

Reducing Smith College's Dining GHG emissions: An analysis of beef and milk substitutions

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Executive Summary

The life cycle of food is responsible for over a quarter of global greenhouse gas (GHG) emissions through production, processing, distribution, and waste. The environmental impact of food varies by product, production method, and sometimes by region. Food purchasing currently contributes 27% of Smith College's Scope 3 emissions. As an educational institution, Smith has both the means and the incentive to make responsible food purchasing decisions that align with its goal of achieving carbon neutrality by 2030. While there are some emissions reductions that occur with the current purchasing practices, more of the procurement needs to be centered around emissions reduction to make a concrete change to Smith's environmental impact.

Throughout this project we worked with Smith Dining Services to analyze current purchasing practices in beef and dairy milk — two of the highest GHG-emitting food categories both at Smith and globally. Our key findings from this analysis were: 1) transportation emissions are a tiny fraction of the total emissions created from food production and most GHGs are emitted during the production phase; 2) substituting turkey, tofu, or black beans for beef would result in a GHG emissions reduction of 3,621-4,022 metric tons CO₂ equivalent and a cost decrease for Smith College at a rate of \$17-\$33 saved per ton GHG reduction; and 3) implementing plant-based milk substitutes such as soy milk or almond milk would result in GHG emissions reductions of 148-185 metric tons CO₂ equivalent and a cost increase for Smith purchasing at a rate of \$142-\$665 per ton GHG reduction. The results of our project give Smith Dining the resources to run rough emissions and cost analyses for different substitution scenarios that help to decrease emissions.

Introduction

The life cycle of food production accounts for 26% of global greenhouse gas emissions and draws resources from 43% of land and 66% of freshwater (Poore & Nemecek, 2018). Carbon footprints vary considerably within food groups and are dependent on variables like production, processing, and location (Poore & Nemecek, 2018). For example, the emissions reduction in buying local beef is only significant if the local producers value sustainable and low-emissions practices as well (Avetisyan et al., 2014). Only 1% of associated emissions come from delivery of beef compared to the 11% of emissions associated with the delivery of produce, primarily because the other emissions associated with beef are extremely high (Weber & Matthews, 2008).

Smith College has pledged to divest from fossil fuels and reach carbon neutrality by 2030 (Climate Leadership); however, this goal only includes reductions and offsets for direct emissions (Scope 1) and electricity purchase (Scope 2). To fully account for its environmental impact as an institution, Smith College needs to reduce its Scope 3 emissions, which are made up of indirect emissions through purchasing. Scope 3 emissions account for 44% of the college's total greenhouse gas emissions (Dietz, 2018). Over a quarter (27%) of Smith College's Scope 3 emissions (12% of total college emissions) can be attributed to food purchasing practices (Dietz, 2018). This means that shifting food purchasing towards low emissions options has the potential to minimize Smith's Scope 3 emissions.

One way that Smith is holding itself accountable to report on food purchasing data is by participating in the Real Food Challenge (RFC) — a project that challenged institutions to commit to 20% “Real” food by 2020. “Real” food is defined by the project as food that

“encompasses a concern for producers, consumers, communities, and the earth” (Real Food Challenge, *About: Our Principles*). The RFC project is a student-led initiative to hold institutions accountable for responsible food sourcing. Smith’s commitment to the Real Food Challenge in 2016 was spearheaded by former students Claire Westa ‘17, Lily Carlisle Reske ‘17, Lily Williams ‘18 (Smith College, 2016; Real Food Challenge, 2017). According to Smith’s Director of Dining Andy Cox, Smith Dining has surpassed the 20% benchmark and is continuing to increase purchasing of “Real” food (Cox, 2020).

The four pillars of the purchasing encouraged by the RFC are “local/community-based” (within 250 mile radius), “humane” (humanitarian treatment of livestock), “ecologically sound” (certified to conserve ecosystem biodiversity and resilience; minimize greenhouse gas and toxic emissions and natural resource exploitation), and/or “fair” (employee working conditions) (Real Food Challenge, 2017). Cox is currently prioritizing local sourcing because close proximity allows for site visits to assess sustainability initiatives, workforce health, humane treatment of livestock (if applicable), and progress towards organic and antibiotic-free production. In addition to this traceability, local sourcing also aligns with Smith College values. By buying locally, Smith puts money back into the community and has the potential to use local farms as educational tools — for example, many Environmental Science & Policy students learn about anaerobic digesters by touring Barstow’s Dairy Farm on class field trips.

Local procurement can also utilize middlemen—mediators in sales and transportation—to streamline the process of purchasing large quantities of food. For example, Smith’s current demand for beef is too high for one local farm to fill. A previous study by a Smith student

(Mansen, 2011) recommended that Smith partner with an “aggregator” to purchase local beef, which would make it possible to purchase meat from multiple sources in one order. A study by Coley et al. (2008) examined the emissions impacts of door-to-door delivery versus farm stand pick-up of fresh vegetables on an individual consumer level. They found that coordinated delivery of produce could have lower carbon emissions per unit of food as well as eliminate inefficiency at round-trip distances of over 7.4km (Coley et al., 2008). On industrial scales, however, the use of middlemen can make it harder to identify and track the sources and production emissions of different food products (Robinson et al., 2018).

In short, local foods are more traceable and are therefore more easily selected to encompass other RFC criteria, but they do not necessarily minimize Scope 3 emissions. The visibility of transportation can often overshadow the larger sources of GHG emissions of some foods. Beef is a good example of this: although local beef is transported fewer miles, a study by Avetisyan et al. (2014) suggests that the region of production can have a big enough impact on emissions intensity to outweigh the extra transportation emissions. Avetisyan et al. (2014) investigated the differences in emissions intensity raising livestock at different sites and compared this to the differential transportation emissions. They found that the production of ruminant livestock was much more efficient in certain regions, and only in those regions would a shift to local consumption contribute to emissions reduction (Avetisyan et al., 2014). In addition to differential costs, then, there may be drastically different emissions benefits to weigh when considering which foods should be sourced locally rather than distributed from larger-scale vendors. At the core of economically viable procurement lies an issue between sourcing as much local food as

reasonably possible and not going over budget; purchasing solely local foods can be significantly more expensive than purchasing food produced on a larger scale.

Previous studies by Smith students, as well as global studies, have found dairy and beef to be two of the highest-emitting categories in food (Weber and Matthews, 2008; Dietz, 2018). These emissions are illustrated by Weber and Matthews (2008) and can be seen in Figure 1. Based on these numbers it is clear that red meat and dairy are significantly higher in emissions than other categories. It is also clear how small the transportations emissions are, represented by the categories ‘Delivery,’ ‘OtherFreight, Dom,’ and ‘OtherFreight, Int’ (Weber and Matthews, 2008).

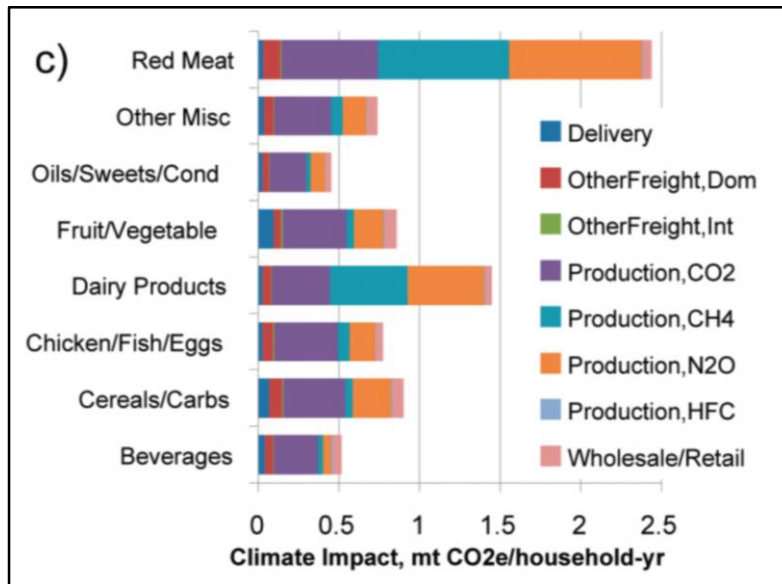


Figure 1. Life cycle emissions by source for select food groups. Blue, red, and green bars represent emissions from transportation, while bars to the right (purple and beyond) represent all other emissions. From Weber and Matthews (2008).

Food purchasing decisions are an opportunity for Smith College to look beyond the Real Food Challenge requirements and take its procurement values a step further in considering GHG emissions. In this project our goal was to locate places where Smith Dining can reduce emissions through procurement. Because transportation contributions to GHG emissions are low, our

objective is to showcase potential beef and milk substitutions which hopefully will have a larger impact on Smith's Scope 3 total. The results of our project can influence responsible allocation of college funds while prioritizing reduced Scope 3 emissions, which will help Smith reach a more rigorous carbon neutrality standard.

Methodology

Interviews

The initial phase of our project involved conducting in-person interviews with Smith Dining Services representatives Andy Cox, Patrick Diggins, and Dino Giordano. In our interview with Cox, the Director of Dining Services, he provided us with access to Smith's food purchasing data from the fiscal years 2019 that guided most of our analysis. Cox also spoke to us about Smith's commitment to the Real Food Challenge, highlighting that a focus on local food is an easy way to see how animals and employees are treated and also supports the local economy.

Interviewing Patrick Diggins, the Dining Purchasing Manager, provided insight into Smith's current food purchasing practices as well as how Dining Services handles its budget for purchasing local, healthy, diverse, allergy-conscious and low emissions food options. Diggins also introduced us to the Whole Animal Project, a collaboration with Amherst College, Mount Holyoke College, and Westfield State University to purchase entire heads of hog and beef during the low season. The purchase of these animals, which will be stored in large freezers on Smith's campus, can prevent seasonal layoffs by supporting local businesses in the off-season, and could reduce emissions that stem from processing and waste (see Conclusion for suggestions for future work). The Whole Animal Project also increases the variety in cuts of meat available to Smith

and partner colleges, providing more choices for students. In theory, the variety of meat cut also evens out the associated cost.

Our last interview was with Executive Chef Dino Giordano, who is in charge of menu creation and oversight for Smith Dining. Giordano provided insight into the recipe development process at Smith and explained which meat and dairy substitutes are most viable in practice. He also clarified that making comparable substitutes is fairly straightforward because the recipe database is quite simple, though vetting the actual products does take some time.

Research

Our research came from three main literature sources, as well as data from Cox. “Food-Miles and the Relative Climate Impacts of Food Choices in the United States” by Weber and Matthews (2008) revealed that although transportation is the most visible part of the food emissions equation, it only comprises a small fraction of the GHG emissions during the food production and distribution process. This study helped us narrow our focus specifically down to food production instead of including transportation into our emissions calculations.

A previous Smith study on the College’s Scope 3 Emissions by student Cara Dietz (2018) provided an excellent starting point for our research. This study presented a list of USEEIO multipliers for different food categories. The USEEIO Model, which stands for United States Environmentally Extended Input Output Model, helped us estimate the greenhouse gas emissions of these food categories based on cost. However, because these multipliers were established on a

price basis, they were not the most accurate method of estimating emissions since meat and dairy prices fluctuate and the cost of food products varies by source.

Our third report, Poore & Nemecek (2019)'s, "Reducing food's environmental impacts through producers and consumers," provided a list of multipliers based on food mass and volume which were better suited to our purposes. These multipliers allowed us to perform the necessary calculations to create estimates for current emissions created by Smith's beef and milk purchases, as well as estimates for emissions reductions should Smith implement lower GHG substitutions for its current purchases of beef and milk.

Our food purchasing data came from spreadsheets and documents shared with us by Andy Cox. One particularly extensive spreadsheet listed each food item purchased in the fiscal year 2019 alongside its food category, brand, manufacturer, weight purchased, cost, and other identifiers, including indicators of which Real Food Challenge classifications, if any, it fell into. We used these spreadsheets during the quantitative analysis phase of our project to determine the GHG emissions and cost estimates for Smith's current food purchases, as well as for the projected food purchases if Smith switched to less emissions-intensive beef and dairy substitutes.

Choosing Substitutes

Smith purchases a huge amount and variety of food annually. In order to make the project feasible for our group of four to conduct emissions research on Smith food purchases, it was necessary to hone in on a select few specific food categories to investigate. We decided to focus our research on two key food categories, beef and milk, that were relatively heavy in emissions

and a significant portion of Smith's dining budget. These are foods that are seen in the dining hall every day, are purchased frequently and in large quantities, and have a higher carbon footprint than other food categories. Investigating these categories, which are foods that have a high impact on the school's Scope 3 emissions, helped us maximize the efficacy of our report.

In choosing substitutes for beef and milk, we had three key criteria: substitutes had to be nutritionally similar (e.g. protein for protein), have comparable use (e.g. liquid for liquid), and be financially reasonable. These requirements ensured that we selected substitutes that would be relatively simple to implement in current recipes, provide similar nutritional content, and stay within Smith's food purchasing budget.

Data Analysis

We drew purchasing data from a detailed spreadsheet on Smith food purchases for the fiscal year 2019 (FY19). All GHG emissions estimates were based on emissions multipliers from the study by Poore and Nemecek (2018). Cost estimates were drawn from Smith food purchases whenever possible, or in the case of oat milk, estimated using the cheapest bulk source we could find in an online search. All data for milk and milk substitutes were calculated in units of gallons, while data for beef and beef substitutes relied on units of 100 grams of protein. Smith's current proxy carbon price was provided by Alex Barron.

Determining quantities of milk and beef purchased:

Using FY19 purchasing data, we estimated that Smith purchased milk at an average price of \$4.20 per gallon. We divided total dollars spent on milk in FY19 to estimate that Smith purchased 19,465 gallons of milk in that year. We used purchasing data on beef to estimate an

average cost of \$4.04 per 100g protein, and divided total beef purchases by this price to estimate a FY19 purchase of 81,741 units of beef (1 unit=100g protein). These quantities were the baseline quantities we used for all substitutions: for each substitution we assumed a replacement of the full volume (19,465 gallons for milk substitutes) or protein equivalent (81,741 units for beef substitutes, with 100g protein per unit).

Projecting emissions:

We used emissions multipliers from Poore and Nemecek (2018) to calculate emissions from 19,465 gallons of milk or an equivalent volume of plant-based substitutes, and from 81,741 units of beef or the protein equivalent of turkey, tofu, and black bean substitutes. The multipliers used are reported in Table 1. We converted all emissions estimates into metric tons of carbon dioxide equivalent (MT CO_{2e}).

Table 1. Emissions multipliers reported in kilograms of carbon dioxide equivalent (kg CO_{2e}) for milk and milk substitutes (per gallon), and beef and beef substitutes (per 100g protein). Multipliers are from Poore and Nemecek (2018).

	kg CO_{2e}/gallon			kg CO_{2e}/100g protein
Dairy milk	12.1		Beef	50
Rice milk	4.5		Turkey	5.7
Soy milk	3.8		Tofu	2.0
Oat milk	3.4		Black Beans	0.8
Almond milk	2.6			

Estimating cost:

Using FY19 purchasing data, we estimated the average cost of all substitutes (per gallon for milk substitutes; per 100g protein for beef substitutes). The spreadsheet did not contain data for oat milk purchase by volume; we instead estimated this cost by conducting an online search for oat milk and used the cheapest bulk price we could find. We then multiplied the estimated unit price for each substitution by the baseline quantities of milk and beef purchases. The estimated price per unit of each substitution used in our calculations is reported in Table 2.

Table 2. Unit price for milk and milk substitutes, and beef and beef substitutes, estimated from Smith College FY19 purchasing data or cheapest bulk price found online (for oat milk).

	\$/gallon			\$/100g protein
Dairy milk	\$4.20		Beef	\$4.04
Rice milk	\$7.52		Turkey	\$2.80
Soy milk	\$5.39		Tofu	\$3.21
Oat milk	\$10.00		Black Beans	\$2.43
Almond milk	\$6.98			

Determining cost of emissions reductions:

We calculated emissions reductions for each substitution by subtracting total estimated emissions from the baseline emissions associated with FY19 purchase of milk or beef. We calculated the difference in cost between FY19 milk or beef purchases and their substitutes by subtracting estimated costs of substitutions from the baseline cost. We then found the cost to Smith of reducing Scope 3 emissions through each substitute by dividing the difference in cost by the projected emissions reductions to get a dollar-per-ton rate (\$/MT CO₂e emissions reduction). We compared this to Smith’s current proxy carbon price of \$74 per MT CO₂e.

Putting emissions reductions in context:

To contextualize estimated emissions reductions in terms of removing cars from the road, we divided the emissions reductions of each substitution (MT CO₂e) by 4.6 MT CO₂e, the average emissions of a car in one year (EPA, 2020). We also used data on Smith College's sources of carbon emissions to put projected emissions reductions in a campus context (2018 Smith College emissions data).

Calculating the environmental and financial impacts of a substitution scenario:

We used the emissions reduction data and the dollar-per-ton calculated rate to estimate the environmental and financial impact of replacing half of beef purchases with equal parts (in 100g protein units) turkey, tofu, and black bean substitutes.

Results

Milk

Dairy milk purchases for FY19 totaled just under \$82,000 to account for an estimated 19,465 gallons of milk. The GHG emissions estimate for FY19 dairy milk purchase was 236 metric tons of carbon dioxide equivalent (MT CO₂e). Table 3 displays cost and emissions data for FY19 dairy milk purchases and plant-based substitutes, including projected emissions reductions and cost differences of plant-based milk substitutes relative to dairy milk baseline values for a full substitution by volume (19,465 gallons). Figure 2 compares the emissions estimates associated with FY19 dairy milk purchases and those associated with a full substitution for rice milk, soy milk, oat milk, and almond milk. Figure 3 shows the costs associated with each of those full substitutions.

Table 3. Cost and emissions data for actual FY19 milk purchases and projections for full volume substitutions (19,465 gallons) of plant-based milk substitutes. Emissions reductions and additional cost are relative to dairy milk baseline.

	Total emissions (MT CO ₂ e)	Projected cost	Emissions reduction (MT CO ₂ e avoided)	Additional cost
Dairy milk	236	\$82,000	N/A	N/A
Rice milk	88	\$146,000	148	\$64,000
Soy milk	74	\$105,000	162	\$23,000
Oat milk	66	\$195,000	170	\$113,000
Almond milk	51	\$136,000	185	\$54,000

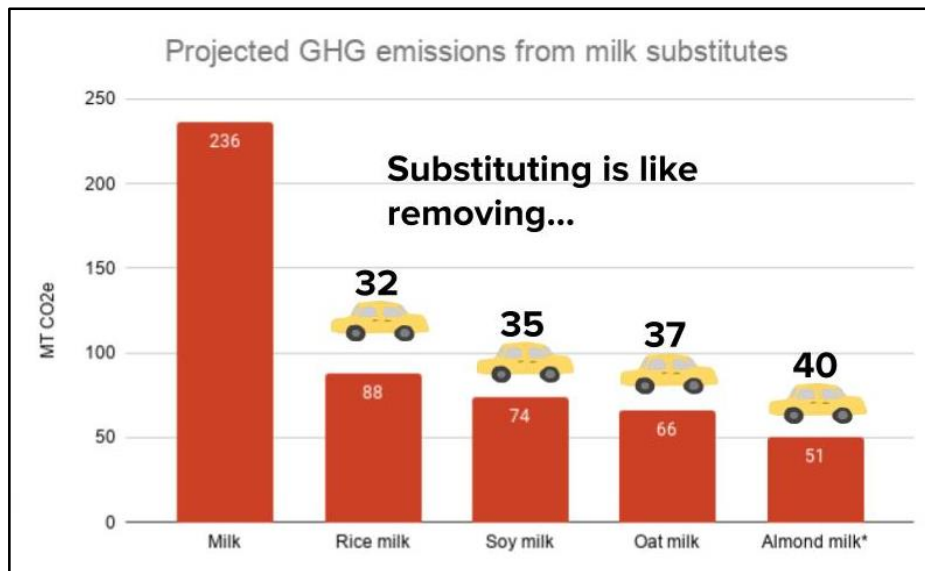


Figure 2. Emissions estimate for FY19 dairy milk purchase (far left) and projected GHG emissions for full volume substitution of dairy milk for plant-based substitutes in metric tons of carbon dioxide equivalent. The emissions reductions projected from a dairy milk baseline are shown in terms of cars removed from the road in a year.

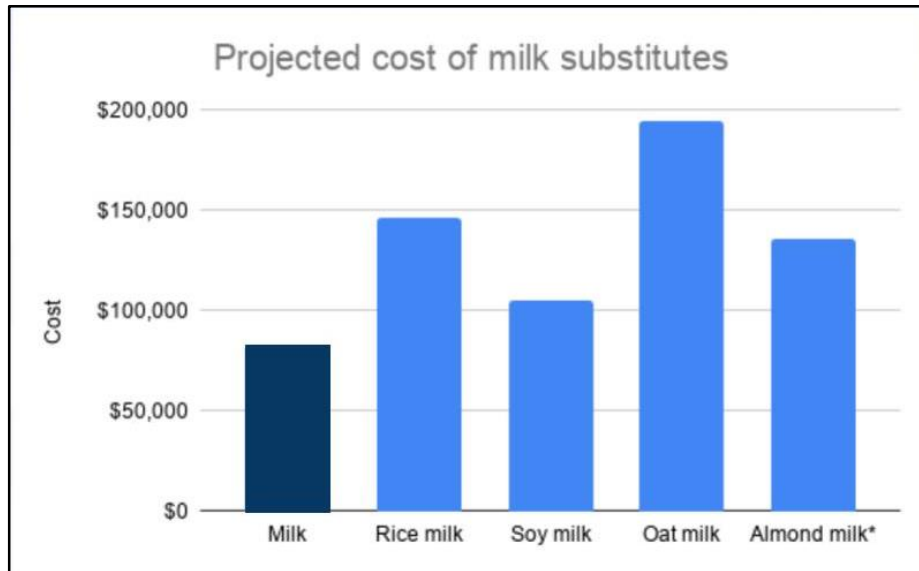


Figure 3. Cost comparison of dairy milk purchase and equivalent volume of plant-based milk substitutes. Actual money spent in FY19 on dairy milk is shown in dark blue (far left), while projected costs for an equivalent volume of each plant-based substitute are shown in lighter blue.

Milk substitutes

Rice milk: Replacing all FY19 dairy purchases with a rice milk alternative could reduce associated emissions by 62.8%. Total emissions were estimated at 88 MT CO₂e (Figure 2), which is 148 MT CO₂e lower than the dairy milk baseline (Table 3). The projected cost was \$146,000 total (Figure 3), an increase in cost by \$64,000 (Table 3). Emissions reductions were equivalent to removing an estimated 32 cars from the road (Figure 2).

Soy milk: Full substitution of FY19 dairy milk purchases with soy milk alternative resulted in estimated emissions reduction of 162 MT CO₂e (68.5%) and an increase in cost by \$23,000 over the year (Table 3). Estimated total GHG emissions for a soy milk substitute were 74 MT CO₂e (Figure 2). The cost associated with a full soy milk substitution was an estimated \$105,000 (Figure 3). Emissions reductions were equivalent to removing an estimated 35 cars from the road (Figure 2).

Oat milk: Oat milk substitution, with estimated total emissions of 66 MT CO₂e (Figure 2), resulted in a 71.9% emissions reduction of an estimated 170 MT CO₂e (Table 3). The estimated cost of full oat milk substitution was \$195,000 (Figure 3), a cost increase of \$113,000 over dairy milk purchase (Table 3). Emissions reductions were equivalent to removing an estimated 37 cars from the road (Figure 2).

Almond milk: Full almond milk substitution would reduce GHG emissions by 78.5%, resulting in total estimated emissions of 51 MT CO₂e (Figure 2), a decrease of 185 MT CO₂e from the dairy milk baseline (Table 3). The projected cost of a full almond milk substitution was \$136,000 (Figure 3), a cost increase of \$54,000 over dairy milk purchase (Table 3). Emissions reductions were equivalent to removing an estimated 40 cars from the road (Figure 2).

Beef

Beef purchases in FY19 totaled just over \$330,000 for an estimated 81,741 units (1 unit=100g protein). The estimated GHG emissions for total beef purchase in FY19 were 4,087 MT CO₂e. Table 4 displays cost and emissions data for FY19 beef purchases as well as estimated emissions reductions and cost estimates for beef substitutes, assuming full substitution. Figure 4 compares emissions estimates associated with actual beef purchases and a full substitution of turkey, tofu, or black beans. Figure 3 compares cost for the same substitutions.

Table 4. Cost and emissions data for actual FY19 beef purchases and projections for full protein substitutions (81,741 units of 100g protein each) of lower-emissions substitutes. Emissions reductions and additional cost are relative to beef baseline. Negative values in additional cost are dollar savings.

	Total emissions (MT CO ₂ e)	Projected cost	Emissions reduction (MT CO ₂ e avoided)	Additional cost
Beef	4,087	\$330,000	N/A	N/A
Turkey	466	\$229,000	3,621	- \$101,000
Tofu	163	\$262,000	3,924	- \$68,000
Black beans	65	\$199,000	4,022	- \$131,000

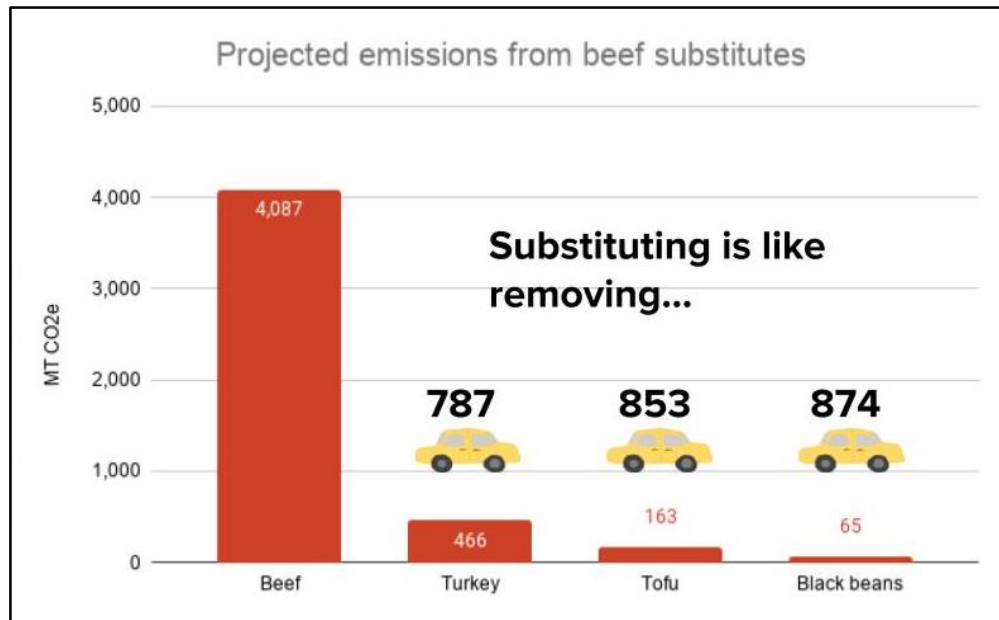


Figure 4. Emissions estimates in metric tons carbon dioxide equivalent for FY19 beef purchases and projected emissions for full substitution of turkey, tofu, or black beans on a grams-of-protein basis. Estimated emissions for actual FY19 beef purchases are shown on the far left. Projected emissions for an equal-protein purchase of substitutes are shown to the right, with emissions reductions displayed in terms of cars removed from the road in a year.

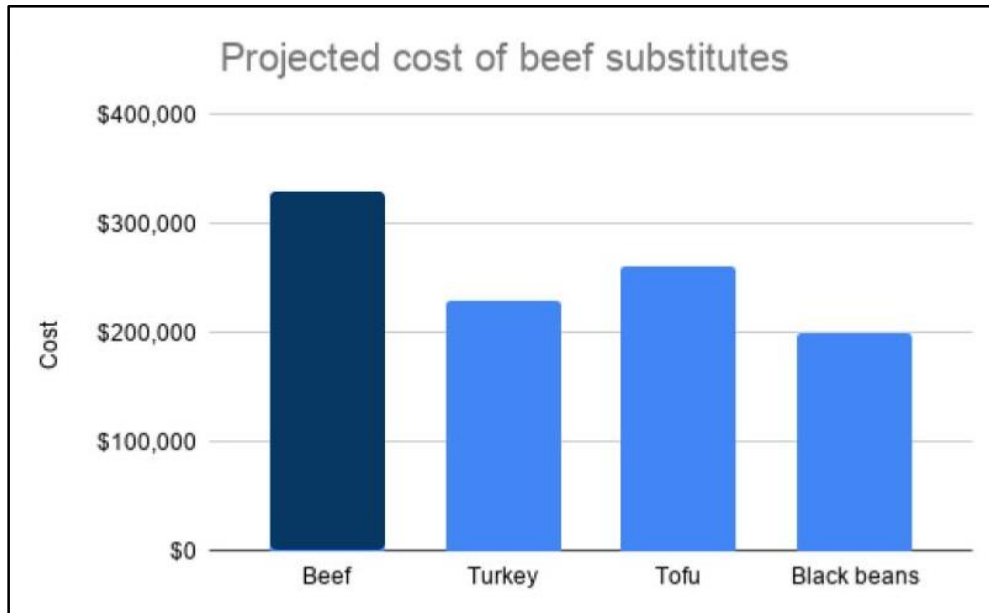


Figure 5. Cost comparison of FY19 beef purchases and beef substitutes. Actual money spent on beef in FY19 is shown in dark blue (far left), while projected costs of a full protein substitution for substitutes are shown in lighter blue to the right.

Beef substitutes

Turkey: Fully substituting FY19 beef purchases with an equivalent amount of protein from turkey would decrease emissions by 88.6%. The GHG emissions estimate for such a substitution was 466 MT CO₂e (Figure 4), with a total cost projection of \$229,000 (Figure 5). These estimates are 3,621 MT CO₂e and \$101,000 lower than the beef purchasing baseline (Table 4).

Emissions reductions are equivalent to removing an estimated 787 cars from the road (Figure 4).

Tofu: A full substitution of beef for tofu would decrease associated GHG emissions by 96%.

Total emissions for an equivalent amount of tofu in 100g-protein units were estimated at 163 MT CO₂e (Figure 4). The cost of the substitution was projected to be \$262,000 (Figure 5), which is \$62,000 less than the baseline beef purchase (Table 4). Projected emissions reductions, at 3,924 MT CO₂e, are equivalent to removing 853 cars from the road (Table 4; Figure 4).

Black beans: GHG emissions for a black bean substitution were estimated at 65 MT CO₂e (Figure 4), a 98.4% reduction from the beef baseline. The cost associated with this substitution was estimated at \$199,000 (Figure 5), a reduction of \$131,000 in total cost (Table 4). The 4,022 MT CO₂e reduction in GHG emissions is the equivalent of removing 874 cars from the road (Table 4; Figure 4).

Cost of emissions reduction

Milk substitutions reduced emissions at costs over \$100 per ton CO₂e avoided. Beef substitutions reduced emissions at a cost less than \$0 per ton CO₂e avoided. See Figure 6 for a comparison of the cost of emissions reductions through milk and beef substitutes to the \$74 per ton CO₂e used by Smith College.

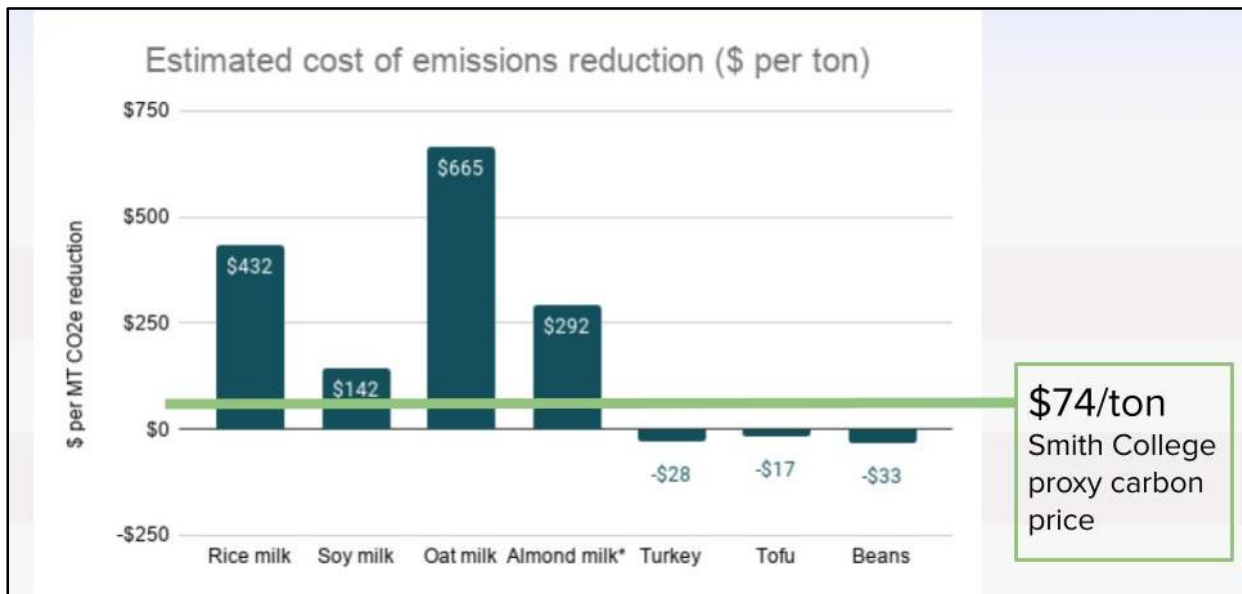


Figure 6. Cost of emissions reductions in dollars per metric ton of avoided GHG emissions (carbon dioxide equivalent) for each milk or beef substitute, compared to Smith College’s proxy carbon price. Each bar shows the amount Smith College would pay to reduce GHG emissions by one metric ton.

Milk substitutes

Rice milk substitution costs an estimated \$432 per metric ton GHG emissions reduction (MT CO₂e). The cost of emissions reductions through soy milk substitution is \$142 per ton.

Reductions through oat milk substitution cost at an estimated \$665 per ton, while almond milk substitution reduces emissions at a cost of \$292 per ton.

Beef substitutes

Substituting turkey for beef reduces emissions at a cost of -\$28 per ton, while GHG reductions through tofu occur at a cost of -\$17 per ton. The cost of emissions reductions through black bean substitution is -\$33 per ton.

Discussion

To place our results in the context of the Smith College campus, replacing all dairy milk purchases with any plant-based milk substitute results in emissions reductions of a magnitude equivalent to decarbonizing Smith's entire gasoline-fueled fleet of vehicles, which emit 137 MT CO₂e per year (2018 Smith College emissions data).

Emissions reductions associated with substituting beef for lower-emissions protein sources outweigh the emissions from all of Smith's purchased electricity (2,318 MT CO₂e per year) as well as all the estimated emissions from faculty and staff commuting (868 MT CO₂e per year; 2018 Smith College emissions data). On Smith campus, the largest single source of GHG emissions is the cogeneration power plant, which emits approximately 20,500 MT CO₂e per year (2018 Smith College emissions data). Emissions from Smith's FY19 beef purchases, and the

potential emissions reductions of a full substitution of beef for black beans, are approximately 4,000 MT CO₂e, or one fifth of the Cogen plant emissions.

Ultimately, our analysis found that, by completely substituting all FY19 beef purchases with alternatives such as turkey, tofu, and beans, Smith College could reduce annual Scope 3 emissions by an estimated 3600-4000 MT CO₂e. Any substitutions made will also save money, as all protein substitutes mentioned are generally less expensive than beef. With milk substitutions, the college could cut between an estimated 148 and 185 MT CO₂e, but all milk substitute prices are generally higher per unit than dairy milk. This is partially due to how heavily milk is subsidized by the US government, creating artificially low milk prices. Smith College set a proxy carbon price in 2018 that increases by 2.5% each year, which is used to determine which emissions reductions measures should be taken. All estimated milk substitute prices fall above Smith's proxy carbon price (currently \$74 per metric ton of carbon dioxide reduction), while all estimated beef substitute prices fall well below this threshold and would theoretically save the college money.

As beef is a high-impact category in terms of greenhouse gas emissions, any substitutions made in this area would have a far greater impact than substitutions made in food categories such as dairy and produce. This is consistent with the well-established fact that beef is one of the highest-emitting food products (Weber & Matthews, 2008; Poore & Nemecek, 2018). The college could save an estimated 1,900 metric tons in CO₂ emissions and \$50,000 by substituting half of its FY19 beef purchases with equal amounts of turkey, tofu, and black beans.

Conclusion

Since beef is both the highest-impact food category in terms of greenhouse gas emissions and one of the most expensive, the college would reduce its Scope 3 emissions and save significant amounts of money by purchasing less beef. We strongly recommend that the college purchase less beef and less dairy, although dairy milk is a lower priority than beef due to its lower associated greenhouse gas emissions. To implement substitutions at a dollar-per-ton rate that falls below Smith's proxy carbon price, the college could first substitute some portion of beef before addressing milk purchasing so that the money saved through beef substitutions could offset the increased cost of milk substitutes, which are universally more expensive than dairy milk.

Selecting which type(s) of non-dairy milk to substitute for some portion of Dining's dairy milk purchasing could constitute further work on this project. Our results found that replacing all the FY19 dairy milk purchases with almond milk would reduce carbon dioxide emissions by an estimated 134 MT per year, but our estimates do not account for water use. As almonds are notoriously water-intensive to grow and primarily grown in California, an area that often experiences drought, using almond milk on a larger scale in recipes may not be the most sustainable option. Further analysis is required to determine which milk substitute is the most all-around sustainable option, rather than solely the option that will produce the highest reductions in the college's Scope 3 emissions.

In going forward with the Whole Animal Project, we recommend data collection to document how the project compares financially to purchasing meats from a larger distributor, such as US

Foods. Researching whether local methods of production and processing release fewer GHGs than large-scale commercial production could also be a worthwhile future project; the emissions associated with feed production and meat processing can be especially intensive, and these emissions vary regionally and may be lower on a local scale (Adom et al., 2012). This would add further value to the Whole Animal Project; in addition to providing an economic boost to businesses during their low season and preventing layoffs, the college would be contributing to an initiative that potentially reduces the GHG emissions associated with beef and pork production.

For further future work on this project, a group could perform a similar analysis in other high-impact categories, such as produce. For this project, the focus was on beef and dairy milk as two of the overall highest greenhouse gas emitters, but the college also has a high potential to reduce its Scope 3 emissions by making substitutions in produce, pork, and other categories. Produce is an especially complex category with many subdivisions: green vegetables, starchy vegetables, berries, hard fruits, and so on. It is one of the highest impact categories at Smith College partially because of the sheer quantity of produce that the college purchases, so looking deeper into this category would likely be a project of its own.

Important to note while addressing the minimization of Smith's food emissions is the response of the student body to changes in dining hall food. One ENV 312 study from 2013 surveyed the student body about its willingness to give up nonlocal food and produce, and found that students surveyed were willing to give up popular nonlocal produce items like pears and tomatoes up to five times a week to help Smith source more locally (Mogensen, 2013). Student input is valued

at Smith; in 2007, Smith shifted purchases away from Coca-Cola products in response to college-wide concern over business practices (Wein, 2017). Surveying the student population to understand how receptive students may be to small-scale or large-scale dining changes may be an important step in successfully reducing the amounts of beef and dairy milk purchased each fiscal year. As a follow up to our project, we met again with Andy Cox, who was eager to discuss how Smith Dining might leverage our findings to influence student demand for emissions-intensive food products.

Literature Cited

- 2018 Smith College emissions data. FY18_SLC edit.xlsx.
https://drive.google.com/file/d/1ybBBjXfVQT-xFhgbQl_Akx1wCtKup-Lm/view.
- 2019 Fiscal Year Food Purchases. Smith College Dining Services.
https://docs.google.com/spreadsheets/d/1nJZGF6e_z1wkbIMqHW8d5aLFIgW17yUFUy_uau2h8zR4/edit#gid=81854220.
- Adom, F., Maes, A., Workman, C., Clayton-Nierderman, Z., Thoma, G., & Shonnard, D. (2012). Regional carbon footprint analysis of dairy feeds for milk production in the USA. *International Journal of Life Cycle Assessment*, 17, 520-534.
<https://doi.org/10.1007/s11367-012-0386-y>.
- Avetisyan, M., Hertel, T., & Sampson, G. (2014). Is local food more environmentally friendly? The GHG emissions impacts of consuming imported versus domestically produced food. *Environmental & Resource Economics*, 58, 415-462. <https://doi.org/10.1007/s10640-013-9706-3>.
- Climate Leadership. (n.d.). Retrieved May 7, 2020, from <https://www.smith.edu/about-smith/sustainable-smith/climate-leadership>
- Coley, D., Howard, M., & Winter, M. (2009). Local food, food miles and carbon emissions: A comparison of farm shop and mass distribution approaches. *Food Policy*, 34, 150-155.
<https://doi.org/10.1016/j.foodpol.2008.11.001>.
- Cox, A. (2020, February 14). Personal Interview.
- Diggins, P. (2020, March 12). Personal Interview.
- Dietz, Cara, "Estimation of Smith College's Scope 3 Emissions" Group project by Dietz, Cara, Eliana Gevelber, Gray Li. (2018). Other Projects. 36.
https://scholarworks.smith.edu/other_projects/36.
- EPA. (2020). Greenhouse gas equivalencies calculator - calculations and references.
<https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references>
- Giordano, D. (2020, April 20). Online Interview.
- Mansen, S. (2011). Smith's journey into the local food system: identifying the bottlenecks. *Other Projects*, 18. https://scholarworks.smith.edu/other_projects/18.
- Mogensen, Hanna. (2013). Farm to Fork: Increasing and Celebrating Local Food on Smith College Campus (excerpts). *Smithies on Food*.
- Poore, J. & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science*, 360(6392), 987-992. <https://doi.org/10.1126/science.aaq0216>.
- Real Food Challenge. *About: Our Principles*. (n.d.). Retrieved May 6, 2020, from <https://www.realfoodchallenge.org/about/>.
- Real Food Challenge. (2017). *Real food standards 2.1*.
<https://www.realfoodchallenge.org/resources/implementation-product-shift-resources/real-food-standards-20/>.
- Robinson, O. J., Tewkesbury, A., Kemp, S., & Williams, I. D. (2018). Towards a universal

- carbon footprint standard: A case study of carbon management at universities. *Journal of Cleaner Production*, 172, 4435-4455. <http://dx.doi.org/10.1016/j.jclepro.2017.02.147>.
- Smith College Dining Real Food Vendor Outline. Smith College Dining Services. https://docs.google.com/document/d/1E2FiW9p5cuP_Hjx8B_TxEZmePujd-5NiDXNVIKPHrqg/edit.
- Smith College. (2016). Smith Joins National College-Based Real Food Challenge. <https://www.smith.edu/about-smith/news/smith-joins-national-college-based-real-food>.
- Weber, Christopher L., Matthews, Scott H. (2008). Food-Miles and the Relative Climate Impacts of Food Choices in the United States. *Environmental Science & Technology*, 42(10). <https://doi.org/10.1021/es702969f>.
- Wein, Rachael. (2017). Smith College OP-11: Sustainable Procurement. Retrieved from <https://reports.aashe.org/institutions/smith-college-ma/report/2017-03-03/OP/purchasing/OP-11/>.

Contributions

A.C.N., F.D., and K.T. conceived project theme and direction. A.C.N., K.T. and F.D. interviewed Andy Cox and Patrick Diggins from Dining Services. A.C.N. and E.C. researched and compiled data on beef and beef substitute emissions estimates. F.D. and K.T. researched and compiled data on milk, dairy, and milk substitute emissions estimates. F.D. and E.C. conducted quantitative emissions and cost analysis of the Smith College Fiscal Year 2019 Food Purchases spreadsheet and produced graphical representations of results. A.C.N., F.D. and E.C. interviewed Dino Giordano about menu prep and substitutions. A.C.N, E.C., F.D, and K.T. contributed to results analysis and interpretation and wrote this report.