Beef Consumption at Boston College: A Discussion on the Carbon Footprint and Alternative Agricultural Practices

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Abstract

Livestock production for human consumption contributes a significant amount of greenhouse gas emissions into the atmosphere each year. In this study, we specifically focus on beef, the most polluting and emission-intensive livestock derivative. Ruminant cattle emit methane (CH_4) throughout their digestive process, contributing to overall emissions levels and global warming, in addition to the emissions associated with their energy intake and land usage. This study aims to estimate the approximate carbon footprint of beef consumption within Boston College Dining Services for the 2017-2018 year based on Carbon Dioxide and Carbon Dioxide Equivalents (CO_2e) based on a 100-year global warming potential (GWP100) for each of the carbon equivalents. Additionally, Boston College Dining and the Office of Sustainability expressed a need to better understand the ecological impacts of beef delivered to campus and to evaluate alternative methods of fulfilling their nutritional demands in order to remain compliant with future regional and institutional standards, such as substituting current conventionally sourced beef for grass-fed beef or plant-based alternatives. These two objectives guided our research and informed our results. Once carbon equivalent metrics were averaged from the literature, results were determined by multiplying the total beef products purchased by Boston College Dining by that factor, yielding a total carbon footprint of 4,194,906 lbs CO_2e. Grass-fed beef production was determined to have a greater CO_2e of 36.24 lbs of CO_2e per lb of "consumer benefit," however, despite this, transitioning away from conventional grain-fed production methods is recommended for ecological reasons outside of the carbon footprint comparison. We determine that Boston College has the capacity to significantly reduce its carbon footprint through implementing a greater supply of plant-based options in dining halls, but also through alternative livestock raising methods, as the ecological benefits of these alternatives (e.g., carbon sequestration, nutrient cycling) will result in an overall increase in campus-wide sustainability.

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I. Introduction

Environmental Implications of Beef Production and Consumption

Beef production is placing a growing strain on environmental systems throughout the United States and around the globe. This is primarily due to considerable physical and chemical changes to terrestrial and aquatic landscapes, ecosystems, and ultimately, the climate, that the beef lifecycle imposes. These impacts collectively compose the ecological footprint of beef consumption, effectively quantifying resource consumption and waste assimilation of a particular population into a single value (Chapman et al. 2017). Throughout this study, we define sustainability as “meeting society’s present needs without compromising the ability of future generations to meet their own needs” (Capper 2012). A substantial portion of our agricultural and livestock systems currently produce yields and employ industrialized techniques that will not be able to sustain future demand, especially as population is expected to exceed 9.5 billion by 2050 (Capper 2012). Our paper aims to discuss the sustainability implications of current beef consumption through Boston College Dining Services, specifically looking into the greenhouse gas (GHG) emissions associated with current quantity of beef consumed on campus and discussing other associated environmental impacts.

The GHG emissions involved with the raising and consumption of beef products are characterized as the industry’s carbon footprint. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the three most substantial GHGs emitted from agricultural activities and have therefore been major contributors to warming trends, especially since the mid-20th century (Edwards-Jones, Plassmann, Harris 2009). GHGs like halocarbons, ozone, and carbon monoxide also contribute to climate change, but are not typically included in analyses of agricultural activities. Elevated concentrations of GHGs are predicted to persist in the atmosphere for up to thousands of years and ultimately affect the Earth-atmosphere energy balance, enhancing the natural greenhouse effect and thereby exerting a warming influence at the Earth’s surface. Smith et al. emphasize how this warming will “affect biodiversity, soil fauna, and microbial activity” and how increased temperature, water stress, and more extreme weather events over the next 50 years could decrease crop productivity in many regions of the world, creating a positive feedback loop of stress on our agriculture industry (2013). Livestock, especially ruminant species, are responsible for 18% of anthropogenic GHG emissions across the globe, exceeding the impacts of the global transportation sector (Place, Mitloehner 2013). Methane released through the enteric fermentation process in the digestion of ruminant animals is considered to be the greatest source of GHGs in beef production (Lynch 2019). It is important to note that many elements of the agricultural supply chain contribute to climate change, but Clune et al. emphasizes that there is a clear hierarchy across food categories, with grains, fruits, and vegetables contributing the lowest impact, while meat from ruminants such as beef contributing the highest planetary impact (2013). However, proper agricultural management and techniques that rely on and enhance the Earth's natural systems can be beneficial in reducing the impacts of GHG emissions.

The environmental impacts of beef production expand beyond GHG emissions and include land changes, ecosystem disruption, and ocean acidification. Lant et al. states that there is a "complex relationship between the food-energy-water (FEW) systems" and that their impact on Earth cycles, climate change, eutrophication, water-resource depletion and land cover change are likely to exceed planetary limits, potentially altering all environmental systems (2018). More than one-third of global land is used for agriculture, approximately 75% of which is used just for livestock alone (Tichenor et al. 2017). Beef is the largest land user per unit output and is one of the greatest stressors on our land systems alone (Tichenor et al. 2017). Including these impacts in our discussion and quantifying a relative carbon footprint is crucial in informing supply chain professionals and stakeholders about the relative impacts of conventional, small-scale, or grass-fed beef production systems (Edwards-Jones, Plassmann, Harris 2009).

A life-cycle assessment (LCA) model is a common method employed in estimating the carbon footprint of a particular system and was used as a baseline in this study. This model captures emissions levels from "cradle-to-gate," specifically those associated with initial inputs through the point when animals leave the farm (Lynch 2019). To be most effective, the system boundaries must be expanded to include impacts incurred in the production of inputs, including agricultural land use emissions, emissions from the production of feed, the manufacturing of farm equipment, and the energy used in the manufacturing of fertilizers and pesticides (Lynch 2019). Place and Mitloehner broaden this model to include everything from feed production, enteric fermentation of the cattle, organic waste, and processing and transportation, creating a complete "cradle-to-fork" LCA (2013). In one specific study, the value chain LCA results indicated that feed and cattle production phases were the largest GHG emitters, at 6.42 and 28.51 kg CO_2 eq/CB, respectively, in global warming potential (Asem-Hiablie, Senorpe et al. 2015). The most significant challenge in measuring the carbon footprint of a system is identifying a specific scope and scale to use, making it very difficult to compare study results. The CO_2e metric is therefore used to streamline the likely warming potential of any variations of GHGs at a given time. Clune et al remarks that this factor alone prevents synthesized open access LCA data from becoming more available in the public domain, which makes political decision making and small-scale LCA studies increasingly difficult (2013). Additionally, emissions associated with food waste are often overlooked in an LCA, but reducing waste of finished products are likely to have a significant impact on reducing climate change compared to farm-level changes (Markard, Raven, Truffer 2012). Quantifying carbon footprints or GHG equivalents is also challenging due to the uncertainty surrounding the various abilities of each GHG to contribute to climate change over time. The land use ratio (LUR) was developed in 2016 in order to compare sustainability between livestock systems (van Zanten et al. 2016). The scope of this method differs from the LCA in that it identifies the livestock systems that produce more animal-based food (e.g., beef) than would be produced by converting the land used to feed the animals to food crop production for direct human consumption.

The carbon equivalent (CO_2e) is used when measuring and discussing the impact of multiple GHGs in one system. This metric signifies the quantity of CO_2 that would have an equivalent impact on global warming for any volume or type of GHG emitted in an individual system, regardless of variations in climate impact. Variance of GHG potency is primarily derived from atmospheric lifetime and radiative energy (RE), which is measured as the change in Earth's energy balance per unit of change in atmospheric concentration of a given GHG (Lynch 2019). For example, CO_2 has a relatively low RE, but can persist in the atmosphere for millenia (Myhre et al. 2013). CH_4 has a greater RE, but a lifetime of approximately 12.4 years while NO_2 has an even larger RE and a lifetime of 121 years, suggesting significant variance and explanation for the CO_2e metric (Myhre et al. 2013). Most commonly used as a CO_2e metric is the 100-year global warming potential (GWP100), representing the total energy added to the climate system by a GHG relative to that added by CO_2 and its radiative forcing over 100 years (Myhre et al. 2013). This timespan is necessary due to the differing atmospheric lifespans of different gases, but also impacts the resulting carbon footprint. It is worth noting that in cattle production, the large amounts of methane emitted affect the aggregated CO_2e footprint due to its shorter lifetime in the atmosphere (Lynch 2019). The CO_2e was useful in this study as it allowed us to express the impact of multiple GHGs as a single number. More generally, it permits comparisons between different samples of GHGs in terms of their global warming impacts, regardless of variations in lifetime and RF.

Context of Study

From June 2017 to June 2018, Boston College Dining Services purchased 180,628.1 lbs (81,931.5 kg) of beef or animal protein for consumption in student dining halls and catering facilities, primarily derived from conventionally raised cattle. The per capita consumption rate at Boston College is calculated to be approximately 25.4 lbs (11.5 kg) per year, assuming that 7,100 of the 9,500 undergraduate population eats at the campus dining halls for 32 weeks of the calendar year (BC Dining 2019). According to the USDA Economics Research Service data, the most current average per capita consumption of beef in the United States is 27.7 kg or 61.6 lbs of beef each year (Kannan et al. 2018), suggesting that BC consumes slightly less beef per capita than the general population when the 32 week per capita average is converted to a 52 week average of 41.3 lbs (18.7 kg).

Boston College Dining Services and the Office of Sustainability are currently involved in several on-campus programs and national initiatives to increase sustainability within university dining systems. The university has put a new emphasis on proper waste management and local sourcing through its FRESH to Table initiative, farmers markets, and introduction of the LeanPath food waste tracking system, reducing waste by 60% in the Corcoran Common Dining Hall by repurposing, rescuing, and composting food products (Boston College Dining). In 2014, Stanford University launched the Menus of Change University Research Collaborative (MCURC) and has since called Boston College and over 60 other institutions to prioritize sustainable and healthy food options at a systems level by sharing data on food purchases as part of a collective impact study (Stanford University & World Culinary Institute). Similarly, Boston College is involved with the Association for the Advancement of Sustainability in Higher Education (AASHE), which provides institutions with a transparent and standardized reporting system to gauge progress in sustainability efforts. Furthermore, the Office of Sustainability demonstrated the need for a carbon footprint measurement as part of the New England Food Vision report, calling for New England to develop the capacity to produce 50% of its food by 2060 with support for sustainable farming and thriving communities (Donahue et al. 2014). Currently, Boston College purchases 11% of its beef from grass-fed farms, 53.7% of which is raised locally at Maine Family Farms . It is crucial for Boston College to better understand the environmental and economic implications of transitioning to New England-sourced beef products in order to make strides in contributing to this vision.

The alternatives to conventionally-raised beef discussed in this study are grass-fed systems and local and small-scale cattle farms. Conventional beef production (CON) is generally referred to when cattle is grain-fed, finished in feedlots, and likely utilizing growth-enhancing technology (Capper 2012). Conversely, grass-fed (GF) systems do not use growth-enhancing technology and the cattle is strictly forage-fed (Capper 2012). In the New England region, local beef production systems are often considered to be small-scale as well because most farms tend to be smaller than the national average (Berlin, Lockeretz, Bell 2009). Therefore, these two systems will be referred to in unison throughout this paper.

Estimating the carbon footprint between various systems is necessary because there is significant variability amongst studies determining which beef production system is more sustainable and how these compare to plant-based crop systems. For example, GF systems require a larger land base than CON systems, but have a greater potential to convert substantial quantities of products that humans cannot eat (e.g., grasses) into digestible nutrients (Tichenor et al. 2017). A 2017 study in New England revealed that all beef production systems had a land use ratio (LUR) greater than one, likely because a large fraction of the forage land used would lend itself to a moderately productive crop system (Tichenor et al. 2017). Unless beef production systems can make use of range and pastureland, which is generally unsuitable for human crop production, locally-raised beef will likely be unsustainable, generating less human-digestible protein per square meter than crop land and potentially limiting the success of the NE Food Vision report (van Zanten et al, 2016). Surprisingly, one study concluded that the CON system required 56.3% of the animals, 24.8% of the water, 55.3% of the land, and 71.4% of the fossil fuel energy to produce a given quantity of beef, compared to a GF system (Capper 2012), rejecting the common perception that GF systems have lower carbon footprints than intensive, confined systems.

The primary goal of this study is to determine which type of beef production systems is more sustainable for Boston College Dining. Specifically, we estimate a workable carbon footprint measure based on the averages seen in the literature for both conventionally raised and grass-fed cattle in order to quantify the greenhouse gas emissions that could be attributed to each process. Additional environmental and ecological benefits and consequences were then considered, as the carbon footprint measure does not account for the wide scale impacts of processes like carbon sequestration, nutrient fixation, or water purification. The multi-faceted approach to understanding the sustainability of beef product consumption at Boston College will allow us to make significant conclusions and recommendations for Boston College Dining and the Office of Sustainability, in line with their other initiatives and institutional partners.

II. Methods

Data Collection

This study utilized data from Boston College records and existing literature via *Web of Science* and the *Agricultural & Environmental Science Database*. The Office of Sustainability at Boston College provided a *SYSCO Annual Usage* report, which included the quantity of food products purchased for BC Dining from May 28, 2017 through May 26, 2018, broken down by quantity, vendor, and product description. Additional information was sourced from the 26 vendor websites and direct calls to determine which processors and distributors use grain or grass-fed beef sourcing. This collection process revealed a significant lack of transparency between vendors, their clients, and consumers. Dans Prize eventually divulged that graded USDA Select beef, frequently found on vendor websites, can be assumed to be grain-fed or conventionally raised. Other unexpected challenges arose when trying to identify the original source of beef products, as the range was wider and less specific than expected.

Existing literature from a variety of external databases was used to supplement the data provided by the Boston College Office of Sustainability. This paper relies on a myriad of other studies and articles across the U.S., Canada, and the New England region to obtain carbon equivalent estimates for conventional and grass-fed beef.

Assumptions

A challenge in this study was finding a consensus in the literature on carbon equivalent factors to use in our primary calculations, likely due to the inconsistency in methodology, interpretation of the life-cycle assessment (LCA) model, and variation in time and geographic scope. For example, the GHG emissions impact of transportation of raw and finished products is frequently excluded from the LCA model because it accounts for less than 1% of all emissions (Place, Mitloehner, 2013). This assumption, in conjunction with limited vendor information on beef sourcing location, led us to omit transportation factors from our calculations and discussion. An in-depth review of the literature on conventionally-raised beef eventually revealed a workable range of results, which we averaged to get a CO_2e/lb of consumer benefit. Repeating this strategy for grass-fed and local systems proved to be even more challenging due to the limited supply of literature on this subject. However, we felt comfortable working with the single factor from Capper (2012) because it is based in the New England region, suggesting that it was appropriate for Boston College. Furthermore, we rely on information from Stelmaczyk and Dans Prize (vendor) to assume that all beef delivered to Boston College is raised in a conventional system with grain-feeding, unless otherwise determined through vendor discussion.

Calculations

In order to evaluate the quantity (lbs) from the Sysco food report, we calculated the product of “Pack/Size” and “Sales Cases,” filtering for beef and steak items. To determine the pounds of actual “beef consumer benefit” from each line item, we relied on Stelmaczyk’s assumptions to be congruent with the Office of Sustainability’s methodology. For Grateful burgers produced by CW Nessen, we used 60% of the total burger weight to account for the 40% mushroom that the burgers contain. For OSI Industries meatballs, we calculated half of the vendor’s total weight as beef products to account for filler. For soups produced by Kettle Cuisine, we used 25% of the total food product weight to represent beef.

Calculating the pounds of CO_2e per pound of beef consumer benefit incorporated two separate calculations for conventional production methods. First, we compared two “cradle-to-gate” life cycle analysis studies of conventional grain-fed beef production systems from the literature that each provided a range of CO_2e/kg for beef. The two studies by Lynch (2019), and Rotz et al. (2015) were converted into CO_2e/lb of beef and then the means of both of these studies were averaged to estimate an approximate lbs of CO_2e per lb of beef “live weight.” Finally, we applied a factor outlined by Capper (2012) to convert this emissions constant to apply to the specific consumer benefit that the Sysco report measured.

Our method for determining lbs CO_2e for grass-fed production involved using a ratio of metric tons of emissions from a conventionally-raised head of cattle to an equivalent grass-fed head of cattle in the same location outlined in the Capper (2012) study. We applied this factor to the CO_2e from conventionally-raised beef to determine the CO_2e factor for grass-fed production. To determine a total carbon equivalent emissions for beef production at BC Dining, we segmented the total beef in the Sysco report by grass-fed and grain-fed vendors and applied the respective CO_2e factor to each weight total.

Part of our research aimed to understand how CO_2e from beef at BC Dining compared to the CO_2 emissions of caloric substitutes. We found kCals per pound and CO_2 equivalents per pound for chicken, lentils, and raw Soybeans. We initially determined the kCals delivered in beef at BC Dining by calculating the product of total beef consumer benefit weight from the Sysco report and the kCal per pound for beef from the (USDA 2018). Second, we divided this value by each of the respective kCal per pounds for chicken, lentils, and soybeans to derive the equivalent pounds of each source to normalize caloric value across the food groups. Then, we applied each of the emissions factors for these foods to their respective quantity (lbs) to determine their carbon footprint and offer a point of comparison for beef.

To contextualize the quantity of emissions from yearly beef consumption at BC Dining, we compared emissions to round-trip driving miles to the moon as well as round-trip flight seats between Boston and London. To calculate the CO_2 emissions in a journey to the moon, first, we determined the gallons of gas it would require to drive the 238,000 miles to the moon. We found the carbon emissions in a gallon of gas, 17.8 lbs CO_2e, and multiplied that factor to the distance to the moon divided by 22, the average fuel economy of passenger vehicles (EPA). By finding the quotient of the total CO_2e footprint from beef production at BC Dining and the CO_2 emissions to drive to the moon, we found the total driving trips to the moon that were equivalent to beef's carbon footprint at BC Dining.

For flight seats over the 3,200 mile journey between Boston and London, we used 52 miles per gallon as the average MPG per seat in commercial aviation based on the EPA to find the gallons used to get to London on a per seat basis. We assumed the same CO_2e footprint for jet fuel as for gasoline to determine the equivalent round trip seats that could be offered for the same CO_2 usage as beef at BC Dining.

III. Results

Beef usage in BC Dining:

From our calculations, we found that from June 26, 2017 to June 24, 2018, BC Dining collectively sourced 180,628 lbs of beef from 26 vendors, distributors, or packers, emitting 4.19 million lbs of CO_2e emissions (Table 1). Only three distributors were found to source from grass-fed beef farms, based on calls with each vendor and website information, comprising 11%, or 19,600 lbs of total beef sourcing to BC. Despite using many regional vendors, Maine Family Farms is the only locally sourced beef farm, representing 5.9%, or 10,580 lbs, of total beef production.

Vendor	Production Method	Lbs	Cradle to Gate Lbs CO2 equivalents
ADVANCE PIERRE FOODS	Grain Fed	38,017.0	822,371.9
MEATBALL OBSESSION LLC	Grain Fed	22,419.5	484,971.7
OSI INDUSTRIES LLC	Grain Fed	20,028.0	433,239.5
MAINE FAMILY FARMS	**Grass Fed**	10,580.0	383,395.0
DANS PRIZE	Grain Fed	14,336.2	310,116.2
J&G FOODS INC	**Grass Fed**	8,167.5	295,971.5
BAUGH SUPPLY CHAIN COOP	Grain Fed	13,276.0	287,182.3
AMERICAN FOODS GROUP	Grain Fed	13,116.0	283,721.2
MILMAR FOOD GROUP	Grain Fed	10,845.4	234,605.1
MURCO	Grain Fed	4,720.2	102,105.9
MALCOLM MEATS COMPANY	Grain Fed	4,690.0	101,452.6
TYSON FRESH MEATS	Grain Fed	4,251.0	91,956.3
NATIONAL BEEF PACKING CO	Grain Fed	3,812.0	82,460.0
WOLVERINE PACKING	Grain Fed	3,530.0	76,359.9
ASTRA FOODS INC	Grain Fed	2,526.0	54,641.6
BURGER MAKER INC	**Grass Fed**	944.0	34,208.4
LINCOLN PACKING	Grain Fed	1,308.0	28,294.2
HORMEL FOODS CORP	Grain Fed	1,262.0	27,299.2
KAYEM FOOD INC	Grain Fed	1,008.0	21,804.7
BOSTON BRISKET CO INC	Grain Fed	585.0	12,654.5
OLD NEIGHBORHOOD FOODS	Grain Fed	536.3	11,601.3
CW NESSEN FOODS	Grain Fed	300.0	6,489.5
BUONA VITA INC	Grain Fed	208.0	4,499.4
KETTLE CUISINE LLC	Grain Fed	120.0	2,595.8
BUCKHEAD BEEF RHODE ISLAND	Grain Fed	24.0	519.2
GREATER OMAHA PACKING CO INC	Grain Fed	18.0	389.4
Total:		**180,628.1**	**4,194,906.5**

Table 1: BC Dining Beef Lbs and Emissions by Vendor and Production Method

CO2 and CO2 Equivalent Results for Grain and Grass-fed Production Systems:

Table 2 shows our calculations of CO_2e from the studies, indicating an average CO_2e of 21.63 lbs. CO_2e/ lb of Consumer Benefit for conventional Grain-fed sources. This includes energy expended in the production of farm machinery, feed, land, waste, and transportation. 1% of the total CO_2e from the beef life cycle results from transportation, making the sourcing location less significant than farm-specific land-use practices. While we were hoping to apply this additional step to derive the full “Cradle-to-Kitchen” analysis, the beef processors said they did not know in most cases where their beef came from within North America.

Grass-fed CO_2e were much higher based on the Capper (2012) study, at 36.24 lbs CO_2e/lb of consumer benefit. While we found that most studies support an elevated level of CO_2e emissions from grass-fed production systems compared to grain-fed systems, the Capper study was the only source that calculated a specific ratio. The elevated enteric methane emissions from extending the cattle growth phase on grass-fed diets was the primary detriment to the emissions intensity of the production system (Capper 2012).

Study	Lbs CO2e/lb Live Weight	Live Weight to Consumer Benefit	CO2e/lb Consumer Benefit
Lynch, 2019	7.60	3.45	26.21
Rotz et al. 2013	4.94	3.45	17.05
Grain-fed lbs CO2e:			**21.63**
Grass Fed Emissions Factor[1]			1.68
Grass-fed lbs CO2e:			**36.24**
[1] Capper, 2012			

Table 2: Grain-fed and Grass-fed lbs CO2e /lb of Consumer Benefit

Substitute Comparison:

We compared the caloric density and emissions data for beef substitutes, such as chicken, lentils, and soybeans, synthesized in Table 3 (USDA 2018). We noted that while beef has the highest carbon footprint per lb, 23.2 lbs CO_2e/lb (weighted average of grain and grass fed production systems), it's also the most calorically dense, at 1,134 kCal/lb. Figure 1 compares the carbon footprint of each of these substitutes to beef, assuming they each deliver enough weight to provide 204.8 million kCals, the caloric value of BC Dining beef for the 2017-2018 year.

Surprisingly, under this scenario, chicken would amplify the carbon footprint of BC Dining if it were substituted, because the 460,786 lbs required to meet the caloric capacity of beef would offset its superior CO_2e/lb factor. While beef produces 4.2 million lbs of CO_2e, chicken would produce 7 million lbs.

Based on this metric, chicken underperforms relative to beef, but the plant-based substitutes yield significantly less emissions than both animal products. Soybeans would require 307,190 lbs to achieve the caloric content of beef, yet would significantly reduce carbon intensity, producing only 1.4 million lbs of CO_2e. Lentils are the most efficient beef substitute, requiring 426,009 lbs while producing only 845,000 lbs of CO_2e. This analysis demonstrates the advantages of plant-based food options as the primary path to reducing BC Dining's carbon footprint.

	kCal/lb	Lbs CO2e/lb
Beef	1,134.0	23.2
Chicken	444.5	15.2
Lentil (sprouted)	480.8	2.0
Soybean (Raw)	666.8	4.4

Table 3: Caloric Density and Emissions of Beef and Beef Substitutes

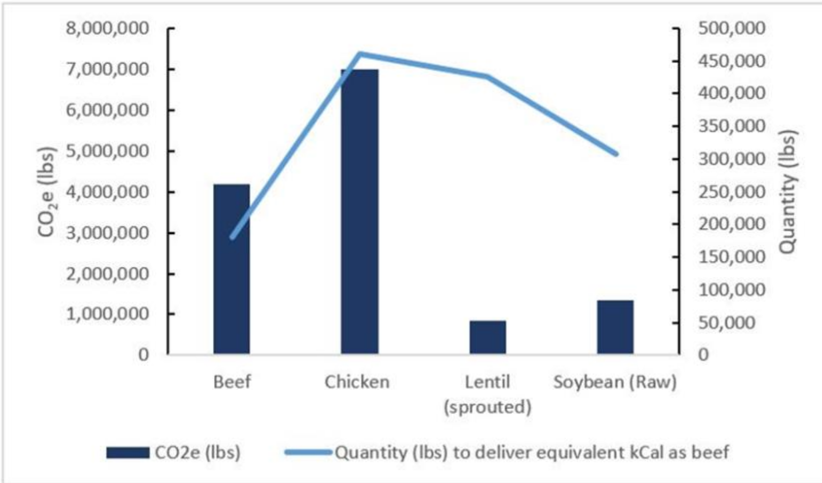

Figure 1: GHG emissions for Beef and Beef Substitutes Based on Equivalent Caloric Value

IV. Discussion

Interpretation of Results

The current level of CO_2e for beef consumption at Boston College is compelling and should be considered as a significant source of pollution and contribution to aggregate global warming on campus. To better convey the considerable levels of GHGs emitted through the cradle-to-gate lifecycle, as well as those not accounted for in waste and byproducts, it is necessary that the CO_2e metric is converted to more attainable measurements. Exhibit 1 demonstrates that 4.19 million lbs of CO_2e is equivalent to over 11 round trip car journeys to the moon, 238,000 miles away. Closer to home, these emissions represent 1,863 round trip plane seats travelling the 3,200 miles between Boston to London.

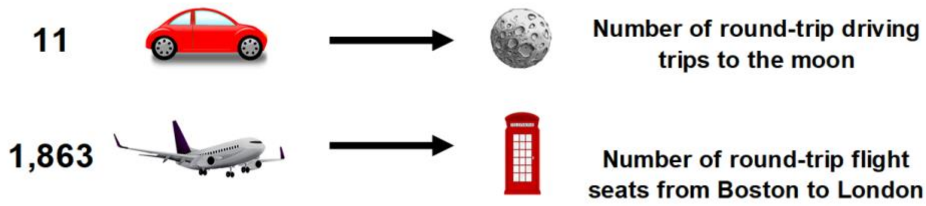

Exhibit 1: Contextualizing BC Dining Lbs of CO_2e from Beef Production

The overall conclusions of the current and expected CO_2e levels for conventional and grass-fed beef production systems may be surprising to the general consumer. Grass-fed has the connotation of being more natural, less invasive, and therefore more ethical and sustainable, but the results of this study suggest otherwise. Although the GHG emissions appear to be greater in grass-fed conditions, farms that graze their cattle yield a significant number of positive environmental benefits that ultimately reveal why Boston College should still commit to obtaining a greater percentage of its beef products from grass-fed farms.

Grass-fed based cattle farms have agricultural and ecological advantages over conventional practices, emphasizing why it is important for Boston College to consume and support cattle raising of this kind. The primary benefit of employing a grass-fed model is that there is greater capacity for that land area to sequester carbon dioxide, removing the GHG from the atmosphere and increasing organic matter in the soil (Clark, Tilman, 2017). A study carried out in Vancouver, B.C. found that grass-fed beef reduced net-carbon emissions between 10% and 94%, depending on whether or not the cattle grazed on more productive or marginal land (Chapman et al. 2017). When carbon is sequestered into the soil, the agricultural land becomes increasingly healthy and prosperous, encouraging deep roots, nutrient cycling, and overall land productivity and biomass. In cases where cattle grazed on soils that host native grasslands, which are co-adapted to ruminants, the levels and rates of carbon sequestration were greater than that of comparable croplands (Chapman et al. 2017). A particular study in West Virginia from 2002 to 2007 calculated a 4.2% increase in average soil organic matter and determined that 15 tons of CO_2 per acre was sequestered when adapting their land to more organic methods (Holdridge 2008). Nutrient management and cycling of nitrogen, phosphorus, and carbon are other key agricultural benefit of grass-fed systems and are a crucial component in crop productivity and soil health and sustainability, especially as the grazing process facilitates the physical breakdown, soil incorporation, and rate of decomposition in plant material (Derner, Schuman 2007). Grass-fed systems promote within-pasture nutrient cycling and decrease eutrophication from runoff (Clark, Tilman 2017), in turn supporting local water bodies and their diverse ecosystems. This process also aligns with the Silvo-pastoral and intensive rotational grazing models supported in the literature, which each utilize well-managed livestock grazing, along with diverse plants and forestry, to create more sustainable and productive land areas. Grass-fed beef is also noted in promoting food security in regions that are not suitable for crop production for human consumption (Smith et al. 2013), reiterating why grass-fed beef should still be encouraged over conventional methods.

There are also significant impacts of growing corn compared to grass for cattle feed that suggest why CO_2e cannot be the only determinant in selecting beef products for consumption. The water footprint of beef is significant, regardless of feed type as cattle are inefficient in converting feed to human consumable energy compared to other livestock. Corn, frequently used in conventional or grain-based systems, typically consumes more water than a native grass species, but is often grown in regions experiencing high levels of water scarcity and agricultural stress, therefore increasing the CON system's environmental impact (Kannan et al. 2018). It is also valuable to note that cattle grows more efficiently when being raised on grain or corn, decreasing the capacity for the animal to emit GHGs, particularly methane, into the atmosphere. This is a key reason why the CO_2e level for grass-fed systems is greater than that of a conventional system.

In estimating the ecological footprint of beef production in general, it is also important to consider the GHG emissions associated with legitimate substitute food products, such as chicken, lentils, and soybeans. It was surprising to find that comparing caloric value as opposed to another nutritional metric, such as protein, resulted in chicken having a significantly higher carbon footprint than beef. It was also interesting to find that lentils were much less carbon intensive than other vegetables such as soybeans. While there has been such a rapid domestic development of soy-based products as a meat and dairy replacement, it seems as though lentils could become another significant meat filler or replacement that would have superior carbon emissions savings.

Recommendations and Future Research

Boston College Dining must take action to reduce consumption of beef from grain-fed vendors in order to meet the local and national sustainability standards of the next few decades through the implementation of grass-fed and locally-raised beef products, as well as more plant-based food options. A previous Boston College Environmental Studies Seminar paper suggests that Boston College should produce and market more “50% beef blend” options in dining halls, satisfying student preferences while also reducing beef intake (Ellwell, Ferrara 2017). Other sustainable alternatives include offering more “meat-less” products (e.g., Grateful Burger, Impossible Burger) or utilizing lentils and legumes to fulfill nutritional needs. If hamburgers were removed from dining halls just one night per week, the school could save 122,716.9 lbs CO_2e annually.

From an ethical perspective, we suggest that Boston College and other universities begin demanding vendor supply chain transparency to better serve the health of their clients and the environment. As a Catholic university, Boston College also has the potential to reduce meat consumption, under the principle that we have an innate responsibility to care for the well-being of others and the planet, or even removing all meat from campus on Fridays during the lenten season.

If provided with more time and resources, we would have completed our own life-cycle assessment and included a greater emphasis of calculated food waste on campus. It would have also been beneficial to have access to the price paid for purchased food items to make more holistic recommendations on economic feasibility and potential benefits of product transitions.

Future research should increasingly focus on establishing an agreed upon value for the carbon equivalent measures and sustainability standards of grass-fed and locally-raised beef products. There is also a need to gauge public opinion on food preferences and environmental ethics to better understand how to curb beef demand at Boston College.

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