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AGRICULTURAL STAKEHOLDER OUTREACH:

ATTITUDES & PERCEPTIONS TOWARDS METHANE REDUCTIONS IN BEEF

FOOD, AGRICULTURE, RESEARCH & POLICY.

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ATTITUDES & PERCEPTIONS TOWARDS METHANE REDUCTIONS IN BEEF

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ABSTRACT.

The importance of Canadian beef production in the context of Albertan economics, environment, and identity, cannot be understated. With the highest percentage of the national beef herd located in Alberta, beef cattle producers are crucial in the transformation of the sector to ensure sustainable practices that reduce enteric methane emissions. The Canadian Beef Advisors, consisting of national beef organizations involved in Canadian beef marketing, policy, research, and sustainability, announced Canada's National Beef Strategy in 2015. The strategy aims to ensure Canadian beef production practices adapt to changes in markets across sustainability and environmental dimensions, with a target to reduce primary production GHG emission intensity by 33 percent by 2030. This goal aligns with current Agricultural and Agri-Food Canada's research on methane emission reductions and offers critical perspective on the role of beef cattle production in eco-system services, through carbon sequestration and pasture grazing management. Ultimately, the choice to implement and adopt practices will depend on the cattle producer at the on-farm level.

This research aims to better understand the attitudes and perceptions towards the emission reduction target and more generally around emissions mitigation strategies within the beef production sectors. Interviews with beef producers (cow-calf operators, feedlot, backgrounding), geneticists, and stakeholders in policy and production advocacy were conducted over July and August 2022. Participants were asked questions about climate change, the role of different levels of government in the development of emission regulations, potential strategies on a short- and long-term horizon basis, and incentives. Interviews were transcribed and categorically defined, highlighting reoccurring themes. These themes provide insight into awareness of different strategies considered by different actors within the agricultural supply chain, and potentially anticipate avenues by which the Government of Alberta should prioritize in developing policies. Ensuring future protocols account for benchmarks of current agricultural operations and management secures accessible and producer-inclusive policy, that optimizes transition risks and secures the pathway forward, balancing the precarious equilibrium of burden on agricultural producers of food security and sustainable, resilient agriculture.

HIGHLIGHTS & POLICY RECOMMENDATIONS.

The following generalized policy recommendations are meant to serve as a foundation to be further refined and built upon, facilitating adaptation for different stakeholders along the beef supply chain based on current operational benchmarks and future growth within the sector.

- Stakeholders in the sector consistently demonstrated clear belief in climate change and that it would impact the Canadian beef sector.
- The role of beef operators in the preservation and potential expansion of native grasslands and their associated ecosystem services was prevalent in speaking with stakeholders along the supply chain. Formal recognition of value attribution is necessary by the provincial and Federal government of production practices that promote carbon sequestration through sustainable grazing practices.
- Opportunity for producers in the beef production chain to participate in the carbon offset market must be expanded and rectified. Current limitations on eligibility to participate and burden associated with adoption need to be addressed to drive uptake and develop favourable conditions for participants, increasing adoption. Ensuring protocols are specific to actions measurable at the on-farm level will facilitate verification.
- Re-investment in agricultural extension within the province should be prioritized. Extension programs, that include provincial research and outreach specific to beef producers and stakeholders in Alberta, are a valuable in supporting unbiased and accessible information about emission reduction strategies and research results. Extension programs also offer an opportunity to establish a strengthened relationship between government and producers, encouraging development of improved communication between the two groups.
- The role of the Federal government should center on setting national emission reduction goals and targets, providing funding and research, and ensuring the responsibility of emission reductions are equitably distributed across the provinces. Policy and protocol to be implemented at the on-farm level in order to reach these targets is best suited for Provincial governments and legislations.

INTRODUCTION.

Increased environmental, social, and political pressures to reduce emissions in response to climate change have influenced practices across sectors. Currently, the agricultural sector accounts for approximately 10 percent of total Canadian greenhouse gas (GHG) emissions. Methane production from the agricultural sector is principally derived from enteric fermentation in cattle (The Government of Canada, 2020). The Canadian beef cattle herd is comprised of 10.5 million cattle, with 48 percent of the total beef cattle population within the province of Alberta. Methane emissions from cattle are linked to herd population size; beef cattle population peaked in 2006, and significantly decreased from 2006 to 2011. This decrease is attributed to a combination of factors, most prominently remnants of bovine spongiform encephalopathy (BSE) outbreak, changes in export flows to the United States, and country-of-origin labelling on beef products (Agriculture and Agri-Food Canada, 2014). Emissions from the cattle sector have declined since 2006 and remained relatively stable since 2010 (Bourassa & Vinco, 2022). Although variability in production practices and on farm operational management styles exist across the province and country, the typical beef production cycle in Alberta follows cattle from cow/calf operators either to stockers and backgrounders, or directly to feedlots. Carcasses are then slaughtered and processed to enter the retail supply chain.

Cattle enteric fermentation and methane emissions depend on several factors. Methane is emitted as a natural byproduct of ruminal micro-organisms' fermentative process during digestion. Variance in emissions between different cattle breeds has been demonstrated, with certain breeds associated with increased or decreased methane production. Diet influences enteric fermentation, as high-fiber, low nutritional quality dietary components are associated with increased fermentation and methane production. On-farm operational factors can influence cattle's enteric fermentation process, demonstrating additional variability between farms, as feeding frequency and bunker management is linked to changes in methane production (Black et al., 2021; Kowk & Vinco, 2022).

Each of these factors, independently or in combination, offer potential levers in reducing methane emissions from beef cattle production (Black et al., 2021). Different production stages may offer opportunities and challenges in introducing and implementing a strategy. This is a practical challenge in the beef sector, as priorities for individual actors in the chain of production do not always align. While cow-calf operators may

favour traits associated with low birth weights and lean body conformation, feedlots may favour high feed-to-gain ratios and body confirmation scores that indicate higher carcass quality. Despite this, overarching improvements in feed utilization and feed quality would result in an overall benefit to producers, with advantageous effects across the supply chain.

The province of Alberta's carbon offset system includes the beef production supply chain. The Quantification Protocol for Reducing Greenhouse Gas emissions from Fed Cattle and the Quantification Protocol for Selection for Low Residual Feed Intake Markers in Beef Cattle both target beef production and reduction of methane emission reduction through adoption of Best Management Practices (The Government of Alberta, 2012, 2016; van Wyngaarden, 2022). Uptake of these protocols are low – as of 2021, only a total of 5 projects are registered throughout the province, with limited farm and feedlot participation (van Wyngaarden, 2022). Overall, livestock producers are less likely to adopt BMPs; therefore, protocol development should prioritize accessibility and inclusivity (Gillespie et al., 2007). The current Alberta protocols target industrial cow-calf producers with verified beef cattle, and feedlot operations. Previous protocols, such as the Quantification Protocol for Reducing the Age at Harvest of Beef Cattle, and the Quantification Protocol for Emission Reductions from Dairy Cattle, were previously withdrawn due to low uptake and high complexity, highlighting the need for simplified and low-barrier protocol development in the livestock sector (van Wyngaarden, 2022).

Other emission mitigation strategies have been researched and demonstrate significant potential to reduce enteric fermentation and methane emissions from beef cattle, such as the addition of certain feed additives, and changes in diet (Black et al., 2021; Kowk & Vinco, 2022).

While technical tools appear to be available in the field, little is known on the willingness of producers to adopt such technologies, and their attitudes and perspectives towards curbing GHG emission. Currently, there little incentivization exists for beef production stakeholders to adopt BMPs, as adoption is not associated with increased economic viability or gain and would require increased farm management and oversight (Liu et al., 2018).

The objective of the current work is to identify and analyze perceptions and attitudes of actors in the beef cattle production supply chain towards future methane emission reduction strategies. Insights from participants directly involved in current production practices were analyzed to highlight overarching themes

and topics, indicating areas that should be prioritized in future policy and protocol development, potentially increasing uptake and adoption, and improving support of methane emission reduction targets.

METHODOLOGY.

This research was reviewed and approved by the Conjoint Faculties Research Ethics Board (CFREB), University of Calgary (Ethics ID: REB22-0688). Questions asked to participants are listed in Appendix 1.

RESEARCH PARTICIPANTS AND ENGAGEMENT

The beef production supply chain is approached through the lens of stakeholders and actors that have a role in cattle production systems and their inputs. This includes animal geneticists, operators and farmers involved in cow/calf, backgrounding, and feedlots, actors in beef policy, farmer advocacy groups, and animal welfare experts.

Potential participants within these categories were recruited through centralized stakeholder lists. Contact was made through email and phone, inviting participants to complete the consent form, indicating their consent to the use of recording and transcription through the interview, and included preference for the use of personal information and details in the report. Participants had the option to consent to be referred to by their name, professional role/title, or to remain anonymous in the report. The data collected was completely anonymized and retained according to the University of Calgary's Secure Computing Data Storage requirements and Retention Policy.

RESEARCH SCOPE AND QUESTIONS

The proposed interview questions were divided into several segments:

1. General perceptions on climate change and links to the agricultural sector
2. Role of government in agricultural emission reductions
3. How emissions can be reduced on a short- and long-term horizon
4. Monetization and incentivization of GHG reductions

Within each of these segments, interviews were filtered and refined, in order to identify over-arching thematic dimensions and sentiments, in conjunction with the dichotomous questions. These themes were the basis of nodes within NVivo software. Working within these themes, answers to questions were compiled to

extract reoccurring sub-themes within these categories; this included specific strategies that were proposed by participants.

INTERVIEWS AND ANALYSIS

Interviews were conducted by two researchers throughout July and August 2022. The interviews were conducted through Zoom software, and recorded and/or transcribed, according to the participant's consent. Additionally, interviewer notes were taken throughout the interview for further context. The transcriptions were checked for accuracy against video, and the transcription text was uploaded to NVivo. Using the questions and scope as a guideline, the transcript for each interview was reviewed to fit within interview segments, which are as follows:

- Climate change and its potential impact on agriculture
- The role of government and industry (Top-down vs. Bottom-up approaches and solutions)
- Mitigation strategies on a short- and long-term horizon
- Incentivization and monetization
    - Longevity and profit
    - Carbon credits and the offset market

Climate Change and Agriculture

Opening interview questions probed participants background within the agricultural sector and defined their current role and progression throughout the sector. Participants were then asked about their belief in climate change and suggest how Alberta agriculture would be impacted by climate change. Analysis of answers was defined as sentiment towards belief of climate change and how it would impact Alberta, as well as reoccurring themes around how climate change would manifest within the Alberta agricultural supply chain.

The Role of Government and Industry

The relationship between agriculture and government was divided into three defined sub-structures for participants: the Federal government, the Provincial government, and local/municipal governments and organizations, which includes organizations like producer cooperatives and advocacy groups. Participants were asked what level of government should have the majority of responsibility in implementing emission

reduction policies, and define the role each level of government should have in the development and adoption of emission reduction strategies and BMPs, and the potential role of industry.

Mitigation Strategies: Short- and Long-term Horizons, and the Importance of Selection Traits

Participants were asked about if the federal target of a 30 percent methane emission reduction target by 2030 was feasible, supplemented with information about the Beef Advisors target of 33 percent emission reduction by 2030 and the Dairy Farmers of Canada target of net-zero by 2050 (Canadian Beef Advisors, 2020; Dairy Farmers of Canada, 2022; Environment and Climate Change Canada, 2021; National Beef Advisors, 2020). Following, participants were asked about short term mitigation strategies, considering the current beef production cycle and operational management, and insights from their own experiences within the supply chain, and interactions with other stakeholders. Long-term mitigation strategies considered current and future transformations within the beef cattle supply chain, in addition to external factors that influence the beef sector, such as changes in consumer preferences and perceptions. These strategies focussed less on current economic and societal barriers, instead concentrating on applications of emerging and innovating research in beef production. Finally, the role of genetics and trait selection in breeding methodology was defined, with participants describing current and future perspectives on applications and potentials into the future within the context of emission reduction targets.

Incentives and Monetization: Emissions as Indicators for Prosperity, Longevity, and the Carbon Offset Market

Participants were asked if emissions were linked to current and future prosperity and longevity at the on-farm level, and how these factors are connected. Further, participants were probed about options that would offer the best avenues for emission reductions to be monetized.

If participants had not yet brought up the carbon credit and offset market in the previous question, the interviewer introduced the idea, and asked participants about their existing knowledge of the market and potential current or previous participation in the market. Participants that had engaged in the market and sold credits were asked about their previous experience and overall sentiment, and why they were no longer participating. Participants who had not engaged in the market explored barriers to participation, and what

changes would be required in order to start participating in the market. Finally, participants were asked if carbon credits are perceived as a viable future revenue stream to offset transition risks.

This concluded the interviewer questions. Participants were then invited to further contribute and elaborate on previous questions and responses, and discuss any topics related to methane emission reduction strategies that were not covered in the questions. This concluded the interview.

RESULTS & DISCUSSION.

A total of 24 participants were interviewed (Table 1). Participants represented a mix of longstanding actors with little change in professional roles or affiliations, while others, more so on the policy and advocacy side, had more varied professional roles and experiences. Researchers identified four themes that encapsulated the key points which were covered in interviews with participants:

1. Climate Change
2. The Role of the Government and Industry - Top-down vs. Bottom-up approaches and solutions
    - The Role of the Federal Government,
    - The Role of the Provincial Government,
    - The Role of Producers and Adjacent Industries
    - Increased Producer Involvement in Policy Making
3. Enteric Methane Reduction Targets
    - Emission Reduction Strategies: Short-term Horizon
        - Improved diet
        - Feed additives
        - Cattle Management
    - Emission Reduction Strategies: Long-term Horizon
        - Genetics & Breeding
4. Incentives
    - Carbon Credits
    - Longevity and Profit
    - Additionality and Measurement

Table 1

Participant Breakdown

Industry Role	Participant Number	Distribution of Location
Producer	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	Central Alberta, Southern Alberta
Producers Association	13, 14, 15, 16, 17, 18, 19	Central Alberta, Saskatchewan, New Brunswick
Livestock genetics	20, 21, 22, 23	Central Alberta
Professor	24	British Columbia

1. CLIMATE CHANGE

All participants agreed that climate change is currently, and will continue to, impact agricultural production in Alberta. "*Climate change is a problem that animal agriculture has to embrace and accept*" (Participant 24). There was no apparent link between length of experience or variety of roles and sentiment towards climate change.

Increasingly severe weather events have introduced additional challenges for cattle producers at each stage of production. Extended droughts can have drastic impacts on grassland and pasture, reducing quality and quantity, especially impacting cow-calf operations directly (Edwards et al., 2018; Wheaton et al., 2008). Hot and dry weather leads reduced length of seasonal grazing potential, resulting in cow-calf operators securing increased feed supply for wintering, shifting to reliance on feed and rations (Schulz, 2021). Cow-calf operators highlighted that feed costs directly correlate to growing season climate and adverse weather events. Additionally, feedlot operators are heavily reliant upon the crop sector for the entirety of the feedlot phase; therefore, it is in both sectors' best interest to adopt practices that reduce drought risk and increase climate resiliency. Colder weather in the winter increases production costs by increasing cattle feed requirements due to increased energy converted to body heat (Anderson et al, 2011). Adverse weather events linked to climate change will require cattle operators across the production chain to increasingly consider risk management and resiliency on operations

Participants felt the beef sector was disproportionately targeted in conversations to reduce greenhouse gas emissions. Increased social pressure on cattle operations evident in public facing marketing and consumer-oriented campaigns prompt consumers to reduce, specifically, red meat consumption (Hedenus et al., 2014). Retailers like McDonalds, Harvey's and Walmart have initiated programs that consider beef producers' practices to appeal to shifting consumer concern towards sustainable beef products; however, actual verification of practices for sourcing remains convoluted (Browne, 2021; Roberts, 2019). While participants anticipate changes in the agricultural industry as a result of climate change, producers are confident in their ability to adapt and maintain production.

2. THE ROLE OF GOVERNMENT AND INDUSTRY - TOP-DOWN VS. BOTTOM-UP APPOACHES AND SOLUTIONS

The Role of the Federal Government

Participants viewed the Federal government's role in regulating emissions as setting goals and promoting emission reduction strategies, without mandating how goals will be met. Stakeholders across the beef production sector did not feel the Federal government bodies effectively understand the affordability and practicality of solutions; and therefore, are not in a position to mandate practices on producers. "*It is not their role to dictate what practices are used on farm, it is their job to set the ultimate goals of what needs to be done*" (Participant 21). If emission reductions are a priority for Canadians, participants felt that "*to level the playing field, at least at the national level, it has to be driven through the Federal government*" (Participant 21). Participants felt that it is the Federal government's role is to consult with both the Provincial government and local/industry beef sector leaders to provide producers with a framework and guidelines to meet emission targets, while ensuring equitable distribution of targets, mitigating inter-provincial conflicts related to emission reduction responsibilities. Ultimately, participants felt it is up to the Federal government to facilitate the operational aspects required to elevate the voices of all stakeholders when creating policy and regulations. Interviews with cattle operators confirmed that primary producers are looking for innovative solutions that will increase operational efficiency and productivity. This highlights an increasing need for the Federal government to continue expanding research funding and facilitate projects that progress technology and information required to effectively reduce emissions at the on-farm level, and ensure results are accessible to producers across the beef production supply chain.

The Role of the Provincial Government

Whilst participants agreed it is important to have harmonization between the Provincial and Federal governments to eliminate interprovincial competitiveness, the industry feels that the Provincial government can better account for operational and management variability, compared to the Federal government. "*At a federal level it is hard to encapsulate all production systems across Canada because they are very diverse within provinces*" (Participant 13). Participants saw an opportunity for the Provincial government to narrow Federal frameworks down to strategies that are implementable on a local level. "*Provincial organizations can help set out ways to achieve targets and help direct research*" (Participant 3). Participants felt as though there is clarity lacking around the prioritization of emission reductions within the beef cattle sector currently and into the future and questioned if the main driver of sustainable beef is shifting consumer demand, or government regulated goals related to sustainability and environment in Alberta and across Canada. Participants felt that "*the more our government is involved in setting direction, the better outcomes there will be for farmers*" (Participant 16).

Participants drew attention to the Provincial government's role in extension work. "*Every risk factor has this associated need for support from government programs and funding*" (Participant 16). Participants felt the Provincial government carries a responsibility of ensuring information is available to producers and accessible in different ways. Participants highlighted a need for the expansion of research and educational programs in order to increase the adoption of emission reduction strategies. "*Whether it is educational institutions who are involved, research associations, industry associations, we have got to get people on the ground to get it going*" (Participant 5). Overall, participants would like the Provincial government to put more resources into research, as well as consultation with the agriculture industry when developing polices. Integration of stakeholders throughout the development of policy and protocols is linked to increased subsequent adoption (OECD Regulatory Policy Outlook, 2021; Whitehead et al., 2020).

Producer's Role and Support from Adjacent Industries

Participants agreed that the role of industry is adopting and implementing strategies to reduce emissions at an operational level. Participants felt that it is important for producers to be presented with a range of options for provincial polices and strategies so that they can autonomously choose what will work best based on individual operation and management. "I*t is going to have to be tackled on farm by individual farmers, not*

a blanket 'this is what you have to do to solve the problem'" (Participant 3). Discussions with participants exposed an underlying resistance to change within the agriculture industry. Many producers accredited this reluctance to change to a lack of communication and understanding, resulting in a feeling of loss of sovereignty and autonomy. Participants felt the information required to make informed decisions regarding the trade-offs associated with new technologies and practices is currently inaccessible or misleading, favouring government aligned emission reduction targets, rather than farmer livelihood and on-farm economic viability. Producers are looking for solutions that are sustainable and balanced from an economic and environmental standpoint; extension programs in place to educate producers on what practices will support emission reductions specific to their operation and drive economic possibility must be prioritized in order to achieve this goal.

Industries across the beef production supply chain indicated wanting to be involved in the policy development process to ensure that new protocols and programs consider the industries perspective and are accessible to producers. "*Industry is really best positioned to determine what beneficial management practices have an impact on some of these environmental challenges [and] are actually logistically capable of being implemented on farm*" (Participant 16). Participants felt there is "*a lot of nuances*" that the actual producers in industry organizations can provide to conversations "*to help [put in] perspective and context*" (Participant 16). Associations, such as the Alberta Cattle Feeders Association, Alberta Beef Producers, and the Canadian Cattleman's Association, and the Canadian Roundtable for Sustainable Beef production, and programs in place such as Verified Beef, were viewed as producer-centric and representative organizations that should be working alongside governments to advocate for industry perspectives and input, as voiced by participants.

Increased Producer Involvement in Policy Making

Most participants indicated preference for emission reduction efforts to be approached from the bottom-up. Participants disfavour policy developed with a top-down approach in the view that the government lacks practical understanding of solutions that are feasible on an operational level. To achieve emission reduction targets, participants called for the implementation of a bottom-up approach that includes the voices of all relevant stakeholders, creating policy that the industry feels is representative of their challenges and perspectives. "*We can't have policy coming down from the Federal Government that's contradicted by a*

provincial policy and that is not implementable on farm" (Participant 16). Many participants suggested that the industry is striving to advance and develop, however, there is a disconnect in understanding what needs to change. "*The government needs to agree on a particular direction and the industry needs to be consulted along the way*" (Participant 4). Producers demanded that the government recognizes they are "*part of the solution, not a part of the problem*" (Participant 18). Participants concluded that if the government wants to reduce emissions, they must be consulting with industry to build an effective framework to achieve aligned goals. This will require effective communication and consultation between levels, at each stage of policy and protocol development. "*When it comes to climate change, mitigation strategies have to be accepted, and they have to be accepted at the farm level, at the provincial level, and at the federal level*" (Participant 24). Participants felt a need for collaboration between the government and the agriculture industry to ensure that new policy and protocols promote innovative management practices in a way that will not impair the livelihoods of producer operations.

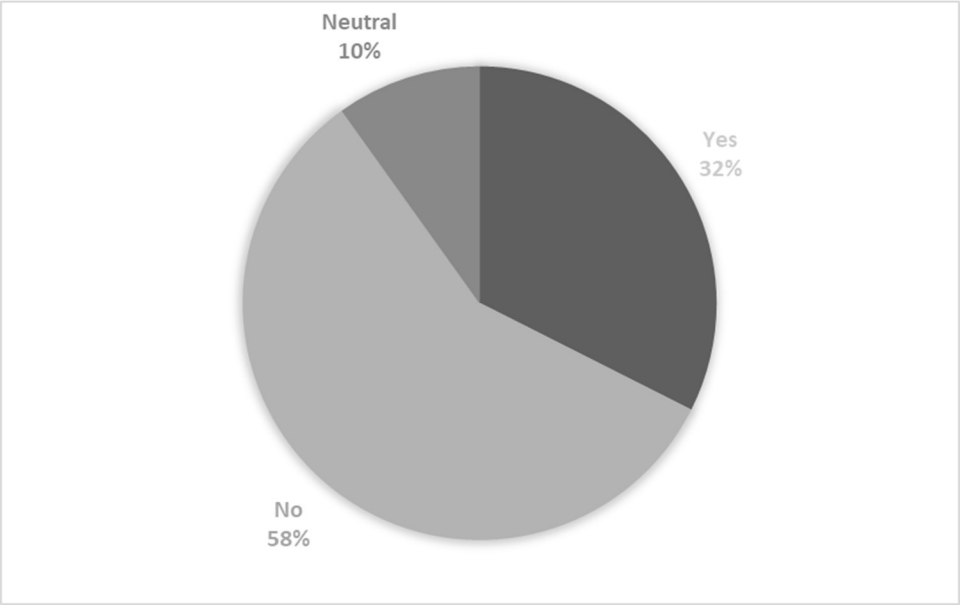
3. ENTERIC METHANE EMISSION REDUCTION TARGETS

The majority of participants did not feel the Beef Advisors 2030 emission target of 33 percent respectively is feasible (Figure 1). Cattle operators considered current emission targets to be overly ambitious and out of reach. Ultimately, producers consistently commented on the 2030 timeline being drastically too short to successfully reduce emissions. "*Eight years is not a whole lot of time to go through that whole cycle of developing technologies, getting producers to accept the technology, and then successfully incorporating it into their operations*" (Participant 21). Conversations exposed a level of frustration with the Federal government's methane emission reduction target of 30 percent by 2030, as participants feel unattainable expectations have been set without providing a framework that details pathways for implementation considering variability in operations and practices. "*It has to be a target that we can actually hit, it has to be developed with the farmers voice*" (Participant 7).

Participants across the beef supply chain highlighted the importance of sustainability from an environmental lens, as well as an economic lens. There was concern amongst producers that there will be negative repercussions from adopting strategies aimed to reduce enteric methane emissions. Operators felt as though the changes required to meet these targets are unsustainable into the long term and threaten operational

profit. The enteric methane dimension of the emission targets is complicated due to variations in operations between each phase of production (cow-calf, backgrounding, feedlots). What may be possible at one stage of production and within the supply chain may not be applicable at other stages. Unanimously, the dairy industries target for net zero by 2050 was seen as unrealistic. Participants felt as though *"the technology needed to meet 2050 net zero has not been discovered yet"* (Participant 18). It is important that government bodies set targets that participants feel are attainable.

Figure 1:



Perception of feasibility of 2030 enteric methane emission targets, by percentage of participants.

Emission Reduction Strategies: Short-Term Horizons

Considering a short-term horizon, discussions around enteric methane (CH_4) reduction highlighted three emission reduction strategies that can be readily implemented today (Figure 2):

- Improved diet
- Feed additives
- Cattle management

Figure 2:

Frequency of references to enteric methane emission reduction strategies throughout interviews with participants.

Improved Diet

Participants conveyed the important role of diet in enteric CH_4 production. Lower feed quality and higher feed intake leads to higher CH_4 emissions (Min et al., 2022). Beef producers are aiming to minimize diet cost while simultaneously optimizing production and quality (Kerley, 2012).

Enteric methane emissions are higher in the cow-calf phase of production, compared to feedlot phase, due to higher fiber content in forages (Broocks et al., 2020). Changing to forages with improved quality and forages with certain secondary compounds, such as tannins and saponins, has demonstrated capacity to decrease methane emissions (Kowk & Vinco, 2022; Thompson & Rowntree, 2020). The feasibility of these methane reduction strategies would vary across operations, as operation location, pasture management methods, and the effects of extreme climate and weather events, such as droughts, influence pasture quantity and quality (Kulshreshtha & Klein, 1989).

Feed Additives

Participants view feed additives as a promising option to further improve cattle diets and feed efficiency, in turn reducing enteric CH_4 emissions. Feed additives improve feed efficiency, feed quality, animal performance, and animal health (Honan et al., 2022). There are a variety of feed additives with potential to reduce enteric CH_4 currently available or in development (Honan et al., 2022). The additive 3-nitroxypropanol (3NOP) stood out in discussions as many participants feel as though it is the most assuring strategy to directly target and reduce enteric CH_4 production. "*One of the biggest opportunities in the feeding sector are feed additives, and primarily the one that we are most interested in at the moment is 3NOP*" (Participant 16). 3NOP inhibits an important step in the methanogenesis pathway and has shown significant reductions in methane production without having any apparent effects on milk or beef production (Honan et al., 2022). 3NOP is not yet approved in Canada. Participants expressed that regulatory approvals of 3NOP will play a significant role in potentially meeting 2030 emission targets and present a significant barrier considering the limited timeline. "*Regulatory approvals of products like 3NOP are important because we estimate that could provide us with another 8-11 percent [emission reduction]*" (Participant 13).

Several participants articulated the challenges associated with distributing feed additives in different management systems. "*A lot of technologies are really easy to deliver in a feedlot setting, [however], are a quite a bit more difficult to deliver on an extensive grazing system*" (Participant 16). Cow-calf operations do not have a mechanism to deliver and allocate feed additives at a prescriptive dosage, ensuring cattle receive amounts required for effect. Interviews highlighted an overall theme of hesitation to change in the cattle industry. Producers perceived a high-risk with changing-well developed feed rations without a comprehensive understanding of how it may impact production. *"There's a lot of lack of clarity around these products about, yes they may reduce greenhouse gas emissions, but is there an associated performance benefit?"* (Participant 13). Many participants felt as though further research is needed to understand the chemical profile in feed additives and how impact on animal and human health, and the final product. "*While these products are beneficial and they do have an [emission] reduction, you do have toxicity levels associated with them and other concerns that have shown up in the research that needs to be very carefully understood and communicated to producers so that they are aware of the risks*" (Participant 13). Participants were

apprehensive that the introduction of additives may compromise public trust in the food production system. *"There is a generalized concern around unnatural things being put into the food system"* (Participant 16).

Cattle Management

Participants suggested that sustainability, especially at the phase of cow-calf operations, is greatly improved with proper cattle and grazing management. This includes proper rotational grazing management to prevent overuse, adequate forage based on requirements, grazing native rangeland at appropriate times, protection of riparian areas, and maintaining proper stocking rate to ensure livestock efficiency (Wang et al., 2021). Participants drew attention to increased labour requirements associated with rotational grazing (Boyer et al., 2022). Proper rotational grazing requires moving cattle frequently and additional fencing infrastructure. "*Rotational grazing requires more frequent moves, that requires more labour to put up and take down fences*" (Participant 16). With increasingly prevalent labour shortages within the agricultural industry, participants expressed that any additional labour demand is a barrier to adoption. "*Grazing management is both an art and a science, and more often than not, the art side of things, so the skilled labour side*" (Participant 14). Adoption of several grazing management practices is high in Alberta, according to the 2018 Environmentally Sustainable Agriculture Tracking Survey; however, results from the survey demonstrate adoption variability across the province and did not include questions about management-intensive grazing practice adoption (Kynetec Canada, 2018).

Emission Reduction Strategies: Long-Term Horizons

Considering a more long-term lens, participants believed the following strategies will have a substantial role in the reduction of enteric methane production from cattle:

- Genetics & Breeding

Genetics & Breeding

Genetic selection and breeding have enabled producers to finish cattle sooner and more efficiently, and influences producers' choices on their operations. Most beef producers select for cattle that have a low birth rate and high weaning weights, as voiced by participants. Selection for these growth traits has resulted in significant genetic improvement in cattle (Kerley, 2012). There is additional genetic potential to improve feed efficiency through selection for residual feed intake (RFI), contingent on measures of metabolic efficiency,

improving feed to gain proportions and increasing production markers. This factor also includes a degree of heritability, with is evidence demonstrating cattle with low RFI produce offspring that exhibit RFI traits (Kerley, 2012). Participants foresaw the use of genetic improvement as a tool to improve economic profitability and efficiency of beef and dairy production while simultaneously reducing enteric CH_4 production. "*I do believe genetic selection of specific traits like feed efficiency would reduce emissions, in terms of producing more feed efficient animals so that we make the same amount but with less resources*" (Participant 20).

The province of Alberta has implemented a quantification protocol for selection for low residual feed intake in beef cattle. Conversations with participants suggested that Alberta's RFI protocol has low uptake due to over-complexity and lack of cost-benefit. Many participants felt the program requires substantial additional resources and allocation with minimal monetary reward. Participants attributed low uptake of the RFI protocol "*to the onerous nature of the programs, and how much extra work they are for a relatively, at this this point in time, little payoff*" (Participant 16). Producers identified the data[1] requirements of the protocol as a barrier to adoption, as many farmers do not have adequate data quality and data management systems to track feed in correlation to cattle gains. Producers suggested that "*because the protocol demands evidence in a certain way, the industry has had trouble tweaking their systems to provide the evidence grade data to understand that the animal received what the protocol prescribed*" (Participant 11). Protocols such as the RFI are viewed as the right approach, however, in need of further refinement to gain uptake. With improvements, participants agreed that the RFI protocol has the potential to be "*a great situation for farmers because you get a more efficient herd which basically means less costs associated with the input cost for feed, and you are addressing climate change*" (Participant 21).

Beef producers highlighted a shift away from pure-bred cattle. The cattle industry utilizes crossbreeding as a strategy to achieve optimal genetic improvement, and interviews indicated that producers understand this connection, with implementation on-farm. "*We very much see our genetic variation as a strength that we bring to adapting to different environments and different production systems*" (Participant 13). Crossbreeding

[1] Data refers to the burden associated with data collection, management, storage and maintenance. Data is required for the measurement and benchmarking of emissions, and detailed data is compulsory when applying for carbon credits in the offset market.

provides an opportunity to take advantage of breed differences and breed progeny that are more efficient than their dam breed (Kerley, 2012). "*Being able to adopt genetics that work best for their situation and operation" is seen as a huge advantage within the cattle industry* (Participant 13). One of the challenges associated with the development of cattle genetics was that "*there are a lot of different breed mixes in different proportions*", which can make it challenging to capitalize on genetic benefits (Participant 16). Participants highlighted the differences in genetic requirements between sectors. "*The cattle you are raising for the feedlot system have to grow a certain way but you kind of want a different set of traits when you are building a cow-calf herd*" (Participant 16).

Participants communicated a need for additional research that studies the interactions and correlations between reduced methane production and other economically important traits, in order to increase adoption of genetic technology in the cattle industry. "*When we put pressure on specific traits there can be negative or positive effects on other traits*" (Participant 20). Participants across sectors expressed certainty that genetic improvements are likely to make a substantial difference in enteric methane emissions; however, it will be a challenge to implement and reap the benefits of genetic selection and breeding strategies within the current proposed timelines. "*The challenge is it's a short time period between now and 2030 to make genetic improvement*" (Participant 9).

4. INCENTIVES

The agriculture industry would prefer as little government intervention as possible; however, to encourage cattle operators to change practices, participants believe the government must implement an incentive program. "*If society has a desire to see changes, then they need to incentivize farmers in order to make those changes*" (Participant 19). It is not feasible for producers to "*do the right thing*" with no economic incentive attached.

Economic incentives were viewed as the best strategy to increase the adoption of emission reduction practices by participants. "*There needs to be voluntary carrots, and the carrots need to be money"* (Participant 19). An effective incentivization program will clearly define and guide the adoption of emission reduction strategies. For incentivization programs to be meaningful, participants must feel as though the programs goals

are achievable and that they will be compensated for their contributions. Cattle operators expressed that they are more likely to participate in an incentive program that they feel is realistic and beneficial to their operation across multiple dimensions, but most importantly, economically, and financially. Participants voiced a need to refine current incentivization programs so that they are straightforward and easy to adopt, minimizing any potential barriers and burdens producers would have to take on throughout the adoption process and implementation. "*We need something simple that encourages farmers and ranchers to take up a certain type of operation or change something slightly*" (Participant 1). Current protocols such as the Residual Feed Intake Protocol, have several barriers to adoption mentioned by participants, such as increased labor requirements, narrow eligibility relative to the beef production cycle and supply chain, over-complexity, and data constraints. There is a need to differentiate protocols between different cattle operations, as there are drastic differences within the beef production cycle and between on-farm operations across the province. Before effective protocols can be put in place, the question of measurement and baseline at the cow-calf level, a topic consistently brought up throughout interviews, must be addressed, to ensure operations have an accessible and accurate way to track grazing management indicators and intake.

Discussions uncovered major disconnects between the government and the agricultural sector in Alberta. It was clear participants do not want to be told by the government how to run their operations. Across participants, industry stakeholders felt the government lacks qualification and requisite practical knowledge to be making decisions on behalf of producers. Information and data being used at government levels, especially Federally, does not always align with on-farm circumstances and reflect producer objectives according to interviews. Participants suggested incentivization programs and protocols should include producers in the development process to align benefits and increase farmers willingness to adopt. "*It needs to come within, and from the grassroots to be captures or to get the uptake*" (Participant 2). This will ensure there are recognizable and equitable benefits for both the government targets and stakeholders in the agricultural sector. An effective incentivization program should prioritize leveraging operators in the beef supply chain who already adopted or have a high likelihood of adopting emission reduction practices with demonstrable benefits to the producer.

Carbon Credits

Incentivization programs such as the carbon credit protocol are not effectively creating changes in practice. Interviews drew attention to a chasm between the protocol's goals and outcomes. The carbon credit protocol is primarily viewed by participants as a relatively easy way for producers to "*fill out paperwork and get a couple thousand dollars, having no effect on anybody's practices or operation*" (Participant 8). Protocols applicable in the beef sector have very little uptake (van Wyngaarden, 2022). Poor uptake was linked to its impracticality for the majority of producers, as indicated throughout interviews and across participants. Producers felt as though there are currently more challenges than opportunities associated with participation in the carbon credit market. Considering the data requirements and extensive administrative and record keeping burden associated with carbon offset protocol and market, producers did not feel there is a significant economic benefit; a sentiment further re-enforced as participants who engaged previously within the market indicated that only a relatively small portion of each carbon credit payment actually ends up in producers' hands, with requirements of payment allocation to the aggregator, and often depending on the production dynamic, the landowner.

Currently, the use of native rangeland for pasture and grazing, associated with sustainable grazing practices, does not qualify for the carbon credit program. This was an especially frustrating topic to many cattle operators as their role is perceived as providing significant ecosystem services within this capacity and would like the carbon sequestration dimension associated with this service to be recognized. The first carbon offset protocol applicable to Canadian grasslands is in development, proposed by The Reserve and Viresco Solutions, and funded in part by funded in part by the Canadian Forage and Grassland Association (Climate Action Reserve, 2019). Ultimately, the benefits of carbon offset protocols do not out-weigh the potential risks and previous experience of faults within the system. Producers would like to see the government improve the current program so that it is easy to implement on-farm and can become an additional revenue stream for their operations, without incurring significant additional costs or resources, including labour and administrative burden.

Longevity & Profit

The majority of participants believed operations that produce fewer emissions will have a higher chance of continued longevity. Many cattle operators recognized a heightened consumer awareness and demand for environmentally conscious and sustainable products, suggesting producers that adopt emission reduction strategies will become more competitive in the market. Social incentives, such as a producer's reputation, may play a role in motivating the adoption of sustainable practices. *"In the last years we've seen opportunities for producers to sell certified sustainable beef that needs a certification, that is we're seeing a demand pull from the marketplace"* (Participant 13). Participants provided the example of high-margin companies such as Mcdonald's that have implemented a sustainability index that surveys producers' practices and ranks their sustainability, offering higher payouts to top-ranking producers (Roberts, 2019). Participants acknowledged that climate change is happening and imply operations that are willing to adapt and proactively change practices will be the most successful in the long run. Generally, participants linked the adoption of emission reduction practices and strategies with operational and management efficiency and are therefore associated with enabling expansion and growth. Some opposing participants, however, did not correlate operations that reduce emissions with a higher chance of continued longevity or efficiency. *"It is really difficult to correlate those two, there are so many aspects to that"* (Participant 13). These participants drew attention to the fact that the environment is only one aspect of a three-pillar system. An effective and comprehensive business strategy must also account for social and economic pillars to effectively support the viability of an operation that pursues sustainability. Participants stated that *"there are a lot of factors that influence the longevity of an operation, but emissions are not one of them"* (Participant 24).

Generally, participants did not feel as though operations that reduce emissions will have increased profit. Most emission reduction strategies were not currently viewed as being profitable or having the potential to drive profits by participants, as a cattle producer stated, "*price isn't influenced by your operation; it is influenced by the type of calf*" (Participant 6). Cattle operators' priorities remained centered around maximizing the rate of gain to ensure optimal profits. Some participants were optimistic that in the future operations that reduce emissions will have higher profits as a result of increased efficiency and market demand; however, that is not seen as a reality at this point in time.

Additionality & Measurement

The consideration of additionality is critical to the development of establishing emission baselines and subsequent eligibility of carbon credit protocols. Additionality is defined as the creation of additional emission reductions through practice adoption and implementation; it is crucial that these reductions would not have occurred in the absence of emission credit and trading protocols to ensure environmental effectiveness and economic efficiency (Climate Change Authority, 2014).

Additionality was a large point of contention amongst Albertan producers. Early adopters of emission reduction practices and best management practices associated with cattle production, especially at the cow-calf level, want to be recognized for being proactive on environmental and sustainability fronts, and expressed frustration about potentially being left out as policy is developed and adopted now. Cattle producers maintaining native grasslands and pastures felt "*there is no consideration as to what we [producers] have already done*" (Participant 5). Conversations with participants suggested that producers felt disproportionately targeted in conversations to reduce emissions, with the beef sector being a main target for pressures to change. Cattle operators emphasized that they have been improving their practices and providing ecosystem services while optimizing production for generations. "*I think in the last years farmers have done a lot more to change their emission habits than the rest of the population*" (Participant 6). Participants did not feel as though there is a good framework in place to reward producers for the ecosystem services and environmental contributions up to this stage.

Native grasslands are carbon sinks, working to sequester carbon from the atmosphere (Richard et al., 2017). Many producers felt as though carbon sequestration is currently being grossly underestimated and that the benefits of proper landscape maintenance through pasture and grazing management should be monetized. Producers pointed out that "*right now we are being taxed on emissions, but emission reductions or carbon sequestration are not being recognized*" (Participant 18). Cattle producers indicated feeling as though crop producers had more opportunities to participate in incentive programs, encompassed by the statement in reference to pasture grazing, "*grain farmers get paid for zero-till and when we do it, we don't get recognized*" (Participant 12).

Not only were cattle operators concerned about accounting of their previous contributions, but many operators did not feel as though there is currently a feasible or accurate way to measure changes in enteric

CH_4 emissions. There was concern surrounding what measurement is being used as the baseline, since enteric methane emissions and soil carbon sequestration can depend on several factors, and vary significantly across farms and livestock (Donoghue et al., 2016; Samsonstuen et al., 2020; Zhang et al., 2021). The Provincial government needs to invest in developing stronger protocol around measurement and quantification of greenhouse gas emissions and extend that framework so that it can adapt to the beef production sector. This will support producer understanding and perspectives of current benchmarks, helping producers contextualize how implementing emission reduction strategies at the on-farm level will translate into quantifiable emission reductions, contributing to industry goals and appealing to consumer demand.

CONCLUSION.

The Canadian beef sector has faced numerous challenges in the past years across multiple dimensions. Despite shifts in consumer demand and public perception, the beef industry has leveraged their unique position and production cycle to adapt to ongoing transformation in the agri-food sector, ensuring continuing growth and stability.

Adoption of the Beef Advisors proposed strategies for sustainable beef production encompasses more than uptake and adoption of best management practices. Rather, the beef production cycle must be recontextualized to consider sustainability within environmental, social, and economic axes. Participants indicated frustration related to the lack of recognition of the cattle sector's role in maintaining native grasslands and landscapes through pasture management and grazing at the cow-calf level. Although this stage of production is linked to higher emissions compared to cattle in the feedlot stage, the value of eco-system services provided by grazing cattle through carbon sequestration must be recognized.

Overall, participants across the beef production supply chain indicated the importance of developing agricultural policy within the sector using a bottom-up approach, as the Federal government lacks on-farm operational and practical knowledge. Rather, providing access for stakeholders directly involved in beef production to voice their concerns will ensure subsequent policy is relevant and producer-inclusive. This approach can also present as a potential opportunity to improve measurement of emissions at the on-farm

level, facilitating data collection and utilization from stakeholders directly involved in beef cattle production across the production cycle, including producers that use alternative production methods and strategies.

Current poor uptake and restricted applicability of protocols in Alberta were mainly attributed to two factors by participants: limited eligibility, and increased administrative burden on producers that did not equate the potential gain in value. In order to drive interest in incentivization and monetization for adoption of emission reduction strategies at the on-farm level, further development and expansion of protocols that can be applied throughout different stages of the beef production supply chain must be prioritized. Incentives should be communicated as an avenue to potentially increase cattle and on-farm efficiency, as participants associated emission reduction as an indicator of overall improvement in productivity, with increased likelihood of prosperity and longevity. Structures that mitigate perceived risks associated with adoption may further increase adoption, as increased costs associated with management and feed were perceived as barriers to participants throughout interviews.

Re-investment and expansion of agricultural extension programs and services is a critical next step in ensuring stakeholders within beef production in Alberta are fully informed on emission reduction strategies. Participants expressed frustration and dissatisfaction with current provincial extension services and the reduced availability of extension events over the past years. Extension services and the opportunity to tangibly see results of strategy implementation at the on-farm level was consistently cited as being important among participants and producer groups. Research and outreach in short- and long-term emission reduction strategies discussed throughout the report throughout the province, demonstrating specific pathways for adoption throughout the province can potentially drive adoption. This is also an important opportunity to re-establish and strengthen communication channels and engagement between producers and government.

The resilience of the Canadian beef sector throughout numerous challenges over the past decades is a testament to its future and roots in Alberta identity. Ambitious transformation described in the Beef Advisors National Beef Strategy to reduce primary production GHG emission intensity by 33 percent by 2030 will require changes across the entire beef production supply chain. Ensuring beef production is re-framed to include the value of eco-system services provided through cattle pasture and grazing management will be critical going forward and shifting consumer perception of beef products.

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APPENDIX.

Appendix 1: Interview questions

General Questions:

How long have you been working in your industry?

Can you provide an overview of your role/profession? Can you provide an approximate location?

Do you think that climate change will impact agricultural production?

How do you think it will specifically impact your business/operation?

Do you feel that addressing agricultural emissions and reductions should be a federal task/a provincial task/a local or farm level task?

What should be the role of the federal government in regulating emissions and promotions in the development of Best Management Practices? (Top-down)

What role should industry have in the promotion or development in the adoption of Best Management Practices? (Bottom-up)

Cattle Production Questions:

The global methane pledge committed to reducing Canadian methane emissions by 30% by 2030. This aligns with the Canadian Beef Advisors action plan, and the Dairy Farmers of Canada's announcement to reach net-zero by 2050.

- Do you feel this target can be met?
- Is 30% too much/too little?

If cost adoption was not a factor, what do you believe to be the most effective way at reducing cattle enteric methane emissions that is currently available/in the near term?

- What are the challenges associated with adopting those practices?
- Will the adoption of this practice require changes to human capital? (I.e., more trained technicians, increased tech literacy, more workers)
- Will the adoption of this practice require changes to physical capital? (I.e., infrastructure and equipment)

Considering economic considerations, what do you believe to be the most cost-effective way at reducing cattle enteric methane emissions that is currently available/in the near term?

- What are the challenges associated with adopting those practices?
- Will the adoption of this practice require changes to human capital? (I.e., more trained technicians, increased tech literacy, more workers)
- Will the adoption of this practice require changes to physical capital? (I.e., infrastructure and equipment)

Has genetic selection/breeding methodologies influenced your choices on your operation?

- Has this contributed to reducing input?

- Has this contributed to reduced emissions from on-farm operations/production?
- Do you see increased/decreased use of genetic selection with increasing pressure to reduce emissions?

What opportunities/challenges can adoption of mitigation strategies present in animal health and production/market measures?

Looking into the future, are there any emerging technologies or practices that have the potential to significantly reduce cattle enteric methane emissions that you are aware of?

- What are the challenges associated with adopting those practices?
- Will the adoption of this practice require changes to human capital? (I.e., more trained technicians, increased tech literacy, more workers)
- Will the adoption of this practice require changes to physical capital? (I.e., infrastructure and equipment)
- Do you foresee any barriers for bringing this product/technology to market?

Monetization and Incentive:

- Do agricultural emissions influence the longevity of an operation? Do you feel that operations that produce less emissions have a higher chance of continued longevity?
- Do you feel that operations that reduce emissions have higher profits?
- How can strategies to reduce emissions be monetized? What options do you believe would create the best opportunities in this market?
- Were you aware of the Carbon Credit/Offset market? Have you participated in the market? What are some of the challenges you have experiences/foresee in participating in the market?
- Where do you see the developing Carbon Credit system/sale of carbon offsets becoming more significant in reductions of on-farm emissions?
- Do you foresee the sale of Carbon Credits as a viable way to offset costs and provide an additional revenue stream based on your operation?

I do not have any more questions. Would you like to add anything else, or highlight any themes or responses to any of the questions?

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