

Consumer Preferences for Beef and Grassland Ecosystem Services

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Overview

1. Introduction
2. Data and Experiment Design
3. Econometric Model
4. Results
5. Discussion and Conclusions

Introduction

Grasslands Ecosystem Services

- Grasslands cover 40% of Earth's land surface and provide a wide range of ecosystem services that benefit both people and nature.
- However, 60% of native North American grasslands have been converted or degraded in the past century (Commission for Environmental Cooperation, 2025).

Cattle Grazing and Grasslands

- In cow-calf operations, cattle graze on grasslands as their main feed source.

Introduction

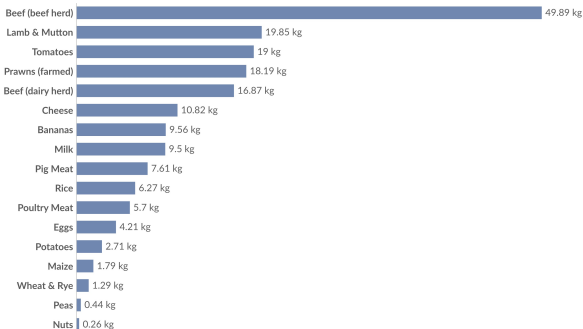
Beef's Environmental Concern

- Per kilogram of protein, beef has the **highest** greenhouse-gas (GHG) footprint of popular proteins.

Greenhouse gas emissions per 100 grams of protein

Our World
in Data

Greenhouse gas emissions are measured in kilograms of carbon dioxide-equivalents.



Introduction

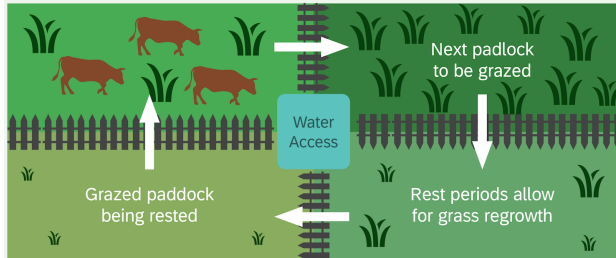
What is Less Known: Grasslands Need Grazing

- Grasslands are **disturbance-dependent**: periodic grazing, fire, and drought are necessary to maintain productivity and biodiversity (Carlyle, 2019).
- Cattle can play an ecologically similar role to historical bison herds on native grasslands.
- Environmental outcomes depend on **how** grazing is managed:
 - *Undergrazing*: dead plant matter accumulates, shrub encroachment increases, biodiversity declines, wildfire risk grows.
 - *Overgrazing*: soil compacts, erosion accelerates, carbon storage and biodiversity decline, grasslands degrade permanently.
 - *Climate-Smart Grazing*

Introduction

Climate-Smart Grazing

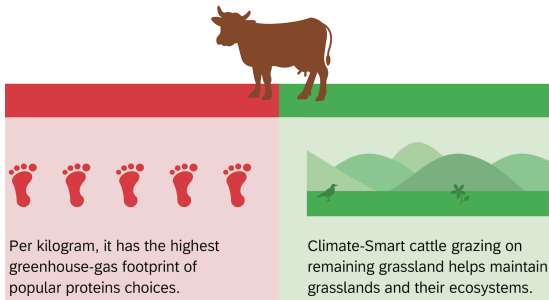
- Carefully manage how cattle are grazed.
- **Rotating cattle** between paddocks so plants can rest and regrow deeper roots, and matching herd size to what the land can be supportive so soils and ground cover survive dry years.



Introduction

Consumer Protein Choices

- A tradeoff between beef's high footprint and its role in sustaining grassland ecosystem services.
- Limited awareness of the beef–grazing–grassland nexus.



Introduction

Using an online survey across North America combined with a basket-based choice experiment:

- How does information about beef–grazing–grassland affect consumer beliefs and preferences for beef products?
 - Consumer beliefs about beef's environmental role
 - Demand for conventional beef and climate-smart beef

Data

An online survey conducted in Canada and the United States.

- Consumption patterns for beef and other protein products
- Attitudes, perceptions, and beliefs about beef, grazing, and grassland
- Information treatment on beef, grazing, and grassland
- Basket-based choice experiment to elicit consumer preferences for protein products
- Socio-demographic characteristics

Pilot Sample

Table 1: Number of Respondents in the Pilot Survey

Country	Information treatment group		Total
	Control	Treatment	
Canada	98	110	208
United States	98	101	199
Total	196	211	407

Information Treatment

General information for all respondents

Grasslands Ecosystem Services

- Grasslands are open ecosystems dominated by grasses and herbaceous plants.
- An ecosystem service is a benefit a natural system provides to people.
- Grasslands are one of the world's most widespread and important ecosystems, covering approximately **40%** of Earth's land surface.
- Grasslands provide **a wide range of ecosystem services** that benefit both people and nature, including biodiversity (habitat for plants, birds, pollinators, and soil organisms), soil health, erosion control, water regulation, soil carbon storage, and the cultural landscape of open country and ranching tradition.
- However, grasslands are **disappearing** rapidly. Approximately **60%** of native grassland ecosystems in North America have been converted to **other land uses or degraded** in the last century, raising significant conservation concerns.

In cow-calf operations, cattle graze on grasslands as their main feed source, directly linking beef production to the health of grasslands.



Image Source: Tom Koerner/USFWS, CC BY 2.0

Information Treatment

Treatment group:



Beef's Environmental Concern

- Per kilogram of protein, beef has the highest greenhouse-gas footprint of popular proteins. Cattle are ruminants, which means their digestion hosts microbes that produce enteric methane, a potent greenhouse gas.
- Chicken and pigs are not ruminants and produce far less enteric methane, but their systems carry other greenhouse-gas drivers. Plant proteins (legumes, tofu) generally have the lowest per-kilogram footprint among popular proteins; seafood varies widely by species and fishing method.
- Environmental concern has led many consumers to change their protein choices.

Information Treatment

The Role of Cattle Grazing in Grassland Ecosystem Services

- What is less widely known is that grasslands are a disturbance-dependent ecosystem, and they require periodic disturbance (e.g., grazing, fire, drought) to remain productive and diverse. For thousands of years, large herbivores such as bison and elk shaped North American grasslands through grazing, trampling, and movement. The grasses and soils of these ecosystems developed in direct response to this sustained disturbance.
- Across North America, most native grassland has been lost to cropland conversion, and much of what remains is on private cattle ranches. Cattle can play an ecologically similar role to the historical herds of bison. However, the environmental outcome depends on how grazing is managed:
 - **Undergrazing:** insufficient livestock pressure on grasslands. Dead plant matter accumulates, suppressing new growth, facilitating shrub encroachment, reducing biodiversity, slowing nutrient cycling, and building fuel loads that drive large wildfires.
 - **Overgrazing:** too many animals concentrated in one area for too long. Soil compacts, erosion accelerates, carbon storage capacity declines, biodiversity declines and grasslands can be pushed into permanent degradation.
 - **Climate-smart grazing:** practices that carefully manage how cattle are grazed: rotating them between paddocks so plants can rest and regrow deeper roots, and matching herd size to what the land can be supportive so soils and ground cover survive dry years. Done well, grazing practices sustain the ecosystem services grasslands provide while lowering beef's per-kilogram greenhouse-gas footprint.

Information Treatment

Where this Leaves the Consumer

- Choosing what to eat involves a mix of considerations: nutrition, cost, taste, tradition, animal welfare, impact on climate and ecosystems. These considerations don't always point the same way.
- Beef sits at the centre of that complexity. Per kilogram, it has the highest greenhouse-gas footprint of popular proteins. At the same time, cattle grazing on remaining native rangeland is part of how the grassland ecosystem and the species that depend on it are maintained.
- Climate-smart beef is one option a consumer can choose; whether it is the right choice for any given person depends on how that person weighs these factors against each other and against the alternative proteins available.

Basket-Based Choice Experiment

Number of protein products: 16

1. **Beef:** Ribeye Steak, Top Sirloin Steak, Ground Beef
2. **Climate-Smart Beef:** Ribeye Steak, Top Sirloin Steak, Ground Beef
3. **Pork and Poultry:** Pork Loin Chops, Chicken Breasts, Chicken Drumsticks
4. **Fish/Seafood:** Shrimp, Salmon
5. **Plant-Based:** Plant-Based Burger Patties, Tofu, Canned Beans, Lentils

Table 2: Price Levels in the Experiment (Canada)

Product	Package size	Low	Medium	High
Ribeye Steak	340 g	\$20.49	\$25.49	\$30.49
Top Sirloin Steak	340 g	\$11.99	\$14.99	\$17.99
Ground Beef	454 g	\$6.99	\$8.49	\$9.99
Pork Loin Chops	454 g	\$5.49	\$6.99	\$8.49
Bacon	375 g	\$5.99	\$7.49	\$8.99
Chicken Breasts	454 g	\$5.99	\$7.49	\$8.99
Chicken Drumsticks	454 g	\$3.49	\$4.49	\$5.49
Shrimp	340 g	\$6.99	\$8.49	\$9.99
Salmon	454 g	\$12.49	\$13.99	\$15.49
Plant-Based Burger Patties	226 g	\$5.99	\$7.49	\$8.99
Tofu	454 g	\$2.49	\$3.24	\$3.99
Canned Beans	398 mL	\$0.99	\$1.49	\$1.99
Lentils	450 g	\$1.39	\$1.89	\$2.39

The price of Climate-Smart Beef is dependent on the assigned price of the conventional beef: Low premium (0%), Medium premium (25%), High Premium(50%)

Basket-Based Choice Experiment

Experimental design:

- 6 blocks, each containing 9 choice tasks.
- Respondents can select multiple products or none.
- Product order is randomized at the respondent level.
- Conventional and climate-smart beef products are displayed next to each other.

[1/9] Please select all the products you would likely purchase at the prices shown, then click “Finish” to continue. Remember that you stated your weekly expense for food is [piped text].

 Beef Top Sirloin Steak 340 g · \$4.41/100 g \$14.99 - 1 +	 Beef Top Sirloin Steak (Climate-Smart) 340 g · \$6.61/100 g \$22.49 - 0 +	 Lentils 450 g · \$0.35/100 g \$1.39 - 1 +	 Chicken Breasts 454 g · \$1.65/100 g \$7.49 - 0 +
 Salmon 454 g · \$2.75/100 g \$12.49 - 0 +	 Shrimp 340 g · \$2.94/100 g \$9.99 - 1 +	 Bacon 375 g · \$1.60/100 g \$5.99 - 0 +	 Canned Beans 398 mL · \$0.25/100 mL \$0.99 - 0 +
 Pork Loin Chops 454 g · \$1.87/100 g \$8.49 - 0 +	 Plant-Based Burger Patties 226 g · \$3.31/100 g \$7.49 - 0 +	 Ground Beef 454 g · \$1.54/100 g \$6.99 - 0 +	 Ground Beef (Climate-Smart) 454 g · \$1.92/100 g \$8.74 - 1 +
 Chicken Drumsticks 454 g · \$1.21/100 g \$5.49 - 0 +	 Tofu 454 g · \$0.88/100 g \$3.99 - 0 +	 Ribeye Steak 340 g · \$8.97/100 g \$30.49 - 0 +	 Ribeye Steak (Climate-Smart) 340 g · \$8.97/100 g \$30.49 - 0 +

 4

Total Bill:
\$35.11

Finish

Clear Cart

- Beef Top Sirloin Steak **\$14.99** ✕
- Lentils **\$1.39** ✕
- Shrimp **\$9.99** ✕
- Ground Beef (Climate-Smart) **\$8.74** ✕

Figure 1: A Choice Task Example (Canada)

Econometric Model

The Multivariate logistics (MVL) model (Caputo and Lusk, 2022; Kilders et al., 2024; Caputo et al., 2025): $U_{ib} = V_{ib} + \varepsilon_{ib}$

$$V_{ib} = \sum_{j=1}^J \alpha_{ij} x_j + 0.5 \sum_{j=1}^J \sum_{k \neq j}^J \gamma_{jk} x_j x_k$$

Baseline utility of item j can depend on information treatment, price, and demographics:

$$\alpha_{ij} = \alpha_{0j} + \lambda_j \textit{Treatment}_i + \beta p_j + X_i \delta_j$$

Choice probability follows logit form:

$$\textit{Pro}[i \text{ chooses basket } b] = \frac{\exp(V_{ib})}{\sum_{b=1}^B \exp(V_{ib})}$$

Results: Attitudes, Perceptions, and Beliefs

Belief of Beef-Grazing-Grassland (1 – 5, from Strongly disagree to Strongly agree)

1. Cattle grazing on natural grassland helps maintain the grassland ecosystem.
2. Beef has a larger climate impact than chicken or pork.
3. Grasslands require periodic disturbance (e.g., grazing and fire) to remain productive and diverse.
4. Beef labelled 'climate-smart' is meaningfully different from conventional beef in its environmental impact.
5. How beef cattle are raised affects soil health, biodiversity, and water quality on the grassland.
6. I trust environmental claims printed on beef product labels.

Results: Attitudes, Perceptions, and Beliefs

2. Beef has a larger climate impact than chicken or pork.
3. Grasslands require periodic disturbance (e.g., grazing and fire) to remain productive and diverse.

Table 3: Information Treatment Effects on Beliefs of Beef–Grazing–Grassland

	(1) Belief_1	(2) Belief_2	(3) Belief_3	(4) Belief_4	(5) Belief_5	(6) Belief_6
Canada						
Treatment	0.145 (0.097)	0.290** (0.115)	0.363*** (0.107)	-0.058 (0.112)	0.140 (0.105)	-0.117 (0.108)
N	206	208	208	208	208	208
US						
Treatment	0.144 (0.106)	0.470*** (0.111)	0.394*** (0.122)	0.246** (0.106)	0.262** (0.103)	0.014 (0.100)
N	199	199	199	198	198	198

Results: Attitudes, Perceptions, and Beliefs

Post-treatment questions (Displayed only if treated):

- According to the brief you just read, what does climate-smart grazing try to do?
- According to the brief, why does grazing matter for grassland ecosystems?

Table 4: Test Recall of Brief Content

	Canada			US		
	(1) True	(2) False	(3) Don't remember	(4) True	(5) False	(6) Don't remember
Climate-smart grazing	80.91%	16.36%	2.73%	78.22%	14.85%	6.93%
Grazing and grassland ecosystems	82.41%	13.89%	3.70%	67.68%	22.22%	10.10%

Environmental Perceptions and Attitudes (1 – 7)

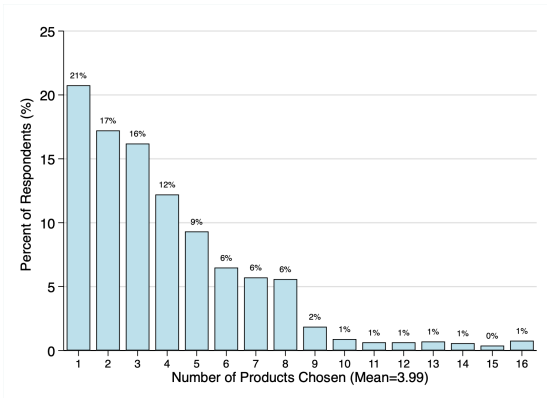
- In general, how do you view the impacts of beef cattle grazing on the ecosystem services provided by grasslands?
- How concerned do you feel about beef's environmental impact?
- How hopeful do you feel that beef production can support healthy grasslands?
- "I feel like the kind of person who cares about the environment."

Table 5: Information Treatment Effects on Perceptions and Attitudes

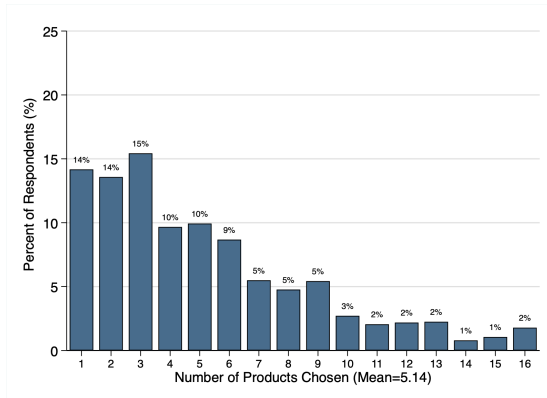
	Canada				US			
	(1) Impact	(2) Concern	(3) Hopeful	(4) Env identity	(5) Impact	(6) Concern	(7) Hopeful	(8) Env identity
Treatment	0.105 (0.205)	0.001 (0.330)	0.306 (0.257)	0.214 (0.230)	-0.178 (0.197)	0.394 (0.336)	-0.084 (0.275)	0.104 (0.236)
N	206	208	206	207	197	199	195	197

Results from the BBCE

The Number of Products Chosen (Excluding the No-Buy Choices)



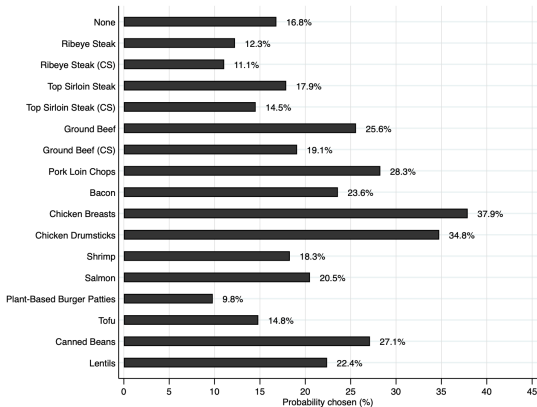
a. Canadian Sample



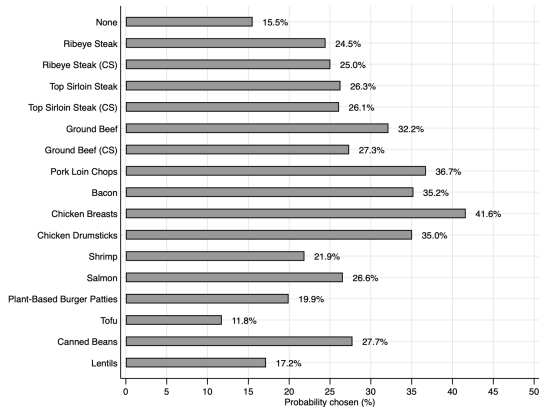
b. US Sample

Results from the BBCE

Probability of Product Being Selected



a. Canadian Sample



b. US Sample

Table 6: T-Test: Probability of Product Being Selected by Treatment Group

	Canada			US		
	Control	Treatment	Diff (T-C)	Control	Treatment	Diff (T-C)
Ribeye Steak	0.119	0.121	0.002	0.262	0.223	-0.039*
Ribeye Steak (CS)	0.101	0.110	0.009	0.237	0.253	0.016
Top Sirloin Steak	0.194	0.163	-0.032*	0.294	0.234	-0.060***
Top Sirloin Steak (CS)	0.128	0.163	0.034**	0.265	0.258	-0.007
Ground Beef	0.282	0.216	-0.066***	0.336	0.308	-0.028
Ground Beef (CS)	0.178	0.195	0.017	0.238	0.311	0.073***
Pork Loin Chops	0.281	0.272	-0.010	0.371	0.364	-0.007
Bacon	0.222	0.231	0.009	0.355	0.360	0.005
Chicken Breasts	0.382	0.343	-0.039*	0.400	0.454	0.055**
Chicken Drumsticks	0.355	0.319	-0.036	0.369	0.332	-0.037
Shrimp	0.200	0.163	-0.038**	0.261	0.187	-0.075***
Salmon	0.196	0.202	0.006	0.235	0.292	0.057***
Plant-Based Burger Patties	0.111	0.077	-0.034**	0.199	0.203	0.004
Tofu	0.181	0.127	-0.053**	0.127	0.102	-0.025
Canned Beans	0.286	0.252	-0.034*	0.259	0.294	0.036*
Lentils	0.233	0.206	-0.027	0.166	0.178	-0.012
None	0.159	0.181	0.022	0.148	0.159	0.011
<i>Number of choice tasks</i>	864	990		873	900	

Results from the BBCE

Results from the MVL model

- Treatment effects on baseline utility estimates
- Cross-utility estimates: utility complements and substitutes
- Extracts of own- and cross-price elasticities at mean prices
 - Price sensitivity
 - Demand substitution and complementarity patterns

Table 7: Baseline Utility Estimation from the MVL Model

	Canada			US		
	Constant	Treatment	Price	Constant	Treatment	Price
Ribeye Steak	-1.202***	0.276	-0.115***	-1.837***	-0.229*	-0.007***
Ribeye Steak (CS)	-1.195***	0.063	-0.115***	-1.647***	0.017	-0.007***
Top Sirloin Steak	-0.669***	-0.207	-0.115***	-1.513***	-0.386***	-0.007***
Top Sirloin Steak (CS)	-0.992***	0.326**	-0.115***	-1.465***	-0.110	-0.007***
Ground Beef	-0.968***	-0.279**	-0.115***	-1.407***	-0.129	-0.007***
Ground Beef (CS)	-1.514***	0.096	-0.115***	-2.368***	0.441***	-0.007***
Pork Loin Chops	-1.281***	0.096	-0.115***	-1.687***	-0.123	-0.007***
Bacon	-1.966***	0.202	-0.115***	-1.915***	0.014	-0.007***
Chicken Breasts	-1.052***	-0.084	-0.115***	-2.057***	0.314**	-0.007***
Chicken Drumsticks	-1.184***	-0.045	-0.115***	-1.542***	-0.174	-0.007***
Shrimp	-1.597***	-0.263*	-0.115***	-2.270***	-0.624***	-0.007***
Salmon	-2.284***	0.159	-0.115***	-2.332***	0.454***	-0.007***
Plant-Based Burger Patties	-2.954***	-0.474**	-0.115***	-2.686***	0.096	-0.007***
Tofu	-3.350***	-0.485***	-0.115***	-3.602***	-0.360**	-0.007***
Canned Beans	-2.260***	-0.094	-0.115***	-3.129***	0.312**	-0.007***
Lentils	-2.436***	0.086	-0.115***	-3.969***	0.065	-0.007***
None	-1.452***	0.158	-0.115***	-1.919***	0.052	-0.007***

Note: Demographic variables (female, university degree, high income (> \$75,000), household number, and diet restrictions) are included in the model

Change in Utility of Purchasing Ground Beef

Complements Substitutes

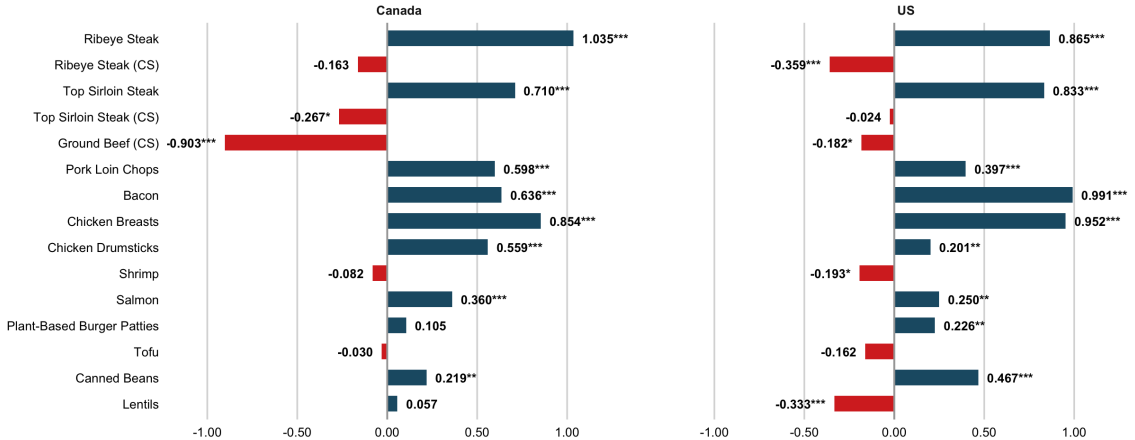


Figure 2: Cross-Utility Estimates: Change in Utility of Purchasing Ground Beef

Change in Utility of Purchasing Top Sirloin Steak

Complements Substitutes

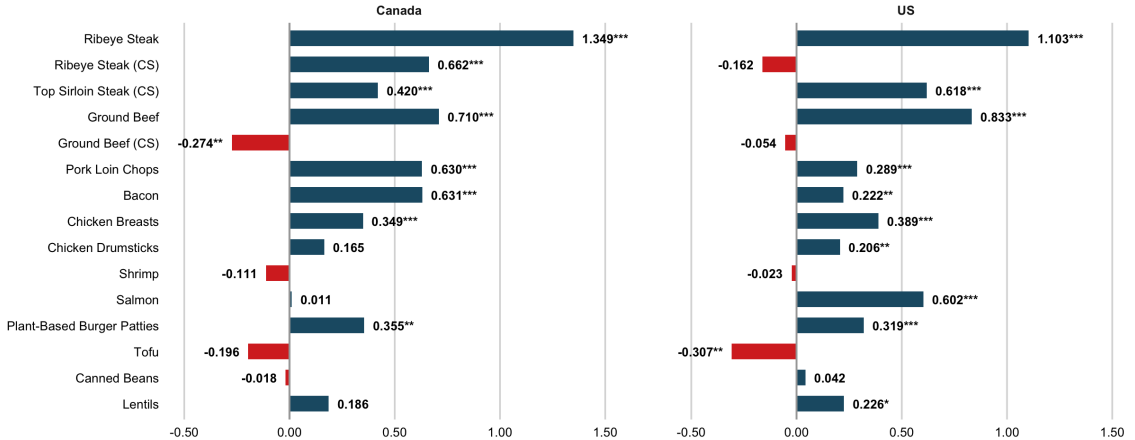


Figure 3: Cross-Utility Estimates: Change in Utility of Purchasing Top Sirloin Steak

Change in Utility of Purchasing Ribeye Steak

Complements Substitutes

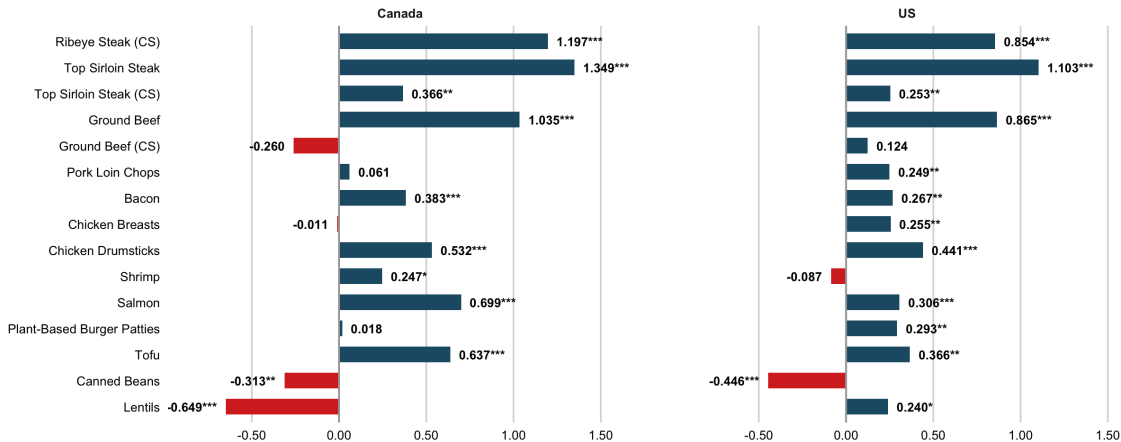


Figure 4: Cross-Utility Estimates: Change in Utility of Purchasing Ribeye Steak

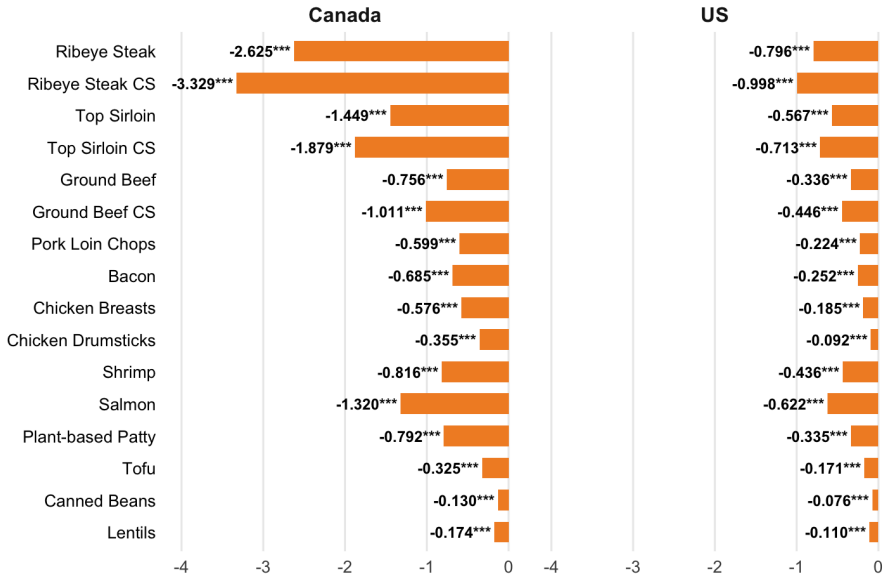
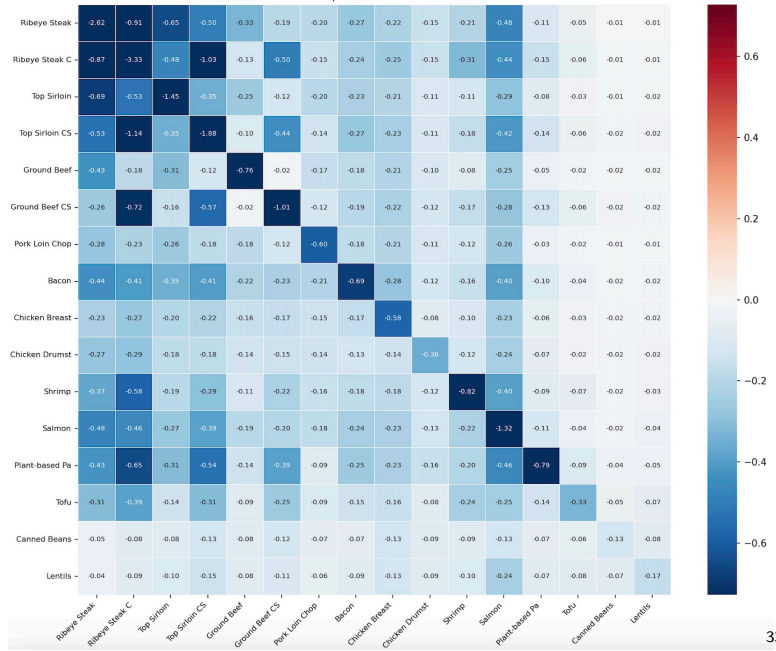


Figure 5: Own-Price Elasticities

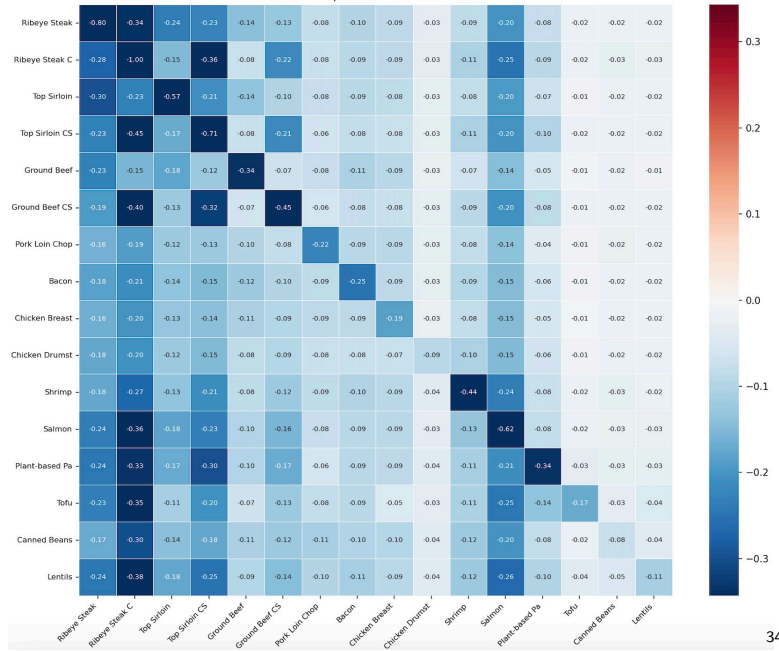
Cross-Price Elasticities (Canada)

- Blue: Demand Complement
- Red: Demand Substitute



Cross-Price Elasticities (US)

- Blue: Demand Complement
- Red: Demand Substitute



Discussion and Conclusions

Information Treatment Effects on Beliefs

- The treatment updated beliefs about beef's climate impact and grasslands' need for disturbance.
- No significant effects on consumer perceptions and attitudes in either country.

Demand Effects from the BBCE

- Treatment reduced demand for some conventional beef products while increasing demand for climate-smart beef products.
- Conventional and climate-smart beef steaks behave as **utility complements**, while ground beef shows **utility substitution** toward the climate-smart variant.
- Canadian consumers are more price-sensitive than US consumers.
- Proteins are **demand complements** or independent of each other (Caputo and Lusk, 2022; Neill and Lahne, 2022; Ma et al., 2024; Börger et al., 2026).

CAT-G: CLIMATE ACTION THROUGH GRAZING



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Agriculture and
Agri-Food Canada

Agriculture et
Agroalimentaire Canada



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Bacon

12 oz (340 g) - \$0.58/oz

\$6.99 - 0 +



Shrimp

12 oz (340 g) - \$0.79/oz

\$9.49 - 0 +



Canned Beans

15 oz (425 g) - \$0.07/oz

\$0.99 - 0 +



Salmon

1 lb - \$10.49/lb

\$10.49 - 0 +



Ground Beef

1 lb - \$6.99/lb

\$6.99 - 1 +



Ground Beef (Climate-Smart)

1 lb - \$6.99/lb

\$6.99 - 0 +



Pork Loin Chops

1 lb - \$4.99/lb

\$4.99 - 0 +



Chicken Drumsticks

1 lb - \$1.99/lb

\$1.99 - 0 +



Chicken Breasts

1 lb - \$2.99/lb

\$2.99 - 0 +



Tofu

16 oz (1 lb) - \$0.22/oz

\$3.49 - 1 +



Beef Top Sirloin Steak

0.75 lb (12 oz) - \$18.68/lb

\$13.99 - 0 +



Beef Top Sirloin Steak (Climate-Smart)

0.75 lb (12 oz) - \$18.68/lb

\$13.99 - 1 +



Lentils

16 oz (1 lb) - \$0.12/oz

\$1.89 - 0 +



Ribeye Steak

0.75 lb (12 oz) - \$13.34/lb

\$9.99 - 1 +



Ribeye Steak (Climate-Smart)

0.75 lb (12 oz) - \$16.67/lb

\$12.49 - 0 +



Plant-Based Burger Patties

2 ct (226 g) - \$3.00 each

\$5.99 - 0 +



4

Total Bill:

\$34.46

Finish

Clear Cart

Ground Beef \$6.99 ✕

Tofu \$3.49 ✕

Beef Top Sirloin Steak (Climate-Smart) \$13.99 ✕

Ribeye Steak \$9.99 ✕

Figure 6: A Choice Task Example (US)

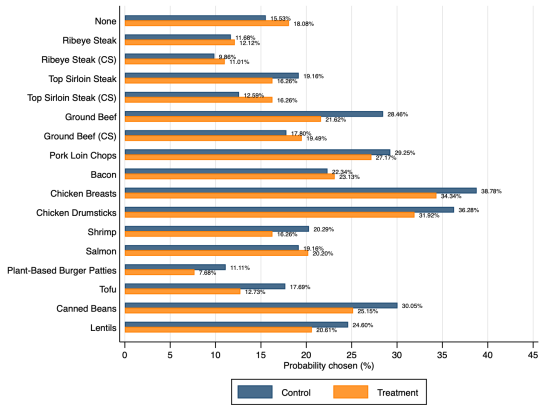
Table 8: Price Levels in the Experiment (US)

Product	Package size	Low	Medium	High
Ribeye Steak	12 oz	\$9.99	\$14.99	\$19.99
Top Sirloin Steak	12 oz	\$7.99	\$10.99	\$13.99
Ground Beef	1 lb	\$5.49	\$6.99	\$8.49
Pork Loin Chops	1 lb	\$3.49	\$4.99	\$6.49
Bacon	12 oz	\$3.99	\$5.49	\$6.99
Chicken Breasts	1 lb	\$2.99	\$4.49	\$5.99
Chicken Drumsticks	1 lb	\$0.99	\$1.99	\$2.99
Shrimp	12 oz	\$6.49	\$7.99	\$9.49
Salmon	1 lb	\$10.49	\$11.99	\$13.49
Plant-Based Burger Patties	2 ct/226 g	\$4.49	\$5.99	\$7.49
Tofu	1 lb	\$1.99	\$2.74	\$3.49
Canned Beans	15 oz	\$0.99	\$1.49	\$1.99
Lentils	1 lb	\$1.39	\$1.89	\$2.39

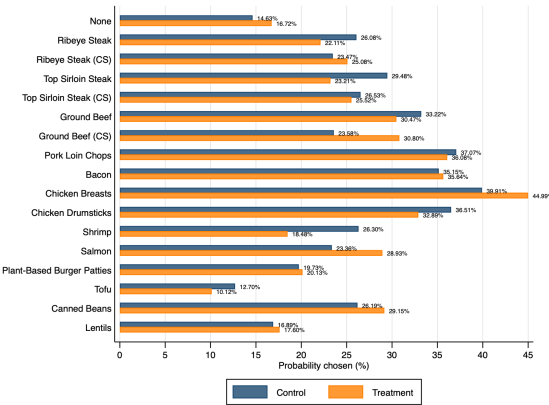
The price of Climate-Smart Beef is dependent on the assigned price of the conventional beef: Low premium (0%), Medium premium (25%), High Premium(50%)

Results from the BBCE

Probability of Product Being Selected by Treatment Group



a. Canadian Sample



b. US Sample