Forward Food GHG Assessment Report
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Carbon Footprint of Food Purchases at [redacted]

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Introduction

The food system is closely and inextricably linked with the environment. Agriculture occupies half of all ice-free land on Earth, and the global food system is responsible for 34% of all greenhouse gas (GHG) emissions[1]. As the human population and economy continue to grow, it will become ever more important to meet society's needs within the bounds of planetary sustainability.

Some foods have much larger environmental impacts than others. Animal products generally use more resources and cause more GHG emissions than plant foods[2]. In fact, a shift toward plant-based diets is one of the only options available to simultaneously improve society's carbon footprint, land use, and food security[3,4]. Institutions and individuals can make a real environmental difference by reducing meat consumption – all while improving health and reducing costs.

[redacted] commitment to improving the availability of plant-based meals on campus provides an excellent opportunity to address climate change emissions from food. This report, based on one semester of dining hall purchase data, shows how meat purchases contribute to the University's carbon footprint and how shifts toward plant-forward menus can reduce emissions.

Methodology

Food Purchase Data

[redacted] supplied data on the weight of food purchases during the Fall 2019 semester (August 1 to December 31, 2019), categorized by animal species and food type. The full data set contained over 1400 items, from which 1081 unique foods in 52 categories were matched with environmental impact data. These were consolidated into 19 categories of meat, dairy, eggs, plant-based meat and dairy alternatives, plant proteins, grains, vegetables, and fruit. For a full list of the original categories, see Appendix A.

The number of servings protein from animal and plant food product categories were estimated using USDA nutritional guidelines. Protein ounce-equivalents for each category of high-protein food were

[1] Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F. N., & Leip, A. (2021). Food systems are responsible for a third of global anthropogenic GHG emissions. Nature Food, 2(3), 198-209.

[2] Searchinger T, Waite R, Hanson C, Ranganathan J, and Dumas P. (2019) Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050. Ed. Emily Matthews. World Resources Institute, Washington DC. https://www.wri.org/our-work/project/world-resources-report/world-resources-report-creating-sustainable-food-future

[3] IPCC (2019) Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Summary for Policymakers. https://www.ipcc.ch/report/srccl/

[4] IPCC (2018) Global Warming of 1.5 °C: An IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. https://www.ipcc.ch/sr15/

used to convert edible product weights to protein-equivalent servings[5]. These protein-equivalent servings were used as a proxy for the number of nutritionally-equivalent animal and plant-based entrees served.

Greenhouse Gas Emissions Assessment

Greenhouse gas emissions of purchased plant and animal products were calculated using a "life cycle" approach that includes the energy and emissions required to grow crops and animal feed, as well as breed, house, transport, and process livestock at a slaughterhouse. Emissions from post-farm food storage, processing, packaging, and transportation to distribution centers are included using global averages[6]. This life cycle emissions measurement approach is similar to the GHG Protocol Scope 3 carbon emissions standard[7]. Emissions are reported as carbon dioxide-equivalent emissions (CO_2e), a unit combining carbon dioxide, methane, nitrous oxide, and other GHGs on a common basis. All GHG emissions are adjusted according to their warming effect relative to carbon dioxide over 100 years. For more detailed information the data sources, see Appendix B.

Limitations

This assessment includes several broad assumptions about the composition of purchased foods that limit its accuracy and precision. One problem is that the composition of multi-ingredient foods, like breaded meats, sweetened yogurt drinks, breakfast cereals, etc. was not available. Another challenge is that high-quality life cycle environmental impact data is only available for a limited number of crops and food categories.

Because of these limitations, foods were assigned to 52 categories based on their primary ingredient. For example, breaded meats were categorized by meat type and breakfast cereals were categorized as grains. The carbon footprint of these foods was then assumed to be equivalent to the primary ingredient. For foods with a high-impact primary ingredient, like breaded meats and sweetened yogurts, this may lead to a slight overestimate of the carbon footprint. The same process could underestimate the carbon footprint of foods with a low-impact primary ingredient, like breakfast cereals and filled pastas. Overall, due to the relatively low purchase quantities of mixed-ingredient foods, we expect these assumptions will not affect the broad conclusions from this assessment.

The data set of food GHG emissions (see Appendix B) was developed for use in the United States, with a focus on North American food production. Differences between Canadian and American production and consumption patterns (for example, the proportion and origin of imported meats and vegetables)

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[5] Protein servings defined as 4 ounce-equivalents of high-protein foods according to the USDA (approximately 4 ounces of meat, 8 ounces of eggs, beans, and tofu, or 2 ounces of nuts and seeds; https://www.myplate.gov/eat-healthy/protein-foods).

[6] Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.

[7] For information on the GHG Protocol standards, see https://ghgprotocol.org/standards

could affect the accuracy of the carbon footprint estimates for individual foods. Overall, due to the relatively low purchase quantities of mixed-ingredient foods and the broad similarities between food consumption patterns in the United States and Canada we expect these assumptions will not affect the broad conclusions from this assessment.

From the initial list of 1400 food products, about 350 foods did not match available food emissions data. These items totaled 33.7 tons, or about 7% of all reported food purchases. These foods include condiments and spices that, because of their wide range of primary ingredients (including water, sugar, and tropical plants), are expected to have a wide range in GHG emissions. It is beyond the scope of this report to assess the GHG emissions from these foods, but we expect this assessment of the remaining 93% of [redacted] food purchases will provide sufficient evidence for food-based emissions reductions.

Results

Data Summary

This assessment covers 503 metric tons of [redacted] food purchases. Broadly, these consisted of vegetables (184 tons), dairy (110 tons), animal protein (meat and eggs, 78 tons), grains (63 tons), fruit (34 tons), plant proteins (plant-based meat, beans, nuts, tofu, etc., 9.7 tons), and plant-based dairy (2.8 tons).

Total food purchases for Fall 2019 represent 1,400 metric tons of GHGs, or 3.2 million pounds of CO_2-equivalent emissions. These include estimates of all the emissions from producing, processing, storing, and transporting food to the University, but do not include emissions from preparing meals on campus or operating dining hall facilities. These emissions from one semester of food purchases are equivalent to operating a fleet of 310 cars or heating a neighborhood of 170 homes for a year[8]. It would take 1,800 acres of US forests to absorb that much CO_2 each year. Mitigating those emissions would cost about $120,000 annually through solar power purchasing agreements, or $270,000 by replacing incandescent lightbulbs with LEDs.

Animal products were 37% of purchases but were responsible for 78% of GHG emissions. Chicken was the highest-volume meat purchased, followed by pork and beef. Combined, these three meats represent 12% of assessed purchases by weight and 41% of GHG emissions (Table 1). Dairy products also represented major purchase categories. Milk was the second-largest category by weight (after vegetables) and by GHG emissions (after beef) at 320 metric tons of CO_2e. Vegetables, the largest category by weight at 37% of all reported purchases, were responsible for only 9% of GHG emissions.

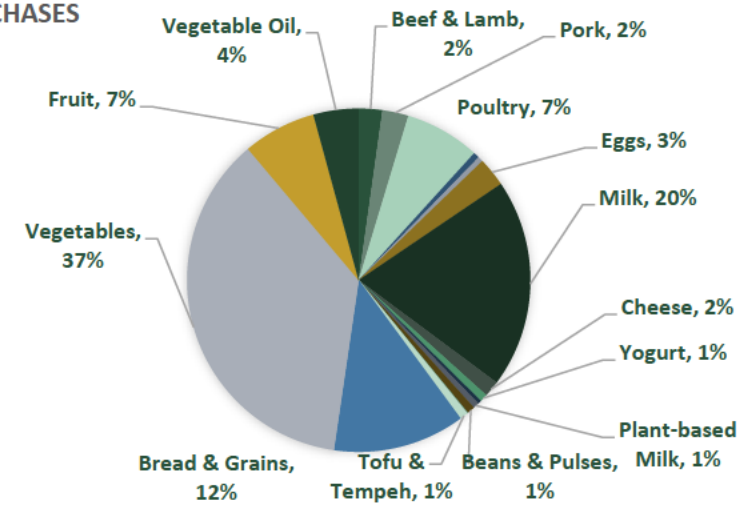
[8] Estimated using the EPA Greenhouse Gas Equivalencies Calculator: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Table 1: Purchased weight (in kilograms), greenhouse gas (GHG) emissions (in carbon dioxide-equivalents), and total number of animals consumed for each reported food type for the Fall 2019 semester. Totals and sums may appear to differ due to rounding.

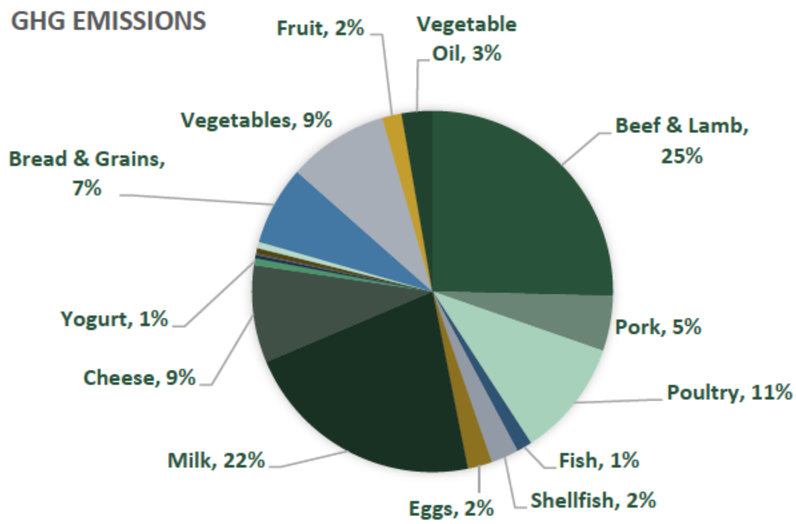
	Purchases		GHG Emissions		Animals Eaten	
	kg	%	$kgCO_2eq$	%	#	%
Beef	11,150	2.2%	370,000	26%	58	0.1%
Pork	12,368	2.5%	71,000	5.1%	175	0.4%
Poultry	35,588	7.1%	150,000	11%	21,409	46.4%
Fish	2,851	0.6%	20,000	1.4%	1,413	3.1%
Shellfish	2,457	0.5%	36,000	2.6%	22,614	49.0%
Eggs	13,771	2.7%	31,000	2.2%	477	1.0%
Milk	98,783	20%	320,000	22%	3.6	0.0%
Cheese	7,613	1.5%	130,000	9.0%	2	0.0%
Yogurt	3,731	0.7%	9,000	0.6%	0.1	0.0%
Plant-based Meat	1,706	0.3%	4,000	0.3%		
Plant-based Milk	2,797	0.6%	2,300	0.2%		
Beans & Pulses	3,636	0.7%	14,000	0.5%		
Peanuts	210	0.04%	400	0.0%		
Nuts & Seeds	240	0.05%	-220	0.0%		
Tofu & Tempeh	3,889	0.8%	8,000	0.6%		
Bread & Grains	62,507	12%	41,000	7.3%		
Vegetables	183,873	37%	88,000	9.3%		
Fruit	34,7030	6.9%	19,000	1.8%		
Vegetable Oils	21,409	4.3%	40,000	2.8%		
ANIMAL TOTAL	188,311	37.4%	1,100,000	80.2%	46,151	100.0%
PLANT TOTAL	314,971	62.6%	210,000	19.2%	0	0.0%
GRAND TOTAL	503,282	100.0%	4,900,000	100.0%	46,151	100.0%

The number of animals used to supply [redacted] assessed Fall 2019 food purchases – 46,000 – shows a much different pattern than the GHG footprint. Chicken and shellfish dominate the chart of total animals consumed, with smaller contributions by fish and chicken (for eggs) (Figure 1). Animal size is an important factor in these calculations. Even though beef accounted for 17% of animal meat purchases, they represented just 0.1% of animals consumed. Because poultry make up over 46% of purchased animals and 24% of meat-related emissions, they make an excellent target for substitution with plant-based meat products. This information can help institutions target and promote menu changes to students and other consumers, particularly as many individuals are becoming more interested in ethics and animal welfare issues.

PURCHASES



GHG EMISSIONS



ANIMALS EATEN

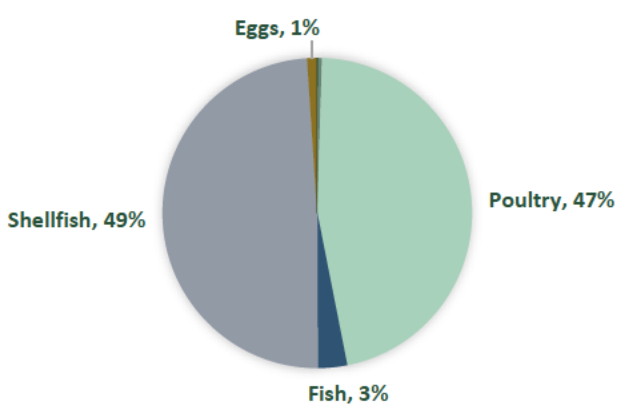


Figure 1: Proportions of food purchases, GHG emissions, and number of animals eaten by food category during the Fall 2019 semester at [redacted]*. Food categories that represent less than 0.5% of the total in each chart omitted for clarity.*

Balance of Plant and Animal Foods

Purchases of plant-based alternatives were generally much lower volume than corresponding animal product purchases. The University purchased approximately 1.7 tons of plant-based meat 2.8 tons of plant-based milk, compared to 64 tons of animal meat and 99 tons of dairy milk. Based on this assessment, the [redacted] purchased 6.5 times more beef alone than plant-based meat, with 90 times more GHG emissions. These large differences highlight an area of opportunity to reduce emissions through a shift in purchasing to plant-based meat and dairy alternatives. As more appealing and cost-effective plant-based meats and dairy alternatives arrive on the market, institutions increasingly have a range of options available to provide low-emissions dining choices. Increasing the proportion of plant-based milk purchases from 3% to 50%, for example, could provide 120 tons in GHG emissions savings. That is equivalent to reducing the University's annual vehicle fleet usage by 470,000 km or planting 57,000 trees[9,10].

GHG Savings Potential

[redacted] has an opportunity to dramatically reduce its GHG emissions through menu changes. Replacing animal sourced meats with plant sourced foods provides more GHG savings than using lower-carbon animal meats (such as switching from beef to chicken) and allows for more menu variety. Plant forward dishes can reduce the GHG emissions of even lower-emitting meat products by over 80%. Animal to plant protein shifts also have numerous unique co-benefits, resulting in lower water, pesticide, fertilizer, and land use[11,12]. There are also numerous health co-benefits related to animal to plant protein shifts. For example, the consumption of 100 g unprocessed red meat per day relates to a 19% increased risk of type 2 diabetes[13], a 21% higher stroke risk[14], and a 17% increased risk of colorectal cancer[15]. Substituting just one serving per day (84 g) of unprocessed red meat with one serving of foods including legumes is associated with a 7-19% lower mortality risk[16].

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[9] Estimated using the EPA Greenhouse Gas Equivalencies Calculator: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[10] Number of trees based on WA DOR 'Planting Forest Seedlings: How to select, plant, and care for tree seedlings. Online at https://www.dnr.wa.gov/publications/frc_webster_plantingforestseedlings.pdf. Accessed July 12, 2021.

[11] Sabaté J, Sranacharoenpong K, Harwatt H, Wien M, Soret S. (2015) The environmental cost of protein food choices. Public Health Nutr. 18 (11):2096.

[12] Eshel G, Shepon A, Makov T, Milo R (2014) Land, irrigation water, greenhouse gas, and reactive nitrogen burdens of meat, eggs, and dairy production in the United States. Proc Natl Acad Sci 111:11996–12001

[13] Pan A, Sun Q, Bernstein AM, et al. (2011) Red meat consumption and risk of type 2 diabetes: 3 cohorts of US adults and an updated meta-analysis. The American Journal of Clinical Nutrition 94:1088-96.

[14] Micha R, Wallace SK, Mozaffarian D. (2010) Red and processed meat consumption and risk of incident coronary heart disease, stroke, and diabetes mellitus: a systematic review and meta-analysis. Circulation 121:2271-83.

[15] Bouvard V, Loomis D, Guyton KZ, et al. (2015) Carcinogenicity of consumption of red and processed meat. The Lancet Oncology 16:1599-1600.

[16] Pan A, Sun Q, Bernstein AM, et al. (2012) Red meat consumption and mortality: results from 2 prospective cohort studies. Arch Intern Med 172:555-63.

GHG Hotspots: Highest-emitting products

Out of all individual products purchased, the five highest-emitting chicken products add up to about 4.1% of total GHG emissions. The most popular product, Chicken Strip Halal, was responsible for 17 metric tons of CO_2 (Table 2). Other products, including chicken leg meat and wings, generated 8 to 13 metric tons of CO_2.

[redacted] purchased pork products in smaller quantities than chicken products in Fall 2019. The top five pork purchases represent just 1.1% of all purchases by weight, compared to 3.0% for the top five chicken products. These pork products are responsible for 2.2% of total purchase GHG emissions (Table 3).

The five highest-emitting beef items, including burger patties, meatballs, and whole sirloin steaks, represent 15% of all assessed food purchase emissions. Though beef was purchased at roughly half the volume of the top chicken products, the GHG emissions from beef are much higher (Table 4).

Table 2: GHG Hotspots - Top 5 Emitting Chicken Purchases

Food Item	Rank (Chicken)	Rank (All foods)	Weight (kg)	GHGs (kg CO_2e)	GHGs (% Total)
CHICKEN STRIP HALAL	1	12	4,288	17,000	1.3%
Chicken Leg Meat Roaster BNLS SKNLS FLAT	2	19	3,309	13,000	1.0%
Chicken Leg diced 1.5-2" Fresh Boneless and skinless 10lb bx cut 1.25"	3	23	3,017	12,000	0.9%
Pub style Wings Par Fried	4	29	2,216	8,800	0.7%
Chicken Leg A/C KNIFE CUT BACK OFF	5	32	2,030	8,000	0.6%

Table 3: GHG Hotspots - Top 5 Emitting Pork Purchases

Food Item	Rank (Pork)	Rank (All foods)	Weight (kg)	GHGs (kg CO_2e)	GHGs (% total)
PORK MEAT GRLC BITES	1	31	1,453	8,400	0.6%
PORK SHOULDER BNLS NED BUT CDN	2	36	1,338	7,700	0.6%
BACON PRECOOKED SLI 18/22 CDN	3	43	1,113	6,400	0.5%
SAUSAGE PORK LINK 12-14 CT CDN	4	58	855	4,900	0.4%
PORK BREAKFAST SAUSAGE	5	69	639	3,700	0.3%

Table 4: GHG Hotspots - Top 5 Emitting Beef Purchases

Food Item	Rank (Beef)	Rank (All foods)	Weight (kg)	GHGs (kg CO_2e)	GHGs (% total)
JITS BEEF BURGER PATTY CHUCK 75/25 LOCAL	1	1	2,913	94,000	7.0%
MEATBALL BEEF .5 OZ W CHSE	2	3	1,324	43,000	3.2%
BEEF STRIPLOIN BNLS UNGRADEDFZ	3	6	915	32,000	2.4%
AA BEEF STRIPLOIN STK	4	9	768	27,000	2.0%
BEEF ROAST SLI SURE SLICE FRSH	5	14	435	15,000	1.1%

Table 6: GHG Hotspots - Top 5 Emitting Dairy Purchases

Food Item	Rank (Dairy)	Rank (All foods)	Weight (kg)	GHGs (kg CO_2e)	GHGs (% total)
10L 18% Cream	1	2	15,060	85,000	6.3%
473mL Chocolate	2	4	14,155	34,000	2.6%
4Lt 2%	3	7	13,000	31,000	2.3%
10L 2% Milk	4	8	11,320	27,000	2.0%
1L 2% Milk	5	10	9,188	22,000	1.7%

Combined, the dairy products assessed in this study account for over one-fifth of all purchases by weight (22%) and nearly one-third of GHG emissions (30%). Most of these purchases were a variety of milk and cream products. The five highest-emitting dairy products, all high-volume milk purchases, account for 12% of purchases by weight and 14% of all assessed GHG emissions (Table 6). This is somewhat unusual among dining systems. Cheese products are often the higher-emitting dairy purchases because cheeses are about 7 times more carbon-intensive than cow milk. The relatively low volume of cheese purchases and higher volume of milk purchases presents an opportunity for [redacted]. Plant-based milk products often have lower GHG emissions than dairy milk and are often more affordable and better-liked by consumers than plant-based cheeses. Replacing some dairy milks with plant-based milks could lead to substantial carbon savings without sacrificing flavor.

Overall, the top five purchases in each high-impact category (beef, pork, and poultry, and dairy) combined make up 18% of all assessed purchases by weight (47% of animal product purchases) and 35% of GHG emissions (44% of animal product emissions). This provides an opportunity for [redacted] to examine new recipes or substitutions for these products. Replacing the five highest-emitting animal products of each type (beef, pork, and chicken) with meat analogs (plant-based products that look and taste like animal meat) could cut GHG emissions by up to 210 metric tons per year (Table 7). Replacing those meats with beans, peas, or other high-protein plants increases the emissions reduction to 280 metric tons annually, or 94%. Achieving the same emissions reductions through solar power purchase agreements would likely cost the University $23,000 per year, or more than $53,000 from installing LED light bulbs.

Replacing all 20 ingredients on these lists, including the top 5 emitting dairy purchases, with low-emissions plant foods could help [redacted] reduce food purchase emissions by about 30%, or 440 metric tons of CO_2e per semester. That is equivalent to purchasing about 1200 MWh of solar electricity at a cost of $35,000 or reducing the University's vehicle fleet usage by 1.8 million km per year.

Table 7: GHG emissions reductions from replacing the 5 highest-emitting chicken, pork, and beef products with meat analogs or beans and pulses. Totals and sums may appear to differ due to rounding.

	Meat Analog Emissions Reduction (kg CO_2e)	(%)	Pulses & Beans Emissions Reduction (kg CO_2e)	(%)
Beef	190,000	92%	210,000	98%
Pork	18,000	57%	28,000	90%
Chicken	22,000	38%	50,000	85%
TOTAL:	230,000	78%	280,000	95%

These emissions reductions are a best-case scenario using lower-emissions plant-based meats. Some beef and chicken meat analogs that have recently been highly successful in the United States and Canada have somewhat higher emissions (3-8 kg CO_2e per kg, compared to 2-3 kg CO_2e per kg for low-emitting products)[17,18]. This difference is not substantial when comparing meat analogs to beef, lamb, and other high-emissions meats, but it does affect the emissions reductions when substituting these products for chicken or pork. Replacing chicken with some of these higher-emitting meat analogs could result in minor emissions reductions or even increase emissions. These meat analogs still provide environmental benefits by reducing land use and improving water quality, and their carbon footprints will decrease as the electricity used to process them becomes more renewable. Meanwhile, replacing meats with pulses, beans, and other whole foods is the most reliable – and healthful – way of reducing GHG emissions from food.

Plant-Based Entrees

The data in this assessment shows that [redacted] has an opportunity to serve more plant-based protein. An examination of high-protein food purchases shows that 88% of protein servings in Fall 2019 came from animal sources (Figure 3)[19]. Without a detailed assessment of recipes and nutritional information of entrees served at the University, this comparison is a general guide to the proportion of nutritionally equivalent plant-based meals served.

Eliminating meat purchases across all dining halls is a daunting task, despite the benefits. But meeting the Forward Food target of increasing plant-based meals by just 20% can also make a large impact. Based on the assessed Fall 2019 purchases, a 20% reduction across all meat purchases (and replacement with equally appetizing plant-based meals) would generate 250 metric tons (550,000 lbs) of GHG savings over a full year. That is equivalent to reducing University vehicle fleet usage by 1

[17] Based on reported carbon footprints of 2.1 and 5.8 kg CO_2e/kg for chicken nugget analogs from Mejia MA, Fresan U, Harwatt H, et al. (2019) Life Cycle Assessment of the Production of a Large Variety of Meat Analogs by Three Diverse Factories. J Hunger & Env Nutrition. DOI: 10.1080/19320248.2019.1595251

[18] Dettling, J, Tu Q, Faist M, DelDuce A, and Mandlebaum S. (2016) A Comparative Life Cycle Assessment of Plant-Based Foods and Meat Foods. Quantis USA.

[19] Protein servings defined as 4 ounce-equivalents of high-protein foods according to the USDA (approximately 4 ounces of meat, 8 ounces of eggs, beans, and tofu, or 2 ounces of nuts and seeds; https://www.myplate.gov/eat-healthy/protein-foods).

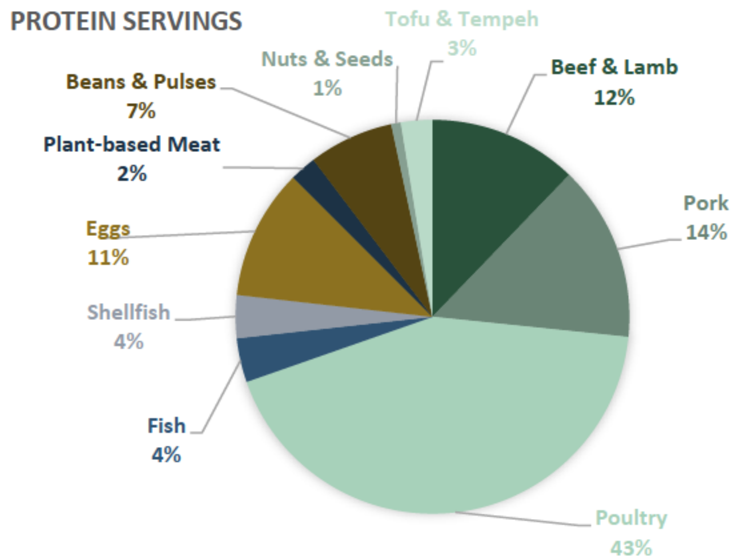

Figure 2: Servings of high-protein foods at [redacted] *in Fall 2019 by food category.*

million km or planting 120,000 trees. With the large – and growing – percentage of vegetarians and "flexitarians" around the country, a 20% shift from meat to whole-plant meals may not be difficult to achieve. In fact, the University's success in shifting milk purchases from dairy to plant-based products highlights the impact that identifying and promoting appetizing alternatives can have for most consumers.

GROUND MEAT SUBSTITUTION

Another way of identifying effective, easy targets for recipe substitutions is to look at ground and processed meat purchases. Ground meats are often used in burgers, sauces, and mixed meat-and-vegetable dishes with easy vegetarian alternatives. A wide variety of plant-based burgers are available, ranging from new products almost indistinguishable from beef to healthier minced vegetable patties. Swapping ground meat for plant-based meat analogs, vegetables, or tempeh in other recipes can even boost flavor while reducing GHG emissions.

In Fall 2019, [redacted] purchased nearly 12 metric tons (26,000 lbs) of ground and processed meat. This included roughly 7 tons of ground beef and 5 tons of pork sausage, amounting to 18% of all meat purchases. The GHG emissions from ground meat – 240 metric tons – were 17% of all assessed food emissions.

Replacing ground meats with plant-based meat analogs could reduce the University's food purchase emissions by 200 metric tons. That is equivalent to driving 820,000 km, or all of the carbon stored by 250 acres of US forest each year[20]. While switching to plant-based meats could be cost-neutral,

[20] Estimated using the EPA Greenhouse Gas Equivalencies Calculator: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

achieving the same GHG emissions reduction with solar power purchase agreements could cost the University $16,000 per semester.

Replacing ground meats with beans, pulses, or other high-protein whole plant foods could be even more climate-friendly. Substituting beans or lentils in ground meat recipes could reduce total emissions from food purchases by 16%, saving 240 metric tons of CO_2. That is equivalent to driving 1 million km, or all of the carbon stored by 290 acres of forest each year. Achieving the same GHG reductions with solar power purchase agreements could cost the University $19,000 per semester, while serving beans, lentils, and other high-protein plant foods can actually reduce costs[21].

Conclusions

[redacted] has an opportunity to reduce its carbon footprint by 370 metric tons each semester by transitioning to a more plant-forward dining service. GHG emissions from high-protein food purchases (meat, eggs, nuts, legumes, and plant-based meats) totaled 540 metric tons in fall 2019, 48% of all assessed food purchase emissions. Several strategies are available to reduce emissions by focusing on different carbon footprint "hot spots:"

- The three highest-volume meats (chicken, beef, and pork) make up less than 12% of purchases but are responsible for nearly 41% of the GHG emissions of all assessed foods.
- The five highest-emissions products in the chicken, beef, pork, and dairy categories represent 35% of all GHG emissions from 18% of purchases, making them prime targets for substituting with plant-based ingredients.
- Focusing on easily replaced ground meats would allow the University to eliminate 38% of GHG emissions from meat purchases.
- Meeting the Forward Food Pledge target of increasing plant-based meals by 20% could reduce GHG emissions by 250 tons and spare 11,000 animals from the food system each semester.

This analysis provides a baseline for [redacted] food purchases, GHG emissions from food, and animal welfare impacts. The data and case studies should serve as inspiration for improvement and setting goals for short-term and long-term improvement in climate change impacts, healthful dining, and animal welfare. For example, a long-term goal of reducing emissions from high-protein food purchases by 50% would guide replacement of certain meat and meal types with convincing plant-based meats and heart-healthy whole-foods dishes. In the short term, focusing on the "GHG hotspots" identified in this report could guide high-impact emissions reduction goals by replacing a certain fraction of ground meat and whole meat foods over just one or two years.

To put [redacted] meat-related emissions in perspective, consider the impacts of a long-term goal to reduce emissions by replacing 50% of meat and dairy with plant-based products. This

[21] Kari Hamerschlag and Julian Kraus-Polk. (2017) Shrinking the Carbon and Water Footprint of School Food: A Recipe for Combating Climate Change. A pilot analysis of Oakland Unified School District's Food Programs. Friends of the Earth, Washington DC. https://foe.org/resources/shrinking-carbon-water-footprint-school-food/

could create a 730 metric ton annual GHG savings. That is equivalent to reducing the University's vehicle fleet usage by 3 million km or planting 360,000 trees[22,23]. Achieving the same reduction by investing in renewable energy would require purchasing an additional 2000 MWh of green power at a cost of roughly $60,000 per year[24]. Case studies show that dining halls can make these beneficial changes at negligible cost – or even with cost savings[25].

Key Takeaways

1. Despite being only 37% of purchases by weight, animal products (meat, eggs, and dairy) are responsible for 78% of all assessed GHG emissions from food purchases.
2. The five highest-emissions products in the chicken, beef, pork, and dairy categories account for 35% of all GHG emissions from food, providing the largest opportunities for emissions reductions through product substitution with plant-based alternatives.
3. 38% of GHG emissions from meat purchases come from ground meats. Replacing these with similar-tasting plant-based products could reduce GHG emissions by 200 metric tons per year.
4. A goal of reducing GHG emissions from animal products by 50% could save 730 metric tons of emissions each year, potentially saving over $60,000 in annual renewable energy costs.

[22] Estimated using the EPA Greenhouse Gas Equivalencies Calculator: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[23] Number of trees based on WA DOR 'Planting Forest Seedlings: How to select, plant, and care for tree seedlings. Online at https://www.dnr.wa.gov/publications/frc_webster_plantingforestseedlings.pdf. Accessed July 12, 2021.

[24] Estimated using DTE Energy's Environmental Impact Calculator: https://newlook.dteenergy.com/wps/wcm/connect/dte-web/quicklinks/migreenpower

[25] Kari Hamerschlag and Julian Kraus-Polk. (2017) Shrinking the Carbon and Water Footprint of School Food: A Recipe for Combating Climate Change. A pilot analysis of Oakland Unified School District's Food Programs. Friends of the Earth, Washington DC. https://foe.org/resources/shrinking-carbon-water-footprint-school-food/

Appendix A

Table A1: Food purchases, GHG emissions, and number of animals consumed in each of 52 detailed food categories. For ease and clarity in reporting, these were consolidated into the 19 categories shown in Table 1.

Foods	Edible Weight (kg)	GHGs ($kgCO_2e$)	Animals Eaten	Protein Servings
Animal	**188,311**	**1,129,768**	**46,151**	**470,483**
Beef	6,974	224,634	31	41,214
Beef (beef herd)	3,942	139,102	18	23,296
Butter	368	4,956	0.01	
Cheese	7,585	125,745	2.3	
Chicken	33,051	130,882	21,079	214,805
Chicken50Beef50	55	1,002	18	343
Crab	2	34	5.7	12
Cream	22,415	126,137	0.8	
Duck	34	284	20	110
Eggs	13,068	30,646	470	57,619
Fish	59	450	46	400
Fish (caught)	168	875	132	1,141
Fish (farmed)	1,557	15,775	1,228	10,574
Lamb	206	5,420	9.4	1,067
Lobster	16	338	16	121
Mayonnaise	703	842	6.3	
Milk	76,000	184,030	2.7	
Pork	12,368	71,391	175	77,536
Scallop	65	492	604	503
Shrimp	2,375	35,266	21,989	18,324
Tuna	1,067	2,774	6.7	7,286
Turkey	2,503	20,908	310	16,133
Yogurt	3,731	9,035	0.1	
Plant	**237,770**	**211,440**		**67,104**
Apples	3,332	1,366		
Bananas	2,936	2,437		
Beans & Pulses	3,636	6,494		37,411
Berries & Grapes	4,434	5,233		
Beyond	232	820		1,578
Brassicas	11,130	8,014		
Bread	8,187	13,180		
Citrus Fruit	4,034	1,694		
Corn	253	261		
Grain	41,161	61,737		
Groundnuts	210	397		
Meat analogs	1,474	3,228		10,045
Mushrooms	3,214	9,940		

Nut milk	514	216		
Nuts	192	-267		3,386
Oats	266	728		
Onions & Leeks	15,001	5,550		
Other fruit	19,966	14,376		
Other Vegetables	45,616	20,984		
Potatoes	52,671	24,755		
Rice	12,894	26,671		
Root Vegetables	6,853	2,741		
Seeds	48	47		847
Soy milk	2,084	1,604		
Tempeh	27	41		216
Tofu	3,862	7,955		13,622
Tomatoes	27,726	18,576		
Vegan mayonnaise	200	479		
Vegetable Oils	21,409	39,691		
Grand Total	**2,758,591**	**5,236,855**	**194,124**	**537,587**

Appendix B: Life Cycle Greenhouse Gas Emissions Factors

Table B1: Greenhouse gas emissions from foods. Values are shown on an edible weight basis, which may differ from the values reported in the original sources (see live weight and edible weight conversion factors in Table C1). Data for beans, legumes, and grains shown on a dry weight basis.

FOOD	KG CO_2E / KG EDIBLE	SOURCE
BEEF (GROUND)	32.2	Rotz, C. A., Asem-Hiablie, S., Place, S., & Thoma, G. (2019). Environmental footprints of beef cattle production in the United States. Agricultural systems, 169, 1-13.
BEEF (BEEF HERD)	34.8	Rotz, C. A., Asem-Hiablie, S., Place, S., & Thoma, G. (2019). Environmental footprints of beef cattle production in the United States. Agricultural systems, 169, 1-13.
PORK	5.8	Pelletier et al. 2010 Life cycle assessment of high- and low-profitability commodity and deep-bedded niche swine production systems in the Upper Midwestern United States
CHICKEN	4.0	Putman, B., Thoma, G., Burek, J., & Matlock, M. (2017). A retrospective analysis of the United States poultry industry: 1965 compared with 2010. Agricultural Systems, 157, 107-117.
TURKEY	8.4	NEMECEK, T., BENGOA, X., LANSCHE, J., ROESCH, A., FAIST-EMMENEGGER, M., ROSSI, V., ... & RIEDENER, E. (2019). WORLD FOOD LCA DATABASE.
DUCK	8.4	Assume same as turkey
LAMB	26.3	NEMECEK, T., BENGOA, X., LANSCHE, J., ROESCH, A., FAIST-EMMENEGGER, M., ROSSI, V., ... & RIEDENER, E. (2019). WORLD FOOD LCA DATABASE.
MILK	2.4	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
CHEESE	16.6	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
CREAM	5.6	NEMECEK, T., BENGOA, X., LANSCHE, J., ROESCH, A., FAIST-EMMENEGGER, M., ROSSI, V., ... & RIEDENER, E. (2019). WORLD FOOD LCA DATABASE.
BUTTER	13.5	NEMECEK, T., BENGOA, X., LANSCHE, J., ROESCH, A., FAIST-EMMENEGGER, M., ROSSI, V., ... & RIEDENER, E. (2019). WORLD FOOD LCA DATABASE.
YOGURT	2.4	Assume same as milk
EGGS	2.3	Pelletier, N., Ibarburu, M., & Xin, H. (2014). Comparison of the environmental footprint of the egg industry in the United States in 1960 and 2010. Poultry science, 93(2), 241-255.
MAYONAISE	1.2	25% egg, 33% veg oil
FISH (CAUGHT)	5.2	Clune, S., Crossin, E., Verghese, K., 2016. Systematic review of greenhouse gas emissions for different fresh food categories. Journal of Cleaner Production. Volume 140, part 2. pp766-783.
FISH (FARMED)	10.1	Poore & Nemecek 2018: Global (w/o losses)
TUNA	2.6	Clune, S., Crossin, E., Verghese, K., 2016. Systematic review of greenhouse gas emissions for different fresh food categories. Journal of Cleaner Production. Volume 140, part 2. pp766-783.
SALMON	3.2	Pelletier et al. 2009 Not All Salmon Are Created Equal: Life Cycle Assessment (LCA) of Global Salmon Farming Systems
SQUID	8.1	Clune, S., Crossin, E., Verghese, K., 2016. Systematic review of greenhouse gas emissions for different fresh food categories. Journal of Cleaner Production. Volume 140, part 2. pp766-783.
OCTOPUS	8.1	Clune, S., Crossin, E., Verghese, K., 2016. Systematic review of greenhouse gas emissions for different fresh food categories. Journal of Cleaner Production. Volume 140, part 2. pp766-783.

SHRIMP	14.9	Clune, S., Crossin, E., Verghese, K., 2016. Systematic review of greenhouse gas emissions for different fresh food categories. Journal of Cleaner Production. Volume 140, part 2. pp766-783.
LOBSTER	21.7	Clune, S., Crossin, E., Verghese, K., 2016. Systematic review of greenhouse gas emissions for different fresh food categories. Journal of Cleaner Production. Volume 140, part 2. pp766-783.
CRAB	21.7	As Lobster; Clune, S., Crossin, E., Verghese, K., 2016. Systematic review of greenhouse gas emissions for different fresh food categories. Journal of Cleaner Production. Volume 140, part 2. pp766-783.
CLAM	7.5	As Mussels; Clune, S., Crossin, E., Verghese, K., 2016. Systematic review of greenhouse gas emissions for different fresh food categories. Journal of Cleaner Production. Volume 140, part 2. pp766-783.
SCALLOP	7.5	As Mussels; Clune, S., Crossin, E., Verghese, K., 2016. Systematic review of greenhouse gas emissions for different fresh food categories. Journal of Cleaner Production. Volume 140, part 2. pp766-783.
TUNA, CANNED	7.1	AGRIBALYSE 3.0 (2019) https://doc.agribalyse.fr/documentation-en/
NUTS	-1.4	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
PULSES/BEANS	1.8	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
TOFU	2.1	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
TEMPEH	1.5	http://www.blonkconsultants.nl/wp-content/uploads/2016/06/english-summary-protein-rich-products.pdf
MUSHROOM	3.1	dataFIELD; Heller, M. C., Willits-Smith, A., Meyer, R., Keoleian, G. A., & Rose, D. (2018). Greenhouse gas emissions and energy use associated with production of individual self-selected US diets. Environmental Research Letters, 13(4), 044004.
VEG OIL	1.9	NEMECEK, T., BENGOA, X., LANSCHE, J., ROESCH, A., FAIST-EMMENEGGER, M., ROSSI, V., ... & RIEDENER, E. (2019). WORLD FOOD LCA DATABASE.
GROUNDNUTS	1.9	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
NUT MILK	0.4	Clune, S., Crossin, E., Verghese, K., 2016. Systematic review of greenhouse gas emissions for different fresh food categories. Journal of Cleaner Production. Volume 140, part 2. pp766-783.
SOY MILK	0.8	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
MEAT ANALOGS	2.2	Mejia et al. 2019 Life Cycle Assessment of the Production of a Large Variety of Meat Analogs by Three Diverse Factories
MORNINGSTAR	5.8	Dettling, J, Tu Q, Faist M, DelDuce A, and Mandlebaum S. (2016) A Comparative Life Cycle Assessment of Plant-Based Foods and Meat Foods. Quantis USA.
IMPOSSIBLE	3.5	Khan 2019 Comparative Environmental LCA of the Impossible Burger with Conventional Ground Beef Burger
BEYOND	3.5	Heller & Keoleian 2018 Beyond Meat's Beyond Burger LCA
VEGAN MARGARINE	2.4	NEMECEK, T., BENGOA, X., LANSCHE, J., ROESCH, A., FAIST-EMMENEGGER, M., ROSSI, V., ... & RIEDENER, E. (2019). WORLD FOOD LCA DATABASE.
VEGAN MAYONAISE	2.4	Assume same as margarine
VEGAN CHEESE	2.4	Assume same as margarine
GRAIN	1.5	AVERAGE (excl. rice)
RICE	2.1	Brodt, S., Kendall, A., Mohammadi, Y., Arslan, A., Yuan, J., Lee, I. S., & Linquist, B. (2014). Life cycle greenhouse gas emissions in California rice production. Field Crops Research, 169, 89-98.

OATS	2.7	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. The International Journal of Life Cycle Assessment, 17(5), 520-534.
CORN	1.0	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
BARLEY	0.7	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. The International Journal of Life Cycle Assessment, 17(5), 520-534.
WHEAT	1.5	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
BREAD	1.6	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
SEEDS	1.0	NEMECEK, T., BENGOA, X., LANSCHE, J., ROESCH, A., FAIST-EMMENEGGER, M., ROSSI, V., ... & RIEDENER, E. (2019). WORLD FOOD LCA DATABASE. Sunflower, at farm [GLO]
SUNFLOWER SEED	1.0	NEMECEK, T., BENGOA, X., LANSCHE, J., ROESCH, A., FAIST-EMMENEGGER, M., ROSSI, V., ... & RIEDENER, E. (2019). WORLD FOOD LCA DATABASE. Sunflower, at farm [GLO]
POTATOES	0.5	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
CASSAVA	1.1	Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
TOMATOES	0.7	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
ONIONS & LEEKS	0.4	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
ROOT VEGETABLES	0.4	Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
BRASSICAS	0.7	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
OTHER VEGETABLES	0.5	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
OTHER FRUIT	0.7	Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
CITRUS FRUIT	0.4	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
BANANAS	0.8	Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
APPLES	0.4	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
BERRIES & GRAPES	1.2	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.

Appendix C: Conversion Factors

Table C1: Live weight to edible and cooked weight conversion factors used to adjust emissions and purchase values.

ANIMAL	LIVE WEIGHT		EDIBLE WEIGHT		BONE-IN / EDIBLE	COOKED YIELD	ANIMALS PER EDIBLE KG
BEEF	604	kg	224	kg	83%	74%	0.004
CHICKEN	2.8	kg	1.6	kg	77%	74%	0.64
DUCK	3.1	kg	1.7	kg	77%	74%	0.58
LAMB	61	kg	22	kg	78%	65%	0.046
PORK	126	kg	71	kg	81%	78%	0.014
TURKEY	14.4	kg	8	kg	77%	73%	0.12
FISH (AVERAGE)	3.2	kg	1	kg	85%	77%	0.788
CLAM	0.5	kg	0.2	kg	29%	86%	6.386
CRAB	0.7	kg	0.3	kg	70%	88%	3.674
SALMON	4.5	kg	1.8	kg	85%	77%	0.55
SCALLOP	0.3	kg	0.1	kg	40%	88%	9.259
SHRIMP	0.3	kg	0.1	kg	40%	88%	9.259
TUNA	249.5	kg	100	kg	85%	77%	0.010