UNC INSTITUTE FOR THE ENVIRONMENT

ENST 698—Environmental Capstone
Spring 2009

Campus Carbon Foodprint

Executive summary

This study sought to understand the carbon footprint of Carolina Dining Services (CDS), which is responsible for food purchasing and distribution at the University of North Carolina at Chapel Hill (UNC). The goal was to determine the total amount of carbon dioxide equivalent emissions (CO_2e) produced by CDS in one calendar year, to use this information to target the most carbon-intensive practices, and make recommendations for their reduction. This report focuses on the operations of the two largest UNC campus dining facilities: Lenoir and Rams Head dining halls.

Research suggests that agriculture is responsible for approximately 6% of the United States' anthropogenic greenhouse gas emissions. With nearly 40,000 students, faculty, and staff, UNC's campus dining halls may represent a significant addition to global carbon emissions.

A life cycle assessment provides a holistic view of the resource inputs and outputs at each stage of a product's life, as well as the associated impacts. This study adopts the cradle-to-grave model, which accounts for all processes associated with the life of a product, from raw material extraction through manufacturing and use, to disposal, because it represents the most comprehensive analysis of carbon dioxide equivalent emissions that feasibly could be performed.

Unfortunately, life cycle analysis of food systems as a research tool is in its relative infancy, so there are few standards in the way these estimations are made. The team reviewed recent literature before choosing two different frameworks for calculating the greenhouse gas emissions from food purchasing. They then gathered data on the types and amount of food purchased for campus and estimated the associated life cycle greenhouse gas emissions. They documented where they were unable to account for emissions and water and energy use, and where inconsistent or unavailable data limited the analysis. They assessed the impact of campus dining in terms of emissions resulting from the creation, processing, use, and disposal of food products; identified various categories of food as heavily represented food groups and as carbon "hot-spots"; and commented on the value and feasibility of other practices, including incorporating local and organic ingredients and low-impact practices into dining services.

Final Products included

1) A work plan and mid-term progress report
2) A set of datasheets and calculations that constitute an estimated carbon foodprint
3) This report, with methods, findings, and recommendations for greenhouse gas mitigation
4) A public presentation to the campus and community (in .pdf format)

UNC's Carbon Foodprint:
The Carbon Dioxide Equivalent Emissions of Carolina Dining Services

by

Rupert Campbell, Jonathan Carr, Madeline Gwyn, Maggie Newcomb, and Molly Rosett

Environmental Studies 698
Spring 2009 Capstone
6 May 2009

Table of Contents

Purpose/Goal

The purpose of this study was to determine the carbon footprint of Carolina Dining Services (CDS), the institution responsible for food purchasing and distribution for the University of North Carolina at Chapel Hill (UNC). The goal was to determine the total amount of carbon dioxide equivalent emissions (CO_2e) produced by CDS in one calendar year, and to use this information to target the most carbon-intensive practices and make recommendations for their reduction. This report highlights the operations of the two largest UNC campus dining facilities, Lenoir and Rams Head dining halls, and will be used to obtain a more complete view of the total UNC greenhouse gas emissions.

A life cycle assessment is a tool that provides a holistic view of the resource inputs and outputs at each stage of a product's life, as well as the associated impacts. Several life cycle analysis models exist that vary widely in scope and definition. The cradle-to-grave model accounts for all processes that occur within the life of a product, beginning with its creation from raw materials and ending with its disposal. Other models include cradle-to-gate, which examines all processes that occur up to the point at which a product is transported away from its original location, and cradle-to-cradle, which includes the recycling of a product for its eventual reuse[1]. The cradle-to-grave model was chosen for this study as it represented the most comprehensive analysis of carbon dioxide equivalent emissions that feasibly could be performed.

Every effort was made to capture the carbon dioxide equivalent emissions resulting from the creation, processing, use, and disposal of food products purchased by CDS. However, other emissions and water and energy use were not accounted for. Furthermore, while the cradle-to-grave carbon footprint of CDS completed in this study is as complete as possible, it includes several omissions due to insufficient or unattainable data. These adjustments are noted and explained throughout later sections.

The 2007 Greenhouse Gas Inventory and Retrospective[2] is the most comprehensive document to date concerning UNC greenhouse gas emissions. However, that report does not account for emissions produced by the delivery, consumption, and disposal of food. This study was conducted with the intent to fill this gap. Moreover, it aims to address student and community interest in sustainable food purchasing and food disposal practices by increasing the transparency of CDS operations. To our knowledge, a complete carbon footprint has not previously been performed at the university dining system level. This report was created with the objective of presenting a database and carbon footprint protocol that will simplify subsequent analyses of the food purchasing, use, and disposal system as practiced by UNC and other universities.

[1] http://www.epa.gov/nrmrl/lcaccess/lca101.html

[2] http://www.climate.unc.edu/GHGInventory

Literature Review

With the rising prevalence of environmental rhetoric, awareness of climate change, and sensitivity to peak oil, it is surprising to note that the field of carbon footprinting and life-cycle analysis (LCA) has a severe lack of empirical studies and data for food systems in the Americas. Globally, carbon footprinting and LCA have gained great momentum, but still a huge gap remains where empirical food studies are concerned. Furthermore, much of the information that does exist provides a contrast to commonly held perceptions.

To begin with, studies from Europe and America both indicate the minimal importance of food transportation emissions in the overall carbon footprint of a particular food item. Matthews and Weber argue that not only does public focus on "food miles" overlook the grander impacts of eating choices, but there is a severe shortage of empirical US studies of industrial food systems[3]

Similarly, environmental consulting firm Ecotrust emphasizes the difficulty in finding virtually any LCA studies of agriculture on American soil.[4] Instead, Ecotrust was forced to rely on foreign data, a phenomenon that will be discussed at length later. These two examples underscore the current trends in food-related awareness in the US, where there is a growing sensitivity to "food miles," a trend that actually puts critical focus on the wrong aspect of food impacts. Not only is there a lack in comprehensive empirical food LCA studies, there is very little awareness or momentum for such studies to appear in significant quantities.

Faced with an almost nonexistent field of data published in the US, Ecotrust relied heavily on European studies instead, which seems to be an LCA norm established internationally. While the US lags behind in LCA and footprinting research, several institutions and organizations in Europe have firmly established approaches and models for carbon analysis. Several public-private partnerships have produced comprehensive methodologies for LCA studies, even including food systems. For example, the UK Department for Environment, Food and Rural Affairs (DEFRA) works closely with businesses to raise green awareness, and has produced a publicly-available LCA rubric, the PAS-2050. In an effort to establish consistent practices, and make carbon analysis accessible to all, however, even DEFRA's models maintain a strong business-oriented approach, focusing more on energy and industrial processes, and lacking capacity to analyze an entire food system. Also, while providing a comprehensive rubric, DEFRA does not seem to maintain a public LCA database. This evidences the youth of carbon footprinting, particularly of food systems, and unlike in the US, this lack of data stems not from lack of awareness, studies or interest, but seems to stem more from the simple time delay from investment in new fields of study to their blooming.

Overall, while there are some outspoken voices in the US, there is virtually no comprehensive set of data or information for calculating US-based lifecycle analyses of food systems. What information and studies that have been performed are concentrated almost

---

[3] Matthews, Christopher; Weber, Scott. 2008. *Food Miles and Relative Climate Impacts of Food Choices in the US*. Environmental Science and Technology online. Downloaded April 30, 2009 from <http://pubs.acs.org/doi/pdfplus/10.1021/es702969f?cookieSet=1>

[4] Ecotrust. 2008. *Research Assumptions Methodologies and Analytical Results for a Low-Carbon Diet Calculator for Public Education*. Downloaded April 30, 2009 from <http://www.circleofresponsibility.com/uploads/documents/low_carbon_diet/research_assumptions_methodologies_paper_4_1_08.pdf>

exclusively in Europe, with a few outliers in places such as Japan[5], India[6] and New Zealand[7]. While fruitful studies of particular food groups exist, even amongst these there are no comprehensive data sets for holistic LCA of whole food systems. Consistency between data assumptions is very important, so the lack of standardized studies is detrimental to the comparability of future studies. Additionally, many of the studies and data available are not transparent in their assumptions and calculations, making the simultaneous use of multiple sources potentially inconsistent. Thus, while LCA has become well established internationally, there are still many shortcomings for the analysis of food systems, and a particular deficit in the US context for which there is no alternative.

To mitigate this deficit, certain assumptions and inconsistencies had to be accepted, the process and impacts of which will be discussed later in this report.

[5] Ogino, Kaku, Osada, Shimada. "Environmental Impacts of the Beef-fattening System with Different Feeding Lengths as Evaluated by a Life Cycle Assessment Method." *American Society of Animal Science.* 2004. <http://jas.fass.org/cgi/content/full/82/7/2115>

[6] Maraseni, Tek Narayan and Mushtaq, Shahbaz and Maroulis, Jerry. "Greenhouse gas emissions from rice farming inputs: a cross-country assessment." *Journal of Agricultural Science*, 147. 2009. <http://eprints.usq.edu.au/4972/>

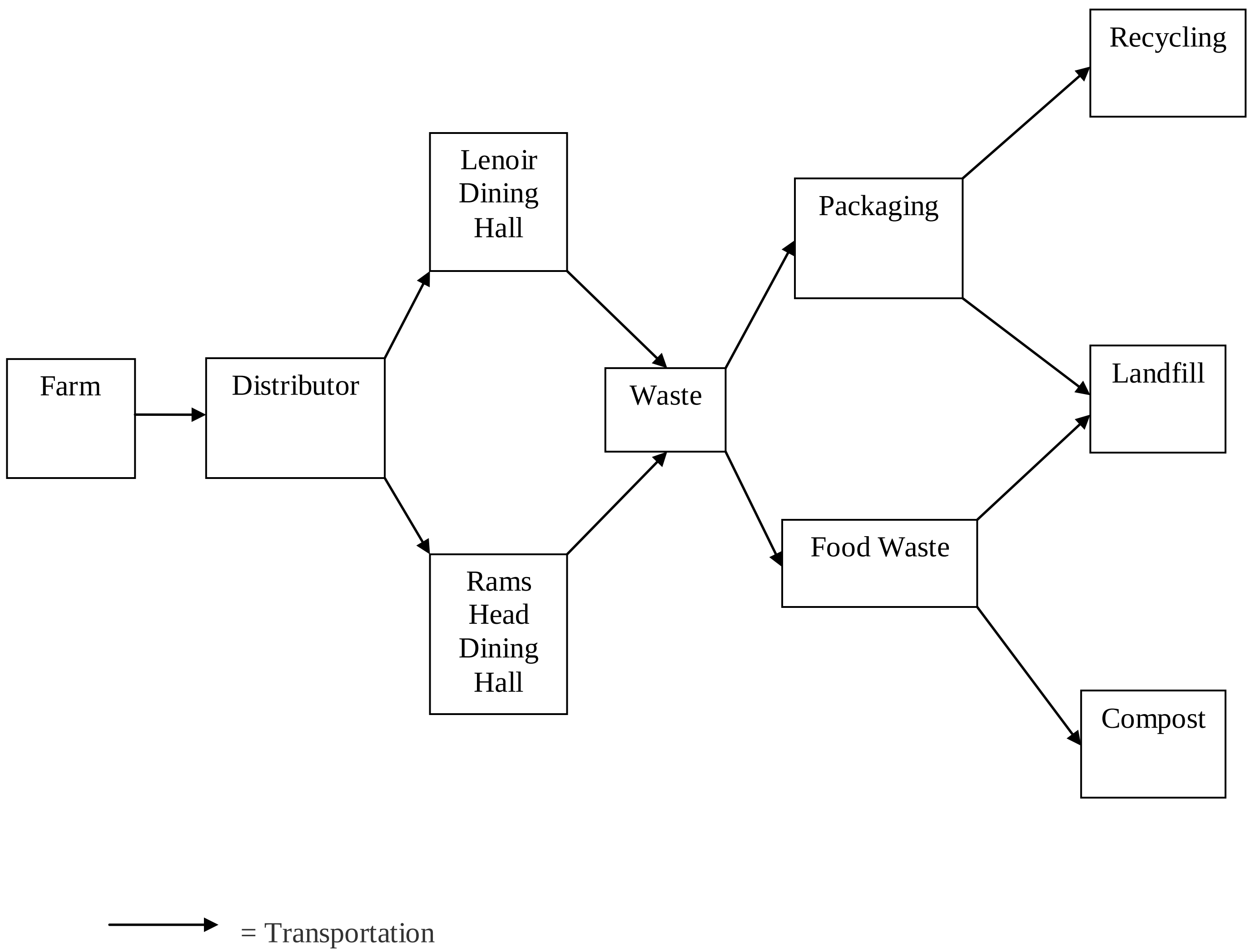
[7] "Meat and Wool New Zealand." *Environmental Stewardship*. <http://www.meatandwoolnz.com/download_file.cfm/Environmental_Stewardship.pdf?id=1928,f>

Process

To clarify the scope and parameters of a food-related carbon footprint study, there are three main Scope categories. Scope I involves direct emissions of a product, i.e., caused by the item itself, and is the narrowest approach to a carbon footprint. Scope II includes the energy demands of a product, for instance the carbon emissions of a power plant would be accounted for when measuring a building's footprint. Most carbon footprints keep within Scope II for pragmatic reasons, as it both accounts for a large portion of emissions, and is relatively specific in its parameters. Scope III, on the other hand, is the broadest and most nebulous Scope for a carbon footprint analysis. A much more involved LCA approach, Scope III would not only account for a power plant's emissions, but would examine where the coal was sourced, by what methods, with what transportation costs, and with what method of disposal. This perspective is particularly pertinent when considering agriculture and food systems, as much of emissions are only indirectly related to the foods themselves. This study utilizes the Scope III approach.

To provide a simplified visual guide of the food systems being analyzed, flow charts will be provided at each stage of this report. Each box indicates a major actor in a food product's lifecycle, indicating a source for which emissions were calculated. While the direction of the chart illustrates the flow of energy and materials from production to disposal, the arrows used actually represent added costs of transportation, which were also included in emissions totals. Part I, *Farm to Fork*, examines the agricultural production of foods, follows them through regional and local distributors, and ends with their delivery to CDS. The actual preparation and consumption of foods, as well as the heating, cooling and other emissions of the Lenoir and Rams Head buildings have already been accounted for and so are not included in this study, but remain on the flow chart as a crucial point in a food's lifecycle. Part II, *Dinner and Beyond*, focuses on the journey food, and its byproducts such as packaging, take after mealtimes, examining the transportation and emissions of local recycling, composting and landfill systems.

Food Systems Flow Chart



Part I: FARM TO FORK

Methods

The acquisition of raw data to compile inventories of food products used in both Rams Head and Lenoir dining halls was the primary step in analyzing the climate impact of UNC's residential dining services. CDS administrators Scott Myers, Bruce Eckmeder and Ricardo Rascon helped to compile inventories of food products ordered in the month of February. The majority of products came from Sysco, a food distributor in Durham, NC, with the remaining products from smaller, more specialized distributors: PET (milk products), Flowers (bread products), and Pepsi (soda and juice products).

Due to its lack of holidays or lengthy breaks, February represents a "busy month," ideal for creating a yearly snapshot of CDS operations. Two separate order lists were supplied by Sysco for the month of February, for Rams Head and Lenoir dining halls. Complete orders for one week in February were obtained from the remaining smaller distributors and these totals were multiplied by a factor of four to represent the entire month of February.

Each list provided specific package sizes, product weights, and quantities ordered over the month in the case of Sysco's reports, and over a week in the cases of PET, Flowers, and Pepsi. Most product weights were listed in pounds or ounces, which were then converted to kilograms. For liquid products reported as volumes, the specific densities were found and applied to convert each product's entry to a weight in pounds and kilograms.

Bon Appétit Database

The Low Carbon Diet Calculator[8] is an online, user-friendly tool developed by Ecotrust, an environmental consulting firm based in Oregon, for the Bon Appétit Management Company Foundation. Bon Appétit Management Company provides restaurant services to colleges, universities, and corporations nationwide, serving a total of 80 million meals per year[9]. This calculator allows users to determine the impact of their food choices in terms of CO_2 equivalent emissions. CO_2 equivalent (CO_2e) is a measure of the climate impact of various gases, including methane and nitrous oxide, expressed as the amount of CO_2 that represents the same global warming potential.[10] A point system is used in the calculator and assigns a certain number of "CO_2e points" to a four-ounce serving of food. One "CO_2e point" equals one gram of CO_2e emissions of greenhouse gases, and, where possible, accounts for the production, transportation, and cooking of each food product. The information provided in this calculator was used to develop conversion factors that allow for the translation of kilograms of food into kilograms of CO_2e emissions.

This database of information was chosen for its completeness, relative transparency, and consideration of European versus U.S. values. The Low Carbon Diet Calculator (referred to herein as "Bon Appétit database") includes point values for seven food categories, including meat, fish, dairy, produce, legumes, starch, and beverages. The Bon Appétit database also includes values for specific products within a category; for example, values are listed for beef

[8] http://www.eatlowcarbon.org/Carbon-Calculator.html

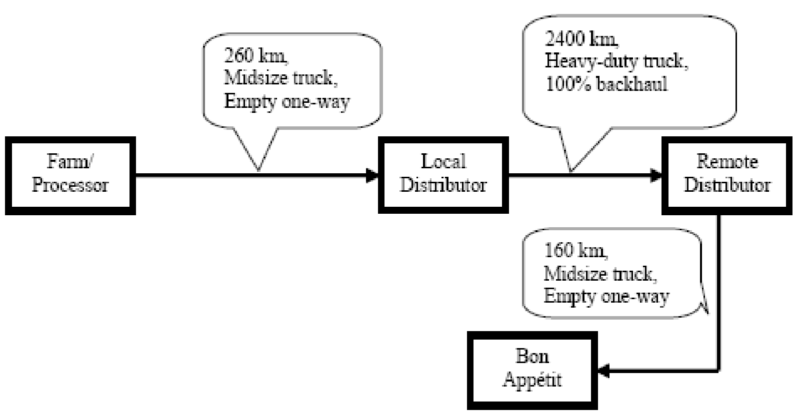
[9] http://www.bamco.com/news.35.htm

[10] http://stats.oecd.org/glossary/detail.asp?ID=285

tenderloin, prime rib, and steak within the meat category. Furthermore, this database acknowledges the impact of different production methods and transportation distances on the CO_2 e value for a single food product. To this end, the database provides CO_2e values for fresh and tropical fruit, seasonal and hothouse vegetables, and wild and farmed seafood. These distinctions allow the calculation of a more precise CO_2e value.

The data in this calculator is based on the results of a literature review of existing LCA studies that determined greenhouse gas emissions from food production systems. Due to the shortage of studies with comprehensive GHG emissions data for food, especially for food produced in the United States, several assumptions were made by the authors of the Bon Appétit Database. The majority of data was obtained from studies conducted on European food production systems, while CDS sources primarily U.S. produced food items. This discrepancy likely skews the results obtained using the Bon Appétit Database, although it is unclear how and to what extent this is the case. In general, "CO_2e points" include greenhouse gas (GHG) emissions from the production, transportation, and cooking of a food product. However, GHG emissions data for some food products has not been published; for these items, the point value reflects only transportation emissions, and is thus an underestimate of the true emissions. In calculating emissions from the distribution of food items, it is assumed that all U.S.-produced products are transported to the place of consumption by road. The Bon Appétit database assumes that food travels an average of 260 kilometers between its origin and a local distributor, an additional 2400 kilometers to a remote distributor, and finally 160 kilometers to Bon Appétit offices. Assumptions were also made about transportation vehicles and are noted in the following flow chart.

Figure 1.
Bon Appétit's summary of domestic distribution assumptions[11]

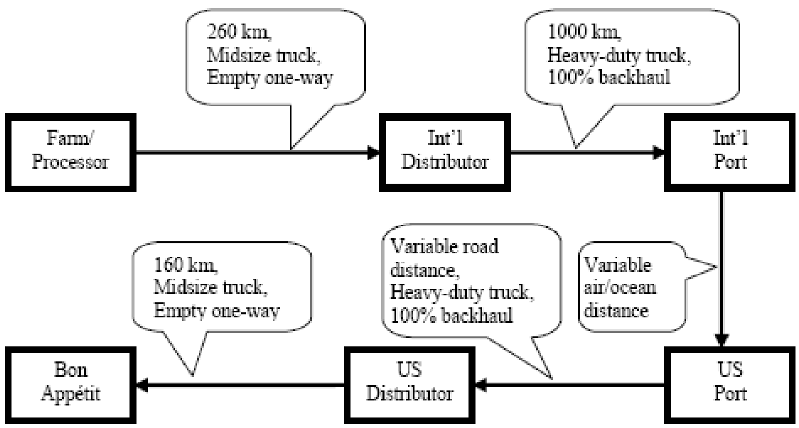


Bon Appétit further assumes that all seafood products originate in Asia, arbitrarily using Bangkok, Thailand as the place of origin for distance calculation purposes. Two transportation

[11] Scholz, Astrid. "Research assumptions, methodology, and analytical results for a low-carbon diet calculator for public education." 1 April 2008.

scenarios are considered for seafood–air and ocean. Strawberries are assumed to originate in South America (Santiago, Chile) and arrive at Bon Appétit via air transport. Assumptions concerning transportation vehicles and distribution processes are summarized in Figure 2.

Figure 2.
Bon Appétit's summary of international distribution assumptions[11]



While the Bon Appétit database is comprehensive and provides values for all major food groups, multiple concessions are made that introduce inaccuracies to the CO_2e values presented in this database. The authors note that the available data for some food items is not transparent enough to allow for the removal of the transportation emissions factor from the item's CO_2e value. Because a transportation emission factor is added to the CO_2e value of every food item in the Bon Appétit database, product transportation emissions may be counted twice for some foods. For products with more transparent data, European electricity emissions values were replaced with emissions for U.S. average electricity generation to bring these values closer to U.S. standards. However, such substitution was not possible for all food items, and thus the CO_2e value for many items reflects the production and farming systems used in Europe.

ProBas Database[12]

ProBas is an entirely public online database formed through cooperation between the German Federal Environment Agency and the private environmental research and consulting institution Öko-Institut (The Institute for Applied Ecology). This institute was founded in response to widely perceived environmental degradation, with the goal of raising awareness to stop and prevent further environmental loss. Under this rubric, the ProBas database claims to be serving the growing role of ecological awareness in society, and provides an extremely wide-ranging array of data, including a large assortment of food groups, with a large degree of transparency as to values used, sources referred to, internal assumptions and total values. However, the usefulness of the ProBas database is severely limited by lack of an English language interface.

[12] <http://www.probas.umweltbundesamt.de>

For those able to understand German, the database provides highly detailed entries for many foods, with a total database size of over eight thousand public values. Most food entries have multiple values, representative of at-field emissions, factory or processing values, and the environmental impact of food items found in stores (retail values). At the most basic at-field level, the inputs to each food are clearly explained, including fertilizers and pesticides by type (for instance nitrate versus phosphate fertilizers), followed by LCA-style output values, including CO_2, NO, CH_4 and many others. Finally, each value has two compounded CO_2e values, accounting for the product alone (generally quite low), and then an additional number accounting for all "upstream" values (factors like fertilizer and diesel tractors). This CO_2e value incorporates all outputs with Global Warming Potential, and converts them to an equivalent Carbon weight, providing an effective measure of comparison.

Scaling up from at-field values, each successive entry further adds processes to create a more comprehensive carbon value. For retail values, storage, cooling, heating and transportation are all included in the final output, with a clear statement for each entry stating the assumed travel distance by transit type. However, all values from basic to complex are fundamentally calculated with German, or at least European, values and assumptions, which create a potential inaccuracy for American clients. In particular, such disparities as differing modes of electricity generation, grid efficiency, agricultural "best practices," and treatment of livestock can make significant impacts on final outputs. Compared to well-received studies in the UK and Japan,[13] ProBas publishes much lower CO_2e outputs for many meat products for instance; for performing an LCA analysis it is more effective to use uniform data in order to provide fair comparison between products, at the expense of a lower total value. Thus for the scope of this project, ProBas was used as consistently as possible for all values.

A major reason for utilizing ProBas, despite language barriers, is the comprehensive nature of its database, and the transparency with which it publishes data. No other database has provided the transparency that ProBas maintains, which is key to understanding CO_2e hotspots. Additionally, aside from language differences, ProBas is designed with as user-friendly an interface as possible, which makes browsing and accessing the database quick to master, greatly helping efficiency in a large-scale project.

Database Assumptions

While the Bon Appétit and ProBas databases represent two of the most comprehensive and transparent LCA food data sources available, it was necessary to make certain assumptions in order to use this data in this study. Furthermore, inventory data obtained from CDS often lacked transparency and clarity, thereby introducing further uncertainties to calculations completed in this study.

Applying the "CO_2e point" system of the Bon Appétit database, food items purchased for use in Lenoir and Rams Head dining halls were classified into one of thirty-three categories. Items were assigned to the category corresponding closest to the food item itself or to the ingredient of which it is primarily composed. Each category has a corresponding point value, and an item's CO_2e value was obtained using this information. In designating each food item to a category, several assumptions were made. First, while the Low Carbon Diet Calculator contains point values for many items, many items purchased by CDS are not listed in the

[13] Fanelli, Danielle. "Meat is Murder on the Environment." *New Scientist.* 18 July 2007. <http://www.newscientist.com/article/mg19526134.500-meat-is-murder-on-the-environment.html>

calculator. To circumvent this problem, items were assigned to the category containing an item or items most similar in composition, production, and origin to the food item not listed in the Bon Appétit database. A complete listing of food category assumptions can be found at the conclusion of this report. For example, beef brisket and eye of round were assigned the point value corresponding to "steak." Similarly, pizza dough and pie lids were classified as "bread." The calculator provides values for only two pork items – pork chops and short ribs – so the average of the CO_2e values for these two items was applied to all pork items purchased by CDS. In this manner, it was possible to assign virtually every food item a representative category and CO_2e conversion factor. However, it is important to note that some food items were excluded from analysis. Because of their small carbon footprint and absence from both databases, spices and condiments were not considered in the calculation of CDS' carbon footprint. The exclusion of these food items is expected to have a negligible impact on the total CO_2e emissions.

Seafood items posed a particular challenge because of the limited information available from CDS inventories. Bon Appétit assigns a CO_2e point value to seafood items based on the production method, i.e., whether the seafood was farmed, wild caught locally, or wild caught far away. Inventories obtained from Sysco Food Systems do not supply information regarding the origin or production methods of seafood products, and thus this information remains unknown. It was assumed that salmon purchased by CDS was farmed, as the majority of salmon sold in restaurants was raised in high-density farms.[14] Catfish, tilapia, and whiting also were assigned the "farmed salmon" point value, as these items did not appear in the Low Carbon Diet calculator.

The Bon Appétit database divides both fruits and vegetables into two categories. CO_2e point values are listed for seasonal and tropical fruit, as well as seasonal and hot house vegetables. As previously stated, Sysco Food Systems sources food items nation and world-wide from numerous suppliers. The complexity of Sysco's food network coupled with a lack of access to specific records meant that it was not feasible to obtain this information for each food item purchased by CDS. Thus, the origin and production method of fruit and vegetables analyzed in this study remain largely unknown. Furthermore, it is understood that certain fruits and vegetables, regardless of their origin, are more energy intensive and require more water, fertilizer, pesticides, or land area than others.[15]. The Bon Appétit database does not list fruits and vegetables item by item, but instead uses an average value that is applied to all fruits or all vegetables. This method likely renders the CO_2e value for produce items inaccurate, although it is unclear how much so. Fruits were classified as "tropical" or "seasonal" based on the location at which the majority of that item is produced. Of the nearly thirty different fruits purchased by CDS, all were designated "seasonal" except banana, mango, melon, and pineapple. This system introduces uncertainties, as many fruits labeled "seasonal" likely have a CO_2e more similar to that of tropical fruit. Namely, two major inaccuracies potentially skew the data. First, the distances assumed for tropical fruits are much larger, yet "seasonal" fruits such as apples from Washington State also travel similar distances. Thus, considering the geographic location of North Carolina, it is likely that the "seasonal" category underestimates travel emissions. Secondly, as many fruits and vegetables are bought year-round, there is a strong likelihood that

[14] http://www.ewg.org/reports/farmedpcbs

[15] "An input-output energy analysis in greenhouse vegetable production: a case study for Antalya region of Turkey." Ozkan et al. 2003. *Biomass and Bioenergy*. Vol 26 Issue 1.

some were grown in hothouses, which contribute much more CO_2e emissions than seasonally grown produce. Yet lacking transparent invoice data, all produce was necessarily given the label of “seasonal”. This method is preferable to guessing which fruit and vegetables were grown where and how, providing a measure of consistency over haphazard guesses. Even so, this classification likely underestimates the true CO_2e emissions generated from vegetable production and consumption.

While this report does not strictly consider energy used in cooking processes in calculating a food item’s total CO_2e emissions, several point values taken from the Bon Appétit database do include this information. Where possible, point values for uncooked food items were used to exclude cooking processes from the item’s CO_2e emissions. Otherwise, point values corresponding to different cooking methods were averaged and applied to an item. For example, the CO_2e value used for “chicken” represents the average of that listed for fried and grilled chicken. Furthermore, many items purchased for use in Lenoir or Rams Head dining halls arrive frozen or canned. Canned and frozen foods carry a larger CO_2e value than fresh food because they must undergo additional processing. Except in rare cases, use of the Bon Appétit database does not allow for distinction between frozen, fresh, and canned food, and thus the additional CO_2e emissions resulting from processing many food items is lost.

The ProBas database, while more specific and transparent in its data and calculations, was also subject to assumptions much like the Bon Appétit database. At the broadest scale, all ProBas data is from Germany, which is important to bear in mind. Additionally, ProBas data entries typically retained two CO_2e values: a direct value, and a value including “upstream” outputs, such as fertilizers, pesticides and tractor use. In accordance with Scope III parameters of carbon footprinting, the upstream value was always used, to account for inputs and outputs indirectly incurred through the production process. Further assumptions were made by product category, and then per each food item classified.

With most values, ProBas provided multiple datasets, representative of “at source,” “in factory” and “retail” stages. As the final stage in a long supply chain, CDS food items were largely categorized as “retail” values, with small traveling distances of one to two hundred kilometers by truck typically included. In light of Sysco and other providers’ massive food networks, this is virtually insignificant in comparison to other factors, or even long distance travel. As such, it is reasonable to assume that even this “retail” value is either a close representation of food products at CDS, or still an underestimate of total emissions, rationalizing its use for most products, such as meat and bread.

A notable exception to the “retail” categorization is fruit and vegetable produce. For reasons noted above, knowing the source and production methods of produce is extremely difficult, so in order to provide a consistent array of data for future studies only basic categories were used. First, all food items were represented by the generic “fruit” or “vegetables” categories. Additionally, within this classification, only two specifications were used: at-field or canned. In a few cases a specifically named value was provided, for example, tomatoes, potatoes or strawberries, but these were principally outliers. The advantages and pitfalls of this approach are very similar to generalizing data with the Bon Appétit calculator, but the further disadvantage of these two categories is that virtually no transportation values are included. More significantly, while the vast majority of produce items were labeled with at-field “generic vegetable” values (a generic produce value similar to Bon Appétit’s), this creates data representative of students literally picking and eating their meals from the earth directly. In reality, this picture is a more accurate description of an ideal food system, and so is an entirely insufficient representation of the CDS and Sysco process. (The benefits for this CO_2e shortfall will be discussed more under future recommendations.) With the "canned fruit/vegetable" category, a similarly simplified food system is described, but the added outputs of collecting, washing, cutting and canning produce are described. Thus this category is used more liberally to represent any fruit or vegetables that are pre-washed, pre-sliced or canned, but still does not capture the whole industrial food process.

Regarding meat and seafood products, ProBas presented what appeared to be a strongly skewed set of data. This database includes only generic fish values and does not account for the differences in wild caught or industrially farmed fish. As a result, it is assumed all seafood is thus of generic type, and caught wild—a potential inaccuracy. A variety of data values were available for meat products, but the calculations used to develop them often lacked transparency. Specifically, aside from "beef," "pork" and "chicken," ProBas provided several "mixed meat," "sausage" and "frozen meat" categories, but did not explain their composition or animal source. However, invoices from CDS also included meat products of uncertain animal source, so in these cases either "mixed meat" or "sausage" values were used. In other cases, food items typically had a meat value to accurately describe them, yet the underlying issue is differences in German and US meat industries. Namely, compared to studies of industrial meat production from England and Japan,[16] as well as less empirical sources from the US,[17] ProBas meat values were as little as one-third of expected CO_2e outputs. For consistency, ProBas data was still utilized, but this example is indicative of the impact of wider assumptions such as these.

With other food items, often no specific category was available, so a process similar to that used for Bon Appétit was implemented. Namely, a category either related by major ingredient type or relevant in method of production was used. In particular, pasta and dough products were typically classified as uncooked bread due to ingredient overlap, while heavy creams and toppings for desserts were described as similar to butter due to production intensity and their highly processed nature. A small data hole of significance was vegetarian products, as this is a major standard against which meat products are compared. For many vegetarian products, including tofu and vegetarian meat patties, a generic soy bean value was used, which lacks much of the condensing and processing of tofu. While using this value does not capture the full CO_2e emissions of vegetarian products, it fulfills a role in still providing a rough measure of comparison. In very few circumstances, data holes were filled by different database values, but these values are clearly highlighted, and their usage avoided at all costs short of inputting nothing. These cases relied on different studies performed specifically as a carbon-related LCA of that food type, such as those referenced above from Japan and India. Relying on peer-reviewed publications in this way provides reliable data; however, relying on disparate sources for and study exacerbates the unevenness of parameters and assumptions across data sources, which is why such data was used infrequently.

Overall, whilst using both the ProBas and Bon Appétit databases, pursuing a less complex, straightforward approach was favored despite the resulting underestimate in CO_2e outputs. This method was used to provide a comprehensible system and value to work with in future studies, and provide a consistent and easily alterable, rather than a convoluted and esoteric,

---

[16] Ogino, Kaku, Osada, Shimada. "Environmental Impacts of the Beef-fattening System with Different Feeding Lengths as Evaluated by a Life Cycle Assessment Method." *American Society of Animal Science.* 2004. <http://jas.fass.org/cgi/content/full/82/7/2115>

[17] Environmental website – "eating 2lbs of beef like idling your car for 2 hours"; also Pollan?

product. Such a product allows for more specific and detailed studies to be conducted in the future to ascertain more accurate empirical numbers, while still providing a method for comparison between food groups.

These conversion values are listed in side-by-side columns and multiplied by the total weight in kilograms of each item to calculate a final CO_2e total. The final page of the spreadsheet reports the total weight in kilograms of CO_2 equivalencies for each dining hall, in the month of February, based on the two databases.

The next step was to extrapolate the data to represent yearly totals. Simply multiplying February's totals by 12 was not an option, for this would gloss over emissions due to seasonal breaks, holidays, and summer camps that occur throughout much of the year. Based on the university's academic calendar and opinions of CDS administrators, multiplying February's final totals by 8.5 gave a reasonable estimate of a complete calendar year's worth of carbon emissions for the dining halls. These totals are also listed on the final page of the spreadsheet.

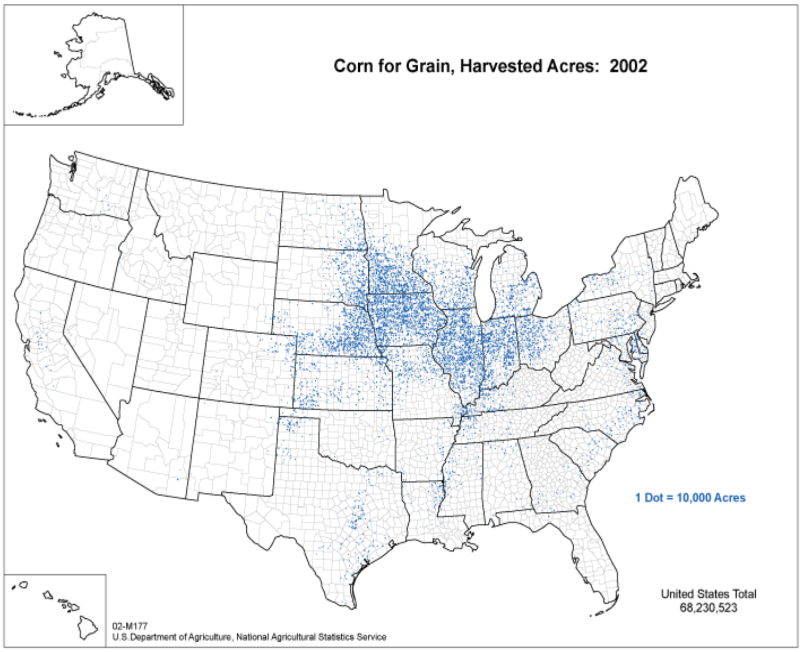
Transportation

As explained in the descriptions of the two databases, a key hole in the Probas calculation is the absence of transportation, while for Bon Appétit the transportation values lack accuracy. The lack of "food-miles" in the results provides a final CO_2e total that falls short of the true emission value, so another means of estimation was developed.

Locating the exact origin for each item included was not feasible for this study. Instead, a value of CO_2e emission totals from transporting staple items to Chapel Hill was roughly estimated. The US Department of Agriculture provided images of geographic densities for a number of these items; the map of corn for grain is displayed on the next page as an example[18]:

[18] US Department of Agriculture, National Agricultural Statistics Service

Figure 3.



The first step was to locate the center, or centers, of highest densities for each crop. For grain in the image above, the center location was Decatur, IL. The distance from Decatur to Chapel Hill was assumed to be the distance the grain items served in Top of Lenoir and Rams Head had traveled. Some items had multiple high density locations. In this case, the average of all the distances to Chapel Hill was used, for the exact original location of UNC's items remained unknown. All distances are listed in Table 5 of the following Results section.

Results

This report features an Excel spreadsheet that includes all the raw data acquired and the steps taken to calculate the final CO_2 equivalency totals. The format remains similar to the format presented in Sysco's reports. Below is an example of the spreadsheet format:

Food Name	Quantity	Weight/Quantity (lb)	Quantity Ordered / Week	Quantity Ordered / Month	Total Weight (lb)	Total Weight (kg)	Bon Appetit Conversion Factor (kg CO_2e/kg food)	Probas Conversion Factor (kg CO_2e/kg food)	Probas Total CO_2 Emissions (kg CO_2e)	Bon Appetit Total CO_2 Emissions (kg CO_2e)
Pork					0.00	0.00			0	0.00
Bratwurst	1	10		7	70.00	31.75	3.14	7.91	251.1540953	99.70
Chili, frozen hotdog	6	5		3	90.00	40.82	3.14	7.91	322.9124082	128.19
Frankfurter	1	10		29	290	131.54	3.14	7.91	1040.495538	1040.495538
Ham, boneless pit smoked	2	15		7	210.00	95.25	9.87	4.74	451.5058451	940.16
Ham, buffet boneless	2	8		7	112.00	50.80	9.87	4.74	240.8031174	501.42
Ham, buffet boneless	2	13		11	286.00	129.73	9.87	4.74	614.9079605	1280.41
Ham, diced	2	5		6	60.00	27.22	9.87	4.74	129.00167	268.62
Pepperoni, sliced	1	25		8	200.00	90.72	3.1	4.74	430.0055668	281.23
Pork, boneless Boston butt	10	6		15	900.00	408.23	9.87	4.24	1730.908484	4029.26
Pork, boneless loin	5	8		14	560.00	254.01	9.87	4.24	1077.009723	2507.10
Pork, spare rib	1	30		9	270.00	122.47	13.1	4.24	519.2725452	1604.36
Sausage, kielbasa rope	1	10		2	20.00	9.07	3.14	4.24	38.46463298	28.49
Sausage, link	1	12		25	300.00	136.08	3.14	7.91	1076.374694	427.28
Sausage, pork patty cooked browned	160	0.0625		8	80.00	36.29	3.14	7.91	287.0332517	113.94
Sausage, pork patty precooked	107	0.094		2	20.12	9.12	3.14	7.91	72.17451115	28.65
Total						1541.36			7707.96	13051.41
Lamb					0.00	0.00			0	0.00
Lamb, chop loin	1	15		3	45.00	20.41	17.9	17.4	355.1628257	365.37
Lamb, boneless leg New Zealand	6	3.5		3	63.00	28.58	17.9	17.4	497.227956	511.52
Meat, gyro slices	4	4		1	16.00	7.26	17.9	5.73	41.58534848	129.91
Total						56.25			893.98	1006.79

Column A lists the descriptive name of each product separated into groups. The first groups contain items from Pepsi, Flowers, and PET. The remaining categories break up the food items ordered from Sysco, including pork and lamb, as pictured above. The dark blue highlighting indicates frozen foods.

The next column, titled "Quantity," may seem to have some discrepancy between different products. The differences come from the many ways a distributor can choose to package the items based on its size or fragility. In some cases, the number listed in this column is the number of the particular food item contained in one package. In this case, the number listed in the next column, "Weight/Quantity," would be the weight of one of those food items. For example, above there are 160 "Sausage, pork patty cooked browned" in one package. One individual patty weighs 0.0625 lbs, as listed under "Weight/Quantity." On the other hand, link sausage is packaged in a different way, so its quantity and weight/quantity are listed differently. In this case, the number listed under "Weight/Quantity" is the weight of one whole package, 12 lbs. No matter how the packaging was listed, the total weights of the packages were accounted for.

"Quantity/Week" and "Quantity/Month" account for the amount of food ordered during the month of February. Only the items from Pepsi, Flowers, and PET have values listed for "Quantity/Week," because only a week's worth of these items was obtained. These figures were multiplied by four to obtain values for the “Quantity/Month” column. Sysco provided values for the “Quantity/Month” column, rendering “Quantity/Week” irrelevant.

By multiplying these three columns, (Quantity) X (Weight/Quantity) X (Quantity/Month), the total weight in pounds was calculated, and then converted to kilograms, by multiplying pounds by 0.45359237 kg/lb, shown in the next column.

The next columns, “Bon Appétit conversion factors” and “ProBas conversion factors,” list the carbon dioxide equivalent factors in kilograms/kilogram of food. The values come from two separate, published databases.

Table 1.
Lenoir Dining Hall Annual CO_2e Totals

	Food	**Bon Appétit**	**ProBas**
Category	**kg CO_2e/year**	**kg CO_2e/year**	**kg CO_2e/year**
Dairy	2981	157938.5	213656
Beef	3235	820250	391340
Pork	2154	124159.5	89717.5
Lamb	76	11594	11262.5
Seafood	1812	115676.5	48764.5
Eggs	1676	82892	27344.5
Poultry	4822	211157	142230.5
Fruits	8761	199274	21564.5
Vegetables	14523	93959	36966.5
Bread	4306	62177.5	22312.5
Potatoes	5752	49844	4547.5
Fats	2791	0	32929
Nuts	36	119	153
Tofu	427	11602.5	2788
Sugar	1373	28475	19813.5
Totals	**54725**	**1969118.5**	**1065390**

Table 2.
Rams Head Dining Hall Annual CO_2e Totals

	Food	Bon Appétit	ProBas
Dairy	**kg/ year**	**kg CO_2e/year**	**kg CO_2e/year**
Beef	2270	119187	198976.5
Pork	2206	481601.5	264061
Lamb	1541	112871.5	70397
Seafood	56	8559.5	7599
Eggs	538	18632	14008
Poultry	1560	77188.5	25466
Fruits	3428	149481	101889.5
Vegetables	11767	132277	37544.5
Beans	6545	46733	11441
Bread	1225	2184.5	3655
Potatoes	6935	90108.5	35173
Fats	5676	49716.5	4488
Nuts	1211	0	8806
Tofu	88	136	374
Sugar	41	1113.5	272
Totals	**1,046**	**22,899**	**26,120.5**

Table 3.
Pepsi , Flowers, and PET Annual CO_2e Totals

	Food	Bon Appétit	ProBas
Category	**kg/year**	**kg CO_2e/year**	**kg CO_2e/year**
Pepsi	14546	70839	166897.5
Flowers(bread)	5211	51382.5	24012.5
PET (milk)	20767	191513.5	137742.5
Totals	**101,654**	**313,735**	**328,652.5**

Table 4.
Annual Total for All Dining Halls and Providers (metric Tons annually)

Total Totals	Food	Bon Appetit	ProBas
Drinks(Pepsi)	14.546	70.839	166.8975
Bread(Flowers)	5.211	51.3825	24.0125
Milk	20.767	191.5135	137.7425
Dairy	5.251	277.1255	412.6325
Beef	5.441	1301.8515	655.401
Pork	3.695	237.031	160.1145
Lamb	0.132	20.1535	18.8615
Seafood	2.35	134.3085	62.7725
Eggs	3.236	160.0805	52.8105
Poultry	8.25	360.638	244.12
Fruits	20.528	331.551	59.109
Vegetables	21.068	140.692	48.4075
Beans	5.531	2.1845	3.655
Bread/Grains	11.241	152.286	57.4855
Potatoes	11.428	99.5605	9.0355
Fats	4.002	0	41.735
Nuts	0.124	0.255	0.527
Tofu	0.468	12.716	3.06
Sugar	2.419	51.374	45.934
TOTALS	**145.688**	**3595.5425**	**2204.3135**

Table 5.
Estimation of CO_2e emissions from food transportation

Staple Item	Location (appx)	Distance (miles)	Distance (km)	CO_2e conversion factor (kg CO_2e/km)[19]	Type of transportation	Total CO_2e (kg)
Produce						
Apples	Yakima, WA	2770	4457.88288	0.131	german truck	583.9826573
Asparagus	Cadillac, MI	840	1351.84896	0.131	german truck	177.0922138
Barley	Stanley, ND	1740	2800.25856	0.131	german truck	366.8338714
Blueberries	Elizabethtown, NC	130	209.21472	0.131	german truck	27.40712832
Broccoli	Fresno, CA	2600	4184.2944	0.131	german truck	548.1425664
Cherries	Traverse City, MI	880	1416.22272	0.131	german truck	185.5251763
Dry Beans	Cass City, MI	770	1239.19488	0.131	german truck	162.3345293
Grain	Decatur, IL	780	1255.28832	0.131	german truck	164.4427699
Grapes	Springville, NY	620	997.79328	0.131	german truck	130.7109197
Lettuce	Fresno, CA	2600	4184.2944	0.131	german truck	548.1425664
Nuts	Albany, GA	560	901.23264	0.131	german truck	118.0614758
Onions	Statesboro, GA	400	643.7376	0.131	german truck	84.3296256
Onions	Millen, GA	360	579.36384	0.131	german truck	75.89666304
Oranges	Avon Park, FL	700	1126.5408	0.131	german truck	147.5768448
Peaches	Allendale, SC	320	514.99008	0.131	german truck	67.46370048
Pears	Vacaville, CA	2800	4506.1632	0.131	german truck	590.3073792
Peas	Stanley, ND	1740	2800.25856	0.131	german truck	366.8338714
Pickles, Cucumbers	Milford, DE	360	579.36384	0.131	german truck	75.89666304
Potatoes	Pocatello, ID	2240	3604.93056	0.131	german truck	472.2459034
Rice	Pine Bluff, AR	880	1416.22272	0.131	german truck	185.5251763
Strawberries	Plant City, FL	700	1126.5408	0.131	german truck	147.5768448
Sugar	Zachary, LA	920	1480.59648	0.131	german truck	193.9581389
Tomatoes	Fresno, CA	2600	4184.2944	0.131	german truck	548.1425664
Wheat	Salina, KS	1200	1931.2128	0.131	german truck	252.9888768
Meats						
Beef Cows	Danville, KY	500	804.672	0.131	german truck	105.412032
Lamb	Midland, TX	1500	2414.016	0.131	german truck	316.236096
Milk Cows	Appleton, WI	980	1577.15712	0.131	german truck	206.6075827
Pigs	Greenville, NC	115	185.07456	0.131	german truck	24.24476736
Poultry	Gastonia, NC	160	257.49504	0.131	german truck	33.73185024
Turkey	Greenville, NC	115	185.07456	0.131	german truck	24.24476736

Total CO2e (kg)	6931.895224
Total CO2e (tons)	6.931895224

ProBas provides a CO_2e conversion factor of 0.131 kg of CO_2e per distance traveled in kilometers of a mid-sized truck. By multiplying this conversion factor by all the food distances, total CO_2e emission values were calculated, and listed at the bottom of Table 5.

[19] ProBas database

Figure 4.
Database Results Comparison

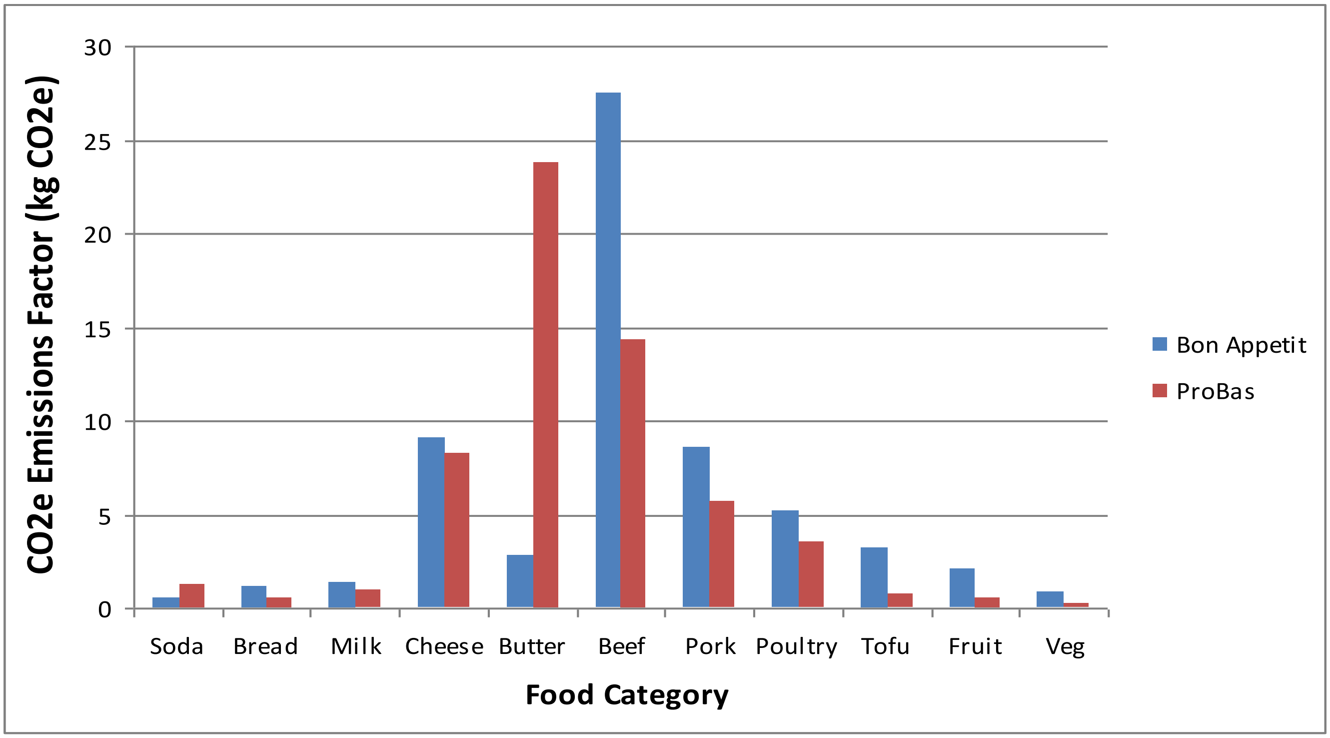
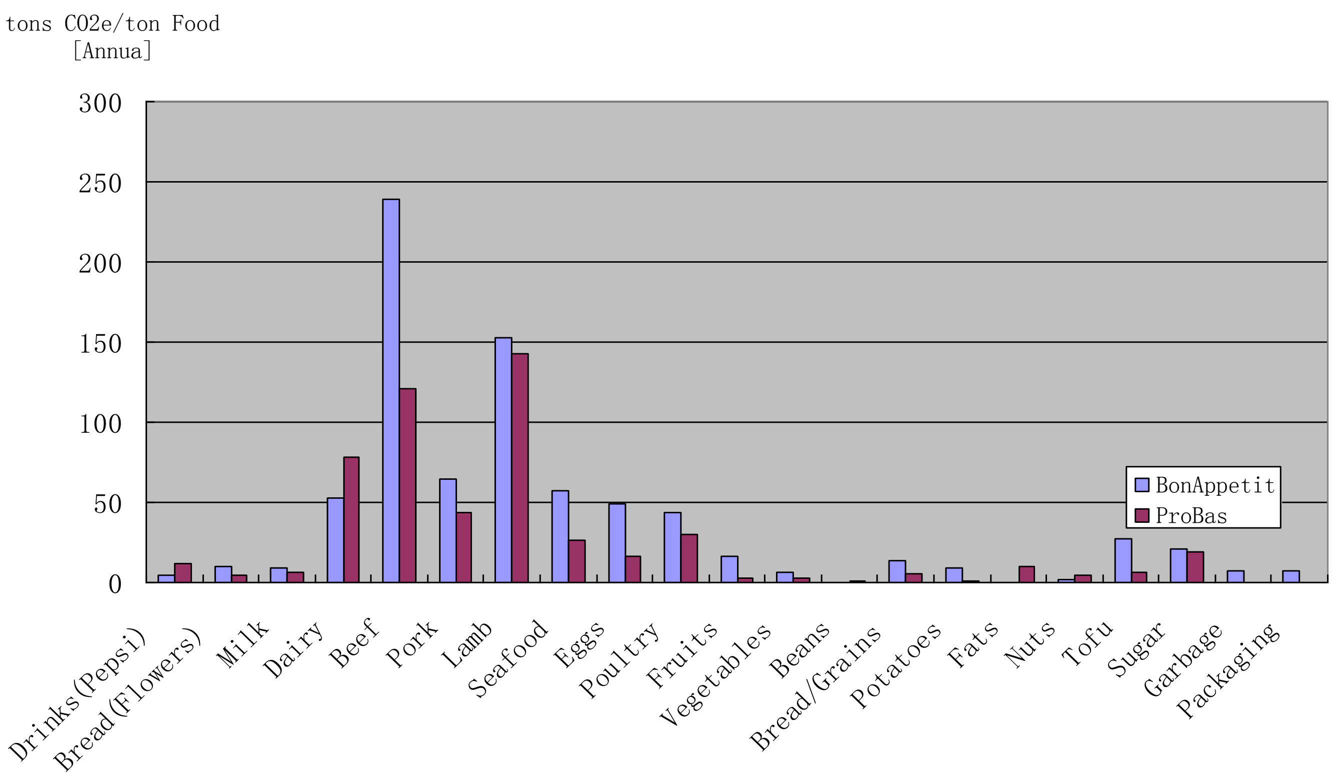


Figure 5.
Carbon Intensity for Various Food Products, Waste Processing, and Package Production



Conclusions

Each table above sums food quantities provided by CDS and multiplied out to represent a year's supply of that food, and the relative CO_2e from both databases used. Pepsi, Flowers and PET data was provided in separate invoices applicable to both Lenoir and Rams Head, so were calculated independently to avoid double-counting. Figure 4 compares annual kilograms of food to annual kilograms of CO_2e emissions according to ProBas and Bon Appétit databases. More detailed graphs can be found attached to the final spreadsheet, but all conclusions draw on the information are illustrated by Figure 4 and Charts 1 and 2. Specific values for information referenced are available in Tables 1 to 4, and in more detail in the attached spreadsheet.

Table 5 provides the CO_2e emissions from the transportation of staple items. The inaccuracies require that these estimates of emissions from food-miles not be added to the final CO2e emission total for CDS. Although these values only show the emissions due to one trip from the farm to UNC-Chapel Hill, it should be noted that transportation emissions have only a small significance when compared to other carbon intensive factors discussed in this report.

Overall, this data serves to illustrate current CDS practices and trends, rather than provide a concrete emissions total. From trends in comparing annual weight of food groups and annual CO_2e impacts according to two different databases, insightful conclusions can be drawn.

Looking at the annual food weights, a few groups are prominent in sheer quantity, but often those with the largest CO_2e impact are entirely different. By weight, vegetables, fruits and milk are clearly the most abundant food categories, closely followed by bread (bearing in mind there are *two* bread totals) and potatoes. As staples to a balanced diet, it is both unsurprising and reassuring that produce far and away constitutes the most purchased categories, while bread and potatoes are also unsurprising leaders. While milk is a fairly dense liquid, its leading annual tonnage is indicative of a Western diet, which is heavily dependent on dairy products. All of these groups are dietary staples, and so have a unique position in CO_2e analysis and reduction, which will be discussed later.

Contrasting to the "heaviest" food groups, entirely different groups can be identified as "carbon hotspots." Carbon hotspots are groups of food products that have unusually high CO_2e intensity per weight, that is, have the highest associated levels of emissions per unit of weight. Identifying hotspots is an effective initial carbon reduction measure, as these products provide the most dramatic impact reductions for the least reduction in actual weight of food. Figure 5 clearly depicts the most severe carbon hotspot according to both databases: beef. The CO_2e impact of beef is 3.6 times larger than poultry, the next most impactful category. The extremity of beef's impact is such that removing beef entirely would achieve more carbon reduction than eliminating all fruit, vegetables, pork, lamb, seafood, poultry and Pepsi products.[20,21] The next most severe carbon hotspots are poultry, closely followed by fruit according to Bon Appétit, while according to the ProBas database dairy is a much more carbon intensive value than both poultry and fruit. The drawbacks and advantages of this database discrepancy will be discussed later, but in any case, poultry and dairy can be established as carbon hotspots, both within the top four most intensive categories, if different per database.

[20] Using Bon Appétit values. Using ProBas values, removing all of those categories would achieve a reduction of 104 tons more than would removing beef. However, the specifics of ProBas' beef data will be discussed later.

[21] It would actually reduce about 8 more tons of CO2e/year than removing all of those categories would.

Along these lines, several categories jump out as carbon intensive food groups, while not necessarily being carbon “hotspots”. The difference is it would take a much more significant reduction in food purchasing to effect a truly significant reduction in carbon, or their annual quantity is so low their impact is less extreme. Groups with a consistently high impact across both databases include *all* meat products, dairy, eggs, and sugars. This categorization merely indicates that for each kilogram of such food types produced and consumed, a much larger quantity of CO_2e is produced. As both databases agree that these groups are generally more energy and CO_2e intensive, it is fair to conclude that this is where the bulk of CDS emissions is found, and so should be prioritized in reduction strategies.

At the other end of the spectrum, several food groups retain extremely high carbon efficiency, occasionally even incurring less CO_2e output than their annual weight. Vegetables, beans, bread, nuts, tofu and potatoes are the key low-carbon food groups. Interestingly, these are also several of the “heaviest” staple food groups mentioned above, indicating that a more traditional agricultural diet dependent on vegetable-based proteins, produce, carbohydrates and starches is essentially a much more carbon-friendly diet, transferring sun-generated food energy rather than oil- and corn-bred forms (such as beef). Overall, these groups have a very low emissions rate per kilogram of food, even those such as bread, which seemingly involve a large amount of energy (from crops into flour, then flour into dough, then the cooking process), or vegetables, which necessarily are often transported very long distances. Inherently these numbers tell us that despite large travel distance, the key emissions must be coming from somewhere else, as argued by Matthews and Weber above.[22] Even using the higher Bon Appétit number, vegetables incur less CO_2e than their annual weight, which is a very powerful statement for such a broad and multitudinous category. In contrast to picking out high-intensity food groups, these low-intensity food groups should be the focus for consumption and dietary needs, as their energy efficiency is much higher than for animal products, as partially illustrated by low relative CO_2e impacts.

From hotspots to high- and low-intensity food groups, there are a still a few outliers that cannot be included in these definitions. In particular, several food groups are subject to strong database conflicts, or are the victims of irreconcilable data holes. Some disputed high-intensity groups serve to provide a more nuanced illustration of their impacts, while resulting in less decisive conclusions than clear-cut categories. In this regard, Fruit is the key category under dispute, as ProBas reports an astonishingly low annual CO_2e output, while Bon Appétit’s is surprisingly high. The specific disjoint in play here will be discussed later, but for the purposes of analysis there is no way to mitigate such extreme unevenness. Other extremely different groups stem from unfortunate data holes. For example, no remotely representative value for Fats could be discerned from the Bon Appétit database, resulting in a zero value. ProBas, on the other hand, did have values for food items in the Fats category; however, they cannot be compared to an alternative database. A very small amount of values, namely sauces, flavorings and spices, had no related values whatsoever in either database, and so were not included in any category. Additional weight with no CO_2e value only serves to unnecessarily deflate impact totals, so instead these culled items are attached to the bottom of respective dining hall spreadsheets. Furthermore, the impacts of such values are most likely fairly negligible, especially within the rubric of comparing hotspots, high- and low-intensity foods, where only large differences are significant.

[22] See Literature Review section

The existence of large data holes – although almost all were effectively mitigated – serves to evidence the incomplete, adolescent nature of carbon footprinting of food systems. Using two databases was an effective measure taken to overcome this challenge, as well as provide other advantages in final data analysis. Considering Figure 5, many of the ProBas and Bon Appétit values are significantly different, but typically in a consistent direction, for example high- and low-intensity food groups all clearly demonstrate trends in one direction, high or low impact. This relative similarity renders the difference in concrete figures relatively insignificant, illustrating instead disparate assumptions and scopes of calculation. What this means is that in such cases both databases agree that the food item has high or low CO_2e outputs; however, one database might have an inflated number due to increased scope of factors, for instance transportation costs, seasonal versus hothouse grown produce, or corn versus grass fed beef. Similarly, in some cases one database produces a deflated number due to highly limited scope, neglecting many clear emissions sources. These disparate assumptions and scopes apply to literally all values, but a particular case in point is fruit. According to Bon Appétit, fruit is actually a very impactful product, while ProBas argues fruit is extremely low-impact. The key difference here stems from the fact Bon Appétit's calculations are geographically based in the Eastern United States, and take into account diverse factors such as tropical versus local fruit, and seasonal versus hothouse-grown, and also accounts for transportation. Naturally the emissions impacts of such fruits would be very different depending on how it was grown, and where, which Bon Appétit tries to take into account, resulting in a much higher (and likely more accurate) CO_2e total. ProBas, on the other hand, fails to account for any of these factors whatsoever, and only differentiates between fruits and vegetables as either "in-field" or "canned." Even using the "canned" values does not take into account the dramatic impacts of hothouse grown produce, or long-distance transportation, particularly if cooled. Furthermore, ProBas data values are based on German climate and geography, presenting inherent inconsistencies, while Bon Appétit adjusts to the US. Thus ProBas presents a much more homogenous array of data values that do not as effectively describe the multiple stages in fruit production and supply. By using largely "at-field" values, ProBas' CO_2e total illustrates more accurately a fictional scenario where all CDS patrons eat produce directly out of the soil where it is grown.

Even so, an inaccurate representation is still extremely useful, as it serves to better depict how assumptions each database makes *actually* manifest in data values, and how dramatic certain small changes actually can be. This is a major incentive to use multiple databases when carbon footprinting, as it takes the emphasis off one set of potentially flawed data, and provides a more nuanced portrayal of emissions impacts. While this method may be less desirable in an industrial or energy-oriented carbon footprint, where food is concerned, and given the status of current "foodprinting" literature and practices, relying on a single database for concrete values is veritably risky.

Part II: DINNER AND BEYOND

WASTE EMISSIONS

The focus of this study is on the CO_2e emissions associated with the food served by CDS. For Scope III analysis, it is also important to examine the waste processing practiced by CDS, and the CO_2e emissions resulting from them. Considering how much waste is produced by large dining facilities such as those on campus, it would be neglectful to ignore its impact. Discounting waste emissions would underestimate the true CO_2e emissions value associated with CDS.

Method

The first step of determining the CO_2e emissions associated with waste processing was to determine how much and what type of waste is generated by CDS. UNC's Office of Waste Reduction and Recycling provided these numbers (see "Amounts of Materials"), and categorized each waste type as one of four categories: garbage, cardboard, food scraps (as well as other compostable material, such as certain paper products), and bottles and cans.[23] Since records of these amounts were not available for after December 2008, comparisons determined at a meeting with CDS officials were used to project the numbers for January 2009 through June 2009. The months of September and February; October, November, March, and April; and January, May, June, July, and August were determined to be comparable in amount of traffic (and thus, food purchasing and amount of waste). So, for example, to calculate the tons of garbage generated for the month of January 2009, the amounts for July 2008 and August 2008 were averaged.

The next step was to find a calculator that could determine how much CO_2e would be emitted from land filling, recycling, or composting a certain amount of waste. The Environmental Protection Agency's WAste Reduction Model (WARM) is the most comprehensive, user-friendly, and transparent calculator that was found, and was created using a reliable method.[24] Using the WARM model, the annual and monthly emissions were calculated for the process of decomposing (in a landfill), recycling, or composting waste. From this data, the emissions factor per ton of garbage, cardboard, food scraps, and recycling was calculated. The WARM model also includes a variable for the transportation of waste from its original location to the facility that processes it.

Assumptions

The main assumption was that the months of September and February; October, November, March, and April; and January, May, June, July, and August actually are similar in amounts of traffic. Recycling bottles and cans was assumed to be comparable to recycling what the WARM model calls "mixed recyclables," as this was the most similar category that the WARM model offers as an option.

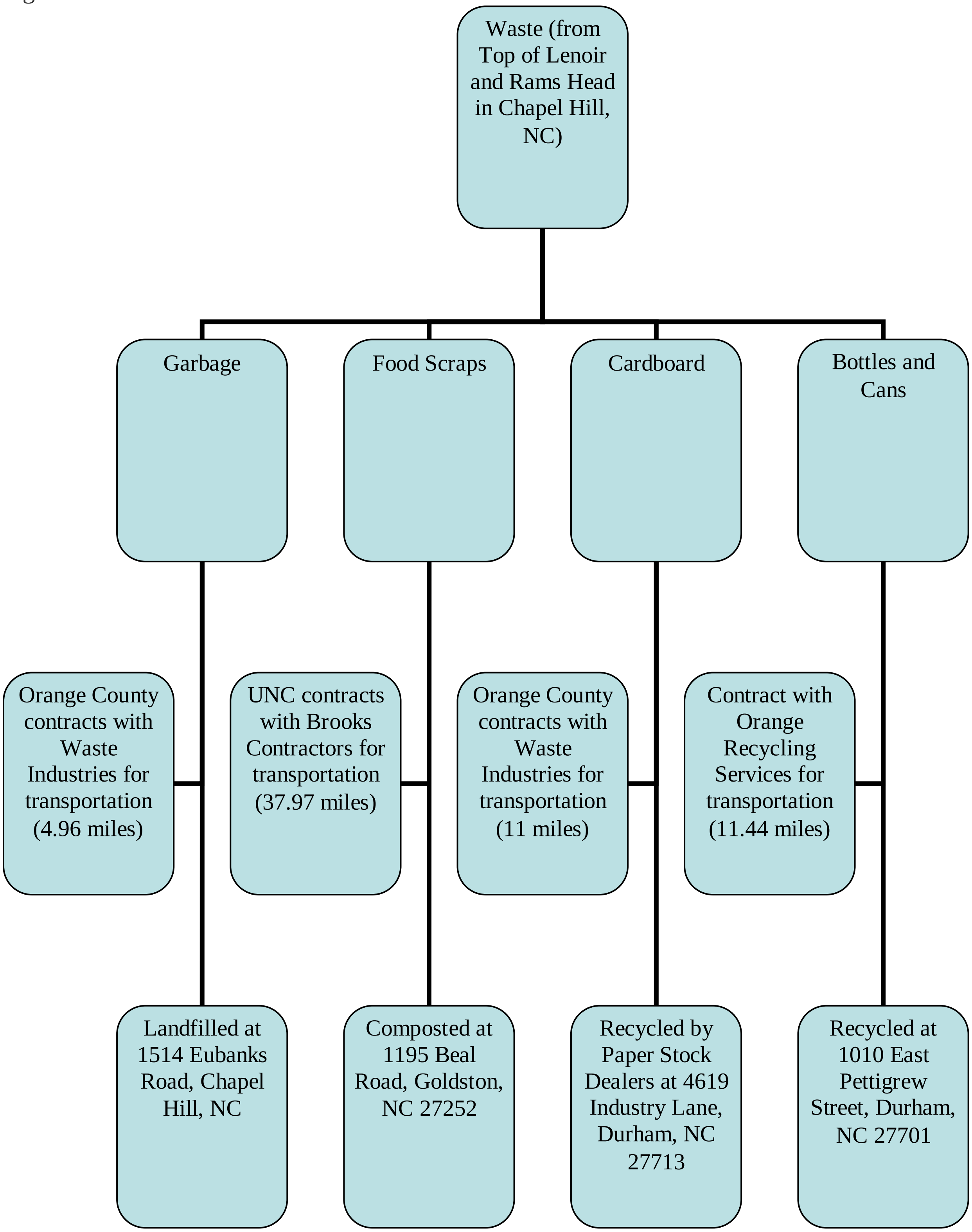
Using the transportation variable in the WARM model meant assuming that the types of trucks and fuels used in reality are similar to the types of trucks and fuels referenced in the WARM model.

---

[23] Alves, Amy and BJ Tipton. *Office of Waste Reduction and Recycling Fiscal Year 2008-2009 Trend Report.* p. 48. 9 February 2009. 28 April 2009.

[24] "Greenhouse Gas Emissions Sources: 2006 emissions ($MMTCO_2$e)." *Environmental Protection Agency*, (2006). April 30, 2009. http://epa.gov/climatechange/wycd/waste/calculators/Warm_home.html#click

Figure 6. Waste and its fate



Results

Amounts of materials (in tons) are shown in the following tables.

Table 6.
Top of Lenoir

Month	Garbage	Cardboard*	Compost	Bottles and Cans
July 2008	10.33	5.72	5.96	0.23
August 2008	13.07	10.29	17.12	0.08
September 2008	27.28	13.96	29.56	0.43
October 2008	35.22	7.63	30.08	0.94
November 2008	28.42	5.78	26.89	0.53
December 2008	11.54	3.71	14.60	0.31
January 2009	11.70	8.01	11.54	0.16
February 2009	27.28	13.96	29.56	0.43
March 2009	31.82	6.71	28.49	0.74
April 2009	31.82	6.71	28.49	0.74
May 2009	11.70	8.01	11.54	0.16
June 2009	11.70	8.01	11.54	0.16
Annual	251.88	98.50	245.37	4.91

*The cardboard compactor for Lenoir is also used by the Student Union

Table 7.
Rams Head

Month	**Garbage**	**Cardboard**	**Compost**	**Bottles and Cans**
July 2008	6.56	2.51	5.56	0.36
August 2008	9.49	5.63	8.55	0.32
September 2008	25.38	7.85	15.96	0.38
October 2008	15.84	13.72	17.82	0.75
November 2008	16.16	12.06	18.10	0.58
December 2008	10.32	7.03	8.11	0.41
January 2009	8.03	4.07	7.06	0.34
February 2009	6.56	2.51	5.56	0.36
March 2009	16.00	12.89	17.96	0.67
April 2009	16.00	12.89	17.96	0.67
May 2009	8.03	4.07	7.06	0.34
June 2009	8.03	4.07	7.06	0.34
Annual	146.40	89.30	136.76	5.52

Table 8.
CDS's Annual Total

Total waste by category	Garbage	Cardboard	Compost	Bottles and Cans
Lenoir	251.88	98.50	245.37	4.91
Ramshead	146.40	89.30	136.76	5.52
Total	398.28	187.80	382.13	10.43

Emissions from recycling, composting, and decomposition of materials (in metric tons of CO_2e) are summarized in the following tables, using the following factors for CO_2e emissions per ton: garbage: 1.34; cardboard: 3.12; compost: 0.20; bottles and cans: 2.88.

Table 9.
Emissions by Category

Emissions by source	**Annual**	**Equivalent to (#) of Cars on Roadway Each Year**	**Monthly Average**
Emissions from compost			
Lenoir	48	9	4.0
Rams Head	28	5	5.6
Total for compost	76	14	9.6
Emissions from garbage			
Lenoir	337	62	28.08
Rams Head	196	48	16.33
Total for garbage	533	110	44.41
Emissions from bottles and cans			
Lenoir	14	3	1.17
Rams Head	16	3	1.33
Total for bottles and cans	30	6	2.50
Emissions from cardboard			
Lenoir	307	56	25.58
Rams Head	278	51	23.17
Total for cardboard	585	107	48.75
Total for Lenoir	706		
Total for Rams Head	519		
Combined total	1225		

Total annual emissions are estimated at 706 metric tons for Lenoir, and 519 metric tons for Rams Head, for a grand total of 1,225 metric tons of CO_2e.

Conclusions
Overall, and not surprisingly, the processing of waste generated by CDS accounts for a significant portion of CDS's total carbon "foodprint."

Referring to "CO_2e Emissions per Ton of Waste," it becomes apparent that composting waste is significantly less carbon-intensive than land-filling it. Decomposing garbage creates significant amounts of "landfill gas."[25] Landfill gas is composed of about 50% carbon dioxide, 50% methane (a greenhouse gas roughly 20 times as potent as carbon dioxide), and non-methane organic compounds. Municipal solid waste landfills accounted for 23% of human-related methane emissions in the U.S. in 2006. The fact that the Orange County landfill does not utilize this landfill gas in any way to generate energy means that the gases are allowed to escape into the atmosphere, creating local smog and global climate change.[26] Composting garbage avoids the creation of these emissions, not to mention it allows matter to be reused productively, and reduces the need for synthetic fertilizers (which are CO_2e-intensive and are responsible for much ocean eutrophication).

Transportation to waste management facilities does not seem to significantly contribute to carbon dioxide emissions. However, this does not imply that transportation is negligible. Since the WARM model measures carbon dioxide equivalent emissions in metric tons (a relatively large-scale unit), transportation to the waste management facilities (which are located only five to thirty-four miles away from campus) simply may not be able to affect a number measured by such a large-scale unit.

[25] "Landfill Methane Outreach Program (LMOP)." *Environmental Protection Agency.* 22 April 2009. http://www.epa.gov/lmop/overview.htm. 28 April 2009.

[26] Some landfills have the capacity to capture, convert, and utilize landfill gas as an energy source.

PACKAGING EMISSIONS

In calculating the carbon footprint of CDS, it is important to consider the emissions due to packaging materials used to transport food to UNC. These materials are varied and abundant, and are used in both the food's transportation and preservation.

Method

Packaging materials and their specific quantities were found in the Office of Waste Reduction and Recycling (OWRR)'s Fiscal Year 2008-2009 Trend Report. The specific CO_2e conversion factors for the production of packaging materials in metric tons were taken from the Environmental Protection Agency's (EPA) WAste Reduction Model (WARM).[1]

OWRR provided numbers only from July through December 2008. Month-to-month averages, recommended by OWRR and CDS, wre used to calculate the quantities and CO_2 equivalencies for the remaining months. The values for July 2008 to December 2008 were averaged. The averaged value was used for the months of January, May and June. September values were used for February because CDS believes the two months usually have similar values. And the averaged values of October and November were used for March and April.

Database Assumptions

OWRR'S Fiscal Year 2008-2009 Trend Report was used to obtain the most accurate carbon footprint as possible for packaging materials used by CDS. OWRR's Fiscal Year 2008-2009 Trend Report, specifically page 48, is a record of the total waste produced by CDS from July 8, 2008 to December 8, 2008. The waste is grouped into specific categories and weights. It was assumed that specific waste materials and measurements listed in OWRR's trend report would provide an accurate representation of the types and total weight of packaging material that pass through CDS.

The packaging materials, based on recommendations from both CDS and OWRR, were divided into two categories: (1) cardboard and (2) bottles and cans. OWRR was unable to provide the exact percent composition of the bottles and cans. However, based on OWRR's recommendations and council, the category "Bottles and Cans" was divided into two sections: plastic, accounting for 80% and steel cans, accounting for 20%. The plastic was divided into three subcategories: HDPE 46%, LDPE 15%, and PET 40%. Because EPA did not provide CO_2e values for plastic, the plastic CO_2e was calculated by breaking down the total plastic value into three percentage-based categories. It was assumed that each subcategory's CO_2e could calculated using the above method and then added together to obtain a rough estimate of the total plastic CO_2e value. It was also assumed that the CO_2e value for steel cans could be added to that of plastic to produce the total CO_2e value for bottles and cans.

Results

Table 10.
Emissions from Production of Packaging (in metric tons of CO_2e) for Top of Lenoir

Month	Cardboard Quantity*	Cardboard CO_2 Equivalent	Bottles and Cans Quantity**	Bottles and Cans CO_2 Equivalent
July 2008	5.19	29.01	0.209	0.467
August 2008	9.34	52.21	0.073	0.165
September 2008	12.66	70.77	0.390	0.878
October 2008	6.92	38.68	0.853	1.920
November 2008	5.24	29.29	0.481	1.080
December 2008	3.37	18.84	0.281	0.632
January 2009	7.12	39.80	0.381	0.857
February 2009	12.66	70.77	0.390	0.878
March 2009	6.92	38.68	0.853	1.920
April 2009	6.92	38.68	0.853	1.920
May 2009	7.12	39.80	0.381	0.857
June 2009	7.12	39.80	0.381	0.857
Annual	97.70	546.13	5.910	13.29

*The cardboard compactor for Lenoir is also used by the Student Union

Table 11.
Emissions from Production of Packaging (in metric tons CO_2e) for Rams Head

Month	Cardboard Quantity	Cardboard CO_2 Equivalent	Bottles and Cans Quantity**	Bottles and Cans CO_2 Equivalent
July 2008	2.27	12.73	0.354	0.776
August 2008	5.11	28.55	0.290	0.653
September 2008	7.12	39.80	0.345	0.754
October 2008	12.44	69.56	0.680	1.530
November 2008	10.94	61.14	0.526	1.180
December 2008	6.38	35.64	0.372	0.838
January 2009	7.38	41.24	0.478	0.955
February 2009	7.12	39.80	0.345	0.754
March 2009	11.69	65.35	0.603	1.360
April 2009	11.69	65.35	0.603	1.360
May 2009	7.38	41.24	0.478	0.955
June 2009	7.38	41.24	0.478	0.955
Annual	96.90	435.05	5.550	10.710

**** OWRR was unable to provide an exact percent composition of the bottles and cans. The calculations and numbers used to get this number can be found at the end of this section[27]

[27]The below method was also used in the "Bottles and Cans" calculations for Rams Head dining hall. Based on OWRR's recommendations and council, the category "Bottles and Cans" was divided into two sections: plastic accounting for 80% and steel cans accounting for 20%. Furthermore, the plastic can be divided into three subcategories: HDPE 46%, LDPE 15%, and PET 40%. The CO_2 Equivalent calculation for Bottles and Cans, in the month of July for Top of Lenoir dining hall is displayed below to illustrate how the CO_2 emissions are calculated for the bottles and cans.

0.209 x 20% = 0.042 (Steel Cans) 0.042 x 3.19 (EPA value) = 0.133
0.209 x 80% = 0.167 (Plastics)

0.167 x 46% = 0.076 (HDPE) 0.076 x 1.8 (EPA value) = 0.137
0.167 x 15% = 0.025 (LDPE) 0.025 x 2.29 (EPA value) = 0.056
0.167 x 40% = 0.067 (PET) 0.067 x 2.11 (EPA value) = 0.141
Total CO_2 Produced = 0.133 + 0.137 + 0.056 + 0.141 = 0.467 metric tons

Table 12.
Total Emissions from Production of Packaging

	Cardboard Quantity (metric tons)	Cardboard CO_2 Equivalent (metric tons)	Bottles and Cans Quantity. metric tons	Bottles and Cans CO_2e, metric tons
Lenoir	97.70	546.13	5.910	13.290
Rams Head	96.90	435.05	5.550	10.710
Annual	194.60	981.18	11.460	24.000

Conclusions
The above tables display the quantities and CO_2e values of the two packaging categories of cardboard and bottles and cans for an entire year, starting from July 2008 to June 2009. The total for CO_2 equivalent emissions for the packaging material used by Top of Lenoir Dining Hall is 559.42 metric tons, while Rams Head dining hall used packaging responsible for 445.76 metric tons. Therefore, the CO_2 emissions from the packaging materials used by both dining halls total 1005.18 metric tons. Based on the assumptions made about the breakdown of bottles and cans and their resulting methods of calculations, the resulting CO_2e value for bottles and cans was surprisingly less than that for cardboard. If the values for bottles and cans are accurate, then it can be assumed that the production of plastics and steel cans is far less carbon-intensive than the production of cardboard. However, the above CO_2e values only account for the production of the packaging materials and do not address any other aspects of the packaging life cycle analysis. In other words, the CO_2e values for the disposal of the packaging materials or other negative externalities that result from the production or use of the material are not represented in the numbers above. For example, cardboard can be composted, which produces less CO_2 than other means of disposal. The entire life cycle analysis for cardboard might reveal that it actually has a smaller carbon footprint that plastics and steel can. Therefore, it is difficult to make recommendations based on the above numbers alone. However, based solely on the number above, the use of plastics and steel cans is less carbon intensive than the use of cardboard in packaging materials.

Part III: LOOKING AHEAD

Conclusion

The results and conclusions presented in sections I and II point to several key findings regarding the campus dining system at UNC and the worldwide food system as a whole. Based on calculations and processes detailed above, it is concluded that the total carbon footprint of Carolina Dining Services is 8,028.98 metric tons. Due to numerous data gaps and assumptions, the numerical accuracy of the total CO_2e emissions produced by UNC's food and food waste systems is uncertain. However, the analysis provided in this report allows for the identification of certain "carbon hotspots," or unusually carbon-intensive processes.

Results presented in Part II further highlight changes to CDS food purchasing and waste processing that would most efficiently and effectively reduce CDS's total carbon footprint. As meat products were demonstrated to emit the most carbon per pound, implementing changes in this category offers the most cost-effective means of reducing CDS' carbon footprint. Research presented by the University of Surrey concludes that while organic and local foods are widely considered to be the most environmentally-friendly option, consuming less meat products trumps both eating locally-sourced food and eating organically-grown food in terms of total CO_2e emissions saved.[28] Thus, a person can most effectively decrease the carbon footprint of their diet by eating a vegetarian versus a meat-eating diet. Furthermore, the results reveal that composting emits a mere fraction of the emissions associated with landfills. Therefore, every effort should be made by CDS to expand its composting program, as well as reduce food waste and garbage.

While the results of this report are presented in tons of CO_2e emissions, it is important to note that this unit does not capture the true environmental cost of the world's food system. In an analysis of ten foods by Cranfield University for the U.K.'s DEFRA, for all ten foods analyzed, nitrous oxide (N_2O) contributes more to global warming potential (GWP) than does CO_2, in some cases accounting for over 80% of a food's total GWP.[29] Considering only the CO_2 emissions of a product or process overlooks the myriad other environmental impacts that stem from the release of other harmful gases, including nitrous oxide. Emissions of N_2O have been associated with increased ocean eutrophication and deposition of acid rain, as well as climate change.[30] Nitrous oxide, while less abundant in the atmosphere than carbon dioxide, traps heat 310 times more efficiently than CO_2, making it a dangerous and important greenhouse gas.[31] The Cranfield University report further notes that while N_2O emissions are significant, there is little understanding of how to quantify this type of emission, and even less data relating N_2O emissions to food systems. Thus, while at present it is not feasible to conduct a nitrous oxide-based footprint analysis of the UNC campus dining system, the disadvantages of considering only carbon dioxide equivalent emissions should be noted.

---

[28] Brandao, Miguel. "Life-Cycle Carbon Emissions from Food Systems." 2008. University of Surrey

[29] Williams, Adrian. "Environmental Burdens of Agricultural and Horticultural Commodity Production – LCA." Cranfield University.

[30] U.S. EPA. "Health and Environmental Impacts of NOx". 2008

[31] U.S. EPA. "Nitrous Oxide". 2006

Recommendations

Targeted Approaches to CO_2e Reduction

The research and findings of this study illuminated several targeted improvements affecting a single sector of UNC's Campus Dining Services that can be made one at a time in order to gradually reduce the total amount of carbon dioxide equivalent emissions. These measures are "targeted," as they focus primarily on carbon hotspots and unnecessary carbon emissions. It is feasible for these recommendations to be implemented in a relatively short time period, and most of them do not require a monetary investment.

The first of these involves dramatically reducing the amount of beef purchased by CDS. Beef is the most carbon-intensive (emitting the highest level of CO_2e per volume) food product that CDS currently orders. Thus, it follows that decreasing the amount of beef, more so than any other food product currently ordered by CDS, would have the greatest impact on CDS' total carbon footprint. Thus, through reducing the amount purchased of only a single food item, CDS could significantly reduce its total CO_2e emissions.

The next step CDS could take toward reducing its carbon footprint is reducing the amount of other high carbon-intensity food products, namely other meats and dairy. High carbon-intensity products that also are unnecessary or don't play an important dietary role, such as soda, should be targeted to be reduced first. It seems that the most carbon-intensive products tend to be the most expensive as well, so the aforementioned steps would most likely save CDS money. An innovative idea explaining how to reduce CDS' purchasing of meat follows (see "Holistic Approaches to CO_2e Reduction").

Aside from reducing carbon intensive food purchases on the supply side, influencing behaviors on the demand side over the short term is also extremely important. Just as removing trays from the dining hall has led to unexpected reductions in food consumption and waste, discreetly altering food availability and choices is a very quick and easy way to reduce their consumption. While much of CDS already depends on food servers to provide portions, as a simple measure to effect reductions in wasteful consumption, transitioning further away from self-serve stations is highly recommended. By only providing limited portion sizes, servers reduce the amount of unnecessary food often taken by patrons. Of course, patrons would be allowed to come back for seconds if they were still hungry. In all likelihood, though, most patrons would be satisfied after a single "normal" serving. This initiative would reduce the amount of total food served (and thus, purchased, wasted, etc.) by CDS, since most people, when confronted with a self-serve station, pile more food on their plates than they actually need or want. This initiative would require certain sections of both dining halls to be remodeled, as well as hiring more employees to work as servers.

The last targeted improvement that CDS should strive to implement involves simply paying attention to the packaging that food arrives in; in particular, CDS should assess whether the packaging is excessive, or can be composted. While certain food products that come in less-than-ideal packaging (plastic wrap, for example, which is not compostable) may be necessary to buy, it is possible that others can be eliminated from CDS' menu or replaced with a substitute that is packaged in less material, or material that can be composted. Purchasing food packaged in compostable materials, rather than materials that must be thrown away, will significantly reduce CDS' carbon footprint.

Holistic Approach to CO_2e Reduction

The following initiatives would serve to increase awareness amongst CDS' patrons regarding how their food choices affect CDS' total carbon footprint, as well as their own individual carbon footprint. These initiatives would also serve to change behavioral patterns over time, hopefully causing CDS patrons to make more environmentally sustainable choices.

CDS should consider offering vegetarian-only meal plans, with the option at each meal to pay an added cost for meat products. In both Top of Lenoir and Rams Head, the layout is already conducive to such a distinction, as all meat products would simply have to be relocated to the grill and rotisserie areas. Before entering the meat section, each patron would be required to swipe their One card a second time, which would either charge to their tuition bill or debit from their Dining Flex account the appropriate amount determined by CDS officials.

The basic vegetarian meal plan could be cheaper than the traditional plans currently offered. This may not detract from CDS' revenue, since meat products are by far the most expensive products CDS purchases. Requiring a second swipe at the meat section would allow CDS to track the demand for meat products more accurately, which would inform CDS of the correct amount of meat to buy per ordering period. This would help CDS avoid purchasing excessive meat products, saving CDS money. The total cost of the basic meal plan (per meal) plus the added fee for meat products at a single meal could be approximate to the cost of CDS' current meal plan (per meal), although this is decision that would need to be made carefully.

Avoiding the purchase of excessive meat products would also reduce CDS' total carbon footprint. Furthermore, this initiative would help CDS avoid the creation of more waste, and the associated CO_2e emissions. This initiative would have the added benefit of not only reducing meat purchasing, but also meat demand. Many college students are money-conscious, and thus a monetary incentive to reduce one's consumption of meat would likely decrease the amount of meals at which he or she eats meat.

Another improvement for CDS to consider is expanding the use of reusable to-go containers. These were recently introduced to Rams Head and Top of Lenoir. Patrons can buy access to these containers for $3.50 per year, as opposed to using the traditional Styrofoam containers for free. In coming years, CDS should completely eliminate usage of the Styrofoam containers and offer the reusable containers at small or no cost. The money for this project perhaps could come from a small increase in student fees, assuming students would vote to pass this referendum. Until this initiative is implemented, CDS should replace the Styrofoam containers with biodegradable corn-based to-go containers, which can be composted (and even if they are accidentally thrown away, they biodegrade much quicker than Styrofoam). Boston's Northeastern University recently implemented this change.[32]

Large-Scale Approaches to CO_2e Reduction

A couple of improvements can be made to the CDS system to reduce its total carbon footprint, but would require a significant financial investment, as well as an overhaul of the system.

The University should establish space for the purpose of composting. While the transportation of food scraps to Goldston, NC (where they are composted) does not account for a huge portion of the emissions associated with the composting process, composting on-site would further reduce UNC's total emissions. This change would also save CDS money, since it will no

---

[32] Leahy, Kate. "SPECIAL REPORT: The Era of Sustainability." *Restaurants and Institutions.* 15 October 2008. http://www.rimag.com/article/CA6603586.html. 28 April 2009.

longer have to contract with a private company to transfer and compost its food scraps. Also, having an on-site composting center hopefully will allow CDS and UNC in general to expand the list of materials that it designates to be composted, diverting waste from landfills, and significantly reducing UNC's carbon footprint.

Middlebury College in Vermont recently implemented this practice.[33] While Middlebury College is a much smaller institution, the amount of food scraps composted there (300 tons per year) is comparable to the amount of food scraps composted at UNC (about 382.13 tons per year). Middlebury College uses a Passively Aerated Windrow System, which would be ideal for UNC. This system does not require actively turning the piles of compost, has low start-up and maintenance costs, reduces odors and pests, and requires little staff time or special skills. The only materials and items needed to implement this system on UNC's campus are an acre of land, a truck to transport compost from the dining halls, a food waste storage container, a concrete pad, manure, wood chips, and perforated PVC pipes. Manure could be obtained from local farms. The resulting compost could then be used for campus landscaping purposes, reducing, if not eliminating, the need to ship fertilizer to UNC, further reducing the University's emissions. Finally, if enough compost was made on campus, it could be sold back to local organic farmers, helping UNC actively sustain an alternative food system, and support local agriculture.

Finally, CDS could shift to purchasing more regional, native, and seasonal produce. Purchasing local food decreases the amount of emissions from transportation that a food product creates. However, at a meeting with FLO Foods and CDS officials, it became clear that farms within 150 miles (the standard definition of a "local farm") simply do not produce enough food to supply CDS with all the food products it needs to best serve the UNC community. But this does not mean that CDS should give up on reducing "food miles" altogether. Instead, CDS should take a regional approach to food purchasing, buying from the entire southeast region. As CDS currently purchases food from all over the country, this regional approach would help CDS lower its carbon footprint. Emory University has been practicing this approach to dining hall food-purchasing since 2003.[34] An added benefit of this regional approach, as opposed to a local approach, is that Emory has been able to be more flexible when choosing the farms it buys from, for example, dining officials could choose to patronize a very sustainable farm slightly farther away, rather than a local farm that does not use sustainable agricultural practices.

CDS also should commit to buying more native and seasonal crops. This means developing a menu based on crops that naturally grow in the region. For example, peanuts naturally grow year-round in the region, so should be more heavily incorporated into CDS's menu as a protein and flavoring option (while remaining an identified ingredient, so that peanut-sensitive diners can steer clear). CDS's menu also should change according to what grows best during the current season. An example of how CDS might do this is only offering apples from mid-August through late February, since this is the time period when they are in season. Crops require much less energy-intensive practices, such as building and maintaining a greenhouse, when they are growing in a suitable region and during the appropriate season. Thus, it follows that purchasing as many native and seasonal crops as possible would significantly reduce the portion of CDS's carbon footprint associated with actual agricultural practices.

---

[33] "Compost Happens at Middlebury College." http://community.middlebury.edu/~enviroc/compost.html. 28 April 2009.

[34] Carlson, Scott. "Colleges Chew on Local-Food Phenomenon." *Chronicle of Higher Education.* 26 September 2003. http://www.chronicle.com. 16 April 2009.

Future Directions

By analyzing the data found in this primary study and considering the recommendations made, we developed a number of proposals for a future UNC Institute for the Environment capstone project. While the spring 2009 group successfully quantified the approximate CO_2e emissions of the dining services, future projects could work toward a goal of improving the accuracy of this number, while pursuing approaches to reduce it.

With the completion of the spring 2009 study, a huge step has been taken toward a more comprehensive, replicable investigation of the food industry. However, as discussed before, certain data holes were inevitable, based on the current state of science in the field of carbon-footprinting food services. One notable hole is the lack of accurate "food-miles" incorporated in the final emission totals.

Firstly, as a direct continuation of this project, the next capstone group could partner with a for-profit company, such as a private consulting firm. This may allow the capstone group access to previously unattainable data. This group could focus on investigating exactly where each food item comes from before being shipped to Sysco, which will answer with more certainty the question—of great current interest to the public—regarding the impact of "food-miles."

The next idea requires working closely with Carolina Dining Services. Based on the data presented in this report, a capstone group could quantify the emissions from particular meals served at Rams Head and Top of Lenoir. The group could create a sample menu of dining hall meals, and calculate the emissions associated with these meals, adopting a more specific approach than could be achieved with the holistic scope of this study. The group would provide the dining halls with displays, similar to the nutritional displays currently in use, which would indicate to patrons exactly how their meal choices impact the climate.

Being constrained by time, this project did not include the creation of a carbon emissions calculator. UNC's dining services would certainly benefit from having a calculator based on the typical Lenoir and Rams Head menu. Requiring certain computer programming skills, a future capstone group could create its own calculator, similar to the online user-friendly calculator created by Bon Appétit. Those who prepare the meals could input into the calculator all the food items and respective quantities used, and then a total emissions value would be reported. To make the number more understandable to the everyday dining hall customer, the value could be reported in hours idling a car or distance traveled in a car. This would allow dining administrators and chefs to continue advertising carbon dioxide equivalent values no matter how their menus change over many years to come.

The emission quantities provided in this report alone may not offer enough evidence for CDS to make serious changes—the changes necessary for the campus to reach carbon neutrality. If this is the case, they may seek an additional study involving an investigation of eater behavior which could complement a project in the anthropology department. The project could begin with simply observing dining hall customers as well as creating surveys to learn why diners eat certain quantities of food and how they choose exactly what to eat. The project would focus on feasible, valuable recommendations for reducing the carbon footprint of food on campus. For example, proposing a practical, but different layout for the dining halls in order to reduce consumption and waste may be an outcome of this capstone project.