution of feed to the life cycle and thereby to the overall carbon footprint.
- The consideration of safe and approved feed additives meant to reduce emissions could substantially reduce GHG emissions due to the influence of enteric methane. Among the strategies proposed, the investigational methane inhibitor 3-nitrooxypropanol (3-NOP; DSM Nutritional Products Ltd., Kaiseraugst, Switzerland) shows tremendous promise with reported 20–80% decreases in methane production. Therefore, further studies could investigate the efficacy of 3-NOP or similar strategies on enteric methane emissions mitigation in beef production systems in Canada (Aklilu W Alemu et al., 2021).
- Similarly, inputs associated with feed production, such as fertilizers, pesticides, and energy, are also of concern. Beneficial management practices, such as, Integrated Pest Management (IPM) and 4R Nutrient Stewardship, being implemented at the crop production level would not only reduce impacts without sacrificing productivity further along the value chain, but also have positive impacts on biodiversity and carbon soil sequestration efforts (Canadian Wildlife Federation, 2021).
- While water use for Canadian beef is already lower than many other beef production systems, it is much higher than other forms of livestock. Water for crop irrigation is the primary contributor, mainly in production systems in the West, which accounts for over 91% and therefore majority of total consumption. Efficiency measures, such as efficient equipment and systems for irrigation should be in place in the Prairies. Additional trade-offs, including the impacts of importing feed from regions requiring less irrigation, could also be considered in future assessments.
- Additional efficiency improvements for beef production should be considered. This includes precision feeding, feed additive adoption, and genetic improvements.
- It is not immediately clear if certain practices are the most sustainable, despite favourable environmental performance. For example, the calf-fed versus yearling-fed scenario assessment revealed generally higher impacts for the yearling-fed system, but it does not account for the biodiversity benefits lost from lack of grazing. Therefore, additional assessment of these scenarios that consider biodiversity, as well as economic and social factors, should be considered.

It is apparent that the recommendations go beyond the boundaries of beef production itself to include upstream value chain members, particularly crop producers. Deepened communication between all players would serve as a valuable and strategic tool moving forward as the beef industry continues to manage and improve its environmental performance.

3.3.2 LAND USE ASSESSMENT

The land use assessment considered various environmental implications from land used for beef production, including biodiversity, water risk, and carbon soil sequestration. In terms of biodiversity, an assessment using the Wildlife Habitat Capacity Indicator on Agricultural Land (WHCI) was conducted. It considered the land used for feed ration production and for grazing to understand habitat capacity for both feeding and reproductive purposes. The following recommendations can be made:

- In general, higher habitat capacity was found on land cover types used by beef cattle for grazing, rather than annual crops using to produce feed rations. Furthermore, increased habitat capacity was observed where greater proportions of grazing lands were allocated to beef cattle, while reductions in habitat capacity generally occurred where more land was allocated to annual crop cover types, which typically occurs at the cost of natural and semi-natural cover types. This implies that there is a strong link between biodiversity and grazing practices. Therefore, best management practices must be kept in place to ensure that grazing does not negatively affect wildlife and continues to support wildlife for feeding and breeding purposes.
- Grazing plays an important role for biodiversity, but proper management is key. Some beneficial management practices that are growing in importance in the industry include rotational grazing, understanding of stocking capacity and grazing days per acre, and soil health. These aspects should be further examined through technical assessments to understand their influence.

In terms of water risk, the assessment focused on three indicators: baseline water depletion, drought risk, and interannual variability. In general, the majority of the risk was observed in the Prairies, therefore the following recommendations could be considered:

- The water risk assessment did not consider cattle-specific water use at its baseline but looked at water demands throughout a given region. Therefore, a method capable of understand on-farm practices should be considered. This assessment should include grazing of animals near bodies of water, manure management on pasture, and the use of antimicrobials or other veterinary drugs that have mobility in water.
- Furthermore, as the risk of drought and changing precipitation patterns grows across Canada, but particularly in the West, a water risk assessment capable of assessing various scenarios of water availability, precipitation, and irrigation would help producers better plan for unexpected conditions.
- Finally, the water risk assessment should go beyond just beef producers to look at crop producers because irrigation for crop production was highlighted as a substantial concern in the E-LCA.

Finally, in terms of carbon soil sequestration, the assessment reiterated the findings from the biodiversity section that improved grassland management practices that increase net accumulation of carbon in grasslands are needed for their potential to minimize the rising concentration of atmospheric carbon dioxide. Sustainability projects, as outlined in the previous NBSA as well, should continue to focus on enhancing the general understanding of rangeland management practices, in particular how livestock grazing regulates carbon soil storage and sequestration in northern temperate grasslands. However, the approach is based on average values for carbon stock change due to land use change and land management change. The assessment considers similar values of GHG emissions due to LMC and LUC for croplands and tame pasture due to data limitations. A refined vision of carbon sequestration could be obtained with regionalized data and specific carbon stock change per crop, to better understand the contribution of the beef industry.

3.3.3 SOCIAL LCA

The social life cycle assessment focused on several indicators and looked at four key social issues of labour management, peoples' health and safety, animal care and antimicrobial use (AMU). The results indicated a few risks and various areas for improvements were identified. As a result, the following recommendations can be made.

Specifically, the assessment on labour management looked at the working conditions provided to the people working in the industry (including farm owners and family members) and the extent to which these conditions contribute to their overall well-being. Based on the key risks identified through the assessment, the following recommendations are suggested to CRSB:

- Put people's well-being at the forefront of the CRSB's sustainability agenda and communicate to members and stakeholders a clear definition of what this means for the industry.
- Ensure that employees' contribution to the industry's success, the advantages of remote living, and clear career paths are fully recognized through internal and external communications to increase people's interest in the industry.
- Document the motivations for and the expectations of the younger generations to work in the Canadian beef industry.
- Identify, at each stage of the industry, champions innovating in the area of labour management and communicate about their success stories to inform and inspire other employers in their own operations.
- Actively seek out and evaluate projects that recognize excellence or advancement in labour management or skills-building as a key industry long-term viability principle and a forum where others can learn.
- Collaborate with national and provincial groups to develop and/or promote resources (training material, communication tools, forums) adapted to regional or local needs to help producers adopt best practices, pool ideas, and build their reputation of being an employer of choice.

Ensuring people's health and safety through the promotion and maintenance of the highest degree of physical, mental, and social well-being and capabilities of all the individuals involved in business operations is another central theme in this assessment. In spite the efforts made to manage this issue in the industry, potential risks were identified through the assessment. To address these, the following recommendations are made:

- Collaborate with national and provincial organizations to develop and/promote health and safety training at the farm level, including stress and fatigue management. Build on the research results regarding mental health and the main stressors affecting beef producers' and their employees' well-being to develop/promote targeted and adapted resources. Promote future research about the health and quality of life benefits (for farmers, their employees and for processing plant workers) and less on the risks associated with high stress levels.
- Document the lessons learned during the COVID-19 pandemic regarding labour management, in particular at the level of packing plants, to identify opportunities to improve employees' safety and well-being.

- Establish clear expectations as to what basic practices are expected to take place on farms regarding health and safety, in particular for vulnerable groups of employees (e.g., basic specifications to be added in work contracts and/or job description).
- Identify champions innovating in the area of health and safety and communicate their success stories to inform and inspire other employers in their own operations.
- Create a culture of health and safety through inviting engaging participation in safety related topics through media that are already widely adopted and trusted by farmers (e.g., town halls, Facebook live). These strategies may differ for different age groups, genders, and regions, and can focus on achievable, short, and cost-effective solutions.
- Create and/or promote awareness of worker's rights and human rights in languages and forums well suited to the targeted audience.
- Foster the capacity and desire for workers to build their own resilience, considering themes that include, but are not limited to, being more than a farmer/worker and engaging in sports, social roles, and hobbies through online/in-person communities already established and trusted by the industry (e.g., social platforms and conferences).

Animal care, which is about providing for the physical and mental well-being of animals to ensure their welfare, came up as a topic that received particular attention within the Canadian beef industry over the years, with tangible and positive results. Yet, the assessment documented certain risks to address, which informed the following recommendations:

- Take advantage of the publication of the new Beef Code (to be updated in 2023 and released in 2025) to inform and train producers and their employees about best practices for animal care.
  - Collaborate with packers, feedlot operations and transport companies to ensure best practices are in place and channels are established to provide feedback and continuous improvement of animal care.
  - Develop business cases documenting the impacts and interactions (synergies, trade-offs) existing between animal care, people's well-being, and business profitability.
- Investigate the potential impacts and risks associated with labour shortage on the industry's ability to meet and maintain performance in animal care.
- Develop, in collaboration with veterinarians, tools to improve early diagnostics (for any health issue, e.g., automated detection strategy and protocols).
- Research the drivers and success factors associated with the adoption of key BMPs among VBP+ certified producers and explore how they could be applied to conventional beef farmers.

Antimicrobial use was the fourth and last social issue considered in the social assessment. While instrumental for ensuring animal health in livestock agriculture, improper use can have adverse effects on animals, human health, and the environment. Accordingly, the assessment looked specifically at management of AMU, and results show that areas for improvement exist. For this reason, the following recommendations are made:

- Promote awareness of the resources available that outline responsible antimicrobial use within the industry for industry stakeholders and consumers.
- Create or promote engaging education opportunities for responsible antimicrobial administration and biosecurity management practices that utilize two-way communication strategies between associations and producers, and among producers with each other.

- Collaborate further with industry members to improve communication and transparency between cattle buyers and sellers and explore incentives to support practices that target responsible antimicrobial use.
- Identify from the CRSB projects inventory champions innovating in the area of animal health and communicate about their success stories to inform and inspire other producers in their own operations, in particular regarding the use of alternatives to antimicrobials.
- Continue to promote collaborative initiatives monitoring AMU and AMR trends over time in commercial feedlot settings, as well as veterinary antimicrobial dispensing data, based on unified approaches.
- Continue to promote antimicrobial stewardship to preserve their effectiveness and alleviate consumer concerns.

4. References

AARD. (2010). *Evaluating environmental and economic impact for beef production in Alberta using life cycle analysis*.

ABMI. (2021). *About ABMI Data*. https://www.abmi.ca/home/data-analytics/DA-top-about-data/About-ABMI-Data.html

Aboagye, I. A., Cordeiro, M. R. C., McAllister, T. A., & Ominski, K. H. (2021). Productivity-enhancing technologies. Can consumer choices affect the environmental footprint of beef? *Sustainability (Switzerland)*, *13*(8), 1–19. https://doi.org/10.3390/su13084283

ADP Canada. (n.d.). *Employment Standards in Provinces and Territories*. Retrieved July 25, 2022, from https://www.adp.ca/en/resources/compliance-and-legislation/employment-standards-in-canada/provinces-and-territories.aspx

AgriShield. (n.d.). *My AgriShield: Ressources - People: Occupational health and safety*. Retrieved July 28, 2022, from https://app.myagrishield.ca/en/account/login

Alberta Cattle Feeders' Association, & Alberta Beef Producers. (2019). *Alberta Beef Industry Competitiveness*. https://cattlefeeders.ca/wp-content/uploads/2020/01/ab-beef-industry-competitiveness.pdf

Alemu, A W, Iwaasa, A. D., Kröbel, R., & McConkey, B. (2017). 294 Productivity and carbon sequestration potential of reestablished native grassland in Canadian prairie following grazing. *Journal of Animal Science*, *95*(suppl_4), 145–146. https://doi.org/10.2527/asasann.2017.294

Alemu, Aklilu W, Kröbel, R., McConkey, B. G., & Iwaasa, A. D. (2019). Effect of Increasing Species Diversity and Grazing Management on Pasture Productivity, Animal Performance, and Soil Carbon Sequestration of Re-Established Pasture in Canadian Prairie. In *Animals* (Vol. 9, Issue 4). https://doi.org/10.3390/ani9040127

Alemu, Aklilu W, Pekrul, L. K. D., Shreck, A. L., Booker, C. W., McGinn, S. M., Kindermann, M., & Beauchemin, K. A. (2021). 3-Nitrooxypropanol Decreased Enteric Methane Production From Growing Beef Cattle in a Commercial Feedlot: Implications for Sustainable Beef Cattle Production . In *Frontiers in Animal Science* (Vol. 2).

Aljoe, H. (2019, December 26). *How to hire, motivate, retain employees*. Beef Magazine. https://www.beefmagazine.com/human-resources/how-hire-motivate-retain-employees

Allen, A. M., & Hof, A. R. (2019). Paying the price for the meat we eat. *Environmental Science and Policy*, *97*(February), 90–94. https://doi.org/10.1016/j.envsci.2019.04.010

American Humane. (2016, October 17). *Five Freedoms: the gold standard of animal welfare*. https://www.americanhumane.org/blog/five-freedoms-the-gold-standard-of-animal-welfare/

Andrés-Lasheras, S., Ha, R., Zaheer, R., Lee, C., Booker, C. W., Dorin, C., Van Donkersgoed, J., Deardon, R., Gow, S., Hannon, S. J., Hendrick, S., Anholt, M., & McAllister, T. A. (2021). Prevalence and Risk Factors Associated With Antimicrobial Resistance in Bacteria Related to Bovine Respiratory Disease—A Broad Cross-Sectional Study of Beef Cattle at Entry Into Canadian Feedlots. *Frontiers in Veterinary Science*, *8*(692646), 710. https://doi.org/10.3389/FVETS.2021.692646/BIBTEX

Anele, U. Y., Domby, E. M., & Galyean, M. L. (2014). Predicting dry matter intake by growing and finishing beef cattle: Evaluation of current methods and equation development. *Journal of Animal Science*, *92*(6), 2660–2667. https://doi.org/10.2527/JAS.2014-7557

Angerer, V., Sabia, E., König von Borstel, U., & Gauly, M. (2021). Environmental and biodiversity effects of different beef production systems. *Journal of Environmental Management*, *289*(April). https://doi.org/10.1016/j.jenvman.2021.112523

Angulo, F. J., Nargund, V. N., & Chiller, T. C. (2004). Evidence of an Association Between Use of Anti-microbial Agents in Food Animals and Anti-microbial Resistance Among Bacteria Isolated from Humans and the Human Health Consequences of Such Resistance. *Journal of Veterinary Medicine, Series B*, *51*(8–9), 374–379. https://doi.org/10.1111/J.1439-0450.2004.00789.X

Arvidsson Segerkvist, K., Hansson, H., Sonesson, U., & Gunnarsson, S. (2021). A Systematic Mapping of Current Literature on Sustainability at Farm-Level in Beef and Lamb Meat Production. *Sustainability*, *13*(2488), 1–14. https://doi.org/10.3390/su13052488

Asem-Hiablie, S., Battagliese, T., Stackhouse-Lawson, K. R., & Alan Rotz, C. (2019). A life cycle assessment of the environmental impacts of a beef system in the USA. *International Journal of Life Cycle Assessment*, *24*(3), 441–455. https://doi.org/10.1007/s11367-018-1464-6

Aust, M. O., Godlinski, F., Travis, G. R., Hao, X., McAllister, T. A., Leinweber, P., & Thiele-Bruhn, S. (2008). Distribution of sulfamethazine, chlortetracycline and tylosin in manure and soil of Canadian feedlots after subtherapeutic use in cattle. *Environmental Pollution*, *156*(3), 1243–1251. https://doi.org/10.1016/j.envpol.2008.03.011

AWCBC. (2022). *Statistics*. National Work Injury/Disease Statistics Program (NWISP). https://awcbc.org/en/statistics/

Bailey, D. W., Mosley, J. C., Estell, R. E., Cibils, A. F., Horney, M., Hendrickson, J. R., Walker, J. W., Launchbaugh, K. L., & Burritt, E. A. (2019). Synthesis Paper: Targeted Livestock Grazing: Prescription for Healthy Rangelands. *Rangeland Ecology and Management*, *72*(6), 865–877. https://doi.org/10.1016/j.rama.2019.06.003

Barry, S., & Huntsinger, L. (2021). Rangeland land-sharing, livestock grazing's role in the conservation of imperiled species. *Sustainability (Switzerland)*, *13*(8), 1–20. https://doi.org/10.3390/su13084466

Basarab, J., Baron, V., López-Campos, Ó., Aalhus, J., Haugen-Kozyra, K., & Okine, E. (2012). Greenhouse Gas Emissions from Calf- and Yearling-Fed Beef Production Systems, With and Without the Use of Growth Promotants. *Animals : An Open Access Journal from MDPI*, *2*(2), 195–220. https://doi.org/10.3390/ANI2020195

Bassi, E. M., Goddard, E., & Parkins, J. R. (2019). "That's the Way We've Always Done It": A Social Practice Analysis of Farm Animal Welfare in Alberta. *Journal of Agricultural and Environmental Ethics*, *32*(335), 335–354. https://doi.org/10.1007/s10806-019-09777-0

BC SPCA. (n.d.). *Laws for farm animals*. Retrieved August 2, 2022, from https://spca.bc.ca/ways-to-help/take-action/farm-animals/laws-for-animals/

BCRC. (2018a, October 22). *Q&A on conventional production of Canadian Beef*. Beef Cattle Research Council (BCRC). https://www.beefresearch.ca/blog/qa-on-conventional-production-of-canadian-beef/

BCRC. (2018b, December 19). *Does Antibiotic Resistance Move Through the Environment?* Canadian Cattlemen Magazine. https://www.beefresearch.ca/blog/does-antibiotic-resistance-move-through-the-environment/

BCRC. (2019a). *BCRC 2013-2018 Results Report*. https://www.beefresearch.ca/files/pdf/BCRC_2013-2018_research_results_report_march_2019.pdf

BCRC. (2019b). *Adoption Rates of Recommended Practices by Cow-Calf Operators in Canada*. https://www.beefresearch.ca/content/uploads/2022/04/Adoption_Rates_of_Recommended_Practices_by_Cow-Calf_Operators_in_Canada_-_March_2019_Final.pdf

BCRC. (2019c, September 17). *On-Farm Antimicrobial Surveillance Moves a Step Closer*. Beef Research Council (BCRC). https://www.beefresearch.ca/blog/on-farm-antimicrobial-surveillance-moves-a-step-closer/

BCRC. (2021). *Five-Year Canadian Beef Research & Technology Transfer Strategy*. https://www.beefresearch.ca/files/pdf/Five_Year_Canadian_Beef_Research_and_Technology_Transfer_Strategy_July_2021_web.pdf

BCRC. (2022a). *Transport*. https://doi.org/10.2527/JAS.2011-4771

BCRC. (2022b). *Vaccination of the Beef Herd*. https://www.beefresearch.ca/topics/vaccination-of-the-beef-herd/

BCRC. (2022c, January 10). *Antibiotic Resistance*. https://www.beefresearch.ca/research-topic.cfm/antibiotic-resistance-11

BCRC. (2022d, May 19). *Updated Livestock Transport Regulations and What You Need to Know*. https://www.beefresearch.ca/blog/updated-livestock-transport-regulations/

BCRC, & Alberta Beef Producers. (2018). *The way you purchase antibiotics is changing*. www.beefresearch.ca/AMR

Beauchemin, K. a., Henry Janzen, H., Little, S. M., McAllister, T. a., & McGinn, S. M. (2010). Life cycle assessment of greenhouse gas emissions from beef production in western Canada: A case study. *Agricultural Systems*, *103*(6), 371–379. https://doi.org/10.1016/j.agsy.2010.03.008

Beef Farmers of Ontario. (n.d.). *Wellness on the Farm*. Retrieved July 29, 2022, from https://www.ontariobeef.com/services/wellness-on-the-farm.aspx

Beef Farmers of Ontario. (2021). *Beef Farmers of Ontario: Research Investment Strategy 2021-2024*. https://www.ontariobeef.com/uploads/userfiles/files/2021_01_15 bfo 2021-2024 research strategy.pdf

Bendixsen, C. (2020, July 29). *Cultivate Safety: Benefits of Farm Work*. National Farm Medicine Center. https://cultivatesafety.org/benefits-of-farm-work/

Beukers, A. G., Zaheer, R., Cook, S. R., Chaves, A. V., Ward, M. P., Tymensen, L., Morley, P. S., Hannon, S., Booker, C. W., Read, R. R., & McAllister, T. A. (2018). Comparison of antimicrobial resistance genes in feedlots and urban wastewater. *Canadian Journal of Veterinary Research*, *82*(1), 24. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5764045/pdf/cjvr_01_24.pdf

Bianchi, M., Strid, A., Winkvist, A., Lindroos, A. K., Sonesson, U., & Hallström, E. (2020). Systematic evaluation of nutrition indicators for use within food LCA studies. *Sustainability (Switzerland)*, *12*(21), 1–18. https://doi.org/10.3390/su12218992

Bock, B., & Buller, H. (2013). Healthy, Happy and Humane: Evidence in Farm Animal Welfare Policy. *Sociologia Ruralis*, *53*(3), 390–411. https://doi.org/10.1111/SORU.12011

Booker, C. W. (2020). Bovine respiratory disease treatment failure: definition and impact. *Animal Health Research Reviews*, *21*(2), 172–174. https://doi.org/10.1017/S146625232000016X

Boyce, M. (2019). Adapting Grassland Grazing to Boost Carbon Sequestration. *Scientia*. https://doi.org/10.33548/scientia451

Bragg, B. (2021). *"NO SAFE PLACE" Documenting the migration status and employment conditions of workers in Alberta's meatpacking industry during the pandemic* . 44. https://actiondignity.org/wp-content/uploads/2021/09/NO-SAFE-PLACE_FINAL.pdf

Brymer, A. L. B., Paul Bryant, Bentley Brymer, A. L., Toledo, D., Spiegal, S., Pierson, F., Clark, P. E., & Wulfhorst, J. D. (2020). Social-Ecological Processes and Impacts Affect Individual and Social Well-Being in a Rural Western U.S. Landscape. *Frontiers in Sustainable Food Systems*, *4*(38). https://doi.org/10.3389/fsufs.2020.00038

CAHRC. (n.d.). *CAHRC Commodity Dashboard*. Retrieved May 11, 2022, from https://app.powerbi.com/view?r=eyJrIjoiNDQyYTQ1MDgtY2QyNC00MmZmLTlhNWEtNzIzOGJmNDYyNmI2IiwidCI6ImM2OTdmYTEzLTY4OGQtNDEzNS1hMzgxLWFkNDEyMDY2ZWQ3YSIsImMiOjZ9

CAHRC. (2018). *Beef Industry Labour Market Forecast to 2025*.

CAHRC. (2021). *How Labour Challenges Will Shape the Future of the 'Beef' Industry: Agriculture Forecast to 2029*. https://cahrc-ccrha.ca/sites/default/files/2021-11/Beef_reduced size_E.pdf

CAHRC. (2022, April 8). *Strategic Plan announced to address labour and skills shortages in agriculture and food and beverage manufacturing*. https://cahrc-ccrha.ca/cahrc/news-releases/strategic-plan-announced-address-labour-and-skills-shortages-agriculture-and

Cameron, A., & McAllister, T. A. (2016). Antimicrobial usage and resistance in beef production. *Journal of Animal Science and Biotechnology*, *7*(68), 1–22. https://doi.org/10.1186/s40104-016-0127-3

Canadian Cattle Association. (n.d.). *Animal Care*. Retrieved May 10, 2022, from https://www.cattle.ca/resources/producer-resources/animal-care

Canadian Food Inspection Agency. (2021). *Provincial and territorial legislation concerning farm animal welfare*. Government of Canada. https://inspection.canada.ca/animal-health/humane-transport/provincial-and-territorial-legislation/eng/1358482954113/1358483058784

Canadian Trucking Alliance. (2022, April 4). *Members of Food Supply Chain Raise Driver Shortage Concerns*. https://cantruck.ca/members-of-food-supply-chain-raise-driver-shortage-concerns/

Canadian Wildlife Federation, D. U. C. (2021). Eight (8) Recommended Priority Actions for the Next Policy Framework for Canadian Agriculture. *White Paper*, *8*, 1–13.

Canfax Research. (2021). *COP Analysis 2021 Results Summary*. 1–10.

CAPI. (2012). *Canada's Beef Food System: A Roadmap for Dialogue on Strategy*. http://www.wsga.ca/pdf/CAPI_Beef-Food-System_2012.pdf

Capper, J. L. (2011). The environmental impact of beef production in the United States: 1977 compared with 2007. *Journal of Animal Science*, *89*(12), 4249–4261. https://doi.org/10.2527/JAS.2010-3784

Cargill. (n.d.). *Animal Welfare at Cargill*. Retrieved May 11, 2022, from https://www.cargill.com/meat-poultry/animal-welfare-at-cargill

Cargill Canada. (n.d.). *Meat Processing*. Retrieved September 13, 2022, from https://www.cargill.ca/en/meat-processing

CASA CAIR. (2016). *Canadian Agricultural Injury Reporting: Agriculture-Related Fatalities in Canada*. https://www.casa-acsa.ca/wp-content/uploads/CASA-CAIR-Report-English-FINAL-Web.pdf

CASA CAIR. (2020). *Seniors (60+ Years) Agriculture-Related Fatalities 2006-2015*. https://www.casa-acsa.ca/wp-content/uploads/CASA-CAIR-Agriculture-Seniors-ENGLISH-2.pdf

CAST. (2018). *Scientific, Ethical, and Economic Aspects of Farm Animal Welfare CAST*. https://www.cast-science.org/wp-content/uploads/2018/04/CAST_R143_Animal-Welfare.pdf

CBC News. (2017, March 8). *Working overtime? Here's how it affects your health*. https://www.cbc.ca/news/canada/british-columbia/working-overtime-here-s-how-it-affects-your-health-1.4011045

CBC News. (2020). *Atlantic Beef Products seeing increased demand after Alberta plant closure* . https://www.cbc.ca/news/canada/prince-edward-island/pei-atlantic-beef-products-increased-demand-covid-19-1.5541526

CCA. (2019). *When Antibiotics Fail*. https://www.cca-reports.ca/wp-content/uploads/2018/10/When-Antibiotics-Fail-1.pdf

CCOHS. (2019). Supporting Farmer's Mental Health. *Volume 17 Issue 9 Canadian Centre for Occupational Health and Safety*. https://www.ccohs.ca/newsletters/hsreport/issues/2019/09/ezine.html

CCOHS. (2022a). *Health and Safety Report*. *17*(09). https://www.ccohs.ca/newsletters/hsreport/issues/2019/09/ezine.html#hsreport-tipstools

CCOHS. (2022b). *OSH Answers - Health and Safety Programs: First Aid - General*. https://www.ccohs.ca/oshanswers/hsprograms/firstaid_general.html

CCOHS. (2022c). *OSH Answers - Health and Safety Programs: Hierarchy of Controls*. https://www.ccohs.ca/oshanswers/hsprograms/hierarchy_controls.html

CDC. (2022). *Combating Antimicrobial Resistance in People and Animals: A One Health Approach*. Centers for Disease Control and Prevention. https://www.cdc.gov/onehealth/in-action/combating-ar-in-people-and-animals.html

Ceballos, M. C., Sant'Anna, A. C., Boivin, X., Costa, F. de O., Carvalhal, M. V. d. L., & Paranhos da Costa, M. J. R. (2018). Impact of good practices of handling training on beef cattle welfare and stockpeople attitudes and behaviors. *Livestock Science*, *216*, 24–31. https://doi.org/10.1016/J.LIVSCI.2018.06.019

Cedillo, L., Lippel, K., & Nakache, D. (2019). Factors Influencing the Health and Safety of Temporary Foreign Workers in Skilled and Low-Skilled Occupations in Canada. *New Solutions*, *29*(3), 422–458. https://doi.org/10.1177/1048291119867757

CFFI. (2021). *2021 Public Trust Research*. https://www.foodintegrity.ca/wp-content/uploads/2021/11/2021-ENG-Public-Trust-Research-Report-3.pdf

CFIA. (2015). *Frequently Asked Questions: Health of Animals Regulations*. https://inspection.canada.ca/about-cfia/acts-and-regulations/list-of-acts-and-regulations/faq-health-of-animals-regulations/eng/1426694335122/1426694360491

CGIAR-CSI. (2015). *Consortium for Spatial Information: Global Aridity and PET Database*. http://www.cgiar-csi.org/data/global-aridity-and-pet-database

Chai, L., Krobel, R., Henry Janzen, H., Beauchemin, K. A., McGinn, S. M., Bittman, S., Atia, A., Edeogu, I., MacDonald, D., & Dong, R. (2014). A regional mass balance model based on total ammoniacal nitrogen for estimating ammonia emissions from beef cattle in Alberta Canada. *Atmospheric Environment*, 292–302.

Challis, J. K., Sura, S., Cantin, J., Curtis, A. W., Shade, K. M., McAllister, T. A., Jones, P. D., Giesy, J. P., & Larney, F. J. (2021). Ractopamine and Other Growth-Promoting Compounds in Beef Cattle Operations: Fate and Transport in Feedlot Pens and Adjacent Environments. *Environmental Science and Technology*, *55*(3), 1730–1739. https://doi.org/10.1021/acs.est.0c06450

Chen, Z., An, C., Fang, H., Zhang, Y., Zhou, Z., Zhou, Y., & Zhao, S. (2020). Assessment of regional greenhouse gas emission from beef cattle production: A case study of Saskatchewan in Canada. *Journal of Environmental Management*, *264*(February), 110443. https://doi.org/10.1016/j.jenvman.2020.110443

Conant, R. T., Cerri, C. E. P., Osborne, B. B., & Paustian, K. (2017). Grassland management impacts on soil carbon stocks: a new synthesis. *Ecological Applications*, *27*(2), 662–668. https://doi.org/https://doi.org/10.1002/eap.1473

Cook, D. A., & Artino, A. R. (2016). Motivation to learn: an overview of contemporary theories. *Medical Education*, *50*(10), 997–1014. https://doi.org/10.1111/MEDU.13074

Cormier, A. C., Chalmers, G., Cook, S. R., Zaheer, R., Hannon, S. J., Booker, C. W., Read, R. R., Gow, S. P., Mcallister, T. A., & Boerlin, P. (2020). Presence and Diversity of Extended-Spectrum Cephalosporin Resistance Among Escherichia coli from Urban Wastewater and Feedlot Cattle in Alberta, Canada. *Microbial Drug Resistance*, *26*(3), 300–309. https://doi.org/10.1089/MDR.2019.0112

Creutzinger, K., Pempek, J., Habing, G., Proudfoot, K., Locke, S., Wilson, D., & Renaud, D. (2021). Perspectives on the Management of Surplus Dairy Calves in the United States and Canada. *Frontiers in Veterinary Science*, *8*, 344. https://doi.org/10.3389/FVETS.2021.661453/BIBTEX

CRSB. (2016a). *National Beef Sustainability Assessment: Environmental and Social Assessments*. *June*, 400. https://crsb.ca/assets/Uploads/About-Us/Our-Work/NBSA/8e68cb86c3/NBSA-EnvironmentalAndSocialAssessments.pdf

CRSB. (2016b). *National Beef Sustainability Assessment and Strategy: Summary Report*. https://crsb.ca/wp-content/uploads/2021/12/Assessment-and-Strategy_summary_report_2016.pdf

CRSB. (2020a). *National Beef Sustainability Strategy: Interim Progress Report*. 1–51.

CRSB. (2020b). *Sustainable Beef Processing Standard v1.1* . https://www.crsbcertified.ca/assets/Uploads/Framework-Documents/CRSB-Sustainable-Beef-Processing-Standard_v1.1.pdf

CRSB. (2020c). *Sustainable Beef Production Standard v1.1* . https://www.crsbcertified.ca/assets/Uploads/Framework-Documents/CRSB-Sustainable-Beef-Production-Standard-v1.1.pdf

CRSB. (2021a). *Animal Health and Care Goals*. https://crsb.ca/wp-content/uploads/2021/11/FACTSHEET_2030-Goals_Animal-Health-Care.pdf

CRSB. (2021b). *Benchmarks - Goals & Progress* . https://crsb.ca/benchmarks/goals-progress/

CRSB. (2021c). *Canadian Beef Advisors – Industry Goals to 2030: People Health and Safety*. https://crsb.ca/wp-content/uploads/2021/11/FACTSHEET_2030-Goals_People-Health-and-Safety.pdf

CRSB. (2022). *CRSB Annual repport - 2022*. https://crsb.ca/wp-content/uploads/2022/08/2022_07_CRSB_annualreport_english_web-1.pdf

CRSC. (2020a). *Canadian Grains Sustainability Metrics Platform*. http://metrics.sustainablecrops.ca/

CRSC. (2020b). *Labour Relations : Social Responsibility*. http://metrics.sustainablecrops.ca/home/criterion/5

CRSC. (2020c). *Work Safety & Security : Social Responsibility*. http://metrics.sustainablecrops.ca/home/criterion/11

CRSC. (2020d). *Working Conditions : Social Responsibility*. http://metrics.sustainablecrops.ca/home/criterion/12

CSMOTA. (2021). *Diagnostic sectoriel de l'industrie de la transformation alimentaire du Québec*. https://cdn.ca.yapla.com/company/CPYMRwu2vJ6WoYs0CTkZFUGBK/asset/files/Diagnostic_CSMOTA_Rapport_Final.pdf

Cui, X., Wang, Y., Niu, H., Wu, J., Wang, S., Schnug, E., Rogasik, J., Fleckenstein, J., & Tang, Y. (2005). Effect of long-term grazing on soil organic carbon content in semiarid steppes in Inner Mongolia. *Ecological Research*, *20*(5), 519–527. https://doi.org/https://doi.org/10.1007/s11284-005-0063-8

Davies, J., & Davies, D. (2010). Origins and Evolution of Antibiotic Resistance. *Microbiology and Molecular Biology Reviews*, *74*(3), 1092–2172. https://doi.org/10.1128/MMBR.00016-10

Del Prado, A., Manzano, P., & Pardo, G. (2021). The role of the European small ruminant dairy sector in stabilising global temperatures: lessons from GWP* warming-equivalent emission metrics. *Journal of Dairy Research*, *88*(1), 8–15. https://doi.org/10.1017/S0022029921000157

Dominati, E. J., Mackay, A. D., Rendel, J. M., Wall, A., Norton, D. A., Pannell, J., & Devantier, B. (2021). Farm scale assessment of the impacts of biodiversity enhancement on the financial and environmental performance of mixed livestock farms in New Zealand. *Agricultural Systems*, *187*(June 2020), 103007. https://doi.org/10.1016/j.agsy.2020.103007

Dong, R. L., Zhao, G. Y., Chai, L. L., & Beauchemin, K. A. (2014). Prediction of urinary and fecal nitrogen excretion by beef cattle. *Journal of Animal Science*, *92*(10), 4669–4681. https://doi.org/10.2527/jas.2014-8000

Doreau, M., Corson, M. S., & Wiedemann, S. G. (2021). *Water use by livestock: A global perspective for a regional issue? 2*(2). https://doi.org/10.2527/af.2012-0036

Dreyer, L. C., Hauschild, M. Z., & Schierbeck, J. (2006). A Framework for Social Life Cycle Impact Assessment. *The International Journal of Life Cycle Assessment*, *11*(2), 88–97. https://doi.org/10.1065/lca2005.08.223

Drozdowski, N. (2021, March 16). *Decades of effort does little to reduce the rate of fatal injuries for farm kids*. University of Alberta; Academic Press Inc. https://doi.org/10.1016/j.ypmed.2020.106233

EC. (2011). International Reference Life Cycle Data System (ILCD) Handbook - Recommendations for Life Cycle Impact Assessment in the European context. In *European Commission - Joint Research Centre - Institute for Environment and Sustainability* (First edit). Publications Office of the European Union. https://doi.org/10.278/33030

ECCC. (2022). *NATIONAL INVENTORY REPORT 1990–2020: GREENHOUSE GAS SOURCES AND SINKS IN CANADA PART 2*. https://unfccc.int/documents/461919

Ellingsen, K., Coleman, G. J., Lund, V., & Mejdell, C. M. (2014). Using qualitative behaviour assessment to explore the link between stockperson behaviour and dairy calf behaviour. *Applied Animal Behaviour Science*, *153*, 10–17. https://doi.org/10.1016/J.APPLANIM.2014.01.011

EMEP/EEA. (2013). *Air pollutant emission inventory guidebook — European Environment Agency*. https://www.eea.europa.eu/themes/air/air-pollution-sources-1/emep-eea-air-pollutant-emission-inventory-guidebook

Estrada, J. M. (2016, May 24). *Employee turnover: A measure of your people management philosophy*. Progressive Dairy. https://www.agproud.com/articles/19868-employee-turnover-a-measure-of-your-people-management-philosophy

FAO. (2003). *FAO Food and Nutrition paper 77. Food energy - methods of anlysis and conversion factors* (FAO (ed.)). FAO Food and Agriculture organization of the United Nations.

FAO. (2016). *Environmental Performance of Large Ruminant Supply Chains*.

FCC. (2020). *Rooted in strength: Taking care of our families and ourselves*. https://www.fcc-fac.ca/fcc/knowledge/wellness/mental-health-publication-e.pdf

FCC Market Insights. (2020). *Canadian Ag Safety Study - Highlights*. https://www.casa-acsa.ca/wp-content/uploads/2020_Ag_Safety_Study_NationalResults.pdf

FMC, & Wilton Consulting Group. (2020). *Healthy Minds, Healthy Farms - Exploring a Connection between Mental Health and Farm Business Management*.

Food and Beverage Canada. (n.d.). *Food and Beverage Associations Present Revised Emergency Foreign Worker Program Proposal*. Retrieved May 31, 2022, from https://fbc-abc.com/food-and-beverage-associations-present-revised-emergency-foreign-worker-program-proposal/

Food Processing Skills Canada. (2019). *Securing Canada's Meat Workforce - Executive Summary*. www.fpsc-ctac.com

Forrest, F., Lorenz, K., Thompson, T., Keenliside, J., Kendall, J., & Charest, J. (2011). A scoping study of livestock antimicrobials in agricultural streams of Alberta. *Canadian Water Resources Journal*, *36*(1), 1–16. https://doi.org/10.4296/cwrj3601001

Foster, J., & Barnetson, B. (2020). Cargill, COVID, and the failure of Alberta OHS policy. *Parkland Institute*. https://doi.org/10.3138/CPP.2018-014

Fraser, D. (1995). Science, Values and Animal Welfare: Exploring the "Inextricable Connection." *WBI Studies Repository*, 103–117. https://www.wellbeingintlstudiesrepository.org/cgi/viewcontent.cgi?article=1036&context=acwp_awap

Fraser, D. (2008). Understanding animal welfare. *Acta Veterinaria Scandinavica*. https://doi.org/10.1186/1751-0147-50-S1-S1

Fukasawa, M., Kawahata, M., Higashiyama, Y., & Komatsu, T. (2017). Relationship between the stockperson's attitudes and dairy productivity in Japan. *Animal Science Journal*, *88*(2), 394–400. https://doi.org/10.1111/ASJ.12652

Furber, D. (2017, March 28). *Facing up to pain in cattle*. Canadian Cattlemen. https://www.canadiancattlemen.ca/features/facing-up-to-pain-meloxicam-brings-comfort-to-cattle-and-producers/

Gao, J., & Carmel, Y. (2020). A global meta-analysis of grazing effects on plant richness. *Agriculture, Ecosystems and Environment*, *302*(June), 107072. https://doi.org/10.1016/j.agee.2020.107072

Gerbens-Leenes, P. W., Mekonnen, M. M., & Hoekstra, A. Y. (2013). *The water footprint of poultry, pork and beef: A comparative study in different countries and production systems $ Water Resources and Industry*. https://doi.org/10.1016/j.wri.2013.03.001

Gooch, M. (2012). *Motivating and Enabling Value Chain Innovation in Canada's Agri-Food Industry*. https://vcm-international.com/wp-content/uploads/2013/04/Motivating-and-Enabling-Value-Chain-Innovation.pdf

Gosnell, H., Emard, K., & Hyde, E. (2021). Taking Stock of Social Sustainability and the U.S. Beef Industry. *Sustainability*, *13*(21), 11860. https://doi.org/10.3390/SU132111860

Government of Alberta. (2018). *Alberta Farm Safety Program: A Farm Employer's Guide to Employee Orientation and Training*. https://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/aet16699/$FILE/AF_FarmSafety_Employer_Training_Manual_WEB.pdf

Government of Alberta. (2021a). *Workplace injuries, diseases & fatalities in Alberta 2019*. https://open.alberta.ca/dataset/3bea9097-eb0a-44f2-9e15-acbc93984abd/resource/0e0e5027-d5c1-49c6-a0f8-7f0efd52aab9/download/lbr-workplace-injuries-diseases-fatalities-in-alberta-2019.pdf

Government of Alberta. (2021b). *Workplace injury, illness and fatality statistics : Provincial summary 2019*. https://open.alberta.ca/dataset/4fb90b70-7660-4553-98fc-a59574f8fd5a/resource/5e959e64-50f5-41d4-b5a7-c5db093835f1/download/lbr-2019-workplace-injury-illness-fatality-provincial-summary-2019.pdf

Government of Canada. (2019). *Health of Animals Act*.

Government of Canada. (2022). *Program requirements for low-wage positions: Two-year employment duration for meat processors pilot*. https://www.canada.ca/en/employment-social-development/services/foreign-workers/median-wage/low/requirements.html#h2.8a

Government of Manitoba. (2022). *Manitoba Workplace Safety and Health Act and Regulation*. https://www.gov.mb.ca/labour/safety/pdf/whs_workplace_safety_act_and_regs.pdf

Government of Ontario. (2022). *Occupational Health and Safety Act, R.S.O. 1990, c. O.1*. https://www.ontario.ca/laws/statute/90o01

Government of Quebec. (2022). *Act Respecting Occupational Health and Safety*. https://www.legisquebec.gouv.qc.ca/en/pdf/cs/S-2.1.pdf

Government of Saskatchewan. (1996). *The Occupational Health and Safety Regulations, 1996*. https://www.canlii.org/en/sk/laws/regu/rrs-c-o-1.1-reg-1/latest/rrs-c-o-1.1-reg-1.pdf

Government of Saskatchewan. (2013). *The Saskatchewan Employment Act*. https://www.canlii.org/en/sk/laws/stat/ss-2013-c-s-15.1/latest/ss-2013-c-s-15.1.pdf

Gow, S., Bergen, R., Booker, C., Butters, A., Clinic, C. V., & Producers, A. B. (2021). *National surveillance of antimicrobial use and antimicrobial resistance in Canadian feedlots*.

Grant, T. (2017, October 27). Canada's deadliest jobs . *The Globe and Mail*. https://www.theglobeandmail.com/news/investigations/fishing-methodology-deadliest-sector-canada/article36725323/

Greenext. (2015). *Greenext© hybrid LCA method and knowledge database*.

GRSB. (2018). *GRSB Statement on Antimicrobial Stewardship*. *June*, 255027.

Hagen, B. N. M., Sawatzky, A., Harper, S. L., O'sullivan, T. L., & Jones-Bitton, A. (2021). What Impacts Perceived Stress among Canadian Farmers? A Mixed-Methods Analysis. *International Journal of Environmental Research and Public Health 2021, Vol. 18, Page 7366*, *18*(14), 7366. https://doi.org/10.3390/IJERPH18147366

Hannon, S. J., Brault, S. A., Otto, S. J. G., Morley, P. S., McAllister, T. A., Booker, C. W., & Gow, S. P. (2020). Feedlot Cattle Antimicrobial Use Surveillance Network: A Canadian Journey. *Frontiers in Veterinary Science*, *7*(November), 1–10. https://doi.org/10.3389/fvets.2020.596042

Harmony Beef. (n.d.). *Harmony Beef - Quality Products*. Retrieved May 11, 2022, from https://www.harmonybeef.ca/quality-products

Health Canada. (2009). *Categorization of Antimicrobial Drugs Based on Importance in Human Medicine - Canada.ca*. https://www.canada.ca/en/health-canada/services/drugs-health-products/veterinary-drugs/antimicrobial-resistance/categorization-antimicrobial-drugs-based-importance-human-medicine.html

Health Canada. (2019). Canada's Dietary Guidelines for Health Professionals and Policy Makers. In *Health Canada*. https://food-guide.canada.ca/static/assets/pdf/CDG-EN-2018.pdf

Heuston, C. E. (2017). *Epidemiology of Compromised and Unfit Cattle Arriving at Auction Markets and Abattoirs in Alberta*. https://harvest.usask.ca/bitstream/handle/10388/8582/HEUSTON-THESIS-2018.pdf?sequence=1&isAllowed=y

Hilton, W. M. (2022). Nutritional Requirements of Beef Cattle . In *Merck Veterinary Manual*. https://www.merckvetmanual.com/management-and-nutrition/nutrition-beef-cattle/nutritional-requirements-of-beef-cattle

Hofmann, N., & Beaulieu, M. S. (2006). *A Geographical Profile of Manure Production in Canada, 2001*. https://publications.gc.ca/Collection/Statcan/21-601-MIE/21-601-MIE2006077.pdf

Hofste, R., Kuzma, S., Walker, S., Sutanudjaja, E., Bierkens, M., Kuijper, M., Faneca Sanchez, M., Van Beek, R., Wada, Y., Galvis Rodríguez, S., & Reig, P. (2019). Aqueduct 3.0: Updated Decision-Relevant Global Water Risk Indicators. *World Resources Institute*, *July*, 1–53. https://doi.org/10.46830/writn.18.00146

Huijbregts, M. A. J., Steinmann, Z. J. N., Elshout, P. M. F., Stam, G., Verones, F., Vieira, M., Zijp, M., Hollander, A., & van Zelm, R. (2017). ReCiPe2016: a harmonised life cycle impact assessment method at midpoint and endpoint level. *The International Journal of Life Cycle Assessment*, *22*(2), 138–147. https://doi.org/10.1007/s11367-016-1246-y

IDF. (2015). *A common carbon footprint approach for the dairy sector* (Issue 479). https://doi.org/10.1016/s0958-6946(97)88755-9

INSPQ. (2022). *Blessures à la ferme*. https://www.inspq.qc.ca/securite-prevention-de-la-violence-et-des-traumatismes/prevention-des-traumatismes-non-intentionnels/dossiers/blessures-la-ferme

IPCC. (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, & P. M. Midgley (eds.)). Cambridge University Press. https://www.ipcc.ch/report/ar5/wg1/

IPCC. (2018). Annex I: Glossary. In *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change,* (pp. 541–562). Cambridge University Press. https://doi.org/10.1017/9781009157940.008

IPCC. (2019). *Chapter 10 Emissions from Livestock and Manure Management*. https://www.ipcc.ch/site/assets/uploads/2018/07/WGI_AR5.Chap_.8_SM.pdf

IPCC. (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, & B. Zhou (eds.)). Cambridge University Press. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf

ISO. (2010). *Guidance on Social Responsibility: ISO 26000*. https://documentation.lastradainternational.org/lsidocs/3078-ISO 26000_2010.pdf

ISO. (2014). *ISO 14046:2014, Environmental management — Water footprint — Principles, requirements and guidelines*. https://www.iso.org/obp/ui/#iso:std:iso:14046:ed-1:v1:en

ISO. (2020a). *ISO 14040:2006/AMD 1:2020 Environmental management — Life cycle assessment — Principles and framework* (p. 54). International Organization for Standardization.

ISO. (2020b). *ISO 14044:2006/AMD 1:2017/AMD 2:2020 Environmental management — Life cycle assessment — Requirements and guidelines* (p. 7). International Organization for Standardization.

JBS Canada. (2020). *Sustainable Food Report A Journey of Continuous Improvement and Performance*. https://jbs-foods-site-uploads.s3.us-east-2.amazonaws.com/bd2ac8b3-e071-41a0-a12a-75dc88e86d77/JBSCanadaSustainability.pdf

JBS USA. (2021). *Sustainability Report: Animal Care*. https://sustainability.jbsfoodsgroup.com/chapters/animal-care/

Johnson, J. E., & Lascano, G. J. (2014, February 6). *Don't overlook the intangibles: Intrinsic, extrinsic motivation*. Ag Proud - Progressive Dairy. https://www.agproud.com/articles/24790-don-t-overlook-the-intangibles-intrinsic-extrinsic-motivation

Jones-Bitton, A., Best, C., MacTavish, J., Fleming, S., & Hoy, S. (2019). Stress, anxiety, depression, and resilience in Canadian farmers. *Social Psychiatry and Psychiatric Epidemiology*, *55*(2), 229–236. https://doi.org/10.1007/s00127-019-01738-2

Jones-Bitton, A., Hagen, B., & Thompson, R. (2022). *Farmer Mental Health in Canada Worsened During Pandemic, U of G Research Finds*. University of Guelph. https://news.uoguelph.ca/2022/06/farmer-mental-health-in-canada-worsened-during-pandemic-u-of-g-research-finds/

Khara, T. (2020). Animals suffer for meat production – and abattoir workers do too. *The Conversation*. https://theconversation.com/animals-suffer-for-meat-production-and-abattoir-workers-do-too-127506

Kilgo, J. C., Vukovich, M., Scott Ray, H., Shaw, C. E., & Ruth, C. (2014). Coyote removal, understory cover, and survival of white-tailed deer neonates. *The Journal of Wildlife Management*, *78*(7), 1261–1271. https://doi.org/10.1002/JWMG.764

Kleppel, G. S. (2020). Do Differences in Livestock Management Practices Influence Environmental Impacts? *Frontiers in Sustainable Food Systems*, *4*(September), 1–15. https://doi.org/10.3389/fsufs.2020.00141

Kuehne, G., Llewellyn, R., Pannell, D. J., Wilkinson, R., Dolling, P., Ouzman, J., & Ewing, M. (2017). Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy. *Agricultural Systems*, *156*, 115–125. https://doi.org/10.1016/J.AGSY.2017.06.007

Lacewell, R. (2018). *SDC354: Animal Production Systems: Synthesis of Methods to Determine Triple Bottom Line*

Sustainability from Findings of Reductionist Research. https://agrilife.org/s1032/files/2013/09/SDC354_Revised.pdf

Lamothe, S. (2018). *Northern Beef Study: Northern Ontario and Northern Québec Cow-Calf Production*. https://www.uqat.ca/beef-symposium-production/doc/northen-beef-study.pdf

Larney, F., & Larney, F. (2021). *Do synthetic hormones used in beef production have environmental effects when excreted ?* 1–2.

Lebbink, G., Dwyer, J. M., & Fensham, R. J. (2021). Managed livestock grazing for conservation outcomes in a Queensland fragmented landscape. *Ecological Management and Restoration*, *22*(1), 5–9. https://doi.org/10.1111/emr.12460

Legesse, G., Beauchemin, K. A., Ominski, K. H., McGeough, E. J., Kroebel, R., MacDonald, D., Little, S. M., & McAllister, T. A. (2015). Greenhouse gas emissions of Canadian beef production in 1981 as compared with 2011. *Animal Production Science*, *56*(3), 153–168. https://doi.org/10.1071/AN15386

Legesse, G, Cordeiro, M. R. C., Ominski, K. H., Beauchemin, K. A., Kroebel, R., McGeough, E. J., Pogue, S., & McAllister, T. A. (2018). Water use intensity of Canadian beef production in 1981 as compared to 2011. *Science of the Total Environment*, *619–620*, 1030–1039. https://doi.org/10.1016/j.scitotenv.2017.11.194

Legesse, Getahun, Cordeiro, M. R. C., Ominski, K. H., Beauchemin, K. A., Kroebel, R., McGeough, E. J., Pogue, S., & McAllister, T. A. (2018). Water use intensity of Canadian beef production in 1981 as compared to 2011. *Science of The Total Environment*, *619–620*, 1030–1039. https://doi.org/10.1016/J.SCITOTENV.2017.11.194

Legesse, Getahun, Kroebel, R., Alemu, A. W., Ominski, K. H., McGeough, E. J., Beauchemin, K. A., Chai, L., Bittman, S., & McAllister, T. A. (2018). Effect of changes in management practices and animal performance on ammonia emissions from Canadian beef production in 1981 as compared with 2011. *Canadian Journal of Animal Science*, *98*(4), 833–844. https://doi.org/10.1139/cjas-2017-0184

Lhermie, G., Verteramo Chiu, L., Kaniyamattam, K., Tauer, L. W., Scott, H. M., & Gröhn, Y. T. (2019). Antimicrobial Policies in United States Beef Production: Choosing the Right Instruments to Reduce Antimicrobial Use and Resistance Under Structural and Market Constraints. *Frontiers in Veterinary Science*, *0*, 245. https://doi.org/10.3389/FVETS.2019.00245

Lhermie, G., Wernli, D., Jørgensen, P. S., Kenkel, D., Lin Lawell, C. Y. C., Tauer, L. W., & Gröhn, Y. T. (2019). Tradeoffs between resistance to antimicrobials in public health and their use in agriculture: Moving towards sustainability assessment. *Ecological Economics*, *166*. https://doi.org/10.1016/J.ECOLECON.2019.106427

Little, S., Linderman, J., Maclean, K., & Janzen, H. (2008). *HOLOS–a tool to estimate and reduce greenhouse gases from farms. Methodology and algorithms for versions 1.1*.

Little, Shannan, Beauchemin, K., Janzen, H., Kroebel, R., & Maclean, K. (2013). *Holos - A tool to estimate and reduce GHGs from farms* (Issue Version 2.0).

Liu, S., Proudman, J., & Mitloehner, F. M. (2021). Rethinking methane from animal agriculture. *CABI Agriculture and Bioscience 2021 2:1*, *2*(1), 1–13. https://doi.org/10.1186/S43170-021-00041-Y

Loans Canada. (2021). *Minimum Wage In Canada 2021* . https://loanscanada.ca/minimum-wage/

Lynch, J., Cain, M., Pierrehumbert, R., & Allen, M. (2020). Demonstrating GWP*: a means of reporting warming-equivalent emissions that captures the contrasting impacts of short- and long-lived climate pollutants. *Environmental Research Letters*, *15*(4), 044023. https://doi.org/10.1088/1748-9326/AB6D7E

Manning, P., Gossner, M. M., Bossdorf, O., Allan, E., Zhang, Y. Y., Prati, D., Blüthgen, N., Boch, S., Böhm, S., Börschig, C., Hölzel, N., Jung, K., Klaus, V. H., Klein, A. M., Kleinebecker, T., Krauss, J., Lange, M., Müller, J., PAŠALIć, E., … Fischer, M. (2015). Grassland management intensification weakens the associations among the diversities of multiple plant and animal taxa. *Ecology*, *96*(6), 1492–1501. https://doi.org/10.1890/14-1307.1

Maritime Beef Council. (2018). *2017 Atlantic Cow-Calf Production Survey: Aggregate Results* . https://bovinsnbcattle.ca/wp-content/uploads/2018/05/2017-Atlantic-Cow-Calf-Survey-Final-Report.pdf

McDonald, S. E., Lawrence, R., Kendall, L., & Rader, R. (2019). Ecological, biophysical and production effects of incorporating rest into grazing regimes: A global meta-analysis. *Journal of Applied Ecology*, *56*(12), 2723–2731. https://doi.org/10.1111/1365-2664.13496

Mellor, D. J. (2016). Updating Animal Welfare Thinking: Moving beyond the "Five Freedoms" towards "A Life Worth Living." *Animals*, *6*(3), 21. https://doi.org/10.3390/ani6030021

Moggy, M., Pajor, E. A., Thurston, W. E., Parker, S., Greter, A. M., Schwartzkopf-Genswein, K. S., Campbell, J. R., & Windeyer, M. C. (2017a). Management practices associated with pain in cattle on western Canadian cow–calf operations: A mixed methods study. *Journal of Animal Science*, *95*(2), 958–969. https://doi.org/10.2527/JAS.2016.0949

Moggy, M., Pajor, E. A., Thurston, W. E., Parker, S., Greter, A. M., Schwartzkopf-Genswein, K. S., Campbell, J. R., & Windeyer, M. C. (2017b). Management practices associated with stress in cattle on western Canadian cow–calf operations: A mixed methods study. *Journal of Animal Science*, *95*(4), 1836–1844. https://doi.org/10.2527/JAS.2016.1310

Moggy, M., Pajor, E., Thurston, W., Parker, S., Greter, A., Schwartzkopf-Genswein, K., Campbell, J., & Windeyer, M. C. (2017c). Attitudes of western Canadian cow-calf producers towards the Code of Practice for the Care and Handling of Beef Cattle. *The Canadian Veterinary Journal*, *58*(11), 1209–1211.

Moya, D. (2020). *Current and future welfare issues of the beef cattle industry*. https://www.mvma.ca/wp-content/uploads/2020/02/Current-and-future-welfare-issues-of-the-beef-cattle-industry-Diego-Moya-CenCan2020.pdf

National Beef Quality Audit. (2018). *2016/17 Plant Carcass Audit*. https://www.beefresearch.ca/files/pdf/NBQA-Carcass-Audit-Mar-27-2018-F.pdf

Natural Resources Canada's Office of Energy Efficiency. (2012). *Energy Consumption of Major Household Applicances Shipped in Canada - Trends for 1990-2010*. https://publications.gc.ca/collections/collection_2011/rncan-nrcan/M141-16-2008-eng.pdf

Nekouei, O., Checkley, S., Waldner, C., Smith, B. A., Invik, J., Carson, C., Avery, B., Sanchez, J., & Gow, S. (2018). Exposure to antimicrobial-resistant Escherichia coli through the consumption of ground beef in Western Canada. *International Journal of Food Microbiology*, *272*(October 2017), 41–48. https://doi.org/10.1016/j.ijfoodmicro.2018.02.022

NFACC. (n.d.). *Codes of Practice Under Revision: Transportation*. Frontiers Media S.A. https://doi.org/10.3389/FVETS.2019.00036/FULL

NFACC. (2013). *Code of Practice for the Care and Handling of Beef Cattle* . https://www.nfacc.ca/pdfs/codes/beef_code_of_practice.pdf

OCC. (2018). *Ontario Cow-Calf Production Survey Aggregate Results*. https://www.beefresearch.ca/files/pdf/Ontario Cow-Calf Summary Nov 12 2018.pdf

OECD. (2011). *Compendium of OECD Well-Being Indicators*. https://www.oecd.org/sdd/47917288.pdf

Ontl, T. A., & Schulte, L. A. (2012). Soil Carbon Storage. *Nature Education Knowledge*, *3*(10), 35. https://www.nature.com/scitable/knowledge/library/soil-carbon-storage-84223790/

Ostle, N. J., Levy, P. E., Evans, C. D., & Smith, P. (2009). UK land use and soil carbon sequestration. *Land Use Policy*, *26*, S274–S283. https://doi.org/https://doi.org/10.1016/j.landusepol.2009.08.006

Owens, J. L., Thomas, B. W., Stoeckli, J. L., Beauchemin, K. A., McAllister, T. A., Larney, F. J., & Hao, X. (2020). Greenhouse gas and ammonia emissions from stored manure from beef cattle supplemented 3-nitrooxypropanol and monensin to reduce enteric methane emissions. *Scientific Reports*, *10*(1), 1–14. https://doi.org/10.1038/s41598-020-75236-w

PACNEXT. (2014). *Summary of eleven global EPR programs*.

Persson, U. M., Johansson, D. J. A., Cederberg, C., Hedenus, F., & Bryngelsson, D. (2015). Climate metrics and the carbon footprint of livestock products: where's the beef? *Environmental Research Letters*, *10*(3), 034005. https://doi.org/10.1088/1748-9326/10/3/034005

Pozo, R. A., Cusack, J. J., Acebes, P., Malo, J. E., Traba, J., Iranzo, E. C., Morris-Trainor, Z., Minderman, J., Bunnefeld, N., Radic-Schilling, S., Moraga, C. A., Arriagada, R., & Corti, P. (2021). Reconciling livestock production and wild herbivore conservation: challenges and opportunities. *Trends in Ecology & Evolution*, *xx*(xx), 1–12. https://doi.org/10.1016/j.tree.2021.05.002

Prasuhn, V. (2006). *E.coli factsheet*. Public Health Agency of Canada. http://www.phac-aspc.gc.ca/fs-sa/fs-fi/ecoli-eng.php

Pulungan, M. A., Suzuki, S., Gavina, M. K. A., Tubay, J. M., Ito, H., Nii, M., Ichinose, G., Okabe, T., Ishida, A., Shiyomi, M., Togashi, T., Yoshimura, J., & Morita, S. (2019). Grazing enhances species diversity in grassland communities. *Scientific Reports*, *9*(1), 1–8. https://doi.org/10.1038/s41598-019-47635-1

RDAR. (2021). *Surveillance of antimicrobial use and antimicrobial resistance in Canadian fed cattle; supporting sustainable production for increasing market demands*. RDAR. https://rdar.ca/project/surveillance-of-antimicrobial-use-and-antimicrobial-resistance-in-canadian-fed-cattle-supporting-sustainable-production-for-increasing-market-demands/

Richardson, S. B. (2021). *From Slow Food to Slow Meat: Slowing Line Speeds to Improve Worker Health and Animal Welfare in Canadian Abattoirs*. https://albertalawreview.com/index.php/ALR/article/view/2666/2618

Ross, L. (2020, May 29). *With meat production, it's time to learn that bigger is not always better*. Rabble.Ca. https://rabble.ca/columnists/time-learn-bigger-not-always-better/

Rude, J. (2021). COVID-19 and the Canadian cattle/beef sector: A second look. *Canadian Journal of Agricultural Economics*, 233–241. https://doi.org/10.1111/cjag.12277

Rushen, J. (2003). Changing concepts of farm animal welfare: Bridging the gap between applied and basic research. *Applied Animal Behaviour Science*, *81*(3), 199–214. https://doi.org/10.1016/S0168-1591(02)00281-2

Saskatchewan Workers' Compensation Board. (n.d.). *Statistics*. Retrieved August 12, 2022, from https://www.wcbsask.com/statistics

Sayre, N. F. (2004). Viewpoint: The Need for Qualitative Research to Understand Ranch Management. *Journal of Range Management*, *57*(6), 668–674. https://doi.org/10.2111/1551-5028(2004)057[0668:VTNFQR]2.0.CO;2

Schuetze, S. J., Schwandt, E. F., Maghirang, R. G., & Thomson, D. U. (2017). Review: Transportation of commercial finished cattle and animal welfare considerations. *The Professional Animal Scientist*, *33*(5), 509–519. https://doi.org/10.15232/PAS.2017-01620

Schwartzkopf-Genswein, K. S., Faucitano, L., Dadgar, S., Shand, P., González, L. A., & Crowe, T. G. (2012). Road transport of cattle, swine and poultry in North America and its impact on animal welfare, carcass and meat quality: A review. *Meat Science*, *92*(3), 227–243. https://doi.org/10.1016/J.MEATSCI.2012.04.010

Scurlock, J. M. O., & Hall, D. O. (1998). The global carbon sink: a grassland perspective. *Global Change Biology*, *4*(2), 229–233. https://doi.org/https://doi.org/10.1046/j.1365-2486.1998.00151.x

Shrestha, B. M., Desjardins, R. L., McConkey, B. G., Worth, D. E., Dyer, J. A., & Cerkowniak, D. D. (2014). Change in carbon footprint of canola production in the Canadian Prairies from 1986 to 2006. *Renewable Energy*, *63*, 634–641. https://doi.org/https://doi.org/10.1016/j.renene.2013.10.022

Slade, J., & Alleyne, E. (2021). The Psychological Impact of Slaughterhouse Employment: A Systematic Literature Review. *Trauma, Violence, & Abuse*. https://doi.org/10.1177/15248380211030243

Smith Thomas, H. (2017, September 18). Do you have a veterinary-client-patient relationship? *Canadian Cattlemen*. https://www.canadiancattlemen.ca/features/do-you-have-a-veterinary-client-patient-relationship/

Statistics Canada. (2019). *Percent of Average Precipitation (national)*. https://www150.statcan.gc.ca/n1/daily-quotidien/190912/mc-b001-eng.htm

Statistics Canada. (2021a). *Agricultural Water Survey 2020*. https://www150.statcan.gc.ca/n1/daily-quotidien/211213/dq211213d-eng.htm

Statistics Canada. (2021b). *Departure from average precipitation (in millimetres) from April 1 to October 11, 2021 (during the growing season), compared with annual average, by province*.

Statistics Canada. (2021c). *Red meat conversion factors*.

Statistics Canada. (2021d, December 22). *2021 Census of Agriculture*. https://www.statcan.gc.ca/en/statistical-programs/instrument/3438_Q1_V6

Statistics Canada. (2022a). *Table 14-10-0306-01 Employee wages by occupation, monthly, unadjusted for seasonality*. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1410030601

Statistics Canada. (2022b). *Table 14-10-0064-01 Employee wages by industry, annual*. https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1410006401

Statistics Canada. (2022c). *Table 32-10-0125-01 Cattle and calves, farm and meat production*.

Stone, R., & Hilborn, D. (2015). *Universal Soil Loss Equation (USLE)*. http://omafra.gov.on.ca/english/engineer/facts/12-051.htm

Sura, S., Degenhardt, D., Cessna, A. J., Larney, F. J., Olson, A. F., & McAllister, T. A. (2015). Transport of three veterinary antimicrobials from feedlot pens via simulated rainfall runoff. *Science of the Total Environment*, *521–522*, 191–199. https://doi.org/10.1016/j.scitotenv.2015.03.080

Thapa-Magar, K. B., Davis, T. S., & Kondratieff, B. (2020). Livestock grazing is associated with seasonal reduction in pollinator biodiversity and functional dispersion but cheatgrass invasion is not: Variation in bee assemblages in a multiuse shortgrass prairie. *PLoS ONE*, *15*(12 December), 1–18. https://doi.org/10.1371/journal.pone.0237484

Thompson, P. B. (2015). *From Field to Fork: Food Ethics for Everyone*. Oxford University Press.

Toor, K., & Hamit-Haggar, M. (2021). *Analysis of the beef supply chain*. https://www150.statcan.gc.ca/n1/en/pub/18-001-x/18-001-x2021002-eng.pdf?st=5cgqfaxw

UNEP. (2020). Guidelines for Social Life Cycle Assessment of Products and Organizations 2020. In *United Nations Environment Programme (UNEP)*.

UNEP. (2021). *UNEP Food Waste Index Report 2021*. https://drive.google.com/file/d/1KTB1mq9sSWXx38bDfvF0PQy0sEKYsgrn/view

UNEP Setac Life Cycle Initiative. (2009). Guidelines for Social Life Cycle Assessment of Products. *Management*, *15*(2), 104. http://www.unep.fr/shared/publications/pdf/DTIx1164xPA-guidelines_sLCA.pdf

United Nations. (1987). *Report of the World Commission on Environment and Development: Our Common Future* . http://www.un-documents.net/our-common-future.pdf

VandenBygaart, A. J., Bremer, E., McConkey, B. G., Janzen, H. H., Angers, D. A., Carter, M. R., Drury, C. F., Lafond, G. P., & McKenzie, R. H. (2010). Soil organic carbon stocks on long-term agroecosystem experiments in Canada. *Canadian Journal of Soil Science*, *90*(4), 543–550. https://doi.org/10.4141/cjss10028

VBP+. (2022). *Audit Results as of May 2022*.

Velado-Alonso, E., Morales-Castilla, I., Rebollo, S., & Gómez-Sal, A. (2020). Relationships between the distribution of wildlife and livestock diversity. *Diversity and Distributions*, *26*(10), 1264–1275. https://doi.org/10.1111/ddi.13133

Verified Beef Production Plus. (2022, September 1). *Current VBP Statistics*. http://www.verifiedbeef.ca/about-vbp/current-vbp-statistics.cfm

Vrasdonk, E., Palme, U., & Lennartsson, T. (2019). Reference situations for biodiversity in life cycle assessments: conceptual bridging between LCA and conservation biology. *International Journal of Life Cycle Assessment*, *24*(9), 1631–1642. https://doi.org/10.1007/s11367-019-01594-x

Waldner, C. L., Jelinski, M. D., & Mcintyre-Zimmer, K. (2013). Survey of western Canadian beef producers regarding calf-hood diseases, management practices, and veterinary service usage. *Canadian Veterinary Journal*, *54*(6), 559–564. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3659451/pdf/cvj_06_559.pdf

Waldner, C. L., Parker, S., & Campbell, J. R. (2019). Vaccine usage in western Canadian cow-calf herds. *Canadian Veterinary Journal*, *60*(4), 414–422. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6417607/pdf/cvj_04_414.pdf

Waldner, C. L., Parker, S., Gow, S., Wilson, D. J., & Campbell, J. R. (2019). Attitudes towards antimicrobial use and factors associated with antimicrobial use in western Canadian cow-calf herds. *The Canadian Veterinary Journal*, *60*(4), 391. /pmc/articles/PMC6417609/

Wang, L., Delgado-Baquerizo, M., Wang, D., Isbell, F., Liu, J., Feng, C., Liu, J., Zhong, Z., Zhu, H., Yuan, X., Chang, Q., & Liu,

C. (2019). Diversifying livestock promotes multidiversity and multifunctionality in managed grasslands. *Proceedings of the National Academy of Sciences of the United States of America*, *116*(13), 6187–6192. https://doi.org/10.1073/pnas.1807354116

Wang, W., & Fang, J. (2009). Soil respiration and human effects on global grasslands. *Global and Planetary Change*, *67*(1), 20–28. https://doi.org/https://doi.org/10.1016/j.gloplacha.2008.12.011

Wang, X., Vandenbygaart, A. J., & McConkey, B. C. (2014). Land management history of Canadian grasslands and the impact on soil carbon storage. *Rangeland Ecology and Management*, *67*(4), 333–343. https://doi.org/10.2111/REM-D-14-00006.1

Ward, S. E., Smart, S. M., Quirk, H., Tallowin, J. R. B., Mortimer, S. R., Shiel, R. S., Wilby, A., & Bardgett, R. D. (2016). Legacy effects of grassland management on soil carbon to depth. *Global Change Biology*, *22*(8), 2929–2938. https://doi.org/https://doi.org/10.1111/gcb.13246

Wasige, J. E., Groen, T. A., Rwamukwaya, B. M., Tumwesigye, W., Smaling, E. M. A., & Jetten, V. (2014). Contemporary land use/land cover types determine soil organic carbon stocks in south-west Rwanda. *Nutrient Cycling in Agroecosystems*, *100*(1), 19–33. https://doi.org/10.1007/s10705-014-9623-z

WCCCS. (2018). *2017 Western Canadian Cow-Calf Survey: Aggregate Results*. http://westernbeef.org/pdfs/wcccs/2017_WCCCS_Summary-FINAL.pdf

Weidema, B P, Bauer, C., Hischier, R., Mutel, C., Nemecek, T., Reinhard, J., Vadenbo, C. O., Wernet, G., & O, V. C. (2013). *Data quality guideline for the ecoinvent database version 3 - Overview and methodology*. https://www.ecoinvent.org/files/dataqualityguideline_ecoinvent_3_20130506.pdf

Weidema, Bo P. (2018). *Towards a Taxonomy for Social Impact Pathway Indicators*. https://doi.org/10.1007/978-3-030-01508-4_2

WHO. (2021, November 17). *Fact sheets: Antimicrobial resistance*. https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance

Wong, K., Chan, A. H. S., & Ngan, S. C. (2019). The Effect of Long Working Hours and Overtime on Occupational Health: A Meta-Analysis of Evidence from 1998 to 2018. *International Journal of Environmental Research and Public Health*, *16*(2102), 1–22. https://doi.org/10.3390/ijerph16122102

WorkSafeBC. (n.d.). *Health and Safety: Statistics - Agriculture*. Retrieved August 12, 2022, from https://www.worksafebc.com/en/health-safety/industries/agriculture/statistics

World Animal Protection. (2021). *Five Domains vs. Five Freedoms of Animal Welfare* . https://www.worldanimalprotection.us/blogs/five-domains-vs-five-freedoms-animal-welfare

Zaheer, R., Cook, S. R., Barbieri, R., Goji, N., Cameron, A., Petkau, A., Polo, R. O., Tymensen, L., Stamm, C., Song, J., Hannon, S., Jones, T., Church, D., Booker, C. W., Amoako, K., Van Domselaar, G., Read, R. R., & McAllister, T. A. (2020). Surveillance of Enterococcus spp. reveals distinct species and antimicrobial resistance diversity across a One-Health continuum. *Scientific Reports*, *10*(1), 1–16. https://doi.org/10.1038/s41598-020-61002-5

Zulkifli, I. (2013). Review of human-animal interactions and their impact on animal productivity and welfare. *Journal of Animal Science and Biotechnology*, *4*(25), 1–7. https://doi.org/10.1186/2049-1891-4-25

APPENDIX A
SCIENTIFIC ADVISORY COMMITTEE AND CRITICAL REVIEW

A.1 Composition of SAC and Critical Review Panel

Table A-1: Scientific Advisory Committee Composition

Name	Organization	Profile
Brenna Grant	Canfax	As Manager of Canfax Research Services, Brenna provides industry with statistical information and economic analysis, focusing on both the Canadian and global beef markets. Brenna is originally from a cow-calf operation at Val Marie, Saskatchewan.
Brad Downey	ACA	Brad Downey is a Senior Wildlife Biologist with Alberta Conservation Association focused on collaborative habitat stewardship projects with landowners and the cattle industry over the last 20 years.
Kerrianne Koehler-Munro	AAFRED	Kerrianne is an Environmental Program Specialist within the Natural Resource Management Branch of Alberta Agriculture, Forestry and Rural Economic Development (AAFRED).
Reynold Bergen	BCRC	Dr. Bergen provides scientific and industry expertise to the BCRC and Beef Science Cluster, working with industry to identify research priorities and review research proposals and scientific reports, and engaging with industry and research experts on an ongoing basis. To ensure producers have access to current research information, he develops fact sheets for projects funded through the BCRC, and writes articles that are available through the CCA, provincial beef organizations, various agriculture media outlets and BeefResearch.ca. Reynold also works to gather and provide relevant research-based information for industry, public and government communications on specific issues.
Marianne Possberg	SCA	Marianne is the Beef Production Specialist for the Saskatchewan Cattlemen's Association. In this role, she communicates with producers and researchers to create a stronger conduit of information that results in stronger research projects. She also provides advice on research proposals and supports programs, educational videos, and events which strengthen producers' operational sustainability.
Kim Ominski	University of Manitoba	Dr. Ominski is a professor in the Department of Animal Science and the Director of the National Centre for Livestock and the Environment at the University of Manitoba. Since joining the University, Kim has established a multidisciplinary research program improving the productivity and sustainability of beef cattle production systems in Western Canada. Kim also teaches in both degree and diploma programs at the U of M.
Tim McAllister	AAFC	Dr. McAllister has been a research scientist in Rumen Microbiology, Feed and Nutrition since 1997. His research focuses on microbiology, nutrition, and beef production, and on food and environmental safety issues related to livestock production, strategies for mitigation of Escherichia coli O157:H7, prion inactivation within the environment and, more recently, studies of antimicrobial resistance in bacteria in feedlots. He also has extensive research experience in GHG emissions within animals from manure and the impact of manure handling procedures, such as composting, on emissions.
Christoph Wand	OMAFRA	Christoph is the Livestock Sustainability Specialist with the Agriculture Development Branch of the Ontario Ministry of Agriculture Food and Rural Affairs.
Katie Wood	University of Guelph	Dr. Wood is an Associate Professor in Ruminant Nutrition and Physiology in the Department of Animal Biosciences at the University of Guelph. Her research focuses on improving the understanding feed efficiency in the cow/calf and feedlot

Name	Organization	Profile
		sectors and the development of management and nutritional strategies to improve efficiency, health, and sustainability in the beef sector.
Dorothy Erickson	Zoetis	Dr. Erickson is a cattle veterinarian with both clinical practice and animal health industry experience. With Zoetis, a global animal health company, Dorothy has worked in roles as Manager Veterinary Services, Cattle and Strategic Account Manager.
Michael Lohuis	Semex	Dr. Lohuis is a cattle breeding expert with 35+ years of experience in dairy, beef, swine, and plant sectors. As VP Research for Semex, Michael leads research and innovation projects and sustainability strategy. He also is a board member for Genome Alberta and scientific advisor for Gentec and DairyGen/Lactanet.
Sean Thompson	Olds College	Sean serves as Manager for the Olds College Technology Access Centre for Livestock Production. He provides oversight to the research program and technical services offered by the centre, which focus on improving production efficiencies, enhancing animal health and welfare, and improving environmental sustainability. Sean also operates a small purebred beef operation in the Alberta foothills.
Kristine Tapley	Ducks Unlimited	Kristine is the National Lead of Sustainability – Agriculture, with Ducks Unlimited Canada and operates a cow-calf operation near Langruth Manitoba. She is also a director of the CRSB council.
Graeme Finn	Foothills Forage and Grazing Association	Graeme is a director with CRSB and BCRC and a past chair of FFGA. He and his wife operate Southern Cross Livestock, a cow/calf operation based on regenerative beef management in the foothills of Alberta. The operation was used as one of the pilot farms for the McDonald's and Cargill Sustainable Beef Program, which became the CRSB. He is also the president of Union Forage, a forage seed company based in Calgary.
Kevin Teneycke	NCC	Kevin Teneycke is the Regional Vice President of the Manitoba Region of Nature Conservancy Canada (NCC). He is responsible for all aspects of NCC operations in the province and has over 25 years of experience in the development and delivery of voluntary, biodiversity conservation programs with agricultural producers across Manitoba.
Jenna Sarich	CCA	As the Technical Consultant for Public and Stakeholder Engagement, Jenna provides scientific support when working directly with CCA and Canada Beef staff to develop issue-specific responses, recommended key messages, response plans, and consumer communications materials, and track relevant research. She is also a graduate student studying ruminant nutrition, publishing on ergot alkaloids in beef cattle.
Dr. Karen Schwartzkopf-Genswein	AAFC	Dr. Schwartzkopf-Genswein is a Canadian federal scientist with expertise in farm animal behaviour, health, and welfare and has led several projects for BCRC including within the Beef Cluster projects. She is a Senior Research Scientist at the Beef Cattle Physiology and Welfare centre of Agriculture and Agri-Food Canada in Lethbridge, Alberta.

Critical Review Panel Composition

Table A-2: Scientific Advisory Committee Composition

Name	Expertise	Organization	Profile
Jean-François Ménard	Environmental LCA expert	CIRAIG	Jean-François Ménard is Senior Analyst at the International Reference Centre for the Life Cycle of Products, Processes and Services (CIRAIG) with more than 15 years of experience in LCAs. He has also worked in the development of several courses on LCA and regularly participates in graduate students training. Since 2005, he gives several times a year, continuing education sessions to professionals from various sectors. Finally, as an LCA expert, he supervises and participates in numerous LCA projects and conducts critical reviews of LCA done by third parties.
Sara Russo Garrido	Social LCA expert	CIRAIG	Sara Russo Garrido is the Executive Director and Coordinator for Social Analysis at the International Reference Centre for the Life Cycle of Products, Processes and Services (CIRAIG), as well as an Associate Professor at Université du Québec à Montréal (UQAM). She has authored, led, and managed social life cycle assessment (S-LCA) studies and analyses related to the inclusion of social aspects in sustainability strategies and corporate social responsibility (CSR), both for the private and public sector. She is a published author in S-LCA, is a regular reviewer for the International Journal of Life Cycle Assessment and is Co-Chair of the SLC Alliance initiative to review the UNEP-SETAC Guidelines for S-LCA.

A.2 Critical Review Panel Comments

CRSB NBSA Draft Report Critical Review Feedback Form

Name of reviewer: Jean-François Ménard

Title of report: UPDATE TO THE CANADIAN ROUNDTABLE FOR SUSTAINABLE BEEF'S (CRSB) NATIONAL BEEF SUSTAINABILITY ASSESSMENT (NBSA)

Date: 2023-02-24 (last received)

Comment no.	Section no.	Comment (justification for change of technical aspects must be supported by either scientific literature or technical documents)	Proposed change (please provide alternative text)	Decisions on each comment submitted	Addressed (Yes/No)	Decisions on each comment submitted2	Addressed (Yes/No)2	Decisions on each comment submitted3
Executive Summary								
1		*Ozone depletion* is not an impact category that was conisdered in the interpretation phase.	Remove its mention.	Ozone depletion removed from the sentence.	Y			
Section 1: Objectives and Methodology								
2	1.4.1	It is not clear if only the wastes generated during the secondary processing (blood) were excluded from the study or also all slaughter wastes (hooves, horns, blood, gut content).	Clarify.	Clarification added to state that all waste are excluded, not only those during secondary processing.	Y			
3	1.4.1	-As I understand it secondary packing and processing was excluded from the study (lines 640-642), this should be clearly indicated in the figure. -Dairy cattle was included only for the carbon footprint and through the direct use of results generated in another study (for DFC), as such this "life cycle stage" was not included in the LCA modeling for this study, this should be more clearly indicated. -I did not see in Appendix D any mention of bedding material at the farm stage, nor refrigerants used at the slaughter and primary packing stage, the figure seems then to be misleading as to what is included.		1 - Clarification added; secondary processing (after slaughterhouse, transformation into beef cuts) and packaging for retail were both included. 2 - Clarification added. 3 - Table D-8 added in Appendix D to cover bedding. Refrigerant leaks provided already in Table D-11	Y, Table D-12 covers the retail stage not the slaughter and primary packing stage but those data are confidential and not shown in the report.			
4	1.4.2	There is no recommendations for mass-based functional unit in ISO 14040-44 either. The standards make no recommendations on what the functional unit should be for a particular LCA study.	Remove sentence.	Line regarding nutrient indices in the ISO guidelines has been removed.	Y			
5	1.4.2	Meat from culled dairy cows is a co-product of the dairy sector, not the other way around (milk as a co-coproduct of the beef sector). As you say, the "part allocated to meat" of the dairy sector impacts were considered in the present study, meaning that meat is the co-product.	Correct sentence.	Changed to correctly describe the co-products of dairy production	Y			
6	1.4.2	Based on the text, I would have thought that animals going through the bakgrounding phase are either backgrounders or yearlings and then going directly to finishing. Table 1-1 seems to suggest that animals go through both types of backgrounding sequentially, which is not the same thing.	Clarify and make consistent.	Clarification added, they are indeed considered sequentially in this model in order to capture a wider range of production practices	Y			

7	1.4.2	I have a hard time understanding what exactly you did to model the animal rearing as related to the functional unit. It would be helpful if Figure 1-5 showed the value for each animal category used to model the feeding as described in Appendix D, especially including the mortality and replacement rates.	Clarify and focus on how the modeling was done in relation to the functional unit (1 kg live weight).	A better explanation of the connection between the cohort, number of days, and daily impacts has been added. Adding these numbers to figure 1-5 would be a bit confusing given how they are calculated, so instead a reference to table 1-1 with the values is provided.	N, it is still not clear how the mortality and replacement rates were accounted for. For example, for the calves mortality rate, did you simply multiply the values related to the calves category by 1.033? Are the mortality rates compounded (as material loss rates at sequential processing stages would be), for ex. to compensate for the finishers' mortality you need to have more yearlings, more backgrounders and more calves, and more cows as each calf needs a cow? How about the replacement rates? How many bulls, I can understand there being 1 cow per calf but there doesn't need to be 1 bull per calf?	Yes, mortality rates are compounded (note added to line 813). However, the calculation for cohort multiplier is not simply 1 + 0.33, it is 1/(1-0.33), so this note has been added as well.	Y, it woudl have been nice to give the final numbers for the cohort calculations (i.e., the number of each aninal type considered in the inventory calculations).
8	1.4.2	The flows in the figure and the outputs of the system should be related to the functional unit (1 kg of live weight).	Correct figure.	Output of 1 kg liveweight added, however, it is not possible to distinguish each animal type into the amount of kg that result in the kg liveweight output. Furthermore, modelling of the cohort was very crucial to the model, which is why the values in the figure must remain.	OK, so for the West calf-fed system, at the end there is 1 finisher (50% steer, 50% heifer) weighting 1450 lbs and 0.13 cow weighting 1490 lbs, for a total of 1644 lbs of liveweight going to slaughter per cohort? So for 1 kg liveweight at the farm gate, you divide the cohort's inventory by 1644*0.4536?	Yes exactly. Comment added to text under figure.	Y
9	1,7	You say you have used the ReCiPe (H) 1.13 LCIA method. In SimaPro 9.3.0.3, the 2016 version of the ReCiPe (H) method is the 1.06 version. The only mention of the 1.13 version I can find is in openLCA in the ecoinvent LCIA package. What LCA software have you used and what was the source of the ReCiPe method used?		Corrected to 1.06, as per ReCiPe (H) 2016. The software used was Simapro.	Y		
10	1,7	You say you have included biogenic emissions in the global warming impact category indicator calculations, I take it then that you have included the atmospheric CO2 uptake during crop growth and have used a -1 kg CO2 eq/kg CO2 uptake GWP. Have you then used the same GWP for biogenic and fossil methane, which include the oxidation of CH4 into CO2 and its further contribution to global warming? Looking at Appendix D, I see nothing concerning the biogenic CO2 emissions from cattle or manure management, how were those accounted for?	Provide details on how biogenic CO2 emission and uptake were accounted for.	Biogenic emissions (carbon/methane) were excluded based on previous LCA methodology in NBSA 2016, which stated that short-lived renewable or biogenic carbon dioxide uptake and release are considered to be neutral with respect to global warming emissions. The carbon sequestered by plants and its release through animal respiration are considered to be in steady-state with surrounding conditions, and therefore these impacts are excluded. This is in line with PAS 2050 guidance for product carbon footprint assessment. Non-carbon dioxide biogenic gases (i.e. methane) are characterized according to the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report. Carbon stock change and corresponding release / sequestration depending on land use management / land use change are assessed and reported separately as recommended by most of the standards. Biogenic methane has not been treated differently than fossil methane for their global warming potential in this study, based on the lack of specific guidance from FAO LEAP guidelines, given that very few studies in literature have accounted for the difference. This has been clarified in text (Appendix D).	N, the biogenic CO2 neutrality assumption needs to be clearly indicated. For the LCIA methods used (ReCiPe 2016 H 1.06, IPCC 2013 GWP100 and IPCC 20221 GWP100), biogenic methane and fossil methane do not have the same characterization factors, as implemented in SimaPro, did you modify the methods?	We would like to note a correction in the previous response. In all the methods, the value for biogenic methane is different than fossil methane as the neutrality principle requires. To note, CFs for ReCiPe 2016 H 1.06, IPCC 2013 (AR4) GWP100 (biogenic CH4: 22.5; fossil CH4: 25) and for IPCC 2022 (AR6) GWP100 (biogenic CH4: 28; fossil CH4: 30). We did modify the methods in AR6 so that biogenic CO2 was 0 (not -1). A clarification has been added to Table D-26.	Y

11	1.7.1	If you are interested in accounting for timing of GHG emissions and emissions rates, I would strongly suggest you use a dynamic modeling approach such as the one proposed by Levasseur et al. (2010) as it precisely accounts for yearly changes in all GHG emission rates. The Dynamic Carbon Footprinter 2.0 software (https://ciraig.org/index.php/project/dynco2-dynamic-carbon-footprinter/) could be used to model the dynamic inventory of the beef production associated GHG emissions (CO2, biogenic and fossil, CH4 and N2O).		The rationale behind applying GWP* was to be consistent with other national beef assessments and guidance from the Global Roundtable for Sustainable beef which specifically discuss GWP* and not generic dynamic models. That being said, a comment on other dynamic models has been added in section 2.1.2.	Y			
12	1.7.1	The enteric methane emissions for beef cattle for 2021 and 2001 (2021 - 20) are not available in ECCC NIR 2022. Did you use the 2020 and 2000 values? I can only find a 1990-2020 time series for total enteric fermentation and manure related emissions, covering all livestock. The enteric methane and manure related emissions in the 2022 NIR are not exactly calculed in the same way as you have done, it would be important to note that. As is noted in line 3896, the GWP* does not follow an LCA approach, it should be clearly indicated here.	Specify which years and values were considered in the calculation of the GWP*.	Added statements addressing (1) years of data used in the assessment, (2) the method of calculation in NIR not matching the study, and (3) the method used in NIR additionally not following an LCA approach.	Y			
13	1.7.2	The ReCiPe 2016 *Land use* impact category, as implemented in SimaPro, has for indicator unit m2a crop eq., thus including time. Have you modified the unit of the indicator to only account for the area occupied/transformed? Did you modify the characterization factors?	Clarify.	We have decided to report as m2a instead given the several comments on this and the fact that we ourselves questioned this when reading the original methodology, although we did modify the characterization factors in the previous draft. We have left an explanation on why the methodology was altered in the land use section 2.1.3.	N, the ReCiPe indicator is for Land use, not land use occupation as it accounts for both land occupation and transformation flows. As you are only accounting for land occupation, you should remove the reference to land transformation. The m2a unit accounts for both the area and the period of occupation, it represents a finite amount of land occupation, as the kWh unit accounts for both the power and the period of energy use to represent a finite amount of energy. It is not the occupation on a annual basis, meaning per year as I understand it. 10 kWh is not 10 kW per hour.	Removed reference to land transformation. Agreed on the interpretation of the indicator. We are essentially capturing the occupation phase, wherein the land is utilized for a certain period. Hence, since it is a time-integrated indicator, the reference to a year was not removed. In this study, the square metre represents being multiplied by annual crop land (m2a) under the year of the study (2021).	N, land use occupation is reported in m2a, the ReCiPe indicator unit is m2a of annual crop (land use) equivalent.	The process for the land use indicator calculation has been cl;arified in section 1.7.2 to refect that it included the area and time integrated for land use attributed to beef production and reported as m2.yr annual crop equivalents and the mid-point CF was applied to the land occupation flows with the same time refernce as the databases.
14	1.7.2	In the ReCiPe 2016 method, as implemented in SimaPro and openLCA, there are no characterization factors for NO3 emissions to water for the *Freshwater eutrophication* category, nitrates will be considered as contributing to this impact category in the results. This is then misleading. Freshwater system as generally phophorus limited ecosystems, whereas marine ecosystems are generally nitrogen limited.	Either indicate that nitrates, and nitrogen compounds, are not included in the E-LCA assessment or remove their mention.	Removed mention in nitrates/nitrogen compounds in the Freshwater eutrophication explanation	Y			
15	1,9	As was stated in lines 640-642, beef co-products (fats, hides) were excluded from the study, this, I take it, means that they were allocated none of the burdens of the system, or that 100% of the burdens were allocated to the meat. This would need to be clearly specified here.	Specify the allocation rule used for beef co-products.	Added statement on allocation.	Y			

16	1,9	Meat packaging materials are in part sent to recycling, which is a multifunctional process, how was recycling treated for such foreground process, and in general for background processes as well?	Clarify how recycling was treated.	Added comment on recycling rates in the main body with a link to Appendix D	N, the treatment of recycling as a multifunctional process is not specified.	While the process of recycling is multifunctional, in this study, it is treated as a waste stream with the beef system not incorporating any credits based on the end-use. This has been clarified in Appendix D.	N, I have the impression you have used a cut-off approach to recycling but it is not clear. This should be clearly stated in this section.	We have clarified in section 1.9 that a cut-off approach has been selected for recycling.
17	1,9	The cut-off criterion seems to have been only applied to inputs. As was already stated, were slaughter wastes also exlcuded based on the 2% criterion.	Clarify.	Added a statement regarding treatment of slaughter and processing wastes.	Y			
18	1,9	The text does not seem to apply to prescirption drugs.		Corrected the content to reflect the study's boundaries with respect to prescription drugs.	Y			
19	1.10	No end-point indicators are used in this study, no need to refer to them.	Remove reference to end-point indicators.	Mention of end-points was removed from the text.	Y			
Section 2: Results								
20	2.1.1	Section 1.7 states that IPCC AR6 GWP were used for the baseline global warming assessment, Section 2.1.2 Inclusion of dairy sector states that IPCC AR5 GWP were used to match the dairy sector carbon footprint. Considering that biogenic methane as a GWP of 27.2 kg CO2 eq./kg in the IPCC AR6 and a GWP of 27.75 kg CO2 eq./kg in the IPCC AR5, I find it surprising that, given the very high relative contribution of biogenic methane to the carbon footprint, the results with the AR6 and the AR5 GWP are the same.		There are a couple of factors at play here. Firstly, the difference between the GW values in the East looks more drastic than the West because the carbon footprint of dairy in the East is larger (6.7 kg CO2eq vs 6.0 in the West). Furthermore, they are similar in magnitude but the boundaries of the dairy carbon footprints is expanded, increasing the impact and making it appear more similar in value. If you look at the National value at 9.76 kg CO2 eq/kg with dairy, it varies more drastically from the value of 10.4 kg CO2 eq/kg without dairy.	N, my comment was related to the results for the system without dairy using the AR6 (Table 2-1) and the AR5 (Figure 2-6) GWP, those seem to be the same, I would have thought considering the important contribution from biogenic methane, there would have been a difference in the total results.	Initially, we presented the dairy values using AR5 and the without dairy values using AR6. We understand that this is an inconsistency, but did so in order to avoid confusion raised by presenting 2 sets of results for 2021. However, we understand your point about consistency in this regard, so we have decided to remove the AR6 values and compare to AR5 without including them in the figure directly. For your information, the results of AR5 are 12.4 kg CO2e/kg (national), 12.5 kg CO2e/kg West and 11.6 kg CO2e/kg East, indicating as you described, a difference between the AR5 and AR6 values due to the different factors for biogenic methane and nitrous oxide. The clarification has been provided in the footnote under Figure 2-5 to ensure transparency.	Y	
21	2.1.1	It seems to me that the carcass FU refers to the output of the slaughterhouse, it should then not be referred to as "at the farm gate" but as "at the slaughterhouse gate".		Changed to processor's gate	N, Table 2-3 refers to the processor's gate, what is the difference then between Table 2-2 and 2-3 or between the carcass and boneless meat FU?	Changed to slaughterhouse gate	Y	
22	2.1.1	It is not clear how the Packaging stage losses were included. Ideally, those would be reflected in an proportional increase in the contributions of the Farming, Transport and Processing stages, thus not appear as a Packaging stage contribution.	Clarify how losses were modeled.	Clarification added. As you mentioned, it is included as a proportional increase in farming impacts because a larger amount of liveweight is required to meet the same 1 kg output.	Y			
23	2.1.1	The interpretation of the results seems to only focus on the Western production scenario, the Eastern production scenario shows quite different results.	Separate the interpretation of the results between the Western and Eastern production scenarios.	Separated the sections on packaging, retail, and consumption accordingly.	Y			
24	2.1.1	Provide more information on the link between electricity consumption and landfilling of waste and freshwater eutrophication.		Added clarification on the waste produced from electricity production (mainly raw material extraction for coal) and its subsequent landfilling.	Y			
25	2.1.1	If the GWP result for 1 kg boneless beed consumed (32.6 in Table 2-4) is multiplied by 0.075/1 it gives 2.4, how were the results in the table generated?	Clarify and correct if necessary.	Added a clarifying statement and caption of Table 2-5. These are identical to Table 2-4, just scaled down to 100 g instead of 1 kg to be meaningful to consumers.	N, in section 1.4.2, the FU for the consumption stage is of a 75 g serving.	Removed the reference to 75 g.	Y	
26	2.1.1	Based on Figure D-1, more meat is lost at the Consumption stage than at the Packaging and Retail stages combined, but only for the Retail stage the contribution of landfilled waste to the *Freshwater eutrophication* impact category is mentioned, does it not also contribute for the Consumption stage?	Clarify and correct if necessary.	Added a mention of landfilling waste in the consumption section as well due to its large contribution.	Y			

27	2.1.1	Can you be a little more concrete than "the waste management of by-products from fossil-based energy (electricity) generation"?.		Added explanation where the specific processes (landfilling of lignite ash from mining) contributing to eutrophication are mentioned.	Y		
28	2.1.2	Replace "when pasture is applied" by "when manure is applied".		Corrected to "manure."	Y		
29	2.1.2	Looking at Figure 2-5, for the Western production scenario, the contributions of pasture and storage manure associated emissions are more in a 2-1 (11% to 6%) ratio, do you consider them to be "similar in value"? For the Eastearn production scenario, they are similar in value (9% to 10%). If you mean the manure associated emissions are similar in (absolute) value between the Western and Eastern production scenarios, you should refer to their absolute value, not their relative shares.	Clarify.	Added in section 2.1.2: "In the West, the contribution from manure storage was 6% (0.63 kg CO2 eq/kg liveweight) compared to 10% (0.96 kg CO2 eq/kg liveweight). This is due to the fact that intensive production is more common in the East, shown by longer times on feed in confinement. Likewise, the contribution from manure on pasture is 11% in the West (1.1 kg CO2 eq/kg liveweight), almost twice that of manure storage, due to the longer grazing periods in the West. In the East, contribution from manure on pasture is 9% (0.86 kg CO2 eq/kg liveweight), much more similar in both absolute and relative value to manure storage in the East."	Y		
30	2.1.2	Manure nitrous oxide associated emissions are related to feed protein levels, which have increased since 2016, but methane enteric emissions are reduced with protein levels. How do the two trends compare?	Provide some indications as to the global effect of higher feed protein levels, even if only qualitatively.	This sentence has been removed since updates to that paragraphs from other comments have made it seem redundant.	Y		
31	2.1.2	CO2 emissions from feed production account for 57% of the carbon footprint of feed production or beef production for the Western produciton scenario? The use of "Overall" is confusing.	Clarify.	Clarified; changed "overall" to "considering all feed-related inputs."	Y		
32	2.1.2	There seem to be more difference between the enteric methane emissions between the Western and Eastern production scenarios than between their feed production emissions. Or the difference seems to be as important, thus the difference between the two scenarios is due to the differences for both life cycle stages.	Clarify.	A more in-depth explanation, along with the absolute values of enteric emissions, added to the discussion to better justify this difference.	Y		
33	2.1.2	As the total feed production emissions are lower for the Eastern production scenario, it would have been better to indicate the absolute contribution of the N2O emissions to show a higher fertilizer use.	Indicate the absolute contribution of N2O emissions for both production scenarios.	Added the absolute value for both West and East and it ended up indicating that fertilizer application in the West was higher on beef feed crops compared to the East.	Y		
34	2.1.2	Using the proposed dynamic modeling shows that in order to show a net reduction of radiative forcing when adding the residual radiative forcing of a methane emission 20 years before and of the present methane emission, the present emission would need to be about 20% of the earlier emission. In terms of a reduction in emission rate, that reduction would need to be of at least 2.63% per year (the present emission rate would be about 54% of the emission rate 20 years earlier) to get a net total radiative forcing reduction after 20 years. This is far from being the case for the beef sector. I would suggest tempering the language used to describe the effect of a reduction in the methane emission rate.		We have removed the sentences about linking the reduction in emission rate and a pulse of CO2 removal as well as the potential net cooling effect. We have also cited the different references on the required reduction in annual methane emission rate to get a neutral effect on the climate.	Y		
35	2.1.2	GWP values represent time intergrated effects on global warming, as such they are not annual global warming values as I understand GWP* values are supposed to represent. It is then misleading to present GWP as annual impacts. In the same way the summation of GWP values does not represent the yearly cumulative effect on global warming.		The figure depicting GWP-100 as a time series has been removed. The "annual" impacts figure has been changed to points for GWP-100 and renamed as annually calculated to avoid confusion. Any cumulative impacts reference has been removed.	N, as you also only have calculated three discrete results for the GWP*, it would be better if you showed them as such as for the GWP results.	Changed the GWP* to discrete points as well.	Y

36	2.1.2	What GWP values were used to construct the Figure? I have looked at ECCC 2022 and can only find a complete time series over the years covered by the figure for total enteric and total manure management emissions. For the years I find (Table 5-1 of Part 1, I can't find annual values in Part 2), the GWP100 values given for enteric fermentation and manure management CH4 emissions are not those shown in the figure, for example I find 21 Mt CO2 eq. for 2015, you show 25 Mt CO2 eq.	Provide details of the values used to construct the figure.	Three data points consisting of a pair of data taken 20 years apart are used, including 1990 and 2010, 1996 and 2016, and 2000 and 2021. While 2020 could have been used, 2021 was selected to eliminate the possibility of skewed data as a result of the Covid-19 pandemic and to be more consistent with the reference year used throughout this study. Statement added to report.	Y			
37	2.1.2	You say Figure 2-8 shows the cumulation, or summation, of the annual values shown in Figure 2-7. Figure 2-7 shows about 26 Mt CO2 eq. for 2010 and 2011, but 2011 shows only 30 Mt CO2 eq. In Figure 2-8. The values for GWP* in Figure 2-7 go rapidly down from 2016 but only become negative in 2021, the cumulative curve in Figure 2-8 should then show a decreasing, but still positive, slope until 2021. The curve in the figure shows a negative slope from about 2018.	Provide details of the values used to construct the figure.	Added a table (Table 2-6) with the values themselves along with explanation of why the values were selected.	Y			
38	2.1.2	The sentences "Ruminants, including beef and dairy cattle, are known to be larger water consumers. This is evident from their large water footprints per kg of beef or milk (Legesse et al., 2018). Furthermore, water consumption for slaughter, processing, and packaging can be additional concerns for the industry." are a repeat but for the different water footprint reference.	Removed repeated text and correct reference if necessary.	Removed the repeated sentence. Reference stayed the same in this case.	Y			
39	2.1.3	Replace "Figure 2-11" by "Figure 2-10".		Changed to Figure 2-10.	Y			
40	2.1.3	I suppose the sentence "To convert values obtained from the processed modelled from m2a to m2, characterization factors (CF) were applied." was meant to be "To convert values obtained from the processes modelled from m2a to m2, characterization factors (CF) were applied."		Corrected to "processes."	N, the sentence was changed to mean another thing. If I understand correctly, you modified the NBSA 2016 m2 result into m2a values using the 1 m2a/m2 for annual crops and 0.55 m2a/m2 for grazing land. This is an incorrect interpretation of the ReCiPe Land use CF. The unit of the ReCiPe Land use indicator unit is m2a annual crop land use equivalent, not simply m2a. It converts m2a of other land use into m2a of annual crop land use accounting for the effect on biodiversity of the different land uses, it does not convey a measure of the period of time a m2 is used for the different land uses.	Corrected to the appropriate units and clarification added on calculation procedure in section 2.1.3.	N	The process for the land use indicator calculation has been cl;arified in section 1.7.2 and 2.1.3 to refect that it included the area and time integrated for land use attributed to beef production and reported as m2.yr annual crop equivalents and the mid-point CF was applied to the land occupation flows with the same time refernce as the databases.

41	2.1.3	Land occupation values in m2a are the result of multyplying the area used (what you are looking for) by the amount of time this area is used/occupied. If the area is used for less than a year than simply multiplying the m2a value by 1 will underestimate the area used. Simply look at a crop production process, you will see that the land transformation value (based on the yield) is different than the land occupation value. The ReCiPe 2016 Land use impact category characterization factor for grassland is indeed 0.55 m2a crop eq./m2a, this is simply the conversion factor of grassland occupation into an equivalent annual crop equivalent, not into a m2 value.		As stated previously, we have decided to report as m2a instead to eliminate more confusion like this and be more consistent with other beef LCAs.	N, did you collect land occupation data (area x time) or did you obtain area data and converted those to m2a using the ReCiPe CF as you have indicated?	We obtained area data and converted those to m2a using the ReCiPe CF. Added a note in the methodology	N, You have assumed the length of the occupation period and converted the thus calculated m2a values into m2a annual crop eq. Values using the ReCiPe CF.	The process for the land use indicator calculation has been cl;arified in section 1.7.2 and 2.1.3 to refect that it included the area and time integrated for land use attributed to beef production and reported as m2.yr annual crop equivalents and the mid-point CF was applied to the land occupation flows with the same time refernce as the databases with an update of the area per land use type.
42	2.1.3	You consider a 40% difference a slight difference?		Changed to "substantial."	Y			
43	2.1.3	"in the West" seems to be missing after "from 56% to 62% of the carbon footprint".		Added "in the West."	Y			
44	2.1.3	The text is not clear. Do the imported dairy cattle to be raised for beef come with zero burden, but for the extra transport?	Clarify.	Clarification added - transport + raising considered, but rearing and weaning not considered.	Y			
45	2.1.3	Replace "caused by a lower end-weight" by "caused by a higher end-weight".		Corrected to "higher."	Y			
46	2.1.3	Fossil fuel depletion is the impact category showing the least sensitivity in both regions with changes of ±0.1-0.2% compared to the ±10% in end-weight.	Correct.	Corrected to reflect carbon footprint, land use, and terrestrial acidification.	Y			
47	2.1.3	Strictly based on Table 2-12, highly important data related to Mortality rates, Feed and Enteric emissions, Meat waste (Retail and Consumption stages) were modelled based on secondary data not primary data.		It is a mixed data quality dataset: Mortality rates, Feed, Meat waste (Retail and Consumption stages) were modelled based on reliable secondary data while enteric emissions are from primary sources based on the previous NBSA 2016	N, this should then have been indicated in the text.	It is now included in text (section 2.1.7)	Y	
48	2.1.7	-If I understood correctly what was said in the text, activity data was only assess in terms of their reliability and completeness. Mortality rates, "Animal stage" duration, Animal weight, Land use by animals, Enteric emissions are all clearly activity data, why are there data quality scores for them for the LCI dataset representativeness criteria? -Enteric methane emissions have a clear dominant contribution to the *Global warming* impact category result, but I don't see for which other impact category they have the same importance (Figure 2-24 for ex.). Shouldn't they just be indicated as moderately important? - Some data/datasets seem to be missing, for example: Processing energy consumption, Processing water consumption. -To what refer the Packaging Emissions and to what impact category is their contribution dominant?	Review the whole table.	-The LCI DQI criteria for activity data (mortality rates, animal weight, land used by animals,and feed) have been removed. - For enteric emissions, they were assigned higher importance based on their relative importance with respect to their contribution to the overall beef production system. However, we agree that from a LCA perspective, its contribution towards all indicators is moderate. -Processing information have not been updated since NBSA 2016 and were confidential. A note regarding this has been added in the appendix (Table D-17). -Packaging emissions relate to those for the production of Polystyrene, Injection moulding, Plastic film, Corrugated board and Wood pallet. The specific emissions are described in the appendix (Table d-17)The impact categories with the highest contribution from packaging are ozone formation, terrestrial ecosystems (15%), ozone formation, human health (14%), and fossil fuel depletion (15%). This has been clarified in section 2.1.1	-Y -N, as this does not follow your own definition of how the importance is determined, you should indicate it in the text. -Y -N, either remove the data quality assessment value for the "Material consumption" activity data and indicate "Material production emissions" and remove the data quality indicator scores as those as not activity data but are included in the background datasets OR simply remove the "Emissions" line in the table as the background datasets assessment is already included in the "Material consumption" line.	-(2) We have added a footnote explaining the exception to the importance of the enteric emissions under Table 2-13. - (4) We have removed the "Emissions" line under Packaging in the table as suggested and agree that as the background datasets assessment is already included in the "Material consumption" line.	-(2) Y -(4) Y	
49	2.1.7	There is no flow values uncertainty included in Agri-Footprint datasets.	Remove its mention.	Removed	Y			

Section 3: Conclusion								
50	3.1.2	Pesticide use was not mentioned in the contribution analysis for either the *Freshwater eutrophication* and *Photochemical oxidant formation* impact categories.	Remove mention of pesticide use or correct relevant sections on the contribution analysis.	Added mentions of pesticide use under freshwater eutrophication and photochemical oxidant formation so it matches what was said in this section.	Y			
Appendix D: Data Collection and Life Cycle Inventory								
51	D.2 Feed Rations	DMI values are relative values (in % of body weight), as the weight goes from start to finish weights for each animal category. I assume the animal weight was considered to increase linearly from start to finish weight over the growing period and that is why the mid-weight is indicated, as it was used to calculate the average DMI over the growing period (values indicated in Table D-19)? The composition of the feed is based on dry or wet weight? What are the moisture content values considered for the feed fractions?	Clarify.	Correct, comment added on linear weight gain assumption and table added with the moisture content of feed, as it is presented on a dry matter basis.	Y			
52	D.2 Feed Rations	There are no colums for backgrounders and yearlings on grass as there were for calves on grass. If that is seen as not necessary, as animals in pasture, i.e., on grass, are 100% on grass and their DMI and start and end-weights are the same, then those columns should be removed for calves, cows and bulls in the other tables.	Make tables consistent.	Removed the "on feed" from the title of the columns for backgrounders and yearlings and removed all "on grass" columns, as suggested.	N, Table D-5 still shows "on feed".	Corrected.	Y	
53	D.2 Feed Waste	There are no LCIs indicated in Table D-7, I think you may have meant Table D-15.	Correct reference. Replace "Wastage" by "Feeding wastage".	Corrected to Table D-15. Changed to "Wastage during feeding" to match the text.	Y			
54	D.2 Land Use	You provide a land occupation values in m2/animal/day, how were those values converted into a overall land occupation value in m2?		As stated previously, we have decided to report as m2a instead to eliminate more confusion like this and be more consistent with other beef LCAs.	Y			
55	D.2 Food Waste	I don't understand the rationale behind this figure, the size of the color shapes do not match the amounts lost indicated in the accompanying table. It would also be good if the meat waste and losses were translated into how much carcass and live weight animal are required to provide the different functional units.	Make consistent and provide the amounts related to the functional units.	Figure adjusted to be more accurate and to scale and multipliers added for amount of liveweight required for each functional unit.	N, the figure is still not clear to me. It seems to me that the final product would be 1 kg of consumed meat at the consumer, not 1 kg of bone-free meat at the processor's gate. The sum of the waste and losses in the table is 1.84 kg, I suspect that the reason why it is only 2.65 kg of liveweight per kg of consumed meat is because of the two-stage allocation at the processor.	This was unfortunately a typo that occurred during this review process. The final value is **2.85** kg of liveweight per kg of consumed meat for 1 kg of bone-free meat at the processor's gate. This has now been corrected.	N, to have 1 kg of consumed bone-free meat, there needs to be 1+0.12+0.05=1.17 kg of bone-free meat at the secondary processor's gate, or 1.17+0.06=1.23 kg of bone-free meat that the primary processor's gate. The 2.65 value needs to be corrected in the text that follows Figure D-1.	The value has been corrected in the text that follows Figure D-1. It is also clarified that these amounts are calculated on a mass basis (physical allocation) and does not account for the economic allocation assumptions at the processor’s gate and onwards. Further, the cohort replacement rates and the number of bulls have been clarified in Figure 1-5. Replacement animals and bulls represented in Figure 1-5 were excluded from the model based on the cut-off criteria
56	D.2 Energy Consumption	There is no information on data used to model energy use at the slaughter and (first) processing stages.	Provide energy use data for slaughter and processing stages.	A note was added in Appendix D to clarify that all data related to processing is confidential and cannot be included in the report.	Y			

57	D.2 Energy Consumption	The amounts indicated seems very small, is the unit (g/kg bone-free meat) correct?	Check unit.	Grams to changed to "kg."	Y			
58	D.2 Packaging	The PS trays recycling rate seems very high to me. I could not find this value in the ECCC (2019) reference. The only one I found for packaging plastics was 15%. The recycling rate for paperboard seems however quite low, especially considering that the corrugated board box used is the secondary packaging from processing to retail, thus B2B.	Check recycling rate values.	Agreed. A clarification has been added regarding this, however, due to its minor influence on results it will not be changed and will remain consistent with the 2016 study.	Y			
59	D.2 Life Cycle Inventory for E-LCA	-I don't understand the datasets highlighted in green, those were supposed to have been updated to newly available datasets but the source is for many still ecoinvent v3 (2015), have they been updated? -Why use the Agri-Footprint 5 electricity dataset when more recent and regionalized (provincial) datasets are available in the ecoinvent v3.8 database? -What version of the Agri-Footprint 5 database was used? -Natural gas combustion does not seem to be included in the model for the natural gas input to farming, is that correct? - Anhydrous ammonia (NH3) is not the same as nitrous dioxide (NO2). -What datasets were used to model the processing wastewater treatment and the end-of-life of the meat waste and by-products and the used packaging?		The original citation was meant to capture the overall version of ecoinvent (3), but it has been updated to reflect the one that was used (3.8). Agrifootprint was used for electricity to be consistent with the modelling done in 2016 and because it was determined to have minor differences compared to ecoinvent. Agrifootprint 5.0 was used, clarification added and the year was initially incorrect as well. Agreed, however, it was used as a proxy last time and was deemed to be negligible impact on the results so we kept it the same for consistency (a note has been added). Emissions from wastewater treatment and meat waste being landfilled were modelled as individual emissions based on survey data from 2016. These are confidential but a note has been added.	-N, the ecoinvent 3.7 database is indicated in the table. -Y -N, I meant what allocation approach version was used, the Agri-Footprint 5 database comes in three versions using either mass, energy or economic allocation. -N, how were the natural gas combustion emissions modeled? -There are several anhydrous ammonia production datasets in ecoinvent 3.8. -N, how was modelled the landfilling of the used packaging?	- This was a typo - we did in fact mean 3.7. - The Agri-Footprint 5 processes used mass allocation. - Natural gas combustion is modelled in an industrial boiler using the US Life Cycle Inventory Database. - Again, due to negligible impacts, it is not worth updating the anhydrous ammonia process at this time. - Landfilling of used packaging was handled the same way, using individual emissions data.	-Y -Y -N, the US LCI dataset is not indicated in the table. Why use that one when gasoline is modeled using an ecoinvent gasoline passenger car dataset and the heat from natural gas at the processor is modeled with an ecoinvent dataset. -Y -N, "landfilling of meat waste and wastewater treatment" were modeled with individual emissions data from processors, no mention of used packaging.	-Given the lower impact of said processes on the beef impacts, the decision was made to keep these processes fromm the previous model. - Further clarification is added to the Packaging assumptions in Table D-16.
60	D.2 Economic Allocation	It is not clear how the allocation factors were used as they apply to what seems to have been modeled as a single life cycle stage, the processing of animal at the slaughterhouse (Section 2.1.1 Results per FU: 1 kg boneless beef, processor's gate). Do the slaughter and first processing by-products indicated in Figure D-1 include the co-products or do they only represent waste? I don't understand how the allocation factors for both stages are related to live weight and add up to 100% at each stage? How are applied those factors?	Clarify and provide the calculations details.	Clarifications added to the figure (D-1) and to the text. The relationship between the liveweight and each subsequent functional unit has been provided. It is related to liveweight each time because our Simapro model includes a "liveweight" process within each functional unit and adds additional processes as necessary.	N, two things: - I still can't follow your allocation calculations and reproduce the amounts of liveweight per FU following Figure D-1 (What are the amounts of meat and co-products at the slaughter stage and primary processing where allocation is applied?) - In section 1.9, you now say "For all co-products and wastes of beef production, 100% of impacts were allocated to the meat meaning none of the burden was allocated to co-products.", how can this be compatible with using allocation factors other than 100% at the slaughter and primary processing?	(1) There was a typo in the figure - it should have read 2.85, in which case, the losses and 1 kg output now add up. (2) Section 1.9 has been corrected to reflect the actual allocation procedure, as per Table D-18.	-(1) I still can't reproduce your allocation calculations, so the allocation procedure is still no clear. -(2) Y	It is clarified (after Figure D-1) that these amounts are calculated on a mass basis (physical allocation) and does not account for the economic allocation assumptions at the processor's gate and onwards due to confidentiality of the data required to make the calculations public.
61	D.2 Water Consumption	I don't understand what the "Share of beed-specific irrigated area" refers to. It is not mentioned in the text. It seems to have been multiplied by the irrigation intensity of the different feed production (crops, hay or tame pasture). Are the indicated intensities maximum values or average values? The amount of irrigation water coming indirectly through the feed is not directly dependent on the amount of feed and its specific irrigation intenisty?	Clarify.	Clarification added that it is the share of the total irrigated area required for beef feed/input production.	N, I don't see how knowing that of all the irrigated field crops area only 3.1% are used for beef feed production (which is what you indicate represents the 3.1% value) can be used to calculate the average irrigation intensity of the field crops used for beef feed production. If the 3.1% value represented the irrigated share of the total field crops area used for beef feed production and the irrigation intensity on those 3.1% was 2800 m3/ha, then the average irrigation intensity for all field crops used for beef feed production would be 2800 * 3.1% = 86.8 m3/ha.	Agreed, clarified that the average crop irrigation is only for beef specific areas.	N, you still indicate "Share of beef-specific irrigated area of total irrigated area (%)" which does not allow you, in my opinion, to multiply it with the "Average crop irrigation for beef-specific irrigated areas".	The calculation has been clarified in Appendix D (above Table D-20). It was calculated as the ratio (in percentage) of the irrigated area under beef production and the total area of each land use type occupied by the beef industry.

62	D.2 Methane Emissions from Enteric Fermentation	Why make a distinction between manure management systems, as best as I can see the DMI and Ym values do not change from one to another? The manure management systems are not shown in Table D-20. The animal types are not the same as in Table D-19 (combination of animal and feed). The column on manure management system shows the type of feed used.	Remove manure management systems from Table D-19 and make the two tables consistent in terms of animal type.	The distinction is another legacy description from NBSA 2016 and although we note that there are no differences between the DMI and Ym values, it is preferred to keep the distinction to be consistent with the descriptions in NIR (2021) (specifically, A3.4.3. CH4 Emissions from Manure Management) where an Animal Waste Management System (AWMS) Distribution Factor is included in calculations of enteric and methane emissions. The distinction in these tables will allow for any future updates where the AWMS factor becomes relevant to the emissions calculation	OK but I still think this is confusing and overcomplexing things.	We understand and appreciate this comment, due to the long term nature of this project, we'll have to leave them separate.
63	D.2 Manure-Related Emissions and Impacts	The figure is more focused on the impact pathways from manure related emissions. There is no indication of how the NOx and N2 emissions arise from manure storage. There is no indication on how the P, NH4 and NO3 (from organic N) emissions arise from manure spreading and pasture. In the ReCiPe 2016 method, as implemented in SimaPro and openLCA, there are no characterization factors (CF) for NOx run-off emissions to water or soil for the *Terrestrial acidification* impact category, and as was said before, nor are there for NO3 run-off or leaching emissions to water for the *Freshwater eutrophication* category (there are CF for NOx emissions to water and soil for *Marine eutrophication*). The figure is then misleading as to what is actually accounted for in the LCIA phase of the study.	Clarify the content of the figure and either remove the unaccounted for impact pathways or clarify that those are not accounted for in the LCIA.	Created additional part of the figure with pathways to midpoint indicator, but kept original as the overall picture of what's actually happening. Clarification added in text.	OK but I still think the figure is confusing and overcomplexing things.	We understand and appreciate this comment, however in order to add meaning to our intended audience, this figure aims to combine information relevant both to the LCA and the actual agricultural flows.
64	D.2 Methane	You indicate "0.00" values for some of the animal types and manure management systems, is that only because you show results with two decimals only or did you actually use a zero value in the calculations?	Clarify. If only due to rounding, it would be better to use scientific notation to show the actual values. (this can be generalized for all values throughout the appendix).	Changed all values to scientific notation	Y	
65	D.2 Nitrous Oxide Emissions	In lines 2113-2114, you state that crude protein content in feed rations increased from 11% to 16% from 2016 to 2021. I assume this is due to a change in feed ration composition as the different feed fractions have different crude protein content? Did you consider the same average crude protein content for all feed rations for the different aninal types? How was the 16% crude protein content measured? Is the 16% crude protein content based on wet or dry feed mass? This goes again to the need to indicate the moisture content of the different feed fractions and overall feed rations. The FAO 2003 document refers to an average 16% nitrogen content of protein, which can be used to calculate the amount of protein in food based on Kjeldahl nitrogen measurement.	Clarify what crude protein content values were used for the different aninal types.	Table (D-27) added specifying the % of crude protein on a dry matter basis in feed components.	Y	
66	D.2 Nitrous Oxide Emissions	You state that leaching of nitrogen leading to N2O emissions only occurs on pasture, why give Efleach values for the other manure management systems?	Show "N/A" for the other manure management systems.	Clarified that it applies to confinement (storage) too, not only pasture.	Y	
67	D.2 Ammonia Emissions	How do the TANex and the Nex,urinary (Table D-25) compare? Why not use the same value to be consistent?		A clarification on its relation to Nex (TANex = 0.60Nex) has been made clearer. It should be noted that the equation itsel for NH3 is borrowed from Chai et al. 2014 who refer to Nex and TANex separately, which is the case in other ammonia emissions related studies. It appears that approximating TANex as a 60% of Nex is not the case for all livestock.	Y	

68	D.2 Ammonia Emissions	-Calves on grass and feed, whether in the yearling-fed or calf-fed systems, whether in the West or East, have the same DMI, why then would their TAN values be different? Based on DMI values in Table D-19, I find for the calves 0.06 kg N/head/day for the calf-fed and 0.05 kg N/head/day for the yearling-fed systems. -In Table D-3, backgrounders in the West and East show the same start and end weight and DMI values, why would the TAN values on grass and feed be different? -The same with yearlings on grass and feed, the mid-weight being different between the West and East, I can see different TAN values for the two regions but not for the different feeds. -Why do the finishers with deep bedding show a significant increase in EF x ATA values compared to those with solid storage and composting and compared to the other animal types with deep bedding? -Are the NH3 values in kg NH3 or kg NH3-N?		(1) TAN is a function of DMI and crude protein in feed. Since the feed rations are different, the TAN value is different between production system and region. This is not apparent due to rounding. A link to the TAN calculations has been added. (2-3) See above - this has now been better explained. (4) Emissions from deep bedding for finishers are typically higher, a note has been added.	-Y -Y -Y -Y -N, the formula gives NH3 emissions in kg NH3/head/day, in the table you indicate kg N/head/day, I take that to mean kg NH3-N/head/day.	Corrected to NH3/head/day.	Y	
69	D.2 Nitrogen Oxide Emissions	Since emissions related to manure application were included to the crop production processes, how were values of kg NOx/head/year included to crop production datasets with 1 kg crop as reference flow? Table D-15 only states that crop datasets were modified to account for Canadian irrigation practices, silage yield or allocation factor.	Clarify.	We have clarified that the emissions associated with manure management up to the point of field application are assigned to the animal system, and emissions from the field were assigned to the crop production system in accordance with FAO LEAP guidelines. This implies that any values of kg NOx/head/year included to crop production datasets with 1 kg crop as reference flow is out of the boundaries of this study and is also consistent with the assumptions made in NBSA 2016.	N, so was the value of 0.094 kg NOx/head/year included in the study model? Since you use the NOx emissions related to manure application on crops that are included in the crop production datasets you use, you have not allocated NOx values yourselves to crop processes.		N	The value of 0.094 kg NOx/head/year refers to emissions related to storage (and not application) for each animal category. The statement has been clarified.
70	D.2 Nitrate Emissions	As was said, nitrate emissions to (surface or groundwater) have no characterization factors for either the *Terrestrial acidification* or *Freshwater eutrophication* impact categories. As they are not included in the land use assessment either, why quantify them. No interpretation of the calculated inventory values was done.	Either add some interpretation of the calculated inventory values or remove the whole section.	Agreed. This was residual from the previous study where marine eutrophication (which does characterize nitrate) was included. It has therefore been removed here.	Y			
71	D.2 Phosphate Emissions	I don't understand this section. How can phosphate emissions from manure for animals in confinement only occur at the pasture level? You state that phosphate emissions are related to feed phophorus content. Then say that since feed phosphorus content is unknown, general emission (leaching) factors per animal type were used and those are presented in Table D-29 in kg PO4 to water/head/day in pasture. Then you detail three models to calculate phosphate emissions from leaching to groudwater, run-off to surface water and erosion to surface water, whose results are in kg P/ha/day using constant values related to land use category. Where is the link with the feed phosphorus content and to the values in Table D-29? Why detail phosphate emissions related to animal in confinement if those were not included in the LCA modeling? Table D-29 isn't suppose to be for emissions to water for animals in pasture? Were the manure application emissions, allocated to crop production, included in the crop datasets modified to reflect any of the values you have presented in this section? Values in Table D-31 are for phosphorus excretion rates from manure, are those meant	Clarify. Maybe just present the phosphate emissions values in Table D-31, as those seem to be the only ones that were used in the LCA modeling.	Clearer separation between values used for confinement and for grazing added. Removed redundant table removed. Overall explanations improved upon, as per your suggestion.	N, still not clear. (1) You say that the model proposed by Prasuhn 2006 considers the diet phosphorus content but the three equations you present, based on Prasuhn 2006, do no include diet phosphorus content. (2) I don't see how the three equations you present relate to animals in confinement. The first two use Pgwi and Prol values which apply to meadows and pasture. All three are related to a certain area of land, did you use the area allocated to the confined animal? The Fgw factor is not included in equation 2, should it be? Table D-31 has "animals in confinement" in the title but "(on pasture)" indicated for the total calculated value. I find Per = 0.94*0.00095*1.86*0.2 = 0.00033 kg P/ha/day.	(1) Clarification added - Prasuhn's set of equations requires phosphorus excretion rates based on feed P content. Since this was unavailable, generic P excretion rates from Hofman & Beaulieu were used. (2) This was an error - the section refers only to animals on pasture.	N, since Prasuhn's equations are not used, it would have been better not to show them in detail and only show the Hofmann & Beaulieu values.	It has been clarified that since data regarding the phosphorus content of the diets was unavailable, phosphorus loss rates that are applied to the excretion rates were taken from Hofmann & Beaulieu (2006)
72	D.2 Phosphate Emissions	What does "or on feed" refer to?	Clarify.	Included clarification. On feed refers to confinement, as opposed to on pasture.	Y			

Appendix E: Data Quality and Uncertainty								
73	E.2 Uncertainty of the E-LCA Results - Monte Carlo Simulations	-Looking at the shape of the distribution of the Monte Carlo results, it is hard to see a recognizable shape. What types of distribution were used to describe the uncertainty related to the activity data used in the modeling (mortality rates, "animal stage" duration, star and end weights, etc.)? -It is surprising that the deterministic result (10.5 kg CO2 eq./kg live weight) is not inside the range of probabilistic results indicated in the figure. There seems to be very little uncertainty associated with the *Global warming* result (Figure E-1). This is surprising, I would have thought the enteric methane emissions would be associated with some uncertainty that would be driving the total uncertainty. From what I can see in the ECCC NIR 2022, IPCC Tier 2 factors, similar to those used here, show at least a ± 10% uncertainty. -There are 50 bars on the figure and not one reaches a 0.02 probability, the sum of those 50 individual probabilities will not be 1, does the figure cover the complete range of results?		There seems to be a display glitch in Simapro (only part of the MC results were shown earlier). Figure E-2 has been updated accordingly. A paragraph regarding the uncertainty on the global warming indicator has been added.	N, the uncertainty for the *Global warming* result is still very small, was uncertainty introduced in the model for the enteric methane emissions and other foreground activity data or was just the background uncertainty included in the ecoinvent datasets used in the Monte Carlo simulations?	No, the uncertainty data (DQIs) from this study were not included in the model and the uncertainty analysis only reflects the background uncertainty included in the ecoinvent datasets used in the Monte Carlo simulations.	N, this should have been indicated. Also the Agri-footprint 5.0 datasets used do not include uncertainty information, as the S version of the ecoinvent 3.7 datasets used, in effect only a few background datasets, and not the major contributors, contributed their uncertainty for the Monte-Carlo simulations.	Agreed, we have added a clarification in 2.1.7.
74	E.2 Uncertainty of the E-LCA Results - Monte Carlo Simulations	-Same as for Figure E-2, the deterministic result (9.3 kg CO2 eq./kg live weight) is not within the range of probabilistic results.		Figure E-4 has been updated accordingly.	Y			

CRSB NBSA Draft Report Critical Review Feedback Form

Name of reviewer: Sara Russo Garrido

Title of report: UPDATE TO THE CANADIAN ROUNDTABLE FOR SUSTAINABLE BEEF'S (CRSB) NATIONAL BEEF SUSTAINABILITY ASSESSMENT (NBSA)

Date: 2023-01-23 (last received)

Comment no.	Section no.	Comment (justification for change of technical aspects must be supported by either scientific literature or technical documents)	Proposed change (please provide alternative text)	Decisions on each comment submitted
Congratulations on your report! It was very interesting to read. My comments below point to some possible improvements regarding technical aspects, coherence, clarity and point to the occasional typo. I also included in my last comment some overall feeling I get from reading the study, about the fleeting occasional disconnect between your study and S-LCA methodology. This comment is harder to connect to a single location of the study given its general nature but pervades my reading experience. Do not hesitate to contact me if you have questions or wish to discuss.				
1	Exec summ	Sentence "the approach can be used to assess a business' behaviours to establish socioeconomic impacts" is oddly worded, especially where underlined. Also, it lacks connexion with the concept of organizations' stakeholders, mentionned in the second part of the sentence. (You can also look at your line 1079, where you word the same idea in a very adequate manner)	…to assess the social performance of organizations across the value chain…"	Done. See edit: "But, instead of measuring the potential impacts of physical processes, the approach can be used to assess ~~a businesss' behaviours~~ the social performance of organizations across the value chain to establish socioeconomic impacts with respect to the organization's main stakeholders and to different social issues of concern."
2	Exec summ	The full name of the Guidelines is not correct	*Guidelines for Social Life Cycle Assessment of Products and Organizations*	Done
2b	Exec summ	Should you not also say that your results come from your on-farm and packer-plant surveys? You make it sounds like it is only your deep dives that brought the results and these are defined as being separate from the survey on p.19, Figure 1-6.		Done. See edits in the section "Methodology" (above Figure ii) and the section S-LCA Results.
3	Exec summ	The paragraph starts by discussing work load level results, then working conditions, then finishes on a sentence regarding work load level and job satisfaction. It would be better structuredto first discuss work load fully, then working conditions, and end with job satisfaction.	Proposed change is mentioned in comment.	Done. See edits in the section "S-LCA Results"
4	Exec summ	The ratio of information about workload level compared to working conditions is uneven. It would be also interesting to hear whether working conditions issues face the same recognition as work load level issues and hear about rate of adoption of practices to deal with this issue. If the assessment did not have information on this or if for whatever reason workload level issues are dominating, it would be relevant to hear. Otherwise it feels like the workload level issues are well covered in this summary but the rest is very scant.		Done. Additional information was added with respect to other related themes. See edits in the section "S-LCA Results"
5	Exec summ	Sentence starting with "There is also a recognition" repeats information that is already communicated in the previous sentence.	Delete sentence.	Done
6	Exec summ	Sentence starting with "Also, given" : it is unclear whether this information comes from the results (it is the respondents' opinion that this should be a priority) or if it is the message from the authors.	Clarify sentence.	Adjustment done. The sentence was moved at the end of the paragraph to distinguish between what relates to the farm, and to packers. Sentence was also edited to clearly indicate that this information is based on the results, no from the authors

7	Exec summ	I suggest to reinforce the link between the social issues that the study focuses on and the communication of the results. This paragraph is very detailed on the practices analysed but the link between these and the list of social issues presented in page vi is missing.	See Comment.	I added 2 sentences to give a bit more context
8	Exec summ	After 4 detailed paragraphs of conclusions for the ELCA, it seems quite diminutive to have one paragraph for SLCA results, which is not about the conclusion of the assessment but rather a comment on the methodology used. The main conclusions emanating from the S-LCA portion of the study should appear here. Morevoer, it seems that it would be better to place comments on the methodology used on p. vi/vii, when the methodology is introduced for the first time.	See Comment.	Additional details were added
9	Exec summ	The last sentence of the paragraph essentially says the same thing as the first sentence of the paragraph.	Choose which sentence to delete and adapt paragraph accordingly	Adjustment done. The paragraph was moved and reviewed
10	Exec summ	Sentence starting with "Specifically" and the next sentence do not communicate much. Perhaps they need more flesh around them to convey relevant information, but as such, they just look like space-fillers.	Evaluate whether these sentences should be deleted or should be accompanied by more text, that would make them be more meaningful.	Adjustment done. The paragraph was moved and reviewed
11	Exec summ	This is a question: Are there recommendations regarding the working condition challenges in the packer plants? I do not see any at first sight but perhaps they are encompassed in transversal practices that are recommended? I am asking since it is one of the important results that came out in your assessment, with regards to Labour Management.	None, this is a question.	The two first recommendations are related to working conditions, and would apply to all businesses, farms and packers alike
12	1.3.3	Add "potential" to sentence starting with "Similar"	See Comment.	Adjustment done. "Similar to an E-LCA, an S-LCA evaluates the potential socioeconomic impacts of a product at different stages in its life cycle, from cradle to grave."
13	1.3.3	SEE COMMENT #1		Done - see above
14	1.3.3	There are two "and" in the enumeration.	Delete one.	Done
15	1.3.3	Perhaps you mean "systemic" instead of "systematic"?	Replace as suggested	Done
16	1.3.3	"." missing at the end of the Figure title.	Add .	Done
17	1.4	Replace "where" by "whereas"?		Done
18	1.4.1	This last sentence is unclear - what do we mean by "national level"? Perhaps it could be relevant to point when exactly in the unfolding of the study this is discussed? Is it at the level of recommendations, in the interpretation phase, etc.?		We modified a little bit the structure of the last sentence: "That said, the social performance of the upstream and downstream business partners with respect to social issues (including transport companies, producer associations and veterinarians), is discussed ~~at a national level~~ with respect to how these ~~social~~ issues are faced and managed by producers and packers."
19	1.4.1	There is a typo "An-on farm"	relocate hyphen after on.	Done
20	1.11	SEE COMMENT #2		Done
21	1.11	SETAC is not involved in the 2020 Guidelines.		Done
22	1.11	S-LCA relies on quantitative and qualitative data - adjust sentence		Yes, "S-LCA is a practice-based approach that relies on quantitative and qualitative data and provides a qualitative assessment of the performance of organizations involved in a supply chain.
23	1.11	About sentence starting with "Consequently" - Here, you make a claim about S-LCA in general which is not true. A lot of studies in S-LCA do report results related to a functional unit (if practitioners use an activity variable). Your study doesn't and it is ok. But this claim is incorrect.		Sentence deleted
24	1.11	The 2020 Guidelines also list "Children" as part of the stakeholder categories.		Changed 5 groups to six groups and added children
25	1.11	This is an editorial comment - I find that whenever the issue of positivie contributions and risks emerges in your report, positive contributions are always listed first. It always sounds a bit marketing-oriented to me.		This way of presenting the information/results was preferred to account for the target audience, comprised primarely of producers and their representatives. It provides the opportunity to recognize/acknowledge current efforts, and list areas for improvements that build on them. It is also a more systematic way of presenting results.

26	1.11	For a more complete sentence: In "the 2016 NBSA report"	Done
27	1.11	In sentence: "as well as to recommendations…", delete "to"	Done
28	1.11	Editorial comment: "realization steps" sounds like a frenchisism. Revise.	Done - Removed the word "realization"
29	1.11	You mention the "how" in your phases 1 and 2 (Q method, interviews, etc.). You should also provide that information for Phase 3. In a similar vein, it could be interesting to highlight for Phases 2 and 3 the number of respondents involved, as you do it for Phase 1. These changes would reinforce the structure of your Figure.	Done. See adjusted figure
30	1.11	To better ground your methodology in S-LCA methodology/concepts, you could here refer to the fact that this was the materiality assessment which contributed to your selection of subcategories/life cycle steps for your study.	As mentioned above in the report, the process of selecting the subcategories/life cycle steps was iterative and not the result of a particular 'Phase'. Each Phase was the opportunity to revise and prioritize what information should be considered as "material".
31	1.11	Remove the "s" at the end of concern.	Done
32	1.11	Do you mean "for the on-farm survey" or "from the 2016 on-farm survey?" not clear.	Edited. Changed 'for"
33	1.11	When I read the title of the Table and I see the percentages, it is not clear this is how the indicator is presented WHERE? To the interviewee or is this how the responses are compiled? The % is confusing to me. It's a % of what?	Added a mention that the % corresponds to the number of farmers who answered the question
34	1.11	It would be useful to reader to show which indicators are meant to evaluate which key themes. Otherwise the reader is left to figure it out on his/her own. It would be easy to integrate this information in Table 1-3.	See edit to Table 1-3.
35	1.11	In the portion regarding People's health ans safety: the last sentence of the "what is it" section is misleading as these topics (labour relations, etc.) are covered in Labor management, not People's health and safety. At the very least this should be made clear in the text.	Sentence deleted
36	1.11	It is surprising that human beings (farm owners, employees, etc.) are deemed to be stakeholders for the topic "Animal care". Stakeholders are meant to be affected stakeholders, not all stakeholders involved in the topic at hand. I understand these humans are involved in the various practices regarding animal care, but I have difficulty seeing how they can	Farm owners and employees are key stakeholders with respect to animal care, as they are also impacted --being the ones handling animals and ensuring their care (or lack thereof). Poor animal care practices also affect people's well-being.
37	1.11	Regarding "Antimicrobial Use" it is surprising that the only key theme associated to this is training. Are all the indicators below simply about training on these topics or practices other than training are also considered? Some indicators sound like it could be the case...	Adjustments made. Additional themes were added: record keeping, antibiotic categories and procedures/situations when using antimicrobials
38	1.11	The identity (by this, I mean general identity: business owners, employees, TFW...) of the respondents who have responded to the on-farm survey and the deep dive interviews is never mentioned (or perhaps I missed it?). Same thing for the scoping exercise. It is important to mention this in the body of the text, without having to go check the information in the Annexes. It is key information to understand the study design.	It is mentioned at page 11 under section 1.6 Data Collection. Each bullet point describe the primary data collection activities (Q-Sort, On-farm survey, Interviews and Packer surveys). See also section D.4 of the Appendix D for more information on the participants' profile
39	1.12	The sentence "Following the E-LCA methodology" should be rephrased, it sounds very odd to start the sentence with these words.	Changed "Following" by " As with the E-LCA methodology, the S-LCA Guidelines also describe…"

40	2.2.1	It is odd to have as a general definition of what Labour management is "Labour management refers to the working conditions provided to the people working in the industry" and have as a distinct assessed area listed in this table "working conditions". If working conditions are the "blanket term" used to describe what goes under labour management, perhaps there is a more precise term to use when describing the assessed area itself?		Reference to Working conditions was removed from Table 2-13.
41	2.2.1	The sentence starting with "The focus" is unclear. Not sure what you mean by "bound"		Delete sentence (RP).
41b	2.2.1	The arrow "contextualization" at the bottom is enigmatic.	Delete it or explain in the body of the text what it is about, if important.	The whole figure was deleted (see also comment 71 below).
41c	2.2.1	The explanations about the impact pathway suggest unidirectional pathways, starting from labour management/stressors to potential impacts affecting ultimately key areas of concern. Yet, when we read the paragraphs below, you draw links between stressors, between potential impacts, between key areas of concerns and potential impacts - it's all over the map. It gives a feeling of disorderliness to the reader and weakens the arguments you are trying to make.	My advice would be to "faire le ménage" and present in an ordely way to unidirectional links first and then those that are transversal in nature. And you should warn your reader about the fact that links can be made from stressor to impact but also between stressors and between impacts.	Removed lines 2388-2405 in section 2.2.1. These lines are repeated in each deep dive: removed lines (2836-2847; 3915-3199; 3687-3691). Added fourth level heading (same heading level as rationale), that says "Impact Pathways" right before potential impact pathways figure. Replaced with: "Evidence of stressors and potential impacts along the beef value chain are defined by stakeholders and the sustainability literature. In some cases, the interrelations are known and have been characterized scientifically by recent studies. In other cases, the interrelations are theoretical possibilities that have not yet been characterized through an examination of cause and effect. The impact pathways section takes a first step toward gathering the breadth of potential stressors and potential impacts together to highlight the potential for social consequences (good or bad) in the context of agriculture. The current state of knowledge about how stressors may interelate or manifest in mid-point or endpoint impacts varies. The pathway analysis section below will show that as it describes these interrelations as complex and multi-directional. Furthermore, the interrelations are not always predictable, or uniform, becuase they are defined by relationships between people within an organization or between organizations within the value chain. The aim of impact pathway section is to provide the reader with an awareness of the potential for impact pathways to activate along the beef value chain."
41d	2.2.1	You refer to human health and healthy sustainable communities as "Key areas of concern". Yet, you also use this term to refer to the 4 deep dive topics you focus on. I am writing this comment after reading your sub-title on line 2505, which causes me to wonder what is the key are of concern your are refering to there. I think it is Labour management (because we are in section 2.2.1), but some confusion is present because of same vocab used to refer to different concepts.		The expression "key area of concern" does not have a particular connotation or meaning in our methodology. It is used to refer to key concerns as part of the rationale sections. Throughout the report, we use the expression "Priority social issues" to refer to the 4 deep-dive topics. The expression was adjusted to remove the "key" and keep "areas of concern" to avoid confusion. Besides, Figure 2-27 and 3 others describing the potential impacts were removed to avoid confusion.
42	2.2.1	The way the pathways (1.1, 1.2, 1.3) are entitled is not conceptually uniform. It would help the reader if you would choose a formulation and stick to it, ex: Stressor X leads to potential impact Y. Pathway 1.3 is formulated in a surprising way (unexpected given the explanations above - almost like a reverse pathway), it focuses on how a key area of concern (human health) may cause some potential impacts. It is also surprising to see in the titles concepts that are not included in the Figure (ex: productivity/sales)		See updated language and figure in the four deep-dive section
43	2.2.1	What are the green and purple lines around boxes?		See updated figures in the four deep-dive
44	2.2.1	Sentence starting with "Based…". It is unclear whether these goals were established in 2016 or they are the current goals, coming out of this current report. I think it is the former, but I suggest to specify		Edited: "Based on the 2016 NBSA results, the CRSB has established, as part of the National Beef Sustainability Strategy, the goal of promoting farm safety and responsible working conditions (CRSB, 2021b)."
45	2.2.1	Sentence starting with "While…". Earlier in your draft, you define labout management as providing adequate working conditions (or something along those lines). You make a clear link between labour management and working conditions. In this sentence, you contradict this claim. -- This comment also reinforces a previous comment I made above, about the need to more clearly define what you consider to be 'working conditions'.		The sentence you are referring to is not meant to link labour management to labour conditions. It highlights the fact that no particular actions were implemented in the National Beef Sustainability Strategy to address labour management per se. No change were made to the text.

46	2.2.1	In key observation #2, many of the documented strengths and risks seem - at first sight - to have very little to do with the issue of adressing the workload level. A few more words to make the links obvious would be relevant. And naming the practices that would help deal with workload level (second point in the risk section) would be relevant.	As explained in the text following that table (under Key observation #1), workload levels are linked to labour management practices by the fact that sound working conditions are needed to recruit / retain workers - and therefore limit workload for farmers and the other employees. Examples of practices were added under the "Documented risks" for Key Observation #2
47	2.2.1	In key observation #3, I fail to see why the strengths and risks have not simply been placed under key observation #2. It feels like the innovative aspect that you are trying to communicate does not come through in the strengths and risks. Perhaps there are some additional details you can add to make it clearer, because it just reads as an additional observation but it is unclear how it is novel compared to observation #2.	Based on the results, it was decided to create this Key Observation as a standalone - instead of merging it under #2, which is already covering a broad range of considerations. The importance of thinking 'outside the box' (or being innovative) to address a challenge difficult to address at the business level. That said, we reworded the "Documented strenghts" and added a "Document risk" to better capture that innovation piece.
48	2.2.1	These two paragraphs seem to contradict each other with regards to whether cow-calf operators are vulnerable or not with regards to recruitment and retention.	Adjustments were made to the two paragraphs for clarty reason: "The interviews with industry informants indicated that the overall challenge of labour management is experienced differently depending on the sector and the size of the operation. ~~Whereas~~ For feedlots and packers, they are more directly facing issues related to recruitment and retention~~, cow-calf operations are less directly exposed, but nonetheless impacted~~. At the cow–calf level, interviewees expressed concern with respect to the ability of operators to address labour management related issues. In fact, the cow-calf sector seems particularly vulnerable on the labour side due to operation size or capacity.[...]Overall, the workload induced by labour shortages and its repercussions on people’s health is one common denominator affecting many businesses across the industry.
49	2.2.1	Typo: requires.	Done
50	2.2.1	This paragraph is not clear.Especially sentence starting with "Especially" - which does not make sense.	There is no paragraph starting with "Especially" around the line 2734. And we couldn't find any using "control F".
51	2.2.1	The way the results are presented is interesting, but it would be clearer (and more S-LCA-like) to present the hotspots identified through the surveys & deep dives. We get to read about them as we read through the results, but we do not emerge from this with a clear view of what comes out clearly - we remember the key observations, but not so much the hotspots. For example: the findings regarding suboptimal practices with regards to work schedule and overtime is an important finding but it is not brought forward. It seems that workload and recruitment issues are obscuring other issues to emerge.	In the assessment, the terms 'hotspot' and 'risk' have the same meaning. In that sense, the "Documented risks" listed in each section refer to the hotspots the industry should take into account. To avoid potential confusion, the term 'hotspot' was replaced by 'risk' throughout the report when the expression was used interchangeably. The term 'risk' is preferred as it is likely to be better understood by the industry than the word 'hotspot'.
52	2.2.1	The fact that no employees responded to the surveys or interviews is an important limitation of the study and should be highlighted in the executive summary and earlier in the study. It is only when we read the results that we realize this.	A reference to this was added at the end of section 1.12 (p.26) and a bullet point about that in appendix D.4 (p. 227). For the executive summary, we used the text suggested to answer comment #69 (see below). We also added the text under the methodology section.
53	2.2.2	The title of the pathway does not reflect a pathway as described in the paragraphs above (2836-2847).Based on the Figure, I thought awareness (raising awareness) was identified as a practice which can be a stressor. But here the title says that awareness has an impact on workplace practices... I understand the point being made: awareness and motivation affect the practices that are being put on the farm - but the link between that claim and the Figure above is hard to grasp.	Paragraphs 2836-2847 deleted and figure 2-30 deleted.
54	2.2.2	In the Figure, the geometrical figure around "Hazards" should be revised - it looks like it does not belong with the rest of the image. What the green and orange lines around boxes mean is not clear nor the dotted line around animals. How does mental and physical health affect working conditions? The arrow starting from mental health is meant to by-pass decision making and safety protocols? Perhaps the Figure also tries to do too much by including aspects related to Animal H&S - this is not the focus of this section.	See updated figure

55	2.2.2	Sentence starting with: "Where". What you mean by 'may stand-in as a decision made long before…' is not clear. What do you mean?	Update sentence to: "Consistent health and safety practices and protocols can play an important role to support safe-waor when decision-making or focus is under stress."
56	2.2.2	You repeat the same sentence twice.	Done - deleted
57	2.2.2	After reading the results lines 3001-3026 (and paragraphs after that), I am surprised that key observation #1 is not worded more directly as for example what is done on line 3025 or 3051. It seems odd that the first element to point out is that there are efforts being made, whereas the take home message from the results is that there are clear risks and rates of adoption of relevant practices are not where they should be.	Key Observation #1 was reworded to account for this comment: "Room for improvement remains with respect to the adoption of practices to prevent incidents, particularly on farms."
58	2.2.3	Consider erasing "an" for a better sentence? Actualy, upon reading again the sentence, it is not fluid. Consider rephrasing.	Replaced: "It is an inherently…" with "Animal care is a…"
59	2.2.3	Title for Pathway 3.1 and 3.4 does not refer to pathways identified in the Figure. Should you consider revising your Figure?	See revised figure
60	2.2.3	Pathway 3.4 should be adequately numbered.	Done
61	2.2.3	The title for the subsection announces refers to the documented hotspots in 2016, but when we read the whole section no hotspot can be found.	The section's title is the same across chapters for consistency reason. Here, we are referring to the 2016 NBSA report and highlight that a low risk level was documented with respect to animal care. "These objectives were established in part based on the results of the 2016 NBSA which showed low risks with respect to animal health and welfare, a result attributed to the industry's investment in developing and disseminating the Beef Code (CRSB, 2016a, 2016b). Only a moderate risk was identified with respect to the use of pain control for branding, based on the limited use by farmers of pain control techniques (CRSB, 2016a)." No changes were made
62	2.2.3	Paragraph is a repetition with previous paragraph. Delete.	Deleted
63	2.2.3	Typo: …are handled…	Done
64	2.2.4	The title of the pathway should be worded as a pathway (causal relation) - use terms such as X affects Y or X has a potential impact on Y, rather than X is important for.	Revised the pathway title on lines 3696 and 3697 to "Pathway 4.1 - Responsible antimicrobial use in beef cattle production affects animal welfare, profitability and employee morale."
65	2.2.4	Figure 2-37 is complex and reader is left to his/her own devices to decipher it. Perhaps more accompanying text is needed to clarify the intent. As a general comment, all Figures of this type in the report are very challenging to interpret and their added value is thus limited. Consider supporting them better with text or getting rid of them. I recognize the ambition of these figures and I am sure they result from a lot of work, but they don't succeed in bringing clarity, which in theory should be their main purpose.	Figure revised. Sentence lines 3730-3731 "Dotted…unclear." was deleted
66	2.2.4	I would recommend placing this paragraph first in the section, in order to first highlight what the 2016 survey revealed and then discussing what happened since then. Given the title of the section, it would be a logical progression.	Adjustment done
67	2.2.4	Typo: percentages	Done
68	No comments on conclusions, as they would overlap with comments made before.		
69	3.2	I would also name the fact that respondents to questionnaires, interview included employers, etc. - but excluded employees	Edit made: "Moreover, the assessment covered a limited scope (e.g., respondents to questionnaires and interviews included employers, managers, industry experts, associations, etc. – but excluded employees), and results could not be readily compared to those from the 2016 NBSA and Implications of doing so include a limited."

70	Appendix C1	The identity (general identity) of the stakeholders who participated in the scoping phase should be revealed in the section Background and method (like you have done in p.224, Table D-34 for interviews). This is a key information to provide (giving a clear picture of the array of people involved in the scoping exercice) given that this exercise has played a central role in the selection of topics for the study. We should not have to look for this information in a piecemeal fashion, in the factor interpretation section. This information should also be presented within the body of the report, when the scoping phase methodology is explained.	Please review the scoping report and add that information to the main body of the report.	A section was added in the Appendix to provide an overview of who participated to the Scoping report: `"Of the 39 respondents involved in the scoping phase of the assessment, 22 were male (56%) and 17 were female (44%). Respondents identified as veterinarians (18%), human nutritionists (5%), ruminant animal nutritionists (5%), agricultural researchers (5%), retail employees (5%), processing plant employees (15%), farm employees (21%), agricultural business owners (15%), government employees (8%) and non-governmental organizations (3%). Seventy-nine per cent of respondents were from Western Canada (i.e. British Columbia, Alberta, Saskatchewan or Manitoba) and 21% were from Eastern Canada (i.e. Quebec, Ontario, Maritimes). Respondents 35 to 44 years of age (33%) were the largest age cohort, however, others were between 18 to 24 years (3%), 25 to 34 years (18%), 44 to 54 years (28%), 55 to 64 years (13%), or over 65 (1%). " Also, a footnote was added to section 1.6 on data collection.
71	Appendix X	The evaluation here is not developed with the standard reference scale. The results provided are "raw results". This also concerns other indicators in the study, it would be relevant to explain why this choice is being made.		Clarification is now provided in section 1.11 just before Table 1-2 (p.21): "However, not all indicators are reported using this standardized evaluation scale. For instance, perception-based indicators (e.g., Indicator 1.9 – Workload Dissatisfaction; how often is dissatisfaction with overall workload expressed by employees?) report the answers to the question asked using figures. This is to facilitate interpretation and account for the fact that such perception-based results are not suited to be assessed using a normative evaluation scale."
72	General comment after reading it completely.	There is some disconnect between S-LCA methodology and the vocabulary and ways of presenting results in this report. The interchangeable use of terms such as 'social issues', 'related themes', 'assessed areas', 'stressos', 'pratice', 'key area of concern' is sometimes disconcerting even though some of these terms could be indeed used for the same concept. The issue is that given that the nomenclature of S-LCA has not been chosen for the study (ex: impact subcategories, area of concern, etc.), it is important to be coherent with the nomenclature you end up using when you refer to your main framework. A related issue that I have a hard time to pinpoint precisely is that it feels like some items that are listed as social issues under the four main social issues considered in the study are not social issues in themselves but rather indicators of social issues. The granularity or level of detail of some of them (ex: record keeping - can record keeping really be considered as a 'social issue'?) is almost too great. Another issue, is that the study makes uneven efforts to discuss results from a hotspot perspective or by identifying social issues at risk -- the results are always very practice-based, or results-based (41% of respondent say X) and through it all, we lose sight of where are the hotspots and what social issue is at risk if practices are suboptimal. Some comments to address this are in the comments above.		Different adjustments were made throughout the report to address this comment: => The expression "social issue"(or priority social issue) is now systematically used to refer to the four key topics addressed through the Deep-Dive: Labour Management, People's Health and Safety, Animal Care, and Antimicrobial Use => The term "theme" is now systematically used to refer to the specific areas addressed under each social issue (e.g., working conditions, training) => The term "stressor" is only used with respect to the 'pathway analysis' described in each deep-dive => Similarly, the concept of "area of protection" is only used as part of the pathway analysis With respect to the comment on the degree of granularity: the assessment being based on a practice-based approach, we considered and focused on practices that affect and/or are related to the priority social issues. The identification and selection of those practices were based on the 2016 assessment, the literature review (incl. industry standards) and discussion with experts and SAC members. Specific practices such as record-keeping is of interest in that respect, as it is a practical way for farmers to manage risks and show commitment with respect to the priority social issues (animal care, animal health, OHS, ...). Lastly, the 'hotspots' are captured through the Key observations listed in each Deep-Dive. As mentioned above, the concept of 'hotspot' was replaced by the expression "Documented risks". These risks are informed based on the documented evidences, which include the adoption rate of certain practices, interviews with informants and available literature. Hopefully these adjustments and clatifications will bring additional clarity to the report.

Date 20 jan 2023				
Thank you for your responses, calrifications and integration of comments in the paper. In particular, good job on re-vamping the impact pathway sections; uniformizing the 'social impact/risk' vocabulary in the report; adding information about the identity of respondents in the survey. Below are some additional comments.				
73	Exec summ	Is "to S-LCA" necessary? Not sure why it is there.	Erase it.	Done - deleted
74	Exec summ	I would specify "the S-LCA methodology devised for this report", to underline the fact that this methodology is not "classical" and takes some liberties in re-defining some terms in ways that are not aligned with S-LCA. I think it is fine to adapt the methodology to the needs of the report, but it should be made clear that this is an adaptation. Editiorial note: you have the word S-LCA twice in your sentence now. The second one could easily be removed.		Adjustment done. See below: "In-keeping with the three building blocks comprising the S-LCA methodology devised for this report, namely the Scoping Phase, the Practice-Based Assessment and Deep-Dive Assessment, ~~the S-LCA~~ it led to the identification of key observations associated with positive contributions as well as potential risks for the industry."
75	2.2.1	I see that Figure's 2-27's title has been removed, but the Figure remains on the manuscript. If indeed the Figure has been removed (as suggested in comment 41b above) we are good.		
76	2.2.1	Figure 2-27. Above figure has been deleted? (not clear on the PDF) I imagine because otherwise there is a lot of overlap between two figures. On the bottom figure: explanations are useful but the different colours for the external part of the squares (green, purple and dark green) are still unexplained and enigmatic.		The comment is related to the previous version of Figure 2-27. The updated figure does not have different colours for the external part of the squares. No further changes needed.
77	2.2.1	I trust the Figure has been removed, although it is not so clear on the pdf version.		Yes the figure has been removed.
78	2.2.1	I think the paragraph would be better connected to the above paragraphs if its first sentence was the second sentence of the paragraph (starting with While…). The sentence starting with "Consistent…" could be preceded with 'Indeed', to make your point or even deleted because the same information is encapsulated with the sentence starting with 'While'.		Adjustment done
79	2.2.1	I trust the upper Figure is not kept (there is a small purple line across it). The figure below is still a bit unclear. Wouldn't you place safety protocols and practice between mental health and decision-making? Because they are a factor that may affect decision making. Also, 'Safety awareness and motivations' seems to be oddly placed. Why would it only affect protocols and practice? Doesn'it rather affect decision making? Also, why would hazards be just on one side? Wouldn't they also be relevant to Animal welfare? It is also surprising that 'stress' does not appear anywhere on its own, as it is a stressor affecting decision-making and ultimately mental and physical health. Last point: the fill of the boxes is explained below the figure but not the colour of the "encadré". After reading your paragraph on the previous page, I would have thought the pathways are the following: working conditions (in particular workload) lead to stress. Stress leads to decision-making leading to: 1) physical safety risks; 2) animal welfare risks; 3) mental wellbeing risks. There are intervening factors between stress and decision-making, these are: safety protocols and practice and safety awareness and motivations.		The comment is related to the previous version of Figure 2-29. The updated figure is the upper one. No further changes needed. SEE THE SCREENSHOT OF THE PDF TO UNDERSTAND THE COMMENT
80	2.2.1	Revise sentence that ends with 'toward'. Towards what??		Adjustment done. We deleted the whole sentence and integrated it into the previous one. See below: "That journey involves the whole supply chain working in tandem, and since trust is a two-way street, when violated, it can put road blocks toward animal care, transparency, and communication (CAST, 2018, p. 3). ~~Trust is a two-way street that when violated can put up road blocks toward.~~"
81	2.2.1	In the title, it might be more representative of figure to replace the term 'from' by 'in'. It would also be consistent with how previous Figure was named.		Adjustment done
82	2.2.1	Same comment as above.		Adjustment done

APPENDIX B
UPDATE OF THE 2016 E-LCA AND LU METHODOLOGIES

B.1 ENVIRONMENTAL LIFE CYCLE ASSESSMENT

INCLUSION OF DAIRY

In the previous assessment, the implications of the dairy sector were excluded from the study in order to be consistent with other national-scale beef inventories that had been conducted at the time. For the updated assessment, however, it was important to consider the impacts of beef coming from the dairy sector as a case study for just the global warming indicator.

In 2021, 17.2% of beef produced in Canada came from the Canadian dairy sector. This includes all dairy animals, including steers, heifers, and cows. The breakdown regionally varies slightly, as shown below. These figures are based on data from Canfax regarding cattle inventories and slaughter figures.

Table B- 1: Breakdown of meat from beef and dairy animals in 2021 and 2013/14

Year	2013/14			2021		
Regional	National	West	East	National	West	East
% meat from dairy animals	17.9%	1.8%	31.3%	17.2%	5.8%	29.6%
% meat from beef animals	82.1%	98.2%	68.7%	82.8%	94.2%	70.4%

Furthermore, the transport of dairy animals imported from the United States to the Western beef production system was also included. This was approximated as transport of 1,200 km between the Pacific Northwest (Seattle, Washington, USA) and the Prairies (Calgary, Alberta, Canada). In 2021, the fraction of total slaughter from imported dairy was 3.6% (0.036 kg imported meat per kg live weight), compared to 0.14% (0.0014 kg imported meat per kg live weight) in 2016 (Canfax, 2022).

In 2018, the Dairy Famers of Canada have carried out the LCA of Canadian milk. The boundaries of the study, cradle to processor's gate, were the same as this study. The impacts related to milk production were allocated between milk and meat based on the following equation (IDF, 2015):

Allocation factor for meat = 1 − 6.04 × (weight of live animals sold / weight FPC milk)

The part allocated to meat was used in this study. This was a value of 6.5 kg CO_2 eq/kg live weight meat from the dairy sector, at a national scale. Regionally, the values considered were 6.7 and 6.0 kg CO_2 eq/kg live weight in the East and West, respectively. These values are based on the Dairy Farmers of Canada study conducted in 2018. An updated value was not available at the time of this study, so the same value was applied to determine the combined carbon footprint in 2013/14 and 2021.

A weighted average, using values in Table B-1, with the carbon footprint of meat from dairy and the carbon footprint of beef (as determined in this study) were applied to determine the overall carbon footprint of beef produced when both the beef and dairy production systems are considered. This was repeated at a national and regional scale (East and West).

It should be noted that in the DFC study, cow manure produced at the farm and applied on crops not used to feed cows, a cut-off rule was used, as recommended by the IDF guidelines. Based on this allocation rule, the manure that is not used in a closed loop for dairy feed production is considered a residual material, and no allocation of the milk production impacts is required.

B.2 Updates to the Land Use Assessment

Biodiversity

The relationship between biodiversity and cattle production is a growing area of concern. The purpose of the biodiversity assessment is to quantify and understand the influence that the Canadian beef sector has on the biodiversity of land used both directly and indirectly.

Since the publication of the 2016 NBSA, improvements have been made to biodiversity assessment, but there is still no widely accepted framework for an assessment of this nature. Furthermore, the 2016 assessment left room for improvement regarding differentiation between different pasture types, accounting for management intensity, and capturing land not just used by agriculture. In order to address these limitations, in this assessment two different models were applied to get a national perspective of biodiversity changes due to beef cattle rearing, as well as an Alberta-specific profile due to its importance in the Canadian beef sector. The application of these models is described in further detail in the following sections.

WHCI

The Wildlife Habitat Capacity Indicator on Agricultural Land (WHCI) model was developed by Agriculture and Agri-Food Canada (AAFC) to address changing biodiversity on Canadian land used for agricultural purposes. It calculates the relative value of farmland for various types of wildlife with respect to both feeding and breeding. This assessment built upon the WHCI model to create a provincial beef-specific indicator based on feedstock requirements, including crops and land for grazing.

Reporting Area and Time Frame

Potential WHCI[A] and WHCI[B] was determined on agricultural land in Canada for 2016 and 2021. While feed rations data was representative of 2013/14, as used throughout the rest of the environmental LCA and the land use assessment, the underlying biodiversity and species data was representative of 2016 which is why the benchmarking year is referred to as such. Furthermore, in this report, the term agricultural land includes cropland and pastureland including natural land for pasture. All analysis were done at the Provincial level then rolled up for National *State* and *Trend* reporting.

Wildlife

A habitat association matrix was constructed for 545 terrestrial vertebrates (332 birds, 134 mammals, 41 amphibians and 38 reptiles) that use land cover within the agricultural extent of Canada for reproduction and/or feeding. Each cover type (used as a synonym for habitat in this report) used by wildlife species was classified as *Primary* (always used, critical or strongly preferred habitat), *Secondary* (often used, important habitat) or *Tertiary* (occasionally used, low value habitat) with values of 1.0, 0.75 and 0.25 assigned, respectively, to reflect the relative importance of the land cover for both reproduction and feeding.

Land Cover

Land cover information was obtained from (1) the AAFC Earth Observation Semi-Decadal Land Use (SDLU) Time Series Product (2015 and 2020, 30 metre resolution) and (2) the Statistics Canada Provincial Census of Agriculture (COA; 2016 and 2021). Cover types included in the SDLU were *Settlement*, *Vegetated Settlement*, *Cropland*, *Managed Grassland (native grassland)*, *Woodland*, *Woodland Regeneration* (following harvest), *Woodland Regeneration (following fire)*, *Wooded Wetland*, *Wetland*, *Water*, and *Other Land*. The COA was used to differentiate agricultural cover types at the Provincial-level within the *Cropland* area defined by the SDLU. These included cover types used by the beef cattle industry (*Improved Pasture*, *Unimproved Pasture*, *Triticale*, *Wheat*, *Oats*, *Grass* and *Hay*, *Barley* and *Corn*) and those not used (the remainder of *Annual Crops*, *Nurseries* and *Fruits and Berries*). The proportion of each cover type used by the beef cattle industry in 2016 and 2021 was obtained from ration tables.

Wildlife Habitat Capacity Index Calculation

Initially, species-specific habitat availability (SSHA) for reproduction and feeding on agricultural land was calculated at the Provincial level as follows:

$$SSHA = \sum(CT\% \times HUV)$$

where; $CT\%$ is the proportion of the cover types used by a species in the Province and HUV is the habitat use value (Primary=1, Secondary=0.75 and Tertiary=0.25).

Next, the Wildlife Habitat Capacity Index for reproduction and for feeding on agricultural land ($WHCI^A$) was calculated for each Province as:

$$Provincial\ WHCI^A = \frac{\sum SSHA}{n}$$

Where n is the number of species per Province.

The beef-specific Wildlife Habitat Capacity Index on agricultural land ($WHCI^B$) was calculated in a similar fashion as above but was limited to the proportion of cover types used by beef cattle as identified in ration tables.

Results for both applications of the WHCI model are presented in Section 2.1.4 for both 2013/14 and 2021 data in order to benchmark performance of the Canadian beef sector.

ABMI

The Alberta Biodiversity Monitoring Institute (ABMI) is another dataset used for the biodiversity assessment. This model is based on species, habitat, and human influence specific to Alberta. Data is collected via 1,656 data collection sites located on a 20 km grid throughout Alberta. ABMI uses species-habitat models developed for various species to quantify relative abundance of a species in a given region. From here, an intactness index quantifies changing species abundance as a result of human activity. Various indicators are calculated by the ABMI model, but the main contribution to the NBSA is its inclusion of human activity from various sectors.

The ABMI assessment was more qualitative than the WHCI assessment as its primary focus was a deeper understand of biodiversity implications in Alberta. Literature published in collaboration with ABMI was reviewed for the assessment and the main findings are discussed in Section 2.1.4. In addition to this literature review, cattle densities obtained from the 2021 census of agriculture were overlayed on maps displaying three main indicators reported in the ABMI database, including **species intactness, non-native plant richness,** and **human footprint with relation to agriculture**. Areas with high cattle densities and high biodiversity impacts were then examined and analysed with respect to the key findings from the literature review.

WATER RISK

In addition to the water consumption in the E-LCA, a water risk assessment was included as part of the land use assessment. This follows the same approach as the NBSA 2016. Because the quantitative aspect of water use was captured in the water consumption indicator, the water risk assessment focused on a qualitative overview of where areas of high cattle density coincided where areas of high-water risk. Using Aqueduct, a tool developed by the Water Research Institute (WRI), water risk indicators, including baseline water depletion, inter-annual variability, and drought risk. Based on this GIS analysis and an updated literature review, recommendations on best practices for water use were formulated. Further details on the water risk assessment methodology can be found in the NBSA 2016 report.

Since the 2016 NBSA, changes were made to the WRI Aqueduct tool, including the methodology behind certain indicators. For this assessment, the indicators of baseline water stress, interannual variability, and drought risk (previously called drought severity) were of interest. Each indicator was updated based on changing data and updated literature over the past years. The indicator of baseline water stress includes domestic, industrial, irrigation, and livestock uses, where higher values represent lower water availability for regions located downstream. Next, interannual variability was updated to capture the difference between water supply from groundwater and surface water from year to year. Finally, drought risk was updated to capture regions where droughts are more likely to occur and quantifies the vulnerability of the population based on water demands.

In general, the hydrological model used by Aqueduct has also changed in a few ways. First of all, the water supply now includes both surface and groundwater. This is important for the NBSA because both these water systems are crucial to agricultural practices. As a result, use of Aqueduct for agricultural processes has increased accuracy. Next, water supply and demand were previously calculated separately in the model, which implied that double-counting may have occurred. This is corrected in the new model, again increasing accuracy. Finally, each indicator has high spatial and temporal resolutions. Any changes to methodology that affect benchmarking or results drastically are discussed in depth in Section 2.1.4 in order to prevent inaccurate claims about changes to industry behaviour that have affected water risk.

APPENDIX C
RESULTS OF SCOPING FOR THE NATIONAL BEEF SUSTAINABILITY ASSESSMENT UPDATE 2021-23

C.1 Scoping Report

Results of Scoping for the National Beef Sustainability Assessment Update 2021-23

Prepared by:

Canfax Research Services

August 3, 2021

EXECUTIVE SUMMARY

The results of scoping for the National Beef Sustainability Assessment Update 2021-23 are in this report. The aim of scoping was to identify priority, consensus, and contention issues within the current beef sustainability dialogue through a participatory approach to social life cycle assessment (S-LCA). The chosen approach was called the Q method.

In June 2021, a diverse group of 39 purposively sampled beef industry stakeholders completed a Q sort. This involved each respondent sorting 52 cards; each card had a written statement about Canadian beef industry sustainability. Respondents were asked to rank each statement with the guidance: 'what matters most and matters least to you?' Statements were drawn from the public literature, including blogs, websites, academia, research, documentaries, and news articles. Each statement presented an opinion of Canadian beef sustainability that currently exists in the broad public conversation on the topic. Statements were distributed electronically to respondents who sorted and submitted the statements into a forced distribution called a Q grid. This allowed respondents to prioritize sustainability issues in relation to one another. The sorting exercise was immediately followed by a five-question survey.

Following data collection, data were reduced for analysis through statistical procedures. From 39 Q sorts, five distinct points of view were extracted. These points of view, or opinions, are called factors. Each factor can be described as the composite ranking of the multiple Q sorts that loaded significantly onto that factor, based on its relation to an idealized mean. The five extracted factors are described as:

- ***Concerned Customers,***
- ***Better for Business,***
- ***All Aspects of Labour,***
- ***People, Animals and Planet, and***
- ***Healthy, Productive Cattle***

These opinion groups provide five different sets of priorities and perspectives on social risk and social impacts within the Canadian beef industry. These viewpoints outline what matters to beef industry stakeholders right now, how much it matters, why it matters, and who it matters to. These five perspectives are described in detail in the Factor Interpretation section of this report.

The results from analysis include a weighted Factor Array (Appendix 1). The Factor Array presents the rank that each factor has assigned for each statement. The Factor Array is weighted to allow comparisons to be drawn between factors. The Factor Array was used in two ways to interpret the data in this report. First, it was used to characterize which sustainability issues matter from each perspective (See Factor Interpretation section). Second, to identify priority areas for in-depth impact assessment by looking at the highest scoring statements among all perspectives combined (see Factor Summary section). The sum of scores for each statement across all perspectives was calculated and the highest scores were used to justify the recommendation that **antimicrobial use, animal welfare and on-farm food safety, and labour are three high priority issues for a range of stakeholders.** Results show that these issues matter in different ways to different stakeholder groups and point toward multi-faceted impact pathways to investigate during the remainder of the S-LCA.

FIVE FACTOR SUMMARY

Factor 1 – ***Concerned Customers*** – Prioritizes animal welfare, food safety and responsible antimicrobial use. Antimicrobial use is a tool for food security, animal health and productivity. These are issues that matter for business continuity, for product quality and for profitability, but also for enriching animal lives. Antimicrobial resistance matters to this group too. Another fitting name for this group could have been the "Don't Go It Aloners," because what matters to this group most seems to be what can be achieved collaboratively. With the aim of animal well-being and strong farm-business in mind, innovation in the development of antimicrobial products looks like an important way forward for this aim.

Factor 2 – ***Better for Business*** – Prioritizes antimicrobial innovation, labour recruitment, training and retention and animal welfare. This point of view is concerned primarily with how these issues affect the continuity of business and in effect, producers, employers, and customers. In this way, this perspective shares the priorities of the *Concerned Customers*, in that animal welfare is important for strong farm businesses, and that antimicrobial innovation is a path toward future sustainability. The impact of labour availability on business is singled out in that it ranked highest in this group above all other labour issues (e.g., wages, benefits) presented in the Q Sort. Animal welfare matters to this group for business profitability and for food security as well but also because of public pressure.

Factor 3a – ***All Aspects of Labour*** – Prioritizes labour availability, labour recruiting, training and retention, and animal welfare. Like the *Better for Business* group, labour issues matter to this group. Unlike the *Better for Business* group, every aspect of labour presented within the Q sort was prioritized by this group, making this perspective unique in its prioritization of labour issues above all else. The labour issues that matter most to this group and the reasons presented as to why they matter suggest direct effects from labour availability toward personal health of employees and producers.

Factor 3b – ***People, Animals and Planet*** – Prioritizes animal welfare so as not to compromise public goods, like public health and the environment. Like Factor 1 – *Concerned Consumers*, responsible antimicrobial use is viewed as a key tool to support food security, animal health and productivity. Antimicrobial resistance also matters. Sustainability issues are perceived as 'commons' problems with 'commons problem' solutions, whereby the rational acts of individuals can unintentionally lead to the neglect of societal well-being. Day-to-day operational issues ranked lowest among this group, especially with respect to labour. With labour a low priority, and environment a high priority issue for this group, the perspective is opposite Factor 3a.

Factor 4 – ***Healthy, Productive Cattle*** – Prioritizes the health and productivity of cattle. Antimicrobial use is one tool for achieving this aim. Antimicrobial resistance is a significant concern for future cattle health and productivity. This group feels pressure from media and regulation; but takes pride in animal care and land stewardship as both matter to them. The climate narrative may matter least to this group, who indicate that climate action, carbon trading, GHG reduction and carbon sequestration matter least.

The remainder of this report unpacks these perspectives in detail. While tempting to review just the summary of highest and lowest ranking items found in Table 1, the value of Q sort is in understanding the issues in relation to one another. Therefore, understanding each opinion group and how they fit together in their entirety provides a clearer picture of how sustainability is viewed currently in the Canadian beef industry.

Introduction

In June 2021, Canfax Research Services facilitated four online meetings to guide 39 Canadian beef industry stakeholders through the process of Q sort. Stakeholders were asked to inform us about what matters to them by sorting 52 cards containing statements about Canadian beef industry sustainability. Using Q-methodology, five distinct opinions on sustainability in the Canadian beef industry have been identified for the following aims:

1. Help define impact categories and stakeholder categories for the focus of the social life cycle assessment and later policy, communications, and research
2. Identify how, where and to what extent these impacts occur along the supply chain to provide insight for further data collection and analysis in the Social Life Cycle Assessment
3. Incorporate diverse perspectives with a high level of confidence that these perspectives are likely to exist within the general population, with validation of the potential impacts and risks for the Canadian beef industry

The results of statistical analysis of the Q sorts are presented in this report. Results are to be analyzed and interpreted further in the context of a literature review on impact pathways and with data collected from interviews/surveys that will be implemented in September/October 2021 to follow up on the key outcomes listed in the Factor Summary section of this report.

How to read this report

Statistical analysis of the Q-sort data led to the extraction of five factors. A factor is an opinion, a correlated set of Q-sorts using idealized means. Significant correlations are areas of consensus, representing a consensus on a prioritization of issues among a group of respondents. Each consensus group has a distinct opinion from other consensus groups identified in the study by a lack of correlation. This means there are five distinct opinions on what matters, named for their characteristics as follows:

Factor 1. Concerned Customers
Factor 2. Better for Business
Factor 3a. All Aspects of Labour
Factor 3b. People, Animals and Planet
Factor 4. Healthy, Productive Cattle

Each factor is described separately in the Factor Interpretation section. Each factor interpretation is organized as follows:

- Statistics and demographic compositions of the group
- What matters most to the group
- Why it matters most
- Who is most affected by the issues that matter most
- What matters to this group more than other groups
- What matters to this group less than other groups
- What matters least to this group
- Summary of the interpretation
- Recommendations for scope of the social life cycle assessment

Each factor is a collection of stakeholders telling us the issues that matter most to them. Through post sort survey questions, respondents clarified their rankings and told us who may be most affected by the issues that matter most to them and what can be done about it.

A summary of the Q sort data as a whole can be found in the Factor Summary section where recommendations to guide next steps for the social life cycle assessment are also found.

A note on generalization

The results of this report cannot be generalized to the wider population as is traditionally conceived in the case of survey research. "The standard approach to the study of human behavior, what Kuhn (1970) might' call "normal science," is founded on the concept of simple induction i.e.., generalization from the few (sample) to the many (population)' (Brown 1980, p112). In Q methodology, the respondents are the variables which are rotated around a mean, based on set of statements or traits that are said to be generalizable to the broad public conversation, in this case, on Canadian beef sustainability.

The preeminent technical text on the Q method explains how generalizability differ in Q method (versus R method employed in the social survey): "Generalizations in Q relate to general principles, i.e., to the lawful relations by and between factors; generalizations in R are factual generalities based on inductive enumeration (Brown 1980, p 175)." This means that we can say it is reasonable that the distinct factor types within this report exist 'out there' in Canadian society. Results are reliable and valid and are generalized in the way that multiple respondents are generalized onto a single factor (Brown 1980, 67). We cannot however say that respondents of a certain demographic unquestionably share this opinion. Although further tests and analysis can verify any demographic patterns identified here to be generalized in a more familiar way. That is in fact one aim of the next phase of the social life cycle assessment.

Background and Method

Statements of public opinion that reflect the potential social impacts in the Canadian beef production life cycle were developed using the 'structured' approach outlined in the Q methodology literature. Seven critical areas of benefit and concern were first identified for investigation, including mental health, antimicrobial use, animal welfare, labour, nutrition, and environment. As a literature review of databases, national studies, blogs, online magazines, documentaries, and conferences was completed, statements were pulled as representative of the public conversation on beef sustainability. Other relevant topics emerged through the process of coding and categorizing the literature and were incorporated. Statements aim to present "tacit, underlying criteria and perceptions people use to consider an issue." (Donner 2001, p 27). A full concourse of these statements was reduced from over 500 statements to 52 using a factorial design to replicate areas of concern denoted from the impact pathway literature.

Participant sampling was purposive and comprised of outreach to key informants with snowball sampling from there. Phone calls were made, and a follow-up invitation was administered using Survey Monkey for intake and demographic information. Respondents selected for the Q sort were issued a code and an invitation to participate using Qmethod Software for online delivery. Considerations with respect to age, gender, and location of work were made to structure the participant list so that diverse voices along the beef sustainability supply chain were incorporated. A total of 39 respondents participated in the Q-sorts on June 23, 2021.

Of the 39 respondents involved in the scoping phase of the assessment, 22 were male (56%) and 17 were female (44%). Respondents identified as veterinarians (18%), human nutritionists (5%), ruminant animal nutritionists (5%), agricultural researchers (5%), retail employees (5%), processing plant employees (15%), farm employees (21%), agricultural business owners (15%), government employees (8%) and non-governmental organizations (3%). Seventy-nine per cent of respondents were from Western Canada (i.e. British Columbia, Alberta, Saskatchewan or Manitoba) and 21% were from Eastern Canada (i.e. Quebec, Ontario, Maritimes).

Respondents 35 to 44 years of age (33%) were the largest age cohort, however, others were between 18 to 24 years (3%), 25 to 34 years (18%), 44 to 54 years (28%), 55 to 64 years (13%), or over 65 (1%)[83].

The Q sort was hosted and distributed electronically, and Q sorts were returned electronically by respondents after sorting their statements into a forced distribution on a Q grid. Analysis was able to incorporate 32 of 39 total participants after confounding variables were removed.

An ideal solution based on Centroid Factor Analysis with Varimax rotation was found and confirmed with manual rotation and visual inspection of the data points. The results below are based on this solution and meet the practical criteria for an ideal solution outlined by Watts and Stenner (2012). The solution presented is mathematically ideal and statistically distinct, maximizing significance levels and communalities while retaining simplicity, distinctness, consensus, and stability.

RESULTS AND INTERPRETATION

Each of the five opinion groups (or factors) presented below represents a group of stakeholders (2 or more) who sorted statements similarly. Each opinion group is a statistically significant consensus opinion. Table 1 presents a summary of what matters most and least to each opinion group, representing the highest and lowest ranked statements. Recall that the intent of Q method is to present a holistic point of view regarding how statements are ranked in relation to each other, and to other groups; that is the primary aim of data exploration and interpretation. Reviewing each factor interpretation and the factor summary at the end of this report will provide more detail and a fuller picture of Canadian beef sustainability priorities, consensus, and contention items than what is provided in Table 1.

The results from analysis include a weighted Factor Array (Appendix 1). The Factor Array is a table of the statements sorted by respondents, with statement rankings for each of the five factors. The Factor Array allows comparisons to be drawn between opinion groups. The Factor Array is the basis and justification for the interpretation and recommendations in this report. Where interpretation relies on a statement and rank within the results, the Factor Array will be cited as follows (Statement #: +/- rank, or, 15: +3).

[83] Percentages may not add to 100% in the case of rounding or where respondents selected 'prefer not to say' as an answer choice.

Table C-1: Statements that Matter Most and Matter Least for Each Factor

<table>
<tr><th colspan="3">FACTOR 1 – CONCERNED CUSTOMERS</th></tr>
<tr><th>EIGENVALUE</th><th>% OF VARIANCE EXPLAINED</th><th>PARTICIPANTS</th></tr>
<tr><td>6.4498</td><td>17%</td><td>9</td></tr>
<tr><td rowspan="2">KEY INVENTORY ITEMS:
1. Animal welfare
2. Food safety
3. Antimicrobial use

STAKEHOLDERS AFFECTED:
1. Employees/
2. Producers
3. Cattle
4. Customers</td><td colspan="2">MATTER MOST
14. Current pain mitigation and low stress animal handling strategies and practices for animal health and well-being are generally accepted as humane practices by the Canadian consumer.
18. Animal welfare and on-farm food safety are key focus areas for sustainability as these continue to be the areas that the Canadian beef industry feels the most consumer and media pressure.</td></tr>
<tr><td colspan="2">MATTER LEAST
29. Unintended nutritional and personal health challenges that may result from shifting to more plant-based food diets.
37. The complexity of business transition planning between generations and short and long-term sustainability risks and benefits.</td></tr>
<tr><th colspan="3">FACTOR 2 – BETTER FOR BUSINESS</th></tr>
<tr><th>EIGENVALUE</th><th>% OF VARIANCE EXPLAINED</th><th>PARTICIPANTS</th></tr>
<tr><td>3.42504</td><td>9%</td><td>7</td></tr>
<tr><td rowspan="2">KEY INVENTORY ITEMS:
1. Antimicrobial innovation
2. Labour availability
3. Animal welfare

STAKEHOLDERS AFFECTED:
1. Producers
2. Cattle
3. Consumers</td><td colspan="2">MATTER MOST
15.Developing alternative antimicrobial products to use fewer, more effective ingredients to decrease human and animal resistance to antibiotic treatment.
7.Recruiting, training, and retaining new local employees and temporary foreign workers will be critical to the future of the Canadian beef industry.</td></tr>
<tr><td colspan="2">MATTER LEAST
34.The difference between women and men as they face challenges and benefits from working in the Canadian beef industry.
31.The quantity of antimicrobial residues in Canadian beef and the effects on personal health of the consumer.</td></tr>
<tr><th colspan="3">FACTOR 3a – ALL ASPECTS OF LABOUR</th></tr>
<tr><th>EIGENVALUE</th><th>% OF VARIANCE EXPLAINED</th><th>PARTICIPANTS</th></tr>
<tr><td>2.56325 (3a and 3b)</td><td>7% (3a and 3b)</td><td>6</td></tr>
<tr><td rowspan="2">KEY INVENTORY ITEMS:
1. Labour availability
2. Physical health
3. Mental health

STAKEHOLDERS AFFECTED:
1. Employees</td><td colspan="2">MATTER MOST
2.Labour availability in the Canadian beef industry is a day in and day out struggle. COVID hasn't made it any better, it has amplified existing labour issues.
7.Recruiting, training, and retaining new local employees and temporary foreign workers will be critical to the future of the Canadian beef industry.</td></tr>
<tr><td colspan="2">MATTER LEAST
50.Investigate the trade-offs between growing plants for animal feed that supply protein for humans, and plants grown for human food consumption.</td></tr>
</table>

<table>
<tr><td>2. Producers
3. Employers
4. Consumers</td><td colspan="2">29.Unintended nutritional and personal health challenges that may result from shifting to more plant-based food diets.</td></tr>
<tr><th colspan="3">FACTOR 3b – PEOPLE, ANIMALS AND PLANET</th></tr>
<tr><th>EIGENVALUE</th><td>% of variance explained</td><td>Participants</td></tr>
<tr><td>2.56325 (3a and 3b)</td><td>7% (3a and 3b)</td><td>2</td></tr>
<tr><td rowspan="2">KEY INVENTORY ITEMS:
1. Antimicrobial use
2. Environment

STAKEHOLDERS AFFECTED:
1. Producers
2. Society
3. Consumers</td><td colspan="2">MATTER MOST
25.The continued, responsible use of antimicrobials in beef cattle production is important to support food security and productivity with larger animals, fewer livestock sicknesses and losses.
11.Public health issues from outbreaks of infectious diseases from antimicrobial resistance that can develop in intensive animal housing systems.</td></tr>
<tr><td colspan="2">MATTER LEAST
40.Heavy workloads and the positive or negative implications on physical and mental health.
2.Labour availability in the Canadian beef industry is a day in and day out struggle. COVID hasn't made it any better, it has amplified existing labour issues.</td></tr>
<tr><th colspan="3">FACTOR 4 – HEALTHY, PRODUCTIVE CATTLE</th></tr>
<tr><th>EIGENVALUE</th><td>% of variance explained</td><td>Participants</td></tr>
<tr><td>1.98345</td><td>5%</td><td>8</td></tr>
<tr><td rowspan="2">KEY INVENTORY ITEMS:
1. Antimicrobial Use
2. Animal welfare

STAKEHOLDERS AFFECTED:
1. Producers
2. Nutritionists
3. Veterinarians
4. Consumers
5. Cattle</td><td colspan="2">MATTER MOST
25.The continued, responsible use of antimicrobials in beef cattle production is important to support food security and productivity with larger animals, fewer livestock sicknesses and losses.
22.Antimicrobial resistance in cattle is a significant concern for cattle health and future productivity.</td></tr>
<tr><td colspan="2">MATTER LEAST
5.The fair treatment of men and women in the Canadian beef industry with access to equal opportunities.
43.Land in Canada primarily used for cattle pasture should be conserved for biodiversity and habitat for species at risk.</td></tr>
</table>

FACTOR INTERPRETATION

FACTOR 1 – CONCERNED CUSTOMERS

Factor 1 Interpretation

Factor 1 – *Concerned Customers* has an eigenvalue of 6.45 and explains 17% of the study variance. Nine participants are associated with this factor, the highest of all factors. There were five females (56%) and four males (44%). Ages ranged between 25 to 64, with an average age of 47 years. This factor has seven indirect supply chain actors, the highest out of all factors. Factor 1 is a balanced distribution of stakeholders who identified as government employees, farm and processing employees, non-governmental organizations, business owners, researchers, and human and animal nutritionists, with English, Mexican, and Canadian cultural or ethnic origins, working in Western and Eastern Canada.

What matters most in this factor is animal welfare and food safety (18: +4), using pain mitigation and low stress animal handling strategies (14:+4). Antimicrobial use is a key tool to support food security and animal health and productivity (25:+3), but antimicrobial resistance also matters (22: +3). Innovation in the development of antimicrobial products seems an important way forward (15: +3). For this group, it matters that animal welfare continuously improve for the purpose of enriching the lives of animals (19: +3).

Participants explained why the highest-ranking statements (14 and 18) matter most. "Profitability," "concerns to the public and to our customers i.e., packers, retailers, fast food," and the production of "high quality product" were cited. Several participants also indicated that these statements were important for sustainability, having "the most impact on the Canadian Beef Industry sustainability in the future."

When asked who would be affected most by these issues, participants indicated that it would be primarily primary producers and employees working within the supply chain who would be most affected. Participants also said animals, beef cattle researchers, consumers and customers would be affected.

In response to the question of, who do you think is most affected by the issues that matter most to you, one employee provided the following:

> *I do feel the producer and employees, when there is a negative light on things like animal welfare the consumers don't see that we are doing the best job we can with the tools and knowledge we have. With that being said it can be exhausting and defeating when you are doing the best job you can but in one way or another you come up short.*

This participant wants consumers to see their best effort and wants consumers to accept their best effort. Evidence of stress and burnout from the stigma around animal welfare media are in these words. Evidence of "media pressure" (18:+4) is an issue that matters most this group

This viewpoint is concerned with the public gaze and how customer concerns on industry sustainability might impact animals and those working in the industry. Enrichment of animals lives for the benefits of animals was ranked higher (19: +3) than any other group. Animal welfare regulations that enable the well treatment of animals as well as profitability, productivity and quality is an issue that matters more to them than any other group (13:+1 versus zero). The cost of public perceptions around animal welfare practices – pain mitigation, low stress handling, antimicrobial use – are recognized issues that matter, affecting those working in the supply chain, their business, and what consumers may be willing to pay (17: +1).

This opinion is one of interest and comfort with collaboration, structured solutions and increasing business certainty in the supply chain. Ideas requiring concerted efforts like traceability and transparency (30: +2), equal access to opportunity (5: +2), auditing and certification standards (26: +1), grassland management and climate change (45: +2) rank higher in the group than other factors. Scaling, training, and educating employees in animal welfare and the consumer cost of auditing and certifying products to recognized standards matters more or equally to this group than to other factors (17: +1; 26: +1).

Individualism or culture as an attribute within the industry did not resonate with rankings lower than or equal to other groups. These included statements around culture and independence (23: -3) the land and animal stewardship mentality (21: 0), and social isolation (32: -2; 21: 0).

Personal health and nutrition choices (29: -4) was an issue that mattered least to this group. Several participants cited "personal" nutrition choices and responsibilities are not easily influenced, and that issues with respect to plant-based foods "can wait for now. For now, they will not have a significant effect on our industry." Alignment and work with authorities on nutrition and environment were embraced in "promoting responsible consumption," whereas "disparaging" plant-based foods was not. Beef nutrition ranked lower than other factors, including consumer awareness of protein requirements (27: -3) and nutrient value and balanced diets (28: -1).

This group ranked statements relating to operation less highly than other factors. These included transition planning (37: -4), the financial pressures of start-ups (35: -3), the rising costs of capital investments and beef demand (24: -2) and the impacts of volatile markets (1: -2). This makes sense in that most in this group would not experience the visible impacts from day-to-day operations.

Summary and Next Steps

Results show this group of *Concerned Customers* prioritizes animal welfare, food safety and responsible antimicrobial use. Antimicrobial use is a tool for food security, animal health and productivity. These are issues that matter for business continuity, for product quality and for profitability, but also for enriching animal lives. Antimicrobial resistance matters to this group too. Another fitting name for this group could have been the "Don't Go It Aloners," because what matters to this group most seems to be what can be achieved collaboratively. With the aim of animal well-being and strong farm-business in mind, innovation in the development of antimicrobial products looks like an important way forward for this aim.

Table two shows the factor rank for the issues discussed within a structure facilitating next steps for life cycle assessment, with considerations for data collection points.

Table C- 2: Assessment Areas and Data Collection for Factor 1 – Concerned Customer

Area of protection	**Inventory Indicator**	**Sub-group**	**Measures**	**Data points**	**Stakeholder groups affected**
Human Health	Stress/ burnout	Media (+4)	Media Review/ Corporate Responsibility	Mental health statistics	Employees
Healthy Sustainable Workplaces and Communities	Business continuity	Antimicrobials (+3)	Antimicrobial use	Regulation, on-farm practices, resistance risk/VBP+ Producers	Producers
			Antimicrobial innovation	Practices, research, implementation/VBP+ Producers	Producers
		Productivity (+3)	On-farm	VBP+ Producers	Producers
		Product quality (+4)	Animal welfare practices (+4)	Environment enrichment (e.g., RCC, Antimicrobials, housing, pain mitigation, calm animal handling etc.), FEMS/Census/ traceability, feasibility	Producers, customers
			On-farm food safety (+4)	Training, education, practices	Producers, customers
			Pain mitigation (+4)	Training, education, practices	Producers, customers
			Low stress animal handling (+4)	Training, education, practices	Producers, customers
			Certification standards (+1)	Implementation (CRSB/VBP+) cost	Producers, customers
Cattle as Ecosystem Services	Animal welfare (+4)	Pain mitigation (+4)	Antimicrobial use	Training, education, practices	Cattle
			Low stress handling practices (+4)	Training, education, practices	Cattle
	Environment	Grasslands, climate change (+2)	E LCA	E LCA	Society

FACTOR 2 – BETTER FOR BUSINESS

Factor 2 Interpretation

Factor 2 – Better for Business has an eigenvalue of 3.43 and explains 9% of the study variance. Seven participants were associated with this factor. There were four females (57%) and three males (43%). Ages ranged between 35 and 64. Average age was 51 years. The factor contained stakeholders who identified as farm employees, business owners, government personnel and veterinarians, from Dutch, French Scottish, Polish, and Canadian cultural or ethnic origins, working primarily in Western Canada.

What is better for business? What matters most to this group is advancement in antimicrobial products that would involve fewer, more effective ingredients to decrease human and animal resistance to antibiotic treatment (15: +4). What matters most also includes recruiting, training, and retaining new local employees and temporary foreign workers who will be critical to the future of the Canadian beef industry (7: +4).

Issues that mattered most to this group, antimicrobial innovation and recruiting and training, were issues those respondents are "passionate" about and know about, which is why they ranked them so high. One aspect of labour, "hiring," was singled out as becoming increasingly difficult. "It is going to get harder to find employees willing to work and continue to grow in the industry." COVID 19 was a struggle for this group more so than all other groups (except Factor 3a – *All Aspects of Labour*) as it amplified existing labour issues (2: +3).

According to respondents, producers, employers, and on-farm profitability were most affected by recruiting and training. Producer growth, scalability and supply are being constrained by labour recruiting, training, and retention. In this group, industry sustainability is achieved with farm profitability that is being impacted by labour availability. This group also believes that antimicrobial innovation has the potential to have the greatest impact on producers and consumers.

Labour is an issue of equal rank and importance to antimicrobial use for this group. Recruiting, training, and retaining new local employees and temporary foreign workers is critical (25: +4), labour availability is a "day-in-day-out struggle" (2:+3). Farms, processing, and retail start-ups are currently challenged by financial pressures (35:+3).

Next in priority for this group was animal welfare and on-farm food safety. This group views animal welfare and food safety as key focus areas for sustainability as these are areas of consumer and media pressure (18:+3). Responsible use of antimicrobials in beef cattle production is important to support food security and productivity with larger animals, fewer livestock sicknesses and losses (25:+3). For this group, profitability is sustainability, so developing alternative products that reduce interventions and decrease resistance is critical (15:+4).

In this group, preserving, maintaining, and enhancing watersheds (44: +2), beef nutrient value in diets (28: +2), lower beef consumption among consumers (49: +2), and volatile markets (1: +2) matter more in comparison with other groups. These are likely issues that directly impact this group both in purchasing and selling product.

What mattered least to this group was the difference between men and women working in the Canadian beef industry (34: -4). The quantity of antimicrobial residues in Canadian beef and the effects on personal health of the consumer also mattered least to this group (31:-4). The issues of little matter to this group were viewed as short-term trends rather than significant long-term sustainability concerns.

This group was less than or equally concerned with personal physical harm (6: -3), mental health (32: -2, 21: 0), average hourly wage (10: -2), and benefits (3: -2) resulting from the supply chain than other groups. Water use mattered less to this group than to other groups, in a relatively neutral position (51: -1), suggesting that it may viewed as a non-issue for this group.

Summary and Next Steps

The *Better for Business* group prioritizes antimicrobial innovation, labour recruitment, training and retention and animal welfare. This point of view is concerned primarily with how these issues affect the continuity of business and in effect, producers, employers, and customers. In this way, this perspective shares the priorities of the *Concerned Customers*, in that animal welfare is important for strong farm businesses, and that antimicrobial innovation is a path toward future sustainability. The impact of labour availability on business is singled out in that it ranked highest in this group above all other labour issues (e.g., wages, benefits) presented in the Q Sort. Animal welfare matters to this group for business profitability and for food security as well but also because of public pressure.

Table C- 3: Assessment Areas and Data Collection for Factor 2 – Better for Business

Area of protection	Inventory Indicator	Sub-group	Measures	Data points	Stakeholder groups affected
Healthy Sustainable Workplaces and Communities	Business continuity	Antimicrobials (+4)	Antimicrobial innovation (+4)	Practices, research, implementation/VBP+	Producers
		Food security (+3)	Antimicrobial use (+3)	Productivity measures/ VBP+	Producers, consumers
		Labour availability (+4)	Recruiting, training, retaining	Training materials, on-boarding, career paths, average farm size, or # of farms (Census)	Producers
		Animal welfare (+3)	On-farm food safety (+3)	Training, education, practices	Producers, customers
		Consumption (+2)	5-year beef	Stats Can	Producers
		Volatility (+2)	5-year beef	Stats Can	Producers
Cattle as Ecosystem Services	Environment	Watershed protection/ enhancement (+2)	E LCA	E LCA/FEMS	

Factor 3a – All Aspects of Labour

Factor 3a Interpretation

Factor 3a has an eigenvalue of 2.56 and explains 7% of the study variance. Six participants were associated with this factor. There were three females (50%) and three males (50%). Ages ranged between 25 and 54. Average age was 40 years. The factor contained stakeholders who identified as farm employees and processing employees, with English, Canadian, French Canadian and Mi'kmaq cultural or ethnic origin, working primarily within Eastern and Western Canada. Factor 3a is the opposite view of Factor 3b discussed next.

What matters most are all aspects of labour. The effects of labour availability on physical and mental health are described from this perspective. What matters most to this group is day-to-day labour availability (2: +4) and recruiting, training, and retaining new local or foreign employees (7: +4). Access to benefits (3: +3), tools and training to perform safe work (4: +3), safe cattle handling practices (8: +3) and physical harm that occurs from stress, burnout, or depression (39: +3) matter more to this group than others.

These issues matter most to this group because they are deemed "immediate" and "fast growing" challenges. One respondent summarizes:

> *Labour shortages and extreme job demand have real mental and physical health repercussions on employees and management, and threaten the longevity and sustainability of the industry.*

The point was made by participants that a healthy and safe labour force is critical to the entire supply chain.

Like with the *Better for Business* group, *All Aspects of Labour* agree that finding "ways to engage and interest people into working within the agriculture sector" is a way to mitigate impacts. Retention is in one way being constrained by a lack of new training information.

> *Continuing education for employees is…hard with lack of new information coming out. A lot of information is 20+ years old and not up to date with today's [sic] growth and challenges within the industry.*

Some infrastructure may also be 20+ years old. It mattered equally to this group and to Factor 4, and more so than among other groups, that enhancing animal welfare along the beef supply chain, on farms and at processing plants, should but doesn't always provide added value that offsets the cost of capital investment (16:+2).

Unlike the *Better for Business* group, *All Aspects of Labour* listed all labour statements as ranking higher than other groups, making this a uniquely labour oriented perspective among other factors. Access to benefits (3: +3), provisions for safe work (4: +3), efforts to improve safe cattle handling (8: +3), gender equity (5: +2), average hourly wage (10: +2), heavy workloads and the positive or negative implications on physical and mental health (40: +2), and repetitive stress injuries from workplace tasks (6: +1) were all ranked as mattering more within this group than other groups.

With respect to who is most affected by these issues, several respondents point toward beef producers:

> *The producers, lack of employees make it harder for the producers to be able to continue to supply to large companies without burnout of current employees while trying to continue to educate, train and keep up with government regulations.*

Small family operations are affected most, according to respondents. The employees themselves are also affected, as are employers and consumers.

The following items also rank higher among this group that all other factors. Media coverage of the Canadian beef industry and its effect on mental health, personal value and confidence of workers mattered more to this group than others (38: +1), as did mental health effects from social isolation (32: 0), and the responsible management of air quality such as odour noise and dust (42: 0), higher than other groups, although in neutral positions relative to all issues.

What matters least to this group are the trade-offs from land-used to grow plant-proteins for humans or for animals (50: -4), and the nutritional merits of meat or plant-based diets (29: -4). Reasons cited included that these areas are being addressed by research institutions, that nutrition is a personal responsibility, and that they have less knowledge in these areas and perhaps a lack of personal engagement with these issues.

This group is set apart from others for ranking antimicrobial issues as mattering less than other groups. New antimicrobial products and antimicrobial use and resistance (15: -3; 25: -1; 11: -3; 22: -1) matter less to this group than many other groups.

Environmental issues ranked as mattering less than or equal among this group compared to others. Lower ranks or neutral statements about using less water (51: -3), preserving or enhancing watersheds (44: -2), soil nutrient cycling (47: 0), and land stewardship mentality (21: 0) suggest these are lower priority matters to address in this group's opinion. Respondents suggested there are "more pressing matters that need to be addressed first – like the hiring shortages, livable wages, training, … etc."

Summary and Next Steps

The *All Aspects of Labour* group prioritizes labour availability, labour recruiting, training and retention, and animal welfare. Like the *Better for Business* group, labour issues matter to this group. Unlike the *Better for Business* group, every aspect of labour presented within the Q sort was prioritized by this group, making this perspective unique in its prioritization of labour above all else. The labour issues that matter most to this group and the reasons presented as to why they matter suggest direct effects from labour availability toward personal health of employees and producers.

Table C- 4: Assessment Areas and Data Collection for Factor 3a – All Aspects of Labour

Area of protection	Inventory Indicator	Sub-group	Measures	Data points	Stakeholder groups impacted
Human Health	Mental Health (+3)	Media (+1)	Stigma	Secondary	Employees, producers
	Physical Health (+3)	Physical Harm (+3)	Stress/burnout	Secondary	Employees, producers
Healthy, Sustainable Workplaces and Communities	Labour availability (+4)			Labour stats	Employers, consumers
	Worker Safety	Heavy workloads (+3)	Provisions for safe work (+3)	Labour hours	Employees, producers
			Repetitive stress injuries (+1)		Employees, producers
			Safe cattle handling (+3)	Practices	Employees, producers
	Equity/fairness (+2)				Employees, producers
	Competitiveness	Wage (+2)		Labour stats	Employees, producers
		Benefits (+3)		Labour stats	Employees, producers

FACTOR 3B – PEOPLE, ANIMALS AND PLANET

Factor 3b Interpretation

Factor 3b has an eigenvalue of 2.56 and explains 7% of the study variance with Factor 3a. Two participants were associated with this factor, situated mathematically opposite to 3b. There was one female (50%) and one male (50%). Ages ranged between 35 and 64. Average age was 50 years. Stakeholders identified as retail workers or animal nutritionists with Sri Lankan and Canadian cultural or ethnic origins, working primarily in Western Canada.

This group was split from the *All Aspects of Labour* group as it loaded onto Factor 3 negatively at significant levels. The *People, Animals and Planet* group are the smallest group and the least stable grouping of viewpoints but still unique from the perspective of 3a. Antimicrobial use and environmental issues matter most to this group, whereas labour issues matter least.

What matters most to this group is the continued responsible use of antimicrobials to support food security and productivity (25: +4), as well as public health outbreaks from antimicrobial resistance as they can develop in intensive animal housing (11: +4). With respect to responsible antimicrobial use, the issue was ranked highly because respondents, "care about the welfare of animals and impact on our environment." Implementing the Beef Code of Standards for animal treatment mattered more to this group than any other group (9: +3). With respect to antimicrobial resistance, the issue was ranked highest due to the attention is receives from the public. Concern over social risks from antimicrobial resistance are acute within this group. How antimicrobial resistance may facilitate disease outbreaks among cattle and affect public health (11:+4) and how antimicrobial residues may affect consumer health (31:+2), matter more to this group than any other.

Environmental topics were ranked higher in Factor 3b than any other factor. Reducing greenhouse gas emissions was important to this group and more important to this group than any other group (41: +3), as was conservation of cattle pasture for biodiversity and species at risk (43: +3), soil nutrient cycling (47: +2), and water use (51: +3).

The issues that matter most to this group are primarily commons problems, where the rational pursuits of individuals tend to neglect the well-being of society. Common problem solutions are favoured by this group as well. For example, how the beef industry's role mitigating climate change can be collectively enhanced (46:+2) and how carbon credit training may be a meaningful solution to manage carbon footprints (48:+1) matter more to this group than to others. Participants caution that these issues matter as it is "important to protect the environment and to address climate change, however not by compromising today or the industries relevant to Canadian interest."

It matters to this group that animal care and land stewardship is a source of pride and positive mental health that keeps employees in the Canadian beef industry (21: +2), a perspective of equal importance within Factor 4, discussed next.

What matters least to this group are many of the items that matter most to Factor 3a – *All Aspects of Labour,* including heavy workloads (40: -4) and labour availability as it was affected by COVID-19 (2: -4). Most other labour related issues ranked lower for this group than others, including training, recruiting and capital investment into scale and animal welfare (26:-3; 7:-1), workplace safety (6:-3; 39:-3), mental health concerns (38: -3; 33:-2), and wages (10:-2). These responses ranked low in this group as the participants didn't have knowledge of these areas. Topics around labour ranked lower as respondents were "not educated or well versed" in the topic areas.

Summary and Next Steps

The *People, Animals and Planet* group prioritizes animal welfare so as not to compromise public goods, like public health and the environment. Like Factor 1 – *Concerned Consumers*, responsible antimicrobial use is viewed as a key tool to support food security, animal health and productivity, but antimicrobial resistance also matters. Sustainability issues are perceived as 'common' problems with 'common problem' solutions, whereby the rational acts of individuals can unintentionally lead to the neglect of societal well-being. Day-to-day operational issues ranked lowest among this group, especially with respect to labour. With labour low priority, and environment is also a high priority issue for this group, the perspective of Factor 3b is opposite to Factor 3a.

Table C- 5: Assessment Areas and Data Collection for Factor 3b – People, Animals and Planet

Area of protection	Inventory Indicator	Sub-group	Measures	Data points	Stakeholder groups impacted
Healthy, Sustainable Workplaces and Communities	Animal welfare	Human health	Antimicrobial resistance (+4)	Regulation, on-farm practices, resistance risk/VBP+ Producers	Consumers, cattle, society
			Antimicrobial residue (+2)		Consumers, society
		Animal health	Beef code of practice (+3)	Rank on-farm implementation	Cattle
Cattle Ecosystem Services	Habitat	Air quality	Reducing Greenhouse Gas Emissions (+3)	E LCA	Society
	Environment	Land	Pasture, biodiversity, species at risk (+3)	E LCA	Society
		Soil	Nutrient cycling (+2)	E LCA	Society
	Food Security	Water	Reductions (+3)	E LCA	Society

FACTOR 4 – HEALTHY, PRODUCTIVE CATTLE

Factor 4 Interpretation

Factor 4 has an eigenvalue of 1.98 and explains 5% of the study variance. Eight participants were associated with this factor. There were two females (25%) and six males (75%). Ages ranged between 18 and 54. Average age was 34 years. The factor contained stakeholders who identified as primarily business owners and farm employees, with one retail employee and veterinarian.

What matters most for healthy, productive cattle is the responsible use of antimicrobials (25: +4), and antimicrobial resistance is a significant concern for cattle health and future productivity (22: +4). Respondents believe that responsible use of antimicrobials is where efforts can be targeted and promoted to have the most "positive impact" on the Canadian beef industry. Responsible antimicrobial use is important for cattle health and welfare. Antimicrobial use is also about competitiveness, "antimicrobial resistance will hinder production capacity and efficacy and overall costs to producer, which will hinder our beef farmers in the export competition." It feels like the impact to producers is one to stay in front of.

Antimicrobial products that can be used for cattle health matter more to this group than any other group (12: +3). This group may feel pressure from media attention to animal welfare and on-farm food safety (18, +3). The affect that regulations have on the practical ability to implement animal welfare practices also matters more to this group than others (20: +3). More effective antimicrobial products using fewer ingredients matter to this group and suggest this is their perspective on a way forward (15: +3).

Animal care and land stewardship mentality as a source of pride and positive mental health matters more to this group, and Factor 3b, than any other group (21: +2). Similarly, both groups rank the value of cultural of independence, self-sufficiency, resiliency, and stoicism in the Canadian beef industry equally (23: 0), and higher than the other groups.

It's important to this group that they stay profitable and valuable employers that contribute to healthy local food supplies (52:+2), and that capital costs for animal welfare are not always providing added value (16: +2). This group is concerned with the rising demand for Canadian beef that would require capital investment into animal handling and animal care (24:+1).

What mattered least to this group was the fair treatment of men and women (5: -4). Respondents gave reasons: "I feel men and women have always had equally important roles," "I don't personally see a difference in the treatment of men and women," and "I think men and women already have equal opportunity in the beef industry." Land in Canada primarily used for cattle pasture should be conserved for biodiversity and habitat for species at risk (43: -4) also mattered least to this group, perhaps as a non-issue. Air quality (42:-4), carbon credit (48:-3), collective climate action (46:-3), greenhouse gas reduction (41:-3), and carbon sequestration (42:-3) matter less to this group than other groups.

Summary and Next Steps

The *Healthy, Productive Cattle* group prioritizes the health and productivity of cattle. Antimicrobial use is one tool for achieving this aim. Antimicrobial resistance creates a significant concern for future cattle health and productivity. This group feels pressure from media and regulation but taking pride in animal care and land stewardship matters to them. The climate narrative may matter least to this group, who indicate that climate action, carbon trading, GHG reduction and carbon sequestration matter least.

Table C- 6: Assessment Areas and Data Collection for Factor 4 – Healthy, Productive Cattle

Area of protection	Inventory Indicator	Sub-group	Measures	Data points	Stakeholder groups impacted
Healthy, Sustainable Workplaces and Communities	Animal welfare	Antimicrobial use (+4)	Cattle health	Regulation, on-farm practices, /VBP+ Producers	Producers, cattle
	Business continuity	Antimicrobial resistance (+4)	Productivity	Resistance risk	Producers, cattle
Cattle as Ecosystem Services	Food Security	Antimicrobial use	Capacity	Production data, carcass weights, beef cow herd, slaughter capacity/slaughter numbers	

Factor Summary

Antimicrobial use

The continued, **responsible use of antimicrobials in beef cattle production** is important **to support food security and productivity** for larger animals, fewer livestock sicknesses and losses. This issue ranked +4 among two factors and +3 among two factors, making it the highest scoring statement among all factor groups. Each factor group ranked multiple statements concerning antimicrobial use as an issue that matters most, except for *All Aspects of Labour,* who ranked antimicrobial use as an issue that matters least to them. **Resistance is a key impact pathway** cited to matter most to the four out of five factor groups. Resistance is a concern for different stakeholders along the supply chain depending on each perspective. Resistance is a concern for cattle **within intensive animal housing units** (*People, Animals and Planet*), for **cattle health and productivity** (*Healthy, Productive Cattle, Concerned Customers*), and for **human and animal resistance to antimicrobial treatment** (*Better for Business*). Both positively and negatively, this issue has the potential to have the widest reaching impact along the supply chain, affecting producers, nutritionists, veterinarians, employers, consumers, cattle, and society at large, according to respondents.

Animal Welfare and On-farm Food Safety

The next highest scoring statement cited animal welfare and on-farm food safety as key focus areas for sustainability, as these continue to be the areas that the Canadian beef industry feels the most consumer and media pressure. This high-ranking statement is distinguishable from the other media statement within the Q set that positioned the media in reference to its effects on personal mental health. This may lead to the conclusion that for respondents, the impact of **media on the industry** may matter more than the impacts of media on the individual, although several factors seem to feel the effects of media pressure more acutely.

Continuous improvements in **animal welfare for the enrichment of the lives of animals** was of equal matter to all factors as media pressure toward animal welfare and on-farm food safety. The prioritization of animal welfare for the enrichment of animal lives ranked relatively highly among all factors but did vary among factors. The enrichment of animal lives mattered most to the *Concerned Consumers* group (19: +3), followed by the *All*

Aspects of Labour and *People, Animals and Planets* group (19: +2), the *Better for Business* group (19: +1), and the *Healthy, Productive Cattle* group (19: 0). The neutral position among the *Healthy, Productive Cattle* group with the highest proportion of producers and business owners suggests that continuous improvements to animal welfare matters less from this perspective when compared to others. This could be because, from this perspective, the current level of animal care on-farm is not something that needs to be improved for the industry to remain sustainable (excepting the use of antimicrobials for treatment of sickness), in relation to all other sustainability issues. These subtle differences about why animal welfare matters among opinion groups are rife for investigation and consensus building.

The next highest-ranking issue summing all factor ranks was the **training required for Canadian beef industry workers to meet the beef code of practice standards for animal treatment.** It matters to respondents that current pain mitigation and low stress animal handling strategies and practices for animal health and well-being are generally accepted as humane practices by the Canadian consumer. Determining how the goal posts in the code of practice currently resonate with consumers could provide direction for alignment among distinct opinion groups. Whether consumers know, understand, and accept industry code of practice could be a key area of consensus building among all opinion groups to mitigate the impact of media on industry and perceived livelihood of cattle and producers.

LABOUR

Recruiting, training, and retaining new local employees and temporary foreign workers will be critical to the future of the Canadian beef industry, according to respondents. This issue was ranked highest among the *Better for Business* group (+4) and the *All Aspects of Labour* group (+4) and scored lower among the *Concerned Consumers* (0), *Healthy, Productive Cattle* (-1) and *People, Animal and Planet* (-1). Due to the variation, further investigation of regional differences and demographics affected by labour availability may prove fruitful to identify the social impact and social risk of labour availability.

APPENDIX 1 – FACTOR ARRAY

Statement	1	2	3a	3b	4
1.Volatile markets and trade uncertainties affecting employment opportunities and finances in the Canadian beef supply chain.	-2	2	0	-2	1
2.Labour availability in the Canadian beef industry is a day in and day out struggle. COVID hasn't made it any better, it has amplified existing labour issues.	-1	3	4	-4	-1
3.Access to all the following benefits: medical care, sickness benefit, unemployment benefit, old-age benefit, employment injury benefit, family benefit, maternity/paternity benefit, invalidity benefit and survivor's benefit.	0	-2	3	-1	-1
4.Employers ensure that employees have the necessary information, training, and supervision to perform their work safely.	1	2	3	-2	0
5.The fair treatment of men and women in the Canadian beef industry with access to equal opportunities.	2	-3	2	0	-4
6.Human injuries or disorders of the muscles, nerves, tendons, joints, cartilage, and spinal discs from workplace tasks.	-2	-3	1	-3	-1
7.Recruiting, training, and retaining new local employees and temporary foreign workers will be critical to the future of the Canadian beef industry.	0	4	4	-1	-1
8.Efforts to improve safe cattle handling practices that minimize human and animal stress or injury.	1	0	3	0	2
9.The training required for Canadian beef industry workers to meet the beef code of practice standards for animal treatment.	2	0	2	3	1
10.The average hourly wage of employees in the beef industry. While greater than the legal minimum, it is less than the provincial average hourly wage.	-1	-2	2	-2	-2
11.Public health issues from outbreaks of infectious diseases from antimicrobial resistance that can develop in intensive animal housing systems.	2	0	-3	4	0
12.The use of antimicrobials in Canadian beef production to promote cattle health.	2	2	-1	1	3
13.The regulations around animal welfare in Canada enable the well treatment of animals as well as business profitability through productivity and quality.	1	0	0	0	0
14.Current pain mitigation and low stress animal handling strategies and practices for animal health and well-being are generally accepted as humane practices by the Canadian consumer.	4	0	1	1	2
15.Developing alternative antimicrobial products to use fewer, more effective ingredients to decrease human and animal resistance to antibiotic treatment.	3	4	-3	-1	3
16.Enhancing animal welfare along the beef supply chain, on farms and at processing plants, should but doesn't always provide added value that offsets the cost of capital investment.	0	1	2	-2	2
17.Consumer concerns about animal welfare as they are reflected in consumer willingness to pay for higher welfare in the cost of the product.	1	0	0	1	1
18.Animal welfare and on-farm food safety are key focus areas for sustainability as these continue to be the areas that the Canadian beef industry feels the most consumer and media pressure.	4	3	1	0	3

Statement	1	2	3a	3b	4
19.Continuous improvements in animal welfare for the enrichment of the lives of animals.	3	1	2	2	0
20.The effect that regulations have on resource and time availability and the practical ability to provide animal care.	0	-2	1	0	3
21.The animal care and land stewardship mentality is a source of pride and positive mental health that keeps employees and employers in the Canadian beef industry.	0	0	0	2	2
22.Antimicrobial resistance in cattle is a significant concern for cattle health and future productivity.	3	1	-1	-1	4
23.Mainatining a culture of independence, self-sufficiency, resiliency, and stoicism in the Canadian beef industry.	-3	-1	-2	0	0
24.The demand for Canadian beef will rise and will require capital investments into animal handling and care.	-2	1	0	1	1
25.The continued, responsible use of antimicrobials in beef cattle production is important to support food security and productivity with larger animals, fewer livestock sicknesses and losses.	3	3	-1	4	4
26.Future challenges include scale and changes required for training and educating employees in animal welfare, the costs of auditing and certifying products to recognized standards, and the capital investment required to modify or upgrade production systems.	1	0	1	-3	0
27.Consumer awareness of dietary protein requirements and the personal health trade-offs between consuming Canadian beef and alternative proteins.	-3	0	-1	1	-1
28.Consuming the nutrient value in high quality Canadian beef as part of a healthy, balanced diet.	-1	2	1	1	1
29.Unintended nutritional and personal health challenges that may result from shifting to more plant-based food diets.	-4	-1	-4	0	0
30.The traceability of Canadian beef production from farm to plate to enhance transparency and consumer's personal health choices.	2	1	1	1	0
31.The quantity of antimicrobial residues in Canadian beef and the effects on personal health of the consumer.	0	-4	-1	2	0
32.The mental health outcomes from social isolation.	-2	-2	0	-1	-1
33.The personal hesitance to identify and address mental health issues in the Canadian beef industry.	-1	-1	-1	-2	1
34.The difference between women and men as they face challenges and benefits from working in the Canadian beef industry.	0	-4	-1	0	-1
35.The financial pressures of starting-up new farms, processing, or retail facilities as a significant challenge for the Canadian beef industry.	-3	3	0	-1	2
36.Resources to assist with relationship pressures or conflicts when families work together.	-2	-3	0	-2	0
37.The complexity of business transition planning between generations and short and long-term sustainability risks and benefits.	-4	-1	-2	2	1

Statement	1	2	3a	3b	4
38.Media coverage of the Canadian beef industry as it impacts the mental health, personal value and confidence of Canadian beef industry workers, and Canadians.	-1	-1	1	-3	-2
39.Physical harm that occurs as a result of stress, burnout, depression, or other mental health issues.	0	-1	3	-3	-1
40.Heavy workloads and the positive or negative implications on physical and mental health	-1	-2	2	-4	1
41.Reducing greenhouse gas emission intensity from livestock production, transportation, and processing operations.	0	-1	-2	3	-3
42.The responsible management of air quality is important in that Canadian beef cattle operations may lead to proximity issues of nuisance such as odour, noise, or dust.	-2	-2	0	-1	-3
43.Land in Canada primarily used for cattle pasture should be conserved for biodiversity and habitat for species at risk.	1	0	-3	3	-4
44.Preserving riparian areas, wetlands, surface, and ground water sources and managing nutrient runoff through beneficial management practices to maintain or enhance watershed health.	1	2	-2	-1	-1
45.Canadian grasslands are an important tool for climate change in that lands otherwise unused for food production sequester carbon.	2	1	-1	1	-2
46.Collectively, we must enhance the Canadian beef industries' role in mitigating climate change.	1	1	-1	2	-3
47.Canadian beef farms can help recycle nutrients and improve soil.	1	1	0	2	1
48.Carbon credit trading as a meaningful opportunity for the Canadian beef industry to manage its carbon footprint.	-1	-1	-2	1	-3
49.Consumers choosing to eat less beef in efforts to minimize their own environmental footprint.	-1	2	-2	0	-2
50.Investigate the trade-offs between growing plants for animal feed that supply protein for humans, and plants grown for human food consumption.	-3	-1	-4	-1	-2
51.Raising and selling Canadian beef cattle to use less water.	0	-3	-3	3	-2
52.The Canadian beef industry as a profitable and valuable employer that can keep local food supplies healthy.	-1	1	1	0	2

APPENDIX D
DATA COLLECTION AND LIFE CYCLE INVENTORY

D.1 LCA FRAMEWORK

LCA is a leading tool for assessing environmental performance with a method defined by the International Organization for Standardization (ISO) 14040-14044 standards (ISO, 2020b, 2020a). LCA is an internationally recognized approach that evaluates the relative potential environmental and human health impacts of products and services throughout their life cycle. Among other uses, LCA can identify opportunities to improve the environmental performance of products, inform decision-making, and support marketing, communication, and educational efforts.

This assessment follows the ISO 14040-14044 standards described above and builds upon the previously conducted NBSA in 2016. An attributional approach is applied based on the objectives of this study. Furthermore, this study has been critically reviewed, further demonstrating the soundness of methodology and findings.

D.2 DATA SOURCES FOR E-LCA

The following section describes the secondary data collection procedures carried out for the E-LCA and LU assessments. In some instances, specifically for the antimicrobial and growth-enhancing technology use impact category, primary data collected for the S-LCA were used. The description of the primary data collection is presented in Section 8.3.

Mortality Rates

Mortality and replacement rates were relevant for the calculation of the cohort, as described in Section 1.4.1. For each animal category defined in this study, updated mortality rates were obtained from a variety of sources. The values and their sources are summarised in Table D-1.

Table D-1: Mortality rates of each animal category

Animal category	Mortality rate (%)	Source
Calves	3.3%	COP Network
Cows	1.5%	
Bulls	1.2%	
Backgrounded heifers	0.86%	
Backgrounded steers	0.91%	
Yearling heifers	0.86%	
Yearling steers	0.91%	
Finished heifers	1.5%	Canfax Research
Finished steers	1.5%	

In addition, data from the COP Network also indicated a 12-15% replacement rate for cows and a 13% culling rate for cows.

Feed Rations

The rations used in the assessment are summarized in Table D-2, Table D-3, Table D-4 and Table D-5. They are presented on a dry matter basis. It is assumed that weight gain occurs linearly and is calculated using an average daily gain based on the daily DM intake multiplied by the mid-weight of each animal category.

Table D-2: Feed rations modelled for the calf-fed system

Animal Type	Calves		Finishers (Calf-Fed)		
Sex	M/F	M/F	M/F	M	F
Region	East	West	East	West	West
On-Feed Days (expert)	34	17	270	270	270
Pasture Days	166	188	0	0	0
Total Stage Duration	200	205	270	270	270
Daily DM Intake, % of body weight (expert)	2.55%	2.55%	2.35%	2.35%	2.35%
Start-Weight, lbs (expert)	99	99	575	575	575
Mid-Weight, lbs (expert)	337	337	1013	1008	1008
End-Weight, lbs (expert)	575	575	1450	1440	1440
Energy supplement: Barley		15.6%	1.0%	76.0%	66.8%
Energy supplement: Corn	3.0%	1.9%	63.8%	0.0%	2.6%
Energy supplement: Wheat			0.7%	2.9%	6.4%
Energy supplement: Oat grain	23.0%	0.6%	0.7%		
Energy supplement: Screening pellet				1.0%	1.0%
Forages: Barley silage		19.2%		8.5%	8.5%
Forages: Corn silage		8.3%	13.4%		
Forages: Grass silage	15.0%	7.5%			
Forages: Hay	52.9%	44.0%	6.1%		
Forages: Straw (for feed)		1.3%			
Forages: Oat silage		1.2%			
Protein supplement: Dried distiller grains			11.2%	10.3%	10.3%
Other feedstocks (e.g., mill run pellet, soybean, triticale, etc.)	5.0%	0.4%	1.7%	1.3%	4.3%
Minerals & salt-premix	1.1%	0.1%	1.4%		
Animals on grass	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Table D-3: Feed rations modelled for the yearling-fed system: calves & backgrounders

Animal Type	Calves		Backgrounders			
Sex	M/F	M/F	M	M	F	F
Region	East	West	East	West	East	West
On-Feed Days (expert)	34	17	140	113	140	113
Pasture Days	166	188	11	38	11	38
Total Stage Duration	200	205	150	150	150	150
Daily DM Intake, % of body weight (expert)	2.55%	2.55%	2.35%	2.35%	2.35%	2.35%
Start-Weight, lbs (expert)	99	99	500	500	500	500
Mid-Weight, lbs (expert)	300	300	650	650	650	650
End-Weight, lbs (expert)	500	500	800	800	800	800
Energy supplement: Barley		15.6%		22.0%		22.0%
Energy supplement: Corn	3.0%	1.9%	16.5%		16.5%	
Energy supplement: Wheat						
Energy supplement: Oat grain	23.0%	0.6%		4.5%		4.5%
Energy supplement: Screening pellet						
Forages: Barley silage		19.2%		27.5%		27.5%
Forages: Corn silage		8.3%	38.6%	1.5%	38.6%	1.5%
Forages: Grass silage	15.0%	7.5%	2.0%	4.6%	2.0%	4.6%
Forages: Hay	52.9%	44.0%	22.6%	20.0%	22.6%	20.0%
Forages: Straw (for feed)		1.3%				
Forages: Oat silage		1.2%				
Protein supplement: Dried distiller grains			19.3%	19.0%	19.3%	19.0%
Other feedstocks (e.g., mill run pellet, soybean, triticale, etc.)	5.0%	0.4%		1.0%		1.0%
Minerals & salt-premix	1.1%	0.1%	1.0%		1.0%	
Animals on grass	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100%	100%	100%	100%

Table D-4: Feed rations modelled for the yearling-fed system: yearlings & finishers

Animal Type	Yearlings				Finishers (Yearling-Fed)		
Sex	M	M	F	F	M/F	M	F
Region	East	West	East	West	East	West	West
On-Feed Days (expert)	62	8	62	8	130	140	140
Pasture Days	58	92	58	92	0	0	0
Total Stage Duration	120	100	120	100	130	140	140
Daily DM Intake, % of body weight (expert)	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%
Start-Weight, lbs (expert)	800	800	800	800	1150	1000	1000
Mid-Weight, lbs (expert)	975	900	975	900	1375	1250	1250
End-Weight, lbs (expert)	1150	1000	1150	1000	1600	1500	1500
Energy supplement: Barley					1.0%	76.0%	66.8%
Energy supplement: Corn	26.9%		26.9%		63.8%	0.0%	2.6%
Energy supplement: Wheat					0.7%	2.9%	6.4%
Energy supplement: Oat grain	3.8%		3.8%		0.7%		
Energy supplement: Screening pellet	3.1%	0.5%	3.1%	0.5%		1.0%	1.0%
Forages: Barley silage		35.3%		35.3%		8.5%	8.5%
Forages: Corn silage	24.3%		24.3%		13.4%		
Forages: Grass silage	8.9%	6.5%	8.9%	6.5%			
Forages: Hay	1.0%	45.3%	1.0%	45.3%	6.1%		
Forages: Straw (for feed)	12.8%		12.8%				
Forages: Oat silage							
Protein supplement: Dried distiller grains	17.5%	8.0%	17.5%	8.0%	11.2%	10.3%	10.3%
Other feedstocks (e.g., mill run pellet, soybean, triticale, etc.)		4.5%		4.5%	1.7%	1.3%	4.3%
Minerals & salt-premix	1.7%		1.7%		1.4%		
Animals on grass	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100%	100%	100%	100%	100.0%	100.0%	100.0%

Table D-5: Feed rations modelled for the cows and bulls in yearling & calf-fed systems

Animal Type	Cows		Bulls	
Sex	**F**	**F**	**M**	**M**
Region	**East**	**West**	**East**	**West**
On-Feed Days (expert)	102	75	183	78
Pasture Days (Yearling-Fed system)	263	290	182	287
Total Stage Duration (Yearling-Fed system)	365	365	365	365
Pasture Days (Calf-Fed system)	263	290	182	287
Total Stage Duration (Calf-Fed system)	365	365	365	365
Daily DM Intake, % of body weight (expert)	2.05%	2.05%	2.30%	2.30%
Start-Weight, lbs (expert)	1000	1000	1350	1350
Mid-Weight, lbs (expert)	1175	1245	1450	1505
End-Weight, lbs (expert)	1350	1490	1550	1660
Energy supplement: Barley		0.6%		0.6%
Energy supplement: Corn		9.3%		8.8%
Energy supplement: Wheat				
Energy supplement: Oat grain	0.2%	1.8%	0.2%	1.9%
Energy supplement: Screening pellet				
Forages: Barley silage		4.1%		4.1%
Forages: Corn silage	2.8%	0.6%	2.5%	0.7%
Forages: Grass silage	19.1%	0.9%	18.6%	1.0%
Forages: Hay	69.1%	71.2%	70.0%	72.0%
Forages: Straw (for feed)		7.9%		6.9%
Forages: Oat silage	7.3%	2.2%	7.4%	2.8%
Protein supplement: Dried distiller grains	0.1%	0.2%	0.1%	0.2%
Other feedstocks (e.g., mill run pellet, soybean, triticale, etc.)	0.5%	0.2%	0.4%	0.3%
Minerals & salt-premix	0.8%	0.9%	0.8%	0.9%
Animals on grass	0.0%	0.0%	0.0%	0.0%
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Due to the importance of feed rations for the environmental assessment, updated data sources were used along with extensive internal and external validation. Building upon the rations modelled based on 2013/14, the first step was to share the rations with key informants (SAC members, academics, feed experts) and ask them to identify trends in feed rations over the past 5 years and highlight any values worth revisiting.

Data Sources for the Calf Stage

Rations were pulled from the cost of production (COP) network survey which provided typical rations by province. Then, using the feed ingredient/component weightings reported in the Farm Management Survey (FMS, 2017), a weighted average of the typical rations was obtained for each province. For example, a typical corn ration, a typical hay ration, and one other ration described as "Other" were provided in the COP for Ontario. FMS 2017 reported that Ontario cow/calf feed was 10% corn, 51% hay, and 39% other by ingredient/component. Using this, the sum of each feed component in the rations was determined and then the rations themselves were weighted in order to end up at this final distribution of feed component. A similar exercise was conducted for bulls.

Data Sources for Remaining Stages (Backgrounder, Yearling, Finisher, Cows)

For each remaining stage, rations were obtained directly from feed experts at Gowans Feed (West) and OMAFRA (East). Typical rations were provided, and they were then averaged over each stage for the model.

Quality Control

Using the trends identified by key informants, such as an increase in wheat in western finishers, minor adjustments to specific percentages in the feed rations were made. These were then approved again by feed experts at Gowans Feed and OMAFRA, as well as SAC members. Finally, a comparison by stage was conducted with respect to the 2013/14 rations to ensure that any large changes could be justified, and follow-ups were made if further adjustments were needed.

Details of the Weights

The start weight for calves was kept at 99 lbs, as per the 2016 NBSA. The end weights for the finishers/cows/bulls were determined as follows. Carcass weights for the east and the west were obtained for finishers and for cows/bulls from AAFC. Then, using a typical dressing percentage of 59% (steers), 57% (heifers), or 50% (cows), the live weight was determined. An average over the years from 2013/14 to 2020 were considered.

Pre-Conditioning Periods

For calves, pre-conditioning periods were expected to have increased in the West. In order to estimate the number of days, the cow/calf rations obtained from the COP network were considered. Any ration fed for less than 90 days was assumed to be part of the pre-conditioning period, because backgrounding is typically defined as a period greater than 90 days. An average of these rations with durations less than 90 was determined. This resulted in 17 days in the west and 34 days in the east. In 2013/14, 33 days were considered in the east, implying that this methodology is in-line with typical practices in the east and can also be applied for the west. These values were shared with experts for approval before incorporation in the model.

Final Ration Estimations

From there, typical end weights and durations were estimated using the same feed rations provided by Gowans Feed and OMAFRA for a given stage. For example, a typical ration might be recommended for taking an animal from 500 to 800 lbs over the period of 120 days. These values were used as starting points. The on-pasture and on-feed values were then determined using the percentages obtained from the 2013/14 survey and adjusted as needed, such as to account for longer pre-conditioning periods in the west. The breakdown of calf-fed to yearling-fed systems is 45%:55%, as per data from Canfax, utilizing placement weights from the Alberta and Saskatchewan Cattle on Feed reports. The dry matter intake (DMI) was determined to be unchanged from 2013/14, as per expert guidance.

Moisture Content of Feed Rations

The feed rations are presented in the previous tables are on a dry matter basis. The moisture content of each feed component is provided in the following table. They are based on the same data sources described above.

Table D-6: Moisture content in feed ration components

Feed Component	Moisture Content (%)
Energy supplement: Barley	14%
Energy supplement: Corn	16%
Energy supplement: Wheat	15%
Energy supplement: Oat grain	14%
Energy supplement: Screening pellet	12%
Forages: Alfalfa	20%
Forages: Barley silage	65%
Forages: Corn silage	65%
Forages: Grass silage	65%
Forages: Hay	12%
Forages: Straw (for feed)	12%
Forages: Oat silage	65%
Forages: Wheat silage	65%
Protein supplement: Canola meal	12%
Protein supplement: Dried distiller grains	12%
Protein supplement: Soy meal	12%

Average Daily Gain and Feed to Gain

Then, the average daily gain (ADG) was calculated. These values needed to match the industry average, as determined through the literature compilation done by Canfax. Small adjustments were made to both the duration and end-weights (where the start weight for calves and the end weights for finishers were kept constant). In addition to a literature comparison for the ADG, a similar exercise was conducted for feed to gain (F:G). Furthermore, practical values for ADG and F:G were cross-referenced with expert opinion obtained from OMAFRA and Gowans Feed. In general, the modelled values were adjusted until the ADG, end weight, and F:G fit within the range of or be close to expert opinion and literature. This is shown in the following table.

Table D-7: ADG and F:G comparison

Source	Calves (Calf-Fed)	Calves (Yearling-Fed)	Backgrounders	Yearlings	Finishers (Calf & Yearling-Fed)
2021: ADG (lbs) (from Systems Descriptions tab)	2.35	1.98	2.00	2.46	3.37
LITERATURE: ADG (lbs)	1.41	1.41	3.08	3.08	3.57
EXPERT: ADG (lbs) (from Gowan Feed/OMAFRA)	2.25	2.25	2.00	2.00	3.25
2016: ADG (lbs)	2.27	1.45	1.56	2.31	3.13 (calf-fed), 2.66 (yearling-fed)
2021: F:G	*	*	7.64	8.84	8.0
LITERATURE: F:G	*	*	8.81	8.81	6.56
EXPERT: F:G (from Gowan Feed/OMAFRA)	*	*	7.50	7.50	7.30 (heifers), 3.50-6.70 (steers)
2016: F:G	*	*	9.78	14.05	10.81

Feed Waste

In addition to the meat losses considered in this study, losses occurring harvest, storage, and feeding are also considered. The losses occurring during harvest are considered within the LCIs listed in Table D-18. The remaining values of losses from storage and wastage during feeding were obtained from Legesse et al. (2015) and are consistent with the NBSA 2016 study. While differentiation between the harvest and storage losses was impossible, the slight overestimation has a minimal impact on the results of the assessment. These values are listed in Table D-8.

Table D-8: Feed storage and wastage during feeding loss rates

Feed type	Storage losses	Wastage
Hay	12%	20%
Silage	12%	5%
Energy/protein supplement	3%	0%

Land Use

The land use impacts are a culmination of various processes, including those for production of feed crops. Most of these values are captured in the LCIs used to model the system. However, the actual land used by animals on the farm was obtained from the previous 2013/14 survey and was deemed to not have changed significantly. This means that a value of 57 m^2 of land/animal per day was assumed for all animal categories other than finishers. Due to the intensity of finishing animals, they require significantly less land at 0.6 m^2/animal per day.

Bedding Materials

Due to the minor impact bedding materials had on the final results of the previous assessment, the values were not updated and are kept consistent with the NBSA 2016 study. At that time, they were obtained from the

2013/14 on-farm survey. Bedding materials were modelled using a barley straw process as a proxy. The amount of bedding consumed was assumed to be the same in both the West and the East, as shown in Table D-8 below.

Table D-9: Bedding used by animal at the farm level

Animal Type	Bedding (kg/head/day)
Cows	2.8E-04
Bulls	1.3E-03
Calves	3.3E-04
Backgrounded Heifers	1.5E-03
Backgrounded Steers	1.1E-03
Yearling Heifers	7.6E-04
Yearling Steers	1.1E-03
Finisher Heifers	8.8E-04
Finisher Steers	4.6E-04

Energy Consumption

Similarly, due to the minor impact energy consumption had on the final results of the previous assessment, the values were not updated and are kept consistent with the NBSA 2016 study.

Energy consumption at the farm level is summarized in Table D-10. All values were obtained from the 2013/14 survey.

Table D-10: Energy consumption by animal at the farm level

Energy source	Consumption (unit/head/day)
Electricity (kWh)	0.04
Natural gas (cf)	0.05
Diesel (L)	0.02
Gasoline (L)	0.003
Wastewater (L)	0.17

The composition of electricity was based on average Canadian data available in Agri-Footprint 5. It is provided in the following table.

Table D-11: Average Canadian electricity composition applied

Source	Percentage (%)
Hydroelectric	59%
Nuclear	15%
Coal	12%
Natural gas	10%
Biofuels	2%
Wind	2%
Oil	1%

Furthermore, energy consumption at the processing and retail stages were also considered. This included the refrigerant gases and any leaks. These values were not easily obtainable through interviews with packers or from literature, therefore the values used in the previous assessment which were gained from expert opinion are kept the same. This is shown in Table D-12. It should further be noted that data on energy, water, and inputs at the processing stage were all confidential and are therefore not included in the report. They were obtained from the 2013/14 survey and represented 86% of Canadian processors at that time.

Table D-12: Energy and refrigerant consumption at the retail stage

Inputs	Amount
Energy	kWh/kg of bone-free meat
Electricity	1.6
Natural gas	0.11
Heavy fuel	6.1
Leaks of refrigerant gas	kg refrigerant/kg bone-free meat
R404a	0.000079
R408a	0.0000086
R22	0.000054

Finally, energy consumption for storage and cooking were also considered. These values were modelled based on the report by Natural Resources Canada's Office of Energy Efficiency (2012) and are provided in Table D-13. These values are based a typical cooking scenario in which an electric cooking range is used to cook 1 kg meat at 3 minutes per side.

Table D-13: Energy consumed for storage and cooking (NRC, 2012)

Energy consumption	Amount (kWh/kg bone-free meat)
Storage	
Electricity	0.008
Cooking	
Electricity	0.14

Transport

Like energy consumption, it was assumed that no major changes occurred to the transport distances modelled in the previous assessment. Furthermore, default loading parameters of 80% initially and a 20% return were considered. The transport distances are listed in Table D-14.

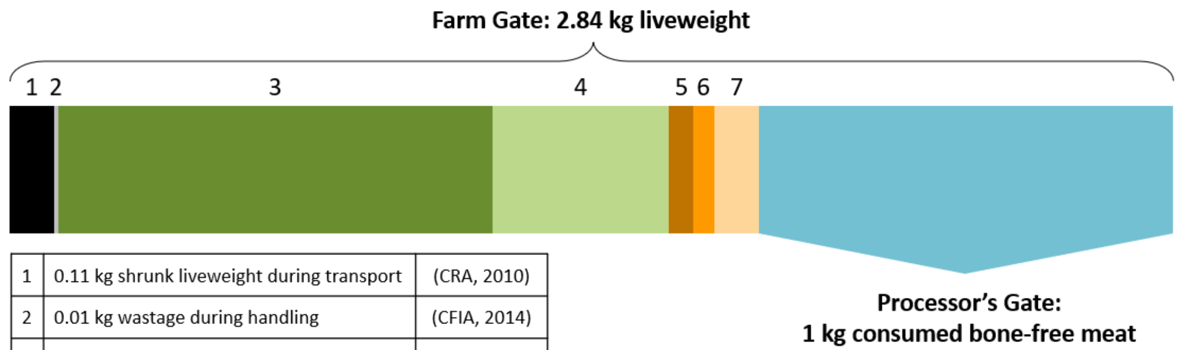
Table D-14: Transport distances for each production stage

Transport stage	Distance	Source
Feed transport	15 km	(AARD, 2010)
Cow/calf to feedlots or backgrounding	300 km	(AARD, 2010)
Backgrounding to feedlots	300 km	(AARD, 2010)
Feedlots to packing plants	300 km	(AARD, 2010)
Imported dairy animals	1200 km	Distance between Seattle and Calgary
Packaging to secondary processing	Excluded	
Processing plants to retailers	Excluded	
Retailers to consumers' home	Excluded	

Food Waste

Across the beef value chain, food waste and losses occur. According to the United Nations Environment Programme (UNEP) and the UN Food and Agriculture Organization (FAO), food waste and food loss are different concepts with distinct definitions. Food waste is defined as "food and associated inedible parts removed from the human food supply chain," while food loss is defined as "all the crop and livestock human-edible commodity quantities that completely exit the post-harvest supply chain…and do not re-enter in any other utilization" (UNEP, 2021). For this assessment, both the wastage and losses which occur are considered as an aggregate value.

Through interviews with producers and packers, it was determined that insignificant changes to food waste and loss across the supply chain have occurred since the previous assessment. Therefore, food waste and loss were modelled identically to NBSA 2016, as shown in Figure D-1. This figure includes all losses and wastage from both inedible parts and waste and loss due to processing.



1	0.11 kg shrunk liveweight during transport	(CRA, 2010)
2	0.01 kg wastage during handling	(CFIA, 2014)
3	1.06 kg by-products (dressing rate)	2016 Survey
4	0.43 kg by-products (carcass to bone-free)	
5	0.06 kg wastage at secondary processing	
6	0.05 kg wastage at retail	
7	0.12 kg wastage at consumer	

Figure D-1: Meat waste and losses from farm-gate to consumer level.
(numbers may not add up due to rounding)

In the model itself, the amount of liveweight at the farm-gate required for each functional unit is shown below. It is noted that that these amounts are calculated on a mass basis (physical allocation) and does not account for the economic allocation assumptions at the processor's gate and onwards.

- 1 kg liveweight at the farm-gate: 1 kg liveweight
- 1 kg carcass at the processor's gate: 1.65 kg liveweight
- 1 kg boneless meat at the processor's gate: 2.1 kg liveweight
- 1 kg boneless meat, retailed and consumed: 2.85 kg liveweight

Packaging

Packaging data remains consistent with the NBSA 2016 study and is based on published data from (Greenext, 2015). The data used in the model is summarized in Table D-15.

Table D-15: Packaging materials used per 1 kg of bone-free meat

Packaging Material	Amount (kg/kg of bone-free meat)
Primary packaging	
Polystyrene tray	0.056
Polyethylene film	0.0095
Secondary packaging	
Corrugated board	0.028
Tertiary packaging	
Polyethylene film	0.0013
Wood pallet	0.035

Additionally, impacts of waste treatment of the packaging materials were also considered within the model. These are unchanged from the previous assessment and are based on average recycling rates in the east and in the west (PACNEXT, 2014). Landfilling of used packaging was handled the same way, using individual emissions data. It was assumed that negligible changes to these recycling and landfilling rates have occurred due to their minor influence on the results and lack of more representative data. While the process of recycling is multifunctional, in this study, it is treated as a waste stream with the beef system not incorporating any credits based on the end-use.

Table D-16: Packaging materials used per 1 kg of bone-free meat

Packaging Material	Recycling Rate	Landfilling Rate
Plastics	61%	39%
Paper and board	29%	71%

Life Cycle Inventory (LCI) for E-LCA

Since the NBSA 2016 study, various updates to life cycle inventories (LCI) have become available. This includes the update from the ecoinvent 3.0 database used in 2016 to the ecoinvent 3.8 database available at the time of this study. Therefore, where possible updated LCIs were used for many of the processes modelled in the study. However, for some processes, either no updated data was available or insignificant changes have been made. For these processes, validation with the Scientific Advisory Committee was made prior to their use in the model. Furthermore, it should be noted that efforts were taken to use Canadian-specific processes where possible. Table D-17 summarizes the LCIs used, along with relevant modifications or assumptions.

Shading in the LCI column represents the following. Note that the shading is not representative of the values themselves, which are described throughout Appendix D.

- **Updated LCI process from NBSA 2016 according to available data**
- **Unmodified LCI process from NBSA 2016 due to unavailability of data or updated processes**
- **Unmodified LCI process from NBSA 2016 due to insignificant changes or effect on results**

Table D-17: LCIs used in the environmental LCA

Stage	Category	Input data	LCI used	Sources and assumptions
Farming	Energy	Electricity mix	Electricity mix, AC, consumption mix, at consumer, < 1 kV/CA energy	Agri-footprint 5.0 (2019)
		Natural gas	Natural gas, high pressure {CA-AB} | natural gas production | Cut-off, U	ecoinvent 3.7 (2021)
		Diesel	Diesel, burned in diesel-electric generating set {GLO} | Cut-off, U | Litres	ecoinvent 3.7 (2021), converted to litres
		Petrol	Petrol consumption | Litres	Gasoline consumption based on ecoinvent 3.7 process called Transport, passenger car {RoW}
	Feed, Energy Supplement	Barley	Barley grain, feed {CA} | production | Cut-off, S	ecoinvent 3.7 (2021), irrigation adjusted based on average Canadian practices
		Corn	Corn grain, feed {CA} | production | Cut-off, S	
		Wheat	Wheat grain, feed {CA} | production | Cut-off, S	
		Oat	Oat grain, feed {CA} | production | Cut-off, S	
		Screening pellet	Energy feed, gross {GLO} | corn grain to generic market for energy feed | Alloc Rec, U	Based on corn grain process listed above
		Soybean	Soybean, feed {CA} | production | Cut-off, S	ecoinvent 3.7 (2021), irrigation adjusted based on average Canadian practices
	Feed, Forages	Barley silage	Barley silage, feed {CA} | production | Cut-off, S	Updated barley grain LCI for a silage yield
		Corn silage	Corn silage, feed {CA} | production | Cut-off, S	Updated corn grain LCI for a silage yield
		Grass silage	Hay silage, Western Canadian production, AGÉCO process or Hay silage, Eastern Canadian production, AGÉCO process	Hay LCI project (2018), conducted by Canfax and Groupe AGÉCO
		Hay	Hay 10% moisture, Western Canadian production, AGÉCO process or Hay 10% moisture, Eastern Canadian production, AGÉCO process or	
		Straw	Barley silage, feed {CA} | production | Cut-off, S	Adjusted yield based on Agri-footprint allocation factor of 58.5:41.5 grain to straw
	Feed, Protein Supplement	Dried distiller's grains	Distiller's dried grains with solubles {GLO} | market for | Alloc Rec, U	ecoinvent 3.7 (2021), global dried distiller's grain
	Animal Transport	Transport	Transport, truck 10-20t, EURO5, 80%LF, default/GLO Energy	Agri-footprint 5.0 (2019)
Processing	Energy	Electricity mix	Electricity mix, AC, consumption mix, at consumer, < 1 kV/CA energy	Agri-footprint 5.0 (2019)
		Heat	Heat, district or industrial, natural gas	ecoinvent 3.7 (2021)

Stage	Category	Input data	LCI used	Sources and assumptions
			{CA-QC} | heat production, natural gas, at industrial furnace >100kW | Cut-off, U	
			Heat, central or small-scale, other than natural gas {GLO}| market group for | Cut-off, U	
		Diesel	Diesel, burned in diesel-electric generating set {GLO} | Cut-off, U | Litres	ecoinvent 3.7 (2021), converted to litres
	Water	Tap water	Tap water {CA-QC} | tap water production, conventional treatment | Cut-off, U	ecoinvent 3.7 (2021)
	Materials	Polyethylene	Polyethylene, low density, granulate {RoW} | production | Cut-ff, U	
		Plastic film	Extrusion, plastic film {RoW} | extrusion, plastic film | Cut-off, U	
		Acetic acid	Acetic acid, without water, in 98% solution state {GLO} | market for | Cut-off, U	
		Bromine	Bromine {RoW} | production | Cut-off, U	
		Sulfuric acid	Sulfuric acid {RoW} | production | Cut-off, U	
		Anhydrous ammonia	Nitrous dioxide {RoW} | market for nitrous dioxide | Cut-off, U (used as a proxy)	
Secondary processing	Packaging	Polystyrene	Polystyrene, expandable {RoW} | production | Cut-off, U	
		Injection moulding	Injection moulding {RoW} | processing | Cut-off, U	
		Plastic film	Extrusion, plastic film {RoW} | extrusion, plastic film | Cut-off, U	
		Corrugated board	Corrugated board box {CA-QC} | production | Cut-off, S	
		Wood pallet	EUR – flat pallet {RoW} | production | Alloc Rec, U	

It should be noted that the waste emissions from the landfilling of meat waste and wastewater treatment were individually modelled within Simapro as shown below. This was based on data obtained from the 2013/14 survey directly from processors. As a result, it is confidential and is not included within the report.

- Emissions to air: carbon dioxide, carbon monoxide, sulfur dioxide, nitrogen oxides, volatile organic compounds, ammonia, particulates, and chlorine
- Emissions to water: ammonia, nitrate, nitric acid, sulfuric acid, phosphorus
- Final waste flows: slag and ashes

Detailed Methodological Assumptions for E-LCA

The majority of the methodological assumptions made in this model remain consistent with the NBSA 2016. This includes the economic allocation used to distribute impacts between meat and co-products, calculations for methane emissions from enteric fermentation, and calculations for manure-related emissions.

Economic Allocation

Starting with economic allocation, the factors were based on the survey conducted with packers for the 2016 assessment. Based on interviews with packers for the current assessment, it was determined that no significant changes have occurred requiring the values to be updated. The allocation factors for each production stage are provided in the following table. The values represent the portion of all impacts either allocated to meat (90-95%) or co-products (5-10%), based on the value of co-products.

Table D-18: Distribution of the environmental impacts between meat and co-products (taken from NBSA 2016)

Stage	Meat	Co-Products
Carcass weight	95%	5%
Bone-free (packers' gate)	90%	10%

Note that percentages are economic allocation values from live weight rather than from the previous stage.

Water Consumption

Water depletion is an area of concern relevant to the beef production. In this study, it is assessed by quantifying the life cycle water consumption. It includes both direct and indirect water consumption and is divided by the weight of the finishing animal. Up to the functional unit of 1 kg live weight, this includes the animal consumption for drinking and for cleaning (direct) and the water used for irrigation to grow feed (indirect). For the functional units of 1 kg carcass and 1 kg of boneless packaged beef, water used for processing is added to the calculation. Furthermore, indirect water uses from throughout the life cycle of the product, such as for energy generation, are also included in the calculation. This equation can be summarized as follows.

$$\frac{\Sigma_{cohort} WI_{direct} t_d + \Sigma_{cohort} FWI_{irrigation}}{W_{finisher}}$$

Where:

- WI_{direct} = direct water intake, per animal stage per day
- t_d = duration of respective animal stage
- F = amount of feed per animal stage
- $WI_{irrigation}$ = indirect water intake for irrigation, per kg of feed
- $W_{finisher}$ = weight of finishing animal, in order to get results per kg live weight (FU)

In terms of direct water use, animal water consumption values were assumed to be unchanged from 2013/14. They were obtained from the Alberta Agriculture and Rural Development (2010) report, however, they were confirmed to be unchanged through the expert opinion of an Agricultural Water Engineer from Government of Alberta. The type and origin of water consumed was also assumed to be unchanged and was obtained from the 2016 NBSA survey. The values are provided in the following table.

Table D-19: Daily water consumption by animal type

Animal Type	Water Consumption (L/head/day)
Calves	8
Cows	41.5
Bulls	45
Backgrounders	20.5
Yearlings	32
Finishers	38

Water used for processing was assumed to be the same as the value used in 2013/14. Through interviews with beef processors in Canada, it was determined that while some processors have made strides to reduce water consumption, the reduction was not large or significant enough to assume a nation-wide reduction. Therefore, the consumption of water at the processing level remains unchanged. The value for processing water is confidential and therefore not included in the report.

Then, in terms of indirect water use, irrigation was considered in the assessment. This included water used for crop production for feed rations as well as water used for fertilizer and other inputs and is referred to as the share of beef-specific irrigated area in Table D-20, which was calculated as the ratio (in percentage) of the irrigated area under beef production and the total area of each land use type occupied by the beef industry. While some existing life cycle inventories were used to model certain crop production, irrigation intensities were modified to reflect production specific to western and eastern Canada. For the most part, this reflected practices in Alberta (west) and Ontario (east). Furthermore, irrigation for hay production specifically was modelled based on findings from the Canfax Hay LCI project undertaken in 2019. The irrigation values for all other crops were derived from the Census of Agriculture (2021). and the Agricultural Water Survey (2018). A change from the 2013/14 assessment is the inclusion of irrigation on tame pasture. Previously, due to insufficient data, irrigation on tame pasture was neglected. However, new findings from the 2021 Alberta Irrigation Report and the 2021 Alberta Agriculture Fact Sheet indicate that irrigation on tame pasture occurs at the same rate as irrigation on field crops. Therefore, for consistency, it cannot be neglected and is included in this assessment.

Table D-20: Irrigation intensity on beef-specific irrigated areas

Crop type	Share of beef-specific irrigated area of total irrigated area (%)	Irrigation intensity (m^3/ha)	Average crop irrigation for beef-specific irrigated areas (m^3/ha)
Field crops	3.10%	2800	86.8
Hay	3.40%	3100	105.4
Tame pasture	1.70%	2800	47.6

Sources: Statistics Canada, Alberta Agricultural Water Survey, and Alberta Agriculture Fact Sheet 2021.

It should be noted that soil moisture, sometimes referred as green water, is not included in the water consumption in this assessment. Inclusion of these values is not recommended under ISO 14046 (ISO, 2014) guidelines. This assumes that the evapotranspiration of soil water by crops has no more impact than that of the vegetation the crops replaced. As a result, only inputs, such as irrigation and direct animal consumption, also known as blue water, are considered.

Methane Emissions from Enteric Fermentation

Methane emissions due to enteric fermentation are a significant aspect of cattle production. In general, these emissions vary depending on the gross energy intake (GE), which is ultimately related to the dry matter intake (DMI). The DMI values changed since NBSA 2016 since efficiency improvements to F:G and ADG have occurred.

Enteric fermentation values were determined in an identical manner as the previous assessment. Combining the following Tier 2 equation from IPCC (2019) with methane conversion factors from Anele et al. (2014) and the Holos model, enteric fermentation rates per animal per day were determined.

$$CH_{4,enteric} = GE \times \frac{Ym}{55.65} \times \frac{1 - AR}{100}$$

Where:

- $CH_{4,enteric}$ = enteric methane emissions in kg CH_4/head·day
- GE = gross energy intake (MJ/head·day), estimated as 18.45 x DMI as per IPCC guidelines
- Ym = methane conversion factor
- 55.65 = energy content of methane (MJ/kg CH_4)

- AR = additive reduction factor, which is 0 for this assessment

The values obtained from this calculation for each animal type and each manure management type are provided in Table D-21, with the actual enteric emissions values in Table D-22.

Table D-21: Dry matter intake (DMI) and methane conversion factor from enteric emissions

Animal type	Manure management	Sex	Region	Calculated DMI (kg/day)		Ym	
				Yearling-fed	Calf-fed	Yearling-fed	Calf-fed
Calves on grass	in pasture	M/F	East	3.46	3.90	0.06	0.06
			West	3.46	3.90	0.06	0.06
Calves on feed	deep bedding		East	3.46	3.90	0.07	0.07
			West	3.46	3.90	0.07	0.07
	solid storage		East	3.46	3.90	0.07	0.07
			West	3.46	3.90	0.07	0.07
	composting		East	3.46	3.90	0.07	0.07
			West	3.46	3.90	0.07	0.07
Backgrounders on grass	in pasture	M	East	6.93	-	0.07	-
			West	6.93	-	0.07	-
		F	East	6.93	-	0.07	-
			West	6.93	-	0.07	-
Backgrounders on feed	deep bedding	M	East	6.93	-	0.07	-
			West	6.93	-	0.07	-
		F	East	6.93	-	0.07	-
			West	6.93	-	0.07	-
	solid storage	M	East	6.93	-	0.07	-
			West	6.93	-	0.07	-
		F	East	6.93	-	0.07	-
			West	6.93	-	0.07	-
	composting	M	East	6.93	-	0.07	-
			West	6.93	-	0.07	-
		F	East	6.93	-	0.07	-
			West	6.93	-	0.07	-
Yearlings on grass	in pasture	M	East	10.39	-	0.07	-
			West	9.59	-	0.07	-
		F	East	10.39	-	0.07	-
			West	9.59	-	0.07	-
Yearlings on feed	deep bedding	M	East	10.39	-	0.07	-
			West	9.59	-	0.07	-
		F	East	10.39	-	0.07	-
			West	9.59	-	0.07	-
	solid storage	M	East	10.39	-	0.07	-
			West	9.59	-	0.07	-
		F	East	10.39	-	0.07	-
			West	9.59	-	0.07	-

Animal type	Manure management	Sex	Region	Calculated DMI (kg/day)		Ym	
				Yearling-fed	Calf-fed	Yearling-fed	Calf-fed
	composting	M	East	10.39	-	0.07	-
			West	9.59	-	0.07	-
		F	East	10.39	-	0.07	-
			West	9.59	-	0.07	-
Finishers	deep bedding	M/F	East	14.65	10.79	0.03	0.03
		M	West	13.32	10.74	0.04	0.04
		F	West	13.32	10.74	0.04	0.04
	solid storage	M/F	East	14.65	10.79	0.03	0.03
		M	West	13.32	10.74	0.04	0.04
		F	West	13.32	10.74	0.04	0.04
	composting	M/F	East	14.65	10.79	0.03	0.03
		M	West	13.32	10.74	0.04	0.04
		F	West	13.32	10.74	0.04	0.04
Cows on grass	in pasture	F	East	10.92	10.92	0.07	0.07
			West	11.57	11.57	0.07	0.07
Cows on feed	deep bedding		East	10.92	10.92	0.07	0.07
			West	11.57	11.57	0.07	0.07
	solid storage		East	10.92	10.92	0.07	0.07
			West	11.57	11.57	0.07	0.07
	composting		East	10.92	10.92	0.07	0.07
			West	11.57	11.57	0.07	0.07
Bulls on grass	in pasture	M	East	15.12	15.12	0.07	0.07
			West	15.70	15.70	0.07	0.07
Bulls on feed	deep bedding		East	15.12	15.12	0.07	0.07
			West	15.70	15.70	0.07	0.07
	solid storage		East	15.12	15.12	0.07	0.07
			West	15.70	15.70	0.07	0.07
	composting		East	15.12	15.12	0.07	0.07
			West	15.70	15.70	0.07	0.07

Table D-22: Methane enteric emissions from beef cattle

Animal type	Manure management	Sex	Region	Enteric methane (kg CH_4/head/day)	
				Yearling-fed	Calf-fed
Calves	on grass	M/F	East	0.069	0.078
			West	0.069	0.078
	on feed		East	0.080	0.090
			West	0.080	0.090
Backgrounders	on grass	M	East	0.161	-
			West	0.161	-
		F	East	0.161	-
			West	0.161	-
	on feed	M	East	0.161	-
			West	0.161	-
		F	East	0.161	-
			West	0.161	-
Yearlings	on grass	M	East	0.241	-
			West	0.223	-
		F	East	0.241	-
			West	0.223	-
	on feed	M	East	0.241	-
			West	0.223	-
		F	East	0.241	-
			West	0.223	-
Finishers	on feed	M/F	East	0.146	0.107
		M	West	0.177	0.142
		F	West	0.177	0.142
Cows	on grass	F	East	0.254	0.254
			West	0.269	0.269
	on feed		East	0.254	0.254
			West	0.269	0.269
Bulls	on grass	M	East	0.351	0.351
			West	0.364	0.364
	on feed		East	0.351	0.351
			West	0.364	0.364

For replacement animals, the emissions are considered to be the same as the emissions for backgrounders (for replacements less than 1 year of age) or for yearlings (for replacements older than 1 year of age).

Manure-Related Emissions and Impacts

Emissions related to manure can occur either on pasture or during storage. The various pathways in which these emissions can occur are summarized in the following figure. The figure depicts both the actual emissions pathways at the farm-level, including those not included in the study, as well as other pathways considered in the LCA. It should be noted that emissions beyond manure production and storage were not included in the scope of this study. According to the FAO LEAP guidelines, "emissions associated with manure management up to the point of field application are assigned to the animal system, and emissions from the field were assigned to the crop production system". Manure application emissions (including methane, nitrous oxide, ammonia, nitrogen oxides, nitrates, and phosphate) related to manure use (e.g. fertilization of fields) were instead allocated to the crop processes (e.g. crops), and are thus encompassed in the crop LCIs models to avoid double counting, as per FAO LEAP guidelines (FAO, 2016).

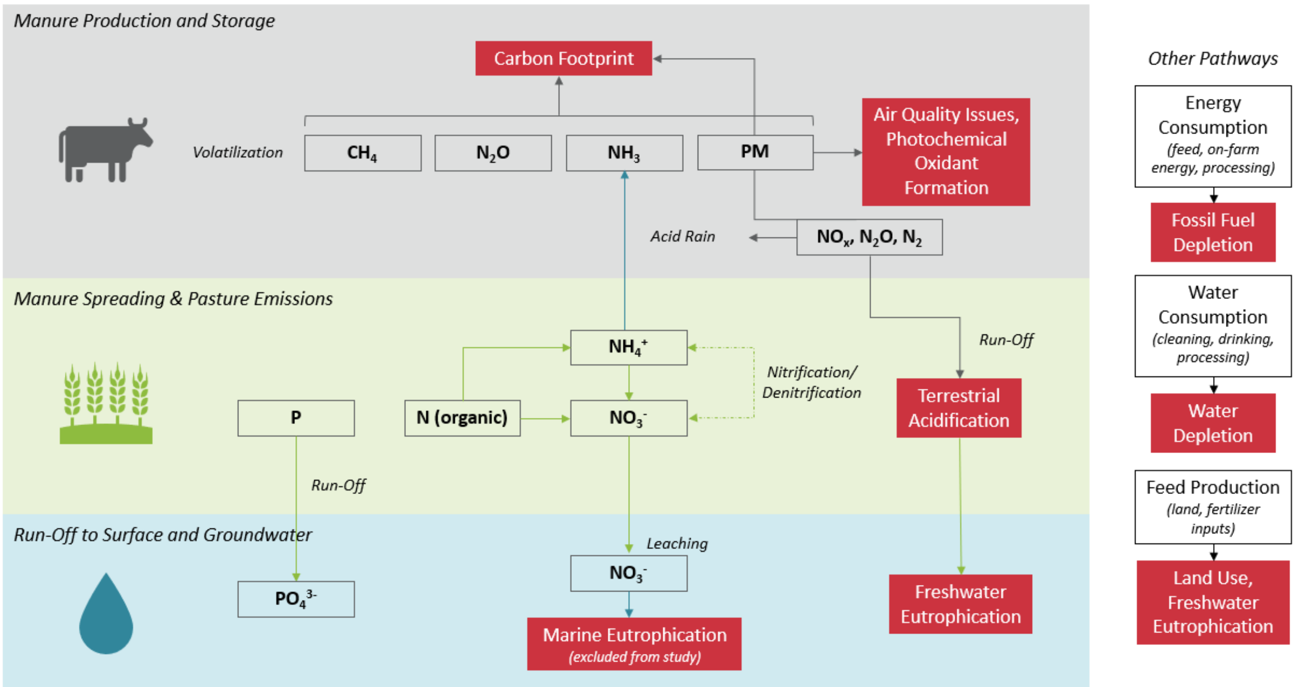


Figure D-2: Impact pathways from manure production and spreading. Adaptation from the 2016 NBSA.

Like enteric emissions, manure-related emissions are also related to the DMI. Additionally, manure management practices also affect these values. Calculations were made for a few main emissions: methane, nitrous oxide, ammonia, nitrogen oxides, nitrates, and phosphate.

Manure management practices in this study were based on the 2021 survey with producers. The practices and their proportions at a national scale are defined in Table D-23.

Table D-23: Manure storage practices at national level, based on 2021 survey

Manure Storage	Average* (%)
Liquid or slurry manure storage (tank, lagoon, basin, etc.)	7.4%
Solid manure stockpile/storage	46.8%
Temporary piles in fields	18.9%
Anaerobic lagoon	3.6%
Anaerobic digester	3.2%
Composting	16.8%

**Percentages do not add up exactly to 100% due to survey answers.*

Methane

Methane emissions result due to anaerobic fermentation during storage. This can occur in various storage situations, including pasture, solid storage, stockpiles, compost, and deep bedding. The emissions themselves are dependent on various factors, including the amount of volatile solids emitted, the methane conversion factor based on the storage type, as well as a constant related to methane producing capacity.

Based on the Holos model and IPCC guidelines (2019), methane emissions from manure were calculated based on the following equation.

$$CH_{4,manure} = VS \times B_0 \times MCF \times 0.67$$

Where:

- $CH_{4,manure}$ = methane emissions from manure in kg CH_4/head·day
- VS = volatile solids excreted in manure (kg/head·day), see following equation from (IPCC, 2019)
- B_0 = methane producing capacity, by default IPCC (2019) value of 0.19 m^3 CH_4/kg VS
- MCF = methane conversion factor (Table D-24)
- 0.67 = conversion factor from volume to mass (kg/m^3)

Methane conversion factors are as follows.

Table D-24: Methane conversion factors for manure (Little et al., 2008)

Handling system	MCF
Pasture/range/paddock	0.010
Solid storage	0.020
Compost – intensive windrow	0.005
Compost – passive windrow	0.005
Deep bedding – no active mixing	0.170

As mentioned above, the value of VS is also obtained from IPCC (2019).

$$VS = \left(GE \times \left(1 - \frac{TDN}{100}\right) + 0.04GE\right) \times \frac{1 - \frac{Ash}{100}}{18.45}$$

Where:

- GE = gross energy intake (MJ/head·day), estimated as 18.45 x DMI as per IPCC guidelines
- TDN = percent total digestible nutrients in feed (Table D-25), as per NBSA 2016
- Ash = 8%, ash content of manure

Values obtained from the VS equation are provided in the following table.

Table D-25: Total digestible nutrient (TDN) and volatile solids (VS) excreted for beef cattle

Animal type	Manure management	Sex	Region	TDN (%)		VS (kg/head/day)	
				Yearling-fed	Calf-fed	Yearling-fed	Calf-fed
Calves on grass	in pasture	M/F	East	65%	65%	1.2	1.4
			West	65%	65%	1.2	1.4
Calves on feed	deep bedding		East	65%	65%	1.2	1.4
			West	65%	65%	1.2	1.4
	solid storage		East	65%	65%	1.2	1.4
			West	65%	65%	1.2	1.4
	composting		East	65%	65%	1.2	1.4
			West	65%	65%	1.2	1.4
Backgrounders on grass	in pasture	M	East	65%	-	2.5	-
			West	65%	-	2.5	-
		F	East	65%	-	2.5	-
			West	65%	-	2.5	-
Backgrounders on feed	deep bedding	M	East	70%	-	2.2	-
			West	70%	-	2.2	-
		F	East	70%	-	2.2	-
			West	70%	-	2.2	-
	solid storage	M	East	70%	-	2.2	-
			West	70%	-	2.2	-
		F	East	70%	-	2.2	-
			West	70%	-	2.2	-
	composting	M	East	70%	-	2.2	-
			West	70%	-	2.2	-
		F	East	70%	-	2.2	-
			West	70%	-	2.2	-
Yearlings on grass	in pasture	M	East	60%	-	4.2	-
			West	60%	-	3.9	-
		F	East	60%	-	4.2	-
			West	60%	-	3.9	-
Yearlings on feed	deep bedding	M	East	60%	-	4.2	-
			West	60%	-	3.9	-
		F	East	60%	-	4.2	-
			West	60%	-	3.9	-
	solid storage	M	East	60%	-	4.2	-
			West	60%	-	3.9	-
		F	East	60%	-	4.2	-
			West	60%	-	3.9	-
	composting	M	East	60%	-	4.2	-
			West	60%	-	3.9	-
		F	East	60%	-	4.2	-
			West	60%	-	3.9	-

Animal type	Manure management	Sex	Region	TDN (%)		VS (kg/head/day)	
				Yearling-fed	Calf-fed	Yearling-fed	Calf-fed
Finishers	deep bedding	M/F	East	85%	85%	2.6	1.9
		M	West	80%	80%	2.9	2.4
		F	West	80%	80%	2.9	2.4
	solid storage	M/F	East	85%	85%	2.6	1.9
		M	West	80%	80%	2.9	2.4
		F	West	80%	80%	2.9	2.4
	composting	M/F	East	85%	85%	2.6	1.9
		M	West	80%	80%	2.9	2.4
		F	West	80%	80%	2.9	2.4
Cows on grass	in pasture	F	East	55%	55%	4.9	4.9
			West	55%	55%	5.2	5.2
Cows on feed	deep bedding		East	55%	55%	4.9	4.9
			West	55%	55%	5.2	5.2
	solid storage		East	55%	55%	4.9	4.9
			West	55%	55%	5.2	5.2
	composting		East	55%	55%	4.9	4.9
			West	55%	55%	5.2	5.2
Bulls on grass	in pasture	M	East	55%	55%	6.8	6.8
			West	55%	55%	7.1	7.1
Bulls on feed	deep bedding		East	55%	55%	6.8	6.8
			West	55%	55%	7.1	7.1
	solid storage		East	55%	55%	6.8	6.8
			West	55%	55%	7.1	7.1
	composting		East	55%	55%	6.8	6.8
			West	55%	55%	7.1	7.1

The following table provides the methane emissions calculated using the values provided in Table D-25.

Table D-26: Methane emissions from manure from beef cattle

Animal type	Manure management	Sex	Region	CH_4 emissions (kg/head/day)	
				Yearling-fed	Calf-fed
Calves on grass	in pasture	M/F	East	1.6E-03	1.8E-03
			West	1.6E-03	1.8E-03
Calves on feed	deep bedding		East	2.7E-02	3.0E-02
			West	2.7E-02	3.0E-02
	solid storage		East	3.2E-03	3.6E-03
			West	3.2E-03	3.6E-03
	composting		East	7.9E-04	8.9E-04
			West	7.9E-04	8.9E-04
Backgrounders on grass	in pasture	M	East	3.2E-03	-
			West	3.2E-03	-
		F	East	3.2E-03	-
			West	3.2E-03	-
Backgrounders on feed	deep bedding	M	East	4.7E-02	-
			West	4.7E-02	-
		F	East	4.7E-02	-
			West	4.7E-02	-
	solid storage	M	East	5.5E-03	-
			West	5.5E-03	-
		F	East	5.5E-03	-
			West	5.5E-03	-
	composting	M	East	1.4E-03	-
			West	1.4E-03	-
		F	East	1.4E-03	-
			West	1.4E-03	-
Yearlings on grass	in pasture	M	East	5.4E-03	-
			West	4.9E-03	-
		F	East	5.4E-03	-
			West	4.9E-03	-
Yearlings on feed	deep bedding	M	East	9.1E-02	-
			West	8.4E-02	-
		F	East	9.1E-02	-
			West	8.4E-02	-
	solid storage	M	East	1.1E-02	-
			West	9.9E-03	-
		F	East	1.1E-02	-
			West	9.9E-03	-
	composting	M	East	2.7E-03	-
			West	2.5E-03	-
		F	East	2.7E-03	-
			West	2.5E-03	-
Finishers	deep bedding	M/F	East	5.5E-02	4.1E-02

Animal type	Manure management	Sex	Region	CH_4 emissions (kg/head/day)	
				Yearling-fed	Calf-fed
		M	West	6.4E-02	5.1E-02
		F	West	6.4E-02	5.1E-02
	solid storage	M/F	East	6.5E-03	4.8E-03
		M	West	7.5E-03	6.0E-03
		F	West	7.5E-03	6.0E-03
	composting	M/F	East	1.6E-03	1.2E-03
		M	West	1.9E-03	1.5E-03
		F	West	1.9E-03	1.5E-03
Cows on grass	in pasture	F	East	6.3E-03	6.3E-03
			West	6.6E-03	6.6E-03
Cows on feed	deep bedding		East	1.1E-01	1.1E-01
			West	1.1E-01	1.1E-01
	solid storage		East	1.3E-02	1.3E-02
			West	1.3E-02	1.3E-02
	composting		East	3.1E-03	3.1E-03
			West	3.3E-03	3.3E-03
Bulls on grass	in pasture	M	East	8.7E-03	8.7E-03
			West	9.0E-03	9.0E-03
Bulls on feed	deep bedding		East	1.5E-01	1.5E-01
			West	1.5E-01	1.5E-01
	solid storage		East	1.7E-02	1.7E-02
			West	1.8E-02	1.8E-02
	composting		East	4.3E-03	4.3E-03
			West	4.5E-03	4.5E-03

Biogenic methane was treated differently than fossil methane for their global warming potential in this study as the neutrality principle requires, while biogenic CO_2 was set to zero.

Nitrous Oxide Emissions (N_2O)

In addition to methane, nitrous oxide emissions also occur from manure management. In general, these include direct emissions and leaching from storage as well as indirect emissions from volatilization and leaching on pasture.

As with the methane emissions discussed previously, nitrous oxide emissions are also dependent on DMI. In this case, the nitrogen excretion rate is determined based on the crude protein content in feed and the equations proposed by (Dong et al., 2014).

The crude protein in feed was determined on a dry matter basis using data from the Merck Veterinary Manual (Hilton, 2022). The percentage of crude protein in each feed component is provided in the following table.

Table D-27: Crude protein content in feed, from Hilton (2022)

Feed Component	Percentage Crude Protein (%, on dry matter basis)
Barley, grain	13.2%
Corn, grain	9.8%
Wheat, grain	17.4%
Oat, grain	13.6%
Screening pellet	14.0%
Barley, silage	11.9%
Corn, silage	8.7%
Grass, silage	19.5%
Straw	19.5%
Hay	18.6%
Oat, silage	13.6%
Wheat, silage	17.4%
Distiller's dry grains	30.4%

Table D-28: Equations for determining nitrogen excretion in urine and feces, from Dong et al. (2014)

Value	Equation
Urinary N excretion (g/day)	$\mathrm{N}_{\mathrm{ex,urinary}} = 0.51N_{in} - 14.12$
Fecal N excretion (g/day)	$\mathrm{N}_{\mathrm{ex,fecal}} = 0.20N_{in} + 15.82$

Where:

- N_{in} = nitrogen consumed in feed (g/day). Assumed to 16% of the crude protein concentration in feed ration (on a dry matter basis) according to the Kjeldahl Method (FAO, 2003).

The following calculations for direct and indirect emissions are adapted from Holos (Little et al., 2013) and IPCC guidelines (2019). Direct nitrous oxide emissions were calculated as follows.

$$N_2O{-}N_{direct} = N_{ex} \times EF_{dir}$$

Where:

- N_2O-N_{direct} = direct manure emission rate (kg N/head/day)
- N_{ex} = nitrogen excretion rate in manure (kg N/head/day)
- EF_{dir} = direct emission factor for N_2O-N, provided in Table D-29.

Next, indirect nitrous oxide emissions from nitrogen volatilization were calculated with the following equation.

$$N_2O{-}N_{vol} = N_{ex} \times P_{vol} \times EF_{vol}$$

Where:

- N_2O-N_{vol} = manure emission rate from volatilization (kg N/head/day)
- N_{ex} = nitrogen excretion rate in manure (kg N/head/day)
- P_{vol} = portion of N that gets volatized
- EF_{vol} = volatilization emission factor, provided in Table D-29.

Finally, indirect nitrous oxide emissions from leaching were calculated with the following equation.

$$N_2O{-}N_{leach} = N_{ex} \times P_{leach} \times EF_{leach}$$

Where:

- $N_2O\text{-}N_{leach}$ = manure emission rate from leaching (kg N/head/day)
- N_{ex} = nitrogen excretion rate in manure (kg N/head/day)
- P_{leach} = portion of N that gets leached, only applied to pasture. Estimated to be 0.215 in Western Canada and 0.393 in Eastern Canada based on data from (CGIAR-CSI, 2015).
- EF_{leach} = volatilization emission factor for both storage and pasture, provided in Table D-29.

The emissions factors used in the above equations were obtained from the Holos model (Little et al., 2008) and are provided in Table D-29.

Table D-29: Emissions factors used for N-related emissions (Little et al., 2008)

Handling system	EF_{dir} (kg N_2O-N/kg N)*	P_{vol}	EF_{vol} (kg N_2O-N/kg N)*	EF_{leach} (kg N_2O-N/kg N)*
Pasture/range/paddock	0.02	0.20	0.01	0.0075
Solid storage	0.005	0.45	0.01	0.0075
Compost – intensive windrow	0.1	0.45	0.01	0.0075
Compost – passive windrow	0.01	0.45	0.01	0.0075
Deep bedding – greater than 1 month	0.01	0.30	0.01	0.0075

** Kg N_2O-N means kg of nitrogen in the form of N_2O.*

Ammonia Emissions (NH_3)

Ammonia emissions are tied to the nitrous oxide emissions discussed previously as they depend on the amount of nitrogen that is released in manure. In this study, emissions associated with manure storage, composting, and pasture are considered based on the study by (Chai et al., 2014), as shown in the following equation. This methodology is consistent with the NBSA 2016. It should be noted that the manure storage method does affect the emission values, with deep bedding generally having higher emissions, particularly for finishing animals.

$$NH_{3,rate} = TAN_{ex} \times EF \times ATA \times \frac{17}{14}$$

Where:

- $NH_{3,rate}$ = ammonia emissions from manure (kg NH_3/head/day)
- TAN_{ex} = excreted N from animal urine, based on cattle diet. The value of TAN_{ex} is assumed to be 60% of excreted nitrogen (N_{ex}), according to (Chai et al., 2014), as described in Table D-28.
- EF = ammonia emission factor (kg NH_3-N/kg TAN), taken from (Chai et al., 2014).
- ATA = correction factor for EF, based on ambient temperature-based adjustments. Also taken from (Chai et al., 2014).
- 17/14 = conversion factor between NH_3-N and NH_3

Table D-30: Ammonia leaching quantities on pasture and in storage

Animal type	Manure management	Sex	Region	TAN (kg N/head/day)		EF x ATA (kg NH_3-N/kg TAN)*		NH_3 (kg NH_3/head/day)	
				Yearling-fed	Calf-fed	Yearling-fed	Calf-fed	Yearling-fed	Calf-fed
Calves on grass	in pasture	M/F	East	0.04	0.05	0.10	0.10	0.01	0.01
			West	0.04	0.05	0.10	0.10	0.01	0.01
Calves on feed	deep bedding		East	0.03	0.04	0.21	0.21	0.01	0.01
			West	0.03	0.03	0.21	0.21	0.01	0.01
	solid storage		East	0.03	0.04	0.35	0.35	0.01	0.02

Animal type	Manure management	Sex	Region	TAN (kg N/head/day)		EF x ATA (kg NH_3-N/kg TAN)*		NH_3 (kg NH_3/head/day)	
				Yearling-fed	Calf-fed	Yearling-fed	Calf-fed	Yearling-fed	Calf-fed
			West	0.03	0.03	0.35	0.35	0.01	0.01
	composting		East	0.03	0.04	0.70	0.70	0.03	0.03
			West	0.03	0.03	0.70	0.70	0.03	0.03
Backgrounders on grass	in pasture	M	East	0.10	-	0.10	-	0.01	-
			West	0.10	-	0.10	-	0.01	-
		F	East	0.10	-	0.10	-	0.01	-
			West	0.10	-	0.10	-	0.01	-
Backgrounders on feed	deep bedding	M	East	0.07	-	0.21	-	0.02	-
			West	0.08	-	0.21	-	0.02	-
		F	East	0.07	-	0.21	-	0.02	-
			West	0.08	-	0.21	-	0.02	-
	solid storage	M	East	0.07	-	0.35	-	0.03	-
			West	0.08	-	0.35	-	0.04	-
		F	East	0.07	-	0.35	-	0.03	-
			West	0.08	-	0.35	-	0.04	-
	composting	M	East	0.07	-	0.70	-	0.06	-
			West	0.08	-	0.70	-	0.07	-
		F	East	0.07	-	0.70	-	0.06	-
			West	0.08	-	0.70	-	0.07	-
Yearlings on grass	in pasture	M	East	0.16	-	0.10	-	0.02	-
			West	0.14	-	0.10	-	0.02	-
		F	East	0.16	-	0.10	-	0.02	-
			West	0.14	-	0.10	-	0.02	-
Yearlings on feed	deep bedding	M	East	0.12	-	0.21	-	0.03	-
			West	0.12	-	0.21	-	0.03	-
		F	East	0.12	-	0.21	-	0.03	-
			West	0.12	-	0.21	-	0.03	-
	solid storage	M	East	0.12	-	0.35	-	0.05	-
			West	0.12	-	0.35	-	0.05	-
		F	East	0.12	-	0.35	-	0.05	-
			West	0.12	-	0.35	-	0.05	-
	composting	M	East	0.12	-	0.70	-	0.10	-
			West	0.12	-	0.70	-	0.10	-
		F	East	0.12	-	0.70	-	0.10	-
			West	0.12	-	0.70	-	0.10	-
Finishers	deep bedding	M/F	East	0.14	0.10	0.90	0.90	0.15	0.11
		M	West	0.15	0.12	0.90	0.90	0.16	0.13
		F	West	0.15	0.12	0.90	0.90	0.16	0.13
	solid storage	M/F	East	0.14	0.10	0.35	0.35	0.06	0.04
		M	West	0.15	0.12	0.35	0.35	0.06	0.05
		F	West	0.15	0.12	0.35	0.35	0.06	0.05

Animal type	Manure management	Sex	Region	TAN (kg N/head/day)		EF x ATA (kg NH_3-N/kg TAN)*		NH_3 (kg NH_3/head/day)	
				Yearling-fed	Calf-fed	Yearling-fed	Calf-fed	Yearling-fed	Calf-fed
	composting	M/F	East	0.14	0.10	0.70	0.70	0.12	0.08
		M	West	0.15	0.12	0.70	0.70	0.13	0.10
		F	West	0.15	0.12	0.70	0.70	0.13	0.10
Cows on grass	in pasture	F	East	0.16	0.16	0.10	0.10	0.02	0.02
			West	0.17	0.17	0.10	0.10	0.02	0.02
Cows on feed	deep bedding		East	0.15	0.15	0.21	0.21	0.04	0.04
			West	0.15	0.15	0.21	0.21	0.04	0.04
	solid storage		East	0.15	0.15	0.35	0.35	0.06	0.06
			West	0.15	0.15	0.35	0.35	0.06	0.06
	composting		East	0.15	0.15	0.70	0.70	0.12	0.12
			West	0.15	0.15	0.70	0.70	0.13	0.13
Bulls on grass	in pasture	M	East	0.23	0.23	0.10	0.10	0.03	0.03
			West	0.24	0.24	0.10	0.10	0.03	0.03
Bulls on feed	deep bedding		East	0.21	0.21	0.21	0.21	0.05	0.05
			West	0.21	0.21	0.21	0.21	0.05	0.05
	solid storage		East	0.21	0.21	0.35	0.35	0.09	0.09
			West	0.21	0.21	0.35	0.35	0.09	0.09
	composting		East	0.21	0.21	0.70	0.70	0.18	0.18
			West	0.21	0.21	0.70	0.70	0.17	0.17

* kg NH_3-N means kg of nitrogen in the form of NH_3.

Nitrogen Oxide Emissions (NO_x)

Nitrogen oxide emissions result from nitrification and denitrification processes which naturally occur during manure application and storage. Manure storage emissions are included in this study which are based on the report published by EMEP/EEA (EMEP/EEA, 2013), which states that a rate of 0.094 kg NO_x/head/year was observed for beef cattle. Consistent with the previous assessment, no additional information regarding emissions varying by animal category was available. Therefore, the same value was applied for each animal. Emissions associated with manure applied to crops were allocated to the crop processes to avoid double counting.

Phosphate Emissions (PO_4^{3-})

Finally, phosphate emissions from manure for animals on pasture was also considered. It was assumed that no phosphate emissions occurred while animals were in confinement. For this study, phosphate losses were calculated in the same manner as for the 2016 NBSA, according to the SALCA emissions model proposed by (Prasuhn, 2006). This model considers the phosphorus content of the animal's diet in terms of phosphorus excretion from manure. However, since data regarding the phosphorus content of the diets was unavailable, phosphorus loss rates that are applied to the excretion rates were taken from Hofmann & Beaulieu (2006) was used (Table D-32). No more recent data was available at the time of the study and no recent research indicated that there could be a decrease in phosphate emissions from beef cattle, therefore the same values applied in the previous assessment were used. For each of the possible pathways of phosphate emissions, equations based on (Prasuhn, 2006) were considered.

First, for the leaching of phosphate to groundwater, the emissions are calculated as follows.

$$P_{gw} = P_{gwl} \times F_{gw}$$

Where:

- P_{gw} = P lost to groundwater (kg P/ha/day)
- P_{gwl} = average quantity of P lost to groundwater, based on land use category. A constant value of 0.06 kg P/ha/year which applies to meadow and pasture is used.
- F_{gw} = correction factor, which in this case is 1.

Then, run-off of phosphate to surface water was calculated as follows.

$$P_{ro} = P_{rol} \times F_{ro}$$

Where:

- P_{ro} = P lost by run-off to surface water (kg P/ha/day)
- P_{rol} = average quantity of P lost to surface water, based on land use category. A constant value of 0.25 kg P/ha/year which applies to meadow and pasture is used.
- F_{gw} = correction factor, which in this case is 0.18. The extensive procedure for calculating this correction factor is outlined in the NBSA 2016 report.

Finally, erosion of soil containing phosphorus is estimated using the following equation.

$$P_{er} = S_{er} \times P_{cs} \times F_{enr} \times F_{erw}$$

Where:

- P_{er} = P lost by erosion to surface water (kg P/ha/day)
- S_{er} = quantity of eroded soil (kg soil/ha/day), set at 0.94 kg soil/ha/da based on the Revised Universal Soil Loss Equation from OMAFRA (Stone & Hilborn, 2015).
- P_{cs} = amount of P in topsoil (kg P/kg soil), which is estimated as 0.00095 kg/kg according to (Prasuhn, 2006).
- F_{enr} = enrichment factor, set at 1.86 (Prasuhn, 2006).
- F_{erw} = fraction of eroded soil, set at 0.2 (Prasuhn, 2006).

Based on these 3 equations, the total phosphorus losses to water modelled in this study are provided in the following table.

Table D-31: Total phosphorus losses to water, animals on pasture

Phosphorus loss pathway	Loss (kg P/ha/day)
Leaching to groundwater, P_{gw}	0.00016
Run-off to surface water, P_{ro}	0.00069
Erosion to surface water, P_{er}	0.00066
Total (on pasture)	**0.0015**

As mentioned, the above equations rely on feed-dependent phosphorus excretion data. Since this data was unavailable, excretion rates based on Hofmann & Beaulieu (2006) which provides excretion rates by animal category, were used. This follows the same procedure applied in NBSA 2016. The values are provided in the following table.

Table D-32: Phosphorus excretion rates from manure, animals on pasture

Animal Category	Phosphate (kg P/head/day)
Cows	0.058
Bulls	0.067
Calves	0.019
Backgrounded heifers	0.029
Backgrounded steers	0.030
Yearling heifers	0.039
Yearling steers	0.042

D.3 DATA SOURCES AND METHODOLOGY FOR LU

The land use assessment included the same sources of data as the E-LCA data for the following: mortality rates (Table D-1), feed rations (Table D-2 to Table D-5), data sources for the calf stage, data sources for remaining life stages (backgrounder, finisher, cows), quality control, details of the weights, pre-conditioning periods, final ration estimations, average daily gain and feed to gain and land use.

BIODIVERSITY: POTENTIAL WILDLIFE HABITAT CAPACITY

The Potential Wildlife Habitat Capacity Index (WHCI) on Agricultural Land in Canada Agri-Environmental Indicator was developed by Agriculture and Agri-Food Canada (AAFC) to provide a multi-species assessment of broad-scale trends in the capacity of the Canadian agricultural landscape to provide reproductive and feeding habitat for populations of terrestrial vertebrates. Calculation methodology relates species found within the agricultural extent with land cover used as primary, secondary or tertiary reproductive and feeding habitat. Applying the same methodology on the proportion of land cover associated with the beef cattle industry allowed calculation of a beef specific WHCI ($WHCI^B$). Harmonized methodologies between WHCI and $WHCI^B$ allowed assessment of the proportion of total overall WHCI associated with the cattle industry. The methodology applied is as follows.

Reporting Area and Time Frame

Potential WHCI and $WHCI^B$ was determined for the agricultural extent of Canada (Figure D-3) for 2013/14 and 2021. All analysis were done at the Provincial level then rolled up for National *State* and *Trend* reporting.

Figure D-3: Canadian agricultural extent considered in the beef-specific WHCI.

Wildlife

A habitat association matrix was constructed for 545 terrestrial vertebrates (332 birds, 134 mammals, 41 amphibians and 38 reptiles) that use land cover within the agricultural extent of Canada for reproduction and/or feeding. Each cover type (used as a synonym for habitat in this report) used by wildlife species was classified as *Primary* (always used, critical or strongly preferred habitat), *Secondary* (often used, important habitat) or *Tertiary* (occasionally used, low value habitat) with values of 1.0, 0.75 and 0.25 assigned, respectively, to reflect the relative importance of the land cover for both reproduction and feeding.

Land Cover

Land cover information was obtained from **(1)** AAFC Earth Observation Semi-Decadal Land Use (SDLU) Time Series Product (2015 and 2020, 30 metre resolution) and **(2)** the Statistics Canada Provincial Census of Agriculture (COA). Cover types included in the SDLU were *Settlement*, *Vegetated Settlement*, *Cropland*, *Managed Grassland (native grassland)*, *Woodland*, *Woodland Regeneration* (following harvest), *Woodland Regeneration (following fire)*, *Wooded Wetland*, *Wetland*, *Water*, and *Other Land*. The COA was used to differentiate agricultural cover types at the provincial-level within the *Cropland* area defined by the SDLU. These included cover types used by the beef cattle industry (*Improved Pasture*, *Unimproved Pasture*, *Triticale*, *Wheat*, *Oats*, *Grass* and *Hay*, *Barley* and *Corn*) and those not used (the remainder of *Annual Crops*, *Nurseries* and *Fruits and Berries*). The proportion of each cover type used by the beef cattle industry in 2013/14 and 2021 was obtained from ration tables.

Wildlife Habitat Capacity Index Calculation

Initially, species-specific habitat availability (SSHA) for reproduction and feeding was calculated at the provincial level as follows:

$$SSHA = \sum (CT\% \times HUV)$$

where; $CT\%$ is the proportion of the cover type used by a species in the Province and HUV is the habitat use value (Primary=1, Secondary=0.75 and Tertiary=0.25).

Next, Wildlife Habitat Capacity Index for reproduction and for feeding were calculated for each province as:

$$Provincial\ WHC = \frac{\sum SSHA}{n}$$

Where n is the number of species per province.

$WHCI^B$ of agricultural land utilized by the beef cattle industry was calculated in a similar fashion as above but was limited to cover types and their proportions (from ration tables) used by beef cattle.

Carbon Soil Sequestration

The previous carbon soil sequestration assessment for NBSA 2016 included the estimation of GHG emissions and removals resulting from land management change (LMC) and land use change (LUC) associated with canola production to model the impacts and benefits of LMC and LUC of crops, forages and grass from improved pasture fed to Canadian beef cattle. The assessment also excluded the impacts and benefits from non-improved pastures with the assumption that these grasslands were established long ago and there is no estimated C emission nor removal for grassland remaining grassland. Based on discussions with key informants (SAC members, academics, experts in soil health), these assumptions used in the previous assessment were kept the same as updated values were not available. Therefore, the impacts and benefits of LMC and LUC for crops, forages and grass from improved pasture were modelled as the average GHG emissions and removals issuing from LMC and LUC of canola for the year 2006, consistent with the assumptions of the previous LCA (Table D-33). In the previous assessment, it was determined that the uncertainty of the proposed methodology is 21% from the National Inventory Report (Environment Canada, 2014).

Moreover, LUC emissions estimated in (Shrestha et al., 2014) considers the effects of direct LUC. The assumptions made in the previous LCA maintained that this is consistent with Canadian feed sourcing practices, and that Canadian cattle producers source feed locally at a provincial level (e.g., cattlemen from Western Canada get their feed within Canadian Western provinces), and that foreign importation of feed is negligible.

Table D-33: Average GHG emissions and removals issuing from LMC and LUC of crops, forages and grass from improved pasture for 2006 (kg CO_2 eq/ha)

Year	LMC	LUC
2006	-399	99

The current assessment compares the associated emissions and removals of LUC and LMC to current organic carbon stocks. The carbon stock values (Table D-34) were updated based on a literature review as well as the estimated total C stock through a predictive SOC regression model including variables of different agricultural soils and crop types being conducted by the AAFC Lethbridge Research Group on soil carbon sequestration. The total Canadian carbon stock for 2021 was estimated as a weighted average of the distribution of carbon stocks in the east and west.

Table D-34: Average current organic carbon stock in Canadian soils to a 30 cm depth (2022)

Carbon stock (t/ha)	2021			2013/14	% change
	Canada	West	East	Canada	2021-2013/14
Cropland	77.1	79.2	65.0	75.9	1.5
Tame pasture	72.4	72.5	73.2	71.2	1.7
Native pasture	74.7	73.9	81.6	74.5	0.2

The goal of the carbon sequestration assessment was to provide a high-level evaluation of impact of cattle farming on carbon stock, from a land use perspective, both at the provincial and national levels. This included a provincial breakdown of the aggregated agricultural land used for beef cattle production versus other agricultural uses, and their respective carbon stock estimates. The contribution of the carbon stock is based on each agricultural land cover referenced in the Census of Agriculture 2011, with their associated average carbon stock intensity value, calculated for either their application to beef cattle production or other agricultural uses.

Next, the average emissions and removals of LMC and LUC from crops, grass and forages (Table D-33) were applied to the rations fed to cattle and to the pasture areas to estimate the GHG emissions and removals of LMC and LUC specific to beef cattle production.

Additionally, the carbon stock intensity (Table D-34) and the crop, native and tame pasture areas were compared to estimate the soil carbon sequestration potential to a 30 cm depth.

D.4 DATA SOURCES FOR S-LCA

This section presents the descriptive results of the primary data collection:

- On-farm survey
- Packer's survey
- Interviews with industry representatives

ON-FARM SURVEY

A web-based on farm survey was communicated to Canadian beef producers to document their practices with respect to various social topics. The survey included about 70 questions, most of which were practice-based. A copy of the document is available below.

The survey was available in French and English, and prizes were drawn among participating Canadian beef farmers to encourage their participation in the survey[84]. The link to access the survey was communicated to producers by CRSB via different media platforms (e.g., LinkedIn, Facebook, newsletter, etc.). The survey took place between September 2021 to January 2022, with an additional push among Saskatchewan and Alberta feedlot producers in February 2022.

All farmers with beef cattle could complete the survey. No exclusion criteria applied (e.g., herd size, farm income).

Below are the key facts and figures about the survey.

- A total of 333 Canadian beef producers from across the country completed the survey. However, the number of respondents per question may vary due to not all questions being applicable to all farmers (e.g., farms with no hired labour were not asked questions about labour management) and that respondents could skip questions. In comparison, 76 questionnaires were completed for the 2016 NBSA.
- Survey results collected through a web-based questionnaire cannot be considered statistically representative as respondents are not randomly selected. That said, results can be considered nationally robust if a certain number of surveys are completed. For instance, 96 completed questionnaires are needed for a 10% margin of error, 196 for a 7% margin of error and 338 for a 5% margin of error.
- The Table D-35 provides a breakdown of respondents per province. Results are compared to the number of active beef cattle operations according to the latest Census of Agriculture data.
- Results show that producers of certain provinces (e.g., Atlantic region and British Columbia) are overrepresented in the sample compared to their actual importance in the national population. Others are underrepresented (e.g., Ontario and Saskatchewan).

[84] Prizes included $20 VISA gift certificate for the first 200 respondents (courtesy of CRSB), a Tag Reader worth $1,100 as grand prize (courtesy of CCIA), and 7 packages valuing between $225-500 each drawn among participants from each region. All prizes were offered by NBSA sponsors.

Table D-35: Number of completed questionnaires compared to the number of beef cattle operations in 2021

	Survey result		Census of agriculture (2021)
Provinces	Part	Number of respondents	Number of beef cattle operations
British Columbia	11%	37	7%
Alberta	32%	107	33%
Saskatchewan	16%	52	22%
Manitoba	12%	41	10%
Ontario	11%	38	19%
Quebec	5%	16	6%
Atlantic Region	12%	41	3%
Territories	<1%	1	---
TOTAL	100%	333	100%

The total number of beef cattle reported by respondents amounted to 262,922 head (including mother cows, backgrounding, yearling grassers and finishing; see also Figure D-4 and Figure D-5). In comparison, 284,538 animals were represented in the 2013/14 survey. Given the number of respondents in the two surveys (76 in the NBSA 2016 vs. 333 in the NBSA 2023), this is to say that the average herd size per farm is notably smaller in this assessment (3 744 animals per respondent in the NBSA 2016 vs. 790 animals per respondent in NBSA 2023), and the proportion of large finishing operations is also lower in this assessment (151,779 animals representing 53% of the sample in the NBSA 2016 vs. 99,225 animals representing 38% of the sample in NBSA 2023).

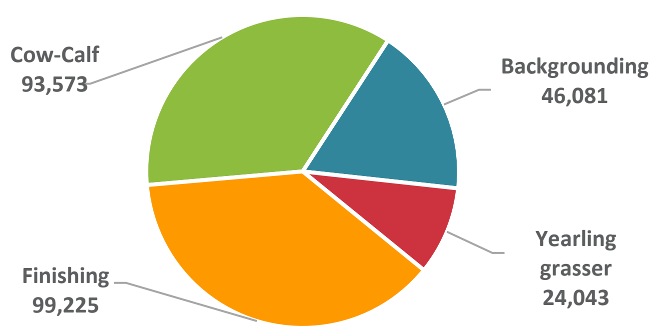


Figure D-4: Number of animals - By types of operation.

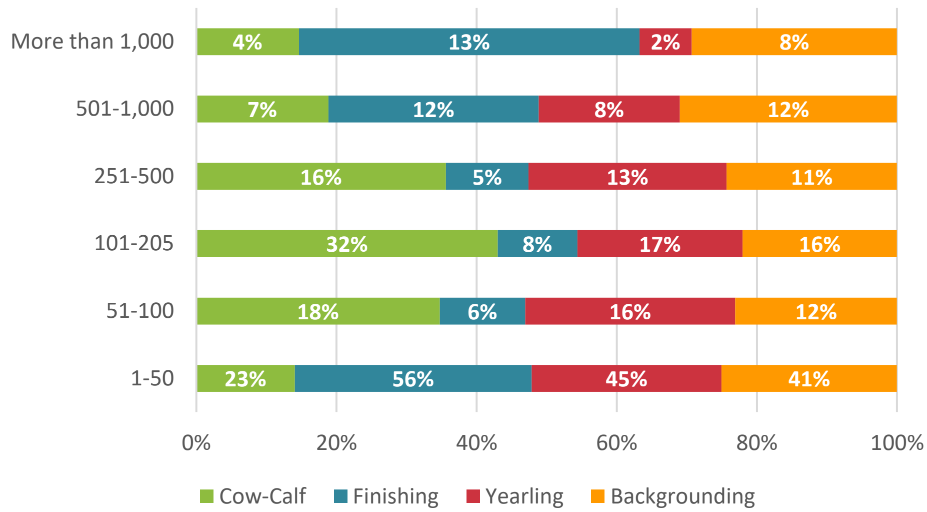


Figure D-5: Number of producers according to the number of animals - By types of operation.

As shown Figure D-6, primary decisionmakers are for the most part males (74%) and most of respondents are of under 54 years of age. In comparison, the average age of farm operations in Canada (for all types of operations) was of 56 years in 2021.

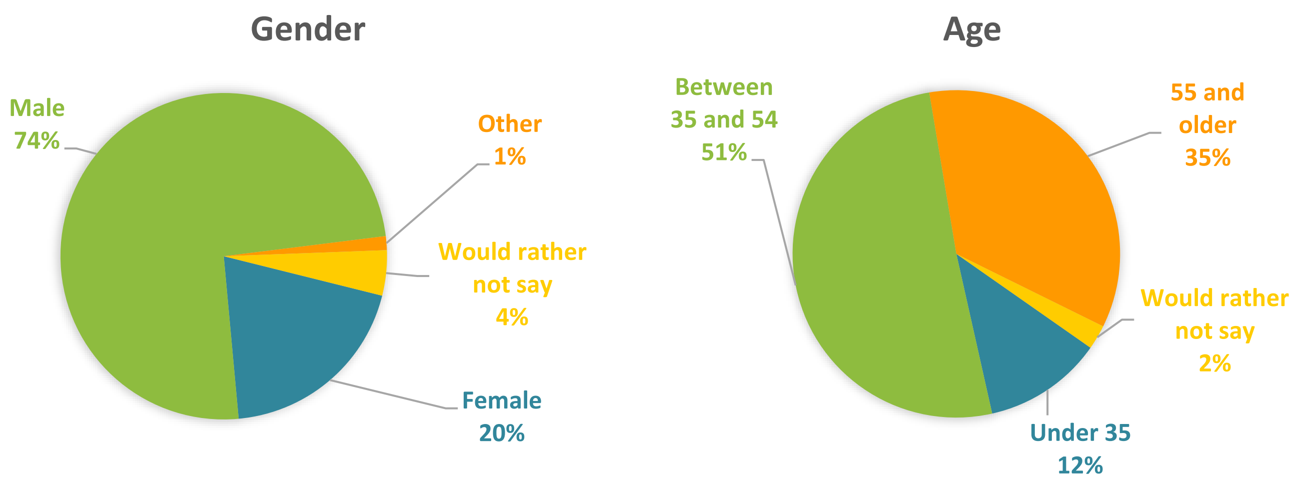


Figure D-6: Gender and Age of the Primary Decision-maker.

Table D-36 below presents the number of participating farms with hired labour, compared to the results from the Census of Agriculture (2021). Overall, a higher proportion of respondents have declared having hired labour (50%) as compared to the population (18%). It is worth noting that the definition used in the survey differs slightly from the one used in the Census[85].

[85] The definition of hired workers used in the survey is: "[…] all who receive a T4 OR are covered under the health and safety regulations for working on your farm." In the Census questionnaire, employees are considered to be: "all agricultural workers who were issued a T4 slip for the 2020 tax year." (Statistics Canada, 2021d)

Table D-36: Number of farms reporting having employees with paid work

	Census of agriculture (2021)		Survey response	
Operator age profile, farm level	Farms reporting	Percentage (%)	Farms reporting	Percentage (%)
Employees with paid work[1]	10 897	18%	155	50%
Farms without employees	49 800	82%	156	50%
TOTAL	60 697	100%	311	100%

[1] It includes family labour, permanent, occasional, and seasonal workers.

Finally, an important proportion of respondents are prescribed to certifications or production attributes (Figure D-7). In particular, CRSB certified and VBP+ audited producers account for 43% of the sample. As of September 1st, 2022, there are 1,385 certified VBP+ operations across Canada (Verified Beef Production Plus, 2022) and 1,403 farms and ranches are certified to CRSB standards as of June 30, 2022 (CRSB, 2022). In comparison, there are over 60,000 beef cattle operations in Canada (Statistics Canada, 2021d), meaning that respondents prescribed to certifications are overrepresented in the sample.

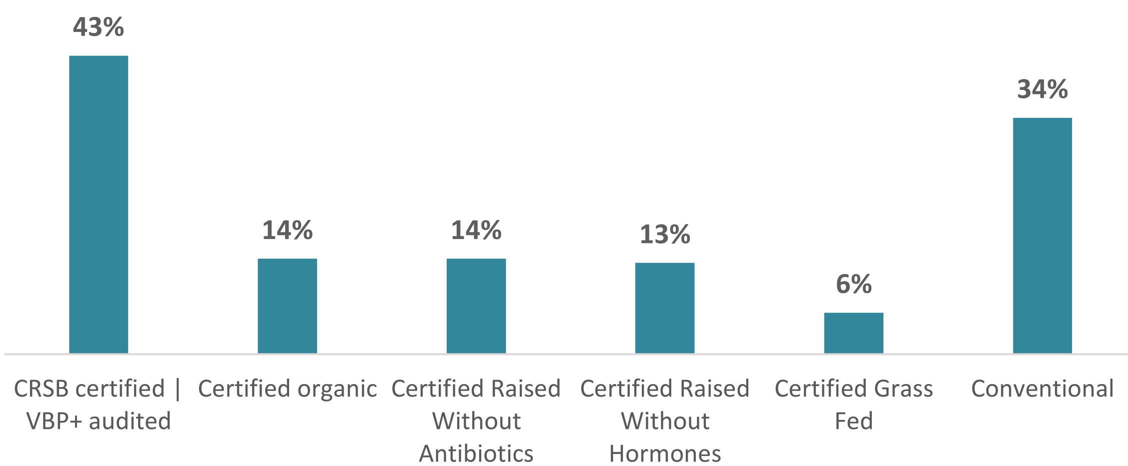


Figure D-7: Percentage of producers according to certifications or production attributes.

Based on these figures, the following observations can be made with respect to the on-farm survey results:

- The participation rate is satisfactory. However, the approach taken which relied on using a generic link to the survey communicated through various media platforms led to certain challenges that impacted the representativeness of the sample. For instance, it was not possible to actively reach out to producers and send targeted reminders to balance participation rate (e.g., based on size or region).
- Due to the above, the sample is skewed with respect to different farm and or respondents' characteristics. Most importantly, audited or certified producers (VBP+ or CRSB) are overrepresented compared to conventional ones. Reasons for this include that CRSB's communication channels were used to reach out to producers, and that audited and certified producers are more likely interested in participating in a sustainability study. Respondents are also younger and operate on average smaller operations.

- Only the perspective of farm owners was documented with the on-farm survey due to the data collection strategy used (i.e., web-based surveys sent through the industry's mailing lists). It is an important limitation in the interpretation of the results, especially for the indicators related to labour management. This limitation was accounted for when conducting the analysis and identifying the key observations.

These characteristics have likely an important impact on the on-farm survey results. That said, these limitations are accounted for in the assessment.

Packer surveys

Two surveys were prepared for packers to document practices taking place at the facility-level. One survey was about animal care and the other about human resources management. Copies of the two surveys are available below.

A total of 5 surveys were completed by 3 individual companies (3 surveys were completed on HR Management [covering 4 facilities] and 1 survey was completed on Animal Welfare.

Only federally inspected companies and facilities were invited to participate. The CRSB was in charge of identifying companies and inviting them to complete the questionnaire.

Participating packers represent approximately 60% (6,950 heads/day/11,450 h/day) ç of the total Canadian slaughter capacity (Alberta Cattle Feeders' Association & Alberta Beef Producers, 2019; Cargill Canada, n.d.; CBC News, 2020). For confidentiality reasons, further details of the plants included in this assessment will not be mentioned in this report.

Interviews

Interviews were conducted among industry representatives and key informants. The objectives were to document and validate current performance, challenges and opportunities facing the Canadian beef industry, to understand what major improvements took place in the industry over the past 5 years and to get insights on what the industry should or could be doing in the next 5 year. Each interview took about 60 minutes to complete. A Copy a of the interview guide is available below.

The interviewees were identified and contacted by the CRSB to participate. A total of 15 interviews were conducted with producer groups (5 interviews), CRSB members (6 interviews) and packers (4 interviews). Five (5) additional discussions took place to collect insights on particular issues: labour Management animal care and operations at packing plant. The qualitative information from these interviews was used to complement the data available in the literature.

Table D-37 lists the participating organizations. For confidentiality reasons, the names of interviewees are not provided.

Table D-37: List of the interviewed stakeholders

Categories	Organizations		
Producer Groups	Alberta Beef Producers Saskatchewan Cattlemen's Association	Beef Farmers of Ontario Les Producteurs de bovins du Québec	Maritime Beef Council
CRSB Members	TrustBIX Nature Conservancy of Canada (NCC)	Farm Credit Canada (FCC) University of Saskatchewan	Canadian Cattle Identification Agency (CCIA) Fulton Market Group (FMG)
Packers	Artisan Farm Cargill	JBS Harmony Beef	
Experts (5 discussions)	Canadian Agricultural Human Resource Council (CAHRC)*	Feedlot Health Management Services* Kasko Cattle Company*	Alberta Beef Health Services* Atlantic Beef Products Inc.*

* Additional discussions on specific topics.

SURVEY TEMPLATE

National Beef Sustainability Assessment (NBSA) 2023 Confidential

Survey on animal welfare practices
for packers and processors
National Beef Sustainability Assessment (NBSA) 2023

This survey addresses topics related to animal welfare practices.

Questions should be answered by a manager who is familiar with the practices in place pertaining to these topics.

Most questions are yes/no or multiple choice. When filling in the blanks, use your best guess.

You will need about 30 minutes to complete the survey.

To leave comments, feedback or additional information about your operation, please enter it in the "Comments" section at the end of the survey.

Answers are being collected and looked at by Groupe AGÉCO and will be kept confidential. Individual answers will not be shared. Answers will be aggregated and shared with the Canadian Roundtable for Sustainable Beef (CRSB).

1

National Beef Sustainability Assessment (NBSA) 2023 Confidential

ANIMAL HEALTH AND WELFARE

1. Has your business implemented a corporate policy, commitment or program with regard to animal health and welfare?
   ( ) Yes and publicly available
   ( ) Yes but not released
   ( ) No
   ( ) I do not know
2. Has your business appointed an animal care manager or director?
   ( ) Yes
   ( ) No
   ( ) Not applicable
3. Do you complete 3rd party animal care / welfare audits for clients?
   ( ) Yes – on a regular basis (e.g., every year)
   ( ) Yes – on demand
   ( ) No
4. How do you ensure animal health and well-being? (Check all that apply)
   [ ] Regular monitoring of live cattle is performed so basic needs are met
   [ ] A protocol is followed to minimize pain and distress during handling of live animals
   [ ] Goals for continued improvement are set
   [ ] Efforts are made to minimize processing wait times
   [ ] In-house video surveillance of employees in animal handling areas (e.g., offloading area, stunning area)
   [ ] Internal (1st party) audits are carried out on a regular basis and corrective actions are always implemented in a timely manner
   [ ] Other. Specify: ______________________
   [ ] None of the above
   [ ] I decline to response
5. Which of the following apply when it comes to animal care training of employees? (Check all that apply)
   [ ] All workers who handle live cattle are trained to understand cattle's needs and take action when cattle are in distress
   [ ] All workers who handle live cattle are trained on low stress animal handling techniques
   [ ] Training is monitored and re-training is provided on a regular basis
   [ ] None of the above
   [ ] I decline to response

2

6. How are workers who handle live cattle trained in regards to animal care? (Check all that apply)

    [ ] Information display | written documents
    [ ] Verbal communication
    [ ] Courses | videos
    [ ] Training by internal resource
    [ ] Training by third-party
    [ ] Job shadowing
    [ ] Other. Please specify: ___________________
    [ ] None of the above
    [ ] Not applicable (no training provided)

7. When it comes to **animal transportation**, which of the following apply to your situation?

	Yes	In part	No	Not applicable	I do not know
My operation is certified under the Canadian Livestock Transport (CLT) or Transport Quality Insurance (TQA) certification program	( )	( )	( )	( )	( )
We require hauling truckers bringing cattle to our facility to be certified under the Canadian Livestock Transport (CLT) or Transport Quality Insurance (TQA) certification program	( )	( )	( )	( )	( )

8. Do you ensure that company representatives (e.g. workers) trained in regards to animal welfare supervise the loading and unloading process as applicable to your operation?

    ( ) Yes
    ( ) No
    ( ) I do not know

9. Which of the following practices are in place to manage compromised or sick animals? (Check all that apply)
   - [ ] The policy for compromised and injured/sick animals is documented, and reviewed at least annually
   - [ ] Workers follow a formal policy to promptly manage compromised or sick cattle
   - [ ] Training documentation exists
   - [ ] Operation addresses cattle that are injured, sick or otherwise compromised in an expedient manner (i.e. within 24h)
   - [ ] Compromised and sick animals are identified and treated or euthanized as soon as they are identified
   - [ ] Euthanization is done with appropriate equipment and trained personnel
   - [ ] Non-ambulatory policy exists
   - [ ] Follow-up is made with producers to understand the reasons and implement corrective actions when needed
   - [ ] None of the above
10. Which of the following technologies/installations are used/in place to improve animal welfare? (Check all that apply)
    - [ ] Non-slip flooring in stunning box
    - [ ] Ventilation equipment in lairage facilities
    - [ ] Passage ways allow 2 or more animals to walk side-by-side
    - [ ] Non-slip flooring in lairage and passage ways
    - [ ] One-way flow of animals to slaughter
    - [ ] Indirect lighting
    - [ ] Noise reducers
    - [ ] Passage ways without sharp angles
    - [ ] Ramp inclination < 20 degrees
    - [ ] Blinders
    - [ ] Other: Specify: ____
    - [ ] None of the above
11. Are cattle stunned before being killed?
    - ( ) Always
    - ( ) Most of the time
    - ( ) Rarely
    - ( ) Never => Go to question #15

12. What is the main method used to stun cattle?
    - ( ) Penetrating captive bolt
    - ( ) Non-penetrating captive bolt
    - ( ) Exposure to a gas or gas mixture
    - ( ) Electronarcosis
    - ( ) Electrocution
    - ( ) Other. Specify: ____
13. Is the effectiveness of the stun monitored?
    - ( ) Always
    - ( ) Most of the time
    - ( ) Rarely
    - ( ) Never
14. Which of the post-slaughter activities apply to your situation? (Check all that apply)
    - [ ] Post-slaughter inspections carried out
    - [ ] Feedback are made to producers in case of quality issues
    - [ ] Mechanisms are in place to implement corrective actions if need be (e.g., malus / bonus system)
    - [ ] Other. Specify: ________________
    - [ ] None of the above

FINAL SECTION

Your name : ____

Your title : ____

Email : ____

Name of your organization : ____________________________

Do you have any comments before finishing the questionnaire?

____

____

____

Survey on HR practices for Packers and Processors
National Beef Sustainability Assessment (NBSA) 2023

This survey addresses topics related to human resource (HR) management.

Questions should be answered by the HR manager of the facility or someone who is familiar with the practices in place.

Most questions are yes/no or multiple choice. When filling in the blanks, use your best guess.
You will need about 30 minutes to complete the survey.

To leave comments, feedback or additional information about your operation, please enter it in the "Comments" section at the end of the survey.

Answers are being collected and looked at by Groupe AGÉCO and will be kept confidential. Individual answers will not be shared. Answers will be aggregated and shared with the Canadian Roundtable for Sustainable Beef (CRSB).

HR MANAGEMENT

Q1. Which of the following are the biggest HR challenges for your company? (Choose a maximum of 3)

- Managing mass retirement 1
- Staff motivation 2
- Supervisor/foreman/team leader management skills 3
- Difficulty recruiting 4
- Intergenerational cohabitation 5
- Optimizing health and safety 6
- Reconciling work/life balance 7
- Employee mental health 8
- Staff retention for entry-level positions (reducing turnover) 9
- Training for existing staff 10
- Onboarding and integrating new labour pools (immigrants, temporary foreign workers, semi-retirees, etc.) 11
- Diversity management (immigrants, temporary foreign workers, semi-retirees, etc.) of production staff 12
- Other. Please specify: ____________________

ONBOARDING AND INTEGRATION

Q2. Which of the following has the business implemented? (Check all that apply)

- Corporate policy handbook or document containing information on applicable labour practices 1
- Onboarding policy for new employees 2
- Non-discriminatory recruitment policy 3
- Formal regulations against all forms of abuse and intimidation within the organization 4
- A mechanism for employees to report abuse by a colleague or supervisor 5
- None of the above 6

RETENTION AND COMMUNICATION

Q3. What do you think helps the most attract and retain employees at your company? (Choose a maximum of 3)

Professional development and training	1
Vacation	2
Salary	3
Employee benefits (pension plan, group insurance, etc.)	4
Interesting challenges to solve	5
Flexible working hours	6
Corporate culture	7
Technological work environment	8
Team skills	9
Company reputation	10
The company's commitment to sustainable development	11
Employment stability	12

Other. Please specify: ______________________________

Q4. Which of the following actions have you implemented in the last three years to retain your production employees and supervisors?
(Check if these actions apply to production employees and/or supervisors)

	Production employees	Supervisors
Competitive salary	1	1
Faster salary progression	2	2
Performance bonus	3	3
Attractive employee benefits (e.g., dental insurance)	4	4
Advancement opportunities	5	5
Training or development	6	6
Work/life balance measures	7	7
Work schedule revisions	8	8
No specific action	9	9

Q5. Does your company hire workers from the following pools? (Check all options that apply)

Immigrants (born outside of Canada, excluding temporary foreign workers)	1
Temporary Foreign Workers (TFWs)	2
Experienced workers (50+ years old)	3
Workers with criminal records	4
Indigenous peoples	5
People with physical/mental disabilities	6

Q6. To what extent do you agree with the following statements describing the integration of your **immigrant or temporary foreign workers**? (1 being «disagree» and 10 being «totally agree»).

	1	2	3	4	5	6	7	8	9	10	Does not apply
Awareness is raised by the employer to avoid cultural bias	1	2	3	4	5	6	7	8	9	10	99
English/French-building activities are offered to workers	1	2	3	4	5	6	7	8	9	10	99
Internal team-building activities are organized	1	2	3	4	5	6	7	8	9	10	99
Hiring instructions and training are available in languages other than English or French	1	2	3	4	5	6	7	8	9	10	99
Our company has received the support of an organization specialized in the integration of immigrant workers or TFWs	1	2	3	4	5	6	7	8	9	10	99

Q7. Does your company use employment agencies to fill these labour needs?

Yes.......... 1 No.......... 2

Q8. To what extent do you agree with the following statements describing the integration of **agency workers**? (1 being «disagree» and 10 being «totally agree»)

	1	2	3	4	5	6	7	8	9	10	Does not apply
Communication with peers is adequate	1	2	3	4	5	6	7	8	9	10	99
There is no isolation or cliques between these workers and the permanent staff	1	2	3	4	5	6	7	8	9	10	99
Workers from employment agencies are well accepted and integrated into the plant	1	2	3	4	5	6	7	8	9	10	99

HEALTH AND SAFETY

Q9. What occupational health and safety measures are in place at your company? (Multiple answers possible)

- Joint Occupational Health and Safety Committee (employer/employee) 1
- Clear and well-understood internal health and safety regulations and policies 2
- Site inspection (by an internal OHS official or other) 3
- Prevention program (incl. machine maintenance) 4
- Clear and well-understood procedures for work-related accidents 5
- Accident investigation and analysis (by an internal OHS officer or other) 6
- Job rotation 7
- Personal protective equipment (PPE) 8
- Fire drill 9
- Pre-employment medical examination 10
- None of these measures 11

Other. Please specify: ______________________________

Q10. In the last 2 years, what occupational health and safety training have you offered to your production employees? (Multiple answers possible)

- First aid 1
- Mental health 2
- Forklift operator 3
- WHMIS (Workplace Hazardous Materials Information System) 4
- Lockout procedures 5
- Enclosed spaces 6

Other. Please specify: ______________________________

Q11. Has the company implemented measures to improve the physical work environment (noise and odour reduction, temperature control, air filtration, etc.)?

Yes .... 1 → What are these measures?: ______________________________

No 2

Q12. In general, on a scale of 1 to 10, how would you rate your company's health and safety practices? (1 being «much work remains to be done» and 10 being «the situation is exemplary»)

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

Q13. How has COVID-19 affected your business? (1 being «not at all affected» and 10 being «very affected»)

	1	2	3	4	5	6	7	8	9	10	Does not apply
Loss of productivity associated with health measures	1	2	3	4	5	6	7	8	9	10	99
Difficulty in hiring due to government programs (e.g., CERB)	1	2	3	4	5	6	7	8	9	10	99
Ease of hiring due to new pools of available workers	1	2	3	4	5	6	7	8	9	10	99
Increase in sick leave and absenteeism	1	2	3	4	5	6	7	8	9	10	99
Disrupted work environment (e.g., employee mental health issues, anxiety)	1	2	3	4	5	6	7	8	9	10	99

Q14. Overall, given the COVID-19 pandemic, how would you rate your performance as an employer with respect to adjustments made at the plant? Would you say you were...

Very dissatisfied........ 1
Dissatisfied........ 2
Satisfied........ 3
Very satisfied........ 4

TRAINING, PROFESSIONAL DEVELOPMENT AND SKILLS FOR THE FUTURE

Q15. Does your company have a structured plan for ongoing employee training?

Yes, a plan for mandatory training only (first aid, WHMIS, HACCP/GFSI etc.)........ 1
Yes, a plan and record of all training (mandatory, job training, team leadership, etc.)........ 2
No, no structured training plan........ 3

Q16. Do you invest 1% of your payroll in training activities aimed at developing the skills of your staff?

Yes........ 1 No........ 2

PRODUCTION AND EMPLOYEE PROFILE

Q17. For the 2020 production year, how many employees did you have at your facility (full-time and part-time status, excluding seasonal workers)?

Less than 50	1
50 - 99	2
100 - 199	3
200 - 399	4
400 or more	5

Q18. Is your facility unionized?

Yes 1 No 2

Q19. What type of workforce planning does your company do?

No workforce planning	1
Short-term planning only	2
Short, medium, and long-term planning, including retirement	3

Q20. Regarding job descriptions for production employees, which statement best reflects your company's reality?

No job descriptions	1
Some job descriptions	2
Regularly updated descriptions for all positions	3

FINAL SECTION

Q21. If we need to clarify your answers, could we contact you?

Yes 1 No 2

Your name : ______________________________

Your title : ______________________________

Email : ______________________________

Name of your organization : ______________________________

Province: ______________________________

Do you have any comments before finishing the questionnaire?

____

____

____

____

____

Survey for Canadian beef producers
National Beef Sustainability Assessment (NBSA) 2023

This survey for Canadian beef producers addresses topics related to sustainable development in agriculture.

Questions should be answered by the primary decision maker or someone who is familiar with the overall business operation.

Most questions are yes/no or multiple choice. When filling in the blanks, use your best guess.

You will need 20 to 30 minutes to complete the survey. Do not close the window before you have completed the survey. Answers will only be saved upon completion of the survey.

To leave comments, feedback or additional information about your operation, please enter it in the "Comments" section at the end of the survey.

Answers are being collected and looked at by Groupe AGÉCO and will be kept confidential. Individual answers will not be shared. Answers will be aggregated and shared with the Canadian Roundtable for Sustainable Beef (CRSB).

Classification: Protected A

Farm Profile

1) What type of operations do you currently manage? (Check all that apply and specify number)

[ ] Cow-Calf : ________Number of mother cows on August 1st, 2021

[ ] Backgrounding: ________Number of animals on August 1st, 2021

[ ] Yearling grasser: ________ Number of animals on August 1st, 2021

[ ] Finishing: ________ Number of animals on August 1st, 2021

[ ] I do not have beef cattle => **Thank you for participating [end of survey]**

2) Are you currently prescribed to any certifications or production attributes? (Check all that apply)

[ ] CRSB certified | VBP+ audited

[ ] Certified organic

[ ] Certified Raised Without Antibiotics

[ ] Certified Raised Without Hormones

[ ] Certified Grass Fed

[ ] Other. Specify: ______________

[ ] Conventional

3) In what province is your farm located (e.g. primary residence)?

() Alberta

() British Columbia

() Manitoba

() New Brunswick

() Newfoundland and Labrador

() Nova Scotia

() Ontario

() Prince Edward Island

() Quebec

() Saskatchewan

() Territories

Classification: Protected A

Management

4) **Have you adopted or tried innovations in the following areas in the last 3 years? (Check all that apply)**

[ ] Feed/nutrition (e.g. winter grazing, feed or forage variety, alternative feed)

[ ] Genetics

[ ] Automation (e.g. robotics/drones)

[ ] Animal welfare practices (e.g. handling, transport)

[ ] Animal health (e.g. veterinary products other than feed)

[ ] Antimicrobial alternatives (e.g. bacteriophage, phenolics, organic acids)

[ ] Environmental management practices (e.g. virtual fencing, grazing)

[ ] Other. Specify: ____

[ ] None of the above

5) **Has at least one farm manager attended a conference or a training session either online or in person over the past 3 years?**

( ) Yes

( ) No **=> Go to question #7**

6) **What was the conference/training session about? (Check all that apply)**

[ ] Animal welfare

[ ] Biosecurity

[ ] On-farm food safety

[ ] Business management or financial management

[ ] Human resources management

[ ] Occupational safety and health

[ ] Environmental management

[ ] Forage / pasture management / soil management

[ ] Risk management (e.g. futures, price insurance, income security...)

[ ] Other. Specify: ____

Classification: Protected A

7) Which of the following areas do you regularly track performance? (Check all that apply)

[ ] Operations (e.g. cost of production, financial results, return on investment)

[ ] Human resources (e.g. productivity, turnover rate, work incidents)

[ ] Environment (e.g. energy consumption, water consumption, waste volumes, emissions)

[ ] Herd (e.g. reproduction, growth performance/animal weights, treatments and interventions, movement tracking)

[ ] Forage production (e.g. abundance of key forage species, abundance of weeds, ground cover)

[ ] Other. Specify: ______________________________

[ ] No performance monitoring is done

Agri-environment

8) How often do you perform a range health assessment of your native and tame pastures and/or rangelands (including grasslands and forested rangelands)?

( ) Multiple times per year

( ) At least every year

( ) Every two to three years

( ) Every four to five years

( ) More than every five years

( ) I do not perform range health assessment

( ) Not applicable (no tame pasture, forested rangelands and/or native rangeland) => Go to question #10

9) What does your written grazing management plan include? (Check all that apply)

[ ] Timing of grazing (stage of plant growth)

[ ] Stocking rates (number of animal units grazed in a given area for a set period of time)

[ ] Stocking density (number of animals grazing a single paddock/area at one time)

[ ] The amount of plant removal (to meet grazing goals and prevent over-grazing)

[ ] Grass species

[ ] Risk of water contamination from manure build-up, droughts

[ ] None of the above (no written grazing management plan)

10) When cattle are fed in pens (e.g. confined feeding), do you have a manure or nutrient management plan?

( ) Yes

( ) No

( ) Not applicable (cattle not fed intensively) **=> Go to question #12**

11) How do you store manure on your farm?
Provide an approximate percentage of your manure storage pertaining to each type, when applicable.

________ Liquid or slurry manure storage (tank, lagoon, basin, etc.)

________ Solid manure stockpile/storage

________ Temporary piles in fields

________ Anaerobic lagoon

________ Anaerobic digester

________ Composting

Animal health

12) Which of the following practices are in place to prevent and assess animal health issues? (Check all that apply)

[ ] A Veterinarian/Client/Patient Relationship (VCPR)

[ ] A herd health management plan for disease prevention, diagnosis and treatment

[ ] Protocols for the identification, care, treatment, and possible euthanasia of sick or injured animals

[ ] A vaccination program developed in consultation with a veterinarian

[ ] None of the above

Classification: Protected A

13) Which of the following practices are used to prevent and assess health issues of newly arrived cattle on the farm? (Check all that apply)

[ ] A disease prevention strategy to manage risk of bovine respiratory disease (BRD) for newly-arrived cattle

[ ] The behaviour of newly-arrived cattle is monitored to facilitate the early detection of illness

[ ] Newly-arrived cattle are put in quarantine / not co-mingled as appropriate

[ ] Communications are made with vendors to check medical history and vaccinations / treatments received

[ ] None of the above

[ ] Not applicable (new cattle – including bulls or cows – are never or rarely brought to the farm)

14) How are records on animal management and health kept? (Check all that apply)

[ ] Paper records

[ ] Electronic records

[ ] Cattle management software

[ ] Other. Specify: ________

[ ] None of the above (no record kept)

15) Which of the following practices are followed when using antimicrobials (excluding ionophores)? (Check all that apply)

[ ] A diagnosis is always performed prior to using any antimicrobials

[ ] Antimicrobials are always selected in collaboration with a veterinarian

[ ] Veterinary and/or label instructions on how to administer the product are systematically followed

[ ] The effectiveness of the treatment is always monitored

[ ] Records of antimicrobial use are kept

[ ] Not applicable (I am not using antimicrobials) **=> Go to question #18**

Classification: Protected A

16) **In what situations are antimicrobials used on your farm (excluding ionophores)? Check all that apply**

	Preventative	Treatment	No	Not applicable
For Cow-Calf Operations				
Situation 1: Cows and calves on grass	[]	[]	[]	()
Situation 2: Retained ownership of calves after weaning (e.g. preconditioned or backgrounded calves)	[]	[]	[]	()
Situation 3: Purchased cattle – On arrival	[]	[]	[]	()
For Backgrounding and Feedlot Operations				
Situation 1: Conventional calves – On arrival	[]	[]	[]	()
Situation 2: Preconditioned calves – On arrival	[]	[]	[]	()
Situation 3: Backgrounded feeders – On arrival	[]	[]	[]	()

17) **Antimicrobials are divided into categories based on their importance in human medicine. Which of the following products are used at the farm? (Check all that apply)**

Category of Importance in Human Medicine	Antimicrobial Class	Brand Names of Antimicrobial Products Registered for use in Beef Cattle in Canada *(this list is not exhaustive)*
[ ] I: Very High	e.g. fluoroquinolones	) A180) Baytril
	e.g. 3rd/4th generation cephalosporins	) Excede) Excenel
[ ] II: High	e.g. macrolides	) Draxxin) Micotil) Tylan) Zactran) Zuprevo
[ ] III: Medium	e.g. tetracyclines e.g. phenicols e.g. Sulfamethazine	) Aureomycin) Liquamycin) Nuflor) Resflor
[ ] I do not know		

Classification: Protected A

18) What is your protocol (or standard operating procedure) for needle injections? (Check all that apply)

[ ] Employees (incl. owners) are trained as to the proper location of the injections

[ ] Injections are given according to label instructions (e.g. intramuscular (IM) or subcutaneous SQ))

[ ] Remote delivery devices (pole syringes or dart guns) are only used where animals cannot easily/safely be captured

[ ] Needles are replaced regularly

[ ] A records check for broken needles is completed

[ ] Injection equipment is cleaned regularly

[ ] Proper restraint is used based on the situation

[ ] None of the above (no protocol or SOP)

[ ] Not applicable (no injection)

19) Are the following growth-enhancing technologies (GET)/hormones used? (Check all that apply)

[ ] Ionophores (e.g. Bovatec, Coban, Coxistac, Monensin, Posistac, Rumensin)

[ ] Growth implants (e.g. Component, Compudose, Ralgro, Revalor, Synovex)

[ ] Beta-agonists category 1 (e.g. Optaflexx/Ractopamine)

[ ] Beta-agonists category 2 (e.g. Zilpaterol)

[ ] Rumen modifiers e.g., yeast or yeast culture, probiotics, prebiotics

[ ] Bentonite, Yeast Cell Wall, glucomannan products, or enzymes

[ ] Other. Specify: ____________

[ ] Not applicable (no GET/hormones used)

20) During the periods where antimicrobials or GETs are given to cattle, how long is fresh manure allowed to sit before application to land?

( ) Up to 24 hours

( ) Up to 1 week

( ) Up to 1 month

( ) Greater than 1 month

( ) Not applicable (manure is composted, not applied to land, or no antimicrobials and GET are used)

Classification: Protected A

21) How do you evaluate the herd's nutritional status? (Check all that apply)

[ ] Hands-on body condition scoring

[ ] Visual body conditioning scoring

[ ] Body weight

[ ] Manure consistency

[ ] Feed testing

[ ] Other. Specify: ____________

[ ] None of the above

22) On average, how often are cattle typically assessed for health problems?

( ) Once a day or more

( ) 2-3 times per week

( ) Weekly

( ) Twice per month

( ) Monthly or less often

( ) Rarely or never

23) What is your typical mortality rate (death loss) of your animals over a 12 month period?
Please provide a percentage (%) for the relevant stages.

________ Calves (birth to weaning)

________ Yearlings

________ Steers and heifers on feed

________ Cows

________ Bulls

Classification: Protected A

24) To what extent do you agree with the following statements related to the topic of animal health on your farm?
1 = disagree and 5 = fully agree

In general, for the majority of my cattle, the respiratory disease treatment rate is stable or has decreased over the last 3 years

1 – 2 – 3 – 4 – 5 / Not applicable

In general, for the majority of my cattle, the digestive disease (e.g. bloat, acidosis, diarrhea) treatment rate is stable or has decreased over the last 3 years

1 – 2 – 3 – 4 – 5 / Not applicable

In general, for the majority of my cattle, the lameness treatment rate is stable or has decreased over the last 3 years

1 – 2 – 3 – 4 – 5 / Not applicable

In general, for the majority of my cattle, the mortality rate is stable or has decreased over the last 3 years
1 – 2 – 3 – 4 – 5 / Not applicable

Animal welfare

25) On your farm, has a manager or any other cattle handler read/reviewed the 2013 Code of Practice for the Care and Handling of Beef Cattle?

( ) Yes

( ) No **=> Go to question #27**

26) Have adjustments been made to any of the following? (Check all that apply)

[ ] Husbandry

[ ] Facilities

[ ] Training

[ ] Disease detection

[ ] Handling

[ ] Other. Specify: _________

Classification: Protected A

[ ] None needed

27) Which of the following situations apply when it comes to animal transportation on or off your farm? (Check all that apply)

[ ] A farm representative (e.g. owner, worker) is always on site to observe the loading / unloading process

[ ] Persons making shipping decisions understand what is not acceptable when loading and transporting cattle

[ ] Loading and unloading equipment, chutes or conveyances are checked to make sure they are free of hazards in order to minimize the risk of injury

[ ] Transporters are certified by the Canadian Livestock Transport (CLT) program

[ ] None of the above

28) Do you typically use pain control techniques for the following procedures?
Pain control techniques include the use of anesthetic (local or general loss of sensation) and analgesic (e.g. painkiller, NSAID), before, at the time, and/or after the procedure.

	Yes	No, due to the age and methods used	No particular pain control techniques are used	Not applicable
Dehorning / disbudding	( )	( )	( )	( )
Castration	( )	( )	( )	( )
Branding	( )	( )	( )	( )

29) [If one Yes] What typical pain control techniques do you use? (Check all that apply)

[ ] As per the Code of practice's requirements

[ ] Above and beyond the Code of practice's requirements

[ ] I do not know what the Code's requirements are

[ ] Other. Specify: _________

30) Do you follow a low-stress weaning strategy (e.g. two-stage, nose paddle, fence-line separation, natural)?

() Routinely

() Occasionally

() Rarely

() Never

() Not applicable (no calves)

31) How are animal handlers trained on cattle behaviour and quiet animal handling? (Check all that apply)

[ ] Courses

[ ] Videos

[ ] Generational/spoken knowledge transfer

[ ] Written documents

[ ] On-site consultants/animal welfare specialists

[ ] Job shadowing

[ ] With veterinarian

[ ] Other. Specify: _______________

[ ] None of the above (no training is provided)

32) When are the following handling techniques practised on site?
1 = Never and 5 = Always

Handling techniques and positioning are adjusted according to the individual animal's flight zone response

1 – 2 – 3 – 4 – 5 / Not applicable

Handling tools (e.g. flags, plastic paddles, rattles) are used to direct animal movement quietly

1 – 2 – 3 – 4 – 5 / Not applicable

Cattle handling techniques are evaluated regularly and improved as needed

1 – 2 – 3 – 4 – 5 / Not applicable

Handling events (e.g. falling, stumbling, hesitation or tripping) are monitored and changes in lighting, noise levels, equipment, handling methods, or environment are made as needed

1 – 2 – 3 – 4 – 5 / Not applicable

33) Over the last 3 years, have you taken particular measures to support cattle during extreme temperature (high or low) such as improved shelter or adjusted feeding?

( ) Yes

( ) No

( ) Not applicable (no changes needed)

34) How do you assess and determine when to euthanize an animal? (Check all that apply)

[ ] A decision-making tool

[ ] Chronic animals assessed frequently

[ ] When the animal is unlikely to recover

[ ] When the animal fails to respond to treatment and recovery protocols

[ ] When the animals have chronic, severe, or debilitating pain and distress

[ ] When the animal is unable to get to or consume feed and water

[ ] When the animal show continuous weight loss or emaciation

[ ] When the animal's condition has passed transportation acceptability limits

[ ] Upon veterinary advice

[ ] Other. Specify: _______

[ ] None of the above

Classification: Protected A

Communities

35) Have you identified potential disturbances for neighbours related to your farm activity (noise, odors, dust, filth, recurrent heavy vehicle passing, etc.)?

() Yes

() No

() Not applicable (no neighbours nearby)

36) Have you taken preventative measures?

() Yes

() No => **Go to question #39**

37) What measures have you taken? : ______________________________

38) Have you, your employees or your farm been affected by media or consumer pressure about eating beef or beef cattle production?

() Yes, in a positive way

() Yes, in a negative way

() No, not really

() No, never

39) To what extent do you agree with the following statements regarding community relations?
1 = disagree and 5 = fully agree

Communication channels are in place to create and maintain a positive connection, perception and understanding with the local community

1 – 2 – 3 – 4 – 5 / Not applicable

Nuisance caused by farm activities (noise, odour, dust, traffic) are proactively identified and corrective actions are always implemented in a timely manner

1 – 2 – 3 – 4 – 5 / Not applicable

Classification: Protected A

Health and safety

40) Which of the following apply to your operation? (check all that apply)

[ ] A health and safety risk assessment covering all activities on your farm site has been carried out over the last 3 years and measures have been taken to reduce the risk of injuries

[ ] At least one person on the operation (including owners) participated in health and safety prevention activities, information sessions or training (on-site or off-site) in the past 3 years

[ ] Everyone working on the farm (including owners) participates in health and safety training (on-site or off-site) on a regular basis or prior to new work activities for the job tasks that apply to them (e.g. cattle handling, farming, feeding)

[ ] At least one person on the farm (including owners) hold a valid and up-to-date first aid certificate

[ ] None of the above

41) In case of an accident, do you have a well-defined procedure (or protocol) known by everyone (all employees and farm owners)?

( ) Yes, in a written form

( ) Yes, in a verbal form

( ) No

42) How is personal protective equipment (PPE) and clothing (e.g. steel-toed boots, gloves, helmet) used on your operation?

[ ] The proper PPE is freely provided to everyone working on the farm

[ ] PPE is maintained regularly

[ ] The proper use of PPE is enforced

[ ] None of the above

Classification: Protected A

43) To what extent do you agree with the following statements related to the topic of occupational health and safety on your farm?
1 = disagree and 5 = fully agree

Everyone working and/or living on the farm are knowledgeable about the health and safety risks associated with their job function or presence on the farm in a way that can be easily understood

1 – 2 – 3 – 4 – 5 / Not applicable

Efforts are taken to address high-risk areas on the farm after accidents occur

1 – 2 – 3 – 4 – 5 / Not applicable

Efforts are taken to look for and address high-risk areas on the farm before accidents occur

1 – 2 – 3 – 4 – 5 / Not applicable

To my knowledge, everyone working and/or living on the farm understand the safety procedures in place

1 – 2 – 3 – 4 – 5 / Not applicable

Workers (either paid and/or non-paid – e.g. family) are trained and prepared to safely complete their tasks

1 – 2 – 3 – 4 – 5 / Not applicable

Workload | Stress Management

44) The following is a list of stressors that are common to producers in the ag industry. To what extent do you consider each to be a stress factor in your life today?
1 = Not at all and 5 = To a large extent

Workload pressures from the beef operation

1 – 2 – 3 – 4 – 5 / Not applicable

Financial pressures from the beef operation (e.g. cashflow, debt repayment)

1 – 2 – 3 – 4 – 5 / Not applicable

Interpersonal conflicts with family about the beef operation

1 – 2 – 3 – 4 – 5 / Not applicable

Interpersonal conflicts with non-family about the beef operation

1 – 2 – 3 – 4 – 5 / Not applicable

Farm transition considerations related to the beef operation

1 – 2 – 3 – 4 – 5 / Not applicable

Efforts to align with animal welfare expectations (e.g. capital investments, variable costs)

1 – 2 – 3 – 4 – 5 / Not applicable

Ability to recruit and retain employees

1 – 2 – 3 – 4 – 5 / Not applicable

Unpredictability of the ag industry (i.e. Weather / market prices)

1 – 2 – 3 – 4 – 5 / Not applicable

Public trust in Canadian ag production

1 – 2 – 3 – 4 – 5 / Not applicable

45) To what extent do you feel disturbing stress resulting in physiological changes such as sleep loss, changes in appetite, body/headaches, etc. as a result of your on-farm occupation?
1 = Not at all and 5 = To a large extent

1 – 2 – 3 – 4 – 5 / Not applicable

46) Overall, given the COVID-19 pandemic and drought situation, how would you rate your performance as a farm manager? Would you say you were...

Classification: Protected A

( ) Very dissatisfied ( ) Dissatisfied ( ) Neutral ( ) Satisfied ( ) Very satisfied

47) Which of the following practices do you follow to manage physical and mental fatigue? (Check all that apply)

[ ] You schedule regular medical check-ups and health assessments

[ ] You adopt a healthy diet and exercise regularly

[ ] You take time to talk about the causes of stress, especially to family and friends

[ ] You seek external resources when needed (e.g. Farmer Specific Crisis Lines, Sentinel Program; In the Know, counselors, mediators, pastors, etc.)

[ ] You get physical therapy when needed (e.g. massage, physiotherapy)

[ ] You take time off and holidays whenever possible (e.g. through labour co-ops)

[ ] You schedule time for family

[ ] You limit alcohol consumption and avoid drug use

[ ] You establish personal goals / Create a bucket list

[ ] Other. Specify: ____

[ ] None of the above

[ ] Not applicable (I do not experience physical or mental fatigue)

48) To what extent do the following outcomes occur on the farm as a direct result of working too much?
1 = Never and 5 = Very often

Absenteeism, not showing to work / family activities

1 – 2 – 3 – 4 – 5 / Not applicable

Repetitive stress injuries (e.g. disorders of the muscles, nerves, tendons, joints)

1 – 2 – 3 – 4 – 5 / Not applicable

Physical injury (other than repetitive stress)

1 – 2 – 3 – 4 – 5 / Not applicable

Stress leave, long term

1 – 2 – 3 – 4 – 5 / Not applicable

Working conditions | Labour relations

49) Do you have any hired labour on your farm (incl. family labour, permanent, occasional and seasonal workers)?
Hired workers are all those who receive a T4 OR are covered under the health and safety regulations for working on your farm.

( ) Yes

( ) No => **Go to question #61**

50) How many workers in the following worker categories do you currently employ?

Number of year-round full-time workers (30 or more hours per week): ___

Number of year-round part-time workers (less than 30 hours per week): ___

Number of seasonal or temporary workers: ____

Number of agricultural family workers : ____

51) Upon hiring, which of the following actions do you take? (Check all that apply)

[ ] You provide a contract or establish a clear relationship understood by the employee

[ ] You discuss the workers' rights and responsibilities

[ ] You keep an up-to-date record of hours of work, wages, and all deductions

[ ] You organize welcoming activities (e.g., introduction of the company, immediate supervisors)

[ ] You provide initial training (e.g. presentation of tasks, work techniques)

[ ] None of the above

52) Which of the following apply to your situation? (Check all that apply)

[ ] You carry out employee performance evaluations on a regular basis

[ ] You conduct regular operational meetings or staff meetings

[ ] You have team meetings and discuss positive actions and irritants with employees in a timely manner

[ ] You provide skills development opportunities to employees (courses, workshops, books, etc.)

[ ] You involve employees in decision-making and in fostering new ideas

[ ] You provide workers with advancement opportunities

[ ] None of the above

53) Which of the following apply to your operation when it comes to the hours worked by employees? (Check all that apply)

[ ] You have an agreement between you and your employees stating expectations about hours worked (including overtime)

[ ] Workers can decline without consequence when asked to work additional hours

[ ] Workers are given regular breaks

[ ] Workers receive equal compensation when working additional hours (e.g. time in lieu, meals)

[ ] You make sure that hours worked do not affect your employees' health and safety

[ ] None of the above

54) How often is dissatisfaction with overall workload expressed by employees?
1 = Never and 5 = Very often

1 – 2 – 3 – 4 – 5 / Not applicable

55) Which of the following apply to your operation? (Check all that apply)

[ ] All important communications (e.g. work contract, safety procedures) take into account language and are developed in such a way that they are understood by all workers

[ ] Procedures are in place (e.g. a section in the employee manual, a clause in contracts) to prevent, avoid and resolve any cases of discrimination, abusive behaviours or intimidation on your farm

[ ] Grievance procedures are in place to enable workers to report complaints safely and without facing repercussions

[ ] None of the above

56) Which of the following benefits do you provide to farm workers? (Check all that apply)

[ ] Disability insurance

[ ] Additional hours

[ ] Health insurance

[ ] Life insurance

[ ] Pension plan contribution

[ ] Paid sick days

[ ] Professional development (e.g. training, education, courses)

[ ] Maternity or parental leave (beyond what is required by provincial regulations)

[ ] Paid vacations (beyond what is required by provincial regulations)

[ ] End-of-year bonuses, performance bonuses

[ ] In-kind donations (e.g. housing, meals, meat, wood, crops, access to a vehicle, etc.)

[ ] Other. Specify: ____

[ ] None of the above

57) Over the last 3 years, have you hired workers with diverse backgrounds in terms of religions, nationalities, cultures and languages? (e.g. temporary foreign workers or people belonging to minority groups)

( ) Yes

( ) No **=> Go to question #61**

58) Did you receive training on best practices in diversity management or get informed about the cultural differences that exist between you and employees from other cultures?

( ) Yes

( ) No

( ) Not applicable

59) Do you offer language training to employees (e.g. ESL classes)?

( ) Yes

( ) No

( ) Not applicable

60) To what extent do you agree with the following statements related to the presence of hired labour on your farm?
1 = disagree and 5 = fully agree

Recruiting hired labour is more challenging than 5 years ago

1 – 2 – 3 – 4 – 5 / Not applicable

Retaining hired labour is more challenging than 5 years ago

1 – 2 – 3 – 4 – 5 / Not applicable

Turn over rate of hired labour has been stable or decreasing over the last 5 years

1 – 2 – 3 – 4 – 5 / Not applicable

Classification: Protected A

Last questions

61) **Does your operation have any success stories that may have happened over the past 3 years in relation to the following topics? Check all that apply.**

- ☐ Occupational health and safety (OHS)
- ☐ Employee training
- ☐ Animal welfare
- ☐ Animal health
- ☐ Reduction of greenhouse gas (GHG) emissions
- ☐ Water management (quantity and quality)
- ☐ Energy efficiency
- ☐ Contributions to local community
- ☐ Waste management
- ☐ Productivity improvement
- ☐ Farm succession
- ☐ Other (specify)

Can you explain or provide more details?

62) **Would you like to make improvements to any of the following areas over the next 3 years across your operation? Check all that apply.**

- ☐ Occupational health and safety (OHS)
- ☐ Employee training
- ☐ Animal welfare
- ☐ Animal health
- ☐ Reduction of greenhouse gas (GHG) emissions
- ☐ Water management (quantity and quality)
- ☐ Energy efficiency
- ☐ Contributions to local community
- ☐ Waste management
- ☐ Productivity improvement
- ☐ Farm succession
- ☐ Other (specify)

Can you explain or provide more details?

Classification: Protected A

Respondent Profile

63) Gender of the primary decisionmaker:

( ) Male

( ) Female

( ) Other

( ) Would rather not say

64) Age of the primary decisionmaker:

( ) Under 35

( ) Between 35 and 54

( ) 55 and older

( ) Would rather not say

65) Would you like to:

[ ] Participate in a prize draw for ___________________________

[ ] Discuss about the results of the survey and answer additional questions, if need be

Thank you to our partners!
ADD LOGO

Please enter your email address:
By submitting your email here, it is being used for the prize draws and personal communication only

____

Please answer this question: 7 + 8 + 1 = ?

____

Prizes will be drawn on January 12th 2022, (9:00 AM), at Groupe AGECO office, 1995, Frank-Carrel Street, Office 219, Québec (QC) G1N 4H9.

Thank you for responding to the survey. Would you like to add comments?

____

____

Information: Jean-Michel Couture - 514 439-9724 ext. 210 - jean-michel.couture@groupeageco.ca

Classification: Protected A

INTERVIEW GUIDE

Interview Guide for Producer Associations

CONTEXT

Group AGECO and Canfax Research Services have been selected to update our National Beef Sustainability Assessment (NBSA) and Strategy, expected for release in 2023.

The NBSA provides farm to fork national sustainability performance metrics for the Canadian beef sector, from environmental, social, and economic perspectives.

The metrics from the first Assessment, released in 2016, are widely used to demonstrate Canada's global sustainability leadership, and have been instrumental in the beef industry's communication efforts with respect to sustainable beef production over the past 5 years.

As a manager of a provincial producer group, you are invited to participate to an interview with Groupe AGECO to inform the NBSA.

The interview is expected to take **60 minutes**. The list of questions is provided below for you to review in advance.

The objectives of this discussion are to:

- Document current performance, challenges, and opportunities for the industry
- Understand what major improvements took place in the industry over the past 5 years
- Get insights on what the industry should or could be doing in the next 5 year

All information will be treated anonymously and only be used to get strategic insights on the current risks and opportunities facing the Canadian beef industry, as well as on actions that could be taken to improve performance in the next 5 years.

Organization :

Name :

Title :

Date :

INTRODUCTION

What is your role in your organization? For how long have you been working there?

In your own words, how would you define the concept of 'social sustainability' in the context of beef production in Canada?

What are the key risks, issues or opportunities facing Canadian beef farmers when it comes to sustainability in general?

What are the specific risks / opportunities related to social issues?

Are these risks and opportunities the same for producers in other provinces? For producers outside the sector?

To what extent are these risks and opportunities shared with the rest of the Canadian beef industry?

CURRENT PERFORMANCE

On a scale of 1 to 10 (10 being very good), how do producers in your province rate on the issue of workforce / working conditions?

Related topics: labour shortage issue, labour retention difficulties, impact of COVID-related measures, mental health, occupational health and safety, public trust / perception

Why this number?

What do producers do well? What best practices?

In what areas did producers improve the most over the past 5 years? Improved the least?

What could producers do to get 10/10?

What more could your organization do in this area?

On a scale of 1 to 10 (10 being very good), how do producers in your province rate on the issue of animal health and welfare?

Related topics: transportation/animal handling, qualification of employees, compliance with regulations, compliance with industry codes, frequency, and thoroughness of audits

Why this number?

What do producers do well? What best practices?

In what areas did producers improve the most over the past 5 years? Improved the least?

What could producers do to get 10/10?

What more could your organization do in this area?

CURRENT PERFORMANCE (continued)

On a scale of 1 to 10 (10 being very good), how do producers in your province rate on the issue of food safety and biosecurity?

Related topics: residue of antimicrobial, use of growth-enhancing technologies/hormones, health impact of red meat consumption

Why this number?

What do producers do well? What best practices?

In what areas did producers improve the most over the past 5 years? Improved the least?

What could producers do to get 10/10?

What more could your organization do in this area?

On a scale of 1 to 10 (10 being very good), how do producers in your province rate on the issue of the environment?

Related topics: GHG associated with livestock production; reduction efforts at the farm/slaughterhouse, consumer perception, impact on water use/degradation, soil management, and biodiversity

Why this number?

What do producers do well? What best practices?

In what areas did producers improve the most over the past 5 years? Improved the least?

What could producers do to get 10/10?

What more could your organization do in this area?

On a scale of 1 to 10 (10 being very important), how important is the role of innovation and the adoption of new technologies in the sustainability journey of the beef producers?

Related topics: resource efficiency, productivity gains, animal welfare

Why this number?

In what areas producers improved the most in regards to innovation over the past 5 years?

In what areas do you see producers to improve in the next five years in regards to innovation? (e.g. antimicrobial innovation?)

COMMITMENTS

In 5 years from now, why should the beef producers in your province be recognized when it comes to the following areas?

Workforce / HR management?

Ideas **:** BMPs in regards to integration, diversity, continuous training, OHS

Animal health and welfare?

Ideas **:** BMPs in regards to enhanced industry standards, certification, equipment modernisation

Food safety and biosecurity

Ideas **:** BMPs in regards to enhanced industry standards, certification, equipment modernisation

Environmental performance?

Ideas : BMPs in regards to GHG reduction targets, water footprint reduction

Innovation?

Ideas : BMPs in regards to increased profitability, improved resilience, reduced environmental footprint

If the industry were to make 3 commitments, what should they be?

1)
2)
3)

Is there anything that you think is a must-have that has not been touched?

Interview Guide for Businesses

CONTEXT

Group AGECO and Canfax Research Services have been selected to update our National Beef Sustainability Assessment (NBSA) and Strategy, expected for release in 2023.

The NBSA provides farm to fork national sustainability performance metrics for the Canadian beef sector, from environmental, social, and economic perspectives.

The metrics from the first Assessment, released in 2016, are widely used to demonstrate Canada's global sustainability leadership, and have been instrumental in the beef industry's communication efforts with respect to sustainable beef production over the past 5 years.

You have been selected to be one of the packers/processors | CRSB members to conduct an interview with Groupe AGECO to inform the NBSA.

The interview is expected to take **60 minutes**. The list of questions is provided below for you to review in advance.

The objectives of this discussion are to:

Document current performance, challenges, and opportunities

Understand what major improvements took place in the industry over the past 5 years

Get insights on what the industry should or could be doing in the next 5 year

All information will be treated anonymously and only be used to get strategic insights on the current risks and opportunities facing the Canadian beef industry, as well as on actions that could be taken to improve performance in the next 5 years.

Organization :

Name :

Title :

Date :

INTRODUCTION

What is your role in your organization? For how long have you been working there?

In your own words, how would you define the concept of "sustainability" in the context of your organization?

How important are the social considerations in your definition?

Would that definition also apply to the Canadian packing and processing sector? To the Canadian beef industry?

What are the key risks, issues or opportunities facing your organization when it comes to sustainability?

What are the specific risks / opportunities related to social issues?

Are these risks and opportunities the same for the whole Canadian packing and processing sector? The Canadian beef industry?

CURRENT PERFORMANCE

On a scale of 1 to 10 (10 being very good), how does the sector rate on the issue of workforce / HR management?

Related topics: labour shortage issue, labour retention difficulties, impact of COVID-related measures, mental health, occupational health and safety, public trust / perception

Why this number?

What does the sector do well?

In what areas did the sector improve the most over the past 5 years? Improved the least?

What could the sector do to get 10/10? Your organization in particular?

On a scale of 1 to 10 (10 being very good), how does the sector rate on the issue of animal health and welfare?

Related topics: transportation/animal handling, slaughter methods, qualification of employees, compliance with regulations, compliance with industry codes, frequency, and thoroughness of audits

Why this number?

What does the sector do well?

In what areas did the sector improve the most over the past 5 years? Improved the least?

What could the sector do to get 10/10? Your organization in particular?

CURRENT PERFORMANCE (continued)

On a scale of 1 to 10 (10 being very good), how does the sector rate on the issue of food safety?

Related topics: Health impact of red meat consumption, residue of antimicrobial

Why this number?

What does the sector do well?

In what areas did the sector improve the most over the past 5 years? Improved the least?

What could the sector do to get 10/10? Your organization in particular?

On a scale of 1 to 10 (10 being very good), how does the sector rate on the issue of the environment?

Related topics: greenhouse gases associated with livestock production; reduction efforts at the farm/slaughterhouse, consumer perception, impact on water and biodiversity

Why this number?

What does the sector do well?

In what areas did the sector improve the most over the past 5 years? Improved the least?

What could the sector do to get 10/10? Your organization in particular?

On a scale of 1 to 10 (10 being very important), how important is the role of innovation and the adoption of new technologies in the sustainability journey of the sector?

Related topics: resource efficiency, productivity gains, animal welfare

Why this number?

In what areas the sector improved the most in regards to innovation over the past 5 years?

In what areas do you see the sector to improve in the next five years in regards to innovation?

COMMITMENTS

In 5 years from now, why should the sector be recognized when it comes to :

Workforce / HR management?

Ideas **:** integration, diversity, continuous training, OHS

Animal health and welfare?

Ideas **:** enhanced industry standards, certification, equipment modernisation

Food safety

Ideas **:** R&D, consumer education

Environmental performance?

Ideas : (More ambitious) GHG reduction targets, water footprint reduction

Innovation?

Ideas : increased profitability, improved resilience, reduced environmental footprint

If the industry were to make 3 commitments, what should they be?

1)
2)
3)

Is there anything that you think is a must-have that has not been touched?

CONTACT

To complete the assessment, we would like to circulate surveys in your organization to document practices related to human resources, animal welfare and food safety, as well as environmental performance.

Would you agree to share contact information or introduce us to key informants within your organization who could provide this information?

HR: ______________________________

Animal welfare and food safety: ________________________

Environmental performance: _________________________

BUSINESS MANAGEMENT

Unless otherwise specified, please answer to the following questions in relation to your **primary business activity** and at the company level (i.e. business operation specify in first question of the survey)

Has your business/organization implemented the following?

	Yes and it is publicly available	Yes but it is not released	No or not formalized	Unknown
A formal written mission	( )	( )	( )	( )
A code of ethics (conduct guidelines for employees and managers)	( )	( )	( )	( )
A supplier code of conduct	( )	( )	( )	( )
A governance structure (e.g. organization chart, position descriptions, roles and responsibilities)	( )	( )	( )	( )

Does your business/organization have a documented strategic plan that sets your short-, medium- and long-term objectives and identifies its future challenges and opportunities?

( ) Yes

( ) No

Does your business/organization have a formal strategy, policy or action plan to incorporate sustainability practices into its business operations?

( ) Yes and publicly available

( ) Yes but not released

( ) No

Has your business/organization appointed the following?

	Yes	No	N/A
A senior executive or manager who is accountable for the attainment of its sustainability targets and goals?	( )	( )	( )
A team that is responsible for implementing sustainability practices and projects?	( )	( )	( )

Does your business/organization allocate budgets for projects and initiatives related to sustainability?

( ) Yes

( ) No

Has your business/organization implemented a sustainable procurement policy with a clear set of criteria to guide its procurement decisions with respect to environmentally and socially responsible products and services?

( ) Yes and it is publicly available

( ) Yes but it is not released publicly

( ) No

Does your business/organization provide training for procurement managers and staff to ensure the effective implementation of a sustainability purchasing policy?

( ) Yes

( ) No

APPENDIX E
DATA QUALITY AND UNCERTAINTY

E.1 DATA QUALITY ASSESSMENT OF THE E-LCI

Data sources are assessed on the basis of time-related coverage, geographical coverage, technology coverage, precision, completeness, representativeness, consistency, reproducibility, source description and uncertainty of the information as prescribed in ISO 14044. The pedigree matrix (B P Weidema et al., 2013) for rating **inventory data** is a useful tool that was used in this study as a guide to evaluate data quality and conduct a quantitative uncertainty analysis. The matrix used in this study is presented in Table E-1.

The importance of data on the total system results is examined using sensitivity testing and contribution analyses. Explanations of their influence on the confidence of the results are reported in Section 2.1.7.

Although every effort is made to establish the best available information, and to consider key influential factors, such as geography, temporal relevance, scientific credibility, and internal study consistency, life cycle assessment is a complex task that relies on numerous data sources and assumptions. While the results presented in this study are intended to be considered reliable, they should be used only within the context of the boundaries and limitations discussed in this report. In cases where important information was unknown, uncertain, or highly variable, sensitivity analyses were performed to evaluate the potential importance of the data gap (see Section 1.10 and 2.1.6).

Table E-1: Pedigree matrix used for data quality assessment developed by Weidema et al. (2013)

Score	1	2	3	4	5
Reliability	Verified data based on measurements	Verified data partly based on assumptions or non-verified data based on measurements	Non-verified data partly based on qualified estimates	Qualified estimate (e.g., by industrial expert)	Non-qualified estimate
Completeness	Representative data from all sites relevant for the market considered, over an adequate period to even out normal fluctuations	Representative data from >50% of the sites relevant for the market considered, over an adequate period to even out normal fluctuations	Representative data from only some sites (<<50%) relevant for the market considered or >50% of the sites but from shorter periods	Representative data from only one site relevant for the market considered or some site but from shorter periods	Representativeness unknown or data from a smaller number of sites and from shorter periods
Temporal correlation	Less than 3 years of difference to the period of the dataset	Less than 6 years of difference to the period of the dataset	Less than 10 years of difference to the period of the dataset	Less than 15 years of difference to the period of the dataset	Age of data unknown or more than 15 years of difference to the period of the dataset
Geographical correlation	Data from area under study	Average data from a larger area in which the area under study is included	Data from area with similar production conditions	Data from area with slightly similar production conditions	Data from an unknown area or distinctly different (North America instead of Middle East, OECD-Europe instead of Russia)
Further technological correlation	Data from enterprises, processes, and materials under study	Data from processes and materials under study (i.e., identical technology) but from different enterprises	Data from processes and materials under study but from a different technology	Data on related processes or materials	Data on related processes on laboratory scale or from a different technology

The datasets used to model the systems are also assessed for their quality. The following criteria were used for this assessment:

> **High quality:** The dataset selected to model the flow is representative of the technology or processes under study.
> **Acceptable quality:** The dataset selected to model the flow is similar to the technology or processes under study.
> **Low quality:** The dataset selected to model the flow is not representative of the technology or processes under study. However, this dataset is the closest estimate of the flow.

The results from this assessment are presented in Section 2.1.7 with a discussion on their influence on the confidence of the life cycle impact assessment.

E.2 Uncertainty of the E-LCA Results – Monte-Carlo simulations

To show the magnitude of the uncertainty around the impact assessment results, graphs with standard error bars are reported for all LCIA results. The uncertainty distributions for global warming (AR6) were included to show the distribution of the Monte Carlo simulation results. This serves as a representative example of the uncertainty distributions seen for all other indicators.

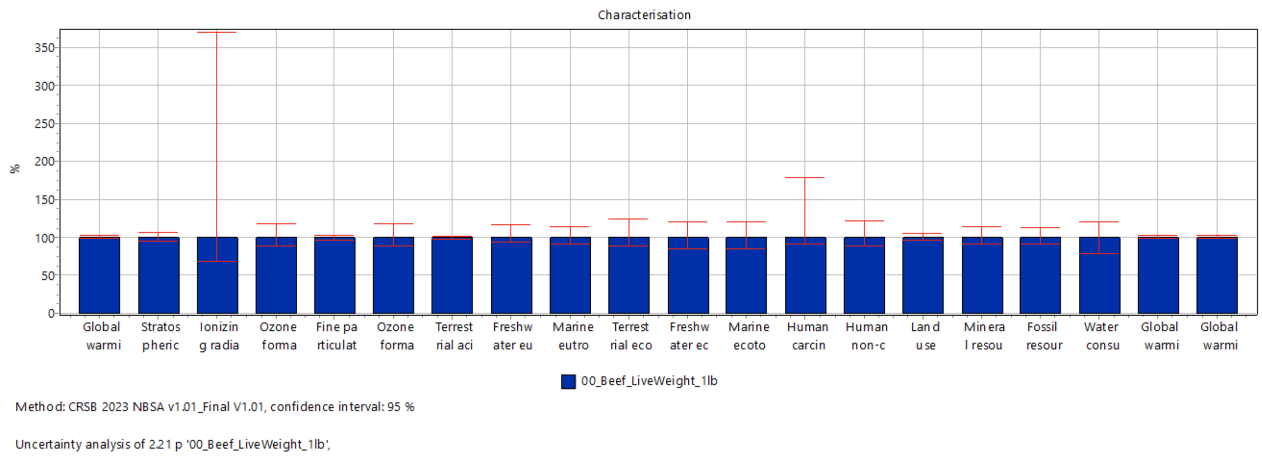
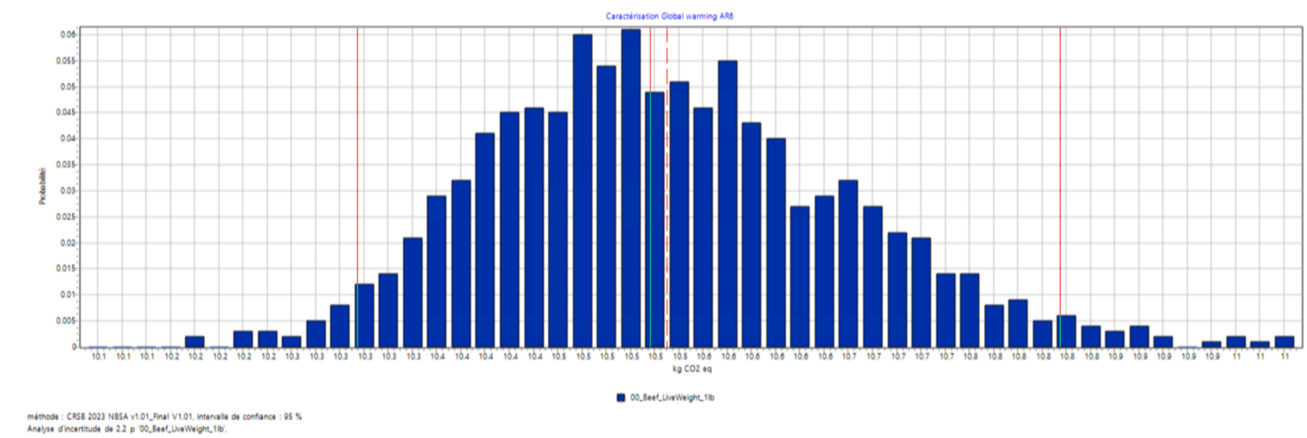


Figure E-1: Monte-Carlo simulation for the impact assessment results for 1 kg live weight, West.



		Produit	Moyenne	Médiane	SD	CV	2.5%	97.5%	SEM
Nombre de boîtes	50	00_Beef_LiveWeight_1lb	10.5	10.5	0.133	1.26 %	10.3	10.8	0.0042
Intervalle Visible	99.9 %								
Intervalle de confiance	95 %								

Figure E-2: Probability distribution of the impact assessment results of carbon footprint for 1 kg live weight, West.

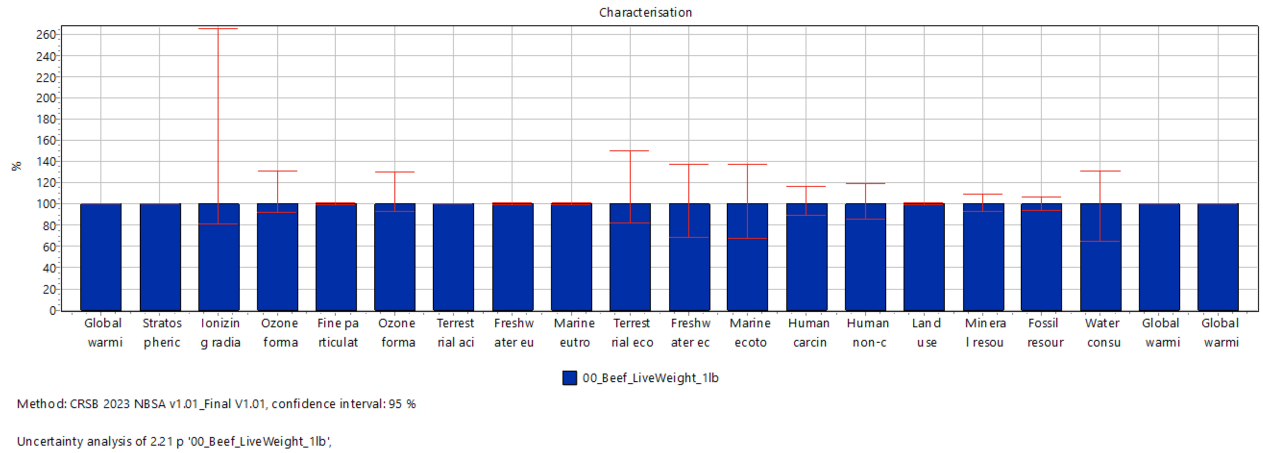


Figure E-3: Monte-Carlo simulation for the impact assessment results for 1 kg live weight, East.

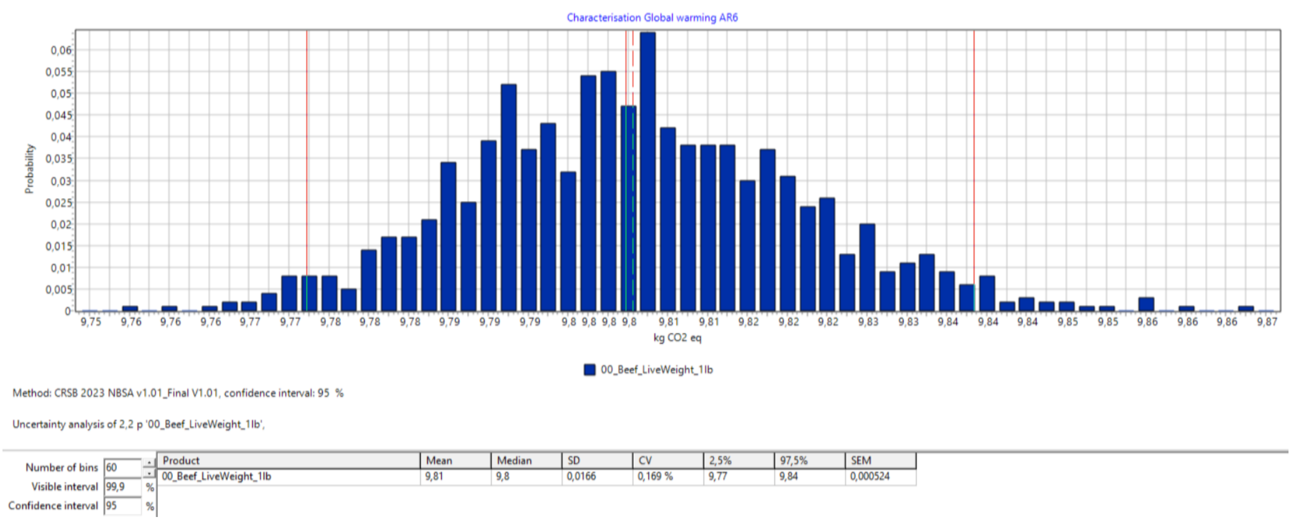


Figure E-4: Probability distribution of the impact assessment results of carbon footprint for 1 kg live weight, East.

This Monte Carlo simulation gives an indication of the model uncertainty. However, the uncertainty of all parameters is not taken into account. For the carbon footprint (AR6), the enteric methane emission factor has a confidence interval between -15% and +18% according to the NIR (ECCC, 2022, Part 1, Table 5-4).

Limitations of the LCIA Methodology

Life cycle impact assessment results present potential and not actual environmental impacts. They are relative expressions, which are not intended to predict the final impact or risk on the natural environment or whether standards or safety margins are exceeded. Additionally, these categories do not cover all the environmental impacts associated with human activities. Impacts related to plastic pollution, noise, odours, electromagnetic fields, and others are not included in the present assessment. The methodological developments regarding such impacts are not sufficient to allow for their consideration within life cycle assessment.

E.3 Results Uncertainty and Data Quality of the S-LCA

Significant efforts were made throughout the project to ensure that the data collected for the S-LCA (both primary and secondary) could provide a robust, credible, and relevant assessment of the positive contributions and of the potential risks associated with the Canadian beef industry's activities with respect to the priority social issues. The active participation of CRSB representatives and SAC members was instrumental in providing guidance and validating sources and results. In addition, various sources of information were used to compare and interpret results. In doing so, this S-LCA provides an evidence-based assessment that can inform the current social sustainability performance of the industry and, most importantly, its sustainability roadmap.

However, data quality is impacted by various factors, including data gaps in the literature as well as caveats and limitations in the primary data collection process. For these reasons, results should be interpreted with caution and within the context of this study. The proposed insights point to recommendations that are meant to further explore the potential risks identified in this study.

APPENDIX F
S-LCA – SURVEYS RESULTS

F.1 List of Indicators Used in the On-Farm Survey

Labour Management

This section is comprised of 10 indicators:

- 1.1 Onboarding Activities
- 1.2 Professional development
- 1.3 Communication and Dispute Resolution
- 1.4 Benefits
- 1.5 Diversity Management
- 1.6 Language Training
- 1.7 Recruitment and Retaining
- 1.8 Overtime
- 1.9 Workload Dissatisfaction
- 1.10 Consequences of Overload
- 1.11 Farm Management Training

1.1 Onboarding Activities		
Description		
This indicator documents the actions taken upon hiring. Options include the following: • You provide a contract or establish a clear relationship understood by the employee • You discuss the workers' rights and responsibilities • You keep an up-to-date record of hours of work, wages, and all deductions • You organize welcoming activities (e.g., introduction of the company, immediate supervisors) • You provide initial training (e.g. presentation of tasks, work techniques)		
Evaluation		
Risky	None of the above	5%
Compliant	1-2 checked	46%
Proactive	3-4 checked	36%
Committed	5 checked	13%
Comments		
69% of respondents declared keeping an up-to-date record of hours of work, wages, and all deductions. About half said they provide a contract or establish a clear relationship understood by the employee (52%), discuss the workers' rights and responsibilities (50%) or initial training (e.g., presentation of tasks, work techniques) upon hiring (54%). 33% said they organize welcoming activities (e.g., introduction of the company, immediate supervisors). Only 5% of respondents declared not conducting any of these activities. 7% of survey participants with hired labour on their farm did not answer this question. Number of respondents: 155		

1.2 Professional Development		
Description		
This indicator documents the practices adopted by producers related to professional development. Options include the following: - You carry out employee performance evaluations on a regular basis - You conduct regular operational meetings or staff meetings - You have team meetings and discuss positive actions and irritants with employees in a timely manner - You provide skills development opportunities to employees (courses, workshops, books, etc.) - You involve employees in decision-making and in fostering new ideas - You provide workers with advancement opportunities		
Evaluation		
Risky	None of the above	5%
Compliant	1-2 checked	40%
Proactive	3-4 checked	44%
Committed	5 and more checked	11%
Comments		
58% of respondents said they involve employees in decision-making and in fostering new ideas, and 48% of them indicated they conduct regular operational meetings or staff meetings. 51% said they have team meetings and discuss positive actions and irritants with employees in a timely manner. About a third provides skills development opportunities to employees (43%), carries out employee performance evaluations on a regular basis (35%), or provides workers with advancement opportunities (32%). 5% of respondents declared not conducting any of these activities. 7% of survey participants with hired labour on their farm did not answer this question. Number of respondents: 155		

1.3 Communication and Dispute Resolution		
Description		

This indicator documents how producers deal with communication and dispute resolution. Options include the following:

- All important communications (e.g. work contract, safety procedures) take into account language and are developed in such a way that they are understood by all workers
- Procedures are in place (e.g. a section in the employee manual, a clause in contracts) to prevent, avoid and resolve any cases of discrimination, abusive behaviours or intimidation on your farm
- Grievance procedures are in place to enable workers to report complaints safely and without facing repercussions

Evaluation		
Risky	None of the above OR All important communications (e.g. work contract, safety procedures) take into account language and are developed in such a way that they are understood by all workers unchecked.	53%
Compliant	All important communications take into account language and are developed in such a way that they are understood by all workers	14%
Proactive	All important communications take into account language and are developed in such a way that they are understood by all workers AND 1 more practice	16%
Committed	All checked	17%

Comments

47% of respondents said that "All important communications (e.g., work contract, safety procedures) take into account language and are developed in such a way that they are understood by all workers."

52% have procedures in place (e.g., a section in the employee manual, a clause in contracts) to prevent, avoid and resolve any cases of discrimination, abusive behaviours or intimidation on their farm. About a third (34%) of respondents also have grievance procedures in place to enable workers to report complaints safely and without facing repercussions.

22% of respondents have none of these practices in place.

Number of respondents: 150

1.4 Benefits

Description

This indicator documents the benefits provided to farm workers. Options include the following:

- Disability insurance
- Additional hours
- Health insurance
- Life insurance
- Pension plan contribution
- Paid sick days
- Professional development (e.g., training, education, courses)
- Maternity or parental leave (beyond what is required by provincial regulations)
- Paid vacations (beyond what is required by provincial regulations)
- End-of-year bonuses, performance bonuses
- In-kind donations (e.g., housing, meals, meat, wood, crops, access to a vehicle, etc.)
- Other

Evaluation

Risky	None of the above/Only in-kind	8%
Compliant	At least 1 (other than in-kind)	12%
Proactive	---	---
Committed	1 and more (other than in-kind)	80%

Comments

The most common benefits include bonuses (45%), health insurance (42%), disability insurance (41%), and in-kind donations (42%).

Paid sick days are offered by 34% of respondents and additional hours by 32% of them. 33% of participating producers said they provide professional development opportunities.

Life insurance (23%), paid vacations (25%), pension plan contribution (18%) and maternity / parental leave (15%) are the benefits the least widely provided.

5% of respondents declared not offering any benefits to hired labour.

Number of respondents: 151

1.5 Diversity Management		
Description		
This indicator documents the proportion of farmers that received training on best practices in diversity management or got informed about the cultural differences that exist between them and employees from other cultures.		
Evaluation		
Risky	---	---
Compliant	No	28%
Proactive	---	---
Committed	Yes	72%
Comments		
A total of 75 respondents declared having hired workers with diverse backgrounds in terms of religions, nationalities, cultures, and languages (e.g., temporary foreign workers or people belonging to minority groups) over the last 3 years. Number of respondents: 68 (out of the 75 for who this question applies)		

1.6 Language Training		
Description		
This indicator documents the proportion of farm owners that offer language training to their employees (e.g., ESL classes).		
Evaluation		
Risky	---	---
Compliant	No	30%
Proactive	---	---
Committed	Yes	70%
Comments		
A total of 75 respondents declared having hired workers with diverse backgrounds in terms of religions, nationalities, cultures, and languages (e.g., temporary foreign workers or people belonging to minority groups) over the last 3 years. Number of respondents: 64 (out of the 75 for who this question applies)		

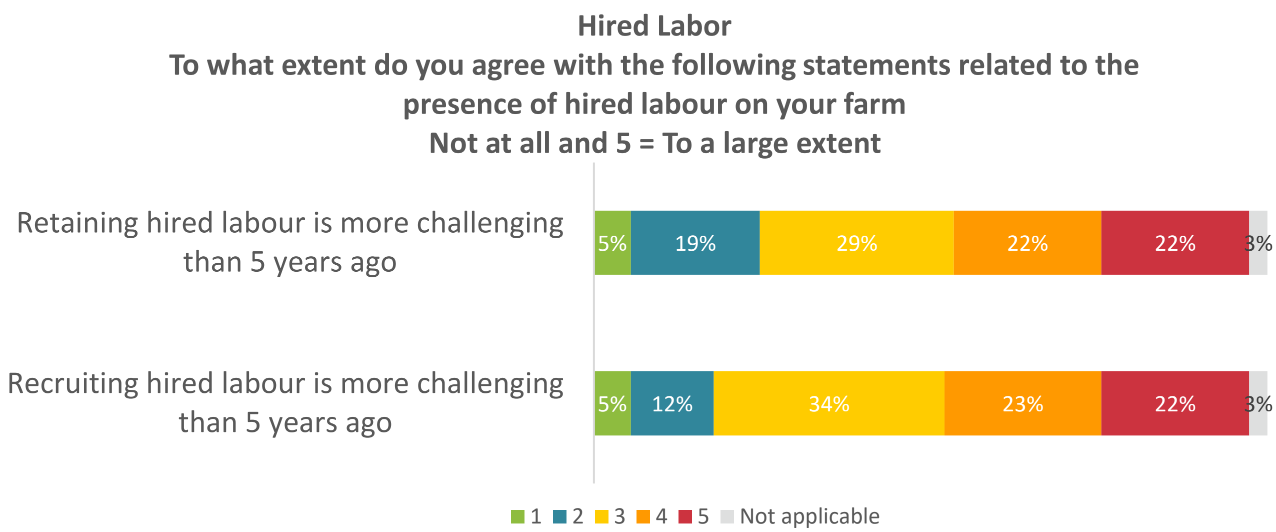
1.7 Recruitment and Retaining

Description

This indicator documents the extent to which producers agree with the following statements related to the presence of hired labour on farm. Options include the following:

- Retaining hired labour is more challenging than 5 years ago
- Recruiting hired labour is more challenging than 5 years ago

Evaluation



Comments

Number of respondents (range): 157-158

1.8 Overtime		
Description		

This indicator documents the situations that can apply to farm operation when it comes to the hours worked by employees. Options include the following:

- Workers can decline without consequence when asked to work additional hours
- Workers are given regular breaks
- You make sure that hours worked do not affect your employees' health and safety
- You have an agreement between you and your employees stating expectations about hours worked (including overtime)
- Workers receive equal compensation when working additional hours (e.g., time in lieu, meals)

Evaluation		
Risky	If the 3 top practices are not all checked	76%
Compliant	The 3 following practices are checked: 'Workers can decline without consequence when asked to work additional hours'; 'Workers are given regular breaks'; 'You make sure that hours worked do not affect your employees' health and safety'	12%
Proactive	---	---
Committed	All checked	12%

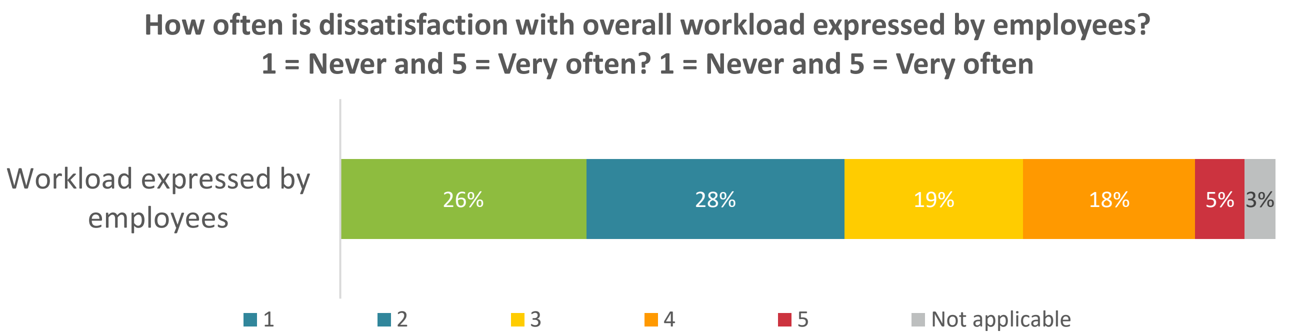
Comments

While only 12% of respondents checked all options, many are those who selected one or more options. For instance, about half of respondents said that they "make sure that hours worked do not affect your employees' health and safety" (53%), that "Workers are given regular breaks" (55%), that they "receive equal compensation when working additional hours" (53%) or that they "can decline without consequence when asked to work additional hours" (49%).

60% said that they "have an agreement between you and your employees stating expectations about hours worked (including overtime)."

Number of respondents: 154

1.9 Workload Dissatisfaction
Description
This indicator documents how often dissatisfaction with overall workload is expressed by employees.
Evaluation



Comments
Number of respondents: 147

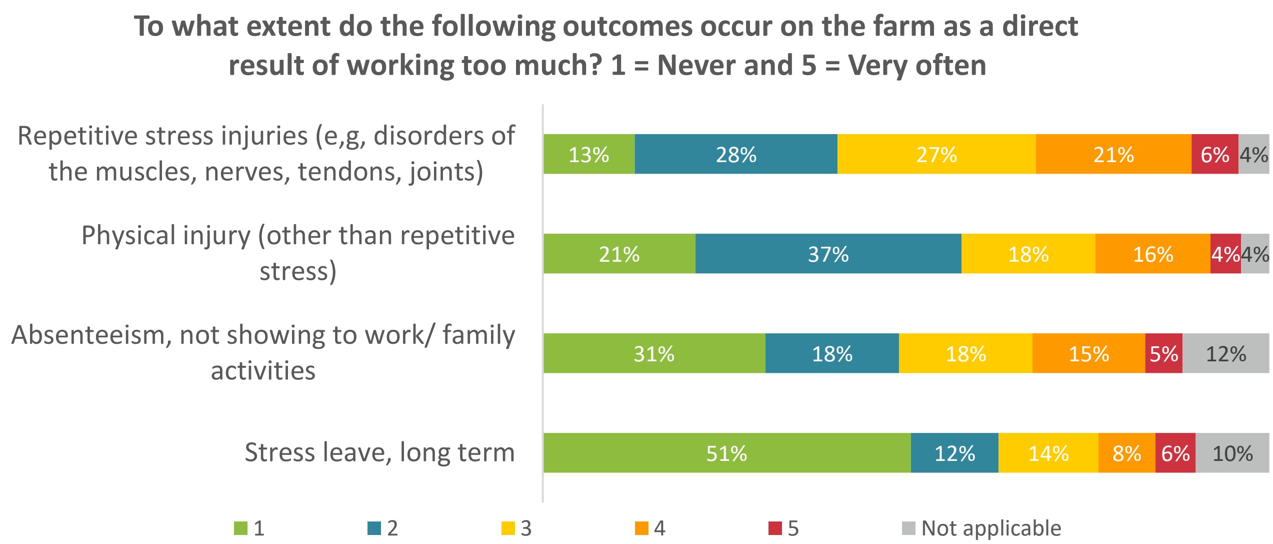
1.10 Consequences of Overload

Description

This indicator documents the extent to which the following outcomes occur on the farm as a direct result of working too much. Options include the following:

- Absenteeism, not showing to work/ family activities;
- Repetitive stress injuries (e.g., disorders of the muscles, nerves, tendons, joints);
- Physical injury (other than repetitive stress);
- Stress leave, long term

Evaluation



Comments

Number of respondents (range): 273-297

1.11 Farm management training		
Description		
This indicator documents if at least one farm manager attended a conference or a training session either online or in person over the past 3 years.		
Evaluation		
Risky	---	---
Compliant	No	22%
Proactive	---	---
Committed	Yes	78%
Comments		
Number of respondents: 328 More than 60% answered they followed a conference/training about Forage/Pasture management/Soil Management, 43% on Animal welfare and Business management, 40% on environmental management, 31% on Biosecurity and On-farm food safety, 27% on Risk management, 19% on Human resources management, 17% on OHS, and 5% Others. Of those who answered yes and have hired labour, 26% of them answered they have at least a manager who attended a conference or a training session either online or in person over the past 3 years on the topic of human resources management.		

PEOPLE'S HEALTH AND SAFETY

This section is comprised of 11 indicators:

- 2.1 Health and Safety Risk Assessment
- 2.2 Prevention Activities
- 2.3 Health and Safety Training
- 2.4 First Aid
- 2.5 Emergency Procedures
- 2.6 Personal Protective Equipment
- 2.7 Degree of Awareness and Preparation
- 2.8 Stress Factors
- 2.9 Level of Disturbing Stress
- 2.10 Fatigue Management
- 2.11 COVID Management

2.1 Health and Safety Risk Assessment		
Description		
This indicator documents if a health and safety risk assessment covering all activities on the farm site has been carried out over the last 5 years and if measures have been taken to reduce the risk of injuries.		
Evaluation		
Risky	No	68%
Compliant	Yes	32%
Proactive	---	---
Committed	---	---
Comments		
About half (47%) of those who answered "No" have hired employees on their farm. Number of respondents: 313		

2.2 Prevention Activities		
Description		
This indicator documents if at least one person on the operation (including owners) participated in health and safety prevention activities, information sessions or training (on-site or off-site) in the past 3 years		
Evaluation		
Risky	No	58%
Compliant	Yes	42%
Proactive	---	---
Committed	---	---
Comments		
About a third (30%) of those who answered "No" have hired employees on their farm. Number of respondents: 313		

2.3 Health and Safety Training		
Description		
This indicator documents if everyone working on the farm (including owners) participates in health and safety training (on-site or off-site) on a regular basis or prior to new work activities for the job tasks that apply to them (e.g., cattle handling, farming, feeding).		
Evaluation		
Risky	No	74%
Compliant	Yes	26%
Proactive	---	---
Committed	---	---
Comments		
About half (49%) of those who answered "No" have hired employees on their farm. Number of respondents: 313		

2.4 First Aid		
Description		
This indicator documents if at least one person on the farm (including owners) holds a valid and up to date first aid certificate.		
Evaluation		
Risky	No	57%
Compliant	Yes	43%
Proactive	---	---
Committed	---	---
Comments		
About half (48%) of those who answered "No" have hired employees on their farm. Number of respondents: 313		

2.5 Emergency Procedures		
Description		
This indicator documents if, in case of an accident, producers have a well-defined procedure (or protocol) known by everyone (all employees and farm owners).		
Evaluation		
Risky	No	29%
Compliant	Yes, in a verbal form	44%
Proactive	---	---
Committed	Yes, in a written form	26%
Comments		
About one fifth (19%) of those who answered "No" have hired employees on their farm. Results are higher when it comes to farms with hired employees; with 35% saying "Yes, in a verbal form" and 46% "Yes, in a written form." Number of respondents: 312		

2.6 Personal Protective Equipment (PPE)		
Description		
This indicator documents how personal protective equipment (PPE) and clothing (e.g., steel-toed boots, gloves, helmet) used on the operation. Options include the following: • The proper PPE is freely provided to everyone working on the farm • PPE is maintained regularly • The proper use of PPE is enforced		
Evaluation		
Risky	Nothing checked	91%
Compliant	All checked	9%
Proactive	---	---
Committed	---	---
Comments		
43% of respondents declared that proper PPE is freely provided to everyone working on the farm and 36% that PPE is maintained regularly. However, only 22% of respondents said they enforce the use of PPE. Number of respondents: 312		

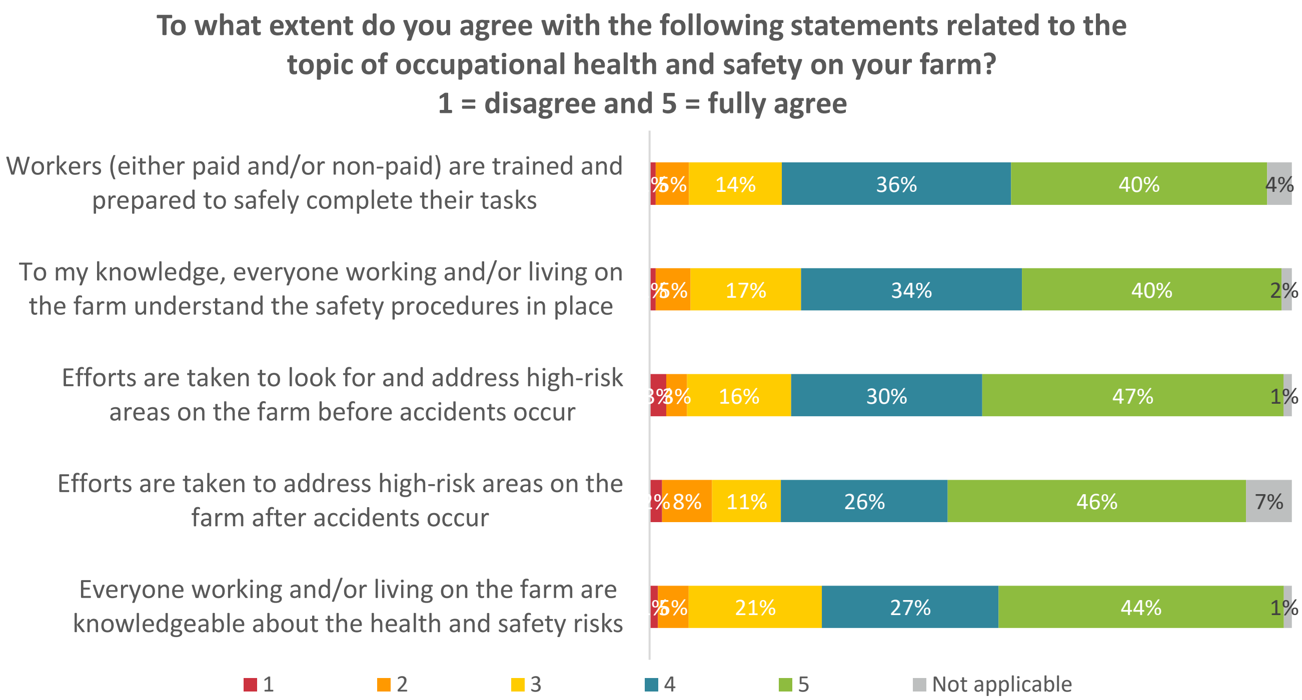
2.7 Degree of Awareness and Preparation

Description

This indicator documents the extent to which measures are adopted by producers related to the topic of occupational health and safety on the farm. Options include the following:

- Everyone working and/or living on the farm are knowledgeable about the health and safety risks associated with their job function or presence on the farm in a way that can be easily understood;
- Efforts are taken to address high-risk areas on the farm after accidents occur;
- Efforts are taken to look for and address high-risk areas on the farm before accidents occur;
- To my knowledge, everyone working and/or living on the farm understand the safety procedures in place;
- Workers (either paid and/or non-paid – e.g., family) are trained and prepared to safely complete their tasks.

Evaluation



Comments

Number of respondents (range): 299-306

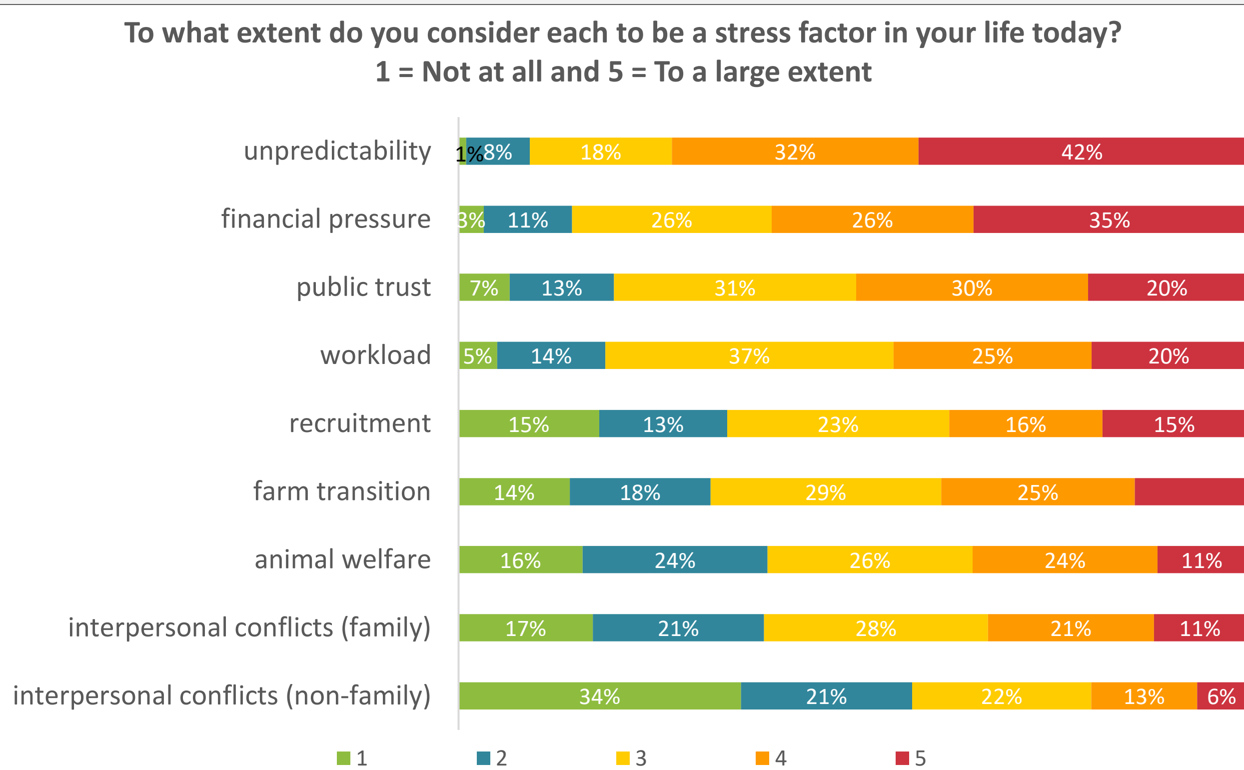
2.8 Stress Factors

Description

This indicator documents the main stressors and the extent to which producers consider each to be a stress factor in their life today. Options include the following:

- Workload pressures from the beef operation;
- Financial pressures from the beef operation (e.g., cashflow, debt repayment);
- Interpersonal conflicts with family about the beef operation;
- Interpersonal conflicts with non-family about the beef operation;
- Farm transition considerations related to the beef operation;
- Efforts to align with animal welfare expectations;
- Ability to recruit and retain employees;
- Unpredictability of the ag industry (i.e., Weather / market prices);
- Public trust in Canadian ag production

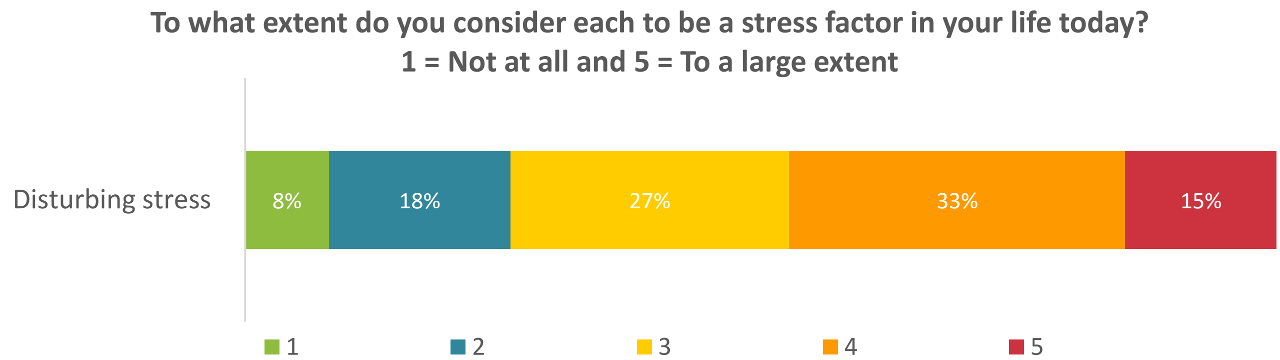
Evaluation



Comments

Number of respondents (range): 252-312

2.9 Level of Disturbing Stress
Description
This indicator documents the extent to which producers feel disturbing stress resulting in physiological changes such as sleep loss, changes in appetite, body/headaches, etc. as a result of their on-farm occupation.
Evaluation



Comments
Number of respondents: 307

2.10 Fatigue Management

Description

This indicator documents practices followed by producers to manage physical and mental fatigue. Options include the following:

- You schedule regular medical check-ups and health assessments
- You adopt a healthy diet and exercise regularly
- You take time to talk about the causes of stress, especially to family and friends
- You seek external resources when needed (e.g., Farmer Specific Crisis Lines, Sentinel Program; In the Know, counselors, mediators, pastors, etc.)
- You get physical therapy when needed (e.g., massage, physiotherapy)
- You take time off and holidays whenever possible (e.g., through labour co-ops)
- You schedule time for family
- You limit alcohol consumption and avoid drug use
- You establish personal goals / Create a bucket list

Evaluation

Risky	None of the above	4%
Compliant	1-2 checked	35%
Proactive	3-4 checked	34%
Committed	5 and more checked	27%

Comments

About half of respondents declared that they "adopt a healthy diet and exercise regularly" (52%), "schedule time for family" (51%) or "take time to talk about the causes of stress, especially to family and friends" (46%). 42% of them said they "limit alcohol consumption and avoid drug use."

About a third said they "get physical therapy when needed" (35%), "take time off and holidays whenever possible" (35%), "schedule regular medical check-ups and health assessments" (32%), or "establish personal goals / Create a bucket list" (30%).

15% said they "seek external resources when needed."

Number of respondents: 305

2.11 COVID Management		
Description		
This indicator documents farm manager's overall performance, given the COVID-19 pandemic and drought situation.		
Evaluation		
Risky	Dissatisfied, Very dissatisfied	5%
Compliant	Neutral	25%
Proactive	Satisfied	57%
Committed	Very satisfied	14%
Comments		
Number of respondents: 307		

Animal Care

This section is comprised of 18 indicators:

- 3.1 Health Assessments
- 3.2 Herd's Health Status
- 3.3 Health of Newly Arrived Cattle
- 3.4 Record-Keeping
- 3.5 Protocol for Needle Injections
- 3.6 Herd's Nutritional Status
- 3.7 Code of Practice
- 3.8 Animal Transportation
- 3.9 Pain Control Technique for Particular Procedures
- 3.10 Typical Pain Control Method Used
- 3.11 Weaning Strategy
- 3.12 Training on Animal Handling
- 3.13 Attendance to Training or Conference
- 3.14 Innovation in Regards to Animal Care
- 3.15 Euthanasia
- 3.16 Health Problem Assessment
- 3.17 Handling Techniques
- 3.18 Extreme Temperature

3.1 Health Assessments		
Description		
This indicators documents what practices are in place to prevent and assess animal health issues. Options include the following: - A Veterinarian/Client/Patient Relationship (VCPR) - A herd health management plan for disease prevention, diagnosis, and treatment - Protocols for the identification, care, treatment, and possible euthanasia of sick or injured animals - A vaccination program developed in consultation with a veterinarian		
Evaluation		
Risky	None checked	<1%
Compliant	1 or 2 practices checked	40%
Proactive	3 practices checked	20%
Committed	4 practices checked	40%
Comments		
81% of respondents declared having a VCPR, 70% a vaccination program, 68% a herd health management plan, and 62% as having "Protocols for the identification, care, treatment, and possible euthanasia of sick or injured animals." Number of respondents: 329		

3.2 Herd's Health Status		
Description		
This indicator documents how often, on average, cattle are typically assessed for health problems, ranging from "Once a day or more" to "Rarely or never."		
Evaluation		
Risky	Rarely or never	<1%
Compliant	Twice per month	6%
Proactive	---	---
Committed	Weekly or more frequently	94%
Number of respondents: 317		

3.3 Health of Newly Arrived Cattle		
Description		
This indicators documents what practices are in place to prevent and assess health issues of newly arrived cattle on the farm (when applicable). Options include the following: - A disease prevention strategy to manage risk of bovine respiratory disease (BRD) for newly arrived cattle - The behaviour of newly arrived cattle is monitored to facilitate the early detection of illness - Newly arrived cattle are put in quarantine / not co-mingled as appropriate - Communications are made with vendors to check medical history and vaccinations / treatments received		
Evaluation		
Risky	None checked	<1%
Compliant	1 or 2 practices checked	58%
Proactive	3 practices checked	21%
Committed	4 practices checked	21%
Comments		
70% of respondents said they monitor the behaviour of newly arrived cattle to monitor early detection of illness, and 62% put newly arrived cattle in quarantine or make sure they do not co-mingle, as appropriate. About half declared that a disease prevention strategy was in place to manage the risk of BRD for newly arrived cattle (48%), and that communications are made with vendors to check medical history of newly arrived cattle (53%). Number of respondents: 329 | Not applicable: 48 (out of calculations)		

3.4 Record-Keeping		
Description		
This indicators documents if and how records on animal management and health are kept (e.g., paper records, electronic records, cattle management software, others).		
Evaluation		
Risky	No record-keeping	3%
Compliant	A record-keeping system is used	97%
Proactive	---	---
Committed	---	---
Comments		
70% of respondents said using paper records, 53% electronics records and 29% cattle management software. Number of respondents: 330		

3.5 Protocol for Needle Injections

Description

This indicators documents what protocol (or standard operating procedure) is in place for needle injections (when applicable). Options include:

- Employees (incl. owners) are trained as to the proper location of the injections
- Injections are given according to label instructions (e.g., intramuscular (IM) or subcutaneous SQ))
- Remote delivery devices (pole syringes or dart guns) are only used where animals cannot easily/safely be captured
- Needles are replaced regularly
- A records check for broken needles is completed
- Injection equipment is cleaned regularly
- Proper restraint is used based on the situation

Evaluation

Risky	None checked	0%
Compliant	1 or 2 practices checked	17%
Proactive	3 or 4 practices checked	25%
Committed	5 or more practices checked	58%

Comments

85% of respondents declared injecting vaccines according to label instructions.

39% using remote delivery devices only when animals cannot be easily/safely captured.

79% of respondents said replacing needles regularly and 52% said completing records check for broken needles. Injection equipment is said to be cleaned regularly by 74% of respondents.

Employees are said to be trained as to the proper location of the injection on 63% of operations, and proper restraint (based on the situation) is used by 67% of respondents.

Number of respondents: 330 | Not applicable: 4 (out of calculations)

3.6 Herd's Nutritional Status

Description

This indicator documents how the herd's nutritional status is being evaluated. Options include:

- Hands-on body condition scoring
- Visual body conditioning scoring
- Body weight
- Manure consistency
- Feed testing

Evaluation

Risky	None of the above	0%
Compliant	1 practice checked	20%
Proactive	---	---
Committed	2 or more practices checked	80%

85% of respondents declared evaluating the herd's nutritional status through "Visual body conditioning scoring"; 52% through "Feed testing"; 51% through "Manure consistency"; 42% based on "Body weight"; and 37% based on "Hands-on body condition scoring."

Number of respondents: 326

3.7 Code of Practice

Description

This indicator documents if, on the farm, a manager or any other cattle handler have read/reviewed the 2013 Code of Practice for the Care and Handling of Beef Cattle.

Evaluation

Risky	No	26%
Compliant	Yes	74%
Proactive	---	---
Committed	---	---

Among the respondents having answered "Yes"; 47% said having made follow-up improvements to their facilities, 35% to their husbandry and handling practices, 32% to their disease detection technics and 28% to their training approach.

8% of respondents said that no adjustments were needed following reviewing the Code.

Number of respondents: 325

3.8 Animal Transportation

Description

This indicator documents what practices are in place when it comes to animal transportation on or off the farm (when applicable). Options include the following:

- A farm representative (e.g., owner, worker) is always on site to observe the loading / unloading process
- Persons making shipping decisions understand what is not acceptable when loading and transporting cattle
- Loading and unloading equipment, chutes or conveyances are checked to make sure they are free of hazards in order to minimize the risk of injury
- Transporters are certified by the Canadian Livestock Transport (CLT) program

Evaluation

Risky	At least one of the first 3 practices is not checked	40%
Compliant	3 practices checked, except for "Transporters are certified by the CLT program"	44%
Proactive	---	---
Committed	All 4 practices checked	16%

About 80% of respondents said they have a farm representative on site (82%), that the persons making shipping decisions understand what is acceptable (78%) or that loading and unloading equipment, chutes or conveyances are checked to make sure they are free of hazards (78%).

Only 22% said that transporters are certified by the Canadian Livestock Transport (CLT) program.

Number of respondents: 334

3.9 Pain Control Technique for Particular Procedures		
Description		
This indicator documents what pain control techniques are typically used for different procedures (i.e., dehorning / disbudding, castration, branding), when applicable		
Evaluation		
Risky	No particular pain control techniques are used – dehorning / disbudding	12%
	No particular pain control techniques are used – castration	12%
	No particular pain control techniques are used – branding	33%
Compliant	Yes or No, due to the age and methods used – dehorning / disbudding	88%
	Yes or No, due to the age and methods used – castration	88%
	Yes or No, due to the age and methods used – branding	67%
Proactive	---	---
Committed	---	---

Dehorning / disbudding: 54% of producers who perform this procedure said they use pain control techniques and 34% indicated they do not due to age and methods used. 12% indicated that no particular methods are used.

Castration: 48% of producers who perform this procedure said they use pain control techniques and 40% indicated they do not due to age and methods used. 12% indicated that no particular methods are used.

Branding: 44% of producers who perform this procedure said they use pain control techniques and 23% indicated they do not due to age and methods used. 33% indicated that no particular methods are used.

Number of respondents (avg): 249

3.10 Typical Pain Control Method Used

Description

This indicator documents what typical pain control techniques are used on the farm. Options include the following:

- As per the Code of practice's requirements
- Above and beyond the Code of practice's requirements
- I do not know what the Code's requirements are

Evaluation

Risky	I do not know what the Code's requirements are	16%
Compliant	As per the Code of practice's requirements	55%
Proactive	---	---
Committed	Above and beyond the Code of practice's requirements	29%

Number of respondents: 332

3.11 Weaning Strategy

Description

This indicator documents how frequently a low-stress weaning strategy (e.g., two-stage, nose paddle, fence-line separation, natural) is followed on the farm, if applicable. Options range from "routinely" to "never."

Evaluation

Risky	Rarely or never	30%
Compliant	Occasionally	25%
Proactive	---	---
Committed	Routinely	45%

Number of respondents: 311 | Not applicable: 13 (out of calculations)

3.12 Training on Animal Handling

Description

This indicator documents if and how animal handlers are trained on cattle behaviour and quiet animal handling. Options include the following:

- Courses
- Videos
- Generational/spoken knowledge transfer
- Written documents
- On-site consultants/animal welfare specialists
- Job shadowing
- With veterinarian

Evaluation

Risky	No	3%
Compliant	Yes	97%
Proactive	---	---
Committed	---	---

Most respondents (69%) mentioned using "Generational/spoken knowledge transfer" to train employees. Courses (32%), videos (30%), and job shadowing (34%) follow. Written documents are used by 16% of respondents, on-site consultants/animal welfare specialists by 20%, and veterinarians by 18%.

Number of respondents: 317

3.13 Attendance to Training or Conference

Description

This indicator documents if at least one farm manager attended a conference or a training session either online or in person over the past 3 years on topics related to animal health or care (e.g., animal welfare, biosecurity)

Evaluation

Risky	---	---
Compliant	No	58%
Proactive	---	---
Committed	Yes	42%

Number of respondents: 328

3.14 Innovation in Regards to Animal Care		
Description		

This indicator documents if producers have adopted or tried innovations related to animal care in the last three years. Options included the following:

- Feed/nutrition (e.g., winter grazing trials, feed or forage variety trial, alternative feed trials)
- Genetics
- Animal welfare practices (e.g., handling, transport)
- Animal health (e.g., veterinary products other than feed)

Evaluation		
Risky	---	---
Compliant	None	14%
Proactive	---	---
Committed	At least one innovation	86%

Comments

Over 50% of the respondents declared having tried/adopted innovations regarding feed/nutrition (59%), animal welfare practices (50%), or animal health (50%). 34% said having tried/adopted innovations regarding genetics.

Number of respondents: 321

3.15 Euthanasia		
Description		
This indicator documents how farmers assess and determine when to euthanize an animal. Several options were suggested, including the following: - A decision-making tool - Chronic animals assessed frequently - When the animal is unlikely to recover - When the animal fails to respond to treatment and recovery protocols - When the animals have chronic, severe, or debilitating pain and distress - When the animal is unable to get to or consume feed and water - When the animal show continuous weight loss or emaciation - When the animal's condition has passed transportation acceptability limits - Upon veterinary advice		
Evaluation		
Risky	None of the above	>1
Compliant	Any practices, except for "A decision-making tool / Upon veterinary advice"	60%
Proactive	---	---
Committed	A decision-making tool OR Upon veterinary advice	40%
The most frequently used criteria include "When the animal is unlikely to recover" (73%), "When the animals have chronic, severe, or debilitating pain and distress" (69%), "When the animal fails to respond to treatment and recovery protocols" (64%) and "When the animal is unable to get to or consume feed and water" (58%). Veterinary advice is used by 57% of respondents. Only 8% of respondents said using a decision-making. Number of respondents: 322		

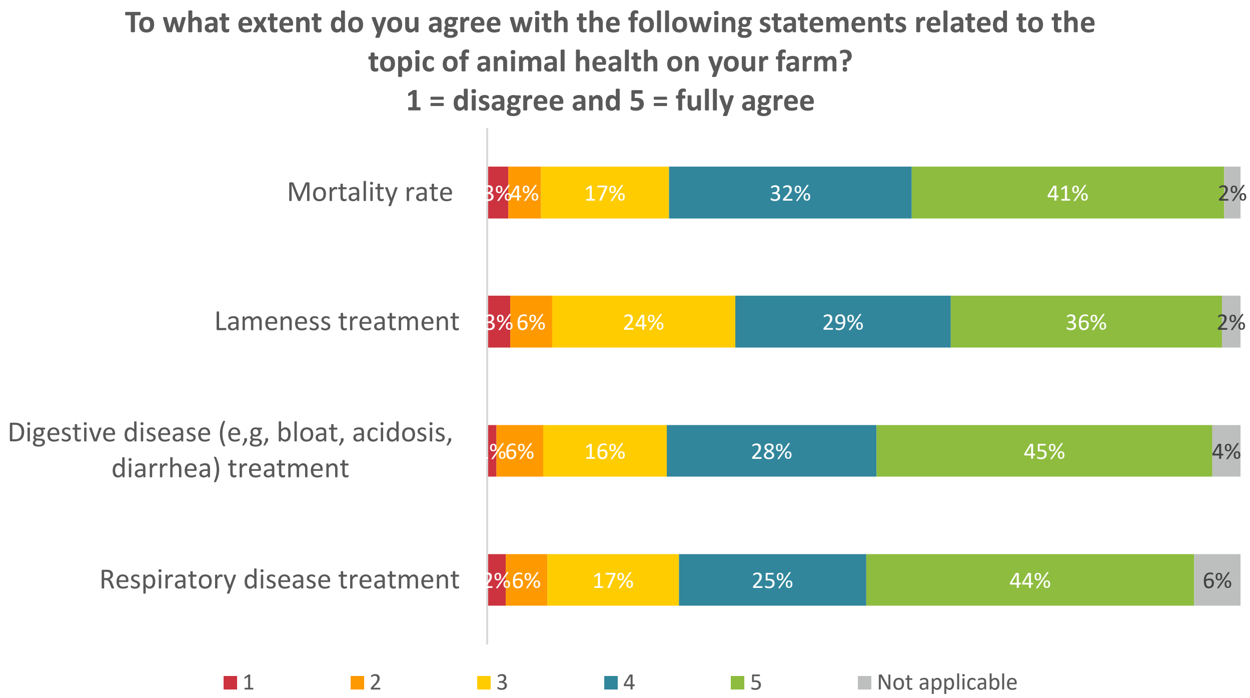
3.16 Health Problem Assessment

Description

This indicator documents the extent to which producers agree with the following statements related to health problems with their herds. Options included the following:

- The respiratory disease treatment rate is stable or has decreased over the last 3 years
- The digestive disease (e.g., bloat, acidosis, diarrhea) treatment rate is stable or has decreased over the last 3 years
- The lameness treatment rate is stable or has decreased over the last 3 years
- The mortality rate is stable or has decreased over the last 3 year

Evaluation



Comments

Number of respondents (range) 306-317

3.17 Handling Techniques		
Description		
This indicator documents the extent to which producers practise handling techniques on site. Options included the following: - Handling techniques and positioning are adjusted according to the individual animal's flight zone response - Handling tools (e.g. flags, plastic paddles, rattles) are used to direct animal movement quietly - Cattle handling techniques are evaluated regularly and improved as needed - Handling events (e.g. falling, stumbling, hesitation or tripping) are monitored and changes in lighting, noise levels, equipment, handling methods, or environment are made as needed		
Evaluation		
Risky	1-2 checked (never) – handling techniques and positioning	6%
	1-2 checked (never) – handling tools	12%
	1-2 checked (never) – evaluation and improvement of handling techniques	6%
	1-2 checked (never) – monitoring of handling events	7%
Compliant	3 checked – handling techniques and positioning	14%
	3 checked – handling tools	19%
	3 checked – evaluation and improvement of handling techniques	22%
	3 checked – monitoring of handling events	23%
Proactive	---	---
Committed	4-5 checked (always) – handling techniques and positioning	80%
	4-5 checked (always) – handling tools	70%
	4-5 checked (always) – evaluation and improvement of handling techniques	72%
	4-5 checked (always) – monitoring of handling events	70%
Comments		
No response (range.): 306-314		

3.18 Extreme Temperature		
Description		
This indicator documents if particular measures have been taken over the last 3 years to support cattle during extreme temperature (high or low) such as improved shelter or adjusted feeding.		
Evaluation		
Risky	No	5%
Compliant	Yes / Not applicable (no changes needed)	95%
Proactive	---	---
Committed	---	---
7% of respondents declared that no changes were needed. Number of respondents: 298		

Antimicrobial Use

This section is comprised of 5 indicators:

- 4.1 Use of Antibiotics
- 4.2 Antimicrobial Alternatives
- 4.3 Use of Antibiotics on Cow-Calf Operations
- 4.4 Use of Antibiotics on Backgrounding and Feedlot Operations
- 4.5 Antibiotics Categories

4.1 Use of Antibiotics

Description

This indicator documents what practices are followed when using antimicrobials (excluding ionophores), when applicable. Options included the following:

- A diagnosis is always performed prior to using any antimicrobials
- Antimicrobials are always selected in collaboration with a veterinarian
- Veterinary and/or label instructions on how to administer the product are systematically followed
- The effectiveness of the treatment is always monitored
- Records of antimicrobial use are kept

Evaluation

Risky	None of the above, or 'Veterinary and/or label instructions on how to administer the product are systematically followed' not selected	21%
Compliant	At least 3 practices checked, including 'Veterinary and/or label instructions on how to administer the product are systematically followed'	47%
Proactive	---	---
Committed	4 practices or more checked, including 'Veterinary and/or label instructions on how to administer the product are systematically followed'	32%

Comments

- 15% of total respondents declared not using antimicrobials.

79% of the respondents that declared using antimicrobials, reported that "Veterinary and/or label instructions on how to administer the product are systematically followed."

two thirds said that the "effectiveness of the treatment is always monitored" (63%), that "Antimicrobials are always selected in collaboration with a veterinarian" (60%), that "Records of antimicrobial use are kept" (59%), or that "A diagnosis is always performed prior to using any antimicrobials" (57%).

15% of producers declared not using antimicrobials.

Number of respondents: 281 (use antimicrobials) and 329 (total respondents)

4.2 Antimicrobial Alternatives		
Description		
This indicator documents if producers have adopted or tried antimicrobial alternatives in the last three years (e.g., bacteriophage, phenolics, organic acids)		
Evaluation		
Risky	---	---
Compliant	No	87%
Proactive	---	---
Committed	Yes	13%
Comments		
Number of respondents: 321		

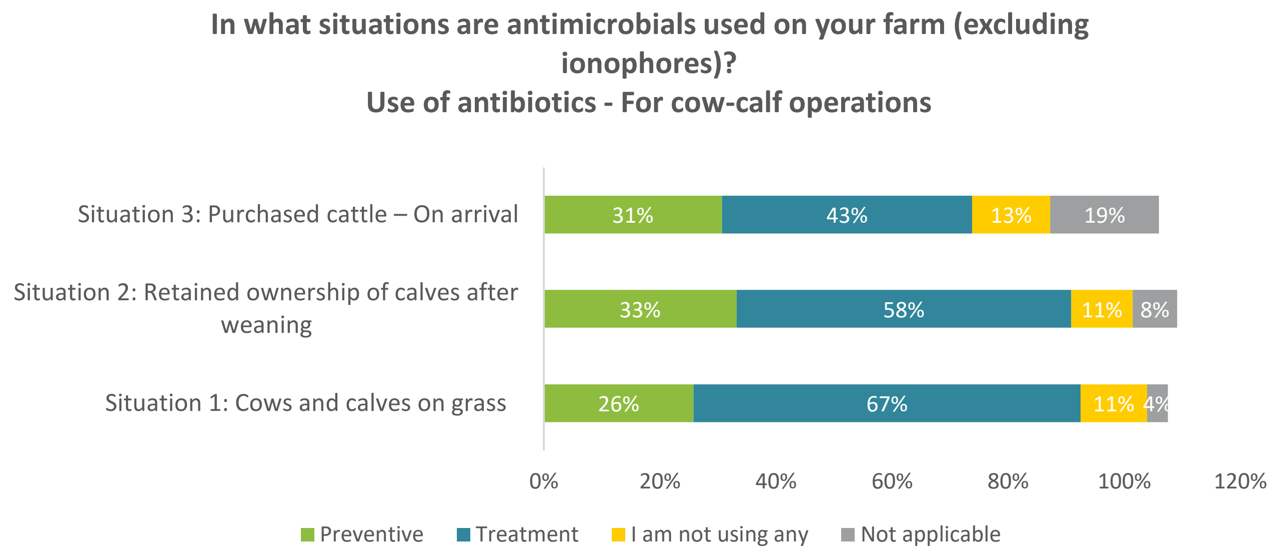
4.3 Use of Antibiotics on Cow-Calf Operations

Description

This indicator documents the situations in which antimicrobials (excluding ionophores) are used on **cow-calf operations**.

Farmers could answer based on three different situations (Cows and calves on grass; Retained ownership of calves after weaning (e.g. preconditioned or backgrounded calves); Purchased cattle – On arrival) and for three types of usage (preventive; Treatment; not using antimicrobials).

Evaluation



Comments

Number of respondents (range): 267-279

No response (average): 18%

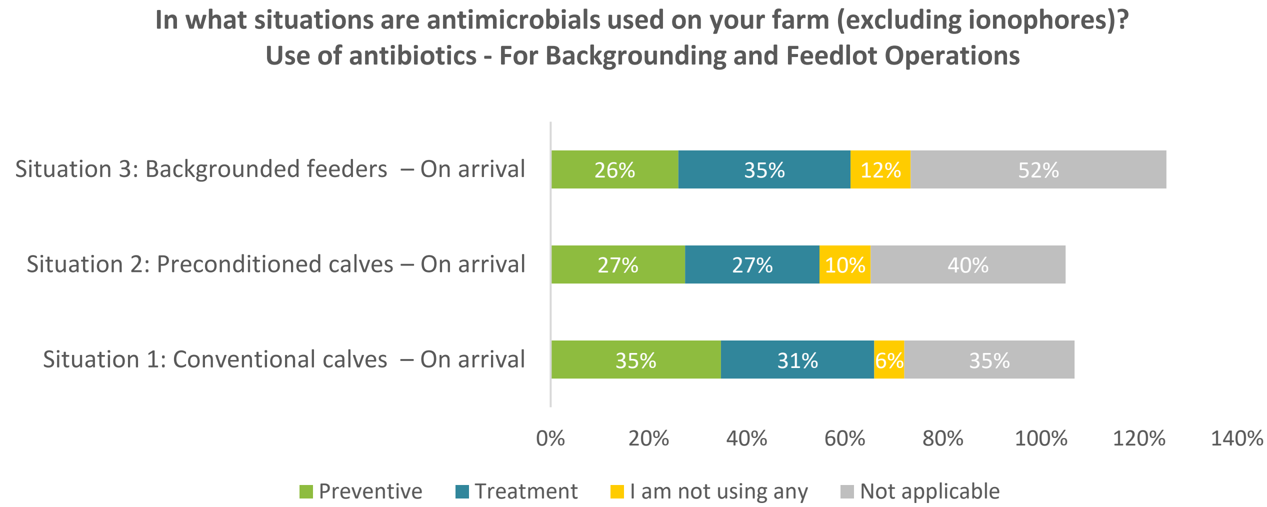
4.4 Use of Antibiotics on Backgrounding and Feedlot Operations

Description

This indicator documents the situations in which antimicrobials (excluding ionophores) are used on **backgrounding** and **feedlot operations**.

Farmers could answer based on three different situations (Conventional calves – On arrival; Preconditioned calves – On arrival; Backgrounded feeders – On arrival) and for three types of usage (preventive; Treatment; not using antimicrobials).

Evaluation



Comments

Number of respondents: 211-262

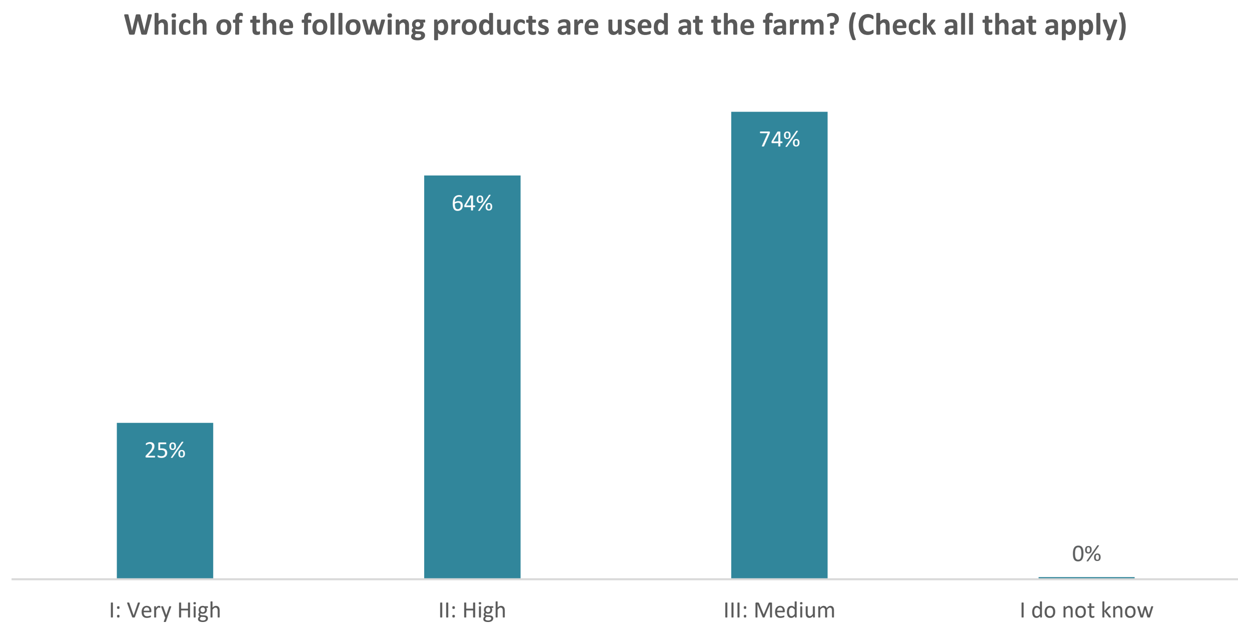
No response (average): 26%

4.5 Antibiotics Categories

Description

This indicators documents which antimicrobials categories (based on their importance in human medicine) are used at the farm, namely: Category 1 (Very high); Category 2 (High); Category 3 (Medium). Only producers using antimicrobials were asked this question.

Evaluation



Comments

This question was asked only to producers using antimicrobials. 25% of producers said using Category 1 antimicrobials.

Number of respondents: 277

F.2 Packer Survey

HR Management

Q1 Which of the following are the biggest HR challenges for your company? (Choose a maximum of 3):	
	AVG (%)
Managing mass retirement	0%
Staff motivation	33%
Supervisor/foreman/team leader management skills	33%
Difficulty recruiting	100%
Intergenerational cohabitation	0%
Optimizing health and safety	0%
Reconciling work/life balance	0%
Employee mental health	0%
Staff retention for entry-level positions (reducing turnover)	67%
Training for existing staff (Management specifically Frontline Supervisors)	33%
Onboarding and integrating new labour pools (immigrants, temporary foreign workers, semi-retirees, etc.)	33%
Diversity management (immigrants, temporary foreign workers, semi-retirees, etc.) of production staff	33%
Other. Please specify:	0%

Onboarding and Integration

Q2 Which of the following has the business implemented? (Check all that apply)	
	AVG (%)
Corporate policy handbook or document containing information on applicable labour practices	100%
Onboarding policy for new employees	100%
Non-discriminatory recruitment policy	100%
Formal regulations against all forms of abuse and intimidation within the organization	100%
A mechanism for employees to report abuse by a colleague or supervisor	100%
None of the above	0%

Retention and Communication

Q3 What do you think helps the most attract and retain employees at your company? (Choose a maximum of 3)	
	AVG (%)
Professional development and training	33%
Vacation	0%
Salary	67%
Employee benefits (pension plan, group insurance, etc.)	100%
Interesting challenges to solve	0%
Flexible working hours	0%
Corporate culture	33%
Technological work environment	0%
Team skills	0%
Company reputation	0%
The company's commitment to sustainable development	0%
Employment stability	67%
Other. Please specify:	0%

Q4 Which of the following actions have you implemented in the last three years to retain your production employees and supervisors? (Check if these actions apply to production employees and/or supervisors)	
	AVG (%)
Production employees	
Competitive salary	100%
Faster salary progression	67%
Performance bonus	0%
Attractive employee benefits (e.g., dental insurance)	100%
Advancement opportunities	100%
Training or development	33%
Work/life balance measures	0%
Work schedule revisions	0%
No specific action	0%
Supervisors	
Competitive salary	100%
Faster salary progression	67%
Performance bonus	100%
Attractive employee benefits (e.g., dental insurance)	100%
Advancement opportunities	100%
Training or development	67%
Work/life balance measures	0%
Work schedule revisions	0%
No specific action	0%

Q5 Does your company hire workers from the following pools? (Check all options that apply)	
	AVG (%)
Immigrants (born outside of Canada, excluding temporary foreign workers)	100%
Temporary Foreign Workers (TFWs)	67%
Experienced workers (50+ years old)	100%
Workers with criminal records	33%
Indigenous peoples	67%
People with physical/mental disabilities	67%

Q6 To what extent do you agree with the following statements describing the integration of your immigrant or temporary foreign workers? (1 being «disagree» and 10 being «totally agree»).	
	AVG (%)
Awareness is raised by the employer to avoid cultural bias	9,5
English/French-building activities are offered to workers	6,7
Internal team-building activities are organized	3,7
Hiring instructions and training are available in languages other than English or French	6,3
Our company has received the support of an organization specialized in the integration of immigrant workers or TFWs	10

Q7 Does your company use employment agencies to fill these labour needs?	
	AVG (%)
Yes	33%
No	67%

Q8 To what extent do you agree with the following statements describing the integration of agency workers? (1 being «disagree» and 10 being «totally agree»)	
Not enough response to present the result	
	AVG (%)
Communication with peers is adequate	---
There is no isolation or cliques between these workers and the permanent staff	---
Workers from employment agencies are well accepted and integrated into the plant	---

Health and Safety

Q9. What occupational health and safety measures are in place at your company? (Multiple answers possible)	
	AVG (%)
Joint Occupational Health and Safety Committee (employer/employee)	100%
Clear and well-understood internal health and safety regulations and policies	100%
Site inspection (by an internal OHS official or other)	100%
Prevention program (incl. machine maintenance)	100%
Clear and well-understood procedures for work-related accidents	100%
Accident investigation and analysis (by an internal OHS officer or other)	100%
Job rotation	100%
Personal protective equipment (PPE)	100%
Fire drill	100%
Pre-employment medical examination	67%
None of these measures	0%
Other. Please specify:	0%

Q10. In the last 2 years, what occupational health and safety training have you offered to your production employees? (Multiple answers possible)	
	AVG (%)
First aid	100%
Mental health	100%
Forklift operator	100%
WHMIS (Workplace Hazardous Materials Information System)	100%
Lockout procedures	100%
Enclosed spaces	33%
Other. Please specify:	33%

Q11. Has the company implemented measures to improve the physical work environment (noise and odour reduction, temperature control, air filtration, etc.)?	
	AVG (%)
Yes	100%
No	0%

Q12. In general, on a scale of 1 to 10, how would you rate your company's health and safety practices?	
	AVG
(1 being «much work remains to be done» and 10 being «the situation is exemplary»)	8,7

Q13. How has COVID-19 affected your business? (1 being «not at all affected» and 10 being «very affected»)	
	AVG
Loss of productivity associated with health measures	7,0
Difficulty in hiring due to government programs (e.g., CERB)	9,7
Ease of hiring due to new pools of available workers	4,0
Increase in sick leave and absenteeism	10,0
Disrupted work environment (e.g., employee mental health issues, anxiety)	8,3

Q14. Overall, given the COVID-19 pandemic, how would you rate your performance as an employer with respect to adjustments made at the plant? Would you say you were...	
	AVG (%)
Very dissatisfied	0%
Dissatisfied	0%
Satisfied	0%
Very satisfied	100%

Training, Professional Development and Skills for the Future

Q15. Does your company have a structured plan for ongoing employee training?	
	AVG (%)
Yes, a plan for mandatory training only (first aid, WHMIS, HACCP/GFSI etc.)	67%
Yes, a plan and record of all training (mandatory, job training, team leadership, etc.)	100%
No, no structured training plan	0%

Q16. Do you invest 1% of your payroll in training activities aimed at developing the skills of your staff?	
	AVG (%)
Yes	0%
No	100%

Production and Employee Profile

Q17. For the 2020 production year, how many employees did you have at your facility (full-time and part-time status, excluding seasonal workers)?	
	AVG (%)
Less than 50	0%
50 - 99	0%
100 - 199	33%
200 - 399	0%
400 or more	67%

Q18. Is your facility unionized?	
	AVG (%)
Yes	67%
No	33%

Q19. What type of workforce planning does your company do?	
	AVG (%)
No workforce planning	0%
Short-term planning only	33%
Short, medium, and long-term planning, including retirement	67%

Q20. Regarding job descriptions for production employees, which statement best reflects your company's reality?	
	AVG (%)
No job descriptions	0%
Some job descriptions	67%
Regularly updated descriptions for all positions	33%

F.3 Interview Summaries

The following tables propose an overview of the information and insights collected throughout these interviews categorized into 5 main topics (Meaning of Sustainability, Sustainability-related Risks and Opportunities, Overall Sustainability Performance, Recognition, and Commitments)[86]. In order to protect confidentiality, the information is reported in an aggregate way that highlights

- Leading ideas: Key recurring observations emerging from the interviews;
- Outlying ideas: Individual or alternative observations heard during the interviews.

Section 1 – Meaning of Sustainability

In your own words, how would you define the concept of [social] sustainability in the context of beef production in Canada?

Leading ideas	Outlying ideas
• Social sustainability = public trust and consumer support • Financial sustainability comes first • Sustainability means different things to different people (different focus) • The 'what's in it for me' is still a concern • Sustainability is about continuous improvements	• Social sustainability = connecting people | be stewards of people • Is animal welfare part of social sustainability? • Sustainability = a two-way dialogue (to understand each other's reality and expectations) • Sustainability is not a topic people are excited about; people do not plan for the future • Sustainability is not only about "how much it will cost," but also "how much money and time I will save"

Section 2 – Sustainability-Related Risks and Opportunities

What are the key risks, issues or opportunities facing Canadian beef farmers when it comes to sustainability in general?

Leading ideas	Outlying ideas

Key risks
• Lack of coordination / transparency in the value chain – information and value are not efficiently conveyed; a threat to the cow-calf sector in particular
  ○ Top-down: market signals are not shared with producers, who do not see / get the benefits
  ○ Bottom-up: producers are not involved enough in the supply chain (they sell, they don't market their products; they don't ask question)
• An 'every man to himself' approach; everyone trying to make margins at the other's expenses; lack of trust; system getting too big and complex (at the packers' end)
• A disconnect between what consumers want and
	Key risks
	• Adaptation to climate change – what will beef production be like under the new conditions due to climate change? Are today's BMPs the ones needed in 10-20 years from now?
	  ○ We also need to account that enacting positive changes can take decades
	• Beef production = low risk enterprise; limited incentives to take risk and innovate
	• People's well-being has been overlooked
	• A fragmented / non-homogenous industry; strong regional specificities – especially at cow-calf level (could be a risk or an opportunity)
	• Getting too laser focus on certain areas (e.g., GHG); missing the larger picture (e.g., from a system

[86] This synthesis includes the comments made by the 'matter experts', in the corresponding sections (HR, AMU)

Leading ideas	Outlying ideas
what the industry thinks is good (or good enough) ◦ The industry is beating its own drum ◦ The further away you are from the industry, the more critical you are; opposite is true • Capacity / willingness to sustain operations overtime (in particular cow-calf); pressure coming from demographics, land value, profitability, public trust, … • Lack of consistency in how the sector operates and communicates (no mandatory program = no consistent messaging)	approach) • The industry focuses its messaging on grass and cows (great reputation), but feedlots are the elephant in the room when it comes to public concerns • Public trust is a moving target; by the time you take action to address an issue, a different one pops up; puts the industry in a reacting mode • Challenging for 'smaller' producers to keep-up with the sustainability-related paperwork / compliance costs • Beef production is under increased public scrutiny and most of the burden falls on the producers' shoulders; yet others benefit from the ESG induced by beef farming • Some people are cheating with labels and claims • Beef quality: ◦ The years the beef price is good, there is very little difference between high-end cattle and low-end one. Same in bad years. Because of incentives are not used to recognize quality ◦ Need to better define what is "high quality beef" – the definition is too vague
Key opportunities • Better story telling – conveying information throughout the value chain to consumers (and getting a signal back) ◦ Finds ways for consumers to 'feel good' about eating beef • Tighter value chain collaboration ◦ For producers: get involved in marketing • Better leverage data at the farm and throughout the value chain	**Key opportunities** • Enhance traceability • Increase benchmarking to showcase champions and inspire others • Change focus to adopt a system approach and highlight the 'ecological goods and services' (EGS) provided by beef production (upcyclers; preserving grassland; bringing value to land unsuited to other uses) and be rewarded for it (as a public good) • Adapt wording to audiences ('harvest' instead of 'slaughter')

Section 3 – Overall Sustainability Performance

How do [producers in your province | the sector] rate on the issue of … Workforce | Animal Health and Welfare | Food Safety and Biosecurity | Environment | Innovation?

Leading ideas
OVERALL • The overall ranking of the 5 domains of sustainability goes as follow: ◦ "Animal welfare / health" and "Food safety / biosecurity" rank first; ◦ The "Environment" comes next; ◦ The domain of "Innovation" is usually scored low, with some contrasting opinions; ◦ "Labour" usually comes last; there is an overall understanding that this is the area for which the industry performs the least and where improvements are most needed. • The perceived performance varies significantly depending on the type of operations (cow-calf vs. feedlot; production vs. processing) – the issues and challenges are not the same

<table>
<tr><th>Leading ideas</th><th>Outlying ideas</th></tr>
<tr><td>

LABOUR

- Cow-calf producers are doing their best, but they are fighting an up-hill battle when it comes to labour recruitment / retention
  - Can’t afford to compete with other industries; some in-kind benefits, but not enough to attract good employees
- Feedlot producers are more competitive re. working conditions
  - But still room for improvements when it comes to labour management (soft skills)
- Processors are now large operations operating on volumes and efficiency; people are overworked
  - But it is an ‘assembly line’ type of job and a risky occupation; short term solution: reliance on TFW; mid/long term solution: automation
- Occupational health and safety (OHS): more efforts are needed. Easy to overlook when under pressure and with high turnover rates.
- Farm succession: a huge challenge (especially for cow-calf operations)
  - Difficult to keep children on the farm (not an attractive occupation); or they may stay but quit beef farming
  - Need to consider alternative models (outside direct family labour, incl. TFW)
- Everyone – within and outside the industry – should recognize that farm and plant employees are doing jobs most Canadians wouldn’t want or do; they should be recognized for this.

</td><td>

- Dissatisfaction with labour partly comes from owner-operators expecting too much from hired labour (based on their own involvement in the operation)
- Mental health: increased awareness and more resources available; less of a taboo, but is enough being down on the ground?
- Size of operations (feedlot / packers): unclear whether it is positive or negative on people:
  - For some, the smaller the better: bottom-line less of a priority
  - For others, smaller operations would actually require more labour in total while offering less advantages to reduce the burden
- Audits: businesses go through them to ‘comply’, not as an opportunity to improve things.
  - Most businesses (farms / processors) will do the minimum to comply with basic requirements when it comes to labour
- The industry (and packers in particular) are good at integrating a diverse population into the workforce
- Labour scarcity: as a result, lots of opportunities for employees willing to get involved in the industry (especially at the processor level)
- One of the challenges common to producers and processors: being able to recruit employees you can trust (cf. Animal welfare)
- Transition: some expect the younger generation to bring changes (e.g., innovation, set of values), while others think changes need to be made for the younger generation to be willing to take over

</td></tr>
<tr><th>Leading ideas</th><th>Outlying ideas</th></tr>
<tr><td>

ANIMAL WELFARE / HEALTH

- The sustainability-related domain that received the most emphasis over the years – with tangible, positive results
  - A demonstration that real, concerted, and concentrated efforts can lead to positive outcomes at the industry level
  - Now producers are comfortable talking about it with their employees, contractors
- Producers understand that healthy, happy animals directly impact their bottom-line
  - Those who do not take action are accounted responsible

</td><td>

- “Professional” beef farmers are doing great; but there are hobby farmers who do not achieve the same results
  - But not a significant threat to the industry
- VPB(+) played a key role in changing practices and perspectives
  - Regulations / requirements are needed to induce changes; most producers won’t go above and beyond otherwise
- Animal welfare standards are evolving and producers need to keep up through training; need for a continuous effort
  - Producers may be doing well without being knowledgeable about the Code’s requirements / recommended practices
- If the industry seems to be doing great overall, some interviewees pointed out to blind spots, such as with vaccination
  - Producers think they are doing the right thing, but

</td></tr>
</table>

    - may not be (same with the use of antibiotics, cf. below)
- Transportation seems to be an area where improvements may still be required

Leading ideas

FOOD SAFETY / BIOSECURITY

- Compared to other industries, beef producers are not doing great regarding biosecurity
- Regulations are playing a key role in explaining the industry's performance when it comes to AMU
    - Yet, many interviewees consider there are significant issues and concerns regarding how antimicrobials are actually being used.
    - Regulations are one thing; but now a cultural shift is needed for things to change on the ground.
- At the processing level, food safety is of outmost importance; not in business otherwise.
    - The CFIA is seen as a key partner in achieving and ensuring this performance

Outlying ideas

- The use of antimicrobials may be legal – but is it responsible?
- The use of antimicrobials in feedlots is particularly concerning; on large operations, things 'slip'
- Food safety and biosecurity is being handled within the walls of each organization
    - There could be an opportunity to work at the supply chain level to remove certain pathogens from the supply chain – but no interest at the moment

Leading ideas

ENVIRONMENT

- The discussion about environmental sustainability is twofold:
    - First, there is the agri-environment level, which refers to how producers manage nutrient, soil, water, waste, and biodiversity at a local / landscape scale
    - Second, there is the global or climate level, which refers to the industry's contribution to GHG and climate change
- As for the topic of 'Animal care', most interviewees consider that producers are doing great when it comes to environmental sustainability
    - Producers understand that healthy environment = healthy animals = profitable business
    - This is even more so the case with cow-calf producers who are directly impacted by their surrounding environment
    - But this applies to the agri-environment level of environmental sustainability
- Beef production and GHG: emphasis is put on pasture management
    - Strong incentives exist in Western Canada to manage pasture properly as a way to preserve moisture; the wetter the climate is, the more buffer producers have
- For packers, the key environmental concerns are about water use, energy efficiency, food waste and packaging

Outlying ideas

- The overall good performance of producers is due to regulations and other well-established incentives, such as EFPs (carrots and sticks)
- When it comes to environmental sustainability, the focus is on grass and cow-calf production; but things are not as 'green' with feedlots
- Beef is currently penalized by the narrow focus on GHG; by adopting a system approach, one can see that beef production delivers several ecological goods and services (EGS)
    - But these EGS are not fully recognized and even less so financially retributed
- Most farm programs are practice-based instead of outcome-based
    - Outcome-based approach allows producers to innovate as entrepreneurs

  - But there are some trade-offs to account for (water use vs. food safety; packaging vs. food safety and preservation);
  - No quick-wins; improvements will come from innovation and through investments

Leading ideas

INNOVATION

- Innovation is not always about the "new thing"; can also be incremental, small things (ex.: use of cellphones to monitor things)
  - Efforts are continuously made to increase resource use efficiency (rotational grazing, less fertilizers, …)
- At the production level, "major" innovations are few, expensive and quickly evolving
  - Feedlots are more likely to invest in R&D than cow-calf producers – due to size and production systems
  - Most innovations are taking place regarding genetics (cattle) and pasture / forage management
- At the processing level, lots of efforts is being made on automation and data management (to phase out manual labour)
- Data management / information technology is the area where more investments are needed – throughout the value chain
  - First, producers should use current tools to better manage / monitor their performances
  - Next, need to use new technologies (AI, drone, sensor, satellite imagery) and leverage this information in different ways – ranging from marketing to traceability or biosecurity

Outlying ideas

- Two types of innovation:
  - Management: producers less likely to innovate here; harder to change practices than using a new technology
  - Productivity: more likely to invest there, even if more risky
- Innovation is the desire to trying something new – and not all producers have that desire
  - Beef farmers are older folks
  - Innovation is mostly taking place at the individual farm level – not sector-wide
- The beef industry is not likely investing in par with other sectors (e.g., oil, automobile)
  - Not enough public research on forage; the canari in the mine
- Key barriers to innovation:
  - Some producers think they have done everything they can; others have their own 'recipe'; they don't appreciate following strict guidelines / standards
  - Farmers need to see the 'what's in for me' in the short-term to buy-in to new things
  - Insufficient extension services to get research results to farmers
  - Some producers are concerned about the 'speed of commerce' that would increase with more innovation
  - The lack of standardization increases the difficulty to find economically viable innovations (no one size fits all)

Section 4 – Recognition

In 5 years from now, why should [producers in your province | the sector] be recognized when it comes to the following areas? (Workforce…)

Leading ideas

- The reason(s) why the sector / industry should be recognized for vary widely across interviewees:
  - Some focus on quality and taste – with food safety as an insurance in the background; then comes the rest
  - Some others focus on animal welfare, animal health and the environment; the other items (HR, innovation) are mean to an end

Outlying ideas

- The sector should be recognized for…
  - its (mandatory) national quality assurance program
  - its ability to innovate
  - the management of biodiversity and ecosystems
  - its (measurable) efforts towards all areas of sustainability – and this should be the basis for product differentiation

○ A third (smaller) group thinks "people" should come first in the coming years	• Recognition should not come from the industry itself (i.e., by beating its own drum); it needs to come from its stakeholders

Section 5 – Commitments

If the industry were to make 3 commitments, what should they be?

Below are the commitments the way they were communicated by the interviewees. They are presented as such to account for the priorities and ordering.

1) Connecting with the consumers in a different way that can also be measured 2) Continue to "educate" consumers on animal welfare, AMU and environment 3) On-going: educating producers; stay ahead of where things are at in society	1) We will take care of the land and water our cattle / producers rely upon (safeguarding the environment) 2) Provide the best high quality beef consumers will love and respect 3) Assure financial and social sustainability (be important part of the community)
1) Profitability - for large but also smaller producers, as they feed the larger system 2) Widen out the packer involvement in the CRSB standard 3) Need more support from government that support carbon sequestration (like for EFP)	1) Establish a mandatory national quality program 2) Reduce the prophylactic use of antibiotics 3) Elimination of the use of growth enhancing technologies (for ethical and reputational reasons)
1) Producing happy, healthy beef in a profitable way that sustains the environment for the next generation --- Happy / healthy: by reducing the use of therapeutic AM / treatments where possible ---Environment: by increasing responsible grazing to reduce GHG	1) Need to work more collaboratively and better understand each organization's challenges. 2) Spend less time discussing how good the industry is doing, and try to improve the processes at the business level to increase sustainability
1) Commit to what they said: stop grassland loss	1) Implement the industry's GHG reduction plan 2) improve soil health 3) Manage water – an issue that we are not taking seriously in Canada
1) Systems must be more connected and considered together 2) Genuinely telling the story of the industry – not lying and keeping it authentic 3) Grazers as part of the ecosystem, and the ecosystem includes humans	1) Establish a baseline and set the bar to increase beef quality 2) Support to achieve the bar 3) Improve collaboration to reconnect when it comes to transparency and information sharing.
1) Individually, align sustainability plans with the CRSB goals 2) Collectively, better alignment in the efforts made / move towards the common goods, pre-competitive advantage 3) Find ways to look beyond CRSB membership to engage the 60 000 producers out there (60 members can't speak on their behalf)	1) Pay people better / train them more 2) Continuing focus on the environment and their impact 3) Incorporate new technologies / measuring inputs – outputs
1) People welfare - keeping people in the industry, and demonstrating to them they are important and are treated fairly 2) Communication - addressing consumer	1) Determine who the true voice is – have one voice 2) Communication – politicians and media included, need to better relate to the consumer 3) Sell the right information – simple and straightforward,

misperceptions, more accessible 3) Demonstration - show that the beef industry is leading / have a positive contribution to the environment as a whole	honest, vulnerable; instead of arguing with people, listen and hear them out
1) Environmentally responsible, H_2O use and re-use 2) Ensure worker safety, grass land utilization, land and resource utilization 3) Commitment to innovation / automation – reduce water usage	