Food at the University of Michigan

A Report Developed for and Supported by the U-M President's Commission on Carbon Neutrality

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Executive Summary

Our Food Internal Analysis Team for the University of Michigan (U-M) President's Commission on Carbon Neutrality (PCCN) was tasked with recommending approaches to decrease greenhouse gas (GHG) emissions associated with food consumption across U-M's three campuses. We propose that the University is best positioned to enact demand-side interventions in its efforts to decarbonize its food system. Specifically, we recommend that the University implement two actions with the greatest potential to reduce food-related GHG emissions: 1) shift food procurement (and thus consumer diets) to emphasize plant-based foods, and 2) reduce and divert food waste.

Within the first action area—shifting food procurement to emphasize plant-based foods—we propose expanding plant-forward menus, altering choice architecture within dining halls and retail locations, modifying preparation and serving practices, and rebranding plant-based meals and food items. Within the second action area—reducing and diverting food waste—we focus on cutting pre-and post-consumer waste, requiring Zero Waste options at all catered events, increasing food donations, prioritizing reusables, reducing single-use plastics, standardizing compostable products, and expanding recycling and compost capacity on all U-M campuses.

Across both priority areas, we emphasize the need for foundational changes to campus culture and institutional norms to ensure successful implementation. In the near term, the University should prioritize and expand upon elements suggested by the PCCN Campus Culture and Communication Internal Analysis Team with food as a central pillar: for example, creation of an Michigan Leadership and Innovation for Sustainable Transitions (M-LIST) Office; unit-specific Sustainability Leads and unit-level carbon neutrality plans; campus-wide training, education, motivational campaigns, and incentives. These efforts should be accompanied by the creation of an explicit food decarbonization goal and Sustainable Procurement Policy and support for a culinary trainer to facilitate the scaling up of plant-forward menus and procurement. Improved food procurement and waste data collection are also needed to evaluate progress toward the decarbonization goal and for experiential learning as all three campuses transform into Living Learning Labs. Robust support from the University will be essential to meet these recommendations given the diversity of food operations across U-M that have vastly different needs and capacities to implement change.

Numerous national and international platforms and initiatives aimed at reducing food-related climate impacts promote a goal of reducing food-related GHG emissions 25% by 2030 (i.e., Cool Food Pledge, Menus of Change, EAT-Lancet Commission). We propose that U-M adopt this goal as well. In this report, we provide a menu of actions under our two key recommendations that the University should support in a phased manner over the next decade, with the ultimate goal of achieving this 25% emissions reduction. We recognize that the enormous diversity of food-related units across the U-M food system precludes a one-size-fits-all approach to change. As such, the specific actions a given unit chooses to adopt from our proposed menu will vary. Yet with robust support from the University to shift institutional and cultural norms, we expect that all units, no matter their size, capacity, or service needs, will be able to achieve this 25% reduction by prioritizing action on these two recommendations. We further expect that national leadership from U-M in decarbonizing its food system over the coming decade will spur bold action among other large institutions and within supply chains nationwide that could lead to transformative change at scale.

Overview of the food systems challenge

Agriculture is responsible for nearly a quarter of greenhouse gas (GHG) emissions globally.[1] These emissions are in large part driven by the clearing of forests to graze animals, the methane-heavy belches of ruminant animals like cows, and on-farm energy consumption. However, at a fundamental level, global diets underlie agriculture's GHG emissions.[2] Agricultural production responds to changing consumer food demand. Dietary transitions and subsequent structural changes to food supply chains, therefore, drive the changes in resource use, food waste streams, and agricultural management practices that contribute so profoundly to global GHG emissions. There are clear supply-side actions that must be implemented to reduce agriculture's emissions (e.g., increasing efficiency of energy and fertilizer use, enhancing livestock productivity, and protecting agroecosystems); however, implementing demand-side actions, that is, actions aimed at reducing growth in demand for food and more efficient use of that food, is an equally urgent imperative.[3]

Our Food Internal Analysis Team for the University of Michigan (U-M) President's Commission on Carbon Neutrality (PCCN) was tasked with recommending approaches to decrease GHG emissions associated with food consumption across U-M's three campuses. We propose that the University is best positioned to enact demand-side interventions in its efforts to decarbonize its food system. Specifically, we recommend that the University implement two actions with the greatest potential to reduce food-related GHG emissions: 1) shift food procurement (and thus consumer diets) to emphasize plant-based foods, and 2) reduce and divert food waste.

Numerous national and international platforms and initiatives aimed at reducing food-related climate impacts promote a goal of reducing food-related GHG emissions 25% by 2030 (i.e., Cool Food Pledge, Menus of Change, EAT-Lancet Commission). We propose that U-M adopt this goal as well. In this report, we provide a menu of actions under each of our two key recommendations that the University should support in a phased manner over the next decade, with the ultimate goal of achieving this 25% emissions reduction.

Prioritized food systems recommendations summary

We propose U-M adopt two priority areas for action based on their potential for large reductions in GHG emissions and scalability: 1) shift toward and scale up "plant-forward" food procurement and consumer diets; and 2) reduce and divert food waste from landfills. Within the first action area, we propose expanding plant-forward menu options, altering choice architecture within dining halls and retail locations, modifying preparation and serving practices, and rebranding plant-based meals and food items. Within the second action area, we focus on cutting pre- and post-consumer waste, requiring Zero Waste options at all catered events, increasing food donations, prioritizing reusables, reducing single-use plastics, standardizing compostable products, and expanding recycling and compost capacity across all campuses. Across both priority areas, to ensure successful implementation, we emphasize the essential need for foundational changes to campus culture and institutional norms: creation of an Michigan Leadership and Innovation for Sustainable Transitions (M-LIST) Office; the establishment of unit-specific Sustainability Leads and unit-level carbon neutrality plans; a culinary trainer to facilitate the scaling up of plant-forward menus and procurement; campus-wide training, education, motivational campaigns, and incentives; a food decarbonization goal and Sustainable Procurement Policy; improved data collection and the conversion of all three campuses into Living Learning Labs; and robust support from the University for the diversity of

food operations across all three campuses that have vastly different needs and capacities to implement change.

Priority #1: Shift toward and scale up plant-forward food procurement and consumer diets

Different diets have vastly different carbon footprints. In the United States, the highest emission diets contribute more than five times the emissions of the lowest emissions diets.[4] These differences are in large part driven by the relative proportion of animal-source foods in diets. Numerous studies have consistently concluded that plant-based foods cause fewer GHG emissions than animal-source foods.[5] Ruminant meat is responsible for the largest amount of GHG emissions (greater than 50 times the emissions per kg of cereals, pulses, and field-grown fruits and vegetables) given feed conversion inefficiencies and emissions from enteric fermentation.[6] Therefore, replacing ruminant meat in diets with plant-based foods, and to a lesser extent fish and poultry, can lead to considerable emissions reductions.[7] "Plant-forward" diets are one culinary strategy to implement such substitutions.

"Plant-forward" eating is "a style of cooking and eating that emphasizes and celebrates, but is not limited to, plant-based foods" (e.g., fruits, vegetables, whole grains, legumes).[8] Importantly, plant-forward diets can include animal-source foods such as meat, dairy, and eggs, though these foods are de-emphasized relative to plant-based foods. Among animal-based proteins, fish and poultry are prioritized, dairy and eggs play a supporting role, and red meats are limited.

Key findings

To understand the extent to which implementing plant-forward diets would reduce GHG emissions across the U-M food system, we estimated total annual emissions from distinct food categories for each unit across U-M based on food procurement data and modeled food substitution scenarios. Our first task was to identify and map all food procuring units across the University.

Mapping the U-M food procurement system

The U-M food system is a complex, decentralized network of both self-operated units and units with contracts to external operators. The Ann Arbor campus has separate food services through Michigan Athletics, Michigan Dining (MDining), Michigan Medicine patient and retail operations, the Ross School of Business, the University Unions, the North Campus Research Center, and the U-M Law School, in addition to strategic catering and vending services, and separate food operations at UM-Flint and UM-Dearborn. Based on FY2019 food spend data obtained from these various units, MDining constitutes nearly half (42.1%) of annual food expenditures across U-M's three campuses, with 28.6% of annual food expenditures coming from the Ann Arbor campus's nine residential dining halls. Appendix H provides a comprehensive overview of the food operations of each unit at the University and their expenditures as a share of the total U-M food system.

Estimating U-M food system-wide emissions based on food purchases

Using food procurement data from all of the menus used across MDining's nine residential dining halls for the Fall 2019 academic term, we estimated that the total GHG emissions from these operations were 4,674 metric tons of carbon dioxide equivalents (tCO_2e) (see methods in Appendix B). Animal products, primarily beef (36%) and dairy (19%), accounted for the largest proportion of these emissions, even though the quantity of plant-based foods purchased far exceeded that of beef (i.e., vegetable purchases [in kg] exceeded purchases of beef by more

than nine times) (**Appendix C, Figure C1 and Table C3**). Based on these calculations, we estimated that U-M's total annual food-related emissions equal 60,867 tCO_2e, or approximately 10% of all scopes 1 and 2 emissions of the University (see Appendix B for a detailed explanation of this calculation).

Assessing substitutions to reduce food-related emissions

On Mondays during Fall 2019, when dining halls were encouraged to eliminate red meat from their menus as part of a "Sustainable Mondays" campaign, GHG emissions dropped by 31% compared to Wednesdays (**Table C4**). Dining halls that had the greatest reductions in beef procurement realized the greatest reductions in GHG emissions (i.e., >40%). Purchases of chicken and fish increased by approximately 50% on Mondays; however, the increase in GHG emissions from these foods was one-fifth the emissions saved from reduced red meat purchases (55 tCO_2e) (**Figures C2 and C3**). Changes in procurement led to a 3.9% increase in costs on Mondays compared to Wednesdays driven largely by increased purchases of fish and chicken (**Table C5**). However, three dining halls that had the greatest beef reductions (i.e., East Quad, North Quad, and Markley) demonstrated average cost savings of 7.5%.

In addition to this natural substitution experiment, we also modeled hypothetical emissions reduction scenarios replacing beef and red meat, fish, and dairy with other protein sources (see methods in Appendix B). Reducing beef by 50% in MDining's residential dining operations would result in a ~15% reduction in GHG emissions, whereas eliminating beef would reduce emissions by 28% to 34% (**Table C6**). The largest differences in emissions reductions were between substitution scenarios, indicating that the protein that is reduced or eliminated is more important for reducing emissions than the substituting protein. However, substituting meat and fish with plant-based proteins showed the largest predicted emissions reductions. Replacing beef with plant-based proteins would result in cost savings of 0.2% and 0.4% for 50% and 100% reductions in beef, respectively, while using chicken or fish as substitutes would lead to modest cost increases (**Table C7**).

Recommendations

Our principal recommendation is to scale up and expand the use of plant-forward menus and food options across all U-M dining, retail, and catering operations. Specifically, we recommend the following actions:

1) Increase the overall number of plant-based dishes and food options available.
2) Restructure choice architecture[9] within dining halls and retail outlets, for example:
    a. Reduce the amount of counter space devoted to serving animal protein;
    b. Ensure that the protein option is an "opt in" choice or is added last to plates in "build-your-own" stations, such as stir-fry and noodle bowl stations;
    c. Control protein portions at all-you-care-to-eat facilities; and
    d. Make plant-forward stations, such as salad bars, the focal point, using grills, wood-fired ovens, and live-action stations where animal protein is served as a complement to plant-based dishes.[10]
3) Employ taste-focused labeling[11] to re-brand plant-based dishes (e.g., "Aromatic Thai Curry Kabocha Squash with Zesty Ginger").
4) Improve the taste of plant-based dishes through use of fresh ingredients, complementary seasonings, and the combination of two or more fruits and vegetables to build flavor.[12]
5) Emphasize plating and the visual appeal of plant-based foods with a focus on rebalancing plates such that vegetables serve as entrees and protein is an accent on the plate (e.g., limit servings of animal protein to 2 oz.).

6) Use products that incorporate blended plant and animal protein (e.g., blended burgers that use 30% mushrooms).
7) Use less carbon-intensive animal proteins (e.g., chicken or meats sourced from regenerative farms[13]) in plant-forward dishes.
8) Ensure that sufficient meal options respecting religious and cultural traditions, as well as dietary restrictions, are maintained.

These changes should be integrated inconspicuously into operations with an emphasis on maximizing consumers' choice of delicious, visually appealing food. The low-carbon option should be the easy choice for consumers. Raising consumer awareness of the GHG footprint of individual dishes may be an important complementary action to explore, but it should not substitute for strategies that emphasize meeting consumer demand for tasty, attractive dishes and maximizing choice in combination with the behavioral nudges listed above.

Operators should prioritize implementing actions that align with their needs and capacities. For those operators that have already begun implementing many of these plant-forward menu actions, future work will emphasize scaling and refining. For other operators, beginning experimentation with these actions will be the focus.

Regardless of the implementation strategy, our findings indicate that achieving a 25% reduction in GHG emissions is possible with appropriate changes to menus and procurement practices. We recommend that all dining, retail, and catering operations across U-M aim to reduce emissions from food procurement by 2.5% per year (of 2020 baseline emissions) through 2030. Based on our scenarios, substituting beef purchases with plant-based proteins by ~7.5% per year (of 2020 baseline purchases) over the coming decade will achieve the 25% reduction goal (i.e., reducing overall beef purchases by ~75% of 2020 baseline purchases by 2030). Substituting beef with pork or chicken at a similar percentage per year would lead to analogous reductions in the same time frame.

Changes to campus culture and institutional norms

The clear implication of changing what food is procured is that menus must also change and, therefore, so must consumer preferences. All food operations across the three campuses manage their own budget independent of the University's General Fund; therefore, rapid, unilateral menu shifts may not be practical for most. Smaller operations may be less able to make even minor changes to their supply chains without external support or longer-term transition plans. Food operations at U-M are independent, customer-driven businesses that must focus on satisfying the preferences of students and others that patronize their facilities. There is a risk, for instance, of students and other customers voting with their feet, going elsewhere if some, but not all, food operators shift too swiftly to offering less meat. Changes to menus can require up-front costs like staff training and creating specialized signage. Therefore, the financial resources and institutional support must be in place to help transition food operations to plant-forward procurement and menus. While independent efforts to reduce carbon emissions through food have already been implemented by certain units across the University (e.g., "Sustainable Mondays" through MDining), there must be top-down leadership, vision, and funding to realize the kind of widespread and sustained change that is needed to achieve a 25% reduction in food-related emissions by 2030. Therefore, we recommend the following four sets of actions be enacted by the University to facilitate the transition to plant-forward menus at scale.

(1) Create a campus-wide culture that prioritizes decarbonization (with food as a central pillar)
The recommendations of the PCCN Campus Culture and Communication Internal Analysis Team provide a roadmap for defining a campus culture that values decarbonization. We propose that food decarbonization be a core pillar of these cultural change efforts, including the establishment of:

- the Michigan Leadership and Innovation for Sustainable Transitions (M-LIST) Office;
- unit-specific Sustainability Leads and unit-level carbon neutrality strategic plans;
- campus-wide Living Learning Labs focused on achieving carbon neutrality; and
- training and education campaigns to integrate decarbonization goals and values into all facets of the workplace.

Unit-specific Sustainability Leads—much like current MDining staff, Michigan Medicine staff, and unit-specific DEI coordinators—could focus broadly on designing and carrying out each unit's culturally relevant carbon neutrality strategic plans. These plans should clearly articulate how units will: 1) provide training and literacy on food decarbonization to faculty, staff, and students; 2) cultivate a low-carbon food culture and purchasing guidelines; and 3) evaluate the impacts of unit-level efforts on changing norms and behaviors.

Required sustainability courses, online trainings, and orientation activities should aim to develop sustainability competencies among students. On-boarding and ongoing training for faculty and staff (including food service staff) should include modules on the impact of food systems and diets on climate change and specific actions that can be carried out to reduce food-related emissions. New students should also be provided guidance on how to navigate residential dining halls to make low-carbon choices. Turning campuses into Living Learning Labs, particularly by establishing a Sustainable Food Systems Center—as many U-M stakeholders expressed—would further create a community of environmentally conscious thinkers and eaters. In this way, U-M can help students and faculty connect, learn, and explore food systems innovations and carry out applied research at the Campus Farm, dining halls, and throughout the three campuses.

Furthermore, incentive programs like Positive Impact Points (PIPs) on Campus, a mobile phone app, provide an opportunity to reward students for engaging in behaviors aimed at reducing carbon emissions, including food choices.[14] The U-M Graham Sustainability Institute is already planning to run a year-long pilot of PIPs on Campus with first-year undergraduates at the Ann Arbor campus, including food- and waste-related actions, such as picking up a plate at a vegetarian station in the dining halls, composting in the residence halls, and volunteering at a Zero Waste event. Accompanying campaigns using influential messengers, slogans, and social media could provide similar incentives to catalyze these proposed cultural shifts.

(2) Align food procurement and a Sustainable Purchasing Policy with a decarbonization goal
The purchase of local and third-party certified foods (i.e., currently defined as "sustainable" according to U-M guidelines, such as Fair Trade) should be supported to accomplish a variety of goals (e.g., building local economies, enhancing biodiversity, supporting fair pay and safe labor conditions, etc.). However, the goal of purchasing such foods should be separated from the goal of decarbonization given that locally sourced or third-party certified foods are not necessarily or consistently associated with lower carbon emissions.[15] As such, we recommend that U-M establish a Sustainable Purchasing Policy, an idea first proposed by the 2015 President's Committee on the Culture of Sustainability focused on all procurement products.[16] We propose a subset of this broader policy focus on a food decarbonization goal, tracked annually, that prioritizes low-carbon food procurement (e.g., plant-based proteins, low-carbon meats sourced

from regenerative farms). Shifting food sustainability goals to a focus on decarbonization aligns with recent changes to national sustainability ranking criteria[17] and will simplify tracking and compliance given the challenges of tracing and verifying point of origin of food items.

As part of a Sustainable Purchasing Policy, we recommend that all requests for proposal (RFPs) for new food contracts—including strategic caterers and contracts for vending and staff break rooms—require suppliers to demonstrate how they will conform to U-M's goal for decarbonization. The decision-making criteria for awarding contracts must explicitly include a vendor's commitment to reducing carbon emissions, and all food providers should be held equally accountable to the University's decarbonization goals. Such accountability will require leadership from Procurement Services on the inclusion of appropriate contract language, verification and enforcement of expectations, and a shift in the M-marketsite purchasing portal to ensure that products meeting decarbonization goals are the default option and incentivized. Developing the details for RFPs, contract negotiation, and the purchasing portal should be established with the Office of Campus Sustainability (OCS), M-LIST, and a Procurement Sustainability Manager. See Appendix J for a more detailed account of these recommendations.

(3) Invest in the hiring of a plant-forward culinary trainer

Plant-forward menus require novel culinary approaches to menu structure, new food preparation skills and techniques, additional knowledge related to food sourcing, and a commitment to creativity. Therefore, we recommend the hiring of a plant-forward culinary trainer that would serve all food providers, including contractual partners and strategic caterers, across all three U-M campuses. This individual would lead the development of plant-forward menus; conduct trainings with food service staff; operate a test kitchen to engage students and the U-M community; collaborate in research; identify appropriate vendors for sourcing plant-based proteins; and coordinate with Procurement Services to ensure acquisition of high-quality, plant-forward ingredients. It will be essential for Procurement Services to establish and enforce clear contractual language with external vendors regarding engagement with this culinary trainer and alignment with the University's plant-forward initiatives. We estimate that an initial investment from the University's General Fund of approximately $160,000 annually (i.e., $110,000 for salary and benefits and $50,000 for food budget) would be needed to support this position. Cost savings realized from the scaled implementation of plant-forward menus (e.g., through lower-cost, plant-based substitutions for some animal proteins and shifts to in-house preparation of currently externally sourced, low-volume plant-based items such as blended burgers) could potentially provide funds to internally support this position in the long term.

(4) Standardize protocols for collecting data and evaluating procurement-related emissions

The diversity of food service and retail outlets that span U-M's three campuses presents obvious challenges to monitoring and accessing supply chain data relevant to understanding GHG emissions originating from the U-M food system. Consistent data that lists the weight and cost of food being procured (by food item and category) by each unit across the University are essential for assessing the cost and carbon footprint implications of menus changes. Such data are also necessary for tracking the University's food-related GHG emissions annually and assessing the progress of each unit in achieving the goal of 25% reduction in food-related emissions by 2030.

To better track the carbon footprint of food procurement across all three campuses, we recommend that Procurement Services negotiate with current vendors to, as possible, submit detailed food item purchase lists for an entire year; as new contracts are established, such lists

should be required of vendors. U-M staff (e.g., an M-LIST Sustainability Manager, OCS staff, or other U-M staff) can then link these food items to a food life cycle emissions database to calculate food-related emissions. This would require a modest up-front investment of time and resources, but the database resulting from this work could be easily updated as items on procurement lists shift incrementally. MDining has in fact nearly completed linking all food items they procure to an emissions database. Adjustments, however, may be needed for smaller food operations (e.g., food providers in the Michigan Union) versus those with large-scale food contracts (e.g., Aramark, Sodexo, Picasso). Furthermore, other qualitative tracking of campus-wide progress could be achieved by adding questions about awareness and behaviors related to plant-based eating to the Sustainability Culture Indicators Program (SCIP) survey.

Priority #2: Reduce and divert food waste from landfills

Consumers and retailers—including universities—waste nearly one-quarter of the global food supply; in the United States, we waste 27% to 40%.[18] Because of the accumulation of carbon impact in earlier phases of the food chain—from production to processing and distribution—food wasted by consumers at the end of the life cycle has an outsized effect on carbon emissions, contributing 37% of food systems emissions.[19] Wasting food also undermines food security and squanders the energy, water, land, and labor used to produce that food.[20] Today, food waste is the largest category of US landfill waste—22%.[21] These multi-faceted impacts and continued growth in food waste prompted the United Nations, Environmental Protection Agency (EPA), and US Department of Agriculture to establish a goal of cutting food waste 50% by 2030.[22]

Earlier U-M commissions[23] established the case for a U-M Waste Reduction Goal[24] that aims to reduce the amount of solid waste sent to landfills[25] to 40% (over 2006 levels) by 2025. While the 40% reduction goal does not explicitly include the UM-Dearborn and UM-Flint campuses, UM-Ann Arbor's campus and hospital system produced 95% of U-M's overall waste by weight (**Figure C4)**, signifying how critical it is that this Waste Reduction Goal be met. This goal sparked efforts to increase recycling across the Ann Arbor campus, expand composting beyond dining halls, and reduce food waste in commercial kitchens and at major events, including the launch of the Zero Waste Events Program.[26] Since 2006, however, UM-Ann Arbor's student, faculty, and staff population grew by 28%.[27] In the face of continued increases in overall waste produced by the University, UM-Ann Arbor's landfill waste has fluctuated between 12,000 and 14,000 tons[28] since 2006, even as diversion has increased. As a result, landfill waste since 2006 has only dropped by 3%—a far cry from the 40% goal.[29] Starting with the baseline of 13,170 tons of waste in 2006, the 40% reduction goal would require UM-Ann Arbor to reduce the amount of waste sent to disposal facilities to 7,902 tons by 2025.[30]

Our second major recommendation, therefore, focuses on the reduction and diversion of U-M's food waste from landfills. Reducing food waste refers to preventing[31] it in the first place, such as buying only what is needed and adopting more efficient food preparation techniques.[32] According to the EPA Food Recovery Hierarchy,[33] reducing food waste is the most important action for lowering GHG emissions. After reduction, the Hierarchy lists a variety of ways to "divert" food from landfills—ways of repurposing food that did not reach its intended use. Composting, one option for diverting food waste, releases some emissions during decomposition, transport, and the turning of compost piles, but keeping food out of landfills ultimately reduces net emissions as compost applied to soil serves as a carbon sink (see Appendix B for more detail). Furthermore, compost offers other environmental benefits, such as improved soil fertility and water retention.[34] In addition to a focus on food waste, reducing

dependency on other compostable and single-use products (e.g., compostable ware, paper towels, napkins, etc.)—which makes up a sizable amount of U-M's landfill waste—and diverting these products from landfills through composting is also critical.

Key findings

To understand the extent to which implementing actions to address food waste would reduce GHG emissions across the U-M food system, we sought to estimate total annual emissions from U-M's current waste management practices and to model different intervention scenarios. Because food waste is intermingled with other aspects of U-M's waste management goals—and particularly recycling—our team chose to incorporate scenarios where the University might increase overall waste reduction and diversion (see Appendix B for our methods).

Mapping the U-M waste management system

Unlike the decentralized system of food operators, U-M's waste management system is more centralized. For nearly all UM-Ann Arbor buildings—with the exception of some Michigan Medicine compost hauling and waste hauling for leased buildings—landfill, recycling, and compost hauling is managed by U-M's Waste Management Services.[35] Ann Arbor hospital waste and other hazardous waste[36] and UM-Flint's and UM-Dearborn's waste are all managed separately. Together, we estimate that U-M produced 21,462 tons of waste in FY2019. Just over a quarter—28.6%—was diverted from landfills via recycling, 6.2% via composting, 3% via mulching of yard waste, and 0.02% (3.3 tons) through food donations, for an overall diversion rate[37] of 37.8% (**Table C8)**. Depending on the amount of recyclables, compostables, and food waste in U-M's landfill, this suggests that 70% recyclable materials may currently be recycled and 33% to 40% of food/compostable waste is being composted or donated (**Figure C5)**.

Estimating U-M waste management system-wide emissions

Despite 13,357 tons of landfill waste, the emissions savings from current composting, recycling, mulching, and food donations resulted in an overall avoidance of 13,010 tCO_2e in FY2019 (**Table C8)**. U-M's current diversion, therefore, supports the University's efforts to reduce emissions, but improved diversion and reduction is imperative to align with the Waste Reduction Goal and to contribute to even more emissions avoidance.

Assessing the impact of food waste interventions on emissions reductions

To determine the impact of intervention scenarios, we first made assumptions about the content of U-M's current landfill stream: Baseline 1 represents 15% food waste, 20% recyclable materials, and Baseline 2 represents 20% food waste, 20% recyclable materials (see Appendix B for an explanation, including why we had to assume that U-M compost was all food waste, and **Table C9**). We then modeled[38] two intervention pathways: divert all recyclable and food waste via recycling, composting, and a doubling of current food donations (Scenarios 1 and 2, based on Baselines 1 and 2, respectively) or reduce food waste by 50% and divert the remainder of recyclable and food waste via recycling, composting, and tripling food donations[39] (Scenarios 3 and 4).

The intervention scenarios we modeled would come close to meeting or would just surpass the Waste Reduction Goal by 2030, lowering landfill waste by 36% to 41% over the 2006 landfill baseline (**Tables C10 and C11)**. The two diversion-focused scenarios would improve avoided emissions[40] by 69% over Baseline 1 (Scenario 1) and by 73% over Baseline 2 (Scenario 2). If 50% of food waste is reduced in addition to diversion, avoided emissions increase to 113% over Baseline 1 (Scenario 3) and 118% over Baseline 2 (Scenario 4); the latter translates into 4.6%

of the University's overall scopes 1 and 2 emissions (**Table C10**). To accomplish these gains over 10 years starting from a current diversion rate of 37.8%, and assuming the total waste produced remains unchanged, this means U-M would need to achieve a 63% diversion rate by 2030, increasing diversion rates each year by 2.5% for the next 10 years[41] (see Appendix B for the methods behind these calculations and for estimates assuming U-M's population and overall waste production continues to grow).

Recommendations

We recommend scaling up waste diversion through additional recycling, composting, and food donations while taking steps to further reduce food waste across all three campuses. As noted, many units across U-M are starting from a significantly improved baseline today from that of even five years ago, having already implemented some of the actions we recommend below. However, there is an appetite for further action (see Appendices E, G, and H). Peer institutions are also adopting more ambitious goals, some pledging to become "Zero Waste campuses" by striving for 90% diversion rates.[42] According to RecycleMania,[43] UM-Ann Arbor campus ranks 11th among universities with over 30,000 students for its current diversion rate. Achieving either diversion rate[44] for Scenarios 1 or 2—59% or 62%—would put U-M in the top two among large-scale universities or higher if 50% of food waste is also prevented.

In addition to education and better data tracking noted below, we recommend the following key strategies be adopted or expanded to reduce and divert food waste across all dining, retail, catering, and contract food services on U-M's three campuses:

1) Cut post-consumer waste[45] (e.g., through trayless dining,[46] smaller portions and plates,[47] customized portion sizes and "try a taste" stations,[48] room service and menu choices for patients,[49] and messaging on the environmental harm of food waste[50]).
2) Further reduce pre-consumer waste and reinforce such strategies with new kitchen staff (e.g., with efficient food storage, preparation, and menu-planning; food repurposing).[51]
3) Adopt creative options for increasing food donations to area food banks and student food pantries on all three campuses[52] and pilot other innovative methods to address food insecurity while also cutting food waste (e.g., Swipe Out Hunger[53]).
4) Offer incentives, cost-sharing, and infrastructure required to prioritize reusable products, reduce single-use plastics,[54] and standardize the use of compostable materials across all three campuses, especially in food operations.
5) Require all caterers, including contractors and strategic caterers, to offer Zero Waste options and develop U-M compostable materials standards they must comply with.
6) Expand the capacity to recycle and compost on U-M Ann Arbor's campus. Already near capacity, U-M's Waste Management Services will not be able to meet the demand if U-M expands composting and recycling. Based on staff estimates, another truck would be needed ($340,000) along with two drivers ($100,000).
7) Consider launching a composting program on the UM-Dearborn and UM-Flint campuses. With no municipal composting, the financial and emissions cost of hauling would need to be examined in comparison to developing systems that could be operated on campus.
8) In all buildings on all three campuses, increase composting and recycling bins through pilots to identify the best placement and provide education to ensure proper and increased use.[55]

As with our recommendations in Priority 1, different campuses, colleges, and buildings should prioritize actions that align with their emerging needs, practices, and capacities. Many food

operators have already made substantial efforts to cut food waste, particularly at the pre-consumer[56] stage (e.g., MDining, Michigan Medicine Patient Food and Nutrition Services, Ross Executive Dining). For these operators, future work will emphasize reducing and diverting post-consumer waste (which is at least three-quarters of food waste)[57] and carrying out food waste audits (detailed below) to understand how to target food waste reduction strategies. For other locations, such as UM-Flint and UM-Dearborn campuses with no campus-wide composting,[58] food waste reduction and diversion pilots will be the focus. More take-out operations on all campuses could also convert to seated dining that uses reusable plateware (as opposed to the single-use disposables that most operations other than MDining use).

When food cannot be donated to area pantries, another option is to partner with area farmers to collect food scraps to feed their livestock, as some farmers in one town hall suggested. Many universities in our national scan (58%) also recycle cooking oil for biodiesel. And as other U-M commissions have suggested, using a biodigester or smaller system that can produce methane from food waste may also warrant further study (see Appendix J).

Changes to campus culture and institutional norms

Additional gains beyond advances already made around waste reduction and diversion will take significant administrative support and leadership to motivate a cultural shift across U-M. To enable the actions we describe above, we recommend the following three steps.

(1) Shift campus cultural norms and build the capacity of institutions to divert and reduce waste
Efforts to scale up waste diversion and food waste reduction should fall under the M-LIST office proposed by the PCCN Campus Culture and Communication Internal Analysis Team. Again, a core element of this work will require unit-based Sustainability Leads to focus on waste reduction and diversion in their carbon neutrality strategic plans, working closely with our proposed plant-forward culinary trainer. This trainer will ideally have experience reducing pre- and post-consumer food waste. Changing norms around waste may also require restructuring waste management billing or a carbon tax—particularly for academic buildings currently covered by the General Fund Allocation—to ensure that schools and units are more aware of the landfill waste they generate.

Waste diversion and reduction should also go hand in hand with the suggested training, professional development, and orientation for students, staff, and faculty. Specific to food waste, this should include: a) trainings and co-learning among chefs on strategies to reduce pre-consumer food waste; b) education around food waste reduction strategies and composting goals in student orientation as well as on-boarding for new staff and faculty working in administrative and academic buildings; and, c) incentives to encourage Zero Waste behavior, such as through PIPs. Instilling a cultural shift related to waste is especially important in students who live in residence halls because of the lasting effect it has on their behavior and, as one staffer noted, because “once they adapt, others on campus will too.” Media campaigns should also be launched to support a cultural shift related to food waste and waste reduction. Noting the power of influential messengers, one interviewee described, “When [U-M President] Schlissel said we should do more Zero Waste, we did 330 Zero Waste events just on his comments.”

(2) Align procurement efforts with waste reduction goals to mitigate emissions
U-M stakeholders reiterated the key role Procurement Services could have in promoting more carbon-neutral products, waste reduction, and diversion through RFPs, contracts, product lists,

and accountability of outside vendors. The same criteria for new vendor contracts and the need for a Sustainable Procurement Policy that we laid out in Priority 1, therefore, apply here. It is beyond the scope of this report to discuss the complexities and uncertainties that still exist around GHG emissions of bioplastics and other compostable products.[59] However, this type of nuance is precisely why more collaboration is needed from the OCS, the new M-LIST office, or a Procurement Sustainability Manager. Clear guidance is needed related to products that align with U-M's decarbonization goal and for developing consistent strategies that cut across campuses to mitigate the confusion many interviewees noted with diversion efforts, as evident in the contamination routinely found in OCS audits of composting and recycling streams.

(3) Improve ongoing evaluation and data tracking

One of the key ways to build awareness and an arsenal of proven food waste reduction strategies is to use carbon neutrality strategic plans to launch and evaluate customized interventions. This operational research could be led by the unit-based Sustainability Leads, in consultation with OCS and the plant-forward culinary trainer. Ongoing food waste tracking and more audits like the one OCS carried out with Wolverine Tower—in which a baseline audit, behavior change intervention, and comparison audit were conducted—would be especially useful for determining which interventions work to reduce waste being sent to landfills.

Improved data collection would establish a more realistic baseline and track university-wide progress more accurately. Just as important, food waste tracking offers chefs and consumers feedback about progress, which in itself helps to reduce waste.[60] A quarter (24%) of universities in our national scan have such systems in place. Food operators could develop internal systems—such as the one used by the U-M Von Voigtlander Women's and C.S. Mott Children's Hospitals—or U-M could invest in waste tracking technologies such as LeanPath[61] or Winnow.[62]

In addition to the coarser data collected by tracking daily food waste, as we noted above, periodic food waste audits[63] would allow for targeted strategies to change food ordering, preparation, and customer behavior among dining and other food operators that have already made significant advances in cutting pre- and post-consumer waste. Food waste audits can: 1) confirm the proportion of pre- and post-consumer food waste still going to the landfill; 2) identify what percentage is inedible—and therefore inevitable food waste; 3) examine the carbon footprint of food scraps being sent to landfills (e.g., beef vs. produce); and 4) expose compost contamination and the proportion of non-food compostables. According to OCS, professional pre- and post-waste sorts[64] can cost up to $30,000, but targeted food waste audits could be run by OCS with temporary staff and student volunteers. This would be cost effective and would have the added benefit of raising student awareness about food waste, contributing to efforts to transform each of the three campuses into a Living Learning Lab.

Finally, to track university-wide awareness, attitude, and behavior shifts related to food waste reduction, recycling, and composting, questions could also be added to the SCIP survey.

Next steps

A shift in campus culture and institutional capacity building are foundational to facilitating the priority actions we recommend. In the near term, the University should prioritize elements suggested by the PCCN Campus Culture and Communication Internal Analysis Team (e.g., form an M-LIST office and hire a culinary trainer; appoint unit-specific Sustainability Leads to develop customized decarbonization plans; and launch education and motivational campaigns).

These actions should be accompanied by the creation of a Sustainable Procurement Policy and an explicit food decarbonization goal; a variety of actions to scale up and expand the use of plant-forward menus and procurement and to reduce and divert food waste; and improved food procurement and food waste data collection to evaluate progress and for use in experiential learning as all three campuses transform into Living Learning Labs. Future analysis that goes beyond the scope of this report may also include the carbon impact of processed and refrigerated foods and the co-benefits of efforts to reduce the carbon footprint of food that could inform behavior change campaigns.

We recognize that the enormous diversity of food-related units across the U-M food system precludes a one-size-fits-all approach to change. Yet with robust support from the University to shift institutional and cultural norms, we expect that all units, no matter their size, capacity, or service needs, will be able to achieve the recommended emissions reduction goals. We further expect that national leadership from U-M in decarbonizing its food system over the coming decade will spur bold action among other large institutions and within supply chains nationwide that could lead to transformative change at scale.

Appendix A: PCCN Food Internal Analysis Team scope of work

Authored by the PCCN Food Internal Analysis Team, August 16, 2019

I. Proposed Scope of Work

The Food Internal Analysis Team sees our scope of work as largely focusing attention on the role that dining services plays in shaping the University of Michigan (U-M) food system. With this in mind, we plan to:

1. Map U-M's dining services practices and data availability/needs by:
    a) Determining which dining operations are in-house or contracted out,
    b) Identifying what types of sustainability-oriented practices and/or agreements have been established with outside contractors and caterers, including how procurement and caterer contract language currently shapes the types of products that are sourced and the type of data and sourcing information that is shared by caterers/contractors, and
    c) Reviewing the type of data collection and data management systems that exist in relation to GHGE and other sustainability metrics associated with U-M's various supply chains.
2. Collect all relevant research that has already been conducted on U-M's food system
3. Speak with representatives from other universities of comparable size that have undertaken efforts to reduce GHGEs (greenhouse gas emissions) associated with food service operations to understand lessons learned related to scalable actions that U-M might enact
4. Gather additional perspectives about key metrics and actions from relevant U-M, regional and national experts and stakeholders
5. Understand the state of science that justifies/theorizes why particular institutional actions would lead to the greatest reductions to food systems-related GHGEs at both the institutional level and catalytically across the sector
6. Explore emergent opportunities that could take advantage of U-M's cutting-edge research capacity and other core strengths to research, develop, pilot and implement innovative strategies and practices that advance carbon neutrality in the food system
7. Compare possible actions in terms of:
    a) The potential impact each would have on U-M's GHGEs (and possible unintended positive or negative impacts on other equity or sustainability concerns),
    b) The political and financial feasibility of different actions, the steps required to implement each and how implementation might differ at the Ann Arbor, Flint and Dearborn campuses and various dining services, and
    c) The potential scalability of U-M's actions elsewhere

As part of our scope of work, our key priorities for analysis include the following:

1. Map out U-M's dining services supply chains, existing data and current practices relevant to GHGE reductions across MDining, Athletics, Michigan Medicine, Ross School of Business, UM-Dearborn, UM-Flint, and strategic caterers. Data we will attempt to collect could include:
    - Who runs each operation,
    - Number of people and volume of food served,
    - Sourcing data related to GHGEs (e.g., products that have Environmental Product Declarations (EPDs), products with eco-labels, etc.)

- Volume of waste, what's done with waste at each site, and the cost of disposal, and
- Actions taken in the last 10 years to improve the sustainability of dining operations and any evaluation of the impact/outcome/challenges of attempting certain changes.

2. Use MDining as a case study or proof of concept, particularly if much of the data above is not available from other dining services sites. This could include:
    - Analysis of procurement data collected by MDining for the past 3–5 years to understand the potential GHGEs associated with the supply chain and how these have changed in recent years, particularly after implementing different practices (e.g., meatless Mondays, mushroom blended burgers, trayless dining),
    - Analysis of bulk food waste data from MDining to examine annual and seasonal trends and the impact of implementing different practices, and
    - Development of a model for collecting, standardizing and organizing food systems data to make it easier to track GHGE related indicators in an ongoing manner
3. Identify "low-hanging fruit" initiatives that:
    - Already have an evidence base of effectiveness elsewhere or are fertile ground for new data collection (e.g., standardizing benchmarks of progress for sustainability efforts, implementing a carbon footprint labeling scheme within dining services), and
    - Present unique opportunities for research, development and implementation of novel, high impact approaches to reducing GHGE in the food system based on existing U-M research strengths

We plan to involve a number of stakeholders through informational interviews, focus group discussions and/or as reviewers of our ongoing analysis and draft reports. This may include but is not limited to:

1. U-M dining procurement staff, service administrators, contract organizations and chefs from MDining, Athletics, Michigan Medicine, Ross, UM-Dearborn, UM-Flint, and strategic caterers
2. Dining services leaders at universities of comparable size where sustainability measures have been implemented (e.g., University of Toronto, Ohio State, University of MA-Amherst, Stanford, Yale, Boston University, University of Maryland, University of Washington, North Carolina State)
3. Faculty at U-M who conduct research on food systems and climate change
4. The student-led UMSFP (U-M Sustainable Food Program) leadership team and individual student-led organizations that are part of UMSFP that are most relevant (e.g., Food Recovery Network, Friends of the Campus Farm, Maize and Blue Cupboard)
5. Key MI stakeholders (e.g., the Center for Regional Food Systems' Michigan Farm to Institution Network, state-level policy advocates and experts on food waste management/composting)
6. Researchers and experts nationally who focus on food-focused campus sustainability (e.g., Directors of food-focused or campus sustainability certification systems and campaigns such as the Real Food Challenge, Cool Food Pledge, Menus of Change, AASHE, EPA's Food Recovery Challenge, Local Food Plus)

II. Student Staffing Requirements

To help us carry out our Scope of Work, the Food Analysis team is looking to hire graduate or undergraduate students who are passionate about environmental linkages to food systems, work well as part of a team, and who are self-starters. Ideal candidates will have:

- Training, expertise and/or experience in either a) life cycle assessment, b) inferential statistics and/or c) interviewing skills (required)
- At least one course on food systems or at least one year of experience working on some aspect of food systems (required)
- Experience researching the environmental impacts of food systems (preferred)
- Experience related to understanding institutional value chains, especially related to food within university settings (preferred)
- Experience researching or working on institutional food procurement practices, waste reduction/composting or other relevant actions that U-M could take to reduce GHGE associated with food sourcing, consumption and waste (preferred)
- Infographics or data visualization/design skills (desired)

III. Key U-M Staff Individuals and Roles on the Team

The following U-M staff members have already accepted the invitation to join our team. While a variety of other faculty, U-M staff and outside stakeholders will be key to informing our process, as noted above, we believe that this mix of individuals will successfully guide the ongoing brainstorming, reflection, research and analysis we will need to develop an effective proposal.

1. ***Lesli Hoey***—Co-lead, Associate Professor of Urban and Regional Planning
2. ***Andrew Jones***—Co-lead, Associate Professor of Nutritional Sciences
3. ***Steven Mangan***—Team member, MDining Director
    a. ***Keith Soster***, Director of Student Engagement at MDining, will stand-in when needed
4. ***Alex Bryan***—Team member, U-M Sustainable Food Program Manager
5. ***Jeremy Moghtader***—Team member, U-M Campus Farm Program Manager
6. ***Marty Heller***—Senior advisor, Research Specialist Center for Sustainable Systems

Appendix B: Research methods

Authored by the PCCN Food Internal Analysis Team

We used mixed-methods to carry out our analyses and to develop our recommendations. These methods included:

- Peer benchmarking based on a document review of reports and websites of 33 universities and semi-structured interviews with 11 dining and sustainability staff from these institutions (Appendix D);
- Interviews with 11 faculty, 4 staff members, and 1 post-doctoral researcher at the University of Michigan (U-M) who all carry out research on, teach about, or work in food systems and climate change (Appendix E);
- Interviews with 23 U-M and U-M-associated staff involved with food procurement/contracts, retail/dining management, and/or food waste reduction and composting efforts. Their recommendations are integrated into the body of the report;
- Informal literature reviews about strategies for promoting carbon-neutral dietary behavior change (Appendix F), the role of institutional food procurement and diets on GHG emissions, and best practices related to increasing food waste reduction and composting;
- An analysis of U-M dining, catering, and retail locations and food spending (Appendix G);
- Three town halls on Ann Arbor's U-M campus (29 attendees), UM-Dearborn (11 attendees), the Washtenaw County Local Food Summit (42 attendees) (Appendix H);
- An analysis of how procurement processes relate to UM's decarbonization goals (Appendix I);
- Analysis of secondary data, including MDining menu-based carbon footprint data, UM-Ann Arbor and UM-Dearborn waste management data, overall food spend data from all self-operated and external food operators, and research carried out by students and faculty on U-M's food/waste systems.

We detail below our assumptions and calculations to estimate U-M's food system-wide emissions based on food purchases and waste management practices. We also document our methods for assessing food procurement substitution scenarios and food waste intervention scenarios.

Estimating U-M food system-wide emissions based on food purchases

Our team set out to obtain data on the quantities of specific food items and categories of foods procured on an annual basis by each unit within the University. However, the diversity and complexity of the U-M food system meant that data on food purchase volumes or expenditures by category of food were not consistently tracked or available. Therefore, the data were not sufficient to carry out the full extent of our initially planned analyses.

Nonetheless, MDining, a self-operated unit, was able to provide our team with disaggregated food procurement data for all of the menus used in its nine residential dining halls for the Fall 2019 academic term. Data on food purchases for all days of the week were obtained. These data on the quantity of each food item procured were paired with food life cycle assessment (LCA) data on the emissions associated with the production of each food. Food LCA is a tool used to quantitatively estimate the environmental impacts of foods by examining emissions and

resource use at various stages of production.[65] GHG emissions factors (kg CO_2 eq/kg) were assigned to approximately 1,700 unique food items based on a LCA database.[66] The GHG emissions in this database are estimated emissions from "cradle-to-farm gate" and exclude downstream emissions such as those from processing and transport, except in the case of minimally processed foods (e.g., flour, dairy, and vegetable oils) which include processing in the emissions estimate. Emissions beyond the farmgate were not estimated given that the boundary conditions of food life cycle assessments are not consistent across studies, and that because many commodity foods are used as ingredients in processed foods, downstream emissions may not reflect emissions from the foods that are actually consumed.[67]

Furthermore, our estimates equate emissions using the 100-year Global Warming Potential (GWP_{100}) of climate pollutants. Despite the ubiquity of use of GWP_{100}, the relationship between aggregated emissions calculated using GWP_{100} and global warming itself is ambiguous.[68] We recognize that alternative approaches, such as GWP*, that use warming-equivalents to differentially reflect warming from short-lived greenhouse gases (e.g., methane) and long-lived greenhouse gases (e.g., CO_2) would yield different results.[69] While the use of GWP* emission factors in policy decision-making is an ongoing academic and political debate, this alternative metric would likely suggest that we overestimate the contributions from methane in a steady-state consumption scenario (e.g., assuming methane emissions from cattle in the United States are unchanging), but underestimate the potential for decreases in warming potential from decreases in methane emissions (e.g., due to reductions in beef consumption). Application of the GWP* metric requires an estimate of the rate of change of methane emissions, and to our knowledge, this approach has not yet been applied at an institutional GHG emission accounting level. Therefore, we do not attempt to quantify these potential differences in estimates using GWP_{100} and GWP*. Nonetheless, understanding the role of short-lived greenhouse gases in climate action policy is highly relevant to food system contributions, and we recommend that alternative emissions accounting approaches be assessed in future work.

Once identified, GHG emissions factors were multiplied by the quantity and weight of the food item to calculate the total emissions from that food item on any given day. To calculate GHG emissions for processed foods, the conversion factor for the primary ingredient was used. For example, to calculate the emissions of bread, the emissions conversion factor for wheat flour was used. Foods were then categorized by food products (e.g., broccoli) and food categories (e.g., vegetables).[70] Within the "beverage" category, we included coffee, tea, carbonated drinks, coconut milk, and fruit juices.

The substantial undertaking of assigning GHG emissions factors to the food items in MDining's procurement database was initially completed by two U-M students (Cameron Clark, SEAS and Caroline Baloga, LSA) with supervision by the Sustainable Food Program Manager at MDining, Alex Bryan. This team calculated the total GHG emissions of food purchases from the 9 MDining residential dining halls for Mondays and Wednesdays during the 2018–2019 academic year as part of a pilot study that predated the work of the Food Internal Analysis Team. The assignment of additional food items for the Fall 2019 academic term, that were not captured during this earlier study, was carried out by a team of students supervised by the Menu Management Administrator with MDining.

In order to estimate U-M's total annual food-related emissions, we first estimated emissions from MDining's residential dining halls for both the Fall and Winter academic terms under the assumption that our calculations for Fall 2019 would equal those for a normal Winter Term. We

expect that this a reasonable assumption given the similar menu cycles used during the Fall and Winter Terms across the residential dining halls. Therefore,

4,674 tCO_2e (calculated Fall 2019 Term emissions) x 2 = 9,348 tCO_2e.

We then estimated the additional post-farmgate emissions not captured in the GHG emissions factors that we used in our analyses. Estimates vary as to the percentage of total food life cycle emissions that is accounted for by agricultural production (i.e., up to the farmgate) in the United States.[71] We used the value of 53.7%[72] given that this percentage accounts for biogenic emissions from livestock. Therefore,

9,348 tCO_2e/ 0.537 = 17,408 tCO_2e.

Finally, we estimated food-related emissions across all U-M units based on the percentage of food expenditures represented by MDining's residential dining halls (28.6%) as a share of all food expenditures across the University. This estimate assumes that the relative proportion of food expenditures on specific food items across all units at the University is equivalent to the proportion we identified for MDining. To be certain, this assumption introduces error into our estimates. Given the lack of availability of food purchase data disaggregated by food item or food category for units other than MDining, we cannot establish the extent of this error. However, given that beef purchases largely drive differences in emissions, if beef purchases in other units are similar to that of MDining, even if there are relatively large differences in purchases across other food categories, our assumption will provide a useful estimate. Therefore,

17,408 tCO_2e / 0.286 = 60,867 tCO_2e.

Using the most recent data (FY2018) on the University's annual scopes 1 and 2 emissions (630,405 tCO_2e),[73] we then calculated the percentage of all scopes 1 and 2 emissions represented by U-M's annual food-related emissions. Therefore,

(60,867 tCO_2e / 630,405 tCO_2e) x 100 = 9.7%.

Assessing substitutions to reduce food-related emissions

GHG emissions for Mondays and Wednesdays were calculated as described above for purposes of examining differences in emissions between "Sustainable Mondays" and Wednesdays. Wednesdays were selected as a comparison day given the comparable class schedules and number of meals served on those days.

To calculate changes in GHG emissions based on the hypothetical substitution scenarios that we examined, the baseline amount (kg) of each food procured by MDining in the Fall 2019 dataset was calculated for every day of the week, Monday through Sunday, in each dining hall and summed to calculate the total weight of each protein category that was procured during one academic semester. The eight scenarios that we modeled are shown in **Appendix C, Table C1**. For Scenarios 1–6, the total grams of protein from each food was calculated based on its protein content (**Table C2**). For the substitutions, grams of protein (from the protein that was reduced) were replaced by another protein source so that the total grams of protein remained the same. For plant-based proteins, a ratio of legumes, soy, and nuts was used so that 60% of

the replaced protein came from legumes and pulses, 20% from soy (i.e., tofu, edamame, tempeh), and 20% from nuts and seeds (including peanuts). This ratio was modified from a ratio of 6:8:7-ounce equivalents of legumes:soy:nuts, derived from the 2015 Dietary Guidelines for Americans vegetarian dietary pattern.[74] In consultation with MDining's staff, we reduced the proportion of soy and nuts because of food allergy risks. For dairy, substitutions were made on the basis of cup equivalents, which normalizes all dairy products on an "equivalence" of fluid milk based on the calcium content of the product. Based on the Dietary Guidelines for Americans, which includes calcium-fortified soymilk as an equivalent replacement for fluid cow milk or products made from milk, soymilk was used as a substitution for both milk and dairy products on the assumption that soymilk can be used to make other soy-based dairy products.

GHG emissions at baseline and after each substitution were calculated using the same GHG emissions conversion factors as for the previous analyses described above (**Table C2**). The average cost of food categories ($/kg) was also calculated and used to estimate the projected cost increase or savings from the substitution. GHG emissions and costs were doubled to estimate annual changes, with the assumption that procurement is similar in the Fall and Winter academic terms, and that the Spring/Summer terms represent a significantly smaller procurement volume.

Estimating U-M emissions based on food/compostable waste, recycling and landfill waste

We describe below our data sources, justify the assumptions we made in our two baseline calculations, and explain the calculations we made in order to analyze U-M's compost, recycling and landfill waste emissions and the impact of the four intervention scenarios we present.

Data sources

For UM-Dearborn and UM-Flint, we obtained recycling and landfill data from UM-Dearborn's Landscape Manager, but we were unable to secure data for UM-Flint. Although we recognize this is not the case, we assumed UM-Flint's waste management system is similar to UM-Dearborn's, and calculated its recycling and landfill tonnage based on UM-Flint's population size in relation to UM-Dearborn.[75] No information was available on the tonnage of yard waste that may be generated and used as mulch for landscaping on either campus, so overall yard waste data for the U-M system is likely an underestimate.

Donated food estimates for each campus were taken from the Michigan Food Recovery Network (FRN) website, specific to UM-Ann Arbor, UM-Flint, and UM-Dearborn.[76] However, we are likely undercounting the amount of current food UM donates that is either not captured in this database by student-run FRN groups, or because many units may be donating to other locations. For example, an unknown amount of unused food is donated by U-M Athletics to a Presbyterian church that donates food to organizations in Detroit, Ypsilanti and other areas.

For the Ann Arbor campus, we obtained recycling, composting, and landfill waste stream data from the Office of Campus Sustainability (OCS) for buildings serviced by U-M Waste Management Services (WMS) and additional data, including yard waste data, from the OCS Environmental Metrics. Our slightly higher diversion rate—37.8% vs. 37% noted in OCS reports—is primarily accounted for by the difference in scope (three campuses in our case, versus OCS' focus on the Ann Arbor campus) and additional composting data we obtained from Michigan Medicine staff for hospital system buildings not serviced by WMS (e.g., University

Hospital and the Von Voigtlander Women's and C.S. Mott Children's Hospitals). We also used FY2018 OCS data to estimated waste management numbers for some Ann Arbor campus buildings not included in the FY2019 data because they were under renovation (e.g., the Michigan Union, Ruthven Museum and Kraus Building). No data is available for other buildings U-M leases that are managed by non-U-M affiliated haulers.

Estimates of baseline assumptions

In order to estimate the amount of landfilled waste that comes from food and recyclables, we categorized buildings on the Ann Arbor campus as either "buildings with major food operations" (which includes approximately 20 buildings[77]) or "academic and administrative buildings." We chose this particular division because we assumed that the volume of food (and therefore composting) handled in buildings with dining, catering and retail operations is significantly higher and involves both pre-consumer (kitchen-based) and post-consumer food waste (see **Figure C4**). UM-Flint and UM-Dearborn also have no campus-wide composting operation—aside from a small composting research project at the UM-Dearborn Environmental Interpretive Center[78]—and no hospital system, so we chose to keep estimates for these campuses separate as well.

To determine the upper and lower bounds of our baseline assumptions regarding the makeup of U-M's landfill waste, we first analyzed the current diversion rates for these groups of buildings to consider how much they may already be composting or recycling. As our report notes, U-M's current waste diversion rate is 37.8%—incorporating all three campuses. This is composed of recycling (28.6%), composting (6.2%), the mulching of yard waste on Ann Arbor's campus (3%), and food donations (0.02%) (**Table C8)**. The buildings with the majority of food operations on the Ann Arbor campus collectively account for 74% of all of U-M's compost and 42% of all recycling. This group of buildings, however, also produces 52% of all landfill waste, resulting in an overall diversion rate of 33%. All other buildings on the Ann Arbor campus—what we refer to as administrative and academic buildings—collectively have a somewhat higher diversion rate overall (38%), and make up nearly half (49%) of all recycling and a quarter of all composting (26%) on campus. Combined, we estimate that buildings on the UM-Dearborn and UM-Flint campuses produce approximately 9% of U-M's total recycling, despite producing only 5% of the university's landfill waste. Even though neither campus has a campus-wide composting program, this amount of recycling means that current, overall diversion rates on these campuses is likely already high: 50%. **Figure C4** shows the percentage these buildings contribute to U-M's total compost, recycling, landfill and combined waste. **Figure C5** shows their overall and specific food waste and recyclable waste diversion rates.

Based on these initial numbers, we determined the upper and lower bounds of our baseline assumptions about the makeup of the remaining landfill waste in these groups of buildings based on audits[79] we obtained from the OCS, peer reviewed literature, and grey literature from the EPA, USDA, State of Michigan and non-U-M university food waste audits. **Table C9** displays the assumptions we made about the percentage of landfill waste across each of these groups of buildings, and the following offers further justification for these assumptions. **Table C10** calculates the GHG emissions of compostable, recyclable and mixed solid waste depending on whether it is left in the landfill, diverted or if 50% is reduced (in the case of food waste). **Table C11** details the current diversion rates University-wide and broken out by different groups of buildings, along with the likely diversion rates based on whether Baseline 1 or 2 assumptions are correct about the make-up of current landfill waste.

Food waste assumptions

Looking at U-M as a system, we assumed in Baseline 1 that food waste makes up 15% of U-M's landfill waste, and 20% in Baseline 2. This is in line with estimates of food scraps found in US landfills that range from 14%[80] to 22%.[81] These estimates may not be appropriate to apply to a university setting, however, as national landfill-based estimates also include food waste from processors and supermarkets.[82] Given the methodological challenges involved in making estimates of food waste,[83] we drew more heavily on recent waste audits conducted at U-M and other universities, both of which show that levels of food waste in university landfill streams are likely higher than the national average, though we explain below why we still took a more conservative estimate.

Although they handle the most food on campus, we assumed there would be the least amount of food waste in the landfill streams of most dining and food retail operations on Ann Arbor's campus—10% for Baseline 1 and 15% for Baseline 2—as staff we interviewed described numerous strategies they have been implementing to increase composting and cut down on food waste, particularly pre-consumer waste. The fact that these buildings collectively contribute 74% of the entire university's composting also suggests that composting efforts in these buildings may already be robust (**Figure C4)**. Furthermore, an audit in 2018 of the U-M Von Voigtlander Women's and C.S. Mott Children's Hospitals found that food scraps made up only 0.9% of landfill waste from pre-consumer waste (from kitchens that serve patients where waste was being composted), and another 12% was post-consumer "compostable," though the composition of food scraps in this case is unclear (as opposed to compostable napkins, compostable plasticware, etc.). The same audit included the University Hospital, which also has patient meal services, and three other Michigan Medicine buildings—at least one with a major cafeteria—showing that landfill waste was composed of 7% of pre-consumer food waste and 13% of post-consumer compostables, or a total of 20% compostable material. Another data point we considered was from the 2015 President's Committee on the Culture of Sustainability report, which suggested that 35% to 40% of MDining's landfill waste at the time was compostable, though the report they referred to was not cited.[84] But as we note below, this estimate was likely a combination of food scraps and non-food compostable materials. Further supporting the assumptions, we made for "buildings with major food operations," a 2016 audit of the U-M Stadium conducted just before the Stadium launched a major campaign to go Zero Waste found that 54% of the landfill waste from the bowl (where people sit) and 34% from the concourse (where the concession stands are located) was "compostable."[85]

No audit of U-M's dining halls exists, and few food waste audits have been described in sufficient detail in peer-reviewed literature or in grey literature to determine how much food waste may be in the landfill waste of dining halls. However, an audit conducted at the University of Illinois, Chicago (UIC) in their trayless dining halls showed that 18% of the landfill waste was food scraps, nearly two years after the university launched a Zero Waste campaign.[86] The University of Maryland also found in an audit of residence halls with dining halls that 25% of the landfill stream was food scraps; even in buildings with composting programs, only 54% of compostable material was being diverted from the landfill.[87]

For Ann Arbor's administrative and academic buildings, we assumed that food waste makes up a higher percentage—20% for Baseline 1 and 25% in Baseline 2—because audits at U-M and other universities show higher rates of food waste in these landfill streams. In a detailed waste audit conducted in Wolverine Tower in 2019, for instance, 19% of the landfill stream was food scraps, even after an intervention was attempted to increase composting.[88] An audit in the LSA

and Beyster engineering building found that 60% of landfill streams were “compostable,” though the percentage of food scraps was not reported.[89] At UIC, food scraps made up between 8% and 30% of the landfill stream in administration, academic and residence hall buildings without dining halls.[90]

Because UM-Dearborn and UM-Flint do not have a campus-wide composting program, we assumed the highest baseline levels of food waste for the landfill streams of these two campuses. Data we collected for UM-Dearborn’s waste management showed that a single building alone—where the main dining facility is located—made up 28% of the overall waste by weight, all of which the Landscape Manager indicated should be considered to be food waste. Considering that we do not know how much food waste is in trash collected from other buildings, we assumed that a minimum of 30% of UM-Dearborn’s overall waste comes from food waste in Baseline 1 and 35% in Baseline 2. Because these two campuses only make up a fraction of U-M’s overall waste stream (5.6%), however, this high food waste calculation has a negligible effect on the overall baseline assumptions for U-M as a whole.

Recycling assumptions

Similar to determining the food waste in U-M’s current landfill waste, we were limited by the data in estimating how much of U-M’s landfill is composed of recyclable content. We decided on an overall rate of 20% for both Baseline 1 and 2 for sets of buildings on Ann Arbor’s campus, and 15% for UM-Dearborn and UM-Flint. This rate was kept constant in the two baselines to study the effects of differing assumptions about food waste diversion and reduction potential, the focus of our report. If our recyclable waste numbers are conservative, therefore, then the GHG emissions potential of diverting even more recyclable materials would increase.

Our 20% assumption is at least half as much as estimates of average municipal landfill contents in the US, which the EPA estimates as nearly 50% recyclable, including paper, glass, plastics and metal.[91] In Michigan, a study in 2016 found that 42% of materials in the state’s landfills could be recycled.[92] Like food waste, however, municipal landfill estimates co-mingle post-consumer recyclable waste with waste from commerce and industry, so landfill estimates cannot be attributed entirely to consumers or institutions. On the other hand, at least with plastic waste, post-consumer waste in landfills is five times higher than pre-consumer plastics, such as packaging generated by commerce and industry.[93]

Our 20% estimate largely falls in the middle of the limited number of waste audits conducted on UM-Ann Arbor’s campus. Audits of the U-M Stadium, six Michigan Medicine buildings, and several administrative buildings revealed that between16% and 26% of landfill streams were recyclable materials. Given that efforts have been made in recent years to improve recycling at U-M after these audits were conducted, we assumed that a middle range might be reasonable. Our estimate may still be conservative, however, since one U-M audit conducted twice at Wolverine Tower, before and after an intervention intended to improve diversion efforts, only improved recycling from 16% to 15% in 2019. Other universities with major recycling efforts also show higher ranges. At UIC, for instance, even after launching a Zero Waste campaign campus-wide for nearly two years, 24% of the landfill stream in residence halls and 33% in administrative buildings was recyclable. Dining halls at the UIC had 24% recyclable materials in the landfill stream,[94] and at University of Maryland, 23%.[95]

As we noted earlier, UM-Dearborn produces a fraction of U-M’s overall waste, yet three times that amount in recycling, suggesting that these campuses’ recycling rates are already high. For

UM-Dearborn and UM-Flint, we therefore assumed that 15% of current landfill waste may still be recyclable.

Calculations of recycling and composting rates

Based on the above assumptions, as a system, we estimate that 33% to 40% of food waste being produced by U-M is being composted (and 1% donated), and 70% of its recyclable materials are recycled. UM-Ann Arbor buildings that house most of the food operations are likely composting, on average, 47% and 57% of all the food waste these buildings generate (and donating a small fraction), and recycling 64% of all recyclable materials. Administrative and academic buildings are likely composting 20% to 24% of the overall food waste they produce, and recycling nearly 73% of their recyclable waste stream. Meanwhile, we estimate that UM-Flint is diverting 0.6% of its food waste through donations, and UM-Dearborn 0.2% (though the amount of food waste being composted in the small UM-Dearborn program is unknown), while these two campuses likely are recycling nearly 87% of all of their recyclable waste (See **Figure C5**).

Methods used to calculate emissions associated with scenarios

Baseline and scenario GHG emissions were calculated using EPA WARM (Waste Reduction Model) Tool, version 15, released in May 2019.[96] The WARM Tool calculates tCO_2e based on life cycle assessments. Short tons (2,000 lbs.) are used specify the weight of waste, and metric tons of CO_2 equivalent (noted as tCO_2e) to report GHG emissions. Other than a few explanations we offer below, we do not recount here the detailed assumptions or explanations for underlying calculations used in the Tool. Some of the more important explanations for our calculations including the following:

(1) We entered data using the Tool's categories "food waste," "mixed recycling," and "mixed solid waste" sent to the landfill (not combusted), as well as "yard trimmings"—composted, and in scenarios, we moved the landfilled food waste and mixed recycling categories to "composted" and "recycled," respectively. We did not separate out different types of landfill waste or recycling materials (e.g., glass, plastics), nor did we incorporate compostable plastics or paper into our calculations of compost. Data about U-M's waste stream, beyond several audits, does not separate out the types of materials in the recycling stream, nor does it indicate the percentage of food scraps vs. other compostable items in U-M's compost stream. More importantly, no category in the WARM analysis considers this potential mix. Similarly, no U-M food waste audit exists, so no estimates can be made about the type of food scraps being landfilled or composted. To calculate the emissions associated with landfilled food waste, therefore, we chose to use the "food waste" category, which assumes a mix of foods—beef, poultry, grains, dairy, fruit, and vegetables—which are weighted based on the shares of food in the US waste stream.[97]

Not being able to enter non-food compostable materials is a clear limitation of our analysis. Particularly as it relates to food waste, this means that we are overestimating the contribution of food scraps to U-M's compost stream emissions. One U-M audit conducted at Wolverine Tower that identified the components of compost streams showed that 50% was food, and the rest napkins (33%), compostable ware (11%), collection bags (4%) and miscellaneous contamination. Food waste audits at other universities have also shown as little as 6% of non-food items in compost of dining halls[98] and between 63% and 92% compostable paper in residence hall compost.[99] The range, therefore, can be quite variable. Even if the amount of compostable paper in U-M's composting was clear, however, the EPA

WARM Tool indicates that evidence related to the GHG emissions of composting paper products is still insufficient to calculate.[100] More precise measures would be possible if future food waste audits make clear the breakdown of food items in U-M's various food waste streams (e.g., the percentage of beef versus fruits and vegetables), along with at least a calculation of compostable plastics (polylactide biopolymer resin—PLA—which is included in the EPA WARM too).

Similarly, the EPA WARM Tool cannot model source reduction of mixed recyclables and mixed solid waste because individual materials have different life cycle emissions factors that must be modeled independently. A more detailed understanding of U-M's current waste and recycling streams would be needed to make such calculations.[101]

(2) EPA's analysis of composting includes carbon sequestration in its calculation of GHGE. As the WARM background file explains, "In WARM, the net greenhouse gas impact from composting all types of organics is negative, implying that composting is a carbon sink—that composting stores more carbon in the soil than it emits to the air."[102]The WARM model uses a 30-year timeframe, unlike other models that use a one-year timeframe, and considers carbon storage after compost is applied to soil.[103]

(3) U-M sends its landfill waste to Sauk Trails Landfill, in Canton, MI, which engages in energy recovery, in addition to some flaring. The EPA WARM Tool, however, does not have a separate category for landfills with energy capture. Instead, the EPA WARM Tool "landfilled" category we used calculates emissions for landfills using a national average that account for landfills that do not manage methane emissions, others that flare the methane gas emitted, and others that capture this methane onsite for energy recovery. The "combustion" category in the Tool, which we did not select, is reserved for "waste-to-energy" facilities that collect and combust solid waste through one of several methods, but usually using a combustion chamber "mass burn technology."[104] As of 2016, there were only two such waste-to-energy facilities in Michigan, in Detroit and Grand Rapids.[105] Waste-to-energy facilities process mixed solid waste, whereas biodigesters only combust organic waste such as food scraps, agricultural losses, livestock manure and wastewater.[106]

(4) To calculate the percentage of scopes 1 and 2 emissions represented by U-M's annual food waste emissions, we used the most recent data (FY2018) on the University's annual scope 1 and scope 2 emissions (630,405 tCO_2e)[107] and the same formula used in the food procurement section, substituting the net emissions for various scenarios for "X": (X tCO_2e / 630,405 tCO_2e) x 100 = Y.

(5) To account for 3% of food that tends to be lost to spoilage during the donation/transportation process, we subtracted this percentage from the total food donated to calculate emissions saved, using the following EPA suggested calculation: Food donated (tons) * (1—loss rate) = Food received (tons).[108]

(6) In Scenarios 3 and 4, we selected a 50% food reduction goal because it aligns with the SDGs, USDA and EPA food waste reduction goals. It also reflects the fact that a certain amount of food waste is unavoidable, given that waste such as bones, peels, the ends of produce, and fat are not edible. For instance, a food waste audit at the University of Missouri all-you-can eat, trayless dining halls, found that 22% of food was inedible, three quarters of which came from post-consumer waste, mostly consisting of fruit peels.[109]

(7) To estimate what U-M's diversion rate would have to reach using a growth factor, we assumed U-M's student, faculty and staff population will continue to grow at the same pace as it has over the last five years—what we calculated as an average of 2% on average, based on news articles about continued expansion[110] and the past five years of U-M population data,[111] though this obviously is put into question under the current COVID-19 pandemic. We also assumed that U-M's waste production is proportional to the population growth factor. If this is the case, then waste production would increase by 22% over the next 10 years, from 21,462 tons today to 26,162 tons in 2030. Today, in order to reduce U-M's landfill waste stream to 40% of 2006 levels (7,902 tons), U-M would have to divert or reduce 13,560 tons of waste. By 2030, if total waste production reaches 26,162 tons, U-M would have to divert 18,260 tons, for an overall diversion rate of 69.8%, or an increase in diversion rates by 3.3% every year until 2030.

Appendix C: Supplemental data

Authored by the PCCN Food Internal Analysis Team

Table C1. Substitution scenarios replacing animal protein with various alternative protein sources

Scenario	Reduction	Replacement
1	50% less beef	pork, chicken, fish, or plant-based proteins[1]
2	100% less beef	pork, chicken, fish, or plant-based proteins
3	50% less red meat (beef, lamb, pork)	chicken, fish, or plant-based proteins
4	100% less red meat (beef, lamb, pork)	chicken, fish, or plant-based proteins
5	50% less red meat, chicken, fish/seafood	plant-based proteins
6	100% less red meat, 50% less chicken, fish/seafood	plant-based proteins
7a	50% less milk	soymilk
7b	50% less milk and dairy products	soymilk

1. Plant-based proteins are calculated as a ratio of legumes:soy:nuts/seeds so that 60% of the replaced protein is legumes and pulses, 20% is soy (tofu, edamame, tempeh), and 20% is nuts/seeds (including peanuts).

Table C2. Protein content and GHG emissions conversion factors for food products used in the substitution analyses

Food Product	Protein Content (g protein/100 grams)[1]	GHG Emissions Conversion Factors ($kgCO_2e/kg$)[2]
Beef, raw	22.7	32.85
Pork, raw	18.0	5.56
Lamb, raw	16.6	34.75
Chicken, raw	22.5	4.19
Turkey, raw	23.7	2.57
Fish, raw[3]	18.4	3.53
Shellfish, raw[4]	17.7	10.02
Legumes and pulses, dry[5]	24.0	0.56
Soy[6]	13.8	1.49
Nuts (including peanuts)[7]	18.3	2.16
Milk	N/A	1.32
Cheese	N/A	9.97
Yogurt	N/A	1.33
Ice cream	N/A	1.32
Soymilk	N/A	0.26

1. Protein contents are sourced from FoodData Central.[112]
2. GHG emissions conversion factors are sourced from Heller et al. (2018).[113]
3. Fish is the average of whitefish, tuna, cod, salmon, catfish, and rockfish.
4. Shellfish is the average of mussels, shrimp, scallops, and clams.
5. Legumes and pulses are the average of black beans, red kidney beans, navy beans, pinto beans, Great Northern beans, chickpeas, and lentils.
6. Soy is the average of tofu, edamame, and tempeh.
7. Nuts are the average of almonds, cashews, pecans, walnuts, sunflower seeds, and peanuts.

Table C3. Greenhouse gas emissions (metric tons of carbon dioxide equivalents) and weight (kg) of food purchased by the University of Michigan dining halls in the Fall 2019 academic term

Food Category	GHG Emissions (tCO_2e)	Weight (kg)
Beef	1,662	50,600
Dairy	909	287,143
Chicken	326	77,925
Pork	213	38,293
Fish	58	15,220
Shellfish	270	10,216
Eggs	170	45,353
Other Meat	164	29,378
Vegetables	247	473,120
Fruits	202	377,542
Grains and Cereals	142	264,097
Legumes and Pulses	26	47,845
Soy	40	55,390
Nuts and Seeds	4	2,304
Oils and Fats	116	72,868
Sugars and Sweeteners	47	61,831
Beverages	59	51,134
Other	19	30,289
Total	**4,674**	**1,990,548**

Table C4. Comparison of GHG emissions (metric tons of carbon dioxide equivalents) from food purchases on Sustainable Mondays and Wednesdays by University of Michigan dining halls during the Fall 2019 academic term

Dining Hall	% Change in Beef-Related GHG Emissions[1]	Monday GHG Emissions	Wednesday GHG Emissions	Absolute Difference in GHG Emissions	% Change in Overall GHG Emissions[1]
South Quad	-80.1%	143	197	-54	-27.5%
Mosher Jordan	-94.9%	123	177	-54	-30.6%
Bursley	-93.8%	105	144	-39	-26.9%
East Quad	-100.0%	56	99	-43	-43.2%
North Quad	-98.4%	35	59	-24	-40.4%
Markley	-98.2%	23	40	-17	-42.7%
Twigs (Oxford)	-96.3%	24	30	-6	-21.0%
Law Club	0.9%	21	22	-1	-2.9%
Martha Cook	-53.7%	9	12	-3	-22.4%
Total	**-87.4%**	**539**	**780**	**-241**	**-30.6%**

1. Total percentage change in beef-related and overall GHG emissions across all dining halls was calculated as a weighted total based on each dining hall's respective total food procurement (in kg) out of the total food procured by MDining for the Fall 2019 semester (South Quad, 26%; Mosher Jordan, 21%; Bursley, 17%; East Quad, 15%; North Quad, 6%; Markley, 5%; Twigs (Oxford), 4%; Law Club, 3%; Martha Cook, 2%).

Table C5. Comparison of food purchase costs ($) on Sustainable Mondays and Wednesdays by University of Michigan dining halls in the Fall 2019 term

Dining Hall	Monday Costs	Wednesday Costs	Absolute Difference in Costs	% Change in Cost
South Quad	$257,179	$241,189	$15,989	6.6%
Mosher Jordan	$233,171	$205,606	$27,565	13.4%
Bursley	$186,340	$173,179	$13,160	7.6%
East Quad	$146,425	$157,767	-$11,342	-7.2%
North Quad	$63,758	$67,802	-$4,044	-6.0%
Markley	$47,581	$53,097	-$5,516	-10.4%
Twigs (Oxford)	$47,560	$43,313	$4,247	9.8%
Law Club	$35,201	$35,688	-$487	-1.4%
Martha Cook	$18,994	$19,288	-$294	-1.5%
Total	**$1,036,207**	**$996,929**	**$39,278**	**3.9%**

Table C6. Projected annual changes in GHG emissions (metric tons of carbon dioxide equivalents) compared to estimated 2019–2020 baseline[1] emissions from food procurement substitution scenarios

Scenario	Substitute	Absolute Change in GHG Emissions (tCO_2e)	% Change in GHG Emissions
Scenario 1: 50% Reduction in Beef	Pork	-1,306	-14.0%
	Chicken	-1,448	-15.5%
	Fish	-1,442	-15.4%
	Plant-Based Proteins[4]	-1,594	-17.0%
Scenario 2: 100% Reduction in Beef	Pork	-2,613	-27.9%
	Chicken	-2,896	-31.0%
	Fish	-2,883	-30.8%
	Plant-Based Proteins	-3,188	-34.1%
Scenario 3: 50% Reduction in Red Meat[2]	Chicken	-1,620	-17.3%
	Fish	-1,610	-17.2%
	Plant-Based Proteins	-1,859	-19.9%
Scenario 4: 100% Reduction in Red Meat	Chicken	-3,241	-34.7%
	Fish	-3,219	-34.4%
	Plant-Based Proteins	-3,718	-39.8%
Scenario 5: 50% Reduction in All Meat and Fish/Seafood[3]	Plant-Based Proteins	-2,241	-24.0%
Scenario 6: 100% Reduction in Red Meat and 50% Reduction in Other Meat and Fish/Seafood	Plant-Based Proteins	-4,100	-43.9%
Scenario 7a: 50% Reduction in Milk	Soymilk	-188	-2.0%
Scenario 7b: 50% Reduction in Milk and Dairy Products	Soymilk	-743	-7.9%

1. Baseline emissions were calculated as 9,348 tCO_2e by doubling estimated Fall 2019 emissions of 4,674 tCO_2e to yield annual emissions for the Fall 2019 and Winter 2020 academic terms.
2. Red meat includes beef, lamb, and pork.
3. Fish/seafood includes freshwater fish, saltwater fish, and shellfish.
4. Plant-based proteins are calculated as a ratio of legumes:soy:nuts/seeds so that 60% of the replaced protein is legumes and pulses, 20% is soy (tofu, edamame, tempeh), and 20% is nuts/seeds (including peanuts).

Table C7. Projected annual changes in cost ($) of food procurement substitution scenarios compared to estimated 2019–2020 baseline annual cost

Scenario	Substitute	Absolute Change in Cost	% Change in Costs
Scenario 1: 50% Reduction in Beef	Pork	$92,750	0.7%
	Chicken	$32,460	0.3%
	Fish	$241,195	1.9%
	Plant-Based Proteins	-$27,772	-0.2%
Scenario 2: 100% Reduction in Beef	Pork	$185,501	1.5%
	Chicken	$64,920	0.5%
	Fish	$482,390	3.9%
	Plant-Based Proteins	-$55,544	-0.4%
Scenario 3: 50% Reduction in Red Meat	Chicken	-$26,251	-0.2%
	Fish	$315,702	2.5%
	Plant-Based Proteins	-$124,925	-1.0%
Scenario 4: 100% Reduction in Red Meat	Chicken	-$52,503	-0.4%
	Fish	$631,404	5.1%
	Plant-Based Proteins	-$249,850	-2.0%
Scenario 5: 50% Reduction in All Meat and Fish/Seafood	Plant-Based Proteins	-$390,834	-3.2%
Scenario 6: 100% Reduction in Red Meat and 50% Reduction in Other Meat and Fish/Seafood	Plant-Based Proteins	-$515,759	-4.2%
Scenario 7a: 50% Reduction in Milk	Soymilk	$70,019	0.6%
Scenario 7b: 50% Reduction in Milk and Dairy Products	Soymilk	$319,477	2.6%

1. Baseline annual cost for Fall 2019 and Winter 2020 terms was calculated by doubling the estimated Fall 2019 costs.

Table C8. Tons of waste diverted and landfilled as a percentage of all waste generated by the University of Michigan (U-M) in FY2019 across the three campuses, and associated GHG emissions

Categories of waste, diverted and landfilled[1]	**Tons**[2]	**Percentage of all U-M waste**	**GHG emissions**[3] (tCO_2e)
Total waste currently diverted	8,105	37.8%	-17,781
Composted, mixed food waste	1,329	6.2%	-234
Donated, mixed food waste	3.3	0.02%	-2
Recycled, mixed recycling	6,131	28.6%	-17,451
Mulched, mixed yard waste	642	3%	-94
Total landfilled, mixed solid waste	13,357	62.2%	4,771
TOTAL waste generated, diverted or landfilled[4]	21,462	100%	-13,010

1. See Appendix B*, Methods used to calculate emissions associated with scenarios*, for an explanation of the EPA WARM Tool assumptions, limitations and calculations behind each of these categories of waste and the loss rate applied to donated food.
2. Short tons = 2,000lbs.
3. Note that a negative number refers to emissions avoided, where a positive number indicates emissions released.
4. To calculate the emissions for this combination of landfill, compost and recycling waste, we used the EPA WARM Tool "mixed solid waste" for all the landfill waste. This results in fewer total emissions avoided than the Baseline 1 and 2 scenarios (in Tables C10 and C11), which assume that some of that landfill waste is food waste or recyclable materials, both of which breakdown in landfills in different ways than general "mixed solid waste." See Table C10 for the contribution of recyclable and food scraps if allowed to remain in the landfill.

Table C9. Baseline 1 and 2 assumptions[1] of the type of waste that makes up landfill waste generated by the University of Michigan (U-M) across all three campuses in FY2019

Groups of buildings	Baseline 1			Baseline 2		
	Mixed waste	Recyclable waste	Food waste	Mixed waste	Recyclable waste	Food waste
UM-Ann Arbor buildings with major food operations[2]	70%	20%	10%	65%	20%	15%
UM-Ann Arbor administrative and academic buildings[3]	60%	20%	20%	55%	20%	25%
UM-Dearborn	55%	15%	30%	50%	15%	35%
UM-Flint	55%	15%	30%	50%	15%	35%
Average	**65%**	**20%**	**15%**	**60%**	**20%**	**20%**

1. See Appendix B, *Estimates of baseline assumptions*, for an explanation of the basis for these assumptions.
2. This includes buildings with dining halls, hospital retail, cafeterias and patient meal services, the U-M Stadium concessions, the Michigan Unions (e.g., Michigan League, Pierpont), Ross School of Business Executive Dining and retail, and others.
3. This group of buildings encompasses all other UM-Ann Arbor buildings not included under the above category, other than off-campus leased buildings that are not serviced by U-M Waste Management Services.

Table C10. GHG emissions contribution of food waste, recyclable, or mixed solid waste if landfilled, fully diverted, or entirely reduced (in the case of food waste), under different baseline assumptions about the proportion of landfill waste each category of waste makes up, focused on the University of Michigan across its three campuses, FY2019

Categories of waste	Tons[1]	Percentage of U-M landfill waste	GHG emissions *emitted* if 100% landfilled (tCO_2e)	GHG emissions *avoided* if 100% diverted (tCO_2e)	GHG emissions *avoided* if 100% reduced (tCO_2e)
Baseline 1[2]					
Landfilled, mixed solid waste	8,721	65%	3,115	-	-
Landfilled, food that could be donated or composted	1,992	15%	1,080	351	7,290
Landfilled, recyclable waste	2,644	20%	244	7,583	-
Baseline 2[2]					
Landfilled, mixed solid waste	8,053	60%	2,877	-	-
Landfilled, food that could be donated or composted	2,660	20%	1,442	468	9,735
Landfilled, recyclable waste	2,644	20%	244	7,583	-

1. Short tons = 2,000 lbs.; Tonnages are based on 12,920 tons of current landfill waste.
2. See Table C11 for the net GHG emissions avoided when current recycling, composting and food donations are combined with different intervention options based on these baseline assumptions about the amount of landfill waste that could still be diverted or reduced. See Appendix B for an explanation as to why the EPA WARM Tool does not allow estimations of emissions reductions related to potential reduction of “mixed solid waste” or mixed recyclable waste.

Table C11. GHG emissions reductions, percentage of U-M scopes 1 and 2 emissions achieved, and percentage reduction over 2006 and current baselines according to four implementation scenarios for the University of Michigan across its three campuses

Baseline and implementation scenarios	Landfill waste[1] (tons)			Diverted waste (tons)			Total waste generated (tons)	Diversion rate[3]	GHG emissions *reduction* (tCO2e)	% of U-M scopes 1 and 2 emissions	% reduction from 2006 landfill baseline[4]	% change from baseline 1 and 2 emissions
	Mixed waste	Recyclable waste	Food waste	Recycling	Compost	Donated food[2]						
Baseline 1	8,721	2,644	1,992	6,131	1,329	3.3	21,462	37.8%	13,341			
Baseline 2	8,053	2,644	2,660	6,131	1,329	3.3	21,462	37.8%	13,218			
Scenario 1: Divert all food waste via compost + double food donations + divert all recyclable waste (Baseline 1)	8,721	0	0	8,775	3,317	6.6	21,462	59%	22,554	3.6%	36%	69%
Scenario 2: Divert all food waste via compost + double food donations + divert all recyclable waste (Baseline 2)	8,053	0	0	8,775	3,986	6.6	21,462	62%	22,910	3.6%	41%	73%
Scenario 3: Prevent 50% of food waste + compost all other food waste + triple food donations + divert all recyclable waste (Baseline 1)	8,721	0	0	8,775	1,652	9.9	19,800	64%	28,355	4.5%	36%	113%
Scenario 4: Prevent 50% of food waste + compost all other food waste + triple food donations + divert all recyclable waste (Baseline 2)	8,053	0	0	8,775	1,986	9.9	19,466	69%	28,874	4.6%	41%	118%

1. Short tons = 2,000 lbs
2. The amount of total food donated is actually 3.4 tons, but we included a 3% loss rate based on EPA estimates of how much donated food spoils during distribution.
3. Technically the diversion rate for Scenarios 3 and 4 are lower (56% and 59% respectively), if only generated waste is considered. By preventing 50% of food waste from being generated in the first place, Scenario 3 would reduce landfill waste by 1,662 tons and in Scenario 4 by 1,996 tons. To make diversion rates more comparable, however, for these scenarios we calculated diversion by including both food waste that is diverted—via composting and donations—and via source reduction/prevention.
4. The U-M Waste Reduction Goal was based on the UM-Ann Arbor landfill waste tonnage in 2006—13,170 tons. Therefore, we calculated the percentage reduction that each scenario might accomplish using the 2006 baseline by first subtracting the landfill waste expected to be generated by UM-Dearborn and UM-Flint from the overall landfill waste generated in that scenario, to arrive at the landfill tonnage that the UM-Ann Arbor campus is expected to still generate, after waste is reduced and/or diverted. This number was then divided by 13,170 tons.

Figure C1. Proportion of total GHG emissions by food categories at the University of Michigan dining halls in the Fall 2019 academic term

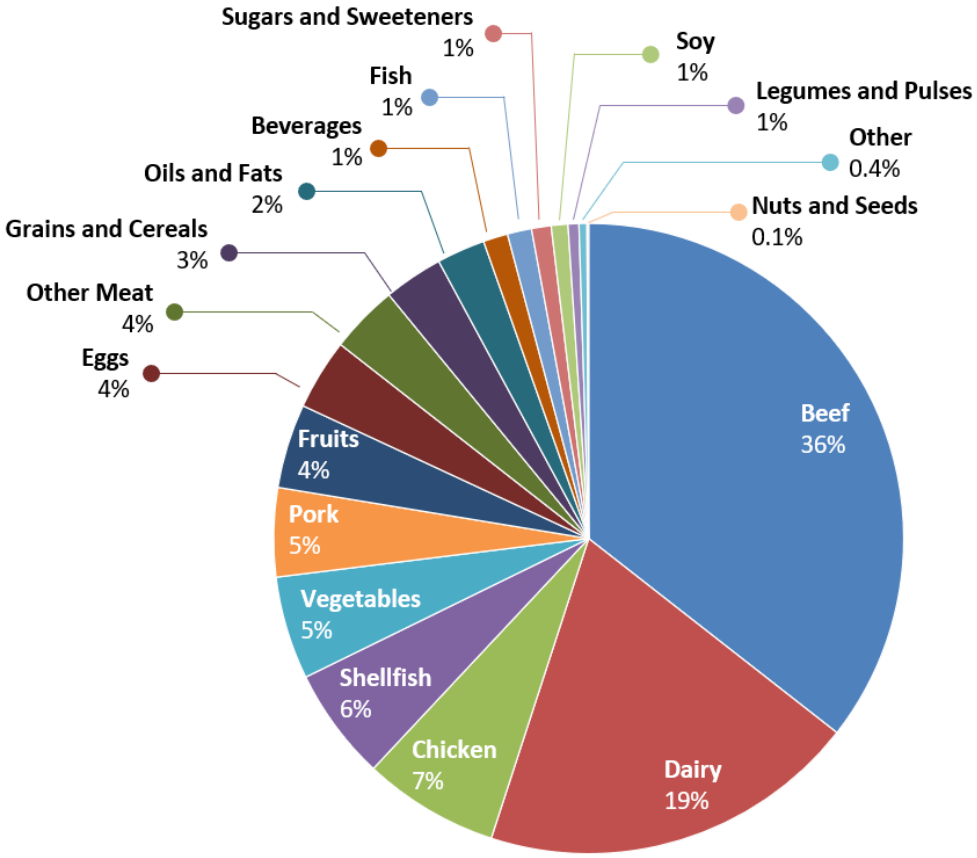


Figure C2. Comparison of the weight of total food purchases of various food categories between Sustainable Mondays and Wednesdays by University of Michigan dining halls in the Fall 2019 academic term

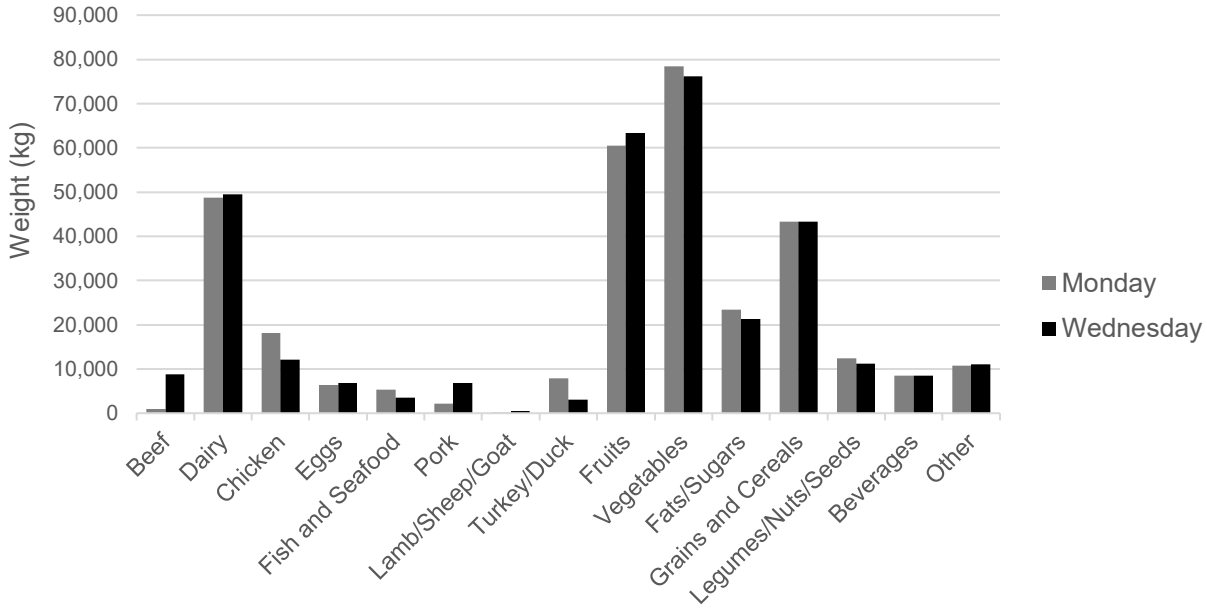


Figure C3. Comparison of GHG emissions (metric tons of carbon dioxide equivalents) of food purchases of various food categories between Sustainable Mondays and Wednesdays by University of Michigan dining halls in the Fall 2019 academic term

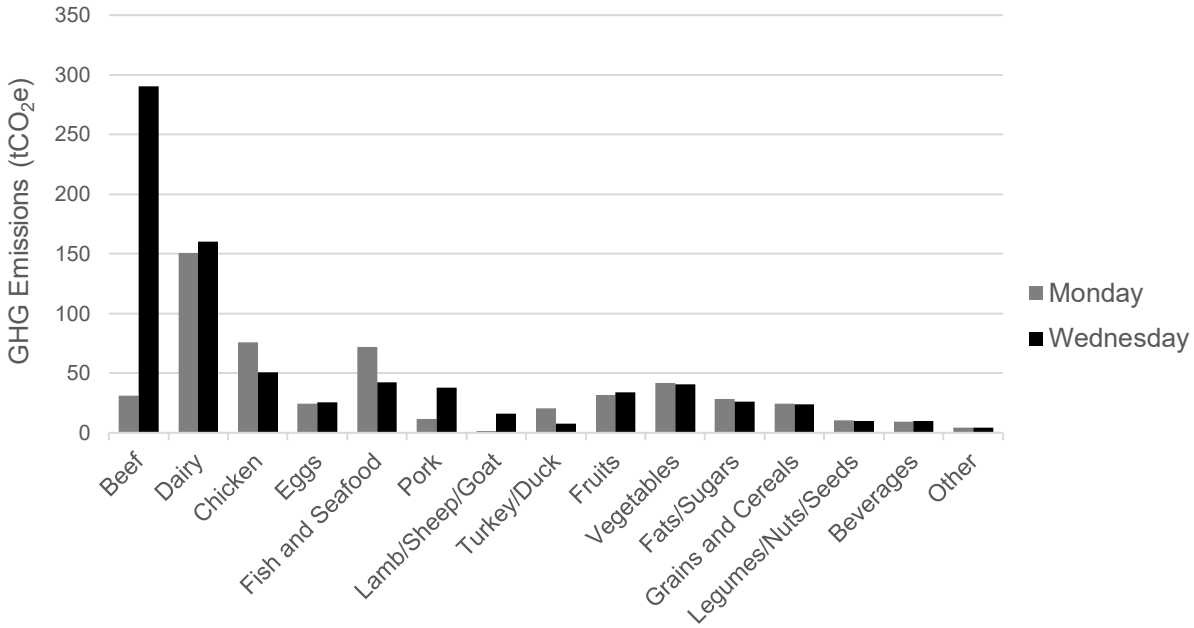
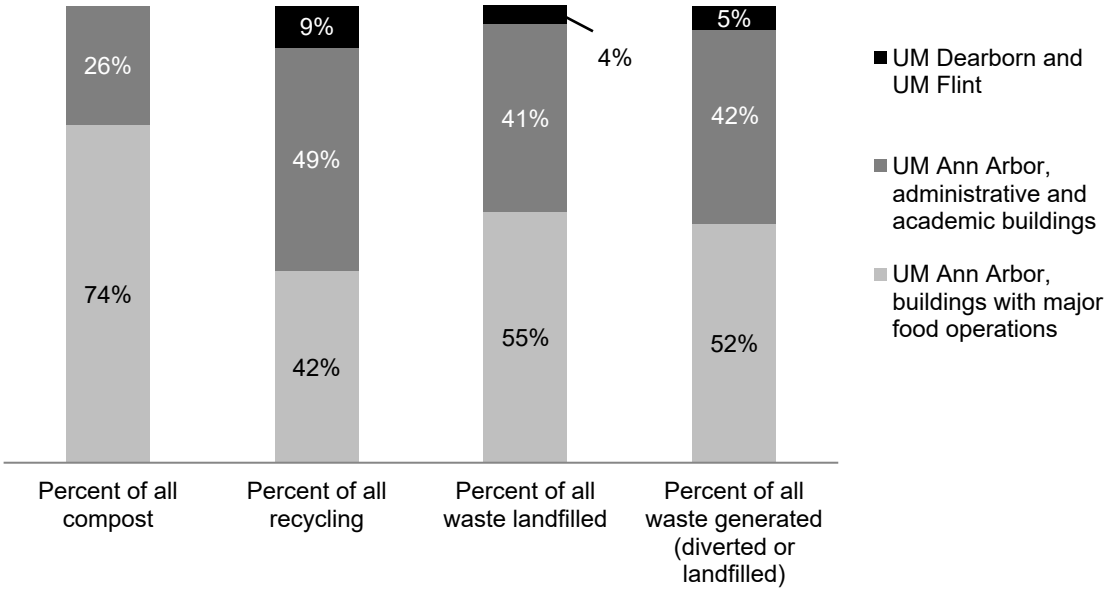
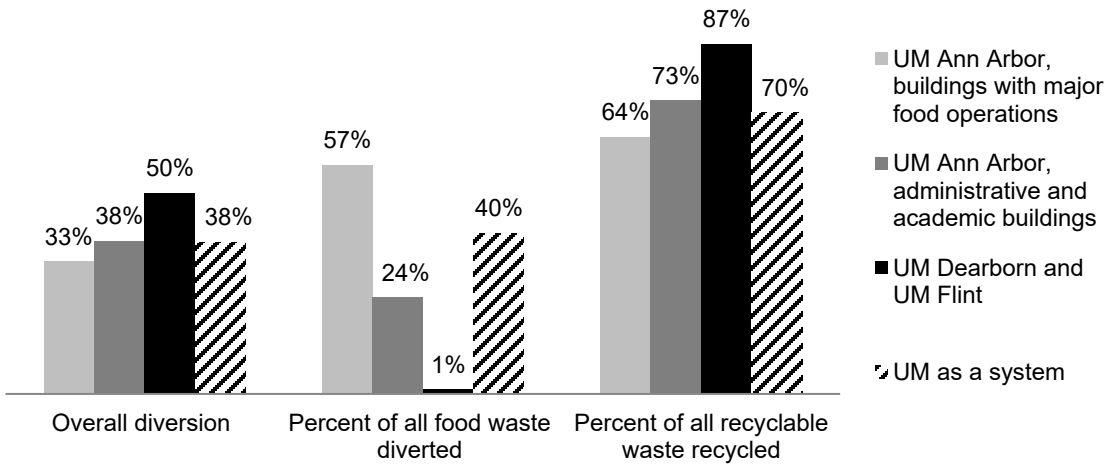


Figure C4. Percentage of compost, recycling, and landfilled waste[1] at the University of Michigan in FY2019 across all three campuses, by building groups



1. We chose not to include food donations since current estimates indicate that food donations make up only 0.2% of all food waste diversion across the three campuses. Of the 3.3 tons we know are donated, 74% comes from the UM-Ann Arbor campus and 26% from the UM-Flint and UM-Dearborn campuses combined. Also not included in this figure is 642 tons of yard waste produced in FY2019 (3% of all waste produced) that was composted on-site and applied as mulch on planting beds on the Ann Arbor campus.

Figure C5. Overall diversion rates and food waste and recyclable waste diversion in FY2019 under Baseline 1 for the University of Michigan as a system across all three campuses and by building groups[1]



1. See Table C9 for the assumptions behind Baseline 1. Under Baseline 2, the percentage of recyclable waste recycled would remain the same since we assumed in both baselines that current landfill is made up of 20% recyclable waste. The percentage of food waste diverted would be lower, however, since Baseline 2 assumes that 20% of current landfill waste is composed of food waste (rather than 15% as in Baseline 1). If Baseline 2 is more accurate, then currently, UM-Ann Arbor buildings with major food operations likely divert 47% of the total food waste they generate, UM-Ann Arbor administrative and academic buildings 20%, UM-Dearborn and UM-Flint combined 1% (through food donations), and combined, U-M as a system diverts 33% of its food waste.

Appendix D: Recommendation summary matrix

Priority	Description	Progress Metrics	Financial Impacts	Organizational Hurdles	Equity Considerations	Key Unknowns
Priority #1	Scale up and expand the use of plant-forward menus and food options	Expenditures on animal vs. plant-based proteins; food-related GHG emissions, by unit and academic year	Investment in cultural change and institutional capacity building efforts	Consumer acceptance of changes; staff training; coordination through Procurement Services	Menu changes must be responsive to the needs and capacities of the diverse food operations across the University as well as the preferences and cultures of individuals	Accurate GHG emissions baseline for units other than MDining
Priority #1 and 2	Implement cultural and institutional capacity building recommendations of the PCCN Campus Culture and Communication Team with food as a core pillar	Creation of the Office of Michigan Leadership and Innovation for Sustainable Transitions (M-LIST) and Sustainable Food Systems Center; creation of unit-specific sustainability officers and new training opportunities	FTE salary and benefits for new staff positions; development of new courses and trainings	Capacity of bureaucracy to integrate a new office in existing organizational system; coordinating creation, support, and training for sustainability officers in all units	Unfunded mandates would inequitably affect smaller and under-resourced units (e.g., UM-Dearborn and UM-Flint)	
Priority #1	Hire a plant-forward culinary trainer	Number of staff/units trained in plant-forward menus across the University; number of research collaborations with new hire; expenditures on animal- vs. plant-based proteins; food-related GHG emissions, by unit and academic year	FTE salary and benefits and food budget for new position estimated at $160,000	Availability of General Fund support for 5-year timeline; ensuring engagement of different food operations with the new hire	Menu changes the trainer suggests must be responsive to the needs and capacities of the diverse food operations across the University as well as the preferences and cultures of individuals	

Priority	Description	Progress Metrics	Financial Impacts	Organizational Hurdles	Equity Considerations	Key Unknowns
Priority #1 and 2	Align institutional food procurement with the goal of decarbonization[1]	University food-related GHG emissions tracked annually against food decarbonization goal; new, emissions-related contract requirements and accountability through Procurement Services	Staff time within Procurement Services; FTE salary and benefits for a Procurement Sustainability Manager	Staff resource availability and cultural shift within Procurement Services; coordination with the Office of Campus Sustainability (OCS) and M-LIST	Equity could be enhanced if U-M supported historically under-represented farmers and food businesses with practices/products with greater carbon sink potential	Accurate GHG emissions baseline for units other than MDining
Priority #1 and 2	Standardize protocols for collecting data and evaluating food procurement-related emissions[1]	Number of units that track food procurement-related GHG emissions; number of external vendors that supply disaggregated food item purchase lists annually	Staff time to link food item purchase list data to emissions databases	Willingness of units to invest staff time in tracking data; staff availability/willingness of Procurement Services to negotiate contracts with vendors with new requirements around purchase list transparency	Prioritizing vendors based on ability to link practices and products to decarbonization goals may impact companies with less capacity, unless U-M offers to build their capacity and ensure equitable access to U-M contracts	
Priority #2	Scale up food waste diversion and reduction[2]	Food waste landfill, compost and donated tonnage and associated GHG emissions, by unit and academic year; reduced contamination in food waste audits	Investment in cultural change and institutional capacity building efforts required for successful implementation	Chef training/willingness to address pre-consumer food waste; willingness of staff, students and faculty to address post-consumer food waste; coordination with food providers and donation sites to increase food donations; improved data tracking/audits	Efforts to scale up diversion and reduction must be responsive to the needs, capacities, and advances already made within different units and buildings on campus; significantly increasing food donations could improve regional and student food security	Accurate diversion and reduction baseline based on actual make up of current landfill waste

Priority	Description	Progress Metrics	Financial Impacts	Organizational Hurdles	Equity Considerations	Key Unknowns
Priority #2	Increase capacity and scale up composting on U-M's campus and launch campus-wide composting programs at UM-Dearborn and UM-Flint[2]	Food waste landfill and compost and associated GHG emissions, by unit and academic year	UM Ann Arbor: investment in a truck ($340,000) and two drivers ($100,000) in addition to more signage and bins; UM-Dearborn and Flint: investment in composting program	Availability of General Fund support; willingness of staff, students and faculty to divert food waste and to avoid contamination; requirement and standardization of use of compostables across all three campuses	Unfunded mandates would inequitably affect smaller and under-resourced units (e.g., UM-Dearborn and UM-Flint)	For UM-Dearborn and Flint, financial and emissions cost of hauling in comparison to systems operated on campus

1. Although these two actions are described in terms of their focus on food-related procurement and data tracking, in an effort to improve U-M's overall GHG emissions and waste diversion capacity through compostable and recyclable products, for instance, and the promotion of other carbon-neutral products, these same decarbonization goals and data tracking should be applied to all vendors and their associated products managed by Procurement Services.
2. Although these actions are described in relation to food waste, the same investments would be needed to continue scaling up recycling.

Appendix E: Peer benchmarking study

Authored by the PCCN Food Internal Analysis Team

To learn from other universities in the U.S. carrying out sustainable food system initiatives, we carried out a document review of reports and websites of 33 universities and conducted semi-structured interviews with 11 dining and sustainability staff from these institutions. Details about these two components of our peer benchmarking are below.

Trends in food systems initiatives being led by U.S. universities

We selected 33 U.S. universities for our review based on institutions identified by key informants or by the AASHE STARS rating system[114] for their leadership on climate action planning, sustainable food systems initiatives, and sustainable dining operations. Most of the universities we reviewed are also comparable in U-M's population size, scale of dining operations and geographic location (i.e. in the northern latitude, which affects seasonality of regional food production) (Table 1).

Table E1. Size and location of reviewed U.S. universities (*n* = 33)

Characteristic	Number of universities (%)
Size of University	
Large student population (15,000 students or more)	23 (70%)
Medium student population (5,000-14,999 students)	6 (18%)
Small student population (less than 5,000 students)	4 (12%)
Region of the U.S.	
Midwest	7 (21%)
Northeast	11 (33%)
South	7 (21%)
West	8 (24%)

Practices we considered were based on the Case Study Matrix of the 2010 U-M Food Report.[115] These included universities' climate action plan, definition of local and regional, goals for local and/or sustainable food spend, innovative procurement initiatives, innovative production programs, innovative waste reduction and/or composting initiatives, educational programs, methods of tracking progress in sustainability, any guidelines they have for sustainability, and any certifications and awards their dining program has received. Information on these criteria was gathered from the university's dining and sustainability websites, and if available, the university's most recent AASHE STARS report.

Generally, the scan revealed three major categories of sustainability initiatives: local and sustainable food purchasing, waste reduction and composting, and plant-forward menus. Universities have implemented many innovative educational programs and interventions within these categories, however, we focused on the activities that were most common across many universities. Table 2 outlines the initiatives universities have adopted under each of the three identified categories, as well as the percentage and number of universities that have adopted these initiatives to show the popularity of each initiative. While our summary offers a sense of the broad trends in terms of initiatives these universities have adopted, we also acknowledge that our scan may have not captured some initiatives, while others noted in a university report or online may no longer be active.

Table E2. Overview of university food initiatives (*n* = 33)

Initiatives	Number of universities (%)
Local and sustainable food purchasing[*]	
Define goals for sustainable food purchasing	20 (61%)
Define goals for local food purchasing	14 (42%)
Purchase food from on-campus production sites (student farms, orchards, dairy, etc.)	14 (42%)
Partner with local farmers and producers	13 (39%)
Waste reduction and composting	
Offer composting at dining facilities	31 (94%)
Practice trayless dining	26 (79%)
Recycle cooking oil for biodiesel	19 (58%)
Donate leftover food from dining halls (to local food banks)	13 (39%)
Offer a reusable to-go container program	11 (33%)
Define goal for zero waste	9 (27%)
Use tracking system for food waste (e.g., LeanPath)	8 (24%)
Run a biodigester on-site (dining hall or on campus)	7 (21%)
Eliminate plastic bags in dining locations	3 (9%)
Use pulper systems for food waste	2 (6%)
Eliminate single-use plastics from food stores on campus	1 (3%)
Plant forward menus	
Offer a plant-based menu	19 (57.6%)
Use blended burgers	6 (18.2%)
Set goal for GHG emissions reductions related to food procurement	2 (6.1%)
Use carbon emissions menu labels	1 (3.0%)

*Note: Of the 33 universities scanned, 69.7% define local food. Of this 69.7%, 60.9% define local food as within 200-250 miles of campus, 26.1% as within the state, and 13.0% as within 100-150 miles of campus. Of the 33 universities scanned, 11.4% define regional food. Of the 11.4%, 40% define regional food as within 250 miles from campus, 40% as within 400 miles, and 20% as within 600 miles.

In-depth interviews with U.S. University Dining and Sustainability Staff

Following the initial university scan, we conducted semi-structured interviews with dining and sustainability staff at 11 of the 33 identified universities across the United States. These 11 universities were selected based on the authors' subjective assessment of the universities' comparability to U-M (with respect to student population and geography) as well as the scope and diversity of the food sustainability initiatives being undertaken at the universities, identified by our initial scan. The purpose of the interviews was to determine best practices for reducing greenhouse gas (GHG) emissions from university food systems that are being carried out at comparable institutions. The questionnaire that guided these interviews is included at the end of this summary of findings.

The categories of findings from the interviews largely paralleled the structure of the questionnaire with a focus on: 1) implementing and scaling up "plant-forward" menus; 2) cultivating consumer behavior change; 3) reducing and managing food waste; 4) improving sustainability requirements within supply chains and contracts; and, 5) improving data collection and monitoring of food-related GHG emissions. The findings are summarized below by category as potential recommendations for action.

1) Implementing and scaling up "plant-forward" menus

Ideas reported multiple times

- Use blended burgers (up to 50% beef).
- Make plant-forward menus the norm across all dining halls, not just a feature of some entrees on some select days of the week.
- Prepare vegetables to be more attractive, with more complex seasoning.
- Reduce the size of plated protein portions:
    - Design lines so the protein goes into the dish last (e.g., in stir-fry and noodle bowl stations);
    - Control protein portions at "all-you-care-to-eat" facilities;
    - Incorporate "Protein Flip"[116] guidance;
    - Use vegetables as entrees rather than side dishes (this includes integrating grains and legumes with vegetables); view protein as an accent on the plate.
- Re-name and re-brand plant-forward menus (e.g., base advice on Menus of Change University Research Collaborative (MCURC) "Edgy Veggies Toolkit"[117]).
- Incorporate global cuisine stations that are heavily plant-based.
- Recruit trained staff and provide technical training to dining staff around the use of different grains and legumes, making food from scratch, and preparing attractive and tasty plant-forward dishes.

Ideas reported once or twice

- Reduce the amount of physical space in dining halls devoted to serving animal protein (e.g., if 40 feet of counter space is available, less than 5 feet should be devoted to serving animal protein).
- Rotate low-carbon menus across dining halls so students have options to eat from such menus any day of the week. A 6-week, rather than 4-week menu cycle may provide more flexibility to provide a greater diversity of plant-forward menu options.
- Become a member of "Menus of Change."[118]
- Highlight "Power Dishes" (i.e., highly-popular plant-forward dishes, such as falafel; tomato soup and grilled cheese) on days when beef is served to divert consumption of the animal protein.

2) Cultivating consumer behavior change

Ideas reported multiple times

- Do not call attention explicitly to shifts away from animal protein
    - Focus on positive messages. Do not tell people what to do. Taking options away and forcing change can be counterproductive;
    - If the changes are built into the system and fairly inconspicuous such that making the low-carbon choice is the easy or only choice, creating awareness will be less important for behavior change;
    - Lead with other goals like delicious food, healthy and fresh food, local/regional procurement, and waste reduction;
    - Focus on food literacy broadly and understanding consumer connection with the food system.
- Create student ambassadors for sustainability.
- Incorporate food sustainability issues into student orientation an essential strategy for defining campus culture:
    - First-time students should be taught about food waste and other sustainability goals;

    - New students should be encouraged to pledge to commit to certain sustainability actions during their time at the university;
    - Students should be given guidance on how to navigate the dining halls.
- Conduct campus-wide educational and special events and make sustainability a core value campus-wide.

Ideas reported once or twice

- Carry-out a campus-wide sustainability survey in which food is integrated.
- Collaborate with student government on instituting changes related to campus culture around food sustainability.
- Empower frontline dining staff with knowledge (e.g., bring in faculty to educate chefs and other staff on the science behind food and climate change) to facilitate greater acceptance among dining staff about the priority of addressing this issue.

3) Reducing and managing food waste

Ideas reported multiple times

- Downscale plate sizes.
- Conduct student-run food waste audits periodically through the year. These events serve multiple purposes including collecting data on food waste, encouraging behavior change among consumers, engaging students, and providing educational opportunities.
- Use dashboard systems to measure and track pre-consumer food waste (e.g., Leanpath or Winnow).
- Invest in anaerobic digesters. An on- or off-campus campus digester can model closed-loop systems for students, provide opportunities for education and research, and will likely pay for itself over time.
- Create comprehensive menu stations to prevent "grazing." Such stations provide consumers with an entire meal in one station.
- Use forecasting systems (e.g., Cbord).
- Increase number of made-to-order stations, and reduce portion sizes at these stations.
- Make all containers and ware compostable.
- Partner with local food recovery organizations.
- Create a campus-wide composting program.
- Create a "Zero Waste" campus culture and require "Zero Waste" events.
- Collect leftover food and provide to students for free at the end of the day (ensuring the food is Safe Serve Certified).

Ideas reported once or twice

- Prevent food waste on the procurement end as a priority. This is more important than diversion of food waste. With a focus on diversion, institutions can end up establishing systems that rely on food waste.
- Purchase "seconds" from farms and use plant by-products like leaves in meals (partnering with a local aggregator may be important for these efforts).
- Provide incentives for dining staff to track pre-consumer food waste.
- Use and issue reusable food containers.
- Invest in an on-campus composting facility (secondary benefits related to opportunities for research and education).

4) Improving sustainability requirements within supply chains and contracts

Ideas reported multiple times

- Include sustainability concerns in contract language and RFPs from the outset:
    - Leadership within the purchasing department should have requirements for sustainability in the contractual language so that all vendors speak to sustainability priorities and efforts as part of their bid;
    - Focus on supplier take-back programs;
    - Increase traceability of products and supply chains;
    - Push contractors to join Cool Food Pledge[119] (easier, more "trackable" guidance to follow for contractor than "be sustainable")

Ideas reported once or twice

- Establish contracts and offer technical assistance (including on-farm research) to "regenerative" regional farmers that can supply the university with product, particularly under-resourced and new farms run by farmers of color and women.

5) Improving data collection and monitoring of food-related greenhouse gas emissions

Ideas reported multiple times

- Track food-related greenhouse gas emissions across all campus units in a consistent and comprehensive fashion. This could be done in concert with the Menus of Change University Research Collaborative (MCURC), using the Cool Food Pledge calculator, or other tools like Vital Metrics, and SIMAP. Tracking high-protein foods only may be sufficient.
- Conduct periodic, comprehensive pre- and post-consumer food waste audits (assessing food recovery, compost, etc. by food vs. other compostables).

Ideas reported once or twice

- Hire a dedicated staff member to conduct operational research to evaluate the impacts of many of the changes recommended.
- Adopt a metric specific to carbon emissions from food procurement that is tracked and reported annually through the Office of Campus Sustainability and/or the Office of the President.

Questionnaire for in-depth interviews with U.S. university dining and sustainability staff

Contact name(s):
Contact title:
Interviewer:
Date:

Intro during interview: As I mentioned in my e-mail, I'm the co-leader of the University of Michigan (U-M) President's Commission on Carbon Neutrality "Food Analysis Team" -- which is charged with developing ambitious, yet actionable strategies that U-M can pursue to reduce GHGEs through all aspects of food on our campus (among other actions).

We are currently conducting a national scan of best practices and lessons learned from similar efforts at other higher education institutions. We would use what we learn from you as part of our larger data scan and interviews to guide the recommendations we develop, and can keep any part of our conversation confidential, if you prefer.

Interview questions

1. Background - can you tell me briefly how long you've been in **your position** and what types of dining operations on campus it covers.

2. What types of food-related interventions - whether within your dining operations, waste reduction/management, curriculum, or other areas - do you believe have had the **biggest impact on reducing your institution's GHGEs**?
    a. Did you collect data to document the impact of those changes? Would you be willing to share that data/report?

3. Has your institution attempted any major behavioral or cultural change efforts to **shift student eating habits and preferences** as a way to reduce GHGEs?

4. Has your institution attempted any major **food waste reduction or reuse** efforts?

5. To what extent have **national certifications, standards or campaigns** contributed to the changes you have pursued?
    a. How?
    b. Have any of these systems helped you track your impact?

6. Have you tried to shape **contract agreements with external dining service operators** to increase transparency or to change practices regarding their food sources? (For example, information/practices related the location of their producers/suppliers, the production practices, or other GHGE data/impacts)
    a. Can you describe the changes you made or that you attempted to make?
    b. With which company?
    c. Were you successful in negotiating those changes?
    d. Have you required all contracts to use the same language/agreements, including for caterers - not just dining contracts?
    e. Did ___company X_____ abide by and actually implement all your agreements?
    f. What changes were dining operators not willing to make?
    g. What has been the biggest impediment to accomplishing even more GHG reductions through a focus on food at your institution?

Appendix F: Interviews with U-M faculty and staff experts

Authored by the PCCN Food Internal Analysis Team

We conducted interviews with 11 faculty, 4 staff members, and 1 post-doctoral researcher at the University of Michigan (U-M) who all carry out research on, teach about, or work in food systems and climate change. To identify interviewees, we first circulated a brief survey through relevant listservs and contacts across all three U-M campuses to identify faculty and staff with appropriate expertise. We estimate that this survey reached at least 80 faculty and staff across U-M Sustainable Food Systems Initiative listserv, along with others on Flint and Dearborn campuses. We received 22 responses to the survey and scheduled interviews with 16 of these respondents. Interviews were conducted in-person and over the phone between January and March 2020.

We asked interviewed experts to identify the highest priority actionable ideas that the University should take to decarbonize its food system, as well as priority areas of research related to reducing food systems related greenhouse gas (GHG) emissions. The interview questionnaire is included at the end of the appendix. Below are key ideas that emerged multiple times across the different expert interviews:

1) Reduce red meat consumption.
Nearly all experts we interviewed voiced the prioritization of reducing red meat consumption at U-M, followed by other meat and dairy due to the high GHG emissions associated with these foods. Some experts spoke from their own research expertise, while others referenced to their teaching and student project experience. Many interviewees emphasized the need for both an institutional shift in what food was offered, such as more vegetarian options, and educational efforts to increase students' awareness of the relationship between food and carbon emissions, such as adding a sustainability component to student orientation and providing information on food's carbon footprint in the dining halls. Several other ideas were proposed to reduce red meat consumption at U-M, including labeling the carbon "cost" of meals so that students could choose low carbon options and creating a "low carbon food station" in each dining hall. Faculty and staff also said that having students adopt low-carbon food behaviors would require a "culture of sustainability" at U-M. As one expert said about the potential for culture and cultural leaders to inspire others to follow suit: "the ripple effects, more than what one person does, has the greater power."

2) Expand composting and reduce food waste.
Nearly all experts we interviewed voiced the need to expand composting and reduce food waste. Drawing from their own experience and that of students, interviewees emphasized the need to add compost bins to more locations, so that compost bins are always accessible when needed. In conjunction with increased composting efforts, interviewees said U-M should work to decrease food waste. As one expert said, "a gram of waste is wasted emissions." As with changes to food offerings, faculty and staff emphasized that increased composting and food waste prevention efforts would need to include education for students, faculty, and staff.

3) Procure sustainable foods.
Two-thirds of the experts we interviewed recommended prioritizing a handful of other sustainability considerations for food procurement (and general procurement).

Recommendations included purchasing from farms using agroecological practices that reduce GHG emissions and reliance on fossil fuels, such as those limiting nitrogen fertilizer use. Other considerations for sustainable food procurement included prioritizing fair trade food, food using ethical and humane practices, organic food, and local food (to support the local economy).

4) Create an experiential learning environment for students.
About half of the experts recommended investing in and supporting a living-learning experience for students, such as hands-on learning at the U-M Campus Farm, running experiments in the dining halls, and launching a food hub (i.e., learning lab) for students. Support in the form of faculty grants, seminars, and increased student grants would further support sustainable food experiential learning. Faculty voiced the need for a living-learning hub or space for students to connect, learn, and explore food systems innovations, as well as for creating a community of environmentally conscious thinkers and eaters. They noted how food is something that every student interacts with daily, and that what they learn about food will be useful throughout their lives. As one faculty member said, “There is no better commodity than food to educate students and create a culture around sustainability. Everyone eats and we eat for the rest of our lives [...] what students learn here they will keep for the rest of their lives.”

5) Incorporate low-carbon purchasing into food procurement guidelines.
About two-thirds of experts recommended changing food procurement guidelines to ensure low-carbon purchasing. They discussed changing contract language for food providers, as well as purchasing or catering guidelines for different offices and academic units within the University. Within that recommendation, half of the interviewees recommended leveraging the University’s bargaining power in demanding more sustainable thresholds, such as GHG reporting or documented food waste reduction measures from our food providers and contractors. Experts suggested that such an action requires moral leadership from the University and a return to its social contract with the community. One expert said, “We have a special social contract to look beyond the current food system and [local] delivery problem.” They expressed that the University should “be a thought leader on this - pushing these ideas, not standing in the way,” following that they should be demanding and expecting sustainable food benchmarks for its partners.

6) Expand food systems research at U-M.
In response to what types of research U-M should invest in, faculty and staff focused on both production-level research and consumer-level research. Several faculty and staff suggested that U-M should harness the research capacity and intellect of faculty and students to further innovation in sustainable food systems. Several faculty noted that, because U-M is not a land-grant university, it is not beholden to constraints in food research and could, therefore, push the limits of this field. As one faculty noted, unlike other industries, food is “still in the dark ages,” which presents an opportunity for U-M to be at the “leading edge of [food systems research].” Several faculty and staff emphasized the need to integrate undergraduate and graduate student projects/theses, and courses projects, into applied food- and dining-related research at U-M. Faculty and staff also noted the need for more research on what motivates U-M students’ food choices in order to better understand how to shift their dietary behavior toward more carbon-friendly diets.

Interview questions

1. What are some actionable ideas that you think the University of Michigan could conceivably do, drawing from your broader research and expertise related to [research domain; e.g., agroecology, fish ecology, climate change]?
2. Are you involved in other conversations about climate action at the University of Michigan? What are some of the key ideas you've generated in that group that you think our food-focused team should be considering?
3. Do you have any other ideas to share with our team?
4. Are there other faculty we might speak with who work in food systems and climate change?
5. What types of research would you want U-M to incentivize and invest in (e.g., campus farm) to further U-M's understanding of food systems and climate change?

Appendix G: Dietary behavior change literature review

Authored by the PCCN Food Internal Analysis Team

We conducted a literature review of research evaluating strategies and interventions to promote dietary behavior change toward consumption of lower-carbon emission diets. We searched for studies that aimed to reduce animal-source food consumption and/or increase plant-based food consumption. We focused this review on studies of students within college/university settings, but also included reviews written on the topic of sustainable dietary behavior change which included other demographic populations and dining settings. We also drew from literature that examines how to promote healthy eating behavior for several reasons, including: 1) there is a greater breadth of literature on this topic; 2) healthy eating goals often align with lower-carbon diets (e.g., increasing intake of fruits and vegetables; reducing intake of red meat); and, 3) these interventions likely target similar aspects of human dietary decision-making behavior.

Increasing awareness of the links between dietary choice and environmental impacts
Student awareness of the linkages between diet, especially meat consumption, and the environment are generally poor. In a survey of undergraduate students eating at campus dining halls, less than 10% of students thought that meat consumption or vegetarianism could benefit the environment.[120] Among freshman undergraduates, few students stated that environmental issues were an important factor in their personal food choices, and when asked about environmental aspects most focused on organic and local food, but not meat-avoidance[121]. Among the general population, there is also a limited knowledge of the environmental impacts of meat, though awareness is increasing, as are trends toward plant-based diets and plant-based meat alternatives.[122]

Given that knowledge may be a barrier to making carbon-reducing diet shifts, studies on college/university students have looked at how increased awareness of the links between dietary choices and environmental impacts change dietary behavior. In an experimental five-week online course on “green eating” behaviors, which included replacing meat with plant-based foods, undergraduates who took the course had a greater knowledge of “green eating,” were more likely to have intentions to act on the behaviors, and slightly increased their frequency of those behaviors, than students who did not take the course.[123] Jay et al. conducted a study of a year-long environmental science course for freshman taught through the lens of food systems compared to a similar course that did not focus on food systems at the University of California Los Angeles.[124] After six months, students in the food systems course had a significantly lower overall dietary carbon footprint and consumed one less serving of beef per week than students in the control course. Professors teaching a “Food and Society” undergraduate course at Stanford University have similarly found that students shift their dietary behavior toward more plant-based and sustainable diets, along with also having stronger beliefs about the importance of environmental sustainability, after a semester-long course focused on the societal and environmental impacts, rather than health impacts, of food.[125] Whether these educational courses can change behavior over the long term is unclear. A review of health-focused dietary interventions among college/university students found that while educational interventions improved the healthiness of student diets immediately following the intervention, such changes were not maintained after a period of 3 to 6 months.[126]

Another type of educational intervention is labeling, either with basic facts or color-coded signals. Brunner et al. examined the impact of a labeling scheme with traffic light color-codes of different carbon dioxide emission categories for meals in a university restaurant.[127] Students and staff modestly increased their purchase of environmentally friendly dishes and decreased purchase of non-environmentally dishes. However, when meat dishes (e.g., poultry) were labeled green (low carbon emissions), sales of meat dishes increased by 11.5%. During the overall study period, there was nevertheless a modest 3.6% reduction in overall emissions from food purchases. In a review of studies examining interventions targeting unhealthy behavior, Bauer and Reisch found that labels which are simple and directive, like color-coded schemes, are generally more effective at influencing behavior than simply providing information.[128] Reviews[129] conducted across several population groups conclude that while education and increased awareness, such as through labeling, may increase the intention to undertake a sustainable dietary behavior, it often does not lead to an actual or sustained reduction in meat consumption or increase plant food intake.

Changes to choice architecture

There are a number of reasons why people may choose to consume diets that are dissonant with their awareness of the environmental consequences of consuming carbon-intensive foods such as meat. Studies on the general population demonstrate that the reasons for this dissonance include individual factors such as prioritizing taste, habits, cost, convenience, health, and values; social factors such as cultural norms and social identity; and, environmental factors such as the food environment.[130] Because people are more likely to make dietary decisions based on habit or convenience, rather than health or environmental issues, an entire body of literature examines how the food environment influences dietary behavior. These studies look at how "nudges" at the point of purchase/choice can promote specific dietary choices that align with positive dietary behaviors. These studies find that changes to the microenvironment or choice architecture—the way in which food choices are presented—are more effective than acting on peoples' internal motivations to eat sustainably.[131] Nudges are small changes to the choice architecture that act on people's behavior but do not preclude choice.[132] Park writes, "By definition, nudges aim to be liberty-preserving, exerting soft influence to encourage sustainable choices, without precluding freedom of choice" (p. 23).[133] College/university students report that, in addition to being influenced by individual factors like taste and convenience, the university food environment and culture has a particularly salient influence on their eating behavior.[134] Thus, changes to the choice architecture of dining services may be particularly useful in shifting diets of college/university students.

Several studies have investigated the impact of nudges aimed at reducing meat consumption in college and university settings. In a study of students and staff dining at a college cafeteria, serving more vegetarian meals at lunch-time resulted in a greater number of vegetarian meal purchases.[135] The intervention did not reduce total sales nor did it shift consumer purchases of meat-based meals at dinner. In an experimental study conducted with 319 undergraduate students, students were more likely to choose a meat-free dish from a menu if it was the default option.[136] Providing additional information about the environmental benefits of reducing meat consumption did not influence students to choose the meat-free option. However, the appeal of the meat-free dish was associated with choosing the meat-free option. The importance of having "appealing" plant-based dishes has been shown in other studies of university students as well. In work done at the University of California, Davis, Spencer et al. emphasize the importance of flavor in "flipped" dishes (the "Protein Flip," part of Menus of Change, partially replaces meat with legumes and vegetables) and identifying dishes that consumers more

readily associate as plant-based.[137] For example, in a study testing the acceptance of increasing the proportion of legumes and decreasing the proportion of meat in dishes, students were accepting of both the high-meat/low-legume and high-legume/low-meat version of Tikka Masala, a popular Indian dish, but not of the high-legume version of Pork Carnitas Arepas, a Latin American dish.[138] The authors hypothesized that because Indian food is often high in legumes, students were more accepting of meat reductions in that dish. In an experimental study comparing the acceptance of three types of burrito bowls (high-meat with mild flavor, low-meat with mild flavor, and low-meat with spicy flavor), students stated they would be equally likely to choose any of the options at a dining hall.[139] Among many demographic populations, reviews have found that, of the many ways to change choice architecture, the most effective strategies for reducing meat consumption through nudges are providing more plant-based and meatless alternatives, making plant-based/meatless items the default option, manipulating the sensory properties of meatless alternatives, and reducing the portion size of meat servings.[140]

As educational institutions that serve students, staff, and faculty, universities and colleges have a unique opportunity to reduce greenhouse gas emissions from food. Evidence suggests that education, combined with small, often inconspicuous changes to the food environment can have a significant impact on peoples' dietary behavior and in turn reduce the carbon-impact of our daily food choices.

Appendix H: U-M food service locations and expenditures

Authored by the PCCN Food Internal Analysis Team

The U-M food system is a decentralized network. The Ann Arbor campus has separate food services through Michigan Athletics, MDining, Michigan Medicine (which has two systems, one focused on retail for staff and visitors, and one focused on patients), the Ross School of Business, University Unions (e.g., Michigan League, Pierpont), the North Campus Research Center, the U-M Law School and AVI Food Systems Inc. (which services coffee for departments), and Continental Canteen (which manages vending and micro-markets). The UM-Flint and UM-Dearborn campuses each have their own food services as well. Some are self-operated (MDining and Michigan Medicine Patient Food and Nutrition Services) while most are contracted to external operators (Picasso, Aramark and Sodexo), and all manage their own budget. The University, through Procurement Services, has also established strategic contracts with over 40 restaurants and caterers which departments and schools are encouraged to use for catered events.

This appendix describes the locations and configurations of each of these operators, as well as their FY2019 overall food spend. We collected food spend data in order to calculate the share that each of these food operators makes up of the entire U-M food service system, in order to estimate food-related emissions for all of U-M based on the percentage of food expenditures represented by MDining's residential dining halls (28.6%), as noted in Appendix B. This is not implying that we are capturing "U-M's" food expenditures, per se, since no food operator depends on U-M's General Fund, but rather, it is an attempt to determine the GHG emissions associated with any food provided to or consumed by the U-M population—other than food brought from home or off-site restaurants. Our research on U-M's food operators captures the majority of locations and food spend within the U-M food system (both self-operated and contract operations) but acknowledges that some information may become outdated even before publication given the size and complexity of the system.

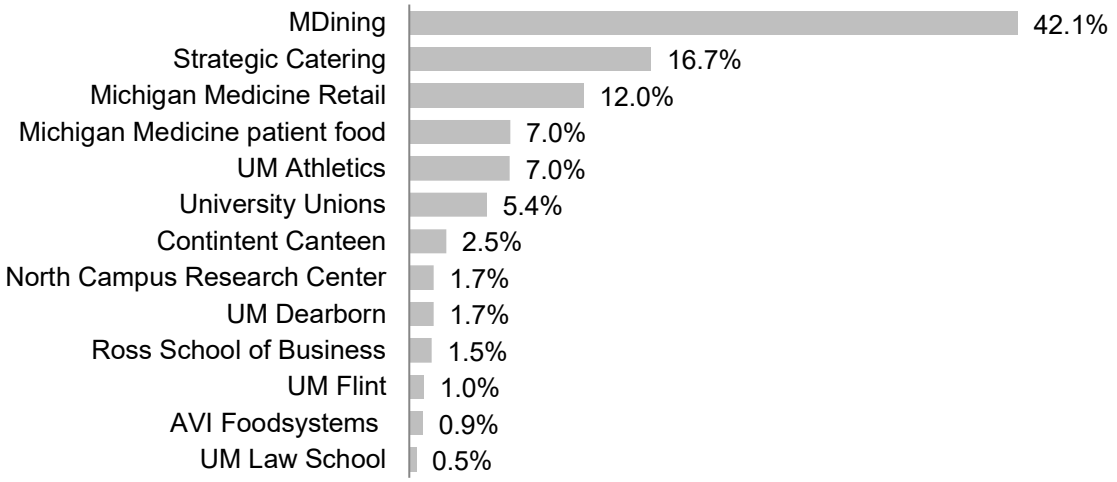
Methodology

Information on annual food spending and the locations and facilities of food operators across all three campuses was collected through an initial website search as well as interviews with representatives from Michigan Athletics, MDining, Michigan Medicine, the Ross School of Business, University Unions, Procurement, and Picasso Restaurant Group. These representatives include executive chefs, directors, procurement agents, program managers, and general managers. All units except for University Unions were able to provide complete FY2019 food spend data. University Unions contracts to a number of companies, which complicates the collection of food spend data; we instead estimated food spend based on FY2019 sales information. Additionally, Michigan Union has been closed for renovation, so we utilized FY2017 sales data in the University Unions estimate. We estimated food spend for vendors in the University Unions (other than MDining operations) to be 30% of sales revenue based on industry standards found online and confirmed by MDining staff.[141] We were also given FY2019 sales data for the AVI, the strategic caterers and Continental Canteen; again, we estimated spend data to be 30% of sales for these food operators. This is not a perfect estimate but allows us to make comparisons between all of the food operators across the three campuses.

Findings

As Figure 1 shows, MDining makes up the largest share of all food expenditures across U-M's three campuses, or 42% of all expenditures. Strategic catering makes up approximately one sixth of all expenditures (16.7%). Combined, Michigan Medicine is 19% of all expenditures, made up primarily of its Retail operations (12%). UM-Flint and UM-Dearborn each make up less than 2% of the entire system, while other units comprise between 0.5% to 7% of all expenditures. Details behind each of these numbers and the particular configurations of each operation are explained below.

Figure G1. U-M food operators by share of overall food spend FY2019



MDining

MDining makes up 42% of annual food expenditures across U-M's three campuses. MDining is exclusively located on the Ann Arbor campus, is self-operated, and is divided into three categories: Residential, Retail, and Catering. Residential dining refers to the student cafeterias and certain shops located within dormitory buildings. Retail refers to the cafes and shops operated by MDining throughout the rest of campus. Lastly, Catering is MDining's self-operated catering service. These categories respectively make up 28.6%, 10.3%, and 3.2% of annual food expenditures. MDining has 9 dining halls, 22 cafes and retail locations, and 5 catering kitchens. Six of their cafes and retail locations are within University Unions buildings but are operated by MDining. Because MDining is purchasing the food for these locations, they are accounted for under MDining rather than University Unions. Gordon Food Service is their prime vendor for all MDining operations.

Michigan Medicine

Michigan Medicine operates on the Ann Arbor campus and accounts for 19.0% of annual food expenditures across U-M's three campuses. This includes one sight outside of the Ann Arbor campus—a cafe within the Brighton Center for Specialty Care in Brighton, MI. Michigan Medicine is divided into two categories: Retail and Patient Food and Nutrition Services (PFANS). Within Michigan Medicine, Retail refers to the cafeterias, cafes and shops available to the public and staff. PFANS refers to the internal food service provided to patients. These two categories are respectively 12.1% and 7.0% of annual food expenditures. PFANS is self-

operated, purchases primarily from Gordon Food Service and operates within four buildings. Michigan Medicine Retail runs 12 cafes and shops, along with a catering service, all of which is contracted to both Picasso Restaurant Group and Aramark. Five locations are operated by Picasso Restaurant Group and 7 locations are operated by Aramark.

Michigan Athletics
Michigan Athletics operates on the Ann Arbor campus, accounting for 7% of annual food expenditures, and is divided into Concessions and Catering. Concessions is the food available to fans during sporting events, covering 10 locations including the Big House, the Crisler Center, and Yost Ice Arena. Catering supplies special events and training tables (food provided to athletes during training sessions). Michigan Athletics is contracted to Sodexo, which uses Gordon Food Service as its prime vendor. Athletics Concessions accounts for 2.5% of annual food expenditures while Catering makes up 4.5%. A single kitchen prepares food for both Concessions and Catering.

University Unions
The University Unions manages four buildings on the Ann Arbor campus: Michigan Union, Pierpont Commons, Michigan League, and Palmer Commons. The University Unions contracts with 8 different restaurants. As noted above, MDining also operates some retail outlets in the University Unions buildings, but these are not managed by University Unions itself. The University Unions accounts for 5.4% of annual food expenditures.

UM-Dearborn Campus
The UM-Dearborn campus is operated by Picasso Restaurant Group and accounts for 1.7% of annual food expenditures across the three campuses. UM-Dearborn has 3 cafes and a Starbucks.

North Campus Research Center
The North Campus Research Center (NCRC) is located on the Ann Arbor campus. NCRC is operated by Picasso Restaurant Group and accounts for 1.7% of annual expenditures. NCRC has 3 restaurants and a guest location. The guest location rotates between different local restaurants that operate for one day each week.

Ross School of Business
The Ross Business School is located on the Ann Arbor campus and makes up 1.6% of annual expenditures. Three operations fall under Ross, including: Retail (which operates three cafes), Catering, and a restaurant run under Executive Residential Dining, all contracted to Aramark. Within Ross, Retail refers to the cafes and coffee shops in the academic buildings. Catering is the catering service operated by Aramark. Executive Residential Dining is the buffet style restaurant available to faculty, students, and Executive Learning and Conference Center guests. These categories respectively make up 0.5%, 0.4%, and 0.7% of U-M's annual food expenditures.

UM-Flint Campus
The UM-Flint campus is also operated by Picasso Restaurant Group and accounts for 1.0% of annual expenditures. UM-Flint has 8 cafés and restaurants.

U-M Law School
Located on the Ann Arbor campus, the U-M Law School has the Kirkland & Ellis Café that is operated by Picasso Restaurant Group. This single location makes up 0.5% of annual expenditures.

Strategic Catering
Operated through Procurement, Strategic Catering is a list of 47 approved Ann Arbor restaurants and caterers that departments on the Ann Arbor campus can contract to cater U-M events. We estimated that expenditures on strategic catering is 16.7% of annual food expenditures.

Miscellaneous
Two additional categories include Continental Vending, which operates the vending machines and ready-made food available at various locations on the Ann Arbor campus (2.5% of annual expenditures) and AVI Food Systems, which provides coffee in departmental staff kitchens (0.9%).

Appendix I: Themes from town halls

Authored by the PCCN Food Internal Analysis Team

This report summarizes the outcomes of three[142] town halls held in 2020 between February 5 and March 9 by the University of Michigan (U-M) President's Commission on Carbon Neutrality (PCCN) Food Internal Analysis Team on the UM-Ann Arbor campus, the UM-Dearborn campus, and at the Washtenaw Local Food Summit. In total, 82 people participated in the three town halls, including 34 students, 9 staff, 3 faculty and 36 community residents from Washtenaw County (Table I1). Participants generated diverse ideas about what U-M could do to reduce greenhouse gas emissions—and other ways to address sustainability—through food-related actions. The most common actions they proposed focused on interventions that could be taken in the dining halls and through external food vendors as well as education and awareness-building campaigns focused on reducing meat consumption, promoting plant-forward diets, addressing food waste, and expanding composting. Though participants focused less on the barriers to accomplishing these changes, they raised issues about the lack of awareness and the need to consider how to make these actions affordable.

Table I1. Participants in each town hall

	Ann Arbor	UM-Dearborn	Local Food Summit	TOTAL
TOTAL participants	**29**	**11**	**42**	**82**
U-M Students	28*	3	3	34
U-M Staff	1	5	3	9
U-M Faculty	0	3	0	3
Non-U-M community residents	0	0	36	36

* This included 17 graduate and 11 undergraduate students, a third from SEAS (10; 34%), four (14%) from Taubman College, and 3 (10%) from the School of Public Health. Nearly half (13; 46%) did not specify an academic home, but many (8) participate in UMSFP.

Methods and participants

At each town hall, PCCN members first offered a short presentation about the PCCN's charge and the activities and emerging recommendations of the Food Analysis Team. Participants were then asked to move about the room to write or discuss their feedback with Food Analysis Team members related to four topics: a) their overall rating of how well U-M is doing on food-focused actions to reduce greenhouse gas emissions, and the actions and potential barriers U-M should consider related to a) food procurement, b) food waste, and c) other topics. Participants could either write a sticky note to express their ideas or feedback or add a dot sicker to a sticky note someone else already wrote to indicate that they agreed with that idea. Because no limit was placed on the number of sticky notes and dot stickers participants could use, in the findings displayed below, common ideas were grouped together and the total number of "votes" were tallied (all sticky notes + dot stickers on those notes), so that votes often exceed the number of participants.

The types of participants who attended (Table I1) reflects the different stakeholders who were targeted for each town hall. The Ann Arbor town hall was advertised for students, since we engaged staff and faculty through other means (interviews and meetings); the UM-Dearborn town hall was held in conjunction with the PCCN Campus Culture and Communication team and was advertised for staff, faculty and students since we had fewer opportunities to engage staff

and faculty on this campus; and the Local Food Summit town hall was held in conjunction with the Ann Arbor carbon neutrality initiative (A2Zero), and was open to anyone attending the Summit which tends to draw Washtenaw County residents who work for food-related non-profits and local growers.

Rating exercise

For our U-M rating exercise, we posted a 10-foot piece of butcher paper running the length of one wall and wrote at the top: *"How well do you think the University of Michigan is addressing climate change through food-related actions?" Write an explanation on a sticky note and place it along the line to rate U-M from "terrible" to "amazing"* (see photo). The ratings included:

0 = Terrible! U-M is doing nothing
5 = Average. U-M is doing some things right, but could still do more
10 = Amazing! U-M is doing all it could possibly do. We're setting the standard for other institutions

As Table I2 shows, UM-Dearborn town hall participants rated U-M's actions lowest, on average 1.8, compared to an average of 4.7 by Local Food Summit participants and 4.9 by UM-Ann Arbor campus participants. The most common reasons stated for these low to mid-range scores was because participants felt U-M could do more to reduce and reuse food waste, to offer more plant-forward food options, and to provide food systems and general sustainability education in an effort to change campus culture. The specific ideas discussed in each town hall are detailed below.

Table I2. Town hall U-M rating exercise results

	UM Ann Arbor	UM Dearborn	Local Food Summit	TOTAL
Quantitative findings				
Number of sticky notes	17	11	8	36
Number of dot sticker votes	8	24	3	35
Average rating	4.9	1.8	4.7	3.8
Range	3 to 7	0 to 4.2	3 to 5.5	0 to 7
Ideas for improvement/explanations for rating				
Reduce/reuse food waste (e.g. more zero waste events, more composting, donate food)	6	9	3	18
Make procurement sustainable (e.g., more plant-forward, no fast food)	8	6	-	14
Provide food systems and sustainability education	11	2	-	13
Increase transparency around food procurement/supply chain	-	4	-	4
Start a campus sustainability office		2		
Support local sustainable efforts (e.g., local food)	1	1	-	2
EIC* community garden great, could do more but must consider costs	-	2	-	2
Incorporate "DEI and justice related action" in food initiatives	2	-	-	2
The course Food Literacy for All is great	-	-	2	2
Dining/cafes could update websites when ingredients run out	-	-	1	1

*EIC = Environmental Interpretive Center

Ann Arbor

UM-Ann Arbor town hall participants rated U-M on average 4.9 out of 10. A common explanation for this rating, which received 11 votes, was the need for more education. As some participants explained, "students need to become less indifferent to these issues," and "food literacy/action is known in niche student groups, but is not university wide." One person noted that there is a need to "demonstrate culture of sustainability from day one [by] incorporating information on waste management and sustainability on campus more into orientations (regardless of undergrad or grad level)." Another eight votes related to food procurement, focused on wanting "less meat," to "improve standards in non-MDining vendors," "eliminate fast food on campus," and to encourage U-M schools to "purchase more sustainable food choices." Six votes focused on issues of food waste, with participants expressing that they wanted more composting, "waste-free events" and compostable products on campus. Finally, two votes focused on wanting "DEI and justice related action," and one person wants to see U-M support local/state-wide sustainable efforts.

UM-Dearborn

To explain their very low rating of U-M—1.8 on average—9 votes at UM-Dearborn were associated with the amount of food participants see wasted and the lack of composting on campus, other than a small composting program at the Environmental Interpretive Center (EIC). Six votes focused on the need for more vegetarian and meatless options. Four agreed with a comment that, "Picasso lacks transparency regarding the procurement and disposal aspects of their food system. They also show a lack of interest in fixing these issues despite pushback from the campus community." Two people want a UM-Dearborn sustainability office. Two others want more education, stating how "So much more is possible. Maybe the biggest need is in the area of educating the entire campus community, and raising awareness so as to create a culture of sustainability." Two people indicated that they appreciate the community garden run by the EIC, and desire to do more but realize that UM-Dearborn is often constrained by costs. Finally, one person wanted more local food sourcing.

Local Food Summit

At the Local Food Summit, where participants rated U-M on average 4.7, three votes related to wanting the university to do more to reduce or repurpose food waste, by holding more zero waste events, connecting food insecure students and community members to food that could be donated from events on campus, and improving composting. Two people commented that the "Food Literacy for All program is great." And one person mentioned the need for university dining and cafes to update their websites when certain ingredients run out (perhaps so that local farmers could be suppliers, but the comment was unclear).

Food waste

To gather feedback about food waste we asked participants to respond to two questions*: What actions or strategies would you like the University of Michigan to implement? What barriers or challenges should we keep in mind?* As Table I3 shows, the most common actions participants suggested, were a variety of interventions to reduce food waste (36 votes), expand composting (33), educate students about food waste/compost (24), and increase compostable packaging (21). The top barrier to addressing food waste, which received 13 votes, was little awareness or education. Specific ideas related to food waste discussed in each town hall are detailed below.

Table I3. Food waste actions, strategies, and barriers

	Ann Arbor	UM Dearborn	Local Food Summit	TOTAL
Actions and strategies				
Number of sticky notes	32	7	2	41
Number of dot sticker votes	77	17	4	98
Reduce food waste (e.g., incentives to individuals, use all parts of veggies, stop unnecessary catering of small events, create competition among suppliers, etc.)	31	5	-	36
Expand composting across campus	19	14	-	33
Educate students about food waste/compost	24	-	-	24
Increase compostable packaging on campus	21	-	-	21
Utilize/buy imperfect produce	10	-	4	14
Use reusable plates, forks/spoons, cups, trays, food containers (and create drop off centers to wash/reuse); get rid of styrofoam	-	6	2	8
Track food waste in all buildings, not just dining halls	4	-	-	4
Donate food	3	-	-	3
Run a surplus store for food, clothes and supplies	3			3
Get Greek life involved in waste tracking/prevention	2	-	-	2
Implement a food biodigester	1	1	-	2
Buy/use grocery store surplus that would have been wasted		-	1	1
Unify food distribution to make implementation of interventions easier	1			1
Replace “pre-made, packaged, industrial foods” with fresh, healthy produce	1			1
Barriers and challenges				
Number of distinct ideas	7	3	1	11
Number of sticker dot votes	10	5	1	16
Little awareness/education—need culture change	11	2	-	13
Lack of transparency		6	-	6
Possible increase in meal plans if some actions implemented	4	-	-	4
Cost of recycling compostable food containers high	-	-	2	2
Constantly changing population of staff, students and faculty	1	-	-	1
City businesses don’t compost	1	-	-	1

Actions and Strategies

Ann Arbor

The idea that received the top number votes at the UM-Ann Arbor town hall, 31, was generally about reducing or preventing food waste. Some of the specific ideas included increasing the number of zero waste events (9 votes) and offering incentives to individuals to reduce food waste (6 votes), such as having students bring their own containers to events. One idea related to this that was suggested is a program implemented by McMasters University, where the university provides students with a reusable container for a $5 deposit for to-go food, offering 25 cents off each time it is used and 10 cents for the use of a reusable coffee cup.[143]

Twenty-four votes were about education. Specifically, four votes were about the need to "educate students to throw food away where it belongs"; four about holding a "listening session" about the challenges related to promoting more zero waste events and to come up with solutions; three about offering dining hall staff training on composting; three about offering students education about corporate responsibility related to food packaging; two votes for the comment "U-M maintenance should mandate correctly sorting compostables/trash/recycling inside and outside of U-M buildings," and one student who suggested that an app could be created "where students can see amount of energy used/food wasted daily per building."

Twenty-one votes were about increasing compostable packaging on campus. Specifically, nine votes were about using "the power of how large the university is to negotiate requirements for compostable supplies for all food vendors," including fast food companies. One person also suggested U-M "require compostable to-go containers for all zero waste events for leftover food."

Nineteen votes were about expanding composting across campus, including 15 votes that specified that U-M should put bins in residence halls, dining halls, the Union, restaurants, cafes, sporting events and other places; 3 votes to reduce food waste in dining kitchens, and 3 who agreed with a student who wrote "Stop making pre-made plates at dining halls so students don't have to waste things they don't want."

Ten students voted for the idea that U-M should "utilize imperfect produce" or "cycle waste fruit into smoothie/juice products." A smaller number of students[144] agreed that U-M should:

- Track food waste of U-M organizations and buildings not associated with MDining (4)
- Run a "surplus store for all food/clothes/supplies (3)
- Donate food (e.g., Food Recovery Network) (3)
- "Get Greek life involved in waste tracking/prevention" (2)
- Implement a biodigester (1)
- Unify food distribution to make implementation of interventions easier (1)
- Replace "pre-made, packaged, industrial foods (e.g., Ugos, Blue Market)" with fresh, healthy produce (1)

<u>UM-Dearborn</u>
At UM-Dearborn, the largest number of votes, 14, focused on the need for composting across campus. One idea for doing this was to update the Planet Blue Ambassador program at UM-Dearborn to promote composting. Six votes were about investing in "reusable plates, forks/spoons, cups, trays, food containers" and getting rid of styrofoam. Five votes were about reducing food waste, like by stopping "unnecessary catering at small events" or by starting a "food supplier cap-and-trade emission/waste reduction" system could be put in place for U-M businesses "to have them compete/work together." One person also though the campus could explore a biodigester.

<u>Local Food Summit</u>
Four votes at the Local Food Summit focused on utilizing and buying imperfect (or "ugly") produce. Two people liked the idea of the university using reusable to-go containers and setting up drop off centers to wash and reuse.

Barriers and Challenges

Ann Arbor

The largest number of votes UM-Ann Arbor participants noted in terms of barriers and challenges that U-M might face in trying to reduce food waste, 11 were about issues with lack of awareness, whether about where compost bins are on campus (3), student organizations not knowing what to do with leftovers (2), student groups not knowing where to get free compostable supplies or cheaper local food (2), U-M Catering not always expressing to event participants that they should take as much food as possible to reduce waste (2), or the lack of education on what is compostable (2). Four votes were associated with the increased cost for dining plans if some of these actions were implemented. One student also was concerned about the "ever changing population of staff, students, and faculty" that can make it hard to sustain efforts to reduce food waste, and the fact that city businesses don't compost.

Dearborn

The top barrier participants in the UM-Dearborn town hall focused on was the lack of transparency related to food waste and composting, voted on by 6 people, because of "No transparency on the Dearborn campus in regards to the food system employed by Picasso." Two people also believed that food waste and composting would have to be addressed through a "big public education campaign," through things like podcasts, newsletters sent to classrooms or other efforts.

Local Food Summit

The only barrier shared at the Local Food Summit, that two people agreed with, was that it's costly to recycle compostable food containers.

Procurement

To gather feedback about food waste, we asked participants to respond to the questions*: What actions or strategies would you like the University of Michigan to implement? What barriers or challenges should we keep in mind?* As Table I4 shows (next page), the top idea was to reduce meat consumption and promote more plant-based options, which received 40 votes. A large number of votes—29—also focused on educating the campus community about the importance of eating less meat. The two barriers that received the most votes were about the added concerns that dining operations have to think about if they plan to reduce meat consumption, such as flavor, appeal and the cost for consumers (9 votes), and the general lack of awareness (7 votes). Specific ideas related to food procurement discussed in each town hall are detailed below.

Table I4. Food procurement actions, strategies, and barriers

	UM Ann Arbor	UM Dearborn	Local Food Summit	TOTAL
Actions and strategies				
Number of sticky notes	22	6	10	38
Number of sticker dot votes	51	10	11	72
Reduce meat consumption and promote plant-based options	31	6	3	40
Educate about food systems and the importance of eating less meat	21	-	8	29
Offer more in-season and local food products	8	-	-	8
Source from local farms	-	4	4	8
Start a campus farm (or grow more food on campus)	1	2	3	6
Join existing campaigns (e.g., Real Food Challenge) or set minimum standards for companies the university will purchase from	4	-	-	4
Ensure food sourcing is better for farm worker justice	4	-	-	4
Source from farms using regenerative agriculture	3	-	-	3
Increase access to fresh, healthy produce	3	-	-	3
Incentivize good sustainable behaviors	-	-	3	3
Increase transparency about food procurement	-	2	-	2
Engage campus vendors in testing different practices	-	2		2
Source animal products from certified humane producers	-	-	1	1
Barriers and challenges				
Number of distinct ideas	6	3	n/a	9
Number of sticker dot votes	8	6	n/a	14
Dining has to also think about nutrition, flavor appeal, and pricing (not just sustainability)—changes must be affordable	3	6	-	9
Lack of awareness	7	-	-	7
Increasing more local food requires setting a "threshold" for what is considered "local"	3	-	-	3
Students may feel choice is taken away if meat reduced	2	-	-	2
Inflexibility of large, national vendors	-	2	-	2

Actions and Strategies

Ann Arbor

Reducing meat consumption and promoting more plant-based options received the most votes at the UM-Ann Arbor town hall. Seven votes suggested U-M should go "meat free" or shouldn't serve beef at all. Five focused on making vegan/vegetarian options more affordable (as one person said "don't charge more for non-dairy milk or veggie burgers"), and two noted that U-M should "highly tax beef products." Eight votes were about offering "more veggie/vegan options at events with food" which are clearly labeled, and five about more "dairy-free" options. Two

suggested U-M could “Find sneaky ways to get plant-based products in e.g., plant-based mayo. No one will know the difference!,” and two want to know more ways U-M could standardize Sustainable Mondays.

Many votes (21) were also about increasing food systems education. They discussed things like explaining why eating less or no meat is important from a carbon footprint standpoint (7 votes), adding a food education requirement (4), training students and offering services to support sustainable food practices as part of housing contracts (3), doing more branding and awareness building about campus and local food systems groups (2), showing where food is coming from (“For ex: Farmer Fridays - bring in local farmers that MDining is sourcing from to come table in the Dining Halls”) (2), requiring “mandatory sustainability training” for staff, if their job involves procurement (“just like PEERS for IRB”) (2) and offering training for students during orientation, (with “different modules for MDining, eating out, etc.”) (1).

Eight votes were about offering more “in-season” products and more local food from local farms and food retailers. Four votes were associated with the idea that U-M should join existing campaigns (e.g., Real Food Challenge) or set standards food procurement, such as the idea that “PCCN Food [could] rate restaurants used for catering, President says cannot use restaurant if doesn’t meet minimum threshold.” Four votes related to U-M taking this as an opportunity to ensure that U-M’s food sourcing is better for farm worker justice. Three votes were about sourcing from farms using regenerative agricultural practices, and another three about increasing access to fresh, healthy produce, whether from farmers markets on campus, the U-M Farm Stand, or a brick and mortar grocery store. Finally, one student wants to see expanded, year-round capacity to supply food from the Campus Farm.

Dearborn

At the UM-Dearborn town hall, six votes were about supplying more vegetarian options. Four votes were about more local food sourcing. And two votes each were cast for increasing transparency around food procurement, engaging campus vendors to test out different practices or starting a campus farm that can supply the school and contribute toward curricula.

Local Food Summit

The largest number of votes at the Local Food Summit, 8, focused on ways education and awareness could be facilitated on campus to promote more plant-forward consumption and other sustainable behaviors. Some thought physical signage and other messaging—developed with students—could be promoted at events as to why plants are preferred over meat and dairy. On the other hand, one person expressed “I agree with the idea of making sustainable initiatives immediately normal as ‘business as usual’ versus making a big deal about something being new/sustainable. Let’s make it normal.” Four votes focused on the university sourcing more local and seasonal foods. As one participant asked, “How much of a plant forward [menu] can be local and organic/ regenerative sourcing?” Another person also thought that the university could increase “Efforts at procurement of local food specifically from farmers of different racial, ethnic, and cultural backgrounds as a means of supporting diversification of farmers and crops.”

Three votes were related to a variety of reasons that more plant-forward menus and reductions in animal products was beneficial. Participants wrote about the need to prevent the collapse of worldwide fisheries, reduce the need for refrigeration, address environmental justice issues connected to CAFOs and other environmental impacts that go beyond GHGE, and lower GHGE emitted from the use of fertilizers on feed crops. Three votes were about strategies for

incentivizing good sustainable choices as opposed to banning bad choices. Another three people think the university could "incorporate agriculture into U-M landscaping," and one person wants to see the university sourcing animal products from certified humane producers.

Barriers and Challenges

Ann Arbor
Challenges raised by UM-Ann Arbor town hall participants included the lack of awareness (7 votes), or how "not everyone on campus is educated or cares about issues with the food system." Three votes associated with increasing local food purchases indicated that it will be a challenge to identify a "threshold" for "local" sourcing. Three votes agreed with the commented: "Dining options need nutrition and flavor appeal and realistic pricing - not just sustainability." Finally, two votes related to "Students thinking their rights are being taken away if meat options are reduced."

Dearborn
At UM-Dearborn, the major barrier discussed was that any changes made to procurement have to be affordable (6 votes). Two people also worry that large, national vendors are too inflexible to make changes.

Local Food Summit
No participants at the Local Food Summit discussed barriers the university should consider for implementing various ideas.

Other ideas not direction related to food
A small number of other ideas not related to food systems were also collected during each town hall. As Table 5 shows, two votes at UM-Dearborn and three votes at the Local Food Summit were about banning single use plastics, including plastic bags, on campus. At UM-Dearborn, five votes were about the need for expanded and more efficient recycling. One person explained that contamination in single stream recycling is causing many recyclers to reject recycling and send it to the waste stream, at a cost to the university. Another three votes at UM-Dearborn were to stop the selling, promotion and provision of bottled water on campus. Finally, one person at the UM-Ann Arbor town hall wants to get glass recycling on campus.

Table I5. Other ideas not directly related to food

	UM Ann Arbor	UM Dearborn	Local Food Summit	TOTAL
Number of distinct ideas	1	5	1	7
Number of sticker dot votes	1	5	2	8
Ban single use plastics and plastic bags on campus	-	2	3	5
Expand and improve recycling	-	5	-	5
Stop selling, promoting, providing bottled water	-	3	-	3
Get glass recycling on campus	1	-	-	-

Appendix J: U-M procurement and decarbonization goals

Authored by the PCCN Food Internal Analysis Team

As we outline in the main body of our report, the first priority when considering procurement should be to reduce waste all together—whether landfill, compostable or recyclable waste. This goal was repeated by stakeholders we spoke to at U-M and at leading institutions who discussed the need to offer incentives, cost-sharing and infrastructure to prioritize reusable products (e.g., converting to-go operations into dine-in operations) and reduce single-use plastics. This waste reduction goal notwithstanding, another consistent message that emerged from our interviews is the need to make the low-carbon option the easiest and preferred option when it comes to institutional procurement. This is true not only as it relates to food, but also applies to the environmental impacts of procurement of non-food items, such as packaging materials, building furniture and office supplies. U-M stakeholders also expressed a need for standardized data sharing across U-M's various vendors and external contractors to allow for more reliable, efficient, and comparable data tracking going forward. Underlying these desired changes is also a need to ensure that U-M's definition of sustainability focuses on decarbonization, and an opportunity that U-M stakeholders expressed for leveraging the University's bargaining power in demanding more sustainable thresholds from outside contractors and suppliers. Many of these ideas are not new, having been proposed by the 2015 President's Committee on the Culture of Sustainability which only emphasizes the need to finally follow-through.

The following recommendations pertain to food-related procurement and data tracking suggestions for RFPs and contracts, suggestions for refining U-M's definition of sustainable food, and strategies for increasing a commitment to low-carbon purchasing in the broader procurement process across the three campuses.

Refining U-M's definition of "sustainable food" toward the goal of decarbonization
To de-carbonize the food system, U-M should reconsider its definition of what is considered "sustainable" such that it accounts for greenhouse gas emissions. Specific to food procurement, current U-M guidelines aim to increase sourcing of "sustainable food" to 20% through coordination with strategic suppliers and other vendors.[145] A food purchase qualifies as sustainable if the food is local (grown or processed in the state of Michigan or within 250 miles of Ann Arbor Campus) or has a third-party sustainable certification (e.g., USDA Organic, Food Alliance Certified Sustainable, Rainforest Alliance Certified, Certified Humanely Raised and Handled, Fair Trade Certified, etc.). Local and third-party certified foods are worthwhile targets that U-M can and should still support to accomplish a variety of goals (e.g., building local economies, enhancing biodiversity, supporting fair labor conditions, etc.), but we suggest that such goals be separated from the goal of decarbonization. As such, we recommend that U-M establish a food decarbonization goal that prioritizes low-carbon foods (e.g., plant-based proteins).

Moving toward a decarbonization goal aligns with recent changes AASHE made to their STARS tracking system, which the University of Michigan uses to measure its sustainability progress. STARS no longer rewards points for food procured based on the point of origin, but on whether food and beverage products are sustainably or ethically produced and/or plant-based.[146] AASHE reports and our interviews with dining and sustainability offices at other universities and

at U-M have all expressed that traceability and verifying the point of origin of food items is challenging, particularly for processed foods that blend items from diverse locations. Many food providers simply do not have the capacity, even when they desire to comply. Tracking the carbon footprint of food items, therefore, should simplify tracking and compliance. We recommend that a carbon emission goal related to food procurement be tracked annually, based on the type of data we outline in the final section of this report.

Prioritize a decarbonization goal in RFPs

We recommend that all requests for proposals (RFPs) require that suppliers demonstrate how they conform to U-M's goal for decarbonization. As some U-M staff suggested, language pertaining to any aspect of sustainability, let alone decarbonization, currently appears to be optional. To signal to suppliers the importance of understanding the carbon emissions of practices and products, we recommend that all calls for bids require bidders to:

1) demonstrate their commitment to the university's goal for decarbonization, based on the goals that are refined/established as a result of PCCN recommendations,
2) verify their ability to provide items that meet U-M certification standards for decarbonization,
3) offer examples of reporting on the life cycle carbon emissions of products, and
4) show how they attempt to reduce carbon emissions from transport, packaging and service of foods
5) Furthermore, information about preferences for and options related to the carbon footprint of products should be clear in online information for suppliers such as on the supplier basics webpage.

Award contracts based on a decarbonization goal

To ensure that external suppliers and food operators comply with U-M's decarbonization goal, we suggest the following steps as a contract is being awarded and negotiated:

1) Develop and implement a clear and measurable method for weighting carbon emissions as a priority in the decision-making process. Clearly indicate to bidders that the ability to respond to requirements related to tracking and minimizing carbon emissions will impact scoring.
2) Require vendors to provide a list of food and other products which will be internally verified to meet U-M's goal for decarbonization. Prioritize contract pricing for low-carbon options, at least for the most common and most impactful product options.
3) Engage the Office of Campus Sustainability—and/or an internally hired Procurement Sustainability Manager—when potential contracts are narrowed to finalists to evaluate the ways the vendor selection will impact U-M's goal for decarbonization.

Make the low-carbon option the easiest and preferred option in ordering systems

As peer institutions have suggested, simply establishing language in contracts is not often sufficient, particularly because product catalogues regularly change and because staff at the institution are usually selecting the products they will purchase from an external vendor. This requires ongoing oversight, product selection guidance and accountability practices that all orient toward low-carbon products. At U-M, we recommend this include:

1) Holding vendors accountable to their decarbonization claims. For example, require quarterly reporting on product sales as it relates to U-M's goal for decarbonization.

2) Creating product lists in the M-marketsite purchasing portal that clearly mark and make low-carbon products the default option. This could be accomplished by using a simple coding system, and/or placing low-carbon options first on various product lists. U-M-wide staff training about new features and best practices would also be necessary.
3) Formalizing a role for the Office of Campus Sustainability, M-LIST—and/or an internally hired Procurement Sustainability Manager—in vetting claims about carbon emissions before new products are added to verify U-M decarbonization standards are met.

Incorporate food-related data needs

We also suggest a system to track the carbon footprint of food procurement across all three campuses. To do so, we recommend that all vendors submit detailed food item purchase lists for an entire year (including cost and weight). This will allow dedicated staff (e.g., Procurement Sustainability Manager, Office of Campus Sustainability staff or other U-M staff) to label the life cycle greenhouse gas emissions of each item using a comprehensive food life cycle assessment database such as that currently used by MDining and used in the PCCN Food Analysis Team's analysis.[147] These data would allow staff to consider the cost and carbon footprint implications of increasing or decreasing particular items on their menus, such as the implications of replacing one protein for another. Such data could also be used to track the university's food-related greenhouse gas emissions annually. This type of data labeling would require a modest up-front investment of time and resources, but the database resulting from this work would be easily updated on an annual basis as items on procurement lists shift incrementally. MDining has in fact nearly completed labeling all of food items they procure, so much of the work has already been completed.

We are aware that some external contractors, particularly if asked to amend a contract or with limited notice (as was the case for this PCCN work), might only be able to provide information about total spending and pounds of food purchased by particular categories (e.g., beef, poultry, produce, dairy, etc.). Such reporting does not allow the identification items with the greatest carbon impact or for modeling substitution scenarios. Going forward, we recommend that the university begin to negotiate with current vendors to determine if detailed item purchase lists can be provided, and as new contracts are established, prioritize vendors that can provide such lists so that GHGEs can be adequately tracked.

Transitioning to self-operation

We further recommend that the University consider investing the up-front capital needed to support efforts of more food providers to become self-operated (as MDining and Michigan Medicine's Patient Food and Nutrition Services already are). The inherent autonomy and flexibility of such operations will almost certainly allow additional units (e.g., Ross School of Business, U-M Athletics, Michigan Medicine Retail Food Services, UM-Dearborn and UM-Flint) to more easily experiment with new menus, engage with new University culinary staff and cultural changes, and establish carbon tracking systems for food procurement and food waste.

Appendix K: Considerations for a potential biodigester

Authored by the PCCN Food Internal Analysis Team

While considering how to handle food waste at University of Michigan (U-M), biodigestion offers a potential diversion option. Biodigesters have been implemented by 21% of the universities in our national scan (Appendix D) and they rank higher than composting in the EPA Food Recovery Hierarchy[148] for their GHG emissions reduction potential. The idea was also raised in our town halls and it has generated interest in past U-M food systems and waste management strategic plans.[149] While some biodigesters appear to be cost-effective ways of both generating energy and reducing emissions, our quick scan of two local feasibility studies—one conducted on U-M by a Dow Sustainability Fellows project in 2016 and another for the City of Ann Arbor in 2017—we are not confident at this time in recommending biodigestion as a key decarbonization strategy. A more thorough examination would be needed to make a definitive conclusion, including investigations of more appropriately sized systems that can also turn methane into energy, such as the Grind2Energy model,[150] but we hope the research we gathered here serves as the basis of future study.

Also known as anaerobic digestion, the process of biodigestion places organic waste into sealed, oxygen free tanks, to be broken down by bacteria. Biodigestion generates methane rich gas that can be compressed for use in CNG (compressed natural gas) vehicles or purified and burned for heat or electricity. The nutrient-rich residual material from biodigesters is also typically used as a fertilizer, which can be used on landscaping or agricultural fields.[151]

Michigan State University (MSU) serves as a case study of a viable system, based on their South Campus Anaerobic Digester. This $5 million investment serves as a regional facility and produces 2.8 million kWh of electricity per year.[152] In addition to its 400 kW electricity capacity,[153] this facility can produce 450 kW of heat.[154] MSU's facility is expected to pay for itself in 18 years.[155] The South Campus Anaerobic Digester collects campus food waste and manure from MSU's dairy facilities, as well as organic waste from local restaurants and the Meijer Distribution Center.[156] However, when considered for implementation at the scale U-M operates, compared to an estimated 17,000 tons of food scrap and manure feedstock used in MSU's biodigester,[157] U-M produces approximately one-tenth the amount of food waste, presenting a considerable scaling challenge if U-M were to pursue a biodigester. Furthermore, if U-M were able to achieve a similar food waste tonnage through partnership with regional facilities, a biodigester would provide only 0.4% of the UM-Ann Arbor Campus' electricity needs.

The 2016 Dow Sustainability Fellows feasibility study also suggested that a biodigester may not be feasible for U-M's scale of waste production.[158] If a U-M-scaled system were possible, they estimated carbon emissions reductions of up to 3,800 metric tons of CO_2 equivalents per year, but concluded that in only some cases would an electricity producing digester be cost effective, while a compressed gas producing digester would likely be cost effective over 10 years. The authors of the study also found that because a U-M specific digester would be much smaller than the regional digester at MSU, it would not be able to overcome the high cost of purification that is essential for electricity production and natural gas pipelines. Capital costs were estimated to be between $1.3 million and $2 million. They also noted additional challenges, including: 1) that U-M's bus fleet does not have any vehicles that can utilize compressed natural gas (CNG) from the biodigester nor a CNG conversion facility; 2) though unlikely, the residual waste from

the biodigester may still need to be composted or landfilled if the residual is not of fertilizer quality; and, 3) currently there is no clear, suitable site for construction of an on-campus biodigester.

Another relevant study that suggests a biodigester may not yet be feasible for U-M is a study commissioned by the City of Ann Arbor in 2017. The study considered the feasibility of a biodigester to address the sludge generated by the wastewater treatment plant. It modeled a biodigester that would use food waste, grease, and oil from the City in the feedstock. The study found that the facility, requiring an investment of $27 million, would not fund itself in either electricity generation or biomethane scenarios.[159] The authors cited low landfill tipping fees in Michigan and electricity prices, along with high capital costs as the primary barriers. Furthermore, in its "Living Carbon Neutrality Plan," released in March 2020, Ann Arbor does not include a biodigester as part of its waste management plan.[160]

While the MSU example raises interesting possibilities for emissions reduction and energy production through biodigestion, both the Dow Fellows and City of Ann Arbor feasibility studies suggest that a biodigester is not a viable option for U-M, at least at the scale that these systems were considering. As we indicate, however, a full study of biodigesters is beyond the scope of our work, and warrants closer scrutiny.

Appendix L: Team biographies

TEAM CO-LEADS

Lesli Hoey
Lesli Hoey is an Associate Professor of Urban and Regional Planning. She uses food systems as a lens to study the socio-political and institutional factors that mediate the ability of communities and professional planners to achieve a more equitable, sustainable and healthy society. She is particularly interested in the intersection of policy advocacy, planning, implementation, and evaluation. Her current projects examine collaborative initiatives aiming to improve healthy food access and local food economies in Michigan; factors influencing the persistence of undernutrition alongside the rise in diet-related chronic disease in rapidly urbanizing Bolivian cities; and strategies for operationalizing sustainable diets in Kenya and Vietnam. Lesli earned a PhD and master's in city and regional planning from Cornell University and a BA in psychology from Earlham College.

Andy Jones
Andy Jones is a public health nutritionist interested in understanding how food systems influence climate change and healthy diets. He has led numerous research initiatives throughout Sub-Saharan Africa, Latin America, and South Asia. Andy is currently Associate Professor of Nutritional Sciences in the School of Public Health at the University of Michigan. He has worked as a consultant for several institutions including the World Bank, the Chicago Council on Global Affairs, the Global Alliance for Improved Nutrition, and UNICEF. He received his PhD in Nutritional Sciences from Cornell University, and holds BA degrees from the Pennsylvania State University in Geography and Film.

STUDENT TEAM

Caroline Baloga
Caroline Baloga is a senior undergraduate student majoring in Program in the Environment and International Studies and minoring in Art and Design. She is interested in sustainable food systems and international foodways. She is a Student Farm Manager at the U-M Campus Farm and Director of Member Relations for University of Michigan Sustainable Food Program. She interned at MDining for a summer as a Sustainability Intern and she was a Farmers' Market Food Assistance Intern at Growing Hope in Ypsilanti. She has studied food systems abroad, as a student at Umbra Institute's Food Studies program in Perugia, Italy and as an Environmental Intern at Olam International's dairy farms in Uruguay.

Sarah Bellaire
Sarah Bellaire is a first-year masters student in the School for Environment and Sustainability (SEAS) studying environmental policy and behavior change interventions. She received a B.A. from the University of Michigan-Dearborn in Environmental Science and has held positions at Oak Ridge National Laboratory and the Food Recovery Network. Her interest in food systems started with a desire to reduce food waste, which is still her core passion. Currently, she is particularly interested in food recovery and access, agriculture policy, local food systems, and global food supply chains.

Becca Harley

Becca Harley is a junior undergraduate student majoring in Program in the Environment with a specialization in agroecology and minors in Food Systems and Community Action and Social Change. She is interested in environmental and food justice as well as ecologically based agriculture. Her interest in food systems stems from working on several farms across the state of Michigan. Becca is a community organizer with the Climate Action Movement. She is also the Food Safety and Orders Manager at the U-M Campus Farm and the incoming Grant Manager for University of Michigan Sustainable Food Program.

Marc Jaruzel
Marc Jaruzel is a second-year graduate student in the Ford School of Public Policy. He focuses on environmental policy as it relates to climate change. His interest in sustainable food systems stems from his childhood on a small farm in Michigan. Marc is a board member of the Environmental Policy Association, is involved with the President's Commission on Carbon Neutrality—Student Advisory Panel, and volunteers with the University of Michigan Chapter of Citizens' Climate Lobby.

Nathalie Lambrecht
Nathalie Lambrecht is a PhD candidate in Nutritional Sciences at the School of Public Health. Her research interest lies in promoting human nutrition and health within ecologically sustainable food systems. Her dissertation research, focused in Ghana, investigates the epidemiology of childhood anemia and the impacts of livestock production on children's health, diets, and exposure to zoonotic disease. Nathalie is on the leadership team of the graduate student-led Michigan University-Wide Sustainability & Environment Initiative and has served several years on the University of Michigan School of Public Health Diversity, Equity, and Inclusion Committee. She holds a BS in Health Sciences from Saint Mary's College of California.

TEAM ADVISORS

Alex Bryan
Alex Bryan is the U-M Sustainable Food Program Manager and works to support applied learning in food systems and sustainability at the University of Michigan. He has served on various farming advocacy boards, including as a founding member of the National Young Farmers Coalition. He is co-founder and co-owner of Food Field, a 4-acre farm in Detroit, and previously worked at the Greater Lansing Food Bank as the Director of Agricultural Programs, supporting community farms, gardens, and farm business development for under-served populations. Alex is a regular presenter and speaker at local, national and international conferences focusing on urban agriculture, community gardening, and food sovereignty.

Martin Heller
Marty Heller is a Senior Research Specialist at the Center for Sustainable Systems, School for Environment and Sustainability at U of M. His research applies systems approaches and life cycle assessment methods to evaluate the environmental impact of food, food systems and dietary choices. Recent work provides the first linkage between food environmental impacts and individual, self-selected diets in the US. He has conducted life cycle assessment studies of short rotation woody biomass energy crops, Beyond Meat's Beyond Burger, a large-scale vertically integrated US organic dairy, and as part of an international team, a spatially-explicit study of US dairy production. He also developed a seminal report on Life Cycle-Based Sustainability Indicators for Assessment of the US Food System. Martin was awarded the 2018 Best Article

Award in the journal, Environmental Research Letters and the 2015 Senior Author Best Paper in Journal of Industrial Ecology. He received a BS in chemical engineering from Michigan State and a PhD, also in chemical engineering, at the University of Colorado at Boulder.

Steve Mangan
Steve Mangan is currently the Senior Director of Michigan Dining at the University of Michigan's Ann Arbor campus. A Certified Executive Chef, Mangan brings more than 30 years of food and beverage experience to his work, first as a chef and restaurateur and later in leadership roles at three Big Ten universities. Mangan's deep experience in the food industry also includes work in restaurants, conference centers, culinary education and competition. Before joining the University of Michigan, he completed a twenty-year career with Sodexo in both public and private institutions, including positions as Executive Chef, Regional Chef, and General Manager and District Manager in the Mid-Atlantic and Midwest regions.

Jeremy Moghtader
Jeremy Moghtader is the Program Manager for the University of Michigan Campus Farm, a Living Learning Lab for authentic and high-impact research teaching and learning at the Matthaei Botanical Gardens. He is formerly the Director of Programs for the Michigan State University Student Organic Farm where he developed and directed the MSU Organic Farmer Training Program and the Farmer Field School. With over 15 years of experience growing food for local and regional markets including institutions, Jeremy has helped to found and lead several local food organizations including the Food System Economics Partnership's Farm to Institution work. Jeremy holds a MS in Resource Ecology and Management from the University of Michigan School of Natural Resources and Environment, where his research focused on Agro-ecology, and a BS in Economics also from the University of Michigan.

Keith Soster
Keith Soster is the Director of Student Engagement, Sustainability, Training and Development for Michigan Dining. In this position, Keith plans, directs, and administers programs, policies, and procedures in the areas of sustainability, inclusive excellence, student programming and engagement, academic partnerships, community engagement and training. At the core of Keith's work is outreach, putting him in constant contact with suppliers, students and campus stakeholders, and involving him in myriad initiatives for a greener, healthier campus. He also serves on the advisory board for Michigan Food to Institution Network (MFIN) as well as the UMSFP (University of Michigan Sustainable Food Program) advisory board.

Endnotes

[1] IPCC 2019 Intergovernmental Panel on Climate Change. “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.” Intergovernmental Panel on Climate Change. 2019. https://www.ipcc.ch/srccl/.

[2] Tilman, David, and Michael Clark. “Global Diets Link Environmental Sustainability and Human Health.” *Nature* 515, no. 7528 (2014): 518–22. https://doi.org/10.1038/nature13959.

[3] World Resources Institute. “Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050.” World Resources Institute, 2019.

[4] Rose, Donald, Martin C. Heller, Amelia M. Willits-Smith, and Robert J. Meyer. “Carbon Footprint of Self-Selected US Diets: Nutritional, Demographic, and Behavioral Correlates.” *American Journal of Clinical Nutrition* 109, no. 3 (2019): 535–43. https://doi.org/10.1093/ajcn/nqy327.

[5] Willett, Walter, Johan Rockström, Brent Loken, Marco Springmann, Tim Lang, Sonja Vermeulen, Tara Garnett, et al. “Food in the Anthropocene: The EAT–Lancet Commission on Healthy Diets from Sustainable Food Systems.” *The Lancet* 393, no. 10170 (2019): 447–92. https://doi.org/10.1016/S0140-6736(18)31788-4.

[6] Clune, Stephen, Enda Crossin, and Karli Verghese. “Systematic Review of Greenhouse Gas Emissions for Different Fresh Food Categories.” *Journal of Cleaner Production* 140 (2017): 766–83. https://doi.org/10.1016/j.jclepro.2016.04.082.

[7] Hallström, E., A. Carlsson-Kanyama, and P. Börjesson. “Environmental Impact of Dietary Change: A Systematic Review.” *Journal of Cleaner Production* 91 (2015): 1–11. https://doi.org/10.1016/j.jclepro.2014.12.008; Peters, Christian J., Jamie Picardy, Amelia F. Darrouzet-Nardi, Jennifer L. Wilkins, Timothy S. Griffin, and Gary W. Fick. “Carrying Capacity of U.S. Agricultural Land: Ten Diet Scenarios.” *Elementa: Science of the Anthropocene* 4 (2016): 000116. https://doi.org/10.12952/journal.elementa.000116; Tilman, David, and Michael Clark. “Global Diets Link Environmental Sustainability and Human Health.” *Nature* 515, no. 7528 (2014): 518–22. https://doi.org/10.1038/nature13959.

[8] The Culinary Institute of America and the Harvard T.H. Chain School of Public Health Department of Nutrition. “Menus of Change 2019 Annual Report.” New York, NY, 2019. https://www.menusofchange.org/images/uploads/pdf/2019MOC_AnnualReport.pdf.

[9] Thaler, Richard H., and Cass R. Sunstein. *Nudge: Improving Decisions about Health, Wealth, and Happiness*. Yale University Press, 2008.

[10] The Culinary Institute of America. “The Protein Flip: A Delicious Strategy for Change.” The Culinary Institute of America, 2016. https://www.menusofchange.org/images/uploads/pdf/CIA-MenusOfChange_ProteinFlip_(May_2016)2.pdf.

[11] Stanford Mind & Body Lab, Stanford SPARQ, Stanford Residential & Dining Enterprises, Menus of Change University Research Collaborative, and Better Buying Lab. “Edgy Veggies Toolkit: How to Incorporate Taste-Focused Labeling to Encourage Healthier Eating.” 2019. http://sparqtools.org/wp-content/uploads/2019/10/20190925_EdgyVeggiesToolkit-1.pdf.

[12] Ibid.

[13] Stanley, Paige, Jason Rowntree, David Beede, Marcia DeLonge, and Michael Hamm. “Impacts of Soil Carbon Sequestration on Life Cycle Greenhouse Gas Emissions in Midwestern USA Beef Finishing Systems.” *Agricultural Systems* 162 (2018): 249–58. https://doi.org/10.1016/j.agsy.2018.02.003.

[14] PIPs Rewards. “PIPs on Campus: Valuing the Good Students Do Everyday.” https://www.pipsrewards.com/pips_on_campus.

[15] Weber, Christopher L., and H. Scott Matthews. “Food-Miles and the Relative Climate Impacts of Food Choices in the United States.” *Environmental Science and Technology* 42, no. 10 (2008): 3508–13. https://doi.org/10.1021/es702969f.

[16] Michels, Kallie, et al. “Report for President Schlissel from the Committee on the Culture of Sustainability at the University of Michigan.” University of Michigan, 2015.

[17] Association for the Advancement of Sustainability in Higher Education. “Stars 2.2 Summary of Changes.” May 2019. https://stars.aashe.org/wp-content/uploads/2019/08/STARS-2.2-Summary-of-Changes-final.pdf.

[18] Buzby, Jean C., Hodan F. Wells, and Jeffrey Hyman. “The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States, EIB-121.” U.S. Department of Agriculture, Economic Research Service. February 2014; Cuellar, A., and M. Webber. “Wasted Food, Wasted Energy: The Embedded Energy in Food Waste in the United States.” *Environment, Science and Technology* 44 (2020): 6464–69; Kumar, V. “The Climate Change and Economic Impacts of Food Waste in the United States.” *International Journal of Food Systems Dynamics* 2 (2011): 431–46; ReFED. “A Roadmap to Reduce US Food Waste by 20 Percent Technical Report.” 2016. https://www.ers.usda.gov/webdocs/publications/43833/43680_eib121.pdf.

[19] Scialabba, N. “Food Wastage Footprint and Climate Change.” Food and Agricultural Organization, 2015. http://www.fao.org/3/a-bb144e.pdf.

[20] Food and Agricultural Organization. “Food Loss and Waste and the Right to Adequate Food: Making the Connection.” Rome, 2018. http://www.fao.org/3/ca1397en/CA1397EN.pdf.

[21] United States Environmental Protection Agency. “Advancing Sustainable Materials Management: 2017 Fact Sheet.” United States Environmental Protection Agency, 2019. https://www.epa.gov/sites/production/files/2019-11/documents/2017_facts_and_figures_fact_sheet_final.pdf.

[22] This goal does not include additional food loss reductions that could be made during the production, processing, packaging, or transportation process. United States Environmental Protection Agency. “Sustainable Management of Food: United States 2030 Food Loss and Waste Reduction Goal.” Last updated November 13, 2019. https://www.epa.gov/sustainable-management-food/united-states-2030-food-loss-and-waste-reduction-goal.

[23] The President’s Committee on Landfill Waste Reduction. “President’s Committee on Landfill Waste Reduction Recommendations Report.” University of Michigan, 2015. http://sustainability.umich.edu/media/files/Landfill-Waste-Reduction-Committee-Report-2015.pdf; Larsen, Larissa, Kevin McCoy, Brad Detjen, Alysia Giatas, Sue Johnson, Margo Ludmer, and Breanna Shell. “Food Analysis: Phase I Report.” In *Campus Sustainability Integrated Assessment: Interim Report*, sponsored by Graham Environmental Sustainability Institute and U-M Office of Campus Sustainability, 272–331. 2010. http://graham.umich.edu/media/files/CampusIA-InterimReport.pdf.

[24] University of Michigan—Office of Campus Sustainability. “Waste Reduction Goal.” Office of Campus Sustainability. https://ocs.umich.edu/sustainability-goals/waste-reduction-goal/.

[25] The President’s Committee on Landfill Waste Reduction report referred to “disposal facilities,” both landfills and incinerators, but to our knowledge, U-M’s solid waste is sent to a landfill, so we refer to non-diverted waste from here on out as landfill waste.

[26] University of Michigan—Office of Campus Sustainability. “Zero Waste Events.” Office of Campus Sustainability. https://ocs.umich.edu/programs/waste-reduction/composting/zero-waste-events/.

[27] UM-Ann Arbor’s campus (including the hospital system)—which makes up approximately 84% of all faculty, staff, and students across the three campuses—had close to 75,000 staff, students, and faculty in 2006 and over 96,000 in 2019. U-M Office of Campus Sustainability. “Waste Reduction.” https://ocs.umich.edu/sustainability-goals/waste-reduction-goal/.

[28] We used EPA (United States Environmental Protection Agency) WARM (Waste Reduction Model) Tool norms, using short tons (2,000 lbs.) to specify the weight of waste, and we use metric tons of CO_2 equivalent (tCO_2e) to report GHG emissions.

[29] U-M Office of Campus Sustainability. “Waste Reduction.” https://ocs.umich.edu/sustainability-goals/waste-reduction-goal/.

[30] The President’s Committee on Landfill Waste Reduction. “President’s Committee on Landfill Waste Reduction Recommendations Report.” University of Michigan, 2015. http://sustainability.umich.edu/media/files/Landfill-Waste-Reduction-Committee-Report-2015.pdf.

[31] We sometimes use “prevention” or “prevent” and “reduction” or “reducing” interchangeably.

[32] EPA. "Sustainable Management of Food: How to Prevent Wasted Food through Source Reduction." Last updated on November 21, 2019. https://www.epa.gov/sustainable-management-food/how-prevent-wasted-food-through-source-reduction.

[33] After food waste reduction, based on a descending level of impact on the environment, society and the economy, diversion options include donating food (e.g., to food banks), turning food scraps into animal food, converting food waste into energy, and composting. https://www.epa.gov/sustainable-management-food/how-prevent-wasted-food-through-source-reduction.

[34] ICF. "Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM): Management Practices Chapters." U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, May 2019. https://www.epa.gov/sites/production/files/2019-10/documents/warm_v15_management_practices_updated_10-08-2019.pdf.

[35] University of Michigan Facilities and Operations, Logistics, Transportation and Parking. "Waste Management." https://ltp.umich.edu/waste-management/.

[36] This includes U-M Health System Facilities Services, which handles all hospital wastes, and the Department of Occupational Safety and Environmental Health, which manages hazardous waste and regulated recycling items. See http://css.umich.edu/sites/default/files/css_doc/CSS06-15.pdf.

[37] Our diversion rate varies somewhat from the Office of Campus Sustainability (OCS) calculations used for the Waste Management Goal (part of the U-M Sustainability Goals) and the U-M (Ann Arbor) Environmental Metrics. See https://ocs.umich.edu/resources/sustainability-data/environmental-metrics/. In 2019, OCS noted that UM-Ann Arbor's diversion rate had reached 37%, while we calculate as 34%. See Appendix B for a more complete explanation of the reasons for these differences.

[38] We used the EPA WARM (Waste Reduction Model) Tool, version 15 to calculate these scenarios. The WARM Tool calculates tCO_2e based on life cycle assessments. See https://www.epa.gov/warm.

[39] The doubling and tripling of food donations in our scenarios, from 3.3 to 9.9 tons, is negligible in its impact on GHG emissions; 3.3 tons of food donations avoids approximately 2 tCO_2e in emissions by not putting that food in the landfill. However, food donations play an important role in addressing food insecurity in the wider community (e.g., local food banks) and among students. A survey conducted on U-M Flint's campus in 2015, for instance, found that 38% of students regularly face a lack of basic food. See https://www.umflint.edu/foodpantry.

[40] These emissions avoided are in addition to emissions associated with food production and transportation, which are not included in our models as they would double count the emissions counted as part of food procurement.

[41] This does not take into consideration U-M's potential growth over the next 10 years. If we assume that U-M's growth rate will be 2% on average over the next 10 years, by 2030, U-M would have to divert 18,260 tons, for an overall diversion rate of 69.8% and an increase in diversion rates by 3.3% every year until 2030. See Appendix B for the method behind this calculation.

[42] UIC Sustainability. "Zero Waste Campus." University of Illinois Chicago. https://sustainability.uic.edu/plans/uicclimatecommitments/zero-waste-campus/; "Zero Waste." Berkeley Sustainability & Carbon Solutions. University of California, Berkeley, September 2018. https://sustainability.berkeley.edu/zero-waste.

[43] Recycle Mania—soon to be referred to as Campus Waste to Zero Waste—is an organization managed by the National Wildlife Federation, which started with support from the EPA WasteWise program in 2001 to offer technical support and tracking of efforts by colleges and universities to reduce and eliminate waste. See https://recyclemania.org/.

[44] Note that diversion rates can drop somewhat if prevention is introduced, since diversion is based on actual waste produced—not avoided—and the amount of that waste that is diverted.

[45] Research in other all-you-can-eat, trayless dining halls found that three-quarters of food waste in the landfill stream came from post-consumer waste. Costello, Christine, Esma Birisci, and Ronald G. McGarvey. "Food Waste in Campus Dining Operations: Inventory of Pre- and Post-Consumer Mass by Food Category, and Estimation of Embodied Greenhouse Gas Emissions." *Renewable Agriculture and Food Systems* 31, no. 3 (2016): 191–201. https://doi.org/10.1017/S1742170515000071.

[46] Research shows that removing trays from dining halls can reduce post-consumer waste from X to 32%. Costello, Christine, Esma Birisci, and Ronald G. McGarvey. “Food Waste in Campus Dining Operations: Inventory of Pre- and Post-Consumer Mass by Food Category, and Estimation of Embodied Greenhouse Gas Emissions.” *Renewable Agriculture and Food Systems* 31, no. 3 (2016): 191–201. https://doi.org/10.1017/S1742170515000071; Kim, Kiho and Stevia Morawski. “Quantifying the Impact of Going Trayless in a University Dining Hall.” *Journal of Hunger & Environmental Nutrition* 7 (2012): 482-86. https://doi.org/10.1080/19320248.2012.732918.

[47] Ahmed, Selena, Carmen Byker Shanks, Martin Lewis, Alicia Leitch, Caitlin Spencer, Erin M. Smith, and Dani Hess. “Meeting the Food Waste Challenge in Higher Education.” *International Journal of Sustainability in Higher Education* 19, no. 6 (2018): 1075–94. https://doi.org/10.1108/IJSHE-08-2017-0127; Babich, Ryan, and Sylvia Smith. “‘Cradle to Grave’: An Analysis of Sustainable Food Systems in a University Setting.” *Journal of Culinary Science & Technology* 8, no. 4 (2010): 180–90. https://doi.org/10.1080/15428052.2010.535747; Berkowitz, Sarah, Len Marquart, Elton Mykerezi, Dennis Degeneffe, and Marla Reicks. “Reduced-Portion Entrées in a Worksite and Restaurant Setting: Impact on Food Consumption and Waste.” *Public Health Nutrition* 19, no. 16 (2016): 3048–54. https://doi.org/10.1017/S1368980016001348; Freedman, Marjorie R., and Carolina Brochado. “Reducing Portion Size Reduces Food Intake and Plate Waste.” *Obesity* 18, no. 9 (2010): 1864–66. https://doi.org/10.1038/oby.2009.480; Kallbekken, Steffen, and Håkon Sælen. “‘Nudging’ Hotel Guests to Reduce Food Waste as a Win–Win Environmental Measure.” *Economics Letters* 119, no. 3 (2013): 325–27. https://doi.org/10.1016/j.econlet.2013.03.019; Kim, Kiho, and Stevia Morawski. “Quantifying the Impact of Going Trayless in a University Dining Hall.” *Journal of Hunger & Environmental Nutrition* 7, no. 4 (2012): 482–86. https://doi.org/10.1080/19320248.2012.732918; Sarjahani, Andy, Elena L. Serrano, and Rick Johnson. “Food and Non-Edible, Compostable Waste in a University Dining Facility.” *Journal of Hunger & Environmental Nutrition* 4, no. 1 (2009): 95–102. https://doi.org/10.1080/19320240802706874; Thiagarajah, Krisha, and Victoria M. Getty. “Impact on Plate Waste of Switching from a Tray to a Trayless Delivery System in a University Dining Hall and Employee Response to the Switch.” *Journal of the Academy of Nutrition and Dietetics* 113, no. 1 (2013): 141–45. https://doi.org/10.1016/j.jand.2012.07.004; Vermote, Marie, Vickà Versele, Marijn Stok, Patrick Mullie, Eva D’Hondt, Benedicte Deforche, Peter Clarys, and Tom Deliens. “The Effect of a Portion Size Intervention on French Fries Consumption, Plate Waste, Satiety and Compensatory Caloric Intake: An on-Campus Restaurant Experiment.” *Nutrition Journal* 17, no. 1 (2018): 43. https://doi.org/10.1186/s12937-018-0352-z; Whitehair, Kelly J., Carol W. Shanklin, and Laura A. Brannon. “Written Messages Improve Edible Food Waste Behaviors in a University Dining Facility.” *Journal of the Academy of Nutrition and Dietetics* 113, no. 1 (2013): 63–69. https://doi.org/10.1016/j.jand.2012.09.015; Yui, Sahoko, and Charlotte Biltekoff. “How Food Becomes Waste: Students as ‘Carriers of Practice’ in the UC Davis Dining Commons.” *Journal of Hunger & Environmental Nutrition* (2020): 1–22. https://doi.org/10.1080/19320248.2020.1721393.

[48] Yui, Sahoko, and Charlotte Biltekoff. “How Food Becomes Waste: Students as ‘Carriers of Practice’ in the UC Davis Dining Commons.” *Journal of Hunger & Environmental Nutrition* (2020): 1–22. https://doi.org/10.1080/19320248.2020.1721393.

[49] McCray, Sally, Kirsty Maunder, Renee Krikowa, and Kristen MacKenzie-Shalders. “Room Service Improves Nutritional Intake and Increases Patient Satisfaction While Decreasing Food Waste and Cost.” *Journal of the Academy of Nutrition and Dietetics* 118, no. 2 (2018): 284–93; Williams, Peter, and Karen Walton. "Plate Waste in Hospitals and Strategies for Change." *The European e-Journal of Clinical Nutrition and Metabolism* 6, no. 6 (2011): e235–41.

[50] Informational prompts reminding guests of environmental damages and nudging prompts have also been used to decrease food waste, with studies showing a 15%–20% reduction in plate waste. Kallbekken, Steffen, and Håkon Sælen. “‘Nudging’ Hotel Guests to Reduce Food Waste as a Win–Win Environmental Measure.” *Economics Letters* 119, no. 3 (2013): 325–27; Whitehair, Kelly J., Carol W. Shanklin, and Laura A. Brannon. “Written Messages Improve Edible Food Waste Behaviors in a University Dining Facility.” *Journal of the Academy of Nutrition and Dietetics* 113, no. 1 (2013): 63–69. However, careful consideration should be applied to the messaging to decrease an informational rebound effect. In one study, participants who were informed of the environmental damages of food

waste while eating reduced their food waste by 77%. When they were also told that their food waste would be composted, however, they only reduced their food waste by 28%. Qi, Danyi, and Brian E. Roe. "Foodservice Composting Crowds out Consumer Food Waste Reduction Behavior in a Dining Experiment." *American Journal of Agricultural Economics* 99, no. 5 (2017): 1159–71. https://doi.org/10.1093/ajae/aax050.

[51] Trivedi, Bhushan Girish. "Food Waste Prevention and Management in Higher Education." In Walter Leal Filho, Nandhivarman Muthu, Golda Edwin, and Mihaela Sima (eds.), *Implementing Campus Greening Initiatives*. World Sustainability Series. Springer, 2015.

[52] Blackwell, Deborah. "Food Programs Grow as Harvard Cooks Up New Ideas." *The Harvard Gazette*, November 21, 2017. https://news.harvard.edu/gazette/story/2017/11/students-package-unused-food-for-distribution-to-those-in-need/.

[53] Over 100 universities have partnered with Swipe Out Hunger, a program that allows students to donate meal plan swipes to fellow students. Although evaluations are needed to determine if such a program can cut down on food waste, it would have an impact on inequitable food insecurity among students on all three campuses. See https://www.swipehunger.org/2019impactreport/, https://www.swipehunger.org/ourwork/faq/; other donation programs suggest U-M dining, catering, and other operations could donate far more than the 10 tons we are suggesting on an annual basis. For instance, Harvard, which is approximately half the size of U-M, has an award-winning program that donates 20 tons of food to the wider community on an annual basis. Students take unused food from the dining halls and create frozen and microwavable meals for families in area schools and shelters with few cooking facilities. https://news.harvard.edu/gazette/story/2017/11/students-package-unused-food-for-distribution-to-those-in-need/.

[54] United States Environmental Protection Agency. "Trash-Free Waters: Marine Debris and Plastic Source Reduction Toolkit—Plastic Source Reduction Toolkit for Colleges & Universities and Other Institutional Settings." Last updated May 23, 2017. https://www.epa.gov/trash-free-waters/marine-debris-and-plastic-source-reduction-toolkit.

[55] Brothers, Kevin J., Patricia J. Krantz, and Lynn E. McClannahan. "Office Paper Recycling: A Function of Container Proximity." *Journal of Applied Behavior Analysis* 27, no. 1 (1994): 153–60. https://doi.org/10.1901/jaba.1994.27-153; DiGiacomo, Alessandra, David W.-L. Wu, Peter Lenkic, Bud Fraser, Jiaying Zhao, and Alan Kingstone. "Convenience Improves Composting and Recycling Rates in High-Density Residential Buildings." *Journal of Environmental Planning and Management* 61, no. 2 (2018): 309–31. https://doi.org/10.1080/09640568.2017.1305332; Ludwig, Timothy D., Timothy W. Gray, and Allison Rowell. "Increasing Recycling in Academic Buildings: A Systematic Replication." *Journal of Applied Behavior Analysis* 31, no. 4 (1998): 683–86. https://doi.org/10.1901/jaba.1998.31-683.

[56] Pre-consumer food waste refers to food handled in kitchens before it reaches the consumer that either is inedible (e.g., bones, peels, fat, the ends of produce), spoils, or is overprepared. We consider post-consumer food waste to be food served to consumers that they do not eat as well as food from off-campus that people throw away on campus. We do not account for "food loss" in this report—produce from the agricultural sector such as unharvested crops or food lost during transport to retail outlets. Costello, Christine, Esma Birisci, and Ronald G. McGarvey. "Food Waste in Campus Dining Operations: Inventory of Pre- and Post-Consumer Mass by Food Category, and Estimation of Embodied Greenhouse Gas Emissions." *Renewable Agriculture and Food Systems* 31, no. 3 (2016): 191–201. https://doi.org/10.1017/S1742170515000071.

[57] Ibid.

[58] Currently, only a small composting research project exists at the UM-Dearborn Environmental Interpretive Center. See "Composting." Environmental Interpretive Center. University of Michigan–Dearborn, November 1, 2018. https://umdearborn.edu/casl/centers-institutes/environmental-interpretive-center/research-resources/sustainability-initiatives/composting.

[59] Vendries, Jorge, Beverly Sauer, Troy R. Hawkins, David Allaway, Peter Canepa, Jonathan Rivin, and Minal Mistry. "The Significance of Environmental Attributes as Indicators of the Life Cycle

Environmental Impacts of Packaging and Food Service Ware." *Environmental Science and Technology* 54, no. 9 (2020): 5356–64. https://doi.org/10.1021/acs.est.9b07910.

[60] Ragab, Yasmeen. "Dining Services Reduce Food Waste through Donation and Tracking System." The Daily Illini, 2018. https://dailyillini.com/news/2018/04/23/dining-services-reduce-food-waste-through-donation-and-tracking-system/; ReFed. "Foodservice Food Waste Action Guide," 2018. https://www.refed.com/downloads/Foodservice_Guide_Web.pdf.

[61] Leanpath. https://www.leanpath.com/.

[62] Winnow. https://www.winnowsolutions.com/.

[63] Food Loss + Waste Protocol. "Food Loss and Waste Accounting and Reporting Standard Version 1.0." World Resources Institute, 2016. https://flwprotocol.org/wp-content/uploads/2017/05/FLW_Standard_final_2016.pdf; Reynolds, Christian, Liam Goucher, Tom Quested, Sarah Bromley, Sam Gillick, Victoria K. Wells, David Evans, et al. "Review: Consumption-Stage Food Waste Reduction Interventions—What Works and How to Design Better Interventions." *Food Policy* 83 (2019): 7–27. https://doi.org/10.1016/j.foodpol.2019.01.009.

[64] Audits can offer detail about the contents of landfill, recycling, and composting streams to identify carbon-intensive materials that could be recycled or targeted for reduction. The cost is prohibitive to do regularly and for all buildings, but U-M could consider investing in periodic audits in different types of buildings (e.g., academic, administrative, athletic, residence halls, etc.) to establish more accurate baselines and targeted interventions specific to the population and sustainability cultures of those buildings.

[65] Heller, Martin C., Gregory A. Keoleian, and Walter C. Willett. "Toward a Life Cycle-Based, Diet-Level Framework for Food Environmental Impact and Nutritional Quality Assessment: A Critical Review." *Environmental Science & Technology* 47, no. 22 (2013): 12632–47. https://doi.org/10.1021/es4025113.

[66] Heller, Martin C., Amelia Willits-Smith, Robert Meyer, Gregory A. Keoleian, and Donald Rose. "Greenhouse Gas Emissions and Energy Use Associated with Production of Individual Self-Selected US Diets." *Environmental Research Letters* 13, no. 4 (2018). https://doi.org/10.1088/1748-9326/aab0ac.

[67] Ibid.

[68] Lynch, John, Michelle Cain, Raymond Pierrehumbert, and Myles Allen. "Demonstrating GWP*: A Means of Reporting Warming-Equivalent Emissions That Captures the Contrasting Impacts of Short- and Long-Lived Chemical Pollutants." *Environmental Research Letters* 15, no. 4 (2020): 44023. https://iopscience.iop.org/article/10.1088/1748-9326/ab6d7e.

[69] Ibid.

[70] Clark, Cameron, and Krysten Dorfman. "Working Towards Carbon Neutrality in Michigan Dining: Assessing the Impact of Sustainable Mondays." Poster session presented at the Association for the Advancement of Sustainability in Higher Education Conference, Spokane, Washington, 2019.

[71] Hitaj, Claudia, Sarah Rehkamp, Patrick Canning, and Christian J. Peters. "Greenhouse Gas Emissions in the United States Food System: Current and Healthy Diet Scenarios." *Environmental Science & Technology* 53, no. 9 (2019): 5493–503. https://doi.org/10.1021/acs.est.8b06828; Weber, Christopher L., and H. Scott Matthews. "Food-Miles and the Relative Climate Impacts of Food Choices in the United States." *Environmental Science and Technology* 42, no. 10 (2008): 3508–13. https://doi.org/10.1021/es702969f.

[72] Hitaj, Claudia, Sarah Rehkamp, Patrick Canning, and Christian J. Peters. "Greenhouse Gas Emissions in the United States Food System: Current and Healthy Diet Scenarios." *Environmental Science & Technology* 53, no. 9 (2019): 5493–503. https://doi.org/10.1021/acs.est.8b06828.

[73] University of Michigan Office of Campus Sustainability. "University of Michigan-FY2018 Annual Environmental Metrics Report." 2018. https://ocs.umich.edu/wp-content/uploads/2019/08/FY-2018-env-metrics-final.pdf.

[74] U.S. Department of Health and Human Services and U.S. Department of Agriculture. "2015–2020 Dietary Guidelines for Americans." 8th ed. December 2015. http://health.gov/dietaryguidelines/2015/guidelines/.

[75] With 8,420 students, faculty, and staff at UM-Flint and 10,364 at UM-Dearborn in the 2019–2020 academic year (see the population census at https://obp.umich.edu/campus-statistics/faculty-staff/), UM-Flint is 81% the size of UM-Dearborn.

[76] See https://www.foodrecoverynetwork.org/michigan.

[77] This includes buildings with dining halls, hospital retail, cafeterias, and patient meal services, the U-M Stadium concessions, the Michigan Unions (e.g., Michigan League, Pierpont), Ross School of Business Executive Dining and retail, and others.

[78] University of Michigan–Dearborn Environmental Interpretive Center. "Composting." https://umdearborn.edu/casl/centers-institutes/environmental-interpretive-center/research-resources/sustainability-initiatives/composting.

[79] OCS audits were conducted between 2014 to 2019 at the Michigan Stadium, Wolverine Tower, LSA and Boyer (Engineering) buildings, and six Michigan Medicine buildings (which included the Women's and Children's Hospital and University Hospital). No audit has been completed in a residence or dining hall at U-M, though one scheduled with MDining for April was canceled due to COVID-19. GT Environmental. "Waste Composition Analysis on the Compost, Recycling and Landfill Streams in Wolverine Tower." U-M Office of Campus Sustainability, 2019; GT Environmental. "Follow-Up Waste Composition Analysis on the Compost, Recycling and Landfill Streams in Wolverine Tower." U-M Office of Campus Sustainability, 2019; RRS. "Building Consumption and Waste Analysis for Consumption Analysis and Waste Audit." U-M Office of Campus Sustainability, 2014; Scarab Waste Solutions. "Michigan Medicine Waste Stream Analysis." U-M Office of Campus Sustainability, 2017; U-M Office of Campus Sustainability. "Waste Composition Analysis on the Compost, Recycling, and Landfill Streams in Wolverine Tower." 2019; U-M Office of Campus Sustainability. "Stadium Waste Sort." 2016.

[80] West Michigan Sustainable Business Forum. "Economic Impact Potential and Characterization of Municipal Solid Waste in Michigan." 2016. https://www.michigan.gov/documents/deq/480236-14_WMSBF_waste_characterization_report_521920_7.PDF .

[81] United States Environmental Protection Agency. "National Overview: Facts and Figures on Materials, Wastes and Recycling." Last updated March 13, 2020. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials.

[82] Natural Resources Defense Council. "Wasted**:** How America Is Losing Up to 40 Percent of Its Food from Farm to Fork to Landfill." 2012. https://www.nrdc.org/resources/wasted-how-america-losing-40-percent-its-food-farm-fork-landfill**.**

[83] Buzby, Jean C., Hodan F. Wells, and Jeffrey Hyman. "The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States, EIB-121." U.S. Department of Agriculture, Economic Research Service, February 2014. https://www.ers.usda.gov/webdocs/publications/43833/43680_eib121.pdf.

[84] Michels, Kallie, et al. "Report for President Schlissel from the Committee on the Culture of Sustainability at the University of Michigan." University of Michigan, 2015.

[85] See the news article https://news.umich.edu/michigan-football-home-games-to-be-zero-waste-events/; U-M Office of Campus Sustainability. "Stadium Waste Sort." 2016.

[86] Illinois Sustainable Technology Center. "UIC Waste Characterization Study." 2019. https://sustainability.uic.edu/recycling/.

[87] Silverman, Matt. "Waste Stream Analysis 2017–2018." University of Maryland, 2018.

[88] GT Environmental. "Follow-Up Waste Composition Analysis on the Compost, Recycling and Landfill Streams in Wolverine Tower." U-M Office of Campus Sustainability, 2019.

[89] RRS. "Building Consumption and Waste Analysis for Consumption Analysis and Waste Audit." U-M Office of Campus Sustainability, 2014.

[90] Illinois Sustainable Technology Center. "UIC Waste Characterization Study." 2019. https://sustainability.uic.edu/recycling/**.**

[91] United States Environmental Protection Agency. "National Overview: Facts and Figures on Materials, Wastes and Recycling—Landfilling." Last updated March 13, 2020. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials#Landfilling.

[92] West Michigan Sustainable Business Forum. "Economic Impact Potential and Characterization of Municipal Solid Waste in Michigan." 2016. https://www.michigan.gov/documents/deq/480236-14_WMSBF_waste_characterization_report_521920_7.PDF.

[93] Hopewell, Jefferson, Robert Dvorak, and Edward Kosior. "Plastics Recycling: Challenges and Opportunities." *Philosophical Transactions of the Royal Society B: Biological Sciences* 364, no. 1526 (2009): 2115–26. https://doi.org/10.1098/rstb.2008.0311.

[94] Illinois Sustainable Technology Center. "UIC Waste Characterization Study." 2019. https://sustainability.uic.edu/recycling/.

[95] Silverman, Matt. "Waste Stream Analysis 2017–2018." University of Maryland, 2018.

[96] EPA. "Waste Reduction Model (WARM)." https://www.epa.gov/warm.

[97] ICF. "Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM): Organic Materials Chapters." U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, May 2019.

[98] Illinois Sustainable Technology Center. "UIC Waste Characterization Study." 2019. https://sustainability.uic.edu/recycling/.

[99] Silverman, Matt. "Waste Stream Analysis 2017–2018." University of Maryland, 2018.

[100] ICF. "Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM): Management Practices Chapters." U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, May 2019. https://www.epa.gov/sites/production/files/2019-10/documents/warm_v15_management_practices_updated_10-08-2019.pdf; ICF. "Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM): Organic Materials Chapters." U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, May 2019. https://www.epa.gov/sites/production/files/2019-06/documents/warm_v15_organics.pdf.

[101] See the EPA WARM Tool guide for more details: https://www.epa.gov/sites/production/files/2019-10/documents/warm_v15_management_practices_updated_10-08-2019.pdf.

[102] EPA. "Composting in WARM." May 2012, 1. https://19january2017snapshot.epa.gov/sites/production/files/2016-03/documents/cmpstng_ovrview.pdf.

[103] EPA. "Make Materials Management Count: Tools and Techniques." 2009. https://archive.epa.gov/region02/webinars/web/pdf/transcript_6-24-09.pdf.

[104] EPA. "Waste—Non-Hazardous Waste—Municipal Solid Waste." Last updated on March 29, 2016. https://archive.epa.gov/epawaste/nonhaz/municipal/web/html/basic.html.

[105] Energy Recovery Council. "2016 Director of Waste-to-Energy Facilities." 2016. http://energyrecoverycouncil.org/wp-content/uploads/2016/06/ERC-2016-directory.pdf.

[106] Environmental and Energy Study Institute. "Fact Sheet—Biogas: Converting Waste to Energy." 2017. https://www.eesi.org/papers/view/fact-sheet-biogasconverting-waste-to-energy.

[107] University of Michigan Office of Campus Sustainability. "University of Michigan-FY2018 Annual Environmental Metrics Report." 2018. https://ocs.umich.edu/wp-content/uploads/2019/08/FY-2018-env-metrics-final.pdf.

[108] EPA. "Modeling Food Donation Benefits in EPA's Waste Reduction Model." 2019. https://www.epa.gov/sites/production/files/2019-06/documents/warm_v15_food_donation_guidance.pdf.

[109] Costello, Christine, Esma Birisci, and Ronald G. McGarvey. "Food Waste in Campus Dining Operations: Inventory of Pre- and Post-Consumer Mass by Food Category, and Estimation of Embodied Greenhouse Gas Emissions." *Renewable Agriculture and Food Systems* 31, no. 3 (2016): 191–201. https://doi.org/10.1017/S1742170515000071.

[110] Slagter, Martin. "Moving Schools, New Student Housing Part of University of Michigan's 5-Year Plan." MLive, September 19, 2019. https://www.mlive.com/news/g66l-2019/07/0927aa4dcb704/moving-schools-new-student-housing-part-of-university-of-michigans-5year-plan.html.

[111] University of Michigan Office of Budget and Planning. "Campus Statistics: Faculty & Staff." 2019. https://obp.umich.edu/campus-statistics/faculty-staff/.

[112] U.S. Department of Agriculture, Agricultural Research Service. "FoodData Central." 2019. https://fdc.nal.usda.gov.

[113] Heller, Martin C., Amelia Willits-Smith, Robert Meyer, Gregory A. Keoleian, and Donald Rose. "Greenhouse Gas Emissions and Energy Use Associated with Production of Individual Self-Selected US Diets." *Environmental Research Letters* 13, no. 4 (2018). https://doi.org/10.1088/1748-9326/aab0ac.

[114] The universities included in our scan included Bates College, Boston University, Brown, Columbia, Cornell, Duke, Emory, George Washington University, Harvard, Indiana University, Loyola University, Michigan State, North Carolina State, Notre Dame, Ohio State, Penn State, Ringling College of Art and Design, Rutgers, Stanford, UC Berkeley, UC Irvine, UC Santa Barbara, UCLA, University of Washington, University of Colorado Boulder, University of Maryland, University of Massachusetts, University of Minnesota–Morris, University of Vermont, Vanderbilt, Washington University–St. Louis, Willamette University, Yale.

[115] Larsen, Larissa, Kevin McCoy, Brad Detjen, Alysia Giatas, Sue Johnson, Margo Ludmer, and Breanna Shell. "University of Michigan Campus Sustainability Integrated Assessment: Food Analysis—Phase 1 Report." 2010.

[116] Culinary Institute of America. "The Protein Flip: A Delicious Strategy for Change." 2016. https://www.menusofchange.org/images/uploads/pdf/CIA-MenusOfChange_ProteinFlip_(May_2016)2.pdf.

[117] Stanford Mind & Body Lab, Stanford SPARQ, Stanford Residential & Dining Enterprises, Menus of Change University Research Collaborative, and Better Buying Lab. "Edgy Veggies Toolkit: How to Incorporate Taste-Focused Labeling to Encourage Healthier Eating." 2019. http://sparqtools.org/wp-content/uploads/2019/10/20190925_EdgyVeggiesToolkit-1.pdf.

[118] Culinary Institute of America and Harvard T.H. Chan School of Public Health. "Menus of Change." https://www.menusofchange.org/.

[119] World Resources Institute. "The Cool Food Pledge." https://www.wri.org/our-work/project/cool-food-pledge.

[120] Campbell-Arvai, Victoria. "Food-Related Environmental Beliefs and Behaviours among University Undergraduates." *International Journal of Sustainability in Higher Education* 16, no. 3 (2015): 279–95. https://doi.org/10.1108/IJSHE-06-2013-0071.

[121] Ibid.

[122] Park, Toby. "A Menu for Change: Using Behavioural Science to Promote Sustainable Diets around the World." London, 2020. https://www.bi.team/publications/a-menu-for-change/.

[123] Monroe, Jessica T., Ingrid E. Lofgren, Becky L. Sartini, and Geoffrey W. Greene. "The Green Eating Project: Web-Based Intervention to Promote Environmentally Conscious Eating Behaviours in US University Students." *Public Health Nutrition* 18, no. 13 (2015): 2368–78. https://doi.org/10.1017/S1368980015002396.

[124] Jay, Jennifer A., Raffaella D'Auria, J. Cully Nordby, David Andy Rice, David A. Cleveland, Anthony Friscia, Sophie Kissinger, et al. "Reduction of the Carbon Footprint of College Freshman Diets after a Food-Based Environmental Science Course." *Climatic Change* 154 (2019): 547–64. https://doi.org/10.1007/s10584-019-02407-8.

[125] Hekler, Eric B., Christopher D. Gardner, and Thomas N. Robinson. "Effects of a College Course about Food and Society on Students' Eating Behaviors." *American Journal of Preventive Medicine* 38, no. 5 (2010): 543–47. https://doi.org/10.1016/j.amepre.2010.01.026; Gardner, Christopher D., and Michelle E. Hauser. "Food Revolution." *American Journal of Lifestyle Medicine* 11, no. 5 (2017): 387–96. https://doi.org/10.1177/1559827617696289.

[126] Kelly, Nichole R., Suzanne E. Mazzeo, and Melanie K. Bean. "Systematic Review of Dietary Interventions with College Students: Directions for Future Research and Practice." *Journal of Nutrition Education and Behavior* 45 (2013): 304–13. https://doi.org/10.1016/j.jneb.2012.10.012.

[127] Brunner, Florentine, Verena Kurz, David Bryngelsson, and Fredrik Hedenus. "Carbon Label at a University Restaurant—Label Implementation and Evaluation." *Ecological Economics* 146 (2018): 658–67. https://doi.org/10.1016/j.ecolecon.2017.12.012.

[128] Bauer, J. M., and L. A. Reisch. "Behavioural Insights and (Un)Healthy Dietary Choices: A Review of Current Evidence." *Journal of Consumer Policy* 42, no. 1 (2019): 3–45. https://doi.org/10.1007/s10603-018-9387-y.

[129] Bianchi, Filippo, Claudia Dorsel, Emma Garnett, Paul Aveyard, and Susan A. Jebb. "Interventions Targeting Conscious Determinants of Human Behaviour to Reduce the Demand for Meat: A Systematic Review with Qualitative Comparative Analysis." *International Journal of Behavioral Nutrition and Physical Activity* 15, no. 1 (2018): 102. https://doi.org/10.1186/s12966-018-0729-6; Taufik, Danny, Muriel C. D. Verain, Emily P. Bouwman, and Machiel J. Reinders. "Determinants of Real-Life Behavioural Interventions to Stimulate More Plant-Based and Less Animal-Based Diets: A Systematic Review." *Trends in Food Science & Technology* 93, no. July (2019): 281–303. https://doi.org/10.1016/j.tifs.2019.09.019.

[130] Stoll-Kleemann, Susanne, and Uta Johanna Schmidt. "Reducing Meat Consumption in Developed and Transition Countries to Counter Climate Change and Biodiversity Loss: A Review of Influence Factors." *Regional Environmental Change* 17 (2017): 1261–77. https://doi.org/10.1007/s10113-016-1057-5; Park, Toby. "A Menu for Change: Using Behavioural Science to Promote Sustainable Diets around the World." London, 2020. https://www.bi.team/publications/a-menu-for-change/.

[131] Bianchi, Filippo, Emma Garnett, Claudia Dorsel, Paul Aveyard, and Susan A. Jebb. "Restructuring Physical Micro-Environments to Reduce the Demand for Meat: A Systematic Review and Qualitative Comparative Analysis." *The Lancet Planetary Health* 2, no. 9 (2018): e384–97. https://doi.org/10.1016/S2542-5196(18)30188-8; Park, Toby. "A Menu for Change: Using Behavioural Science to Promote Sustainable Diets around the World." London, 2020. https://www.bi.team/publications/a-menu-for-change/.

[132] Thaler, Richard H., and Cass R. Sunstein. *Nudge: Improving Decisions about Health, Wealth, and Happiness*. Yale University Press, 2008.

[133] Park, Toby. "A Menu for Change: Using Behavioural Science to Promote Sustainable Diets around the World." London, 2020. https://www.bi.team/publications/a-menu-for-change/.

[134] Deliens, Tom, Peter Clarys, Ilse De Bourdeaudhuij, and Benedicte Deforche. "Determinants of Eating Behaviour in University Students: A Qualitative Study Using Focus Group Discussions." *BMC Public Health* 14 (2014): 53. https://doi.org/10.1186/1471-2458-14-53.

[135] Garnett, Emma E., Andrew Balmford, Chris Sandbrook, Mark A. Pilling, and Theresa M. Marteau. "Impact of Increasing Vegetarian Availability on Meal Selection and Sales in Cafeterias." *Proceedings of the National Academy of Sciences of the United States of America* 116, no. 42 (2019): 20923–29. https://doi.org/10.1073/pnas.1907207116.

[136] Campbell-Arvai, Victoria, Joseph Arvai, and Linda Kalof. "Motivating Sustainable Food Choices: The Role of Nudges, Value, Orientation, and Information Provision." *Environment and Behavior* 46, no. 4 (2014): 453–75. https://doi.org/10.1177/0013916512469099.

[137] Spencer, Molly, Cesar Cienfuegos, and Jean-Xavier Guinard. "The Flexitarian Flip™ in University Dining Venues: Student and Adult Consumer Acceptance of Mixed Dishes in Which Animal Protein Has Been Partially Replaced with Plant Protein." *Food Quality and Preference* 68 (2018): 50–63. https://doi.org/10.1016/j.foodqual.2018.02.003.

[138] Ibid.

[139] Spencer, Molly, Amalie Kurzer, Cesar Cienfuegos, and Jean-Xavier Guinard. "Student Consumer Acceptance of Plant-Forward Burrito Bowls in Which Two-Thirds of the Meat Has Been Replaced with Legumes and Vegetables: The Flexitarian Flip™ in University Dining Venues." *Appetite* 131 (2018): 14–27. https://doi.org/10.1016/j.appet.2018.08.030.

[140] Bianchi, Filippo, Emma Garnett, Claudia Dorsel, Paul Aveyard, and Susan A. Jebb. "Restructuring Physical Micro-Environments to Reduce the Demand for Meat: A Systematic Review and Qualitative Comparative Analysis." *The Lancet Planetary Health* 2, no. 9 (September 2018): e384–97. https://doi.org/10.1016/S2542-5196(18)30188-8; Park, Toby. "A Menu for Change: Using Behavioural Science to Promote Sustainable Diets around the World." London, 2020. https://www.bi.team/publications/a-menu-for-change/; Taufik, Danny, Muriel C. D. Verain, Emily P. Bouwman, and Machiel J. Reinders. "Determinants of Real-Life Behavioural Interventions to Stimulate More Plant-Based and Less Animal-Based Diets: A Systematic Review." *Trends in Food Science & Technology* 93 (July 2019): 281–303. https://doi.org/10.1016/j.tifs.2019.09.019.

[141] Liu, Karon. "How Do Restaurants Decide How Much to Charge?" *The Hamilton Spectator* (Ontario, Canada), July 30, 2019. https://www.thespec.com/life/food-wine/2019/07/30/how-do-restaurants-

decide-how-much-to-charge.html; Laube, Jim. "Restaurant Rules of Thumb: How Does Your Operation Measure Up to Industry Averages & Standards?" Restaurant Owner. https://www.restaurantowner.com/public/Restaurant-Rules-of-Thumb-Industry-Averages-Standards.cfm.

[142] A fourth town hall was scheduled for the UM-Flint campus for March 16, 2020, but the event was canceled due to university-wide measures that began to be put in place on March 12, 2020, to contain the COVID-19 pandemic. Our team attempted to distribute a survey to gather feedback from UM-Flint stakeholders, but we were unable to elicit responses.

[143] McMaster University Hospitality Services. "Choose to Reuse." https://hospitality.mcmaster.ca/app/uploads/2019/06/C2R.pdf.

[144] Some ideas were unclear, such as "Target companies U-M works with" (3 students).

[145] Planet Blue. "University of Michigan, Ann Arbor: Sustainability Goal Reporting Guidelines." 2014. https://docs.google.com/document/d/1kmofOkOQ8glzCUVFjglBUXseoS2VInEgFWyC18Hu05M/edit.

[146] Association for the Advancement of Sustainability in Higher Education. "The Sustainability Tracking, Assessment & Rating System." 2019. https://stars.aashe.org/participate/; The Sustainability Tracking, Assessment & Rating System STARS® v.2.2. "Food and Beverage Purchasing FAQ." 2019. https://docs.google.com/document/d/1Pkk3QkmdWpwkAg-aEL0hI5Bou8Ee0BAyCOH7zqzAvsc/edit.

[147] Heller, Martin C., Amelia Willits-Smith, Robert Meyer, Gregory A. Keoleian, and Donald Rose. "Greenhouse Gas Emissions and Energy Use Associated with Production of Individual Self-Selected US Diets." *Environmental Research Letters* 13, no. 4 (2018). https://doi.org/10.1088/1748-9326/aab0ac.

[148] United States Environmental Protection Agency. "Sustainable Management of Food: How to Prevent Wasted Food through Source Reduction." Last updated November 21, 2019. https://www.epa.gov/sustainable-management-food/how-prevent-wasted-food-through-source-reduction.

[149] The President's Committee on Landfill Waste Reduction. "President's Committee on Landfill Waste Reduction Recommendations Report." University of Michigan, 2015. http://sustainability.umich.edu/media/files/Landfill-Waste-Reduction-Committee-Report-2015.pdf; Larsen, Larissa, Kevin McCoy, Brad Detjen, Alysia Giatas, Sue Johnson, Margo Ludmer, and Breanna Shell. "Food Analysis: Phase I Report." In *Campus Sustainability Integrated Assessment: Interim Report*, sponsored by Graham Environmental Sustainability Institute and U-M Office of Campus Sustainability, 272–331. 2010. http://graham.umich.edu/media/files/CampusIA-InterimReport.pdf.

[150] Emerson. "Grind2Energy™." https://www.emerson.com/en-us/commercial-residential/grind2energy-food-waste-solution.

[151] Battiste, Micaela, Seth Buchsbaum, Andrew Eberle, and Harry Wolberg. "University of Michigan Waste to Energy—Feasibility Study for an On-Campus Biodigester." 2016. http://graham.umich.edu/media/files/dow/Dow-Masters-2016-Biodigester.pdf.

[152] MSU Today. "New MSU Anaerobic Digester to Supply Power for South Campus Buildings." 2013. https://msutoday.msu.edu/news/2013/new-msu-anaerobic-digester-to-supply-power-for-south-campus-buildings/.

[153] Environmental Protection Agency. "Michigan State University—East Lansing, MI." 2014. https://www.epa.gov/sites/production/files/2014-12/documents/msu_digester_agstar_site_profile_508_022614.pdf.

[154] Michigan State University. "South Campus Anaerobic Digester." 2013. https://www.egr.msu.edu/bae/adrec/feature/south-campus-anaerobic-digester.

[155] Battiste, Micaela, Seth Buchsbaum, Andrew Eberle, and Harry Wolberg. "University of Michigan Waste to Energy—Feasibility Study for an On-Campus Biodigester." 2016. http://graham.umich.edu/media/files/dow/Dow-Masters-2016-Biodigester.pdf.

[156] Michigan State University. "South Campus Anaerobic Digester." 2013. https://www.egr.msu.edu/bae/adrec/feature/south-campus-anaerobic-digester.

[157] Ibid.

[158] Battiste, Micaela, Seth Buchsbaum, Andrew Eberle, and Harry Wolberg. “University of Michigan Waste to Energy—Feasibility for an On-Campus Biodigester.” 2016. http://graham.umich.edu/media/files/dow/Dow-Masters-2016-Biodigester.pdf.

[159] Fishbeck, Thompson, Carr & Huber, Inc. “Ann Arbor Biodigester Feasibility Study.” City of Ann Arbor, 2017. https://www.a2gov.org/.

[160] A2Zero. “Ann Arbor’s Living Carbon Neutrality Plan March 2020.” 2020. https://www.a2zero.org/wp-content/uploads/2020/03/A2Zero-Carbon-Neutrality-Strategy_DRAFT_march-20-2.pdf.