Sustainable Sustenance:
Greening Wellesley College's Food System

Environmental Studies 300 Capstone Course
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Abbreviations

AI – Active ingredient
ARMS – Agricultural Management Resource Survey
Bt – *Bacillus thuringiensis* (insect-resistant toxin)
Bu – Bushel
CAFO – Concentrated Animal Feeding Operations
CCD – Colony Collapse Disorder
CE – Carbon equivalent
CET- Center for Ecological Technology
CEO – Chief Executive Officer
CFSC- Community Food Security Coalition
CH_4 – Methane
CO_2 – Carbon dioxide
CO_2e – Carbon dioxide equivalence emissions
CSA- Community-supported agriculture
DEP- Department of Environmental Protection
DT – Desolventizer-toaster
EPA – Environmental Protection Agency
ERS - Economic Research Service
ES- Environmental Studies
ET – Evapotranspiration
FAO – United Nations Food and Agriculture Organization
FDA - Food and Drug Administration
GBDB - Green Bay Dressed Beef
GCAU – Grain-consuming animal unit
GE - Genetically engineered
GHG – Greenhouse gas
GPA – Grade point average
HT - Herbicide tolerant
IARC – International Agency for Research on Cancer
ID – Identification
IPM – Integrated pest management
IQF – Individually quick-frozen
ISO – Isopropylammonium
K_2O – Potassium-based fertilizer
K_2O_4 – Potassium Superoxide
kcal – Kilocalories
kWh – Kilowatt hours
LCA – Life cycle assessment
Ln – Natural logarithm
LP Gas - Liquid petrified gas
MJ – Megajoules
MSC – Marine Steward Council certified
N – Nitrogen
N_2O – Nitrous oxide

NH_4N – Ammoniacal nitrogen
NO_3N – Nitrate
NOAA – National Oceanic and Atmospheric Administration
P_2O_5 – Phosphorus-based fertilizer
PAN – Pesticide Action Network
PET – Polyethelene terephthelate
PHI – Pre-harvest interval
REI – Restricted entry interval
rBGH- Recombinant bovine growth hormone
rBST – Recombinant bovine somatotropin
SSOM- Source separated organic materials
UB-BR - Uncle Ben's Whole Grain Brown Rice
UN – United Nations
UNESCO – United Nations Educational, Scientific and Cultural Organization
USDA – United States Department of Agriculture
WF – Water footprint
WHO – World Health Organization
Whole C-CVP - Whole chicken controlled vacuum packed
WKC – Whole kernel corn
XL – Extra large

Executive Summary

This report evaluates the sustainability of the Wellesley College food system by assessing the environmental consequences of the foods we purchase and of how dining services prepares, serves and disposes of food. The first half of the report is on the impacts of foods dining services orders with regard to climate change, eutrophication, water use, biodiversity, toxicity, animal welfare and labor standards. Our analysis reveals that the two most effective actions Wellesley dining services can take are to decrease campus-wide availability of beef and highly processed foods.

We also recommend decreasing the purchase of animal products and switching to unprocessed vegetarian protein alternatives such as legumes; purchasing foods with certain environmental or ethical certifications; and prioritizing local seasonal foods. Wellesley dining services should also consider contracting with small-scale or highly transparent suppliers to ensure that dining services is well-informed and dealing with suppliers that are accountable for the environmental and social impacts of their operations.

The second half of the report looks at areas of environmental impact from actions taken on campus by assessing food waste, non-food waste from sources such as packaging or napkins, and water and energy use in the dining halls. We suggest potential options for the College to address these on-campus issues. These options include operational changes, composting and hyperlocal purchasing. To reduce food waste, we recommend providing appropriate tools to dining staff (such as apple corers) to reduce food waste during meal preparation. We also recommend increased utilization the Food Purchasing Optimization System and waste logs that are currently used by Wellesley dining services to minimize waste. Students can have significant impacts in this area by choosing to take only the food that they are going to eat.

To reduce non-food waste, dining services should consider ways to enforce the containment of dishware to the dining halls to decrease the amount of dishware that needs to be replaced, and purchase compostable dishware for times when reusable dishware is not an option. To reduce both food and non-food waste, appropriate receptacles should be made available in the kitchens and dining halls so that waste, compost and recycling can be easily separated. An accessible composting system should be established for use by students and staff and recycling should be made more convenient.

To reduce water and energy use, the College should improve metering to enable better identification and improvement of areas of high water and energy consumption. In the long term, the College should consider retrofitting dining halls to be more efficient and consider the environmental and social implications of the structure of the dining system.

These recommendations aim to help Wellesley College pursue its goal of supporting sustainability through the food system. We identify areas where the most positive impact can be made while keeping in mind the feasibility and practicality of our suggestions. We hope that the College will consider these recommendations with regard to future purchasing choices and actions taken on campus.

Introduction

The Sustainability Mission at Wellesley College calls upon the college community to consider sustainability as a factor in all institutional decisions.'[1] In 2009, as a partial fulfillment of this commitment, the College contracted with a dining service provider that demonstrated a clear dedication to sustainability: AVI Fresh. The AVI Sustainability website cites efforts to purchase food locally and seasonally, and to integrate sustainable practices such as recycling into its operations. But ultimately, the sustainability of AVI's operations in practice is either augmented or limited by its collegiate partner. Therefore, AVI's openness to sustainable practices still requires the Wellesley College community to define what sustainable dining means to us. This report offers an empirical analysis of Wellesley dining services' environmental impacts from procuring, preparing, consuming, and disposing of food to help construct a definition of sustainable dining in ways that minimize our contribution to several urgent environmental and social problems.

Rather than limit our focus to ameliorating a single environmental problem, we strive to reflect the nuances of a food's impacts by considering its contributions to a broad array of environmental and social challenges including climate change, eutrophication, water scarcity, biodiversity, toxicity, animal welfare, and labor exploitation. We make both issue-specific and broad recommendations across all factors, but leave readers to ultimately prioritize which of these environmental and social problems Wellesley dining services should address when making purchasing decision. Then we critically examine the purchasing options popularly considered synonymous with sustainable food systems, such as local and organic and make recommendations about how to employ these purchasing strategies in accordance with our environmental and social priorities.

We then look beyond food purchasing to evaluate the sustainability of campus dining operations in the preparation, consumption, and disposal of food. We conduct this analysis in the context of energy and water usage, food waste, and non-food waste. Finally, we consider several possible methods for reducing the dining halls' operational footprint that have a multiplicative effect (methods that address multiple problems at once), including composting, hyperlocal agricultural production, and centralized or swipe-in dining.

Any effort to come to a definition of environmentally sustainable dining that is meaningful for our community must consider Wellesley's unique context. For example, Wellesley's location near Boston, Massachusetts situates us next to 300 farms within a 30-mile radius.[2] Our convenient location makes locally produced food especially accessible. Furthermore, Wellesley students have demonstrated a strong interest in hyperlocal agriculture, establishing a small but thriving student-run farm on Weston Road. If we choose to prioritize local purchases, these characteristics, unique to Wellesley, make us well situated to pursue this strategy. In this spirit, our report highlights the strengths and values of the college, while simultaneously recommending fundamentally important goals that we must prioritize in order to measurably reduce the environmental impacts of our dining system.

Overall, dining halls are among the biggest contributors to the College's total environmental and social impacts. From food production on the farm to its disposal in an incinerator (or, better yet, a compost heap), food and dining represent a key area of focus if

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[1] Wellesley College Office of Sustainability. "Wellesley College: Sustainability." *Wellesley College*. 23 Sept. 2009. Web. 3 May 2011. <http://www.wellesley.edu/AdminandPlanning/Sustainability/>.

[2] MassGrown. "Massachusetts Grown...and Fresher!." *Mass.Gov*. n.d. Web. 3 May 2011. <http://www.mass.gov/agr/massgrown/map.htm>.

Wellesley wants to significantly improve the College's sustainability, however we may define it. Therefore, it is vital that Wellesley begin to set short- and long-term goals that minimize our dining halls' footprint.

Part I:
Food Analysis

Part I of the report evaluates the foods that Wellesley dining services orders and serves each year based on their contributions to a number of environmental issues. It is divided into three sections: Food Analysis, Additional Factors, and Recommendations.

In the Food Analysis section, we quantitatively assess the impacts of 29 foods that Wellesley dining services orders on three environmental problems: climate change, water use, and eutrophication. The Food Analysis section introduces the metrics that we use for our analysis, and then for each of the three environmental problems (climate change, water use, and eutrophication), it describes the problem and its causes, discusses the metric and methods that we use to measure the impacts of the 29 foods, introduces the grade system that we use, presents the quantitative data and grade results for each food, discusses and gives recommendations based our findings, and finally addresses the limitations and shortcomings of our data, data collection methods, and grading system.

The Additional Factors section qualitatively addresses other concerns that we consider to be important: toxicity, biodiversity, animal welfare, and labor. It briefly introduces each issue, explains why we are concerned about it, discusses foods or types of foods to which it applies, and suggests options that Wellesley dining services can choose to address the issue, including any certifications or labels that we recommend.

Finally, the Recommendations section synthesizes our findings and conclusions from the Food Analysis and Additional Factors sections into overall recommendations for practices we encourage Wellesley dining services to continue or change in its food decisions. These recommendations take into consideration the impacts of the 29 foods we examine on climate change, water use, and eutrophication as well as the recommendations for addressing toxicity, biodiversity, animal welfare, and labor.

1- Life Cycle Analysis

We evaluate the impacts that Wellesley dining services have on climate change, water resources, and eutrophication by conducting a life cycle assessment (LCA) of 29 food items ordered in large quantities by Wellesley College. An LCA compiles an inventory of the environmental impacts associated with each phase in a product's life cycle, and may include everything from the production of raw materials to the disposal of the final product when it is no longer in use. In our analysis, we begin the LCA with the production of raw materials, but truncate it when the food arrives at Wellesley College. We do not include the consumer and post-consumer aspects of the life cycle in our analysis because we focus on these aspects in the second part of the report. The set of food items included in our LCA includes multiple representative items from each category in the major food groups, as well as items frequently pegged as "environmentally unfriendly."

Activities that can potentially impact the environment, such as energy use, material inputs, land use, farming methods, and water use, are quantified in an LCA for two purposes:

First, quantifying results illuminates the areas of a product's life cycle that have a particularly high or low environmental impact. Decision makers who want to choose foods that are both affordable and sustainable need to understand the environmental impacts of foods at various stages of their life cycle. For example, by quantifying the impacts of a particular food in terms of agricultural inputs, processing, and transportation, we can evaluate whether switching to local or unprocessed foods will make a difference in overall climate impact.

Second, quantifying results allows for comparison between different products to see which products have the greatest or least overall impact on the environment. In our analysis, we give each food three grades (A – F) based on its impacts on climate change, water usage, and eutrophication related to fertilizer use. When switching to a more sustainable menu, decision makers can look at the grades across foods to find which foods are particularly resource-intensive or environmentally destructive, and alternatively, which foods have a low environmental impact.

Food Selection

For our analysis, we are choosing 29 foods that are representative of the thousands of different food items that Wellesley dining services orders every year. We take some of the largest orders by weight or volume, including potatoes, milk, beef and tomatoes. We then supplement our top orders with some foods that are representative of general categories. For example, wild-caught shrimp represents seafood and Cracklin' Oat Bran represents cereal. Lastly, we round out our selection with popular items such as vegan nuggets and hummus. For simplicity, we often analyze the most common or least processed iteration of a food (i.e. fresh tomatoes provide a baseline assessment for all tomato products such as canned tomatoes or ketchup). Although we sometimes choose specific brands, our analysis estimates a general order of magnitude that can be used for different brands of the same food. This allows our analysis to be useful for any supplier or brand that Wellesley dining services may employ. Our final list of items includes fruits, vegetables, various animal products, grains, beverages and processed foods. See Table 1or the complete list of products. Specific details for each food can be found in Appendix C.

Table 1: Selected foods

Apples
Baby Spinach
Bacon
Beef
Bottled Water
Brown Rice
Butter
Chicken
Chiquita Bananas
Chocolate Chip Cookie Dough
Coffee
Corn
Cracklin' Oat Bran
Cranberry Blast Concentrate
Cucumbers
Eggs
Frozen Raspberries
Hummus
Ice Cream
Milk
Mozzarella Cheese
Pineapple
Potatoes
Sunkist Orange Juice
Tofu
Tomatoes
Turkey
Vegan Nuggets
Wild-Caught Shrimp

Climate Change

Climate change is a pressing environmental problem that threatens the health of humans, animals, and entire ecosystems. Changes in weather patterns and average temperatures are driven by anthropogenic greenhouse gas emissions, and the global food system is responsible for an estimated *one third* of the world's total greenhouse gas emissions.[3] In the United States, the food sector accounts for 19 percent of the nation's total energy use,[4] and over fifteen percent of greenhouse gas emissions per capita.[5] Agricultural production, food processing and packaging account for about three quarters of the energy use associated with the food sector, and food transportation and preparation account for the remaining quarter.[6]

Wellesley dining services should aim to lower its carbon emission output and climate change impact by supporting food suppliers that sell items with low carbon "foodprints". To understand how Wellesley dining services rates on the climate footprint, this chapter evaluates the carbon impacts of the 29 foodstuffs and ranks them according to their carbon dioxide equivalence emissions or CO_2e (CE). We highlight the parts of each item's life cycle that generate the most greenhouse gas emissions, as this information is useful for making recommendations on sustainable food choices.

We use CE as the metric for calculating the total global warming potential of the production, processing, transportation and preparation of our food items. CE is an internationally recognized metric that consolidates the emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) into one metric based on the capacity of each gas to trap heat in the atmosphere. These three greenhouse gases represent the principal sources of climate-altering emissions from human activities. For example, methane is 21 times more effective at trapping heat than carbon dioxide, but methane emissions globally are significantly less prevalent than carbon dioxide.[7] Carbon dioxide is largely emitted from fossil fuel burning and land use conversion such as deforestation. Methane is emitted from enteric fermentation from livestock and rice cultivation. Nitrous oxide is emitted from nitrogen fertilizer and combustion of fossil fuel, and has a global warming potential 310 times more powerful than CO_2.[8] We convert all greenhouse gases into the common unit of CE emissions using the EPA calculator. We use grams as the unit of analysis for CE emissions because it is appropriate for the scale of food purchases analyzed.

Climate Change Methodology

In order to collect and calculate the data for this metric, we estimate the emissions of CO_2, CH_4, and N_2O from transportation, food production, processes that emit methane, and

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[3] Lappe, Anna. "The Climate Crisis at the End of Your Fork." *Sustainable Table*. n.d. Web. 8 Mar. 2011. <www.nyu.edu/sustainability/pdf/Climate%20Change%203%20FCSummit-HO-20091204.pdf>.

[4] Pimentel, David, Sean Williamson, Courtney Alexander, Omar Gonzalez-Pagan, Caitlin Kontak, and Steven Mulkey. "Reducing Energy Inputs in the US Food System." *Human Ecology* 36.4 (2008): 459-471. Print. 459.

[5] Kim, B. and Neff, R. "Measurement and communication of greenhouse gas emissions from U.S. food consumption via carbon calculators." *Ecological Economics*, 1. (2009): Print.

[6] Pimentel, D., and Paztek, T.. "Ethanol Production Using Corn, Switchgrass, and Wood and Biodiesel Production Using Soybean. Plants for Renewable Energy." *Hawthorn Press*. (2007): Print.

[7] Lappe, Anna. "The Climate Crisis at the End of Your Fork." *Sustainable Table*. n.d. Web. 8 Mar. 2011. <www.nyu.edu/sustainability/pdf/Climate%20Change%203%20FCSummit-HO-20091204.pdf>.

[8] Lappe, Anna. "The Climate Crisis at the End of Your Fork." Sustainable Table. n.d. Web. 8 Mar. 2011. <www.nyu.edu/sustainability/pdf/Climate%20Change%203%20FCSummit-HO-20091204.pdf>.

industrial processing. Our section on transportation takes into account the distance from the source of production, growth, processing, etc to Wellesley, Massachusetts and the possible methods of transportation such as truck, rail, plane, boat, etc We consider farm processes that impact the soil through mechanized and non-mechanized farming practices and inputs of fertilizer, pesticides, herbicides and water. We include methane emissions due to rice cultivation as well as enteric fermentation from beef and dairy cattle. Using the available information on how specific foods are farmed and processed with relevant literature, we are able to calculate CE emissions per serving using the equation below.

CE emissions/serving of food = *CE/serving from transportation + CE/serving from methane + CE/serving from farming practices + CE/serving from processing*

Transportation

The information used to calculate the CE emissions associated with transporting food items is generally provided by the individual food analyses. The miles a food item is transported are converted into grams of CE emissions by multiplying the miles a food is transported through each mode of transportation (ship, rail, or truck) by the grams of CE emissions per kilogram transported for those modes of transportation and by the kilograms of food transported.

Grams of CE emissions/serving of food *= (Miles food is transported by mode)x (grams of CE emissions/kilogram transported)x(kilograms of food transported)*

The CE for each mode of transportation is calculated based on the energy intensity (BTU per ton-mile) of each mode of transportation and the energy density of diesel, which we assume is used for all forms of transportation.[9] In the case of air transport, which is used to calculate the upper bound of possible carbon emissions associated with transportation, we assume that aviation fuel is used.

Where transportation is within the United States and by truck or rail, we calculate miles based on information provided by Google Maps.[10] Otherwise, distances are measured in Google Earth as a straight line (on land) or as a series of straight lines that do not cross over land (for ship transport). When more specific information is lacking, we assume foods are transported from the center of a region where they are grown. If foods are transported from multiple locations, we calculate a weighted average of food miles from each location based on the probable contribution from each source to the food item (based on information available in the individual food item analyses).

Our calculations omit some factors that would partially contribute to the emissions associated with transporting food items. We do not include the emissions associated with refrigeration or with the transportation of food packaging. For wild-caught shrimp, we also exclude the energy use of the trawler that harvests the seafood. Unless otherwise indicated, we assume that the shortest route possible is used to transport foods. Our estimate of emissions associated with transportation is likely to be an underestimate in many cases, particularly for

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[9] Davies, John. "Greenhouse Gas Emissions from Freight Trucks." *Technology Transfer Network Clearinghouse for Inventories & Emissions Factors*. EPA, 16 May 2007. Web. 7 Mar. 2011. <http://www.epa.gov/ttn/chief/conference/ei16/session5/davies_pres.pdf>; "Chemical Potential Energy."

[10] Google. "Google Maps." *Google Maps*. 2011. Web. 7 Mar. 2011. <http://maps.google.com/>.

foods that require refrigeration. On the other hand, we generally assume that food is transported by truck, unless otherwise indicated, which may inflate the CE emissions of transportation for foods that are in fact transported by rail.

Methane

Methane, a greenhouse gas with 21 times the global warming potential of carbon dioxide, is produced during the production of six of our foodstuffs: beef, milk, ice cream, butter, mozzarella cheese, and brown rice. Cattle and other ruminant animals emit methane through a digestive process called enteric fermentation. Enteric fermentation occurs in the rumen, a special second stomach unique to ruminant animals, in which microbes break down tough plants and grains that are indigestible by humans and other monogastric species.[11] Methane emissions per serving of food are calculated using the methane emissions' raw data provided in the individual food analyses for beef, milk, and brown rice found in Appendix A (Table 21). Raw data regarding beef and milk production per cow is also provided in the individual food analyses. All raw data is then converted into CE emissions per serving. The CE emissions per serving of milk is used to calculate the CE emissions per serving of the three other dairy products based on how many fluid ounces of milk are needed to produce one serving of the item.

Farming

Current farming practices create significant opportunity for the release of carbon dioxide and its equivalents through processes such as field preparation, tillage, irrigation, seeding, harvesting and the inputs of fertilizers, insecticides, herbicides and pesticides. Careful calculation of the carbon equivalent emissions for each of these practices is incredibly difficult for our course to complete on its own. Other researchers have calculated carbon equivalent emissions for various farming practices, herbicides, fungicides, insecticides and fertilizers.

Citing a paper by Lal, 2004, which gives CE for specific types of farming practices, fertilizers and other chemicals, we quantify the CE emissions for each food, drawing on the information given in the individual food analysis documents. [12] Categories for carbon equivalent emissions from farming supported in the Lal paper include methods of tillage, irrigation, and other miscellaneous farming practices including but not limited to herbicide spraying, combine harvesting and no till practices. (See Appendix A for carbon equivalent emissions and various methods of tillage, irrigation and farming practices) These carbon equivalent emissions are based per hectare and per million gallons of water. The carbon equivalent emissions for these categories are combined with the carbon equivalent emission totals per food for fertilizer, herbicide, fungicides and insecticide. (See Appendix A for further information on fertilizer and pesticide carbon equivalent emissions.) Total carbon equivalent measures are divided by the yield of the specific food per desired area (acre or hectare) to determine CE emissions per serving.

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[11] Environmental Protection Agency. "EPA - Ruminant Livestock - Frequent Questions." *US Environmental Protection Agency*. Web. 30 Mar. 2011. <http://www.epa.gov/rlep/faq.html>.

[12] Lal, R.. "Carbon emissions from farm operations." *Environment International* 30 (2004): 981-990. *Science Direct*. Web. 8 Mar. 2011. <www.sciencedirect.com>.

***CE emissions/serving** = [(acre x applicable tillage practices) + (million of gallons produced x method of irrigation) + (acre x applicable other farming mechanisms) + (kg of fertilizer applied x fertilizer CE) + (kg of herbicide applied x herbicide CE) + (kg of fungicide applied x fungicide CE) + (kg of insecticide applied x insecticide CE)]/ servings/acre or hectare*

Processing

The process of manufacturing common ingredients from raw materials harvested in the fields is one of the most energy-intensive portions of a food product's life cycle, along with primary production. Highly processed food items such as cranberry juice concentrate or chocolate chip cookie dough not only undergo processing themselves before they are ready for consumption, but their ingredients are also individually processed before they are added to the whole. As a result, processed food with many stages of production and a variety of ingredients create the largest footprint. Foods delivered to Wellesley dining services as raw or mostly fresh are exempt from this analysis.

Although information describing the processes by which ingredients are manufactured is readily available, little information is available regarding the carbon emissions associated with these processes. Therefore, we focus on the broad processes that demand a standard energy input, such as dehydrating or freezing the food. Among the most intensive processes are coffee roasting, chocolate manufacturing, and freezing.[13] We rely upon specific data when available, or equate the emissions of similar items where data is missing. For example, we assume that orange juice and lemon juice are processed in essentially the same way, thus emitting a similar level of emissions per kilogram. To convert between energy units (such as megajoules, kilocalories, or kilowatts) and emissions units, we derive an average emissions factor from EPA electricity data that compiles carbon dioxide, methane, and nitrous oxide emissions for regional generators across the United States (see Table 2).[14] We assume that fresh, whole ingredients such as apples, eggs, and baby spinach have negligible processing inputs. Finally, we consider the emissions generated during refrigeration to be negligible in the processing stage as well.

Table 2: Emissions conversions factors used in processing calculations

0.589477289	kg CO_2/kWh
0.000685562	kg CO_2/kcal
0.163849339	kg CO_2e/MJ

[13] Pimentel, David and Marcia Pimentel. "Food Processing, Packaging, and Preparation." *Food, energy, and society*. Rev. ed. Boca Raton, FL: CRC Press, 2008. 245-255. Print.
[14] Environmental Protection Agency. "eGRID2010 Version 1.0 Year 2007 GHG Annual Output Emission Rates." *EPA eGRID*. EPA, n.d. Web. 6 Mar. 2011. <www.epa.gov/cleanenergy/documents/egridzips/eGRID2010V1_0_year07_GHGOutputRates.pdf>.

Ranking System

The letter grade ranking system for the climate change impact of our foodstuffs is based on a hypothetical range of possible greenhouse gas emissions per serving. Beef production is generally considered the most greenhouse gas-intensive of all food items produced worldwide. Thus, we define our upper bound based on a hypothetical "highest conceivable value" of cradle-to-gate equivalent carbon emissions per serving of beef calculated as 2660 grams. We define the lower bound of this range as 0 CE (carbon-neutral).

In order to calculate the upper bound, we include all components from the set of activities we considered in the actual calculations of our 29 foodstuffs that could potentially be included in beef production, including production of corn feed (see Table 22 in Appendix A for complete list). The values for tillage operations, miscellaneous operations, and fertilizer and pesticide applications are based on the upper values in the ranges of carbon emissions provided in Lal's paper.[1] The values for water, methane, and processing are the same as the values used in our actual calculations for beef. We use these values because (1) they represent typical cradle-to-gate emissions for a serving of beef in the US, (2) it is reasonable to assume that beef production in the US generates high water, methane, and processing carbon equivalence emissions, and (3) our values are the best available hypothetical high values for cradle-to-gate emissions. The transportation upper bound value is calculated by assuming that the total food miles are equal to half the circumference of the Earth, and that all transportation is by plane.

Using the upper bound of 2660 grams per serving, we assign emission ranges to letter grades A through F based on a logarithmic scale. The bounds of the ranges and corresponding grade are shown in Table 3 below. Each food receives a letter grade based on the range of its CE emissions per serving. A ranking of an "A" corresponds with the lowest range of CE emissions per serving while a ranking of an "F" corresponds with the highest range of CE emissions per serving. Thus, A is the best and F is the worst.

Because CE emissions from beef are so much higher than any other foodstuff in our analysis, a grading system based on a linear scale would cause beef to receive an F and almost every other item to receive an A. A logarithmic scale allows us to show more variation across foodstuffs. While beef is by far responsible for the greatest amount of CE emissions, the variation in emissions of other food items is also important to consider.

Table 3: Range of grams of carbon equivalent (CE) emissions corresponding to each verbal rank of climate change impact

Range of grams CE	Grade
0-4.84	A
4.85-23.4	B
23.5-113	C
114-549	D
550-2660	F

Climate Change Data

Beef has the highest CE emissions, corresponding to a rating of an F. Potatoes, Cracklin' Oat Bran, Cranberry Blast concentrate and bacon all receive a low ranking of a D. Under this ranking system, the only food to receive an A ranking is eggs, while chicken and some fruits and vegetables such as tomatoes, pineapple, apples and cucumbers receive B ratings (Table 4).

Table 4: Total grams of carbon equivalent (CE) emissions associated with each food item

Food item	Transportation (g CE)	Processing (g CE)	Farming processes (g CE)	Methane (g CE)	Total CE (g CE)	Rank
Beef	9.886	1431	54.98	680.1	2175	F
Potatoes	20.65	171.3	27.19	0	219.2	D
Cracklin Oat Bran	4.493	151.6	2.739	0	158.8	D
Cranberry Blast concentrate	24.43	132.0	1.463	0	157.9	D
Bacon	1.515	56.99	67.71	0	126.2	D
Ice Cream	1.623	92.98	0.01180	9	103.6	C
Milk	3.648	64.12	0.01490	24	91.79	C
Hummus	4.113	68.56	2.913	0	75.58	C
Mozzarella Cheese	0.951	38.39	0.0224	36	75.36	C
Corn	3.508	61.35	3.170	0	68.03	C
Sunkist Orange Juice	23.25	21.05	11.66	0	55.96	C
Vegan Nuggets	3.237	32.74	7.826	0	43.81	C
Frozen Raspberries	0.959	38.35	3.959	0	43.26	C
Chocolate Chip Cookie Dough	3.916	35.02	1.962	0	40.90	C
Coffee	0.8358	35.43	0.8689	0	37.13	C
Tofu	9.626	17.02	0.1279	0	26.77	C
Brown Rice Whole Grain	5.308	6.986	2.899	11.2	26.39	C
Wild-Caught Shrimp	6.995	19.34	0	0	26.34	C
Bottled Water	2.100	22.26	0	0	24.36	C
Cucumbers	6.304	0	14.06	0	20.36	B
Turkey	2.127	6.314	9.936	0	18.38	B
Spinach	14.55	0	0.2882	0	14.84	B
Butter	0.016	0.3309	0.0003	10.97	11.31	B
Chicken	1.067	6	2.061	0	9.442	B
Tomatoes	7.927	0	0.9115	0.5642	9.403	B
Chiquita Bananas	6.239	0	1.296	0	7.535	B
Apples	5.683	0	1.145	0	6.828	B
Pineapple	3.863	0	2.759	0	6.622	B
Eggs	2.586	0	2.061	0	4.647	A

Using a log scale to assign rankings allows for the large range of CE emissions per serving to be represented in a way that reflects variation between foods on the lower end of the scale. Beef has 2175 g CE emissions/serving while eggs only have 4.647 g CE emissions/serving. Except for potatoes, which have high inputs of processing, transportation and farming inputs, most produce receive B ratings. Foods that release methane or have high CE emissions from processing tend to score worse based on this ranking system. In total, 1 food received an A ranking, 9 foods received a B ranking, 14 foods received a C ranking, 4 foods received a D ranking and 1 food received an F ranking.

Transportation

CE emissions associated with transportation are highest for Cranberry Blast Concentrate, Sunkist orange juice, and potatoes, all of which have between 20 and 24 grams CE. The transportation emissions for the juices are in part due to the weight of the serving. If the juices are transported in concentrate form, then transportation emissions are lower. Potatoes have a high CE value because they are transported long distances by truck, a form of transportation that is inefficient compared to rail and ship. Spinach is transported a longer distance by truck, but a serving of spinach is about half the weight of a serving of potatoes, contributing to its lower emissions. Heavy food items, such as potatoes, should be purchased as locally as possible. Based on these results, it seems that emissions can also be reduced if these food items are transported by rail instead.

Butter has the lowest CE value for transportation due to a small serving size and a short transportation distance (292 miles). This suggests that foods served in small quantities (about 1 tablespoon) do not have a significant transportation impact per serving. Mozzarella cheese and frozen raspberries follow butter, with values less than 1 gram CE. For cheese, this is because we assume that it was transported by rail. For raspberries, the low emissions are attributable to a combination of a short transport distance (327 miles) and small serving size, in terms of weight. Other items transported short distances (less than 300 miles) include bottled water, milk, and butter. The CE emissions of milk and water transport are four and two times higher than raspberry transport, respectively, because of the weight of a serving. This again demonstrates the impact of food weight on transportation emissions.

Methane

Butter has the highest methane emissions per serving (702.0 CE), followed by beef (680.1 CE), mozzarella cheese (36.0 CE), milk (24.0 CE), rice (11.2 CE), and then ice cream (9.0 CE).

Of all the dairy products, butter has the highest methane emissions per serving because its serving size is particularly small (1 teaspoon), yet it requires more milk to produce than any other food item, with over 230 fluid ounces of milk needed to produce just one serving of butter. Methane emissions from a serving of mozzarella cheese are twenty times less than methane emissions from a serving of butter because only twelve ounces of milk are needed to produce a serving of mozzarella cheese. Ice cream only requires 3 fluid ounces of milk per serving. As a result, methane emissions from a serving of ice cream are almost 80 times less than the methane emissions from a serving of butter.

More significant than the methane emissions per milk product are the methane emissions from milk and beef. A beef cow emits almost twice as much methane per year as a dairy cow, while the number of servings of beef from one cow is only 1/16 the number of servings of milk a dairy cow produces over a lifetime. As a result, methane emissions from a serving of beef are over 28 times the methane emissions from a serving of milk. This figure helps to explain why the CE generated during the life cycle of a serving of beef are so much higher than those of all other food items in our analysis.

Because beef production and butter generate such a high proportion of methane emissions compared to other food items in our analysis, two ways that the college can significantly reduce the impact of its food purchases on climate change is to order less beef and less butter.

Farming

For farming processes, bacon, beef and potatoes have the highest CE emissions of the 29 foods in our report. Potatoes, cucumbers and orange juice are the highest non-animal protein sources of CE from farming. Milk, butter and ice cream have comparatively small CE emissions. The foods that have higher CE emissions have high inputs of pesticides and chemicals to prevent disease and increase yields. The CE emissions are high for each serving of beef or bacon because these animals consume significant amounts of water and corn, as well as release methane emissions. Foods with lower CE emissions have fewer inputs and lower water requirements. When looking at the CE emissions from farming, consumers should not purchase or limit purchases of red meats and steer clear of produce and fruits with high inputs of chemicals and fertilizers. Purchasing foods with labels that specify fewer inputs or foods that are generally tougher or more resistant to damage from pests or disease will lower the climate impacts of the foods we eat.

Using CE calculations to evaluate farming practices requires significant amounts of guesswork regarding the actual techniques used. Analysis for almost all the foods should include a CE for tillage. The actual grams CE could range anywhere from 2 grams CE for rotary hoeing to 15.2 grams CE for moldboard plowing. We are unable to determine the specific machinery and techniques used, so similar methods are substituted or, in some cases, farming processes are left out of the CE calculations. These substitutions and estimates cause the CE emission figures to be lower than if all techniques and practices were taken into account exactly. Regardless, foods with more intense farming mechanisms, fertilizer, pesticides and other chemical applications have higher CE emissions than those farmed with fewer chemicals and a less mechanized process. Foods farmed with no till or on smaller farms have fewer emissions than foods produced on large farms. Buying organic food will reduce the CE emissions from farming per serving because organic food is not produced with synthetic pesticides and chemicals. Even if our figures underestimate the true CE emissions of a food per serving, buying organic or from smaller growers who use less mechanized farming is a simple purchasing solution to decrease CE emissions.

Processing

Processing beef generates the largest carbon footprint per serving of the foods we examined by far, emitting 1430 grams CE for each 3ounce serving. Corn feed is the source of this large CE footprint; a cow consumes over 4 pounds of corn per serving of meat over the course of its lifetime, and the corn undergoes processing before it is fed to the cow. As a result, the total processing footprint for a single serving of beef is much higher than a non-beef food. Alternatively, grass-fed cattle would avoid the additional emissions required for processing feed corn.

Taking beef out of the equation, the processing footprint for the studied foods ranges from 0 to just over 170 grams CE per serving. Potatoes processed as french fries have the next biggest footprint, estimated at 171 CE for each quarter-pound serving. French fries require intensive processing, during which the potatoes are boiled to remove their skins, then chopped and deep-freezed for transport and storage. Cracklin' Oat Bran comes in third with a processing footprint of just over 151.6 CE per 49-gram serving. The individual ingredients, including whole oats, wheat bran, and brown sugar, had miniscule footprints, but dehydrating and toasting the cereal before packaging pushes the emissions of Cracklin' Oat Bran higher than would be anticipated from the sum of ingredients alone. Other than the unprocessed food items that have a footprint of zero grams CE per serving, butter from Cabot Creamery is the smallest emitter because its processing plant is powered by renewable energy sources.

Climate Change Conclusions

Our analysis offers a solid starting point from which to understand the total carbon-equivalent emissions produced during farming, processing, and transportation of each of our food items. The largest contributing factors to high emitting food items are methane and processing, making food produced by cows such as beef and diary some of the largest emitters. Transportation contributes surprisingly few emissions to the total calculations in comparison to the other factors. As we acknowledge in previous sections, our analysis excludes some information that would have made our results more precise. For example, we generalize by assuming that tractors are driven equal amounts across all farms that use them, though in reality tractor usage depends upon the food being harvested, the size of farm, and the farmer. These generalizations make our calculations simpler and, in many cases, help build consistency in our calculations by allowing us to draw data from the same studies. Additionally, we exclude the emissions generated from refrigeration and packaging from our calculations altogether. Excluding these factors consistently across all food items does not significantly change how the food items compare to each other, but it does mean that our calculations are slight underestimates of the actual greenhouse gas emissions associated with each food item.

From the results of our calculations, we recommend that Wellesley dining services take the following steps to reduce the College's carbon foodprint:

- Minimize the amount of beef that the dining halls serve
- Increase the proportion of vegetarian and vegan items available to students.
- Purchase a greater proportion of seasonal produce.
- Reduce the number of processed foods offered or minimize the number of processing steps that each food item undergoes before reaching the dining hall (e.g. serve baked potatoes instead of french-fries).

Beef is evidently the worst offender across the stages of production that contribute to CE emissions due to the high-energy inputs required during farming and processing as well as the emissions from methane. Any effort to reduce our carbon foodprint must include a campaign to reduce beef consumption. It is also true that other animal products like bacon and mozzarella cheese have high carbon impacts. Decreasing purchases of meat and dairy products in the dining hall will improve our climate footprint, but this effort must also be coupled with a commitment to purchase seasonal produce. Seasonal produce can be grown more locally than non-seasonal fruits and vegetables, thus requiring fewer energy inputs on transportation after the initial farming costs. Finally, considering the high carbon footprint of processed food items like hummus and chocolate desserts, Wellesley dining services should reduce the amount of highly processed food in the dining hall. This recommendation has the added benefit of increasing the proportion of healthy, wholesome food available for the student body to consume. Taken together, our analysis testifies that the implementation of these strategies will significantly reduce Wellesley dining services' greenhouse gas emissions.

Eutrophication

Although standard in large-scale agriculture, the use of chemical fertilizers to supply essential nutrients for plant growth is one of industrial agriculture's least sustainable components. Inefficient use of fertilizers made from phosphorus, nitrogen, and potassium in agricultural production causes accelerated eutrophication in surface waters and leaches nitrates into groundwater. Algae populations explode due to increased nutrients levels, which diminishes the amount of light that reaches deeper water and, through the decomposition process, consumes oxygen. The decreased oxygen in the water is responsible for hypoxic "dead zones" that kill fish and underwater plants. Although eutrophication can occur naturally as lakes age, accelerated eutrophication can alter ecosystems at an unnatural rate.

Excess fertilizer use in agriculture causes surface water eutrophication. Corn only absorbs between 3 and 32 percent of applied nitrogen, depending on its stage of development.[15] To compensate for this loss, farmers apply fertilizer to their crops in excess. For example, California agricultural regulations mandate that farmers apply no more than 140 percent nitrogen. For corn, this means 50 to 65 pounds of nitrogen per acre, at each of 5 to 6 applications over the growing season.[16] Excess fertilizer not taken up by the corn enters run-off. The over-enriched surface water can then cause algal blooms that create "dead zones" in inland and coastal waters alike.[17] In addition to eutrophication, the production of fertilizers requires excessive burning of fossil fuels, increasing the concentration of greenhouse gases in the atmosphere.[18] Wellesley dining services can avoid contributing to these negative impacts by purchasing food items grown with less fertilizer intensive methods.

We analyze the negative environmental impacts of fertilizer by measuring the fertilizer intensity required to produce a specific food. We choose to analyze fertilizer intensity because we are concerned about biodiversity loss caused by eutrophication. Since different crops require different amounts of fertilizer, comparing the potassium, nitrogen, and phosphorus fertilizer use of the selected foods gives a sense of which crops may create the most excess fertilizer, and therefore which ones have the largest eutrophication impact.

We measure the environmental impact of fertilizer in pounds per serving size. Measuring fertilizer use by serving size indicates which foods have the highest environmental impact relative to consumption. We calculate a combined value in pounds of the recommended usage of potassium, nitrogen, and phosphorus fertilizer per acre for each food, then compare the pounds of fertilizer needed per serving of food.

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[15] Mathews, M. C. and Crohn. D. "Assessing Nitrogen Uptake of Corn, Winter Forages, and Alfalfa. *California Alfalfa & Forage Symposium*. 2010. Web. 13 February 2011. <http://alfalfa.ucdavis.edu/+symposium/2010/files/talks/CAS30_CampbellMathewsNitrogenUptake.pdf>.

[16] Mathews, M. C. and Crohn. D. "Assessing Nitrogen Uptake of Corn, Winter Forages, and Alfalfa. *California Alfalfa & Forage Symposium.* 2010. Web. 13 February 2011. <http://alfalfa.ucdavis.edu/+symposium/2010/files/talks/CAS30_CampbellMathewsNitrogenUptake.pdf>.

[17] Ongley, Edwin D. "Control of Water Pollution from Agriculture - FAO Irrigation and Drainage Paper 55." *Food and Agriculture Organization of the United Nations.* Rome, 1996. Web. 12 Feb. 2011. <http://www.fao.org/docrep/w2598e/w2598e06.htm>.

[18] Carpenter, Stephen, Nina F. Caraco, David L. Correll, Robert W. Howarth, Andrew N. Sharpley, and Val H. Smith. "Nonpoint Pollution of Surface Waters with Phosphorus and Nitrogen." *Ecological Society of America*. 1998. Web. 12 Feb. 2011. <http://www.esa.org/science_resources/issues/TextIssues/issue3.php>.

Eutrophication Methodology

The recommended application amounts of nitrogen, phosphorous and potassium compound fertilizer per acre are collected from online databases, documents and websites. Application amounts are typically based on soil compositions common to the region where the food in question is grown. When available, we use statistics on actual application amounts in pounds per acre. For foods containing animal products, we calculate the amount of fertilizer used to grow the feed grain or silage required to provide one serving of the target food. For processed foods, we calculate fertilizer amounts for each ingredient, based on their percentage of the final food product. Based on USDA recommendations for serving sizes, we convert serving sizes to pounds of food per serving. Finally, we use data for the expected yield of each crop in pounds per acre. When available, statistics on actual pounds per acre yield are used in place of expected yield.

To determine how much fertilizer is used per food item, we use the following equation:

Total pounds fertilizer/serving= *(recommended or actual fertilizer application in pounds/acre)x(pounds of food/serving)/(expected yield or actual yield of crop in pounds/acre)*

While we are confident that our metric usefully relates fertilizer use and food production, we make certain assumptions in order to do our calculations. Available data for rates of fertilizer application usually refer only to recommended amounts, not actual amounts applied, although we use actual data where available. In cases where we make our assessments based on recommended application amounts, we assume that farmers follow the recommendations. The recommended application rates are generally tested by agricultural extension services by region and state, and typically serve as a standard reference for farmers. Because those values are tested, they are reliable and there is no reason to conclude that farmers would actively ignore the most reliable standard for optimum crop yield. Figures for acreage and yield are averages over the region in which the food was most likely produced.

When analyzing animal products, we use rough estimates for the amount of grain feed needed to produce one serving of the target food. For chicken, bacon, and dairy products, our calculations assume a diet consisting of 50 percent corn for silage and 50 percent soybeans. We assume an exclusively corn diet for turkey and beef as explained in the specific food analysis section. Processed foods contain a combination of ingredients. With the exception of hummus, we estimate the proportions of ingredients in processed foods.

To enable the comparison of foods across different environmental impact metrics, we use a grade scale (from A to F) based on pounds of fertilizer used per serving of food. 0.0 pounds fertilizer per acre is the lowest possible amount of fertilizer that can be applied and is considered the most environmentally friendly, receiving an “A”. After looking at a number of different crops, including crops not specific to this study, we found hummus to have the highest fertilizer score. This value is used as the upper limit for the grading scale or worst “F” grade possible. Using a log scale, the analyzed foods have been assigned grades. The verbal ranking system and associated value ranges can be seen in Table 5.

Table 5: Grade scale (natural log of fertilizer in lbs/serving)

Range	Grade
0.0-2.46	A
2.46-3.46	B
3.46-4.46	C
4.46-5.46	D
5.45-6.46	F

The most significant difficulty in our data collection involves the lack of available data concerning average rates of fertilizer uptake by plants. Little is known about most plants' biological uptake of macronutrients, and even for those major crops such as sugarcane and corn for which such data is available, rates of intake tend to vary by developmental stage and environmental conditions. Because no comprehensive or consistent uptake rate is available for the majority of the crops included, fertilizer uptake rate is not included in the calculation of our metric. Consequently, our calculations do not assess how much fertilizer actually becomes runoff in hydrologic systems, but rather considers the amount of fertilizer applied as a reasonable proxy for determining which crops and foods have the highest or lowest environmental impacts from excess fertilizer.

Eutrophication Data

Table 6: Summary of food rankings

Food	Pounds of fertilizer per serving of food	(Pounds of Fertilizer per Serving Size) x 10,000	Ln of lbs/serving	Grade
Bottled water	0.0000	0	0	A
Shrimp	0.0000	0	0	A
Apples	0.0004317	4.31734	1.46263947186910	A
Baby Spinach	0.0004610	4.60962	1.52814542410997	A
Coffee	0.0006002	6.00234375	1.79215001795397	A
Butter	0.0007129	7.129	1.96417097213549	A
Turkey	0.001016	10.16242157	2.31869675730024	A
Pineapples	0.001779	17.7885	2.87855218109082	B
Bananas	0.001821	18.21248	2.90210707337384	B
Tomatoes	0.001847	18.47332	2.91632752900537	B
Milk	0.002437	24.37	3.19335286763712	B
Sweet Corn	0.003884	38.83837447	3.65940879050070	C
Potatoes	0.004214	42.13545	3.74088942912457	C
Raspberries	0.004269	42.68739	3.75390356046092	C
Tofu	0.004607	46.07064	3.83017587075496	C
Chicken	0.005182	51.82438078	3.94786070992803	C
Brown Rice	0.005334	53.33775	3.97664433563695	C
Sunkist Orange Juice	0.005700	57	4.04305126783455	C
Cracklin Oat Bran	0.006257	62.57332	4.13633898917477	C
Cranberry Blast Concentrate	0.006745	67.45126	4.21140526298336	C
Cookie Dough	0.007812	78.11663	4.35820296631709	C
Beef	0.008145	81.44812006	4.39996625381618	C
Ice Cream	0.008772	87.71887	4.47413704156977	D
Vegan Nuggets	0.01321	132.11218	4.88365141015446	D
Eggs	0.02024	202.4122825	5.31030662006927	D
Cucumbers	0.02659	265.878	5.58303755695463	F
Bacon	0.03059	305.85607	5.72311463173172	F
Mozzarella	0.03656	365.6	5.90153983958000	F
Hummus	0.06358	635.8263472	6.45492548706448	F

Table 6 shows our final results for pounds of fertilizer per serving and food grades. This data represents fertilizer intensity per serving size for each examined food item. The letter grades, shown in descending order (A-F) translate into an understandable metric to be compared with other metrics in this study.

Our analysis shows a wide range of fertilizer impacts across different foods. We find that heavily processed foods with more inputs, such as hummus and vegan nuggets, tend to be more fertilizer-intensive than raw fruits and vegetables. Meat products vary across our analysis; turkey has a low impact of 0.001 pounds per serving, whereas bacon has a high impact of 0.031 pounds per serving. This difference may have to do with variations in diet. Though both eat corn, soy and other grains, the amount these animals need to eat per day differs, as does serving size for consumers.

The item with the highest eutrophication impact is hummus, which requires almost twice as much fertilizer to produce one serving as the next highest food in our study. A reason for this high level of fertilizer intensity may be the ingredients used in hummus – lemons, tahini, chickpeas, sesame oil and soybean oil. Other high-impact foods include mozzarella cheese, bacon, cucumbers, eggs, and vegan nuggets. The lowest impact foods are apples and baby spinach. Others with low fertilizer impacts are coffee and butter, although the ranking for these items needs to be considered in a broader context. The serving sizes of these items are small (a serving of butter is 0.17 ounces, and for coffee, 0.36 pounds of beans are used for a 6-ounce serving) in comparison to a serving of bacon (1.0-1.5 ounces) or cucumbers (0.5 cups).

Animal products vary across the letter grade rankings. Turkey receives an A, chicken and beef receive high Cs, and bacon receives a D. It is important to acknowledge that beef and dairy cows have different diets, as well as meat and egg laying chickens, contributing to the differences in fertilizer intensity for products coming from the same animal. Raw fruits and vegetables are least fertilizer intensive because they are not composed of multiple ingredients. All fruits and vegetables, with the exception of cucumber receive a letter grade of a high C or above. Foods with multiple ingredients are generally more fertilizer intensive and fall in the C to F range.

Eutrophication Conclusions

The fertilizer analysis is useful for determining which foods are produced with the highest fertilizer intensity. While the use of fertilizer in and of its self is not an issue, excess fertilizer in runoff leads to eutrophication and the production of fertilizer requires extensive use of fossil fuels, contributing to climate change. To decrease its environmental impacts, Wellesley dining services should consider the following recommendations to decrease eutrophication impacts.

When purchasing meat, turkey should be prioritized over chicken, beef and pork, since turkey had the lowest fertilizer impact. Wild-caught shrimp does not require the use of fertilizer and is another a viable protein option. Wellesley dining services can decrease environmental impacts from fertilizer significantly by reducing purchases of processed foods with many inputs, since these foods are often fertilizer intensive. To truly decrease eutrophication impacts, the most meaningful and effective purchasing choice Wellesley dining services can make is to purchase from organic suppliers, especially for animal products. Grass fed beef would significantly reduce eutrophication impacts created during the production of animal feed.

Water Use

As a result of changing climate, population growth, and pollution, the amount of usable fresh water globally is decreasing. In the United States alone, population has doubled and water use has tripled in the past fifty years,[19] and the United States' per capita water footprint is 2,500 cubic meters per year.[20] In 2005, 31 percent of the fresh water withdrawals in the United States were used for irrigation in agricultural and horticultural processes, totaling 128,000 million gallons of fresh water per day.[21] Globally 70 percent of the water withdrawn is for agricultural irrigation.[22] Given the sizeable impact of agriculture and food processing on global water availability, we include water as an important part of our analysis.

Water use and its impacts are universal issues, and the food Wellesley dining services purchases has water impacts both within and outside of the United States. A variety of Wellesley dining services suppliers import water-intensive goods, straining water resources in areas often lacking effective governance and conservation.[23] If global water consumption continues at these rates, people around the globe will suffer from more water shortages, which will negatively affect public health, agriculture, and local economies, and have the potential to weaken political stability.[24]

The appropriate method for quantifying the impact of food production on water use is "water foot-printing." A water footprint is a measure of the total volume of freshwater used directly or indirectly to produce any or all of the goods or services produced by a business or consumed by an individual or community.[25] For example, it takes an average of 16,000 liters of water to produce a kilogram of beef.[26] This footprint is calculated from the amount of water used to grow and produce the cow's feed (grains and roughage), by the cow for drinking, and finally for servicing the beef.[27] Thus, the water footprint of beef varies depending on the composition and origin of the cow's feed, how the beef is produced, and other factors. By comparison, a cup of coffee has an average water footprint of 140 liters.

Water footprints can also account for the specific geographic locations water was used or polluted.[28] For example, Japan has a water footprint of 1150 cubic meters per person per year

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[19] United States Environmental Protection Agency. "Water Conservation." *EPA*. 2010. Web. 13 Feb 2011. <http://www.epa.gov/oaintrnt/water/>.
[20] Water Footprint Network. "Water Footprint Introduction." *Water Footprint Network.* 2011. Web. 9 March 2011. <http://www.waterfootprint.org/?page=files/home>.
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[24] National Resource Defense Council. "Evaluating Sustainability of Projected Water Demands Under Future Climate Change Scenarios." *Tetra Tech Inc.* 2010. Web. 13 February 2011. < http://rd.tetratech.com/climatechange/projects/doc/Tetra_Tech_Climate_Report_2010_lowres.pdf>.
[25] Water Footprint Network. " Media Release: International Leaders Support Global Water Footprint Standard." *Water Footprint Network*. 2011. Web. 9 March 2011. <http://www.waterfootprint.org/?page=files/home>.
[26] Water Footprint Network. "Water Footprint Introduction." *Water Footprint Network.* 2011. Web. 9 March 2011. <http://www.waterfootprint.org/?page=files/home>.
[27] Water Footprint Network. "Water Footprint Product Gallery." *Water Footprint Network.* 2011. Web. 9 March 2011. <http://www.waterfootprint.org/?page=files/productgallery&product=beef>.
[28] Water Footprint Network. "Media Release: International Leaders Support Global Water Footprint Standard."

(much lower than that of the U.S.), with about 65 percent of this footprint being outside of Japan's borders, while China has a lower water footprint of 700 cubic meters per person per year, with only 7 percent of this footprint falling outside of China.[29] This means that most of the water China uses comes from within China, but much of the water used in Japan comes from outside Japan's borders in the form of inputs for agricultural and industrial goods.[30] This geographic aspect of water footprinting allows us to determine how much of a country's water use occurs domestically assess its impacts at home and abroad.

Water footprinting is the chosen metric of the UN Global Compact's CEO Water Mandate, an initiative that helps the private sector analyze its water impacts and policies.[31] Many large food and beverage providers have participated in this project and have conducted water lifecycle analyses based on the water footprinting guidelines.[32] Given this accepted metric for quantifying water impacts, data are readily available for a wide range of food products, and the guidelines for calculations are clearly defined.

Water Use Methodology

We collect data for the water metric from scholarly articles and reports. In addition to information from various sources on the amount of water used to produce different foods, some of our data comes from the Water Footprint Network, which provides average water impact values for a number of foods. These measurements are based on the Global Water Footprint Standard. The equation for this standard is as follows:

$$WF_{blue} + WF_{green} + WF_{gray} = WF_{total}$$

We use a UNESCO Institute for Water Education report, which examines crops in the most populated areas of the world.[33] In the study, the computations are based on daily soil water balances and crop requirements, actual crop water use, and actual yields. For each crop, we use the global average water footprint. This measurement is a combination of green, blue, and gray water, listed in cubic meters per ton. For processed foods, we add up the water footprints of each ingredient used to make the food, taking into account the percentage of the final product that each ingredient makes up. From here, we standardize our results in gallons of water used per serving size for each of the 29 foods we examine. Gallons are a common customary measure of water, and serving size is our standard unit of measure throughout the report.

For the ranking system, we assign a letter grade to each food based on its water footprint. The grades range from A through F, where a rating of A represents the lowest water footprint

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Water Footprint Network. 2011. Web. 9 March 2011. <http://www.waterfootprint.org/?page=files/home>.

[29] Water Footprint Network, "Water Footprint Introduction," *Water Footprint Network.* 2011. Web. 9 March 2011. <http://www.waterfootprint.org/?page=files/home>.

[30] Hoekstra, A.Y. and Chapagain, A.K. "Globalization of water: Sharing the planet's freshwater resources." Blackwell Publishing, Oxford: (2008). Web. 1 April 2011. <http://www.waterfootprint.org/?page=files/NationalStatistics>.

[31] The Global Compact. "The CEO Water Mandate." *UN Global Compact CEO Water Mandate*. 2011. <http://www.unglobalcompact.org/issues/Environment/CEO_Water_Mandate/>.

[32] The Global Compact. "The CEO Water Mandate." *UN Global Compact CEO Water Mandate*. 2011. <http://www.unglobalcompact.org/issues/Environment/CEO_Water_Mandate/>.

[33] Mekonnen, M.M, and A.Y. Hoekstra. "The green, blue and grey water footprint of crops and derived crop products." Enshede: *Hydrol. Earth Syst. Sci. Discuss.* 2011. Web. March 2011. < http://www.hydrol-earth-syst-sci-discuss.net/8/763/2011/hessd-8-763-2011.html>.

and F the highest. The upper boundary of our scale is based on the most water-intensive food, which is beef. Beef's water footprint is much greater than 100 gallons per serving, but, since most foods are far below this measurement, we set 100 gallons per serving as the threshold beyond which foods receive the worst grade (F) and determine the rest of the grade ranges so that there is a fairly normal distribution across the grades. These are the resulting value ranges for each grade: A = 0-1 gallons/serving, B = 1-10 gallons/serving, C = 10-50 gallons/serving, D = 50-100 gallons/serving, F = >100 gallons/serving. Each individual food item is placed into one of these categories based upon its calculated water footprint.

As is true with any such analysis, we make assumptions and estimates in calculating the water footprint. We also use both previously calculated average water footprints for some food commodities (like chicken) and our own calculations for some foods (like hummus). Thus, our findings may vary from either the average or the specific water footprints of the foods we buy. Some of our calculations omit important steps in the production process that use water. For example, in addition to water used in crop cultivation and drinking water used for animals, water is often used in the washing, processing, packaging, transport, and refrigeration of foods. While some of our sources account for these aspects, others look only at agricultural application or animal consumption of water. Thus, some of our foods probably have higher water footprints than those reflected by our data. Underestimates most likely apply more to processed foods. Additionally, unless we are using data from the Water Footprint Network, we do not quantify or differentiate among blue, green, and gray water, although these differences are important.

Water Use Data

Table 7: Summary of water calculations and rankings

Food Type	Serving size (unit)	Gallons of water per serving size	Ranking (1-5)	Grade
Banana	1 medium banana / 120 grams	0.3168	1	A
Baby Spinach	1 cup	0.6750	1	A
Shrimp	2 ounces	1.000	2	B
Bottled Water	8 fluid ounces	1.000	2	B
Butter	1 teaspoon / 0.17 ounces	1.828	2	B
Tomatoes	1/2 cup	3.667	2	B
Hummus	2 tablespoons	7.009	2	B
Pineapple	4 ounces	7.236	2	B
Cranberry Blast	8 fluid ounces	7.483	2	B
Raspberries	0.09479 pounds	8.990	2	B
Cucumbers	4 ounces	9.087	2	B
Vegan Chicken Nuggets	4 nuggets / 3 ounces	14.55	3	C
Potato	0.5 pounds	14.78	3	C
Apple	1 small apple	18.49	3	C
Corn	0.5 cup / 82 grams	19.50	3	C
Cracklin' Oat Bran	0.75 cup / 49 grams / 1.8 ounces	20.33	3	C
Ice Cream	1 cup	28.15	3	C
Chicken	1 ounce	29.21	3	C
Turkey	1 ounce	32.98	3	C
Bacon	1 ounce	36.00	3	C
Brown Rice	1 cup / 47 grams	42.21	3	C
Coffee	10 grams / 0.36 ounces beans	42.94	3	C
Egg	1 egg / 60 grams	52.83	4	D
Orange Juice	1 cup	53.13	4	D
Tofu	1/2 cup	60.79	4	D
Milk	8 fluid ounces / 1 cup	62.50	4	D
Mozzarella Cheese	1.5 ounces	93.75	4	D
Cookie Dough	28 grams	297.1	5	F
Beef	3 ounces	348.3	5	F

Table 8: General Statistics

Statistics	
Mean (Gallons of Water)	45
Median (Gallons of Water)	18
Range (Gallons of Water)	348
Mode (Ranking)	3 (C)

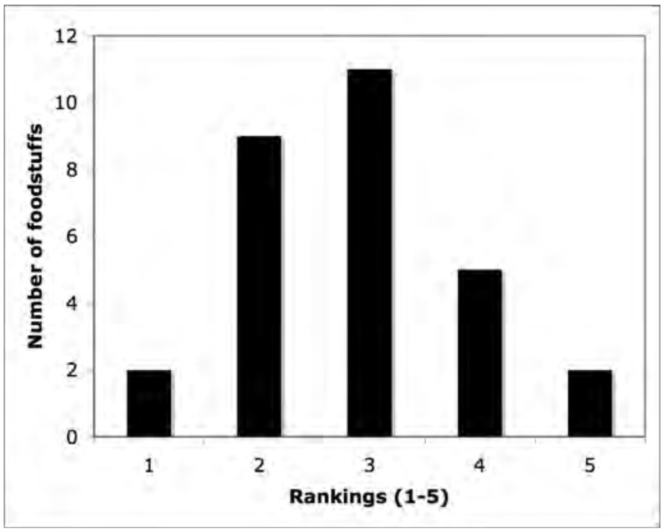

Figure 1: Frequency of water use rankings

Most of our foods have a moderate water impact; more foods (38 percent) receive a C than any other grade. The median (18 gallons/serving) is the best indicator of central tendency for gallons of water per serving given the extremely high values of beef and cookie dough that skew the mean. Only a few foods have very high or very low water footprints. As shown in the following tables, processed foods have a greater water impact (higher mean and median footprint value and lower mode grade) than non-processed foods.

Table 9: Water processing statistics by ranking

Ranking	# Processed	# Non-processed
1 (A)	0	2
2 (B)	4	5
3 (C)	11	0
4 (D)	5	0
5 (F)	2	0

Table 10: Water processing statistics by mean, median and mode

Ranking	# Processed	# Non processed
Mean (Gallons of Water)	102.4	13.19
Median (Gallons of Water)	30.565	7.236
Mode (Ranking)	3	2

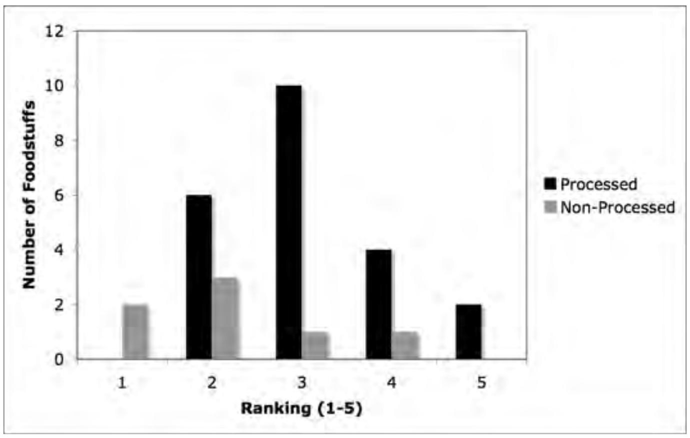

Figure 2: Water statistics of processed and non-processed foods by ranking

The examination of processed vs. non-processed foods reveals that processed foods have a markedly higher mean and median than non-processed food. Processed foods also have a higher mode (“C” category) than non-processed foods (“B” category). Therefore, processed foods have a higher water impact than non-processed foods. Table 11 and Table 12 demonstrate that animal products have markedly higher mean and median water use levels than non-animal products, indicating that the animal products that we covered generally have higher water footprints than non-animal foods. Animal products also have the highest frequencies in the “D” categories as opposed to non-animal products, which have the highest frequency in the “B” category. Therefore, animal products have a higher water impact than non-animal foods.

Table 11: Water statistics of animal and non-animal products by grade

Ranking	Animal Products	Non Animal Products
1 (A)	0	2
2 (B)	0	9
3 (C)	4	7
4 (D)	5	0
5 (F)	2	0

Table 12: Water statistics of animal and non-animal products by mean, median and mode

Ranking	Animal Products	Non Animal Products
Mean (Gallons of Water)	89.42	18.46
Median (Gallons of Water)	50.94	11.82
Mode (Ranking)	4 (D)	2 (B)

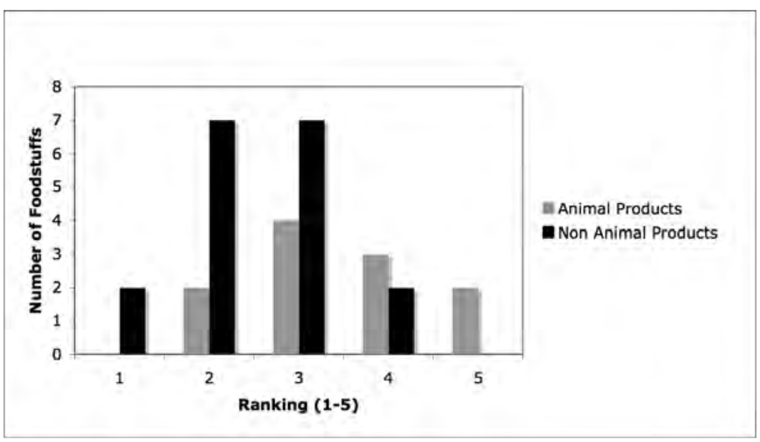

Figure 3: Water statistics of animal and non-animal products by ranking

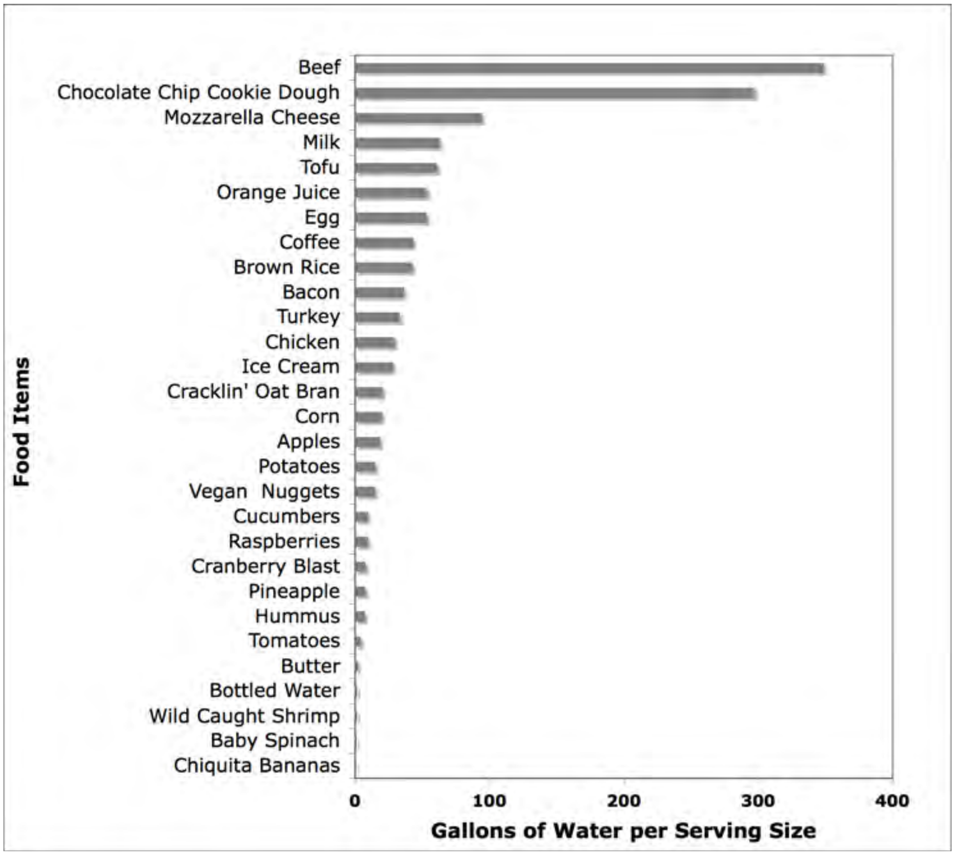

Figure 4: Water footprint (gallons/serving) of selected foods

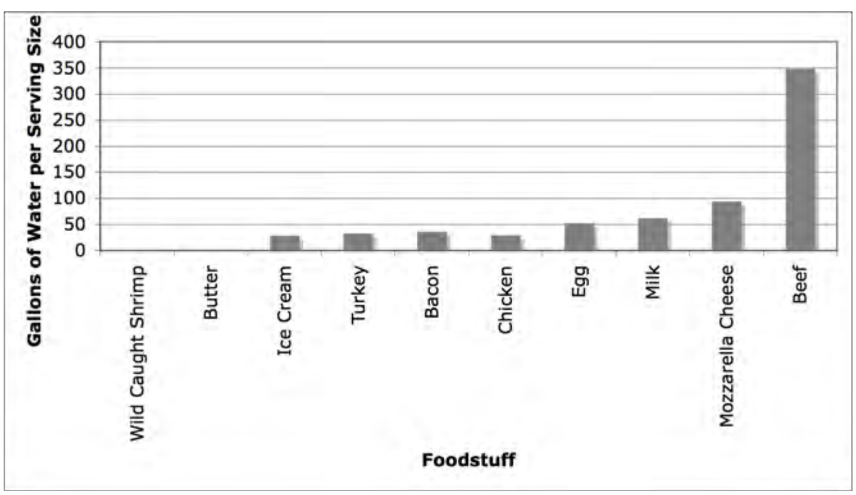

Figure 5: Water footprints (gallons/serving) of animal products

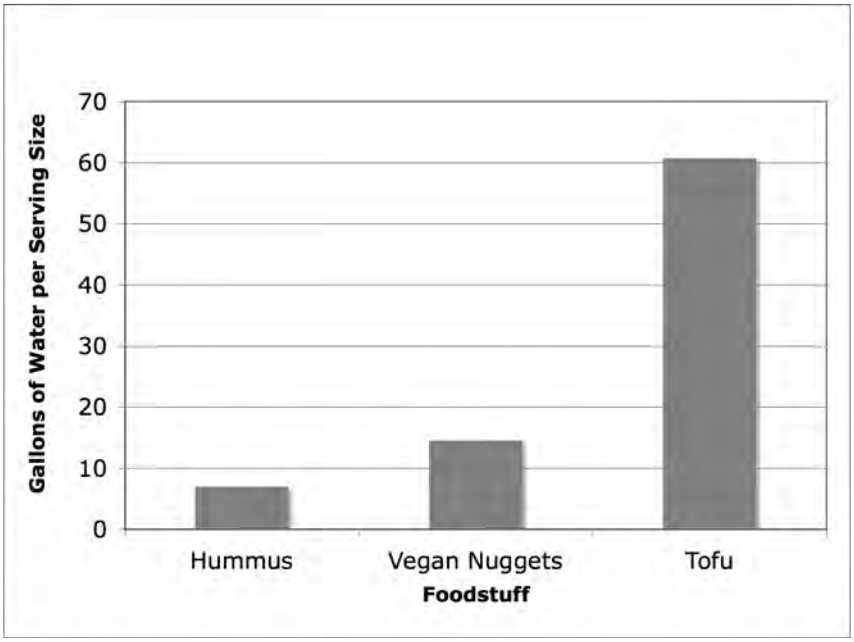

Figure 6: Water footprints (gallons/serving) of plant protein products

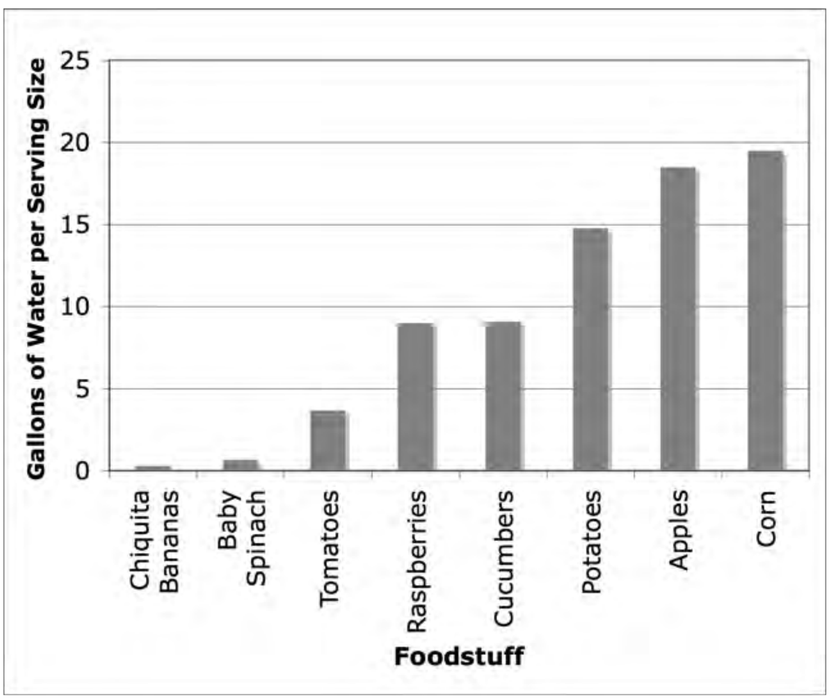

Figure 7: Water footprints (gallons/serving) of fruits and vegetables

Water Use Conclusions

The foods in our sample with the highest water footprints are animal proteins and processed foods such as beef, chocolate chip cookie dough, and mozzarella cheese. Beef uses 348.3 gallons per serving; cookie dough 297.1 gallons per serving; and mozzarella cheese 93.75

gallons per serving. Considering these amounts, it is important that Wellesley dining services reassess its need for these foods and examine possible alternatives.

As shown in Figure 2, processed foods require more water in their production than non-processed foods due to the greater number of ingredients and steps involved in the production of processed foods. Animal products have higher water footprints than non-animal products, as shown in Figure 3. This trend can be explained by the amount of water required to grow animal feed, water consumed by the animals themselves, and water needed in processing. It is reasonable to assume that these trends apply, in general, to the rest of the foods Wellesley dining services purchases.

Beef is by far the most water-intensive of the foods; therefore, decreasing the amount of beef Wellesley dining services purchases is an effective way to reduce the College's water-footprint. There are other protein sources available with lighter water footprints. For example, the total water footprints of chicken, bacon, turkey, and shrimp combined do not even equal one-half of the water footprint of beef (Figure 5). Any of these foods are viable animal protein replacements for beef. In addition, plant proteins such as tofu, vegan nuggets, and hummus all have much lower water footprints than beef (Figure 6). Animal products other than beef and vegetable protein options should be considered when making purchasing decisions so protein with the smallest water footprint can be provided.

Looking beyond just protein, two of the three most water-intensive foods are not meat products. Becoming vegetarian or eating lower on the food chain does not necessarily lower one's water footprint. Chocolate chip cookie dough, mozzarella cheese, milk, and eggs are the highest consumers of water after beef. All of these foods are meat-free but still require intensive water processes. For chocolate chip cookie dough, the high water footprint is due largely to chocolate cultivation, which accounts for roughly 75 percent of the total footprint. The specific chocolate used for this brand of chocolate chip cookie dough requires vast amounts of water. We suggest Wellesley dining services find producers with less water intensive cheeses and purchase cookie dough either with less water intensive chocolate or without chocolate at all.

The majority of the fruit and vegetable products in our sample have fairly low water impacts, despite the fact that irrigation water is used in their cultivation. The most water-intensive fruit or vegetable products in our analysis are orange juice and coffee, each receiving a grade of C. They are water-intensive because, in addition to the cultivation of the raw materials, they are processed beverages (coffee production requires mixing water with ground coffee beans and orange juice concentrate requires the reintroduction of water). As with other processed foods, we recommend reducing the amount of these water-intensive processed beverages or replacing them with less water-intensive beverages. For example, tea is a less water-intensive substitute for coffee.[34]

Although we do not quantify the water use in different steps of the selected foods' lifecycles, our findings indicate that most of the water use associated with a given food takes place during the production and processing stages. During the production step, water is used for cultivation or raising animals. The production stage is especially water-intensive for animal products since it includes water used to grow the animal feed as well as water consumed by the animal. To reduce our water impact in the production stage of foods, it makes sense to buy fewer animal products, replacing them with vegetarian alternatives. If we want to reduce our water impact in the processing step, it makes sense to buy fewer or less processed foods. The

[34] Water Footprint Network, "Water Footprint Product Gallery - Coffee," *Water Footprint Network.* 2011. Web. 1 April 2011. <http://www.waterfootprint.org/?page=files/productgallery&product=coffee>.

transportation step does not include extensive water use, so choosing local food over non-local food should not necessarily be a priority for reducing water impacts.

2- Additional Factors

Although the metrics sections cover some significant environmental impacts of food production processes, there are a number of other issues we wish to examine that are not well suited for the quantitative analysis methods used in this study. By looking more generally at foods production processes, we are able to develop an understanding of what Wellesley dining services should consider when making purchasing choices. Toxicity, biodiversity, animal welfare and labor are identified as significant factors in the life cycles of our chosen foods, and are discussed in more detail in the following sections.

Toxicity

Pesticides

Pesticides are frequently used in crop production to prevent decreased yields caused by insects and other pests. Because they are designed to kill or adversely affect living organisms to maximize agricultural growth, some pesticides do have lasting environmental impacts, and can potentially be harmful to humans and animals, as well.[35] It is essential that we investigate the impacts of pesticide usage because these chemicals, in some form or another, are used in the production of the vast majority of foods. Pesticides treat fruits and vegetables, as well as the corn and soy for animal feed. They are almost omnipresent in the current agricultural system and are often applied in large quantities.

Another point to consider is that other countries may not have comparable pesticide regulations to those of the United States, and therefore, imported foods could be grown with even more pesticide intensive farming techniques. Thus, it is especially important to examine foods imported from tropical or subtropical areas where DDT or other toxic elements may be used to combat malaria carried by mosquitoes, which can contaminate the food as well.

Purchasing organic foods is an action that Wellesley College could take in order to eliminate environmental and potential consumer health impacts due to synthetic pesticides. Another specific area in which Wellesley dining services can prioritize purchasing is fruit. Fruits with peels or a protective skin that is removed when consumed, such as citrus, are less exposed to harmful pesticides. Fruits without these forms of protection should be purchased from organic growers. To minimize impacts from toxins, buying organic is encouraged. However, if it is not feasible for Wellesley dining services to switch completely to organic foods, purchasing priority should then be given to foods that are not prone to extensive fertilizer use.

Hormones and Antibiotics

In the animal production industry, antibiotics are used for disease treatment, disease control or for production efficiency (to make the animal grow faster), while synthetic hormones such as recombinant bovine growth hormone (rBGH) for cows are generally used to hasten time to maturity and slaughter.[36] A number of concerns have been raised about the potential health risks of consuming animal products that have been treated in these manners, such as whether hormones used on animals can increase cancer rates in humans, [37] if antibiotics could cause widespread antibiotic resistance among people, [38] or if hormones and antibiotics negatively affect surrounding environments and wildlife. [39] Although no conclusive studies have been carried out concretely that conclude whether or not hormones or antibiotics used on farm animals have

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[35] Environmental Protection Agency. "Frequent Questions: Pesticides." *US EPA*, n.d. Web. 2 May 2011. <pesticides.supportportal.com/ics/support/default.asp?deptID=23008>.
[36] Neeser, Nicole. "Antibiotic Use in Production Agriculture." *College of Veterinary Medicine, University of Minnesota* May (2003): *From the Proceedings of the Minnesota Dairy Health Conference*. Web. 25 Feb. 2011.
[37] Cornell University Sprecher Institute for Comparative Cancer Research. "Consumer Concerns About Hormones in Food: Breast Cancer and Environmental Risk Factors." *Cornell University Sprecher Institute for Comparative Cancer Research*. n.d., Web. 15 Mar. 2011.
[38] Mason, Tiffany. "Antibiotic Overuse in Food Production Animals." *Yale Journal of Medicine and Law 6.2* (2010): 6-10.
[39] Kümmerer, K. "Significance of antibiotics in the environment." *Journal of Antimicrobial Chemotherapy 52.1* (2003): 5-7.

health impacts on human consumers and the environment, Wellesley dining services should exercise the precautionary principle regarding the purchase of animal products, meaning that a lack of data should not serve as a reason to ignore potential health risks.

Currently, federal regulations do not allow hormones in raising pigs or poultry, so there is no need to seek out pigs or poultry without hormones.[40] In contrast, beef may carry the label “no hormones administered,” which is a USDA standardized label.[41] Red meat and poultry may use the USDA standard term “no antibiotics added” if the supplier can provide the adequate support documentation.[42] Dairy products can be labeled as containing “no rBGH” if the synthetic hormone was not used in raising the animal. USDA Organic meats and dairy are raised without synthetic hormones or antibiotics. Therefore, Wellesley should purchase USDA organic labeled animal products to minimize the risk.

Many regional milk suppliers such as Garelick Farms and Hood currently do not source milk from farmers that use hormones on their milk cows. This is a choice based on consumer preference, not law.[43] It is fortunate that Wellesley already purchases much of its milk from Garelick Farms, and some from Hood, so we should continue this environmentally responsible practice. In contrast, much of the milk used for commercial butter, cheese and ice cream does use milk that comes from cows treated with growth hormones. Likewise, commercial meat production, unless otherwise labeled, generally uses hormones and antibiotics unless prohibited by law.

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[40] USDA Food Safety and Inspection Service Home. "Meat and Poultry Labeling Terms." *USDA Food Safety and Inspection Service Home*. n.d. Web. 15 Mar. 2011. <http://www.fsis.usda.gov/factsheets/Meat_&_Poultry_Labeling_Terms/index.asp>.

[41] USDA Food Safety and Inspection Service Home. "Meat and Poultry Labeling Terms." *USDA Food Safety and Inspection Service Home*. n.d. Web. 15 Mar. 2011. <http://www.fsis.usda.gov/factsheets/Meat_&_Poultry_Labeling_Terms/index.asp>.

[42] USDA Food Safety and Inspection Service Home. "Meat and Poultry Labeling Terms." *USDA Food Safety and Inspection Service Home*. n.d. Web. 15 Mar. 2011. <http://www.fsis.usda.gov/factsheets/Meat_&_Poultry_Labeling_Terms/index.asp>.

[43] Garelick Farms and Hood. "Garelick Farms." *Garelick Farms*. Web. 25 Feb. 2011. <http://www.garelickfarms.com/>.

Biodiversity

Around the world, plant and animals species are becoming extinct at an alarming rate. Loss of biodiversity changes the functionality and resilience of ecosystems.[44] Countless species may cease to exist if one species they rely on disappears. The decline of a population leads to reduced genetic diversity and increased vulnerability of the remaining individuals to extinction.[45] Individuals of the same species may not recover from disease, or the community as a whole may not recover as rapidly from a traumatic event such as a fire.[46] The loss of biodiversity is caused by larger issues such as changes in land use, increased levels of toxic or synthetic chemicals in the environment, or extreme weather patterns due to climate change.

In order to reduce the college's impacts on biodiversity loss, Wellesley dining services should purchase foods that minimally affect existing ecosystems and do not promote the complete dominance of one species, such as monocrops. Other factors explored elsewhere in this report, such as climate change and eutrophication, can have an effect on biodiversity. However, here we consider how foods may have a more direct impact on biodiversity in and near agricultural land through habitat loss and fragmentation. This kind of impact on biodiversity mostly occurs when land is cleared for agricultural production. The effect on biodiversity depends on the habitat that is being transformed and the agricultural methods used.

Foods grown in habitats with previously high diversity have larger impacts on plant and animal species diversity. The diversity of many taxonomic groups is highest in the tropics, so agricultural products grown in the tropics have the greatest impact on biodiversity, all other factors being equal. [47] The methods used to produce a crop can influence the impact on biodiversity as well. The use of multiple crops, or crops grown in mixture with other plants, can increase not only plant diversity, but also the diversity of other taxa in some cases. For example, shade grown coffee can be grown under 1-25 tree species, so plant diversity is higher than in sun grown coffee plantations.[48] In addition, shade grown coffee plantations support bird population diversity that is as high as in a forest not used for agriculture.[49]

In aquatic ecosystems, the impact on biodiversity also depends on the methods used to harvest the seafood. Some methods of fishing, like trawling, have a greater impact on the

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[44] Lawrence, Janet. "World governments fail to halt biodiversity loss." *Reuters*. 10 May 2010. Web. 14 Mar. 2011. <http://www.reuters.com/article/2010/05/10/us-biodiversity-idUSTRE64927W20100510>.

[45] Ecological Society of America. "Biodiversity and Ecosystem Functioning: Maintaining Natural Life Support Processes ." *Issues in Ecology*. Version 4. Ecological Society of America, 1999. Web. 14 Mar. 2011. <www.epa.gov/owow/watershed/wacademy/acad2000/pdf/issue4.pdf>.

[46] Ecological Society of America. "Biodiversity and Ecosystem Functioning: Maintaining Natural Life Support Processes ." *Issues in Ecology*. Version 4. Ecological Society of America, 1999. Web. 14 Mar. 2011. <www.epa.gov/owow/watershed/wacademy/acad2000/pdf/issue4.pdf>.

[47] Gaston, Kevin J. "Global patterns in biodiversity." *Nature 405* (2000): 220-227. Print.

[48] Philpott, Stacy M., Wayne J. Arendt, Cesar Tejeda-Cruz, Guadalupe Williams-Linera, Jorge Valenzuela, José Manuel Zolotoff, Inge Armbrecht, Peter Bichier, Thomas V. Diestch, Caleb Gordon, Russell Greenberg, Ivette Perfecto, Roberto Reynoso-Santos, And Lorena Soto-Pinto. "Biodiversity Loss in Latin American Coffee Landscapes: Review of the Evidence on Ants, Birds, and Trees." *Conservation Biology* 22.5 (2008): 1093–1105. Print.

[49] Philpott, Stacy M., Wayne J. Arendt, Cesar Tejeda-Cruz, Guadalupe Williams-Linera, Jorge Valenzuela, José Manuel Zolotoff, Inge Armbrecht, Peter Bichier, Thomas V. Diestch, Caleb Gordon, Russell Greenberg, Ivette Perfecto, Roberto Reynoso-Santos, And Lorena Soto-Pinto. "Biodiversity Loss in Latin American Coffee Landscapes: Review of the Evidence on Ants, Birds, and Trees." *Conservation Biology* 22.5 (2008): 1093–1105. Print.

ecosystem since they destroy sea floor habitat.[50] Methods that produce large quantities of bycatch, such as netting and longlines, can put sensitive species at greater risk of extinction. Targeting species that are over fished can also cause genetic diversity loss and become extinct.[51] Ocean ecosystems can be protected but in many cases habitat is destroyed to create aquaculture facilities. For example, mangrove swamps are often destroyed to build shrimp farms.[52] Monocultures of farmed fish pose a risk to native fish diversity if they escape.[53] Since various methods of production methods differ to a great extent in their biodiversity impacts, it is possible to purchase similar or identical food items produced in ways that have smaller biodiversity effects.

Wellesley dining services can reduce its impact on biodiversity in two ways: by protecting the diversity of agricultural crops on the market, and by reducing the land-use footprint of crops. Dining services has the power to decrease biodiversity loss through its food purchases. We focus our recommendations on how Wellesley dining services can change its purchasing habits since this is the most cost-effective option. We recommend that Wellesley dining services:

- purchase heirloom produce where possible;
- prioritize purchasing from farms that produce more than one crop in one season and that practice crop rotation to prevent soil degradation;
- prioritize purchasing produce with minimal land footprints;
- avoid purchasing seafood items that are over-fished or unsustainable harvested, such as those identified as “To Avoid” on the Monterey Bay Seafood Watch List (see Table 13);
- avoid buying products with ingredients that originate in the biodiversity hotspot regions identified in Figure 8.

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[50] Monterey Bay Aquarium Foundation. "Wild Seafood." *Monterey Bay Aquarium*. n.d. Web. 10 Mar. 2011. <http://www.montereybayaquarium.org/cr/cr_seafoodwatch/issues/wildseafood.aspx>.
[51] Monterey Bay Aquarium Foundation. "Wild Seafood." *Monterey Bay Aquarium*. n.d. Web. 10 Mar. 2011. <http://www.montereybayaquarium.org/cr/cr_seafoodwatch/issues/wildseafood.aspx>.
[52] Monterey Bay Aquarium Foundation. "Aquaculture." *Monterey Bay Aquarium*. n.d. Web. 10 Mar. 2011. <http://www.montereybayaquarium.org/cr/cr_seafoodwatch/issues/aquaculture.aspx>.
[53] Monterey Bay Aquarium Foundation. "Aquaculture." *Monterey Bay Aquarium*. n.d. Web. 10 Mar. 2011. <http://www.montereybayaquarium.org/cr/cr_seafoodwatch/issues/aquaculture.aspx>.

Table 13: Monterey Bay Aquarium's guide to seafood purchasing in the Northeast United States[54]

Best Choices	Good Alternatives	Avoid
Arctic Char (farmed) Barramundi (US farmed) Catfish (US farmed) Clams, Mussels, Oysters (farmed) Clams: Softshell/Steamers (wild) Cobia (US farmed) Crab: Dungeness, Stone Croaker: Atlantic* Haddock (US hook & line) Halibut: Pacific (US) Lobster: Spiny (US) Salmon (Alaska wild) Scallops (farmed off-bottom) Squid: Longfin (US) Striped Bass (farmed or wild*) Swordfish (Canada and US, harpoon and handline)* Tilapia (US farmed) Trout: Rainbow (US farmed) Tuna: Albacore including canned white tuna (troll/pole, US and BC) Tuna: Skipjack including canned light tuna (troll/pole)	Basa/Pangasius/Swai (farmed) Black Sea Bass (Mid-Atlantic) Bluefish* Caviar, Sturgeon (US farmed) Clams: Hard, Quahog, Surf (wild) Crab: Blue*, Jonah, King (US), Snow Haddock (US trawled and Iceland) Hake: Offshore, Red and Silver Herring: Atlantic Lobster: American/Maine Mahi Mahi/Dolphinfish (US) Oysters (wild) Pollock: Alaska Pollock: Atlantic (Canada and US) Scallops: Sea Shrimp (US, Canada) Squid (except Longfin US) Swordfish (US)* Tilapia (Central & SouthAmerica farmed) Tilefish (Mid-Atlantic) Tuna: Bigeye, Yellowfin (troll/pole) Tuna: Canned white/Albacore (troll/pole except US and BC)	Caviar, Sturgeon* (imported wild) Chilean Seabass/Toothfish* Cod: Atlantic Crab: King (imported) Flounders, Halibut, Soles (Atlantic) Hake: White Mahi Mahi/Dolphinfish (imported) Marlin: Blue*, Striped* Monkfish Orange Roughy* Pollock: Atlantic (Iceland trawled) Salmon (farmed, including Atlantic)* Sharks* and Skates Shrimp (imported) Snapper: Red Swordfish (imported)* Tilapia (Asia farmed) Tilefish (Southeast)* Tuna: Albacore, Bigeye, Yellowfin (longline)* Tuna: Bluefin* and Tongol Tuna: Canned (except troll/pole)* Yellowtail (imported farmed)

[54] Seafood Watch. "Northeast Sustainable Seafood Guide January 2011." *Monterey Bay Aquarium*. n.d. Web. 10 Mar. 2011. <http://www.montereybayaquarium.org/cr/cr_seafoodwatch/content/media/MBA_SeafoodWatch_NortheastGuide.pdf>.

Figure 8: Conservation International map of ecosystems with highest numbers of endemic species[55]

In order to simplify purchasing decisions, we offer four different certification options for food products that adequately, though differently, protect biodiversity.

Rainforest Alliance

The Rainforest Alliance offers the only certification that explicitly protects biodiversity while advocating for social equity and long-term economic viability. Certified farms meet standards set by the Sustainable Agricultural Network. Specifically, farms must not destroy any natural ecosystems during production and, if they have harmed ecosystems such as rainforests in the past, farms must commit to reforesting the land and pursuing conservation projects to restore vitality to the area. The certification also mandates that the Rainforest Alliance does not require farms to adhere to the organic standard, though many of the products they do certify happen to also be farmed organically.[56]

Food Alliance

Food Alliance offers a comprehensive certification system similar to Rainforest Alliance in its approach to the environment, society and the economy. The Food Alliance certification differs mainly in that it prohibits genetically modified organisms (GMOs) from receiving certification, whereas Rainforest Alliance does not.[57]

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[55] Conservation International. "Biodiversity Hotspots - Resources - Maps and GIS Data ." *Biodiversity Hotspots*. Conservation International, n.d. Web. 13 Mar. 2011. <http://www.biodiversityhotspots.org/xp/hotspots/resources/Pages/maps.aspx>.

[56] Rainforest Alliance Certified. "Sustainable Agriculture Standard." *Sustainable Agriculture Network*. n.d. Web. July 2010. <http://sanstandards.org/userfiles/file/SAN%20Sustainable%20Agriculture%20Standard%20July%202010(1).pdf>.

[57] Food Alliance Certified. "Whole Farm/Ranch Inspection Tool." *Food Alliance.* 2011. Web. 13 March 2011.<http://foodalliance.org/certification/producer/WholeFarm.pdf>.

Seafood Watch

Purchasing sustainably harvested seafood is one of the most powerful tools that Wellesley dining services can exercise to preserve biodiversity. Over 75 percent of fisheries are utilized to capacity or over-fished.[58] Monterey Bay Aquarium produces the *Seafood Watch Pocket Guide*, a ubiquitous and peer-reviewed list of seafoods that are currently harvested sustainably. Seafood Watch aims to preserve a diverse ocean biological community, and uses the precautionary principle to err on the side of conservation when there is scientific uncertainty.[59]

Marine Stewardship Council

Marine Stewardship Council does more than just recommend species that are regionally safe to eat, but in fact certifies particular fisheries to ensure their operations and products are sustainable. The MSC certification indicates that the fishery in question has met three main principles: maintaining a sustainable yield of fish stock; minimizing environmental impact on the surrounding ecosystem; and operating within all local, national and international laws and adhering to quality management practices. Currently 104 fisheries are MSC certified around the world, 9 of which are located in the Northwest Atlantic Ocean. The seafood produced at these fisheries includes shrimp, crab, prawn, haddock, swordfish, and yellowtail flounder trawl.[60]

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[58] Seafood Watch. "What is Seafood Watch?" *Monterey Bay Aquarium*. 2011. Web. 16 March 2011. <http://www.montereybayaquarium.org/cr/cr_seafoodwatch/sfw_aboutsfw.aspx?c=ln>.
[59] Seafood Watch. "What is Seafood Watch?" *Monterey Bay Aquarium*. 2011. Web. 16 March 2011. <http://www.montereybayaquarium.org/cr/cr_seafoodwatch/sfw_aboutsfw.aspx?c=ln>.
[60] Marine Stewardship Council. "North-west Atlantic." *Marine Stewardship Council*. 2011. Web. 16 March 2011.<http://www.msc.org/track-a-fishery/certified/north-west-atlantic>.

Animal Welfare

Each year in the United States, approximately 11 billion animals are raised for meat, eggs, and dairy. Farms animals are sentient beings and are capable of feeling pain and suffering, along with excitement, happiness, frustration, and sadness. Industrial agricultural practices often damage farm animals physically, mentally, and emotionally, causing them severe suffering. Within the industrial agricultural system, it is near to impossible to protect animal welfare and provide humane treatment. [61]

On industrial factory farms, poultry raised for their meat and eggs are often subject to inhumane treatment. Broiler chickens and turkeys are often raised in cages where they have little room to move, often no larger than a sheet of paper. Once ready for slaughtered, they are put in crates and stacked on top of each other in trucks; enduring broken limbs, heat exhaustion, dehydration, and starvation. To avoid pecking, their beaks are often cut off before they are slaughtered.[62] When brought to the processing facility, they are dumped onto conveyors, shackled upside down by their legs, and their heads pass through an electrified water bath before their throats are cut by machinery. In the egg industry, male chicks are considered byproducts as they are unable to lay eggs for production. Each year, millions of male chicks are gassed to death, macerated, vacuumed, or thrown into garbage bins, where they are left to die. Egg-laying females are confined in small wire battery cages, where they eat, sleep, lay eggs, and defecate.[63]

For 6 months, pigs are confined in pens and suffer from castration and tail docking in factory farms. They are "rendered to insensible pain" before they are shackled and killed. Female pigs are moved into a restrictive create when they give birth, but have little room to nurse the piglets. Once they cannot reproduce, they are slaughtered. Pigs are highly intelligent and social animals, and are constantly aware of their quality of life throughout the farm raising and slaughtering process.[64]

In the U.S., adult cows are raised for beef and milk production and calves are raised for veal. Most cattle in these inhumane factory farms are castrated, de-horned, and branded without any pain relief. For 7 months they graze on a range before transported to feedlots, where they are fed grain and corn and then within 6 months are slaughtered. These cattle feedlots generally contain thousands of animals in one area.[65] Diary cows are routinely artificially inseminated and milked with machines from 10 months before giving birth. Hormones are often administered to increase milk production. Veal production practices are extraordinarily inhumane. Calves are fed an iron deficient diet and chained to an individual stall for their 4-month lives before they are slaughtered.[66]

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[61] "Farm Animal Welfare." The Humane Society of the United States." *The Humane Society of the United States*. n.d. Web. 4 May 2011. <http://www.humanesociety.org >.

[62] Sustainable Table. "Factory Farming, what is factory farm." *Sustainabletable*. n.d. Web. 4 May 2011. <http://www.sustainabletable.org/issues/factoryfarming/>.

[63] The Humane Society of the United States. "Farm Animal Welfare." *The Humane Society of the United States.* n.d. Web. 4 May 2011. <http://www.humanesociety.org >.

[64] The Humane Society of the United States. "Farm Animal Welfare." *The Humane Society of the United States.* n.d. Web. 4 May 2011. <http://www.humanesociety.org >.

[65] Sustainable Table. "Factory Farming, what is factory farm." *Sustainabletable*. n.d. Web. 4 May 2011. <http://www.sustainabletable.org/issues/factoryfarming/>.

[66] Sustainable Table. "Factory Farming, what is factory farm." *Sustainabletable*. n.d. Web. 4 May 2011. <http://www.sustainabletable.org/issues/factoryfarming/>.

The Humane Methods of Slaughter Act confines the USDA to adhere to certain practices, but many farms still and treat animals cruelly. Aside from this, there are no federal laws regulating the treatment of animals that are raised on industrial factory farms. Often, people disassociate their food from what it was before, an emotional and sentient being that suffered greatly throughout its entire life. Thus, it is important to be mindful of this ethical issue when deciding on food purchases.

Although industrialized factory farms often endorse these operations, there are good animal raising and slaughtering practices that protect animal welfare. One such practice is to raise animals in natural settings without excessive crowding or restriction of movement. Humane treatment also includes raising farm animals on a natural diet rather than subsidized animal feed like corn, grain, and soy. Since animals are social and sentient beings, they need time to play and socialize. Thus, allowing freedom to roam and interact with other animals is extremely important in the quality of the animal's life. And of course, any cruel practices such as branding, shackling, shocking, or causing the animal pain should be eliminated. There are many ways to produce animal products humanely, and we hope that Wellesley will keep this in mind when making purchasing decisions.

Legislative Standards

No federal standards exist for the treatment of the majority of farm animals. The USDA's Animal Welfare Act (AWA) only applies to farm animals used for biomedical research, testing, teaching, and exhibition; it does not regulate farm animals used for food and fiber production.[67] Some states have passed limited regulations that attempt to eliminate some of the cruelest forms of treatment. For example, California and Michigan, legislated phase-outs for battery cages used for egg-laying hens. 6 other states (Florida, Arizona, Oregon, Colorado, Maine, and Ohio) outlaw either veal crates or gestation crates.[68] Massachusetts might soon join these states; two state legislators have introduced the Massachusetts Prevention of Farm Animal Cruelty Act, which would ban gestation crates for pigs, battery cages for egg-laying hens, and veal crates.[69]

Labels

The USDA permits the use of a variety of labels on meat, dairy, and eggs, but most of these labels are not legally standardized and can be misleading.[70] Here are some common labels:

"Cage Free"

Although the USDA verifies "cage free" conditions for egg-laying hens, growers do not necessarily have to provide access to the outdoors for the hens to satisfy the requirements. Often,

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[67] Sustainable Table. "Animal Welfare." *Sustainabletable.* n.d. Web. 4 May 2011. <http://www.sustainabletable.org/issues/factoryfarming/>.

[68] Baur, Gene. "Change for Chickens (and the Nation)." *Grist*. 9 July 2010. Web. 14 March 2011. <http://news.change.org/stories/change-for-chickens-and-the-nation>.

[69] Matheny, Martin. "Factory Farms Under Fire in Massachusetts." *Grist*. 27 January 2011. Web. 14 March 2011. <http://news.change.org/stories/factory-farms-under-fire-in-massachusetts>.

[70] Farm Sanctuary. "The Truth Behind Labels: Farm Animal Welfare Standards and Labeling Practices, Report Summary." *Farm Sanctuary.* April 2009. Web. 14 March 2011. <http://www.farmsanctuary.org/issues/campaigns/summary.html>.

the hens are crowded with thousands of others into large barns and given about a square foot of space.[71]

"Free Range" or "Free Roaming"

The "free range" or "free roaming" label merely requires that poultry have access to the outdoors,[72] but it does not specify the quality or size of the outdoor area or the length of time the birds have access. Consequently, "free range" birds are typically raised similarly to factory-farmed birds – in crowded warehouses, but with limited access to a barren outdoor dirt lot.[73]

"Grass Fed"

Aside from milk before weaning, "grass fed" ruminant animals must be fed only grass and forage. They cannot be fed grain or grain byproducts, and they "must have continuous access to pasture during the growing season."[74] The animals' diets can be supplemented with vitamins and minerals.[75] As with the "free range" label, "access" is a vague term and may be satisfied with a difficult-to-reach or unappealing pasture area. "Grass fed" or "pasture raised" labels only apply to animal feed -- not to hormones, antibiotics, physical alterations, living conditions, or other aspects of treatment.

"Humanely raised"

The USDA will approve the label "humanely raised" if its meaning is defined on the label and backed by a third-party certification program.[76] For more information on third-party certifications, see below.

"Natural" and "Naturally Raised"

The label "natural" only applies to the processing of animal products – not to how the animals were treated when they were alive. The label "naturally raised" requires animals to be

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[71] Farm Sanctuary. "The Truth Behind Labels: Farm Animal Welfare Standards and Labeling Practices, Report Summary." *Farm Sanctuary.* April 2009. Web. 14 March 2011. <http://www.farmsanctuary.org/issues/campaigns/summary.html>.

[72] USDA Food Safety and Inspection Service. "Meat and Poultry Labeling Terms." *USDA*. 29 October 2010. Web. 14 March 2011. <http://www.fsis.usda.gov/factsheets/Meat_&_Poultry_Labeling_Terms/index.asp>.

[73] Farm Sanctuary. "The Truth Behind Labels: Farm Animal Welfare Standards and Labeling Practices, Report Summary." *Farm Sanctuary.* April 2009. Web. 14 March 2011. <http://www.farmsanctuary.org/issues/campaigns/summary.html>.

[74] USDA Agricultural Marketing Service. "Grass Fed Marketing Claim Standards." *USDA*. 2007. Web. 14 March 2011. <http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateN&navID=GrassFedMarketingClaimStandards&rightNav1=GrassFedMarketingClaimStandards&topNav=&leftNav=GradingCertificationandVerfication&page=GrassFedMarketingClaims&resultType=&acct=lss>.

[75] USDA Agricultural Marketing Service. "Grass Fed Marketing Claim Standards." *USDA*. 2007. Web. 14 March 2011. <http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateN&navID=GrassFedMarketingClaimStandards&rightNav1=GrassFedMarketingClaimStandards&topNav=&leftNav=GradingCertificationandVerfication&page=GrassFedMarketingClaims&resultType=&acct=lss>.

[76] Farm Sanctuary. "The Truth Behind Labels: Farm Animal Welfare Standards and Labeling Practices, Report Summary." *Farm Sanctuary.* April 2009. Web. 14 March 2011. <http://www.farmsanctuary.org/issues/campaigns/summary.html>.

raised without the use of antibiotics, animal by-products, or synthetic growth promoters,[77] but it implies nothing about living conditions, physical alterations, or other aspects of treatment.

"Organic"

The USDA verifies organic conditions for all farm animals through its organic certification program. "Organic" certification requires that all animals are provided with "access" to the outdoors and that ruminants (grazing animals) are given "access" to pasture. "Access" is not clearly defined; an unappealing, difficult-to-reach outdoor area may qualify as "access."[78]

In sum, the labels "cage free," "free range" or "free roaming," and "natural" have minimal to no implications for the humane treatment of farm animals. The "grass fed" label accurately describes the animals' diet but does not imply humane treatment practices. The label "naturally raised" indicates that no animal by-products, antibiotics, or synthetic growth promoters were used in raising the animal, but does not ensure other humane treatment practices. The label "organic" prohibits the administration of synthetic growth promoters and antibiotics, but it says nothing about other treatment practices, aside from its weak and vague requirement of access to the outdoors. These labels are a step in the right direction, but they ultimately say little about how farm animals are treated. The label "humanely raised" may be promising, as it requires third-party certification, although it allows for different definitions of the term "humanely raised."

Quality Assurance Programs

Various animal agriculture industries have developed their own voluntary guidelines, known as "quality assurance programs," which essentially define current industry practices as "humane."[79] For example, the National Cattlemen's Beef Association (NCBA)'s guidelines for the care of beef cows do not include audits, do not require access to pasture, and allow castration without anesthesia. Similarly, the National Pork Board has a Quality Assurance Plus (PQA Plus) program. PQA Plus does not include a third-party audit and allows sows (pregnant pigs) to be confined to gestation crates, requires no outdoor access, and allows castration of males without anesthesia.[80] With the exception of the United Egg Producers' "UEP Certified" label, which requires facility audits[81] but allows for tight confinement and de-beaking of egg-laying hens, among other common practices,[82] these programs are usually advertised on promotional materials rather than products.

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[77] Farm Sanctuary. "The Truth Behind Labels: Farm Animal Welfare Standards and Labeling Practices, Report Summary." *Farm Sanctuary.* April 2009. Web. 14 March 2011. <http://www.farmsanctuary.org/issues/campaigns/summary.html>.

[78] Farm Sanctuary. "The Truth Behind Labels: Farm Animal Welfare Standards and Labeling Practices, Report Summary." *Farm Sanctuary.* April 2009. Web. 14 March 2011. <http://www.farmsanctuary.org/issues/campaigns/summary.html>.

[79] Farm Sanctuary. "The Truth Behind Labels: Farm Animal Welfare Standards and Labeling Practices, Report Summary." *Farm Sanctuary.* April 2009. Web. 14 March 2011. <http://www.farmsanctuary.org/issues/campaigns/summary.html>.

[80] Venetucci Harvey, Michelle. "Parsing the new 'humane' food labels." *Grist*. 21 January 2011. Web. 14 March 2011. <http://www.grist.org/article/food-2011-01-21-parsing-the-new-humane-food-labels>.

[81] Venetucci Harvey, Michelle. "Parsing the new 'humane' food labels." *Grist*. 21 January 2011. Web. 14 March 2011. <http://www.grist.org/article/food-2011-01-21-parsing-the-new-humane-food-labels>.

[82] Farm Sanctuary. "The Truth Behind Labels: Farm Animal Welfare Standards and Labeling Practices, Report Summary." *Farm Sanctuary.* April 2009. Web. 14 March 2011.

Third-Party Certification Programs

Third-party certification programs are the most credible labeling system because they are issued by organizations that are completely independent from the product they certify, the product's producers, and retailers. Here are the major third-party certifications for humane farm animal treatment in the United States:

Certified Humane

The Certified Humane program is run by Humane Farm Animal Care (HFAC) and endorsed by animal advocacy groups. It has standards for cows (beef cattle, dairy cattle, veal calves), pigs, sheep, goats, turkeys, and chickens (egg-laying hens and broilers for meat). Developed by animal behavior scientists and farm animal care veterinarians, the standards include a minimum of 4 hours of outdoor exercise daily for dairy cows, bedding and no gestation crates for pregnant sows (pigs). Litter for dust bathing for chickens and egg-laying hens, with no slatted or wire flooring for chickens or wire cage confinement for hens. The standards do not require outdoor access for pigs, chickens, or hens; nor do they prohibit feedlot confinement of beef cows or physical mutilations such as de-beaking hens and tail-docking pigs in some circumstances.[83]

American Humane Certified

Formerly known as "Free Farmed," American Humane Certified is administered and sponsored by the American Humane Association. Its standards are similar to the Certified Humane program and cover bison. The program also has video cameras at some veal and poultry facilities to facilitate compliance.[84]

Animal Welfare Approved

The Animal Welfare Approved (AWA) program, run by the Animal Welfare Institute, has standards for cows (beef cattle, calves, and dairy cattle), pigs, chickens (egg-laying hens and broilers for meat), turkeys, and sheep, and is developing or revising standards for other animals such as rabbits, ducks, bison, and herding dogs. It has high standards with regard to physical alterations, weaning, and access to the outdoors or pasture. Although AWA does not charge for certification, it only certifies family farms, and is smaller in scale than other certification programs. It is estimated that fewer than 700 small farms, with fewer than 100,000 animals, are certified each year, representing less than 0.001 percent of all animals slaughtered in the United States.[85]

<http://www.farmsanctuary.org/issues/campaigns/summary.html>.

[83] Farm Sanctuary. "The Truth Behind Labels: Farm Animal Welfare Standards and Labeling Practices, Report Summary." *Farm Sanctuary.* April 2009. Web. 14 March 2011. <http://www.farmsanctuary.org/issues/campaigns/summary.html>.

[84] Farm Sanctuary. "The Truth Behind Labels: Farm Animal Welfare Standards and Labeling Practices, Report Summary." *Farm Sanctuary.* April 2009. Web. 14 March 2011. <http://www.farmsanctuary.org/issues/campaigns/summary.html>.

[85] Farm Sanctuary. "The Truth Behind Labels: Farm Animal Welfare Standards and Labeling Practices, Report Summary." *Farm Sanctuary.* April 2009. Web. 14 March 2011. <http://www.farmsanctuary.org/issues/campaigns/summary.html>.

Certified Organic

The USDA runs the National Organic Program (NOP), which certified and labels products. Although the organic market is growing, less than 1 percent of U.S. farm animals are raised organically. NOP standards apply to all farm animal species, require access to the outdoors for all animals and to pasture for grazing animals, and conditions that facilitate the "health and natural behavior of animals." The standards do not prohibit the use of electric prods, forced molting, shortened weaning practices, physical alterations such as de-beaking and tail docking, and they do not address minimum space requirements, euthanasia, or transport.[86]

Food Alliance Certified

Food Alliance Certified is a comprehensive certification program for the "production, processing, and distribution of sustainable food," with standards for ecosystem stewardship, sustainability in agriculture and the food industry, safe and fair working conditions, and to humane animal treatment.[87] Its "healthy, humane animal treatment" standards call for the greatest respect for animals' needs and comfort, including proper nutrition for health and fitness, physical and thermal comfort in living conditions and spaces, access to natural light and vegetated pasture, enhanced natural behavior, minimized fear and stress during handling, transport and slaughter, no use of hormone treatments, and antibiotic use limited to treating occasional illness.[88] Food Alliance Certified operations have improved welfare for hundreds of thousands of animals.[89]

Global Animal Partnership 5-Step Program

The Global Animal Partnership grew out of Whole Foods Market's Animal Compassion Foundation. In 2009, Global Animal Partnership launched a pilot test of its 5-Step Animal Welfare program in Whole Foods Market stores. The program rates beef cows, pigs, and broiler chickens according to criteria developed in collaboration with animal welfare advocates, scientists, and farmers. The rating system is as follows:

Step One: No crates, no cages and no crowding
Step Two: Indoor environments must include minimal enhancements to encourage natural behaviors
Step Three: Outdoor access required along with environmental enhancements to encourage natural behaviors
Step Four: Pasture centered – improved standards for outdoor areas
Step Five: Animal centered – all physical alterations prohibited
Step Five Plus: Animal centered – the animals spend their entire life on same farm

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[86] Farm Sanctuary. "The Truth Behind Labels: Farm Animal Welfare Standards and Labeling Practices, Report Summary." *Farm Sanctuary*. April 2009. Web. 14 March 2011. <http://www.farmsanctuary.org/issues/campaigns/summary.html>.
[87] Food Alliance. "About Food Alliance." *Food Alliance.* n.d. Web. 14 March 2011. <http://foodalliance.org/about>.
[88] Food Alliance. "Healthy, humane animal treatment." *Food Alliance.* n.d. Web. 14 March 2011. <http://foodalliance.org/certification/standards-explained/ensure-animal-health-and-humane-treatment>.
[89] Ecolabel Index. "Food Alliance Certified." *Ecolabel*. 2011. Web. 14 March 2011. <http://www.ecolabelindex.com/ecolabel/food-alliance-certified>.

Recommendations

In addition to considering the above labels and certifications for animal welfare, Wellesley dining services should seek animal products from states or locations that legally require animal treatment practices that exceed industry standards (such as California, Michigan, and potentially Massachusetts!), as well as products that are third-party certified for humane farm animal treatment. First- and second-party certification systems (such as producer claims, industry quality assurance programs, and retail supplier preferences) are generally lax and misleading so they should not be prioritized as meaningful labels.

The reviewed labels and certifications are listed below starting with most desirable and strictest standards:

- Animal Welfare Approved: high standards for humane treatment, but it may be a challenging or unviable option for us because it is limited to family farms
- Fool Alliance Certified: simultaneously addresses many issues we are concerned about, including environmental stewardship and safe and fair working conditions, while addressing humane animal treatment
- Global Animal Partnership 5-Step Program: covers different levels of humane treatment, from the most basic (no crates, cages, or crowding) to the most advanced (animal centered)
- American Humane Certified and Certified Humane: eliminate the cruelest aspects of treatment, such as battery cages and gestation crates
- National Organic Program (USDA "Certified Organic"): prohibits the use of antibiotics and synthetic growth hormones and provides vague requirements for other aspects of treatment

While many labels (such as "cage free," "free range" or "natural") have little substance and should not influence Wellesley dining services' purchasing choices, some labels, such as "grass fed" and "naturally raised," should be prioritized when third-party certification is not possible, keeping in mind their limited scope in animal treatment practices. The "humanely raised" label is an exception because it requires third-party certification.

Finally, it is important to recognize the disadvantages and shortcomings of certification. With the exception of the AWA program, certification requires time, resources, and money. Even though they may meet most or all of the requirements, these costs deter some operators, especially small farms, from becoming certified. In light of these limitations to certification, products from suppliers that clearly and transparently outline and follow human animal treatment practices should be prioritized.

Another option is for Wellesley dining services to redirect its meat and animal product purchases towards local farms. Small-scale local farms are less prone to the large-scale practices aimed at maximizing output that create animal welfare concerns. Small-scale suppliers may not necessarily have organic or other specialized labels but generally have more transparent production practices and facilities.

It is essential to highlight, advertise, and celebrate current choices that improve animal welfare, environmental sustainability, and other important issues. Considering the fundamental role that consumer awareness and preference has played in establishing animal welfare standards, the College community should be informed about the labels, certifications, and practices of the animal products Wellesley dining services buys. Food approved by these various outside labeling groups or that is grown and produced by responsible, transparent producers, should be labeled accordingly so students and diners know that Wellesley dining services is conscious of and committed to humane practices.

For a comparison of the USDA National Organic Program and U.S. third-party certification standards to industry standards for the treatment of different farm animals, see Appendix B.

Labor Standards

A basic understanding and awareness of worker rights violations, and the health and safety hazards of food production are a necessary part of socially responsible decision-making. A truly sustainable approach towards Wellesley's dining services should incorporate not only environmental but also social responsibility. By looking at the entire food production process, we can identify where worker's rights infringements, health and safety risks, or other labor issues most often surface in the life cycle of a given foodstuff.

Outside of the United States, labor laws are often not stringent, while domestically, labor laws are not always upheld. In Latin America, banana production has been cited as extremely exploitative because there is an oligopoly on banana production; five companies produce the majority of the world's bananas. This concentration allows the industry to exert control over Latin American governments and enables the continued existence of poor labor conditions and lax labor laws.[90] We would like to emphasize that Wellesley dining services currently orders the majority of its bananas from Chiquita Banana, a company that has significantly increased its labor and environmental standards.

Within the U.S., immigrant laborers, regardless of citizenship status, often face problems regarding worker's rights infringements. Because of language barriers, unfamiliarity with the legal system and labor laws or, in many cases, fear of being fired or mistreated for protesting issues in the work place, immigrant workers are prone to mistreatment,[91] despite the fact that most federal and state labor laws apply to all workers, regardless of citizenship status.[92] 30 percent of workers on Concentrated Animal Feeding Operations (CAFOs) are legal or illegal immigrants.[93] Seasonal workers have little job stability and must find work from season to season,[94] and therefore are also prone to poor working conditions or low wages. Child labor and gender discrimination are other problems common to the food production system.[95] For instance, Wellesley dining services' largest provider of ground beef, Green Bay Dressed Beef, settled out of court in a gender discrimination lawsuit in February 2011.[96]

The planting and harvesting stages of production have the most potential for workers rights infringements but the processing or transportation steps can also have labor standard issues. Food production is often labor intensive and requires hard physical labor in variable conditions.[97] Heavy lifting, prolonged exposure to the sun, and constant repetitive movements

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90 Shah, Anup. "The Banana Trade War." *Global Issues*. 3 Jan. 2010. Web. 16 Mar. 2011. <http://www.globalissues.org/article/63/the-banana-trade-war>.

91 Sustainable Table. "Workers, farm worker safety. "*Sustainabletable*. n.d. Web. 14 Mar. 2011. <http://www.sustainabletable.org/issues/workers/>.

92 Sustainable Table. "Workers, farm worker safety. "*Sustainabletable*. n.d. Web. 14 Mar. 2011. <http://www.sustainabletable.org/issues/workers/>.

93 Purdue University. "Community Impacts of CAFOs." *Purdue Extension*. n.d. Web. 15 Mar. 2011. <http://www.extension.purdue.edu/extmedia/ID/ID-362-W.pdf>.

94 National Immigration Law Center. "Facts About Immigrant Workers." *National Immigration Law Center*. Apr. 2007. Web. 16 Mar. 2011. <www.caimmigrant.org/document.php?id=182>.

95 Shah, Anup. "The Banana Trade War." *Global Issues*. 3 Jan. 2010. Web. 16 Mar. 2011. <http://www.globalissues.org/article/63/the-banana-trade-war>.

96 Allen, Scott, and Rhonda Burke. "US Labor Department Settles Gender Discrimination Case with Green Bay Dressed Beef on Behalf of 970 Female Applicants for $1.65 Million. 11-0146-CHI." *U.S. Department of Labor Office of Federal Contract and Compliance Programs*. 03 Feb. 2011. Web. 9 Apr. 2011. <http://www.dol.gov/opa/media/press/ofccp/OFCCP20110146.htm>.

97 Sustainable Table. "Workers, farm worker safety. "*Sustainabletable*. n.d. Web. 14 Mar. 2011. <http://www.sustainabletable.org/issues/workers/>.

are common health risks for laborers.[98] Workers in most areas of agriculture are at risk for severe or fatal injury from machinery or heavy equipment. Fruit, vegetable and grain production workers are especially at risk for exposure to toxic chemicals sprayed on crops in the form of fertilizers or pesticides.[99] Air quality in grain storage sites is usually poor from grain dust and suffocation in tanks or silos is very real risk. Injuries in meat slaughtering and processing plants from high speed processing lines are common, as are repeat trauma disorders. Manure can contaminate the air with pathogens, decreasing breathable air quality, and is thereby a large cause of disease among workers in the industry. Respiratory problems are cited among 25 percent of CAFO workers. Seafood workers have the highest rate of occupational injuries.[100]

Not only is food production a dangerous occupation, with over 170,000 deaths each year,[101] but the wages are low as well. Table 14 shows the average hourly wages for different types of agricultural work while Table 15 shows the average annual salary of selected food production occupations in the United States.

Table 14: Average agricultural hourly wages[102]

Occupation	Hourly Wage
Animal breeders	$13.02
Agricultural equipment operators	10.92
Farm workers, farm and ranch animals	10.13
Farm workers and laborers, crop, nursery, and greenhouse	8.64
Agricultural workers, all others	12.00
Truck drivers	14.50-19.91

Table 15: Average annual salaries of food production occupations[103]

Occupation	Annual Wage
Dairy product manufacturing	$31,840
Other food manufacturing	25,780
Fruit and vegetable preserving and specialty food manufacturing	24,190
Sugar and confectionery product manufacturing	23,310
Bakeries and tortilla manufacturing	22,800

[98] Centers for Disease Control and Prevention. “Workplace Safety and Health Topics.” *Centers for Disease Control and Prevention.* Web. 15 Mar. 2011. <http://www.cdc.gov/niosh/topics/agriculture/>.
[99] Stellman, Jeanne Mager. "Industries Based on Agricultural Resources." *Encyclopaedia of Occupational Health and Safety.* Geneva: International Labor Office, 1998. Print.
[100] U.S. Bureau of Labor Statistics. “Food Manufacturing." *U.S. Bureau of Labor Statistics*. n.d. Web. 16 Mar. 2011. <http://www.bls.gov/oco/cg/cgs011.htm>.
[101] International Labour Oranization. "The ILO Programme on Occupational Safety and Health in Agriculture." *International Labour Organization*. n.d. Web. 16 Mar. 2011. <http://www.ilo.org/safework/areasofwork/lang--en/WCMS_117367/index.htm>.
[102] U.S. Bureau of Labor Statistics. "Agricultural Workers." *U.S. Bureau of Labor Statistics*. n.d. Web. 15 Mar. 2011. <http://stats.bls.gov/oco/ocos349.htm>.
[103] U.S. Bureau of Labor Statistics. "Agricultural Workers." *U.S. Bureau of Labor Statistics*. n.d. Web. 15 Mar. 2011. <http://stats.bls.gov/oco/ocos349.htm>.

Wellesley dining services has made some socially responsible choices regarding food purchasing. For example, many companies from whom food is ordered, such as Sysco and McCain Foods Ltd., adhere to strict codes of conduct that state that they will only enter into contracts with producers or suppliers with high standards of social responsibility. Wellesley dining services also purchases some Fair Trade coffee. Fair Trade certified products ensure that producers are compensated adequately for their labor and goods, and works to protect the environment through the promotion of sustainable agricultural practices.[104]

To ensure that Wellesley dining services makes responsible choices regarding worker's rights, there are several things that should be looked for when picking suppliers and producers. Bananas and other fruits produced in Latin America are at risk for labor issues. Produce and grain production workers face numerous health and safety risks during planting, harvesting, and processing while meat processing workers are especially at risk during the processing step. Immigrants, children and women are particularly at risk for violations of worker's rights throughout all sectors of food production and processing. While Wellesley dining services' purchasing choices include some responsible providers, it should be responsible for ensuring that all products adhere to ethical labor standards by prioritizing transparent food suppliers with strict codes of conduct.

[104] Fair Trade USA. "What is fair trade?" *Fair Trade USA*. n.d. Web. 15 Mar. 2011. <http://www.transfairusa.org/what-is-fair-trade>.

3- Purchasing Recommendations

In Part I of this report we examine Wellesley's food purchasing choices, focusing on the sustainability impacts that various food items have in the following seven areas: climate change, eutrophication, water use, toxicity, biodiversity, animal welfare, and labor. This concluding chapter provides several food purchasing recommendations for the Wellesley dining services based on findings from Part I. Many of our recommendations have a positive impact on sustainability in more than one of the seven areas examined in Part I, thus we group the recommendations in this chapter into the following categories: animal products, processed foods, vegetarian protein alternatives, organic foods, local foods, green certifications, and transparency.

Animal Products

Of all the food items purchased by Wellesley dining services, animal products, particularly beef, are responsible for the worst environmental impacts. Animal products generally received poor metric grades, and raise biodiversity, toxicity, and animal welfare concerns as well. The most critical change to make across all categories is to reduce consumption of beef, which has the highest cumulative environmental impact of any product assessed. Beef scores so high on the water and climate impact metrics that it effectively defines the upper bound for the worst possible impact for that metric, and requires the use of a logarithmic scale in order to represent the other foods' impacts meaningfully. Animal products as a group are four times as water-intensive as non-animal products; beef produces more methane than other methane-producing foods by a factor of 37; and in terms of carbon, beef produces more than its nearest competitor by a factor of ten. The single most important thing Wellesley dining services can do to improve its sustainability with respect to food purchasing choices is to reduce consumption of beef.

Based on our metrics findings, we recommend that Wellesley also reduce its consumption of bacon, eggs, and dairy products in order to reduce its impact on climate change, eutrophication, and water. Wellesley dining services could potentially replace these environmentally taxing foods with lower-impact animal products, such as poultry and wild-caught shrimp, and plant-based alternatives. If dining services chooses to serve lower-impact animal products, we recommend choosing brands that are certified to meet the environmental, animal welfare, and/or labor standards discussed in the Certifications section below. Products with any of the following labels also represent modest improvements in animal welfare and toxicity: "grass fed," "naturally raised," "humanely raised," "no hormones administered" (beef), "no antibiotics added" (red meat and poultry), and "no rBGH" (dairy). All of Wellesley dining services' milk purchases currently come from suppliers that do not administer hormones to their dairy cows, and we encourage the continuation of this practice. If certified or labeled animal products are not an economically feasible option, the College could at least buy animal products from companies that have strict standards for environmental and social responsibility. Some of dining services' current vendor companies, including Sysco and McCain Foods Ltd., already engage in socially responsible corporate behavior. Additionally, the College could purchase animal products from small farms that are less likely to engage in many of the industrial practices that raise animal welfare concerns, and from local farms that are transparent about animal welfare and labor issues.

Vegetarian Protein Alternatives

To reduce the environmental impacts of our meat consumption, turning to vegetarian protein sources might seem an obvious choice. Yet vegetarian protein alternatives range considerably in terms of environmental impact, and some alternatives have even larger environmental impacts than meat products. According to our metrics, the average grade for meat products overall is a C-, whereas vegetarian protein alternatives on average received a D. While this gives the initial impression that vegetarian proteins are a worse environmental choice, it is important to note that the vegetarian alternatives included in our analysis are highly processed and composed of several ingredients, each also processed. In contrast, we consciously chose to analyze unprocessed, basic forms of all meat products. A more realistic comparison between these two categories of food would include either processed meat products, which compose the lion's share of Wellesley dining services' meat purchasing, or unprocessed vegetarian protein alternatives—namely, legumes.

While we do not examine unprocessed legumes in our analysis, we deduce from our findings that legumes do not have nearly as high an impact on the environment as the processed vegetarian protein alternatives we examine. Legumes only appear in our analysis as an ingredient in hummus, which, because it is so highly processed and reliant on imported, separately processed ingredients, almost certainly has a much higher environmental impact than the legumes it incorporates. Likewise, the soy incorporated in the vegan chicken nuggets and the tofu ordered by dining services receives most of its low metric marks because of the water and energy use expended in processing it, not in the production phase itself.

Given these findings, the necessity of providing vegetarian protein options, and the overall recommendations to buy less beef and less-processed products, we recommend that Wellesley dining services choose whole, unprocessed vegetarian proteins as responsible alternatives to meat for both vegetarian and omnivore diets. Beans and other legumes offer a lower impact profile than either animal proteins or processed vegetarian protein alternatives, thus we suggest that dining services serve more legume-based main dishes such as lentil soup, chickpea curry, or black bean vegetarian chili. Additionally, we recommend that dining services mitigate the impacts that processed vegetarian proteins such as hummus have on eutrophication by choosing organic purveyors.

Processed Foods

A study conducted by David Pimentel et al. in 2008 concluded that a healthier diet consisting of fewer processed and animal foods could make a significant impact on the amount of energy used in the United States.[105] After analyzing the climate change, eutrophication, and water use impacts of the selected foods eaten on Wellesley College's campus, we reach a similar conclusion. Processed foods in general have higher impacts on the environment than whole foods because they require more inputs and use more water and energy for processing. It is important to note that while we only look at a small sample of the processed foods purchased by dining services in our LCA, our findings apply to other processed foods as well.

Processed foods in our LCA such as hummus, chocolate chip cookie dough, vegan chicken nuggets and Cracklin' Oat Bran cereal generally receive worse grades than whole foods on all three metrics. For example, within the water metric, non-processed foods receive grades of

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[105] ScienceDaily. "Eating Less Meat And Junk Food Could Cut Fossil Energy Fuel Use Almost In Half." *Science Daily: News & Articles in Science, Health, Environment & Technology*. 24 July 2008. Web. 11 Apr. 2011. <http://www.sciencedaily.com/releases/2008/07/080723094838.htm>.

As and Bs while processed foods receive mostly Bs, Cs, and Ds. The two Fs in this metric are also given to processed foods. This is because processing requires an exorbitant amount of water. Processed foods in our analysis use an average of approximately 100 gallons of water per serving—an order or magnitude more than non-processed foods, which use an average of approximately thirteen gallons per serving. Similarly, processed foods receive worse climate change and eutrophication grades than non-processed foods. Hummus receives the worst grade in the eutrophication metric. In the climate change metric, hummus, ice cream, vegan nuggets, and cookie dough all receive Cs. Cracklin' Oat Bran received a D.

We recommend that dining services purchase fewer processed foods because they tend to have a more negative impact on the environment than whole foods. We specifically suggest limiting the use of processed corn and potatoes because the production of these foods is particularly water and energy intensive. Additionally, we recommend that fruits and veggies or less processed sweets be offered in place of highly processed desserts such as cookies. In our analysis, chocolate chip cookie dough received poor grades because the environmental impacts of processing chocolate are so high.

Organic Food

Eating organic food is often cited as a straightforward way to reduce environmental impacts and minimize health risks associated with agrochemicals. Yet few people know exactly what organic standards entail or how these standards reduce the environmental impacts of food production. We briefly explain organic agriculture here and then recommend how Wellesley Dining Services should approach organic purchasing.

Organic is both a concept and a certification standard. Organic as a concept differs across various groups and geographical areas, but generally it entails not using synthetic inputs such as antibiotics, hormones, pesticides and fertilizers. Organic as a certification varies between countries, but in the U.S. organic certification standards include regulations that prohibit the use of irradiation, sewage sludge, or genetically modified organisms in organic production, disallow a specific list of synthetic and prohibited natural substances, prohibit antibiotics in organic meat and poultry, and require 100 percent organic feed for organic livestock. Products can be certified "100 percent organic," meaning they are made entirely with organic ingredients, "organic," meaning they have at least 95 percent organic ingredients, and "made with organic ingredients," meaning they have at least 70 percent organic ingredients.[106]

In order to be labeled organic in the U.S., farmers must be certified, but the high cost and long time frame associated with becoming a certified organic farmer discourages many small operations from becoming certified. Making specific policies regarding certified organic foods can exclude local producers. There is also a new trend of large, industrial organic farms, which often go against many of the principles that people associate with organic agriculture. In addition, organic agriculture can have negative environmental impacts, including the need for more land per unit of food produced and higher fertilizer inputs (although the fertilizer is organic not synthetic) than conventional agriculture.[107] At the same time, organic food can reduce

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[106]USDA Agricultural Marketing Service. "Understanding Organic Labeling." 5 Feb. 2010. Web. 1 May 2011. <http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateA&navID=NationalOrganicProgram&leftNav=NationalOrganicProgram&page=NOPUnderstandingOrganicLabeling&description=Understanding%20Organic%20Labeling&acct=nopgeninfo>.

[107] Paarlberg, Robert L.. *Food politics: what everyone needs to know*. New York, Oxford University Press: 2010. Print.

climate and biodiversity impacts and decrease potential health hazards from agrochemicals, antibiotics and added hormones.

Buying exclusively organic foods may not be a cost-effective option for Wellesley dining services, nor should it necessarily be the ultimate goal. Wellesley dining services should prioritize organic among certain food products that tend absorb high levels of agrochemicals or contain particularly toxic chemicals. In doing so, dining services can maximize health benefits and reduce environmental impacts at an affordable price. When it comes to organic produce, we recommend that Wellesley dining services prioritize fruits and vegetables that are eaten raw and that do not have peels (i.e. apples, peaches, baby spinach, tomatoes, cucumbers, and berries) because they are capable of absorbing and retaining high levels of pesticides. Additionally, we recommend that dining services purchase certified organic meat and dairy products to ensure that these products do not contain antibiotics and added hormones, both of which may have negative health impacts. Cereals, grains and sweets are less important to buy organic because their residual pesticide content is relatively low.

Because of the price premium for organic food, we understand that drastically increasing the amount of organic purchasing is unreasonable but recommend that dining services transition to more organic purchasing wherever possible. In addition, local sources that are producing food in an organic way but are not certified should also be prioritized. Other recommendations considered in this chapter (reducing meat and more specifically beef consumption and reducing processed foods) can have larger environmental benefits than purchasing organic, with a smaller price premium. Yet organic foods can be a tangible and effective way to address negative health and environmental effects of Wellesley dining services' purchasing choices, especially for the specific subset of foods mentioned.

Local

The movement to buy local has evolved from a community-led effort to revitalize the local foodshed to, paradoxically, an international movement to reduce the global footprint of the food that arrives on our kitchen tables. Today, local food is popularly paired with organic certification to make up the two necessary conditions for environmentally conscious grocery shopping. In Part I we examine whether this popularized notion of sustainable food is true. Our carbon footprint analysis indicates that transportation generally does not contribute the greatest proportion of carbon emissions for a given food item, suggesting that strictly adhering to a local food rule does not target the biggest sources of emissions for many of the foods we study. However, emissions from transportation are proportionally more significant for fresh produce like apples and spinach, and buying local in these cases would result in a dramatic improvement in their carbon footprints. Furthermore, buying local often has benefits beyond the reduction in food miles, including the following: increasing the share of seasonal food that Wellesley dining halls offer; building relationships with local farmers; providing educational and employment opportunities for Wellesley students; and investing in the local economy.

Any discussion of the local food movement must begin with a clarification of what local means. The precise number of miles that a food item can travel to the plate while still being considered local varies, but the term "locavore" typically refers to a person who strictly eats food produced within a 100-mile radius.[108] From Wellesley, this local foodshed encompasses eastern Massachusetts, eastern Connecticut, Rhode Island, southern New Hampshire and a sliver of

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[108] Sustainable Planet. "What is local?" *Sustainable Planet*. 2009. Web. 12 April 2011. <http://www.sustainabletable.org/issues/eatlocal/>.

southern Maine. Rather than adhere to a specific mileage requirement, it would be more meaningful to consider local produce as seasonal produce--that is, fruits and vegetables that are naturally ripe during the specific season in Massachusetts and surrounding states. That way, we can guard against policies that consider tomatoes grown in Massachusetts' greenhouses environmentally preferable to tomatoes grown on California's farms, which is a false assumption given the carbon impact of greenhouse energy use.[109]

Food that is either seasonal or local will also likely arrive less processed than food items that are shipped long distances. For instance, baby spinach that is frozen for freshness before shipping from California will have a much larger carbon footprint than spinach that is shipped fresh from the Natick Community Organic Farm. However, some processes are standardized—for example, food may be heavily packaged regardless of where it is being shipped from. Heavy packaging is easiest to avoid by purchasing produce in bulk directly from a local farm, similar to the way that community-supported agriculture (CSA) shares are prepared weekly or monthly for customers to pick up. Because processing and packaging make up such a large proportion of the environmental impacts of food items, purchasing local food whenever possible would significantly improve Wellesley dining services' sustainability.

Finally, purchasing local has the potential to revitalize the local economy and bolster local farms. This economic impact could offer benefits beyond reductions in carbon emissions. These purchasing strategies can help Wellesley build relationships with local farmers, both increasing transparency into the production process on the farm but also creating opportunities for Wellesley students to volunteer or work at these farms. Ultimately, buying local can help Wellesley students rediscover the link between the food on their plate and the farm on which their meals are produced.

We recommend that Wellesley prioritize buying seasonal fruits and vegetables locally in cases when long-distance shipment would otherwise involve freezing or heavy packaging of the food item, and in cases when there is a clear opportunity to build a relationship with the local farm.

Green Certifications

Purchasing food items that have green certifications can simplify the process of selecting foods that protect animal welfare, labor rights, and biodiversity, and that have low toxicity impacts. Many certifications, however, are misleading and some certified food items are much more expensive than non-certified alternatives. Here we summarize certifications and indicate which ones are meaningful (Table 16), and which would be most feasible to implement from a budget perspective. A certification is considered meaningful if a third party is involved in the certification process and the standards for the certification go beyond basic legal requirements. The recommendations below represent our understanding of the actions that would have the most beneficial impact on our campus.

Table 16: Summary of certifications relating to additional factors

Certification	Type	Meaningful?
Humanely Raised	Animal Welfare	Depends on specific certifier
Animal Welfare Approved	Animal Welfare	Yes
American Humane Certified	Animal Welfare	Yes

[109] Bon Appetit. "Low Carbon Diet Frequently Asked Questions." *Circle of Responsibility*. 2007. Web. 12 April 2011. <http://www.circleofresponsibility.com/page/331/general-faqs.htm>.

Certified Humane	Animal Welfare	Yes
Global Animal Partnership 5-Step Program	Animal Welfare	Yes
Free Range	Animal Welfare	No
Cage Free	Animal Welfare	No
Grass Fed	Animal Welfare	Somewhat
United Egg Producers Certified	Animal Welfare	No
Organic- Animal	Toxicity, Animal Welfare	Yes for toxicity, no for animal welfare
Organic-Produce	Toxicity	Yes
Without Antibiotics	Toxicity	Yes, for beef
Without Hormones	Toxicity	Yes, for beef and milk
Naturally Raised	Toxicity	Yes
Monterey Bay "Good " Or "Best"	Biodiversity	Yes
Marine Stewardship Council	Biodiversity	Yes, more so than Monterey Bay
Fair Trade	Labor	Yes, but debated
Rainforest Alliance	Biodiversity, Labor	Yes
Food Alliance	Biodiversity, Labor, Animal Welfare	Yes
1st or 2nd Party Certifications		No

Certifications indicating low impact on biodiversity are most common for tropical produce and seafood, where the potential for negative biodiversity impacts tend to be high. For seafood items, the Marine Stewardship Council (MSC) certification is ideal because it comprehensively examines the sustainability of a fishery, while Monterey Bay’s Seafood Watch is less extensive. However, since MSC has certified a limited number of seafood items, we recommend at least following guidelines on fish listed as “Avoid” on the Monterey Bay guide. This will place some limitations on the types of canned tuna, salmon, and shrimp that can be purchased, but still allow enough flexibility to provide students with the types of seafood they are accustomed to consuming.

For produce, Rainforest Alliance certification indicates that the natural ecosystem surrounding the land where a certified crop is grown is protected. We recommend choosing Rainforest Alliance certified foods when purchasing food items grown in the tropics, such as cocoa products, bananas, and coffee. This choice should be feasible, at least for some foods items for which a certified version is readily available. For example, the Chiquita bananas Wellesley dining services currently purchase are certified, so we encourage the continued purchase of bananas from this company. Food Alliance certification is more comprehensive and includes foods grown in temperate regions, but may be less readily available from major food suppliers. If dining services must prioritize between these options, we recommend focusing on certifications for foods grown in the biologically diverse tropics.

Rainforest Alliance and Food Alliance certifications, as well as Fair Trade, address labor issues, such as safe conditions and fair wages. Dining services already purchases some Fair Trade coffee, which ensures that growers receive fair payment for their coffee. As indicated above, Rainforest Alliance certification is more comprehensive, since it also reduces the biodiversity impact of food production, so we recommend buying foods with this certification whenever possible, if the use of tropical produce cannot be reduced. Food Alliance certification for foods produced in the U.S. is a lower priority since the U.S. tends to already have stringent labor laws.

We recommend buying foods with the USDA organic label to address issues involving toxicity. Purchasing certified organic raw fruit and vegetable products reduces pesticide consumption in a more cost-effective way than purchasing organic for all products, as discussed in the Organic Foods section of this chapter. For meat and dairy, the purchase of organic-certified food, as well as meat and dairy with the labels "no hormones administered" and "no antibiotics added," is recommended for reduction of hormone and antibiotic consumption. Complete conversion to organic products is not recommended because of the additional cost.

We do not recommend that dining services prioritize products labeled, "free range," "cage free," or "grass-fed," for the purpose of improving animal welfare, because of the leniency of these standards for animals' quality of life. Whenever possible, third party certification programs should be implemented over first and second party certifications because their independence from producers and retails ensures some improvement in animal welfare over industry norms. Finally, the most effective way to ensure animal welfare is simply to reduce meat consumption by purchasing fewer animal products.

Transparency

In this report, we identify concerns for food products in many phases of their life cycles. We expect responsible decision making from Wellesley dining services as well as the college community to decrease our overall environmental impact, support the ethical treatment of supplier employees and animals used for food products, and consider the health implications of foods served on campus. As such, we recommend that Wellesley label the foods it serves with information regarding the location of the farm or the origin of the product (i.e. whether or not it is a locally purchased product), whether the item has any special certifications (i.e. organic, Fair Trade, Rainforest Alliance, etc.), and any important environmental impacts of the food, which can be extracted from this report. Such labeling may encourage students, faculty and staff to think about the foods they choose to consume and may sway consumption patterns towards healthier and environmentally sound options.

Additionally, we recommend that dining services order from suppliers that practice high levels of corporate transparency with regard to sustainability practices and commitments, processing and packaging procedures, shipment methods, human labor standards and ethics, and quality of on-site animal treatment. An example of the level of transparency we seek can be found in one of Wellesley's current sweet corn suppliers: National Frozen Foods Corporation, headquartered in Seattle, Washington. The supplier's website readily provides information regarding sustainability goals, practices and successes, locations of and contact information for processing plants, information on procedures for everything from farm practices to shipment methods (including machinery used and transportation companies employed), and the company's commitment to its employees and nearby communities.[110] In addition to providing contact information for each plant, the website shows what each facility features in terms of production capacity and rates, the names of transportation companies used to distribute products, and what

[110] *National Frozen Foods Corporation*. 2011. Web. 12 Apr. 2011. <http://www.nffc.com/>.

products are processed at each site.[111] National Frozen Foods Corporation is an example of transparent excellence, customer satisfaction and local and global environmental stewardship.

An example of the type of company we recommend that Wellesley avoid purchasing from is Green Bay Dressed Beef, the beef supplier researched for the LCA in this report. In February 2011, the U.S. Department of Labor's Office of Federal Contract Compliance Programs filed a report documenting the settlement of an investigation of systemic discrimination in 2006 and 2007.[112] This investigation found Green Bay Dressed Beef guilty of violating Executive Order 11246, which prohibits federal contractors from discriminating on the basis of gender in their employment practices. 970 women were turned away from jobs at this plant because of their gender and a fraction of them are now being compensated and hired as positions become available.[113] We encourage Wellesley dining services to make purchases from ethically sound vendors and suppliers. Additionally, we encourage dining services to avoid purchasing products from non-local companies that do not have a website, such as our fresh egg supplier, South New England Eggs Incorporated.

Conclusion

In this chapter we have presented recommendations to Wellesley dining services about how it can improve the sustainability of its food system by reducing the negative environmental and social impacts of food before it reaches the campus. Our two top recommendations for dining services are to purchase less beef and to purchase less highly processed foods. We also suggest that Wellesley reduce the overall amount of animal products it serves, replacing these with unprocessed vegetarian protein alternatives such as legumes. Wellesley dining services can improve food quality while reducing environmental impacts and keeping costs low by purchasing organic foods if they have high pesticide uptake, such as berries and peaches, while buying the conventional alternative for tougher foods, like bananas and avocados. We also recommend purchasing food from local farms as it becomes seasonally available; this action alone can reduce the College's environmental impacts, improve the community's relationship with Wellesley College, and spur the local economy. When buying foods that are associated with animal welfare or labor concerns, the College can seek out certain green certifications to ensure that it is purchasing from socially and environmentally responsible companies. Buying food from transparent and/or local companies is another way for the College to remain informed about the environmental and social impacts of the foods it serves. By turning these recommendations into reality, the College can drastically improve the sustainability of its food system.

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[111] National Frozen Foods. "Locations." *National Frozen Foods Corporation*. 2011. Web. 12 Apr. 2011. <http://www.nffc.com/locations>.

[112] Allen, Scott, and Rhonda Burke. "US Labor Department Settles Gender Discrimination Case with Green Bay Dressed Beef on Behalf of 970 Female Applicants for $1.65 Million. 11-0146-CHI." *U.S. Department of Labor Office of Federal Contract and Compliance Program.*, 3 Feb. 2011. Web. 9 Apr. 2011. <http://www.dol.gov/opa/media/press/ofccp/OFCCP20110146.htm>.

Table 17: Food analysis summary and grades

Food Type	Serving Size (unit)	Water Grade	Climate Grade	Fertilizer Grade
Apples	1 small apple	C	B	A
Baby Spinach	1cup	A	B	A
Bacon	1 ounce	C	D	F
Beef	3 ounces	F	F	C
Bottled Water	8 fluid ounces/1 cup	B	C	A
Brown Rice	1 cup/47 grams	C	C	C
Butter	1 teaspoon/.17 ounces	B	B	A
Chicken	1 ounce	C	B	C
Chiquita Bananas	1 medium banana/120 grams	A	B	B
Chocolate Chip Cookie Dough	28 grams	F	C	C
Coffee	10 grams/.36 ounces beans	C	C	A
Corn	1/2 cup/82 grams	C	C	C
Cracklin' Oat Bran	3/4 cup/49 grams/1.8 ounces	C	D	D
Cranberry Blast	8 fluid ounces	B	D	C
Cucumbers	4 ounces	B	B	F
Eggs	1 egg/60 grams	D	A	D
Hummus	2 tablespoons	B	C	F
Ice Cream	1 cup	C	C	D
Milk	8 fluid ounces/1 cup	D	C	B
Mozzarella Cheese	1.5 ounces	D	C	F
Pineapple	4 ounces	B	B	B
Potato	½ pound	C	D	C
Raspberries	.09479 pounds	B	C	C
Sunkist Orange Juice	8 fluid ounces/1 cup	D	C	C
Tofu	1/2 cup	D	C	C
Tomatoes	1/2 cup	B	B	B
Turkey	1 ounce	C	B	A
Vegan Nuggets	4 nuggets/3 ounces	C	C	D
Wild-Caught Shrimp	2 ounces	B	C	A

Table 18: Food analysis comments and recommendations

Additional Comments	Recommendations
Transportation and storage account for the largest climate impacts for apples	Buy more local and seasonal apples
Transportation accounts for almost all of the climate impact for spinach	Buy more local and seasonal baby spinach
Animal welfare and the use of antibiotics are a major concern for bacon	Purchase less pork products; purchase from small, humane certified producers
Beef's climate grade is disproportionate in comparison to all the other foods	Serve less beef; when possible, buy local
Bottled water is more environmentally friendly than frozen and concentrated juice, but is not as good as tap water	Reduce these purhases; purhase mineral water in bulk containers
Rice is a significant emitter of methane, though brown rice is healthier than white	Purchase more alternatives such as qinuoa, millet, amaranth, and buckwheat
Processed dairy products are rarely labeled, treated with hormones or antibiotics	Purchase organic dairy products, like organic butter
Animal welfare and the use of antibiotics are a major concern for chicken	Purchase organic, free-range, and humane certified chicken
Deforestation and poor labor conditions are major concerns with some brands	Continue to only purchase Chiquita that is Rainforest Alliance certified
The chocolate chips account for almost all of the water footprint	Serve desserts with less chocolate; if we continue to serve desserts with chocolate, make it Rainforest Alliance certified
Coffee can have extremely detrimental biodiversity effects; the labor is subject to rights issues in terms of wages	Purchase shade grown coffee; purchase coffee with fair trade labels (as we already sometimes do)
Sweet corn from Canada is relatively low impact	Purchase more local and organic varieties
The processing is excessive and with high inputs of grains, sugar, and palm oil	Find hearty, less processed cereals; do not serve this as frequently
Cranberries are grown locally but this juice uses cranberries shipped from WI	Choose organic and local producers of cranberry juice
Cucumbers grown in greenhouses have much higher climate impacts	Order organic and outside-grown cucumbers
Egg laying chickens are often violated of their rights; the antibiotics and hormones used for eggs could be a possible threat	Purchase eggs from local farms that utilize organic and free-range chickens
Although this is a popular food at Wellesley, it is highly processed	Choose an organic supplier of hummus; find less processed alternatives
This is a highly processed and relatively unhealthy dairy product	Buy organic, less processed ice creams with fewer additives; more dairy free alternatives
We already buy milk from relatively local farms that do not use hormones	Continue to choose suppliers like these such as Garelick and Hood
This is the most fertilizer intensive dairy food	Serve more organic cheese and less of it
Purchasing whole pineapples require less processing than canned pineapple	Buy organic pineapple and Rainforest Alliance certified pineapple
Processed potato products like French fries have high climate impacts	Buy more whole or unprocessed potatoes and less processed ones
These berries are easy to grow locally and are not input intensive; Wellesley's current supplier has socially responsible practices	Continue to purchase raspberries from our current, local supplier
Juice from concentrate has more additives and processing than fresh, 100% juice	Reduce concentrated juice purchases; serve local and seasonal juices
This is a highly processed vegetarian item	Provide less water intensive vegetarian protein alternatives such as beans
Transportation and storage account for the largest impacts	Buy more local and seasonal tomatoes
Animal welfare for turkey is horrible in factory farms	Purchase from humane treatment suppliers (likely to be local); purchase organic
Processing soy has high water impacts	Provide less water intensive protein alternatives such as beans
Biodiversity impacts are the most problematic, but wild-caught is better than farm-raised	Look to other seafood options by Monterey Bay Aquarium's Seafood Watch or follow these guidelines regarding shrimp

Part II

In Part I, we examine the environmental impacts of the foods Wellesley dining services purchases before the foods reach Wellesley College (production, harvesting, processing, and transportation). Now we turn to an analysis of the sustainability of the food system on campus by considering the areas of food waste, non-food waste and water and energy. We also examine the possibilities and options for operational decisions, such as our unlimited meal plan and the decentralized, small dining halls, hyperlocal purchasing, and composting of food waste.

By observing behavior, talking to dining staff, and looking at records from the College, we are able to come up with estimates for the amount of food waste and non-food waste created by dining services as well as the water and energy use. From these data, we are able to determine what aspects of the dining process lead to the most waste or water and energy consumption.

We next look at the possibilities and options available to Wellesley dining services for operational policies, composting and hyperlocal purchasing. Colleges of similar size and characteristics to Wellesley such as Smith, Bates, Mount Holyoke and Butler have successfully adopted many of these practices and we use these colleges as models when considering next steps for Wellesley dining services. This section also looks at the logistics, community effects and local laws surrounding each topic.

For food waste, non-food waste, and water and energy use, we present an overview of the situation, methodology for data collection, findings and recommendations. For the potential options of operational changes, composting, and hyperlocal purchasing, we present a more informal write-up of Wellesley’s current situation in the area and make recommendations for pursuing each activity.

4- On Campus Activities

Recognizing the impacts of our individual food choices and the importance of conscientious purchasing by the College is an essential component to a more sustainable dining system. Even if food purchases are improved, what happens to the food once it gets to Wellesley, how it is prepared and how it and its relevant packaging is disposed of, is just as important as considering the food we purchase and consume. Purchasing decisions can be influenced by cost, student tastes, and availability of products. Wellesley-specific suggestions about the operational and waste practices on campus can be implemented at the institutional level in ways that will minimally affect students but still make a big difference in the sustainability of the campus. In order to focus our efforts we analyze food waste, non-food waste and water and energy expenditures.

Students and staff have identified food waste as a concern. Food thrown away by students or staff equates to wasted money for dining services, and also time wasted in preparation and effort. In order to assess whether food waste is a concern, we estimate the amount of food waste generated by students on campus. This number can also be used as a point of comparison for future assessments. We are able to make an estimate after observing close to 10% of the student body at a weekday meal in Stone Davis. This number does not capture the food disposed of during meal prep or after serving and therefore is an underestimate of the actual food thrown out.

Food is not the only form of waste in dining hall operations. Packaging and other non-edible substances (like napkins or disposable dishware) are also used. Recycling can reduce the environmental impacts of some of the non-food waste items in the dining system. Our analysis looks at the effectiveness of the recycling program currently in place in dining halls on campus. We look into the recycling practices at both Stone-D and Pomeroy dining halls in order to have more than one example to draw upon. Creating an active recycling program will ensure that much of the waste is put to productive re-use, and will decrease the volume of waste that must be incinerated. A successful policy will communicate the benefits of recycling, employ the necessary procedures to make sure that recyclables are correctly disposed of, and ensure that recycling is accessible.

Along with wasting food and non-food products, the dining system also uses large quantities of water and energy, both of which have negative environmental effects. Water and energy efficiency can be improved by changing practices or technology. Even though Wellesley College provides its own electricity and water, decreasing the use of these inputs will further lower overall costs and improve the environmental impacts of the College. Because the college does not generally purchase water and electricity, few locations on campus have meters to determine levels of use. That lack of metering makes it difficult to assess overall use. We are nevertheless able to gather water data using bottom up calculations and electricity data through a comparison of electricity use between days the dining hall is open and days it is closed.

Food Waste

Slightly more than 800,000 pounds of food waste are generated each year in the state of Massachusetts.[114] According to a 2002 study by the Massachusetts Department of Environmental Protection's Bureau of Waste Prevention, colleges and universities in Massachusetts are responsible for contributing an estimated total of 24,458 tons per year of source separated organic materials (SSOM) (food wastes that can potentially be separated from other wastes at the point of generation).[115] This is a problem that Wellesley College can quickly, efficiently, and inexpensively avoid. We analyze pre- and post-consumer waste from the Stone-Davis dining hall to estimate how much food is disposed of during food preparation by staff and subsequently by students during lunch and dinner. From these observations, we hope to extrapolate a reasonable estimate of the volume of food waste generated by the college annually. Another reason we consider food waste is to stress the importance of the disposal process and encourage handling it in the most sustainable, and environmentally responsible manner possible.

Food Waste Methodology

To calculate the amount of post-consumer food waste, we observe students as they returned plates to the Stone-Davis dish room. When students are finished eating, they scrape any leftover food into trashcans located in the kitchen. Many students take one plate and one cup, but a large number of students take multiple pieces of dishware at each meal. For students that returned multiple plates and bowls, we combined the amount of food left on each piece of dishware.

We collect data by recording the amount of food left on each plate as it is returned. We observe students for one hour during lunch and dinner. The plates are recorded in one of five categories: empty, < 25% food left, 25-50% food left, 50-75% food left, and > 75% food left. We assumed that each student had initially taken a full plate of food. Our back-of-the-envelope calculation uses a standard meal weight of 1 pound, which we use as the equivalent to a full plate of food.

Although not very precise, our methods for assessing food waste were sufficient to provide us with an order of magnitude estimate of the volume of waste being created. While observing the food waste that students throw out, we had to make crude estimates of percent plate coverage remaining. Complicating this further, the food was often combined with napkins or other non-food waste. Our estimate also does not take into consideration food that students take out of the dining hall and then throw out. We observe one lunch meal and one dinner meal. To get a better idea of student food waste, more observations should be conducted.

Because meal preparation does not occur all at once, we are unable to observe most of the preparation and do not have a good estimate for the volume of waste created during this process. Volume of waste varies according to the meal prepared, so it would be informative to observe the full process of a number of meals to get an idea of the average waste created. To get a better sense of the volume of waste created, a larger sample of observed meals should be carried out to guide action aimed at reducing student food waste or addressing waste created in meal

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[114] Massachusetts Department of Environmental Protection. "Trimming the Fat: Cutting Costs by Reducing Food Waste." *Waste & Recycling*. Massachusetts State Government, n.d. Web. 13 May 2011. < http://www.mass.gov/dep/recycle/reduce/foodwste.htm>.

[115] Massachusetts Department of Environmental Protection, Bureau of Waste Prevention.*Identification, Characterization, and Mapping of Food Waste and Food Waste Generators in Massachusetts*. Boston: Massachusetts Department of Environmental Protection, 2002. Print.

preparation. Since we are mainly concerned with whether the volume of waste would be small enough for Wellesley to consider a composting system on campus, an order of magnitude estimate makes sense for our study but has inherent limitations for a thorough analysis.

We are also concerned with the steps in the dining process that create the most waste. Talking to dining staff gives us a general idea of the parts of meal preparation that are most wasteful or foods that produce particularly large amounts of food waste; this discussion only considers the viewpoint of the staff on duty at the time and the staff only represent a single dining hall. Observing all the dining halls during meal preparation and talking to a larger set of staff, as well as distributing a standardized questionnaire regarding waste management procedures would be not only helpful, but essential if Wellesley dining services is interested in exploring more efficient ways to prepare and serve meals and manage the subsequent waste.

Food Waste Data and Analysis

We record observations for nearly 10 percent of Wellesley's students disposing of their food waste during lunch and dinner. 125 students were observed at lunch, and 112 at dinner, for a total of 237 students. Figure 9 and Figure 10 below detail our quantitative data from each meal. From these totals, we estimate the amount of food wasted per meal per day, and further extrapolate food waste generated by the college per year (including all dining halls).

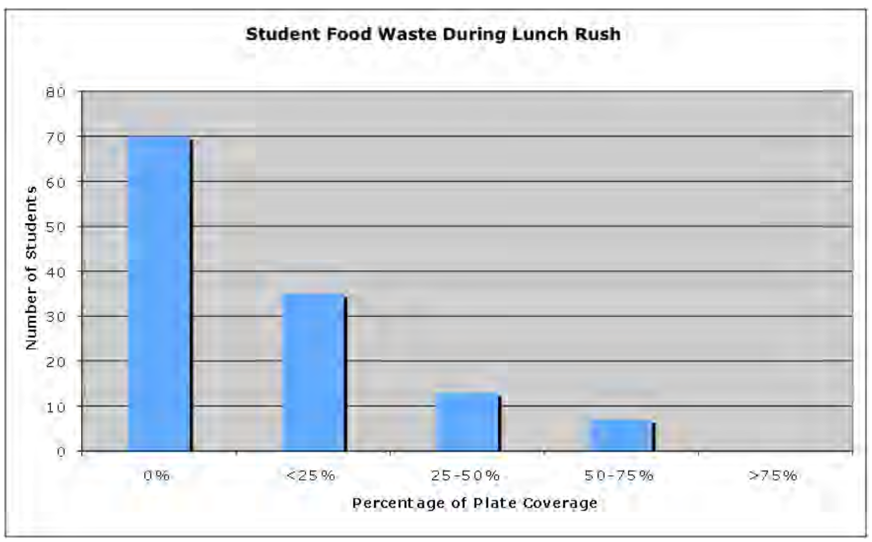

Figure 9: Student food waste at Stone-Davis at lunch (12:30-1:30pm), April 11, 2011

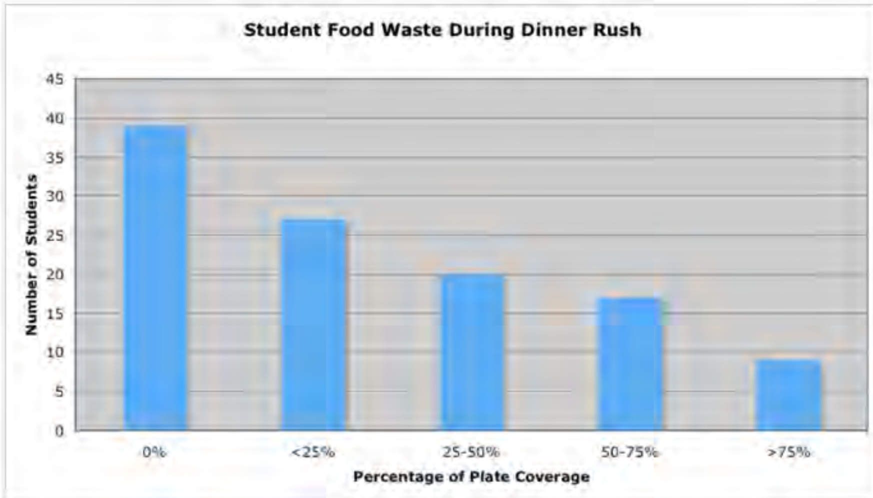

Figure 10: Student food waste at Stone Davis at dinner (5:30-6:30), April 6, 2011

Aggregating these data, we find that students waste 21% of the food they take. Wellesley's student body is approximately 2,400, and, according to the USDA, the average meal for a 20-year-old woman of average weight, height, and activity level weighs about 1 pound.[116] Assuming each student takes a pound of food at lunch and dinner, and wastes 21% of it, students as a whole waste 1,008 pounds of food per day, 7,056 a week, and 28,224 per month, for a grand total of 197,560 pounds per year, assuming seven months of meal plan use. This total is exclusive of the food waste created during meal preparation and the food discarded by dining hall workers every night, which, according to interviews with dining workers, both comprise a significant amount. It also does not consider food eaten by guests. As such, it is a rough estimate and a very bare minimum. Anecdotally, we found that recycling bins contained food waste on the day we surveyed the kitchen facilities at Stone-Davis, indicating the need for clearly labeled disposal bins for different kinds of waste.

One important aspect of the Wellesley dining service system is the use of a Food Production Optimization System (FPOS). Dining staff fill out a waste log recording the specific amounts of each dish that are taken by students and the amount of leftovers that are thrown out. The data from the waste logs are input into the FPOS database so that increasingly accurate estimates can be made in the future for how much of each food to purchase and how much of each dish to prepare. This is an excellent system for both reducing the amount of food waste created by dining services and funds spent on excess food. Unfortunately, our observations revealed that the waste logs are not being used consistently.

Quantifying, or at least estimating, Wellesley's post-consumer food waste allows us to understand the scale of the waste generated at different times of the day and therefore to investigate the options available for disposing of it in an environmentally responsible and economical manner.

It is clear that neither students nor dining hall workers dispose of food waste in a sustainable fashion. On a positive note, both parties seem to share an awareness of this issue and an interest in improving the food waste situation. With the implementation of simple solutions, Wellesley dining services can reduce the level of its food waste while simultaneously educating

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[116] United States Department of Agriculture. "Daily Food Plan." *MyPyramid*. USDA. n.d. Web. 28 Apr. 2011. <http://www.mypyramid.gov/mypyramid/results.html?name=undefined>.

students and dining hall staff about the importance and benefits of sustainable disposal of food scraps before and after meals.

Food Waste Recommendations

The other major sources of food waste are meal preparation and unused food that is thrown out at the end of the day. According to one dining hall worker, there is always “tons” of food left at the end of the day, which is thrown into the dumpster. This includes both prepared hot food and cold foods from the salad bar. Additionally, waste and scraps generated by meal preparation, the majority of which are produce such as apple cores or fruit and vegetable peelings, are thrown away without being composted or reused in any way. A more efficient waste system would include policies to reduce the generation of waste and reuse the waste that is generated.

The first step to reducing waste should be an accurate audit. Programs should be undertaken to ensure that dining hall workers fill out existing waste logs to accurately track the sources and amount of waste being generated. We strongly encourage the increased utilization of this program in order to accurately prepare the right number of servings for student consumption.

More simply, proper disposal bins should be located throughout the dining halls and used correctly. Additionally, tools such as fruit corers should be provided for dining hall staff and used often with the hope of reducing the amounts of food scraps created during meal preparation. Finally, dining hall staff can be trained to prepare food in a way that minimizes waste production; currently there is no system in place for such training.

Overall, steps should be taken to decrease unnecessary food waste. For untouched food that is still edible, a donation service, for instance, to a local soup kitchen, may be possible. Implementation of a composting system or building partnerships with local farms for non-reusable waste is a system that has been effectively implemented at many colleges for waste reduction. For a more detailed account of the costs of implementing a composting system at Wellesley, please see the composting section in the On-Campus Options chapter.

Non-Food Waste

Improving the recycling system in the dining halls is an important part of the process for Wellesley dining services to increase the sustainability of its operations. In this section, we address three questions: (1) What is currently being recycled at the dining halls, (2) what could be recycled that currently is not, and (3) are there any general problems with the system that could be improved?

Non-Food Waste Methodology

To answer these questions, we consider non-food waste created at Stone Davis dining hall by visiting dining hall, interviewing the Chef Manager, and looking in the trash and recycling dumpsters. We also look at the non-food waste created at Pomeroy dining hall.

Non-Food Waste Data and Analysis

Fortunately, Wellesley already has the infrastructure for recycling in place. The types of waste that can currently be recycled at the dining halls include cardboard, paper, cans, plastics, and glass. Cardboard is only compacted at Tower dining hall due to lack of space for a compactor at Stone-Davis. Even though cardboard is not compacted, there is enough space in the recycling bin for the volume of waste created, and it is picked up about twice a month, as needed. We found many cardboard boxes in the trash that were clearly from the dining hall, as they were large boxes from Del Monte and Tyson (Figure 11). The recycling dumpsters contained paper, boxes from Amazon, and individual-serving cans and bottles, which did not seem to be from the dining hall (Figure 12). This suggests that the recycling bin is primarily used for non-dining hall waste, and that much of the non-food dining hall waste is discarded in the trash.

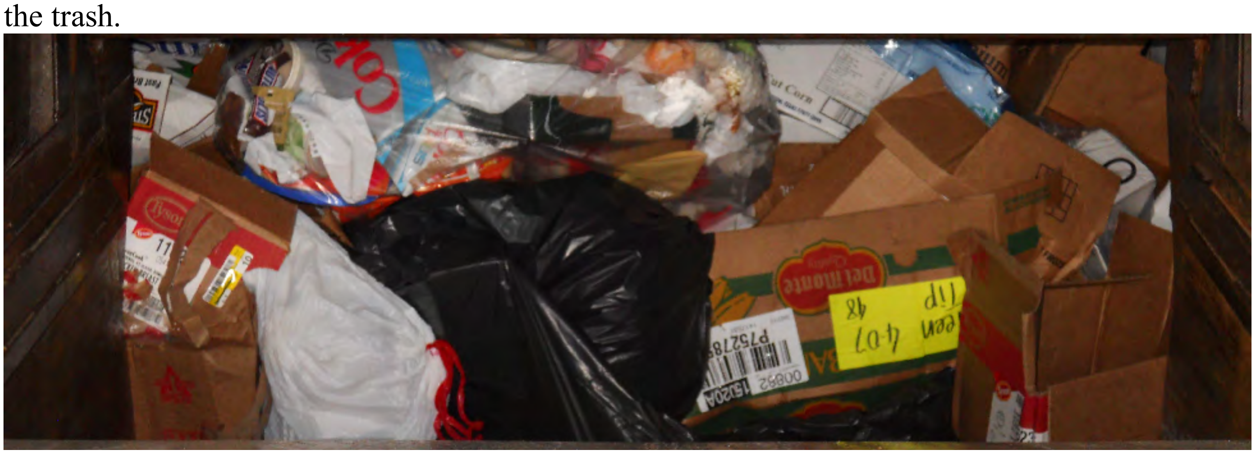

Figure 11: Contents of Stone Davis trash dumpster, including Del Monte and Tyson cardboard boxes

Figure 12: Contents of plastic (left) and paper (right) recycling bins at Stone Davis

According to the Chef Manager of Stone-Davis, the standard practice for recycling entails breaking down cardboard boxes three times a day and rinsing and collecting cans in a biodegradable bag after food preparation. The items are kept on the loading dock, and then placed in the recycling dumpster. Recycling dumpsters are generally not contaminated with food or the wrong recyclable items due to these procedures. The Chef Manager estimates that kitchen staff properly disposes of recyclables approximately 60 percent of the time. Our observations find that many smaller plastic containers are thrown in the trashcans in the kitchen, probably because of the inconvenience of recycling them.

Stone-Davis has other sources of waste that are unlikely to be recycled, for example: artificial sweetener and tea in individual packets, disposable straws and stirrers, individual desserts in aluminum pans and paper, soymilk in small containers instead of a dispenser, and ice cream cones in wrappers. These sources of waste are likely to be produced in all dining halls across campus.

Stone-Davis also uses disposable dishes between 8:30-10:30pm due to the low volume of meals served and the small number of workers available for clean-up at this time. Between 75 and 100 students use the dining hall during this time slot each night, adding disposable dishware to the garbage. The dining hall uses about 1,000 disposable plastic cups each month. Other dining halls sometimes use disposable dishes during peak times or at other periods during the serving day.

Students produce a considerable amount of non-food waste by removing reusable dishes from the dining hall, many of which end up in the trash. Dining Services spends around $45,500 each year to replace dishes lost. Figure 13 shows undamaged dishware that has been thrown out in the Stone-Davis dorm. These lost dishes themselves represent a waste of both money and material, and result in additional non-food waste because, when there are not enough plates to serve students, disposable dishware is used.

Figure 13: Three plates, a cup, small plate and silverware thrown out in Stone-Davis dorm

We look at waste thrown into the dumpster and recycling bins behind Pomeroy dining hall to compare the proportion of recyclable waste that is recycled to what we find at Stone-Davis. We find that the dumpster at Pomeroy, like the dumpster at Stone-Davis, contains a substantial amount of cardboard from the dining hall (Figure 14). Unlike Stone-Davis, however, we find a large amount of cardboard from the dining hall, mostly collapsed, in Pomeroy's paper and cardboard recycling bin, which was nearly full (Figure 15).

As at Stone-Davis, Pomeroy's recycling bin is further from the loading dock than the dumpster (Figure 17), which can easily be accessed simply by standing on the loading dock and tossing a garbage bag or box into it. To access the recycling bin, one must take the stairs down from the loading dock and then walk around the loading dock and past the dumpster to the recycling bin.

Figure 14: Contents of Pomeroy trash dumpster, including many recyclable cardboard boxes probably from the dining hall (banana, pepper and orange boxes)

Figure 15: Contents of Pomeroy’s paper and cardboard recycling bin, including many collapsed cardboard boxes probably from the dining hall (Sysco, Sunkist, oats, and bottled water boxes)

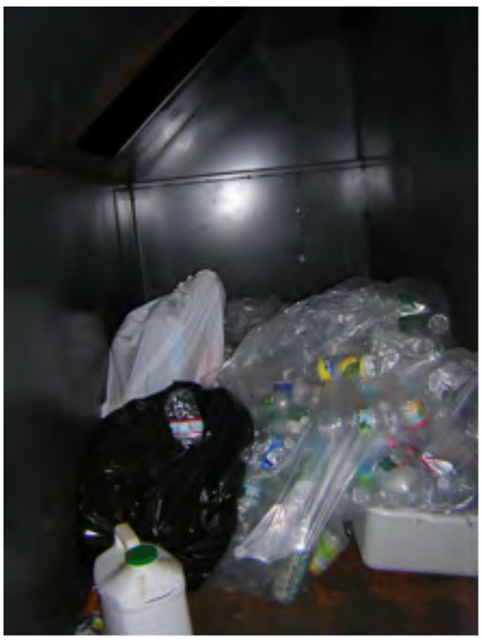

Figure 16: Contents of Pomeroy's plastics recycling bin, with nothing obviously from the dining hall

Figure 17: View of Pomeroy loading dock, including stairs (far left), back door and loading dock (middle-left), trash dumpster (middle-right) and recycling bin (far right)

Non-food Waste Recommendations

In both Stone-Davis and Pomeroy we notice a significant amount of recyclable cardboard in the trash dumpsters. In order to increase the amount of recycling in the dining hall, Wellesley dining services should put recycling bins inside the kitchens so that is it more convenient for dining hall workers when preparing food. This will encourage recycling of smaller cardboard items, metals and plastics. The dining halls should have a specific location to pile larger cardboard that cannot fit into a small container. This way, sorting can occur before wate reaches the loading dock. It is easier to transport a large amount of recyclables to the recycling bin than to transport and then separate mixed pieces of waste. Inside the kitchen, managers and others in charge can take on a larger role in enforcing recycling protocol. Just as AVI Fresh uses a top-down approach to integrate other goals such as the presentation of food, a similar approach is needed to ensure that all recyclables make it into the appropriate bins. Kitchen staff will be more likely to recycle properly if recycling is written in staff members' job descriptions and then consistently enforced (or even rewarded) by lead chefs and managers.

The current locations of dumpsters are not conducive to recycling. In order to recycle at both Stone-Davis and Pomeroy, a dining hall worker has to get down off the loading dock and walk across the parking lot. The trash dumpster is conveniently located right on the loading dock. Relocating the recycling so that it is as convenient as the trash dumpster, or making the trash dumpster less convenient, would be another way to increase recycling in the dining halls.

One related problem in Stone-Davis, as well as other dining halls, is the use of disposable dishware and the loss of reusable dishware. Due to the waste created by disposable dishware in the evenings at Stone-D, we recommend that dining services use reusable dishware in the evening. The current practice of using disposable dishware is not desirable as it creates a significant amount of non-food waste. In some cases, when disposable dishware is used, it is made of recycled or compostable material. If, in the interim, we cannot move away from disposable dishware or must have it on hand to use when, for example, a dishwasher breaks, only recycled content or biodegradable disposable dishware should be available. The manufacturing of recycled-content disposable dishware diverts materials out of the waste stream and reduces the use of raw materials, while compostable dishware does not last as long in the environment as materials like plastic and Styrofoam. If we implement a composting program and compost disposable dishware, it will cause fewer environmental problems than simply discarding waste.

If fewer dishes go missing during the school year, dining services will have to purchase fewer new dishes. In order to reduce the number of dishes lost, dining services should create a student job position to prevent the removal of dishes from dining halls by monitoring people as they leave. For Stone-Davis this would be a student position for 72 hours a week. At a reasonable student wage of $8.25 an hour, such a position would cost $594 a week. Assuming a 16- week semester based on the academic calendar, including finals, this would cost approximately $19,000 a year for one dining hall. Implementing this position into all of the dining halls would exceed the current cost of replacing dishes ($45,475). In order to be cost-effective, this position could be implemented part time, for example, during peak times hours.

Water and Energy

Energy and water consumption in the dining halls on is a significant component of the environmental footprint of dining operations. As represented in our data, dining halls are one of the biggest indoor water users on campus, and electricity use in dining halls contributes to a fair portion of energy consumption. The college provides most of these resources internally, with our electricity coming from a cogeneration plant, and water from the campus' own well water rather than from the town of Wellesley. Because the College does not purchase water, it has less of an economic incentive to decrease water use than it would otherwise. Therefore, it is important to highlight our current consumption patterns to identify what we can do better. Patrick Willoughby, Stacy Blount, Ed Burns, and Mike Dawley assisted us with this section of the report by providing the relevant data.

Water and Energy Methodology

Acquiring precise measurements of energy and water usage in Wellesley's dining hall is difficult given that Wellesley does not have meters to collect this data automatically. As a result, we used a bottom-up method to estimate energy and water usage based upon the efficiency of our kitchen appliances and observations of how long these appliances run daily on average.

To estimate water usage in the Stone-Davis dining facility, we first determine the processes in the dining hall that use the most water by observations and interviews with dining hall staff. Our research shows that dishwashing, food preparation, and beverage services use the most water. Then, we note the make and model of each appliance that contributes to these processes, namely the dishwasher (Hobart CRS-76A) and the ice machine (Manitowac S570). This data allows us to research the average water usage of each according to their operation manuals.

To calculate water usage from the dishwasher, we assume, based upon our observations, that Stone-Davis serves 125 people for lunch and that each person uses two dishes per meal. Therefore, students use 250 dishes for lunch, requiring 10 dishwasher cycles, since a single rack can accommodate 25 dishes. Thus, lunch requires a total of 14.7 gallons of water based upon the manufacturers claim that a Hobart CRS-76A uses 1.47 gallons per cycle.[117] The Stone-Davis manager estimates that the dishwasher runs for 30 minutes for breakfast, 90 minutes for lunch, and 120 minutes for dinner. Extrapolating from these values and from the data calculated for lunch, we estimate that the dishwasher expends 4.9 gallons for breakfast and 19.6 for dinner, resulting in a total yield of 39.2 gallons per day. We rounded this figure up to 50 gallons per day according to our estimate that snack dishes throughout the day and evening hours would require about an additional 10 gallons to wash.

In order to calculate the water usage for drinking, the Stone-Davis manager told us the amount of tea (6 gallons), coffee (22.19 gallons) and ice (477.75 gallons of water) consumed per day. The manager also estimates that food prep requires two 15 gallons tubs, one of which is changed 5 times per day and the other which is changed 3 times per day, for a total of 840 gallons per day.

[117] Hobart. "CRS76A Instruction Manual." *HobartCorp.* n.d. Web. 17 April 2011. <http://www.ckitchen.com/SpecSheet/Hobart/CRS76A+BUILDUP.pdf>.

Finally, we draw upon metered water data from Smith College to generalize how the amount of water used in the dining halls compares to water used in other sectors on campus (e.g. landscaping and residential).

The electricity data that we provide for Stone-Davis dining hall is based on the average electricity usage of Tower dining facility from November 16 to December 15 in the 2009 Fall Semester. Although we used Stone-Davis dining hall as our data collection site for other sections, we are not able to get electricity data for this dining hall due to a lack of metering. The only dining hall on campus to have a separate meter is Tower dining all. Stone-Davis is only open weekdays but long hours while Tower is open seven days a week for a shorter time period each day, making these dining halls fairly comparable in terms of weekly electricity usage. Tower and Stone-Davis serve approximately the same number of students per day.

The College does not meter energy and water use for each the dining halls, therefore we are unable to make precise measurements. As a result, there are some shortcomings to our analysis. For example, we focus on just electricity use and do not incorporate the energy use associated with heating the dining area. Furthermore, we are not able to precisely determine the water used in food preparation or the water used to rinse dishes before they enter the dishwasher. Due to the lack of available data, the actual water and energy consumption of the dining halls is most likely larger than what we represent. In spite of these challenges, we discover the processes with the greatest electricity and water usages in Stone-Davis, and so our results represent the most important energy and water expenditure data in the dining hall.

Water and Energy Data and Analysis

Water Use Data

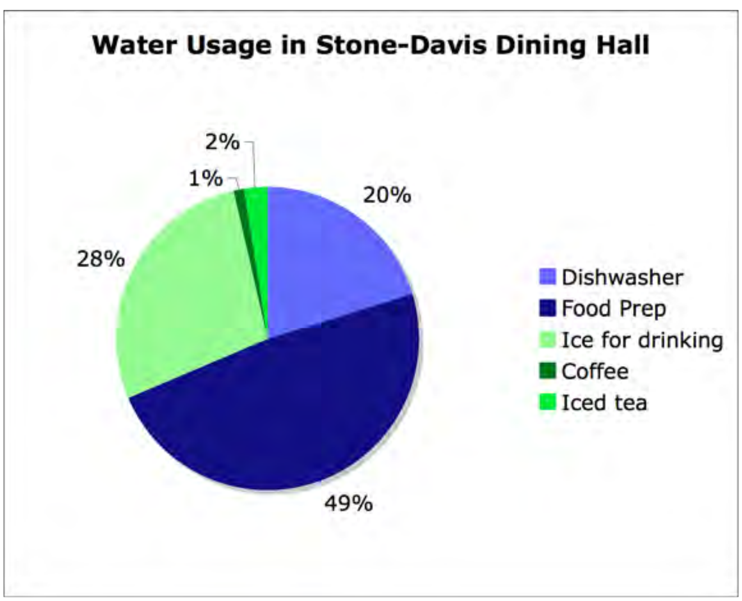

Figure 18: Water usage in Stone Davis Dining Hall by source

Figure 18 depicts the water use for various uses within the dining hall. Meal preparation requires the most water consumptions; essentially half of the water used in the dining hall is used during meal preparation. Beverages and ice aggregate to be 31 percent of total water consumption, and dishwashing contributes 20 percent of water use. Other sources we were unable to find include: drinking water, soda, faucet water, cleaning, miscellaneous. Table 19 shows the amount of water used for each use by volume.

Table 19: Gallons of water used per week by source

Source	Gallons per week
Dishwasher	350
Food Prep	840
Ice for drinking	477.75
Coffee	22.19
Iced tea	42

Energy Use Data

Table 20 lists the weekly and daily average electricity consumption of Tower dining hall including the following sources: ovens, stovetops, lighting, freezers, refrigerators, food warmers, food coolers, toasters, microwaves and other miscellaneous. Figure 19 graphically shows the average daily kWh of energy use for Tower dining hall over a period of 11 weeks.

Table 20: Weekly and daily average electricity consumption in Tower Dining Hall (Nov. 16 2009- Feb. 1, 2010)

Week	**Weekly kWh**	**Daily Average kWh**
11/16/09	628	89.71
11/23/09	485	69.29
12/1/09	663	94.71
12/8/09	563	80.43
12/15/09	555	79.29
12/21/09	441	63.00
12/26/09	400	57.14
1/2/10	262	37.43
1/13/10	449	64.14
1/23/10	480	68.57
2/1/10	690	98.57
	Average	Average
	510.55	**72.94**

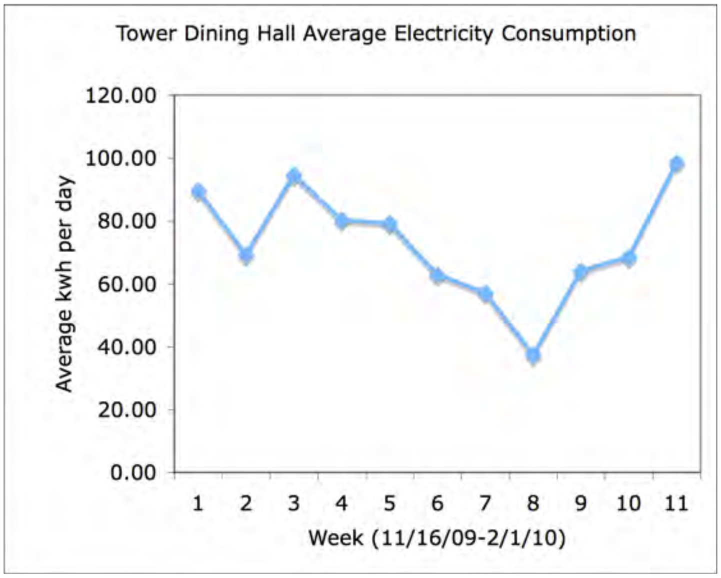

Figure 19: Tower Dining Hall average electricity consumption

- Average weekly electricity consumption when Wellesley is in session: 578.8 kWh
- Average daily electricity usage when Wellesley is in session: 82.69 kWh
- Of the Tower dining hall total electricity usage in session, approximately 45percent comes from the freezers, refrigerators and other sources that run regardless of whether the dining hall is open (at night, during vacations).
- Approximately 55 percent of the dining hall's total electricity usage comes from daily operations, such as lights, ovens, stovetops and food heating during service.

The greatest sources of water use that we observe are food prep, ice and dishwashing. We are unable to measure the amount of drinking water, water used for soda, faucet water and water for cleaning. Data on these uses could reveal new trends of concern in the dining halls.

On the energy side, we are lacking metered energy use for all dining halls except Tower dining hall, which only has limited data. We roughly estimate the energy use (excluding heating and cooling) for daily operations but not the energy used for continuous operations such as refrigeration. A substantial portion of our energy use is from refrigeration or other appliances that cannot be turned off; every effort should be made to ensure that these appliances are as efficient as possible and used in ways that decrease energy use.

The College already has some sustainable practices in effect. Wellesley purchasers are required to purchase Energy Star appliances, a designation for energy efficient appliances. These appliances can reduce energy consumption by 20 to 30 percent.[118] In addition, Wellesley does a good job of conserving potable water in other areas on campus. For example, it has reduced

[118] Tugend, Alina. "If Your Appliances Are Avocado, They Probably Aren't Green." *The New York Times - Breaking News, World News & Multimedia*. The New York Times, 10 May 2008. Web. 30 Apr. 2011. <http://www.nytimes.com/2008/05/10/business/yourmoney/10shortcuts.html?scp=1>.

overall water use and potable water use in landscaping and installed low-flow showerheads in the majority of showers on campus.[119]

Water and Energy Recommendations

Our primary recommendations for Wellesley dining services are to improve the metering of water and energy in the dining halls so as to better understand where there is room for improvement and in what areas dining services is doing well. In the future, we believe dining services can improve operations by retrofitting the dining halls to be more water and energy efficient but also to make it easier for staff to carry out sustainable practices. In place of a complete retrofit we suggest looking into the implementation of low-flow/high-pressure faucets and more efficient refrigerators. Another suggestion is to standardize water use practices so that faucets or dishwashing sprayers are not left continuously running and wasting water.

[119] Sustainable Endowments Institute. "Wellesley College Green Report Card 2011." *The College Sustainability Report Card*. Sustainable Endowments Institute, 2011 Web. 13 May 2011. <http://www.greenreportcard.org/report-card-2011/schools/wellesley-college>.

On-campus Activities Recommendations

From looking at dining hall food and non-food waste as well as the water and electricity inputs for the dining system, we conclude that in all areas, changes can be made to improve Wellesley dining services' sustainability. In order to reduce food waste on campus, a reliable audit needs to be completed. Students should be encouraged to take less food and be more conscious of their waste. Improving available kitchen tools and further utilization of the FPOS by staff can reduce pre-consumer waste. Another option that needs to be researched is donating excesses to food banks or composting. Improving the existing recycling program on campus to make it more effective can reduce non-food waste. This can be done by enforcing a recycling policy and making it part of the job description of dining service workers. Recycling can be made easier by providing recycling bins or a designated recycling space inside the kitchens and moving the recycling dumpsters closer to the kitchen door. Adding technological aids such as reduced flow faucets and more efficient refrigerators can decrease water and electricity consumption. Most importantly, the dining system should have a more accurate metering or monitoring system to track usage so consumption can be analyzed improvements. Some practices such as reducing water usage during dishwashing can be implemented to reduce water use.

5- On-Campus Options

The findings from our evaluation of food waste, non-food waste, and energy and water use indicate that the College has the opportunity to make several positive changes that would bring it to the forefront of sustainably-minded colleges. Wellesley College is well situated to institutionalize changes in its purchasing, distribution, and disposal plans that would not only result in reduced environmental impacts, but would also streamline operational costs and facilitate positive engagement with students and the local community.

Any proposed changes to the current dining system must consider social as well as environmental effects. For example, much of Wellesley's energy and water consumption is attributable to the nature of its traditional dining system, which is based on five separate dining halls and an unlimited meal plan. While sweeping changes, such as limiting the meal plan or consolidating dining halls would be the most effective means for minimizing environmental impacts, eliminating Wellesley's open and communal dining tradition could also negatively impact students' dining experiences.

Similarly, social as well as environmental concerns should influence dining services' decisions about where to source its food. Incorporating more local produce into its foodshed would allow Wellesley dining services to make positive environmental and social impacts on the surrounding community. Small farms tend to be less resource-intensive than industrial operations and promote biodiversity; because they sell directly to consumers, local farms require less refrigeration, packaging, and transport. As comparable colleges have found, supporting local farms allows the college to develop positive relationships with members of the local community, invest in transparent producers, and, more broadly, promote sustainable agricultural management directly. The range of farms in the area includes the College's own student-run organic farm, whose contributions could be a valuable asset to the college's local food supply.

Once students have entered a dining hall (whether renovated or not) and have enjoyed a meal (whether local or not), how should the college handle the food waste they produce? Unlike many liberal arts colleges, Wellesley does not currently have a food waste composting system in place. Composting would allow Wellesley to reduce the volume of waste created and contribute actively to sustainable land stewardship, by returning nutrients to the soil. A look at approaches of other colleges suggests a range of possibilities for executing a composting plan. Whether Wellesley chooses to implement an on or off-site composting site, diverting uneaten food from the waste stream provides an opportunity not only to reduce the environmental impacts of our food waste, but moreover to turn it into a valuable resource.

Dining Services Operations

Several aspects of Wellesley's dining service operations could be modified in order to make the overall system more sustainable. Below we consider some possible areas where improvements could be made, and discuss both the environmental and social costs and benefits of doing so.

Traditional versus Centralized Dining

Two important aspects of Wellesley's dining tradition are its numerous small dining halls and the small, round tables in each eating area, both of which facilitate community building. This approach to dining evolved from when Wellesley had daily sit-down dinners as a regular part of dorm life. Today, this system provides students with a wide variety of dining choices, as well as the convenience of a having a dining hall in every dorm complex and the more personalized dining experience that is characteristic of small dining halls. Wellesley currently has five dining halls along with a handful of cafés. To cut costs a few years ago, the College closed two of the smallest dining halls.

Having multiple, small dining halls is inefficient in terms of costs as well as energy and water use, but we argue that the important social benefits of this system outweigh the environmental costs. A single, centralized dining facility would require fewer staff members and would likely use less aggregate energy and water because food could be prepared in larger batches. Given the tradition of personalized dining at Wellesley and the positive effects on student happiness and community, we recommend that the College maintain the current dining hall structure. Instead of switching to centralizing dining, Wellesley should retrofit its existing kitchens with energy- and water-efficient appliances and improve its policies for food and non-food waste. Positive effects that centralized dining may have on campus sustainability would not counteract the important social benefits of maintaining Wellesley's traditional multi-dining hall structure.

Implementing an ID Card Swipe System

Wellesley College currently provides an "open" meal plan to students. This means that students can go into any dining hall any time that the facility is open, and eat as much as they wish—they need only pay a set meal plan fee at the beginning of each semester. As almost all students are required to be a part of the unlimited meal plan, Wellesley does not have a campus-wide system that requires students to swipe their ID card in order to gain entrance to a dining hall. Although there are swipe recorders at Stone-Davis, Pomeroy and Bates, they are rarely used because swiping is not enforced. No staff member sits by the machine asking students to swipe in before entering the dining hall. The Bae Pao Lu Chow dining facility in the Campus Center is the only hall that consistently enforces a swipe card system to count how many students come through each day.

Requiring students to swipe their ID card in order to enter any dining location could potentially improve the sustainability of campus dining operations in several ways. First, a system that counts how many students come through each dining hall per day would allow dining staff to place more accurate food orders, thereby reducing the amount of food that goes to waste due to excess ordering. Second, a swipe card system would be useful if the college decided to offer other meal plan options, such as weekly meal packages that allow students to enter the dining hall a certain number of times per week, in addition to or in place of the unlimited plan.

The College might be interested in offering more restricted meal plan options because limiting the number of meals that students are able to eat per semester would reduce overall food, energy, and water waste. A third, related reason for implementing a card swipe system is to prevent people other than Wellesley students on the meal plan from eating in the dining hall. There is no easily enforceable system in place to keep non-students from using dining services. This may be a source of lost funds for Wellesley dining services, necessitating increased meal plan prices, which also places an unfair burden on paying students.

Unlimited Dining Plan and Dining Hall Hours of Operation

In addition to implementing a swipe system, Wellesley could improve the sustainability of its campus dining operations by moving towards more restricted hours of operation. Wellesley dining halls are currently open to students all day long, and the College's unlimited dining plan requires that there be food available at all hours that the dining hall is open. While main meals are only served during peak breakfast, lunch, and dinner hours, dining halls continue to provide snacks, access to the salad bar, drinks, and desserts during non-peak hours. Consequently, energy is expended all day to moderate food temperature, keep lights on, make ice and wash dishes. Students have frequent access to disposable to-go cups and utensils, which increases non-food waste. Furthermore, food often sits out for long periods of time, and eventually kitchen staff may have to throw it out in order to comply with food regulations. As a result, more food must be prepared to replace the expired food, leading to more water and energy for meal preparation, cooking and cleaning.

Switching to a limited dining plan in which the dining halls were only open during peak hours, would reduce the College's overall energy and water use, and waste production. Dining services would be able to better predict and control the amount of food that students consume. Less food would need to be prepared, leading to fewer dishes, less food waste and less food consumption. Such a plan would be a major change for the College and would likely require careful consideration before adoption.

To-go Containers

One option Wellesley dining services could pursue in order to improve its sustainability is to eliminate to-go containers. To-go containers are available in most dining halls, though they are most heavily utilized in Pomeroy, where students are prohibited from bringing in or removing dishware of any kind in order to maintain kosher standards. They are currently provided to minimize the theft of dishware, on which the college already spends nearly $50,000 annually. Loss of reusable dishware has negative environmental and economic implications, but the extensive use of disposable containers does as well. For this reason, we recommend that Wellesley dining services stop providing to-go containers in the dining halls and simultaneously implement a system for preventing students from taking reusable dishware out of the dining hall. Such a system could be run by student employees, thereby providing the College with a cheap source of labor and opening up more job opportunities for students.

Special Campus Events

Special events like the Tanner and Ruhlman conferences provide a unique opportunity for reducing non-food waste and composting. These events are particularly important to target because food-purchasing decisions are made separately from other dining operations and typically require the use of large quantities of disposable food containers. Moreover, the high volume of staff support for special events and the limited area in which food is served (for example, Tanner food has previously been served exclusively in the Pendleton Atrium) makes it possible to closely monitor food disposal and enforce the separation of compostables from non-compostables. Students from the Fall 2010 ES 312: Environmental Policy seminar successfully piloted a composting system for special events at the annual Tanner conference that Wellesley dining services could use as a model for future events. We encourage the College to use special events as an opportunity to compost, reduce waste and demonstrate its sustainability efforts to event attendees.

Hyperlocal

The term "hyperlocal" originated in 1991, when it was used to describe local television news content.[120] Hyperlocal content typically refers to a well-defined community-scale area in which products are both produced and consumed by residents of the area. "Hyperlocal" is now becoming a buzzword in reference to restaurants and food stores that grow some of their food to be used their recipes or sold directly to customers.[121] Hyperlocal food is a growing trend that goes a step beyond the local food movement.[122]

Hyperlocal food has a number of positive implications for sustainability: small, local farms are generally less resource-intensive than large factory farms; they tend to apply less fertilizer, pesticides, and herbicides than industrial farms; they consequently have a positive impact on both the biodiversity of the local ecosystem and in the quality of the food produced. In some instances, the quality and nutritional value of hyperlocal food is also higher because it is allowed to ripen longer than non-local food.[123] Hyperlocal farmers can also support biodiversity by cultivating or raising multiple crop varieties--including heirloom varieties--or animal breeds. Additionally, farmers selling directly to local consumers use little or no packaging for their products, which significantly reduces non-food waste. It is also easier to obtain information about the farming practices and ethics of local farming operations, as opposed to operations based in more distant states or countries.

Local food requires less energy expenditure than non-local food for several reasons: (1) local farms (at least in Massachusetts) tend to be relatively small, thus farming practices are less mechanized and rely less on fossil-fuel intensive machinery; (2) because local food does not have to be transported far to go from farm to table, greenhouse gas emissions from trucks, planes, and ships are minimal; and (3) local food requires less refrigeration as it is sold soon after being harvested. For these reasons, seasonal food grown locally can have a lower impact on climate change than food grown at distant, large-scale industrial farms.

In addition to reducing environmental impacts in the ways described above, incorporating food grown by Wellesley students and/or local farmers into the campus food supply would have several health, social, and economic benefits to the campus community. First of all, everyone who eats on-campus can benefit from the higher nutritional value (and superior taste) of hyperlocal food, which is fresher than food from more distant sources. Second, integrating hyperlocal food fosters community engagement and positive relationships, both within and beyond campus, creating educational and business opportunities. Third, in some cases, hyperlocal food can save money. For example, Middlebury College has saved about $27,000

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[120] Farhi, Paul. "Taking Local Coverage to the Limit: 24-Hour Cable News." *Washington Post*. 11 March 1991. Web. 20 April 2011. <http://pqasb.pqarchiver.com/washingtonpost/access/72094684.html?dids=72094684:72094684&FMT=ABS&FMTS=ABS:FT&type=current&date=Mar+11%2C+1991&author=Paul+Farhi&pub=The+Washington+Post+(pre-1997+Fulltext)&desc=Taking+Local+Coverage+to+the+Limit%3A+24-Hour+Cable+News&pqatl=google>.

[121] The Independent. "'Hyperlocal' the latest trend as restaurants grow their own." *The Independent*. 14 July 2010. Web. 20 April 2011. <http://www.independent.co.uk/life-style/food-and-drink/hyperlocalrsquo-the-latest-trend-as-restaurants-grow-their-own-2026388.html>.

[122] The Independent. "'Hyperlocal' the latest trend as restaurants grow their own." *The Independent*. 14 July 2010. Web. 20 April 2011. <http://www.independent.co.uk/life-style/food-and-drink/hyperlocalrsquo-the-latest-trend-as-restaurants-grow-their-own-2026388.html>.

[123] McGill University Food and Dining Services. "Local Foods." *McGill University*. 7 Dec. 2010. Web. 19 April 2011. <http://www.mcgill.ca/foodservices/socialresponsibility/localfoods/>.

each year since its students began making the more than 10,000 pounds of granola that it previously bought from a company.[124] Finally, as this example highlights, another important aspect of hyperlocal food is community involvement in the processing and preparation of food, not just its production.

Fortunately, there exist many potential opportunities for Wellesley to become more involved with hyperlocal food. One such opportunity is the student group Regeneration, founded in 2007, that manages a 5,000-square-foot plot in the Wellesley community garden located on Weston Road. This farm is campus-supported: up to 20 students supply the labor, the campus grounds crew and campus co-ops such as El Table and SCoop provide compost, and the Resources Department provides funding. Regeneration practices no-till farming, which helps to minimize soil erosion. Students grow about 25 crops that consist mostly of open-pollinated heirlooms, including vegetables, herbs, melons, and berries. During peak productivity in the summer, the farm has historically produced about 50 pounds of produce per week. The produce is sold at weekly farmers markets in the summer and fall and to student food co-ops. Unsold food is given to dining services (mostly herbs) or donated to the Natick food pantry. Wellesley also has an Italian Renaissance garden that produces some edible plants, and the College is in the process of developing an edible ecosystem research garden. In addition to supporting biodiversity, this research garden will hopefully produce food with minimal management. Other hyperlocal options are those separate from the College, such as the Natick Community Organic Farm, from which the College already buys some food.[125]

Other colleges and universities with similar growing seasons to Wellesley have succeeded in serving locally grown food in their campus dining halls. Here we present some examples of colleges that have implemented local food sourcing and successfully integrated on-campus farm systems that Wellesley may be able to emulate.

The Butler University campus farm in Indianapolis supplies some of its produce to an on-campus dining hall that is managed by Aramark, its dining services company. In addition to selling part of the produce to a restaurant, a farmer's market, and a Community Supported Agriculture program, Butler donates part of its produce to a food pantry.[126] Selling produce when it cannot be used in the dining halls is likely to provide some of the income necessary to make the farm function and potentially expand, so it can be a more reliable source of food for dining services. The farm is run by four students with support from faculty and staff of the Center for Urban Ecology at Butler.[127] A variety of crops are produced so vegetables and herbs can be harvested throughout the spring, summer, and fall.[128]

Dilmun Hill Cornell Student Farm operates at Cornell University in Ithaca, NY, a university with a strong agricultural background. The farm is part of the Cornell Agricultural Experiment Station, and is run by students.[129] The farm sells produce (21 percent of sales) to a

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[124] Keren, Robert. "The Granola Gang." *Middlebury Magazine*. 21 April 2010. Web. 20 April 2011. <http://blogs.middlebury.edu/middmag/2010/04/21/the-granola-gang/>.
[125] Sustainable Endowments Institute. "Green Report Card 2011: Wellesley College Dining Survey." 2011. Web. 20 April 2011. <http://www.greenreportcard.org/report-card-2011/schools/wellesley-college/surveys/dining-survey>.
[126] Butler University Campus Farm. "The Produce." *Butler University*. n.d. Web. 15 April 2011. <http://butlercampusfarm.com/?page_id=3>.
[127] Butler University Campus Farm. "The Farmers." *Butler University*. n.d. Web. 15 April 2011. <http://butlercampusfarm.com/?page_id=9>.
[128] Butler University Campus Farm. "The Farmers." *Butler University*. n.d. Web. 15 April 2011. <http://butlercampusfarm.com/?page_id=9>.
[129] Cornell Agricultural Experiment Station. "Dilmun Hill Student Farm." *Cornell Agricultural Experiment Station*.

small café on campus, so that purchases can be arranged on a weekly basis depending on availability.[130] In addition, the farm occasionally provides food for special events on campus.[131] The farm has also been in frequent communication with dining services, in attempts to supply produce to a small dining hall on campus, but these attempts have been unsuccessful as of 2010.[132]

The experience of University of Wisconsin's Dining and Culinary Services suggests that a group of organized farmers can fill the needs of a dining hall more consistently than a student-run farm.[133] The Community Food Security Coalition (CFSC) provides guidelines on the use of food from local family farms on college campuses.[134] According to a CFSC survey, one of the most effective ways to incorporate local food in the campus food system is to set a requirement for local food in the dining services' contract. Direct communication between dining services and farmers is also important to begin such a program.[135]

The University of Vermont (UVM) and McGill University in Montreal, Canada, are two northern schools that are working towards integrating local food into a large dining service system. UVM, located in northern Vermont, has a limited growing season but is able to purchase 35 percent of its food from Vermont suppliers.[136] Apples, ice cream and other dairy products, chicken, coffee, bread and greens are all purchased from Vermont companies.[137] In-state purchases at UVM have doubled since its dining service joined the Farm to College Forum and began tracking local food purchases and sourcing from local producers such as Black River Produce.[138]

McGill University is in the process of finalizing a policy to increase its dining service's local food purchasing. At this point, McGill has defined local food as food produced within 500 kilometers of campus, and it has pledged to increase these purchases.[139] McGill Food and Dining Services is committed to a goal of purchasing 75 percent or more local food during the summer, 50 percent or more in the fall and 25 percent or more in the spring.[140] Although McGill's policy

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Cornell University, 2010. Web. 15 Apr. 2011. <www.cuaes.cornell.edu/cals/cuaes/ag-operations/dilmun-hill/>.

[130] Cornell Agricultural Experiment Station. "Dilmun Hill Cornell Student Farm: Farm Report 2010." *Cornell Agricultural Experiment Station*. Cornell University, 2010. Web. 15 April 2011. <www.cuaes.cornell.edu/cals/cuaes/ag-operations/dilmun-hill/upload/2010-Farm-Report.pdf>.

[131] Cornell Agricultural Experiment Station. "Dilmun Hill Cornell Student Farm: Farm Report 2010." *Cornell Agricultural Experiment Station*. Cornell University, 2010. Web. 15 April 2011. <www.cuaes.cornell.edu/cals/cuaes/ag-operations/dilmun-hill/upload/2010-Farm-Report.pdf>.

[132] Cornell Agricultural Experiment Station. "Dilmun Hill Cornell Student Farm: Farm Report 2010." *Cornell Agricultural Experiment Station*. Cornell University, 2010. Web. 15 April 2011. <www.cuaes.cornell.edu/cals/cuaes/ag-operations/dilmun-hill/upload/2010-Farm-Report.pdf>.

[133] Sakai, Jill. "Home Field Advantage." *On Wisconsin.* 2011. Web. 16 April 2011. < http://onwisconsin.uwalumni.com/features/home-field-advantage/>.

[134] Farm to College. "Resources." *Farm to College*. Community Food Security Coalition, n.d. Web. 16 April 2011. <http://farmtocollege.org/resources>.

[135] Farm to College. "Surveys." *Farm to College*. Community Food Security Coalition, n.d. Web. 16 Apr. 2011. <http://farmtocollege.org/surveys>.

[136] Upton, Karen. "University Dining Services Sustainability Initiatives." *University of Vermont*. Sodexho, n.d. Web. 19 April 2011. <uds.uvm.edu/documents/social/sustainability_07.pdf>.

[137] Upton, Karen. "University Dining Services Sustainability Initiatives." *University of Vermont*. Sodexho, N.d. Web. 19 April 2011. <uds.uvm.edu/documents/social/sustainability_07.pdf>.

[138] Upton, Karen. "Sustainability." *University of Vermont*. Sodexho, N.d. Web. 19 April 2011. <uds.uvm.edu/documents/social/sustainability_07.pdf>.

[139] McGill University Food and Dining Services. "Local Foods." *McGill University*. 7 Dec. 2010. Web. 19 April 2011. <http://www.mcgill.ca/foodservices/socialresponsibility/localfoods/>.

[140] McGill University Food and Dining Services. "Local Foods." *McGill University*. 7 Dec. 2010. Web. 19 April

is not yet fully implemented, the detailed and defined standards for local purchases it has created have helped it to begin implementing food purchases from local farmers and growers.

We research local food offerings at colleges similar to Wellesley, community and local farms, and current farming initiatives on campus. We recommend that Wellesley dining services focus on expanding its relationship with local farmers and producers. We further recommend that the College integrate a formal commitment to purchase a certain percentage of its food locally into its dining contract.

On-campus farming operations such as Regeneration, the Italian Renaissance garden, and the upcoming edible ecosystem research garden play an important role within the community. As a result, we recommend that Wellesley dining services work with them whenever possible. We acknowledge that an on-campus initiative cannot be reliable or produce as enough food to support a campus the size of Wellesley without significant institutional support. Reliable foods like herbs, garlic, and fall crops can be incorporated from the campus farms while other foods can come from nearby farms like the Natick Community Organic Farm and other local producers. Utilizing a variety of local producers can provide reliable service while meeting the goal of purchasing within the general region of the College. In the long term, local food could become the theme of one (or more) dining hall(s).

In order to accomplish the goal of purchasing more local food, dining services should first reach out to local farmers and producers. Using an approach similar to McGill, the College should also make a formal commitment and establish goals for local purchasing. Finding a local producer or consortium (as UVM did with Black River Produce and Farm to College Forum) and/or partnering with local producers and other colleges or groups can help Wellesley to increase the success of a local food initiative. Wellesley is located in New England, which makes year-round local food purchasing difficult, but many products used in the dining hall can be produced locally. Thinking broadly about available products and reaching out to other schools or groups for support and cooperation would increase the success of our local food program and the sustainability of our food system.

2011. <http://www.mcgill.ca/foodservices/socialresponsibility/localfoods/>.

Composting

The Massachusetts Department of Environmental Protection (DEP) estimates that food waste accounts for at least 10 percent of all municipal solid waste generated in the state, or nearly 900,000 tons per year, and that less than 5 percent of this waste is diverted to composting facilities or backyard operations.[141] Composting is one solution that can reduce the volume of organic matter unnecessarily going into the waste stream. Composting is a waste-management process that uses food scraps and other plant matter to generate energy and fertility, in the form of organic fertilizer. It is an almost fail-proof, fully self-propelling system that simultaneously reduces the waste stream and generates a rich resource from refuse.[142] Unlike recycling, essentially a passive process that is often wasteful in itself, composting is a completely closed loop; compost produced from food scraps and applied to the soil returns nutrients and minerals to the soil that will be taken up through the growth of new produce.[143] Composting improves the tilth, water-retention capacity, erosion resistance, acidity, and biodiversity of the soil, and produces healthier plants and higher yield.[144] It also improves with age, as its components continue to decompose, making nutrients increasingly bioavailable and killing any remaining pathogens. Because it contains nutrients in the concentration and form specific to plants, compost can replace the need for fossil-fuel intensive synthetic fertilizers, much of which may run off and enter the local watershed, contributing to eutrophication.[145] In short, creating compost out of food "waste" is an environmental benefit at every stage, from microorganisms to plants to whole ecosystems.

According to the 2011 Green Report Card, Wellesley College composts only 15 percent of pre-consumer food scraps, and no post-consumer food scraps.[146] Our observations suggest, however, that this claim is inconsistent with actual practices. The first reason that Wellesley might want to adopt a composting system is to show consistency between what it claims to do and what is actually done. Secondly, institutions of similar stature and comparable size such as Smith College, Mount Holyoke College, Williams College, and Middlebury College, compost anywhere from 65 to 90 percent of their pre- and post-consumer food waste.[147] Standards for environmental consciousness and active stewardship are higher today than ever, and composting provides an opportunity for Wellesley to show its commitment to meeting these standards, as other liberal arts colleges have done.

If Wellesley implements a composting system, it will help to reduce the amount of food waste that enters the waste stream and decrease other environmental impacts as well. For

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141 Massachusetts Department of Environmental Protection. "Fact Sheet: Food Waste Composting." *Mass DEP*. n.d. Web. 4 May 2011. <www.mass.gov/dep/recycle/reduce/organics.doc>.

142 Jenkins, Joseph. *Humanure Handbook.* 2009. Grove City, 4 May 2011. <http://humanurehandbook.com>.

143 Pearson, C. *Regenerative, Semiclosed Systems: A Priority for Twenty-First Century Agriculture*. Bioscience. 2007. 37: 409-418.

144 Rosen, C. et al. "Using Manure and Compost as Nutrient Sources for Fruits and Vegetables." *University of Minnesota Department of Soil, Water and Climate*. 2005. <http://www.extension.umn.edu/distribution/horticulture/M1192.html>.

145 Rosen, C. et al. "Using Manure and Compost as Nutrient Sources for Fruits and Vegetables." *University of Minnesota Department of Soil, Water and Climate*. 2005. <http://www.extension.umn.edu/distribution/horticulture/M1192.html>.

146 Wellesley College - Green Report Card 2011." *The College Sustainability Report Card*. 17 Aug. 2010. Web. 20 Apr. 2011. <http://www.greenreportcard.org/report-card-2011/schools/wellesley-college/surveys/dining-survey>.

147 The College Sustainability Report Card. "Wellesley College- Report Card 2011." *The College Sustainability Report Card*. 2010. Web. 20 Apr. 2011. <http://www.greenreportcard.org/report-card-2011/schools>.

example, an experiment conducted by the Center for Ecological Technology (CET), a non-profit organization that promotes sustainable technologies in New England, found that reducing the amount of food waste entering landfills resulted in significant decreases in the carbon equivalent emissions released. Although waste from Wellesley is burned rather than going into a landfill, the carbon emissions from breaking down food waste are approximately the same. Applying compost as fertilizer also has the ability to help regenerate poor soils by encouraging the production of beneficial microorganisms, suppress plant diseases and pests, and reduce or eliminate dependence on chemical fertilizers while producing higher yields of agricultural crops.[148]

Choosing to send our food waste to compost sites (possibly local farmers, or other composting facilities) could decrease the college's operations costs significantly. According to the CET study, the cost of sending food scraps to landfills has varied between $65-$100 per ton over the last ten years; the CET found that the farmers included in their study were willing to drop tipping fees to $25-$35 per ton, showing an economic incentive for composting.[149]

Finally, the unquantifiable community benefits of implementing a composting program should not be underestimated. Local and student farms will benefit economically from a composting system, as will local waste haulers hired to transport compost. Implementation will not only improve community relations and drop Wellesley's operation costs, but it will also bring the College closer to becoming the sustainable and environmentally aware community it hopes to be.

There are various options available for Wellesley if it decides to seriously pursue composting. The first, and most basic, step is to coordinate the placement of specific collection bins in all dining halls and kitchens for pre- and post-consumer waste, as well as the pickup and transportation of the food waste to a designated location. Pomeroy dining hall occasionally asks students to separate food and non-food waste, which demonstrates that a more systemized and consistent version of this process could easily be implemented. For non-vegetarian dining halls it would be necessary to separate animal products from other food waste because these are less readily composted. Once waste has been collected, one option is to outsource food waste to a local farm or composting facility that can better manage the volume of waste generated by the College. Two farms that might be interested in forming a partnership with Wellesley are the Natick Community Organic Farm and Marino Lookout Farm. Alternatively, Wellesley could expand the existing composting facility used by Grounds Services to handle a larger capacity of waste.

Looking to efforts made by other colleges and universities of similar size to Wellesley is another way to find methods of composting that have already been successful and could work on Wellesley's campus. Middlebury College has developed a system in which waste is collected from the dining halls and then stored in sealed bins in a walk-in cooler until collection to keep food waste from smelling in hot weather or freezing in cold weather. The waste is then collected and composted on-campus, and periodically turned over with a front loader.[150] Ithaca College is able to compost about 20 percent of its total waste flow using a temperature controlled waste

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[148] US Environmental Protection Agency. "Environmental Benefits | Composting." *US Environmental Protection Agency*. 7 Oct. 2008. Web. 20 Apr. 2011. <http://www.epa.gov/epawaste/conserve/rrr/composting/benefits.htm>.

[149] US Environmental Protection Agency. "Success Story: Turning Garbage into Gold. Issue brief no. EPA-530-F-02-021." United States Environmental Protection Agency. July 2002. Web. 20 Apr. 2011. <http://www.epa.gov/epawaste/nonhaz/municipal/pubs/ghg/f02021.pdf>.

[150] Middlebury College. "Compost Process." *Middlebury Recycling and Waste Management*. n.d. Web. 20 April 2011. <http://www.middlebury.edu/offices/business/recycle/compost>.

facility. During the summer, the compost is moved outside until it is ready to be used as topsoil for gardening on campus.[151]

The College will need to obtain permits for compost storage and processing to be in compliance with state regulations. Massachusetts law allows institutions such as Wellesley to dispose of up to 5 tons (10,000 pounds) of food waste per day, on or off site, which is more than adequate to accommodate Wellesley's daily volume.[152] There is a range of composting technologies available that are commonly used by comparable institutions. Depending on the space Wellesley is willing to devote to this effort, it could consider a system as compact as a Rocket composter, which is used by over 200 British universities and institutions.[153] Available in several sizes, many of which are adequate for the volume of waste that Wellesley produces, this unit costs as little as $1,000. Additional costs include $1,125 for obtaining a composting permit from the state of Massachusetts,[154] which would entail additional yearly renewal fees of $1,050.[155]

Once processed, compost is a valuable commodity that the College can use in the greenhouses and the campus grounds. We also recommend determining whether there is a local farm interested in receiving Wellesley’s compost, since selling or giving compost to a local farm would be the easiest and most cost-effective option for the College. In addition to Regeneration, the student-run farm located on Weston Road in Wellesley, there are four community farms within 15 kilometers of Wellesley College that could potentially serve as exporting sites. For instance, Natick Community Organic farm currently composts all of its fruit and vegetable scraps and animal manure for use on-site. The 27-acre farm also has partnerships with community and student groups and might be interested in developing a composting partnership with Wellesley.[156]

Wellesley could expand the existing compost facility currently used by Grounds Services, as this would be a positive way of keeping compost on Wellesley’s property and not involving external parties. Despite these benefits, however, the initial investment to expand this facility could be quite expensive because the College would have to invest in new facilities and employees to aerate, maintain, and apply the compost. In addition, using Wellesley’s current facility might still require the transport of compost from campus to a local farm for application. Therefore, we recommend exporting compost off-site to local farms as the best possible option for reducing the amount of compostable material that enters the waste stream from dining services.

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[151] Ithaca College. "REMP Composting." *Ithaca College*. n.d. Web. 20 April 2011. <http://www.ithaca.edu/staff/mdarling/Composting.htm>.

[152] New Rules Project. "Composting - Massachusetts Rules and Programs." *New Rules Project*. The Institute for Self-Reliance. n.d.Web. 28 Apr. 2011. <http://www.newrules.org/environment/rules/composting/composting-massachusetts-rules-and-programs>.

[153] Tidy Planet. "Food Waste Composters." *TidyPlanet*. n.d. Web. 28 Apr. 2011. <http://www.tidyplanet.co.uk/food-waste-composters>.

[154]Massachusetts DEP. “Permit Application Schedule of Timelines and Fees.” Mass DEP. 4 Sept. 2009. Web. 28 Apr. 2011. <http://www.mass.gov/dep/service/approvals/fy10fees.pdf>.

[155]Massachusetts DEP. "Annual Compliance Assurance Fees." *Permit Application Schedule of Timelines and Fees*. Web. 28 Apr. 2011. <http://www.mass.gov/dep/service/acfees.pdf>.

[156] "Natick Community Organic Farm | History of the Farm.” *Natick Community Organic Farm.* n.d. Web. 20 Apr. 2011. <http://www.natickfarm.org/Pages/History.html>.

On-Campus Options Conclusion

Wellesley has the opportunity to implement several options to reduce its negative environmental impacts and increase its positive social and economic impacts. Choosing an appropriate strategy to address operational, pre-consumer, and post-consumer impacts should take each of these factors into consideration. Specifically, drastic operational changes to improve sustainability, such as implementing centralized dining, could result in undesirable social repercussions. Retrofitting dining facilities presents the most acceptable way to improve environmental performance without being a detriment to the student experience. As a means of supporting sustainable agriculture and investing in the community, Wellesley should consider incorporating more local produce, either from the student farm or nearby farms, into its menu. Finally, if nothing else, Wellesley should implement a comprehensive composting system, to allow us to deal in the most environmentally responsible manner with the volume of food waste our dining system produces. By putting these recommendations into practice, Wellesley could achieve a further-reaching and systemic commitment to sustainable practices in its dining halls.

6- Conclusion

The goal of the 2011 Environmental Studies 300 report is to evaluate the sustainability of the Wellesley College food system and offer concrete recommendations for improvement based on these assessments. The first section on global impacts analyzes 29 selected foods that contribute to a significant portion of what is ordered for our dining services and can be used to represent foods more broadly from different food groups. It evaluates these foods on specific environmental variables. The first three metrics of climate change, eutrophication, and water use are assigned letter grades based upon quantitative calculations. Other additional environmental assessment categories are biodiversity, toxicity, animal welfare, and labor, which we qualitatively measure. The second half of the report regarding on-campus impacts highlights the larger operations within the college's dining system, including food waste, non-food waste, and water and energy consumption. These are measured using numerical data as well as observational data. We also evaluate institutional changes, hyperlocal purchasing, and composting as options to consider as possible solutions to dining inefficiencies.

Our advice for remodeling does not necessarily entail breaking down the system as it is. In fact, most of our recommendations have the potential to be readily implemented within the current dining services plan. From the first part of the report, we recommend purchasing fewer animal products (especially beef), choosing lower impact protein options, ordering less-processed foods, buying more fruits and vegetables, prioritizing third-party certifications and transparency, and purchasing foods produced closer to Wellesley College. Ideally, these amendments to ordering would be implemented on an institutional level, but as an individual consumer, students and staff can make environmentally responsible choices everyday, like eating less beef, eating lower on the food chain, and consuming less processed and more fresh foods. From the second section, we have concluded that dining services should implement a campus-wide composting system, label foods at the dining halls that have third party certifications or other environmental ratings, increase purchasing from local farmers, and consider implementing a swipe card system. As individuals, students and staff can make responsible decisions by making an effort to take only what she or he is going to eat.

By performing a complete and holistic evaluation of the Wellesley College food system, it is our hope that this report may offer guidance for individual practices as well as foster larger institutional improvements towards environmental sustainability.

7- Appendixes

Appendix A: Climate change calculations

Table 21: Calculations for methane emissions for relevant food items

Food item	**CH_4 emissions per cow per year (g CE)**	**Food per cow**	**Serving size**	**CH_4 emissions per serving (g CE)**
Beef	1632000	450 pounds	0.1875 pounds	680.1
Milk	920000	307200 fluid ounces per year	8 fluid ounces	24
Brown Rice			0.1036	11.2
Food Item	**Serving size**	**Milk needed to produce one serving of food item (fl oz)**		**CH_4 emissions per serving (g CE)**
Ice Cream	1 cup	3		9
Butter	1 teaspoon (0.17 ounces)	3.655		10.97
Mozzarella Cheese	0.09 pounds	12		36

Note: 3 CE of methane is emitted per oz of milk produced

Table 22: Calculations of upper bound of carbon emissions for a serving of a serving of beef flown halfway across the world, including sample farming emissions calculations

A: Beef

0.1875 lbs per serving beef
450 lbs per cow
680.1 CH4 emissions/serving (CE)
317.8 g CE/cow due to drinking water
0.1324 g CE/serving beef due to drinking water

B: Corn

9720 lbs corn/cow
23670 lbs corn/acre
0.1808 lbs corn/serving
47610 g CE/acre of corn due to irrigation
0.3636 g CE/serving of corn due to irrigation
5.623 lbs herbicide/acre
0.8775 lbs insecticide/acre
0 lbs fungicide/acre
151.7 lbs N/acre
48.19 lbs P2O5/acre
69.60 lbs K2O/acre
0 lbs lime/acre

Table 23: Upper bound calculations

Category	Activity	kg CE/ha	g CE/serving beef
Tillage	Moldboard plowing	20.1	1.392
	Chisel plowing	11.1	0.7685
	Heavy tandem disking	11.2	0.7754
	Sub-soiler	14.1	0.9762
	Field cultivation	8.6	0.5954
	Rotary hoeing	2.9	0.2008
Water	Irrigation - Corn		8.145
	Drinking water - Cow		0.1324
Miscellaneous	Spray herbicide	2.2	0.1523
	Plan/sow/drill	3.9	0.2700
	Chemical incorporation	7.8	0.5400
	Fertilizer spraying	1.3	0.0900
	Fertilizer spreading	10.1	0.6993
	Windrower	5.5	0.3808
	Rake	2.4	0.1662
	Baler (large round)	8.8	0.6093
	Corn silage	26	1.800
	Shred corn stalk	5.3	0.3670
	Corn harvesting combine	11.5	0.7962
	Forage harvesting	18	1.246
		kg CE/kg a.i.	
Fertilizer	Nitrogen	1.8	21.19
	Phosphorus	0.3	1.122
	Potassium	0.2	1.080
	Lime	0.23	0
Pesticides	Herbicides	12.6	5.497
	Insecticides	8.1	0.5515
	Fungicides	8	0
Methane			680.1
Transportation			0.09259
Processing	Corn		2660
	Beef		214.0
TOTAL			2160

Table 24: Calculations of CE emissions associated with food transported for each food item

Food item	Rail miles	Truck miles	Ship miles	Total food miles	Rail CE (g)	Truck CE (g)	Ship CE (g)	kg in food serving	Total transportation CE (g)
Wild Caught Shrimp		1800		1800	0	6.995	0	0.057	6.995
Beef		1706		1706	0	9.886	0	0.085	9.886
Coffee		1960	3000	4960	0	1.336	0.3354	0.01	1.672
Tofu		1250		1250	0	9.626	0	0.113	9.626
Spinach		3233		3233	0	14.55	0	0.066	14.55
Turkey		1114		1114	0	2.127	0	0.028	2.127
Cranberry Blast concentrate	63.45	1398	76.5	1537	0.1138	24.09	0.2164	0.253	24.43
Vegan Nugget	343.5	211	1900	2455	0.2071	1.223	1.807	0.08505	3.237
Bottled Water		130		130	0	2.100	0.	0.237	2.100
Brown Rice		1657		1657	0	5.308	0	0.047	5.308
Eggs		1084		1084	0	2.586	0	0.035	2.586
Mozzarella Cheese	3120			3120	0.9512	0	0	0.043	0.9512
Sunkist Orange Juice		1375		1375	0	23.25	0	0.248	23.25
Pineapple		80	2570	2650	0	0.6163	3.247	0.113	3.863
Frozen Raspberries		327		327	0	0.9586	0	0.043	0.9586
Milk		209		209	0	3.648	0	0.256	3.648
Potatoes		2680		2680	0	20.65	0	0.113	20.65
Tomatoes		1530		1530	0	7.927	0	0.076	7.927
Cucumbers		1380		1380	0	6.304	0	0.067	6.304
Hummus		650	2200	2850	0	1.329	0.74	0.030	4.113
Chicken		552		552	0	1.067	0	0.02835	1.067
Ice Cream	95.18	200	76.5	372	0.07221	1.459	0.09152	0.107	1.623
Chiquita Bananas		410.6	2147	2557	0	3.359	2.880	0.120	6.239
Bacon		635		635	0	1.515	0	0.035	1.515
Chocolate Chip Cookie Dough	1021	745.6	7316	9082	0.2072	1.423	2.290	0.028	3.916
Corn		627.5		628	0	3.508	0	0.082	3.508
Cracklin Oat Bran	1280	1010	1231.5	3521.675	0.4448	3.374	0.6747	0.049	4.493
Butter			292	292	0	0	0.01632	0.005	0.01632
Apples		458		458	0	5.683	0.00	0.182	5.683

Table 25: Calculations of carbon equivalent (CE) emissions for processing each food item in grams

Food item	Ingredients	%	Serving Size	Description	Processing description	Grams CE/serving	Sum of CE/serving for items w/multiple ingredients	Possible calculations
Brown Rice			47 g	long grain parboiled brown rice	parboiling	6.98590909		0.42 kg CO2eq/kg rice for parboiling, 0.125 kg CO2eq/kg rice for drying
Chiquita Bananas			120 g		riping stops, packaged in 40 lb boxes			Fresh fruit is not processed. REFRIGERATED.
Potatoes			0.25 lb	potato fry str 3/8 XL	washed, steamed, peeled, sliced & heated at 90-95˚C for 7-12 min. Then fried w/oil and cooled. FROZEN	171.349091		5700g CO2/kg of potato
Tofu	soybeans	100	4 oz	extra firm tofu (soybeans & water)	beans are cracked and rolled, soymilk is boiled, protein-lipid film removed, coagulant added, and then blocked curds are run under cold water. FRIDGE.	17.0178		0.0021 + .5501 lbs CO2eq/lb tofu
Raspberries			0.25 lb	frozen raspberries	FROZEN	38.3469153		1815 kcal/kg for frozen fruits
Chocolate Chip Cookie Dough			28 g		mixed, baked, and FROZEN.	9.50189052	35.021578	1815 kcal/kg for frozen foods in general
	wheat flour	30	8.4	conventional white flour	dirt is separated from grain, grain is rolled and shaken, air is blown on the grain to remove bran, grain is ground into flour	0.76015124		484 kcal/kg for flour
	sugar	30	8.4	sugarcane	washing, shredding, and crushing in hot water, cleaning with lime and coagulant, boil syrup, vaccum drying the crystals, and drying under humidity controlled air for days.	5.29278861		3370 kcal/kg for sugarcane

Food item	Ingredients	%	Serving Size	Description	Processing description	Grams CE/serving	Sum of CE/serving for items w/multiple ingredients	Possible calculations
	chocolate & cocoa	20	5.6	cocoa beans	hand dried, roasted and shelled in a winnower, ground to produce chocolate liquor and then kneaded to produce chocolate or pressed to produce butter. Cooled and then heated to temper it.	19.4655258		18591 kcal/kg for chocolate
	palm oil	20	5.6	palm oil	extraction in a digester, refined.	0.00122182		0.8 CO2eq/ tons C extracted
Mozzarella Cheese			1.5 oz	low moisture whole milk mozzarella cheese	milk, citric acid and rennet are mixed and curds are heated at 98˚F. Then kneaded in hot water and cooled in cold water. Shredded and FROZEN.	35.7400094	38.3875255	0.28 MJ per 0.015 kg of cheese
	milk	93	1.395			2.64751613		354 kcal/kg for milk
Milk			8 oz	milk	pasteurizing, bottling, FRIDGE	15.024654	64.1248102	354 kcal/kg for milk
	corn	50	0.164 lb			49.0067202		3542 kcal/kg for dehydrated food
	soybeans	50	0.164 lb			0.09343592		0.0021 CO2eq/lb soybeans
Butter			0.17 oz		separate milk from cream, cream is ripened through aging and pasteurized at 95˚C or higher, then cooled for 12-15 hrs, then heated again and churned to make butter.		0.33093952	Because of the renewable sources of energy utilized by Cabot Creamery, the processing footprint is negligible.
	milk					0.33093952		354 kcal/kg for milk
Coffee			0.36		wet processing, roasted, cooled, and ground. Roasting takes 3-30 minutes at 188-282˚C.	35.4273557		18948 kcal/kg

Food item	Ingredients	%	Serving Size	Description	Processing description	Grams CE/serving	Sum of CE/serving for items w/multiple ingredients	Possible calculations
Turkey			1 oz	turkey breast boneless raw	detailed description in LCA. FROZEN	6.31365288		1206 kcal/kg
Cucumbers			1 cup**		graded, washed, waxed, and hydrocooled. FRIDGE?			Negligible footprint for emissions because it's a fresh veggie.
Cranberry Blast Concentrate			8 oz		Then ingredients are mixed and concentrate is FROZEN. Shipped in steel drums in refrigerated trucks.	77.0331839	131.967592	1815 kcal/kg for frozen food items
	filtered water	30				0		0.00163 kwh/gallon
	cranberry juice	30		cranberries	cleaned, sorted, crushed, concentrated and FROZEN. Macerating enzyme treatment, hot press and water extraction.	7.04727273		juice number: 0.65 kg CO2e
	sugar	30				47.887135		3370 kcal/kg for sugar
Wild Caught Shrimp			2 oz		FROZEN at -35˚C in 90 minutes.	19.3431343		1815 kcal/kg for frozen fish
Bacon			1.25 oz		REFRIGERATED truck and storage.	7.8920661	56.9922222	1206 kcal/kg for meat
	corn					49.0067202		3542 kcal/kg for dehydrated food
	soybeans					0.09343592		0.0021 CO2eq/lb soybeans
Beef			3 oz			213.957446	1430.51616	57 MJ/kg of beef
	corn	4.05 lbs	9720 lbs			1216.55872		3542 kcal/kg for dehydrated food
Pineapple			113 g	fresh pineapple	very little processing. Packaged uncut and shipped.			No processing for fresh fruit.
Cracklin Oat Bran			49 g		detailed description in LCA. Dried.	143.608118	151.566039	15675 kcal/kg for cereals
	whole oats	40	19.6			1.77368623		484 kcal/kg for flour
	wheat bran	25	12.25			1.10855389		484 kcal/kg

Food item	Ingredients	%	Serving Size	Description	Processing description	Grams CE/serving	Sum of CE/serving for items w/multiple ingredients	Possible calculations
	brown sugar	15	7.35			4.63119003		3370 kcal/kg for sugarcane (brown sugar is basically just as processed as white sugar, with flavor and color added back in)
	palm oil	10	4.9			0.00106909		0.8 CO2eq/tons of oil extracted
	oat bran	10	4.9			0.44342156		484 kcal/kg for flour
Eggs			1 egg		FRIDGE.			Since we can't account for fridge, the processing footprint is negligible.
	chicken	100						Chicken not processed in this case.
Corn				whole kernel corn	FROZEN	61.3479381		1815 kcal/kg for frozen food.
Bottled Water			8 oz		1.83 MJ per PET bottle of 8 oz size. The water is also filtered using ozonation and 0.1 micron filtration.	22.2604907		8/1000 kg CO2e/ 1 g of plastic + 44.02/(1000*128) KWh/1 oz
Chicken			1 oz		whole birds are delivered fresh and REFRIGERATED.	6.31365288		1206 kcal/kg for meat
Apples			1 small apple	whole fresh apples	not processed. Refrigerated between 30-31°F after harvesting to delay ripening.			No processing for fresh fruit.
Ice Cream			1 cup		10% of ghg emissions are from REFRIGERATION, mixing, and transportation	18.0988391	92.9765223	880 kcal/kg not including processing for each ingredient
	milk	37.5				2.71370404		354 kcal/kg for milk
	sugarcane	6.25				43.3189544		3370 kcal/kg for sugar

Food item	Ingredients	%	Serving Size	Description	Processing description	Grams CE/serving	Sum of CE/serving for items w/multiple ingredients	Possible calculations
Vegan Nugget			3 oz	breaded vegan nuggets	Assuming this is frozen.	28.8450248	32.7446906	1815 kcal/kg for frozen food.
	soy protein				surge bin (washing of beans), cracking meal, meal conditioner, flaking mill, meal cooler and grinder, flake elevator, toaster, vapor scrubber, evaporator, and multiple stages of condenser	0.05366252		0.0021 CO2eq/lb soybeans
	wheat gluten				In the wet milling process, flour produced by milling is suspended in water and gluten coagulates under high temperature and pressure	3.84600331		484 kcal/kg for flour
Orange Juice			1 cup	sunkist orange juice concentrate	washed, inspected, concentrated. FROZEN?	21.0490909		0.34 kg CO2e/1 kg juice
Tomatoes			0.167 lb	cherry tomatoes	not processed. REFRIGERATED.			No processing for fresh fruit.
Spinach			30 g		sorted, flume-washed (often three times), dried in a centrifuge by forced air, and packaged into cellophane bags. Then REFRIGERATED.			Processing is negligible since it's mostly hand-washed/etc. BUT significant emissions required to keep it refrigerated in transport.
Hummus			2 tbsp		Mixed and FROZEN.	24.0940795	68.559237	1815 kcal/kg for frozen food.
	garbanzo beans (chickpeas)				dried in fan-aerated bins	44.3709494		3542 kcal/kg for dehydrated food

Food item	Ingredients	%	Serving Size	Description	Processing description	Grams CE/serving	Sum of CE/serving for items w/multiple ingredients	Possible calculations
	sesame tahini				sesame seeds are cleaned and hulled; soaked and crushed to remove the kernals. The kernals are then toasted and crushed again to form paste.	0.00021818		0.8 CO_2e/tons of oil extracted compared to palm oil
	lemon juice				juice extraction process (same as orange juice processing?). Pasteurized with steam for 15-20 seconds and then cooled to 2˚C.	0.09272727		0.34 kg CO_2e/kg juice, assuming that orange juice and lemon juice are processed similarly
	water					0		0.00163 kwh/gallon
	soybean oil					0.00126265		0.0021 CO_2eq/lb soybeans

Appendix B: Animal welfare standards

Table 26: Comparison of animal welfare standards by program- beef cattle[157]

Animal Welfare Standard	Industry Guidelines (NCBA)	National Organic Program (USDA)	Certified Humane Program (HFAC)	American Humane Certified (AHA)	Animal Welfare Approved (AWA)	Global Animal Partnership Step 5 Plus
Antibiotics	Not prohibited	Prohibited	Permitted for treatment of disease only	Permitted for treatment of disease only	Permitted for treatment of disease only	Prohibited (all steps)
Growth Hormones	Not prohibited	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited (all steps)
Access to Pasture	Not required; confinement to feedlots allowed	Required; temporary confinement allowed in some situations; feedlots prohibited	Not required; cattle may be maintained in feedlots	Not required; cattle may be maintained in feedlots	Access to pasture required throughout lifetime when climate permits	Cattle must live continuously on range or pasture
Identification	Hot branding and ear notching allowed; jaw brands are not to be used	Not addressed	Hot iron branding & ear cutting prohibited; ear tagging permitted	Hot iron branding & ear cutting prohibited; ear tagging permitted	Hot iron branding & ear cutting prohibited; ear tagging permitted	Branding, wattling & ear notching are prohibited; ear tagging permitted
Castration	Recommended be done before 4 months of age; no recommendation regarding anesthesia	Physical alterations must be performed as needed to promote animal welfare & in a manner that minimizes pain & stress	Recommend be done at earliest age possible; anesthesia required for surgical removal after 2 months of age	Recommend be done at earliest age possible; anesthesia required for surgical removal after 2 months of age	Recommend be done before 2 months of age; use of anesthesia required	Prohibited
Debudding/ Dehorning	Recommended be done before 4 months of age; no recommendation regarding anesthesia	Physical alterations must be performed as needed to promote animal welfare & in a manner that minimizes pain & stress	Debudding in first 4 months using hot iron; anesthesia not required	Debudding in first 4 months using hot iron; anesthesia not required	Dehorning prohibited. Debudding only permitted on calves 2 months of age or younger	Dehorning prohibited (all steps); Debudding prohibited
Spaying of Heifers	Not prohibited	Not addressed	Prohibited	Prohibited	Prohibited	Prohibited (all steps)
Minimum Weaning Age	No limit; usually 7-8 months of age	Not addressed	Not addressed	Not addressed	6-9 months of age	Natural weaning is required
Electric Prod Use	Permitted, but voltage must be less than 50 volts	Not addressed	Permitted in emergencies only	Permitted in emergencies only	Prohibited	Permitted in emergencies only

[157] Farm Sanctuary, Inc.. "Research Reports." *Farm Sanctuary: Media Center*. N.p., n.d. Web. 16 Mar. 2011. < http://www.farmsanctuary.org/mediacenter/standards.html>

Table 27: Comparison of animal welfare standards by program- dairy cattle[158]

Animal Welfare Standard	Industry Guidelines (DQA)	National Organic Program (USDA)	Certified Humane Program (HFAC)	American Humane Certified (AHA)	Animal Welfare Approved (AWA)
Antibiotics	Not prohibited	Prohibited	Permitted for treatment of disease only	Permitted for treatment of disease only	Permitted for treatment of disease only
Growth Hormones	Not prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Ammonia Levels	Recommended be kept below allowable levels	Shelter designed for ventilation & air circulation	Not to exceed 25 parts per million (ppm)	Not to exceed 25 ppm	Shelters must be well ventilated
Housing	Tie-stall housing permitted but animals should be turned out daily for exercise; no minimum duration specified	Opportunity to exercise and access to outdoors must be provided; temporary confinement allowed	Confinement for more than 4 hours prohibited; animals must be turned out for 4 hours of exercise daily	Confinement for more than 4 hours prohibited; animals must be turned out for 4 hours of exercise daily	Continuous outdoor access required
Bedding	Dry, clean bedding recommended; no depth specified	Dry, clean bedding required; no depth specified	Adequate, clean bedding required 3 inches in depth	Adequate, clean bedding required 3 inches in depth	"Sufficient" quantities of clean, dry bedding required.
Calf Hutches/ Tethering	No limit on confinement of calves; tethering not prohibited	Not addressed, but exercise and freedom of movement required	Hutches permitted but calves must be able to stand, turn around, lie down, rest, and groom; tethering prohibited	Hutches permitted but calves must be able to stand, turn around, lie down, rest, and groom; tethering prohibited	Continuous outdoor access required. Isolation from other animals prohibited, except for brief periods.
Colostrum for Calves	4 quarts from 1 cow within 30-60 minutes of birth recommended	Not addressed	2-4 quarts within first 8 hours; 1.6 gallons over next 48 hours	Must receive within 6-8 hours of birth. When nursing is not possible, 2-4 quarts within first 8 hrs	Must be provided within 6 hours of birth
Min. Weaning Age	No limit	Not addressed	5 weeks	5 weeks	6 weeks
Dietary Fiber for Calves	Some dry grain before 4 weeks recommended	Not addressed	Required for calves over 30 days of age	Required for calves over 14 days of age	High quality forage required from 7 days onward
Tail Docking	Switch trimming (i.e., periodic tail hair trimming) preferred; docking allowed after pregnancy confirmed	Physical alterations must be performed as needed to ensure animal welfare	Prohibited; switch trimming permitted	Prohibited; switch trimming permitted	Prohibited
Dehorning/ Debudding	Hot iron cautery method recommended; anesthesia recommended for older calves	Physical alterations must be performed as needed to ensure animal welfare & in a manner that minimizes pain	Cautery method approved; paste & scoop methods prohibited; anesthesia required for older calves	Cautery method approved; scoop method may be used if necessary; anesthesia required for older calves	Cautery method approved for calves 2 months & younger with local anesthetic; prohibited after 2 months of age; paste approved calves younger than 7 days

[158] Farm Sanctuary, Inc.. "Research Reports." *Farm Sanctuary: Media Center*. N.p., n.d. Web. 16 Mar. 2011. < http://www.farmsanctuary.org/mediacenter/standards.html>

Table 28: Comparison of animal welfare standards by program- sheep[159]

Animal Welfare Standard	Industry Guidelines (ASIA)	National Organic Program (USDA)	Certified Humane Program (HFAC)	American Humane Certified (AHA)	Animal Welfare Approved (AWA)
Antibiotics	Not prohibited	Prohibited	Permitted for treatment of disease only	Permitted for treatment of disease only	Permitted for treatment of disease only
Growth Hormones	Not prohibited	Prohibited	Prohibited	Not addressed	Prohibited
Access to Pasture	Not required	Required; temporary confinement allowed in some situations	Required during grass-growing season when conditions allow	Required access to "turn-out lots" for at least 4 hours of exercise per day; access to pasture suggested when climate and season permits	Continuous access required except during extreme weather or other emergency
Access to Shelter	Natural or artificial shade, shelter & windbreaks recommended	Shade and shelter required	Natural or artificial shade, shelter & windbreaks required	Natural or artificial shade, shelter & windbreaks required	Natural or artificial shade, shelter & windbreaks required
Bedding	Not required	Clean, dry bedding required	Clean, dry bedding required	Bedding required only under certain circumstances (e.g., when sheep are shorn in winter, during lambing, etc.)	Clean, dry bedding required
Perforated, Slatted Floors	Not addressed	Not addressed	Prohibited for lying areas	Allowed, though "slats must not result in injury to feet"	Prohibited
Indoor Lighting	Not addressed	Access to direct sunlight required	Artificial light at a level comparable to natural light allowed	Artificial light at a level comparable to natural light allowed	Windows or openings that allow natural daylight required
Min. Weaning Age	Early weaning allowed	Not addressed	5 weeks	5 weeks	3 months
Castration	Encouraged; local anesthetic may be needed if performed after 8 weeks of age	Physical alterations must be performed as needed to promote animal welfare	May be performed between 1 & 7 days of age using rubber ring or surgical methods, or up to 4 weeks of age by other methods if first attempt is unsuccessful; local anesthetic recommended	May be performed using rubber ring between 1 & 7 days of age, or up to 8 weeks of age by other methods if first attempt is unsuccessful; no recommendation on anesthetic	Use of rubber rings on lambs 1 week & younger acceptable only when breeding cannot be controlled by any other method
Tail Docking	Encouraged; local anesthetic may be needed if performed after 8 weeks of age	Physical alterations must be performed as needed to promote animal welfare	May be performed between 1 & 14 days using rubber ring or hot iron; anesthetic not required	May be performed between 1 & 14 days using rubber ring or hot iron; anesthetic not required	Prohibited

[159] Farm Sanctuary, Inc.. "Research Reports." *Farm Sanctuary: Media Center*. N.p., n.d. Web. 16 Mar. 2011. < http://www.farmsanctuary.org/mediacenter/standards.html>

Table 29: Comparison of animal welfare standards by program- pigs[160]

Animal Welfare Standard	Industry Guidelines (NPB)	National Organic Program (USDA)	Certified Humane Program (HFAC)	American Humane Certified (AHA)	Animal Welfare Approved (AWA)	Global Animal Partnership
Antibiotics	Not prohibited	Prohibited	Permitted for treatment of disease only	Permitted for treatment of disease only	Permitted for treatment of disease only	Prohibited (all steps)
Ammonia Levels	Should not exceed 50 ppm	Shelter designed for ventilation & air circulation	Not to exceed 25 ppm; should be less than 10 ppm	Not to exceed 25 ppm	Nothing specified; "shelters and housing must be well ventilated and allow for fresh air and natural light to enter"	No specific requirement; recommended not to exceed 10 ppm
Access to Outdoors	Not required	Required; temporary confinement allowed	Not required	Not required	Continuous access required from 10 days of age onward	Continuous access to foraging areas or pasture required
Tethers/ Gestation Crates/ Farrowing Crates	Permitted	Not specifically addressed but prohibited by the requirement for freedom of movement	Prohibited; except turn-around type farrowing pens allowed (must be at least 6x8 feet)	Prohibited, except turn-around type farrowing pens allowed (min. 5x7 feet) & gestation pens (minimum 20 square feet) during first 35 days allowed	All prohibited, including turn-around farrowing crates	Prohibited (all steps)
Min. Farrowing Space Per Sow	No limit	Not addressed	48 square feet required; 100 square feet preferred	35 square feet required	Minimum 64 square feet required bedding area, plus 32 square feet loafing area	Min 48 square feet required (all steps)
Bedding	Not required	Clean, dry bedding required	Required for housing indoors & outdoors	Required only for outdoor housing in winter	Required for housing indoors & outdoors	Required (all steps)
Slatted, Wire Floors	Permitted	Not addressed	Prohibited	Slatted floors permitted	Prohibited	Prohibited
Indoor Lighting	Subdued artificial light allowed	Access to direct sunlight required	Artificial light allowed (at level of at least 50 lux)	Artificial light allowed (at level of at least 50 lux)	Shelters and housing must have windows or openings that allow daylight; artificial light must not exceed 16 hours per day	Step 5 Plus animals live primarily outdoors with continuous access to shelter
Feed Restriction for Sows/Boars	Daily feed recommended, but controlling the amount encouraged	Not addressed; animals must be provided "a total feed ration"	Permitted, but dietary or environmental supplements must be provided	Swine must have access to food each day unless withheld on advice of a veterinarian	All pigs must have feeding plan to ensure appropriate nutrition; must have continuous access to forage to satisfy hunger between meals	Prohibited (all steps)
Min. Weaning Age	No limit	Not addressed	4 weeks	3 weeks	6 weeks	8 weeks
Tail Docking	Permitted	Permitted	Must not be done routinely; permitted only by veterinary recommendation and review by HFAC	Permitted until information on prevention of tail biting is available	Prohibited	Routine tail docking prohibited; may be done on individual animals for health or welfare reasons

[160] Farm Sanctuary, Inc.. "Research Reports." *Farm Sanctuary: Media Center*. N.p., n.d. Web. 16 Mar. 2011. < http://www.farmsanctuary.org/mediacenter/standards.html>

Table 30: Comparison of animal welfare standards by program- broiler (meat) chickens[161]

Animal Welfare Standard	**Industry Guidelines (NCC)**	**National Organic Program (USDA)**	**Certified Humane Program (HFAC)**	**American Humane Certified (AHA)**	**Animal Welfare Approved (AWA)**	**Global Animal Partnership**
Antibiotics	Not prohibited	Prohibited	Permitted for treatment of disease only	Permitted for treatment of disease only	Permitted for treatment of disease only	Prohibited (all steps)
Ammonia Levels	Should not exceed 25 ppm; goal is 10 ppm	Shelter designed for ventilation and air circulation	Not to exceed 25 ppm; should be less than 10 ppm	Not specified	No limit specified; shelters and housing must be well ventilated and allow fresh air and natural light to enter	No specific requirement; recommended not to exceed 10 ppm
Access to Outdoors	Not required	Required; temporary confinement allowed	Not required	Not required	Required	Must have continuous access to pasture or foraging areas during daylight hours, subject to weather conditions from 4 weeks of age
Max. Stocking Density	6.5 pounds per square foot (for birds below 4.5 pounds) to 8.5 pounds per square foot (for birds more than 5.5 pounds)	Not addressed, but opportunity to exercise & freedom of movement required	6.0 pounds per square foot	56 pounds per square yard	Birds must have adequate space to perform range of natural behaviors. One bird per square foot recommended. Maximum flock size of 500 birds recommended.	Birds must have space sufficient to express natural behaviors without touching other birds; no specific square footage specified
Slatted, Wire Floor	Permitted	Not addressed	Prohibited	Not addressed	Prohibited	Slatted floor may comprise no more than 25% of area (all steps)
Litter for Dust Bath	Not required	Not addressed	Required	Required	Required	Required (all steps)
Indoor Lighting	Near-continuous lighting allowed; 4 hours of darkness per day recommended (need not be continuous)	Access to direct sunlight required	Minimum 8 hours of light (average 20 lux) & 6 continuous hours of darkness required per day	Minimum 8 hours of light (average 20 lux) & 6 continuous hours of darkness required per day	Natural lighting required; No more than 16 hours artificial lighting per day	Indoor lighting must exceed 20 lux; no more than 16 hours artificial lighting per day (all steps)
Toe Clipping/ Comb Dubbing of Breeding Cockerels	Permitted	Alterations to be performed as needed to ensure welfare	Prohibited	Not addressed	Prohibited	Prohibited (all steps)
Beak Trimming	Prohibited in meat birds; permitted in breeding birds	Alterations to be performed as needed to ensure welfare	Prohibited in meat birds; not specified for breeders	Prohibited in meat birds; not specified for breeders	Prohibited for all birds	Prohibited (all steps)
Feed Withdrawal Before Slaughter	No more than 24 hours	Not addressed	No more than 12 hours	No more than 16 hours	No more than 8 hours	No more than 12 consecutive daylight hours (all steps)
Max. Transport Time	No limit	Not addressed	10 hours from start of loading to unloading at plant	12 hours from start of loading to unloading at plant	No more than 4 hours	2 hours
Slaughter Plant Holding Time	**Should not exceed 6 hours**	Not addressed	Not to exceed 10 hours	Not to exceed 10 hours	No more than 2 hours	Not specified
Acceptable Methods of Stunning for Slaughter	**Not specified**	Not addressed	Electrical stunning bath, dry stunner, hand-held stunner; gas permitted for killing only, not stunning	Electrical stunning bath, dry stunner, hand-held stunner	Gas stunning is preferred	Not specified

[161] Farm Sanctuary, Inc.. "Research Reports." *Farm Sanctuary: Media Center*. N.p., n.d. Web. 16 Mar. 2011. < http://www.farmsanctuary.org/mediacenter/standards.html>

Table 31: Comparison of animal welfare standards by program- egg-laying hens[162]

Animal Welfare Standard	Industry Guidelines (UEP)	National Organic Program (USDA)	Certified Humane Program (HFAC)	American Humane Certified (AHA)	Animal Welfare Approved (AWA)
Antibiotics	Not prohibited	Prohibited	Permitted for treatment of disease only	Permitted for treatment of disease only	Permitted for disease treatment only
Ammonia Levels	Should not exceed 25 ppm; less than 10 ppm recommended	Shelter designed for ventilation & air circulation	Not to exceed 25 ppm, should be less than 10 ppm	Not to exceed 25 ppm	No limit specified; shelters and housing must be well ventilated and allow fresh air
Access to Outdoors	Not required	Required; temporary confinement allowed	Not required	Required as per National Organic Program regulations	Continuous outdoor ranging and foraging access required from age four weeks old onwards
Min. Space Per Hen	White hens: 67 square inches; Brown hens: 76 square inches	Not specifically addressed but must provide opportunity to exercise & freedom of movement	1.5 square feet; 1.0-1.2 square feet for houses with overhead perches	1.25 square feet; 1.0-1.2 square feet for houses with overhead perches	Not specified; chickens must at all times have adequate space to socialize, fly, walk, stretch, look for food and water, scratch the ground, and dust bathe
Continuous Confinement to Wire Cages	Permitted	Not addressed but prohibited due to exercise requirement	Prohibited	Prohibited	Prohibited
Litter for Dust Bath/ Nest Boxes	Not required	Not specifically addressed but clean, dry bedding required	Litter for dust bathing required; nest boxes no less than 1 per 5 hens or community nest area not less than 9 square feet per 100 birds	Litter for dust bathing required; nest boxes no less than 1 per 5 hens or community nest area with "adequate" space and dividers to ensure privacy	Litter for dust bathing required; nest boxes no less than 1 per five birds required
Indoor Lighting	Continuous subdued lighting permitted (0.5-1foot candle: approximately 5 to 10 lux)	Access to direct sunlight required	Minimum 8 hours dim light (average 10 lux), 6 hours darkness required per day	Minimum 8 hours dim light (average 10 lux), 6 hours darkness required per day	Light must average 15 lux during daylight hours, with at least 8 hours darkness
Forced Molting	Feed withdrawal prohibited; water must be provided	Not addressed but producers must provide "a total feed ration" and access to direct sunlight required	Feed withdrawal to induce molting prohibited	Feed withdrawal to induce molting prohibited	Prohibited

[162] Farm Sanctuary, Inc.. "Research Reports." *Farm Sanctuary: Media Center*. N.p., n.d. Web. 16 Mar. 2011. < http://www.farmsanctuary.org/mediacenter/standards.html>

Table 32: Welfare standards for egg-laying hens under six certification systems[163]

→ Welfare factors / Certification Systems ↓	Wire cages prohibited?	Space required per hen:	Access to outdoor space required?	Exposure to daylight required?	Perches and dust-bathing materials required?	De-beaking prohibited?	Destruction of male chicks prohibited?
United Egg Producers Certified	No	0.5 sq. ft.	No	No	No	No	No
American Humane Certified	Yes	1.2 sq. ft.	No	No	No	No	No
Certified Humane Raised & Handled	Yes	1.5 sq. ft.	No	No	Yes	No	No
Animal Welfare Approved	Yes	1.8 sq. ft for indoor roosting spaces	Yes: >4 sq. ft. of green pasture per hen	Yes	Yes	Yes	No
USDA Organic	Yes	Not specified	Yes	Yes	No	No	No

Marketing claims unconnected to auditing systems:

"All-Natural"	A marketing flourish that has no bearing on animal production practices.
"Cage Free"	Implies open group housing inside barns. Look for an "American Humane," "Certified Humane," "AW Approved," or "USDA Organic" stamp to substantiate the claim.
"Free Range"	Implies access to an outdoor space—not specifying the quality or size of the space. Look for an "AW Approved" or "USDA Organic" stamp to substantiate the claim.
"Pasture Raised"	Implies hens spend a large portion of daylight hours on green space that enables foraging, scratching, free movement, and all natural behaviors. Look for "AW Approved" stamp to substantiate this claim.

Compiled by Sentient Cincinnati Newsblog, 2010. http://sentientcincinnati.com
Photographs courtesy of http://shutterstock.com and http://www.mercyforanimals.org

163 Sentient Cincinnati, "What lies beneath egg labels," 18 August 2010, http://sentientcincinnati.com/2010/08/18/what-lies-beneath-egg-labels/.

Appendix C: Individual food analyses

Apples

Fresh apples abound in the dining halls year-round. We get a variety of apples from a variety of sources (including some local apples). Since we buy more non-local gala apples than any other variety – two hundred twenty-six 100-count cases, or a total of 226,000 gala apples – we are focusing our analysis on these apples (code G734). Information on the specific brands and vendors is not available, and is likely to vary depending on factors like season and price, so we assume that our apples are distributed by Costa Fruit and Produce like the majority of other produce that dining services purchases.

Serving Size and Yield

The USDA serving size for apples is one small apple.[164] Since a small apple weighs 149 grams,[165] there are 0.328483 pounds in a serving (1 pound = 453.6 grams). If the average gala apple is small, then we purchase 226,000 servings of them. If the average gala apple is medium or large, then we purchase more than 226,000 servings. For our purposes, an estimate of 226,000 servings purchased is close enough. We assume that our apples have the average yield of apples grown in Adams County, Pennsylvania: 17,658 pounds per acre, or 53,758 servings per acre. (219 million pounds of apples are grown on 12,402 acres of land in Adams County.)[166]

Farm Location

In the U.S., Pennsylvania produces more apples (in mega tons) than any other state, followed by Virginia. Since Pennsylvania is closest to Wellesley, we assume the majority of our gala apples come from Pennsylvania.[167] In 2009, the South Central region of Pennsylvania, and in particular Adams County, produced the most apples (in pounds) of any specified region, so we assume our apples were grown there.[168]

Fertilizer Use

The state of Pennsylvania applied fertilizer to apples in the following quantities in total in 2009: 190,000 pounds of nitrogen, 94,000 pounds of phosphate, 181,000 pounds of potash, and 57,000 pounds of sulfur.[169] Since Pennsylvania apples were grown on 23,552 acres,[170] average

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[164] U.S. Department of Agriculture and U.S. Department of Health and Human Services, *Dietary Guidelines for Americans 2010*, 2010. Web. 25 Feb. 2011. <http://www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/PolicyDoc/PolicyDoc.pdf>

[165] Nutrient Data Laboratory, U.S.D.A. Agricultural Research Service, "Search the USDA National Nutrient Database for Standard Reference." Web. 28 Feb. 2011. <http://www.nal.usda.gov/fnic/foodcomp/search/>

[166] U.S. Department of Agriculture, *National Agricultural Statistics Service: Quick Stats*, 2007. Web. 25 Feb. 2011. <http://quickstats.nass.usda.gov/>

[167] Food and Agriculture Organization of the United Nations, *Agro-MAPS: Global Spatial Database of Agricultural Land-use Statistics*. Web. 25 Feb. 2011. <http://www.fao.org/landandwater/agll/agromaps/interactive/page.jspx>

[168] U.S. Department of Agriculture, *National Agricultural Statistics Service: Quick Stats*, 2007. Web. 25 Feb. 2011. <http://quickstats.nass.usda.gov/>

[169] U.S. Department of Agriculture, *National Agricultural Statistics Service: Quick Stats*, 2007. Web. 25 Feb. 2011. <http://quickstats.nass.usda.gov/>

fertilizer application rates were the following: 8.0673 pounds of nitrogen per acre, 3.9912 pounds of phosphate per acre, 7.6851 pounds of potash per acre, and 2.4202 pounds of sulfur per acre. We assume that our apples receive fertilizer applications at these rates.

Water Use

Apples are irrigated either with high-volume sprinklers or with low-volume drip or micro-sprinklers.[171] An acre might use an average of 5,770 gallons of water per day over the course of the year.[172] We assume our apples are transported from Adams County to Costa's distribution center in Boston before arriving at Wellesley (see more information in the Climate Change section below).

Methane

The primary source of methane from apple production is apple decomposition, but this does not apply to the apples we purchase. Apple production is not commercially mechanized.[173]

Processing

Once harvested, apples usually sit in bulk bins in cold storage chambers that delay ripening until they are ordered,[174] after which they are placed in corrugated fiberboard boxes and then palletized for transport to the loading dock. Most varieties must be kept at a temperature between 30˚ and 32˚ Fahrenheit after harvest.[175] Apples can be processed in a variety of ways, and we buy many processed apple products, but the fresh gala apples we consider here are not processed.

Transportation

After our apples are harvested, they are likely trucked to a distribution center in or near Adams County, such as Gettysburg or Fairfield, from which they are likely trucked to Costa's main distribution center in Boston[176] and then to Wellesley. They may be stored for long periods in either location, all the time being kept cold.

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[170] U.S. Department of Agriculture, *National Agricultural Statistics Service: Quick Stats*, 2007. Web. 25 Feb. 2011. <http://quickstats.nass.usda.gov/>

[171] Ontario Ministry of Agriculture Food & Rural Affairs, "Irrigation Scheduling For Fruit Crops," April 1990. Web. 25 Feb. 2011. <http://www.omafra.gov.on.ca/english/crops/facts/90-069.htm>.

[172] Vossen, Paul, "Water Management for Fruit Trees and Other Plants," p. 2. n.d. Web. 25 Feb. 2011. <http://cesonoma.ucdavis.edu/files/27167.pdf>.

[173] Calvin, Linda, "Labor-Intensive U.S. Fruit and Vegetable Industry
Competes in a Global Market," *Amber Waves*, December 2010. Web. 25 Feb. 2011. <http://www.ers.usda.gov/AmberWaves/December10/Features/LaborIntensive.htm>

[174] U.S. Department of Agriculture, "Protecting Perishable Foods During Transport by Truck," July 2006, pp. 27-28. Web. 25 Feb. 2011. <http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3021003&acct=atpub>.

[175] U.S. Department of Agriculture, "Protecting Perishable Foods During Transport by Truck," July 2006, pp. 27-28. Web. 25 Feb. 2011. <http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3021003&acct=atpub>.

[176] Costa Fruit and Produce, "Company Profile." N.d. Web. 25 Feb. 2011. <http://www.freshideas.com/aboutus/comp_profile.html>.

Additional Information

Pesticide Use

Pennsylvania apples received the following pesticide applications in 2009: 16,200 pounds of herbicide, 248,400 pounds of fungicide, 220,800 pounds of insecticide, and 2,500 pounds of other pesticides.[177] Since the apples were grown on 23,552 acres,[178] average application rates were as follows: herbicide, 0.68784 pounds per acre per year; fungicide, 10.547 pounds per acre per year; insecticide, 9.3750 pounds per acre per year; other pesticides, 0.10615 pounds per acre per year. We assume the same pesticide application rates for our apples.

Scale of Operation

Adams County, Pennsylvania, grows 219 million pounds of apples on 12,402 acres of land and among 134 operations, compared with a total of 483 million pounds of apples on 23,552 acres for Pennsylvania.[179] This means that the average operation in Adams County is 92.6 acres large, but many are larger, such as the 500-acre El Vista Orchards Inc.,[180] or smaller.

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[177] U.S. Department of Agriculture, *National Agricultural Statistics Service: Quick Stats*, 2007. Web. 4 Mar. 2011. <http://quickstats.nass.usda.gov/>.
[178] U.S. Department of Agriculture, *National Agricultural Statistics Service: Quick Stats*, 2007. Web. 4 Mar. 2011. <http://quickstats.nass.usda.gov/>.
[179] U.S. Department of Agriculture, *National Agricultural Statistics Service: Quick Stats*, 2007. Web. 25 Feb. 2011. <http://quickstats.nass.usda.gov/>.
[180] AgMap, "El Vista Orchards Inc," 2011. Web. 25 Feb. 2011. <http://agmap.psu.edu/Businesses/666>.

Baby Spinach

We buy a variety of fresh leafy green vegetables from Costa Fruit and Produce, including lettuce (romaine, iceberg, and green leaf), mesclun, baby spinach, baby arugula, cabbage, and collard greens. For this analysis, we look at fresh baby spinach, on which we spend the most money out of all leafy greens. We buy 1,606 cases of baby spinach (ID #G431). Although we buy more cases of mesclun (1,969 cases in 3-pound units, ID #M577), we spend more money on baby spinach. After baby spinach and mesclun, we spend the most money on romaine lettuce (533 cases, ID #00555). Information on the specific brands and vendors is not available, and often varies depending on factors such as season and price, so we assume that our apples are distributed by Costa Fruit and Produce like the majority of other produce that dining services purchases. The size or weight of each case is unknown and may vary depending on factors such as season and supplier.

Serving Size and Yield

We use a serving size of 1 cup for baby spinach, which the USDA recommends as the appropriate serving size for raw leafy vegetables.[181] According to the USDA Nutrient Database, one cup of raw spinach weighs 30 grams.[182] Thus, one pound (453.6 grams) of spinach contains 15.12 cups or servings and there are 0.066138 pounds in a serving of spinach.

From 2004 to 2006, the U.S. produced 867 million pounds of spinach[183] on 44,071 acres and across 1,202 operations.[184] This means that the average U.S. spinach farm produced 721,298 pounds of spinach at 19,673 pounds per acre. In 2008, California produced spinach (total fresh and processing) on 25,500 acres at an average 8.25 tons per acre (16,500 pounds per acre).[185] We assume that our baby spinach has this average yield of 16,500 pounds per acre, which equates to 249,478 servings per acre.

Farm Locations

About 96 percent of fresh spinach consumed in the United States is produced domestically. Of that, 73 percent is produced in California,[186] so we assume that our baby spinach is grown there.

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[181] U.S. Department of Agriculture and U.S. Department of Health and Human Services, *Dietary Guidelines for Americans 2010*, 2010, p. 83. Web. 26 Feb. 2011.
[182] Nutrient Data Laboratory, U.S.D.A. Agricultural Research Service, "Search the USDA National Nutrient Database for Standard Reference." N.d. Web. 28 Feb. 2011. < http://www.nal.usda.gov/fnic/foodcomp/search/>.
[183] U.S.D.A. Economic Research Service, "Fresh-market spinach: background information and statistics," 30 Aug. 2007. Web. 28 Feb. 2011. < http://www.ers.usda.gov/News/spinachcoverage.htm>.
[184] U.S. Department of Agriculture, *National Agricultural Statistics Service: Quick Stats*, 2007. Web. 28 Feb. 2011. <http://quickstats.nass.usda.gov/>.
[185] Koike, Steven, et al., *Spinach Production in California*, University of California Agriculture and Natural Resources, Publication 7212, 2011. Web. 28 Feb. 2011. <http://ucanr.org/freepubs/docs/7212.pdf>.
[186] U.S.D.A. Economic Research Service, "Fresh-market spinach: background information and statistics," 30 Aug. 2007. Web. 28 Feb. 2011. < http://www.ers.usda.gov/News/spinachcoverage.htm>.

Fertilizer Use

For baby spinach, typical nitrogen applications are 20 pounds per acre before or at planting and an additional top-dress or water-run application of 20-30 pounds per acre, for a total of 40 to 50 pounds per acre of nitrogen. Recommended phosphorus (P2O5) application is 20 to 40 pounds per acre before planting or 20 pounds at planting if soil bicarbonate extractable phosphorus is below 60 parts per million. The recommended potassium (K) application is 25 to 55 pounds per acre.[187] We assume that our baby spinach receives the average values for these recommended applications: 45 pounds of N per acre, 30 pounds of P2O5 per acre, and 40 pounds of K per acre.

Because baby spinach is harvested when it is young, it has low nutrient uptake. For example, nitrogen uptake might be 20 to 40 pounds per acre. Potassium uptake is 25 to 55 pounds per acre (the same amount is applied to replace uptake).[188] We assume that our baby spinach has these uptake values and that its phosphorus (P2O5) uptake is equal to or less than the amount of phosphorus applied (or 30 pounds per acre).

Water Use

California spinach is sprinkler-irrigated. Before planting, 2 to 4 inches of water are applied to the soil with sprinklers. Baby spinach is often irrigated with solid-set sprinklers. Between seeding and harvest, “clipped and bagged” spinach (including baby spinach) receives a total of 4 to 8 acre-inches (413 to 862 cubic meters) per acre of water.[189] Bagged spinach is flume-washed, often as many as three times.[190]

Mechanization

Spinach is direct seeded. In California, seeds are planted in high density on 80-inch wide beds.[191] Bagged spinach is mechanically harvested. A machine with a front cutter bar runs on top of the beds, clipping the leaves and stems at the desired height. A conveyor belt then lifts the clipped leaves into bins on trailers, which transport the leaves to a processing plant.[192]

Processing

At the processing plant, the spinach leaves are sorted, flume-washed (often three times),[193] dried by centrifugation or forced air, and packaged (often cello-packed)[194] into various

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[187] Koike, Steven, et al., *Spinach Production in California*, University of California Agriculture and Natural Resources, Publication 7212, 2011. Web. 28 Feb. 2011. <http://ucanr.org/freepubs/docs/7212.pdf>.

[188] Koike, Steven, et al., *Spinach Production in California*, University of California Agriculture and Natural Resources, Publication 7212, 2011. Web. 28 Feb. 2011. <http://ucanr.org/freepubs/docs/7212.pdf>.

[189] Koike, Steven, et al., *Spinach Production in California*, University of California Agriculture and Natural Resources, Publication 7212, 2011. Web. 28 Feb. 2011. <http://ucanr.org/freepubs/docs/7212.pdf>.

[190] U.S.D.A. Economic Research Service, “Fresh-market spinach: background information and statistics,” 30 Aug. 2007. Web. 28 Feb. 2011. < http://www.ers.usda.gov/News/spinachcoverage.htm>.

[191] Koike, Steven, et al., *Spinach Production in California*, University of California Agriculture and Natural Resources, Publication 7212, 2011. Web. 28 Feb. 2011. <http://ucanr.org/freepubs/docs/7212.pdf>.

[192] Koike, Steven, et al., *Spinach Production in California*, University of California Agriculture and Natural Resources, Publication 7212, 2011. Web. 28 Feb. 2011. <http://ucanr.org/freepubs/docs/7212.pdf>.

[193] U.S.D.A. Economic Research Service, “Fresh-market spinach: background information and statistics,” 30 Aug. 2007. Web. 28 Feb. 2011. < http://www.ers.usda.gov/News/spinachcoverage.htm>.

[194] U.S.D.A. Economic Research Service, “Fresh-market spinach: background information and statistics,” 30 Aug. 2007. Web. 28 Feb. 2011. < http://www.ers.usda.gov/News/spinachcoverage.htm>.

bags.[195] If processing is delayed, the spinach can be cooled by vacuum or forced air and stored for a short time. After processing, the spinach must be kept cool (32˚F).[196]

Transportation

We assume that our baby spinach travels a negligible distance to a processing plant in Monterey County and that after processing it travels by refrigerated truck to Costa's distribution center in Boston, from which it travels to Wellesley via Costa's trucks.[197]

Scale of Operation

In California in 2007, 18,844 acres of fresh-market spinach were harvested across 158 operations.[198] This means that the average operation in California harvested 119 acres of fresh-market spinach. The majority of the acres harvested in California (13,181 acres or 70 percent) were located in Monterey County in the central coast region, on 39 farms total.[199] The average farm cultivated 338 acres. We assume that our baby spinach comes from one or more of these operations in Monterey County, with a size equal to its average operation size of 338 acres.

Pesticide Use

Spinach grown in Arizona, California, and Texas in 2006 received the following average pesticide applications, which we assume our baby spinach receives per year: one pound per acre of herbicide; 0.94828 pounds per acre of fungicide; 1.2457 pounds per acre of insecticide; and 9.7177 pounds per acre per year of other insecticides.[200]

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[195] Koike, Steven, et al., *Spinach Production in California*, University of California Agriculture and Natural Resources, Publication 7212, 2011. Web. 28 Feb. 2011. <http://ucanr.org/freepubs/docs/7212.pdf>.

[196] Koike, Steven, et al., *Spinach Production in California*, University of California Agriculture and Natural Resources, Publication 7212, 2011. Web. 28 Feb. 2011. <http://ucanr.org/freepubs/docs/7212.pdf>.

[197] Costa Fruit and Produce, "Company Profile." N.d. Web. 25 Feb. 2011. <http://www.freshideas.com/aboutus/comp_profile.html>.

[198] U.S. Department of Agriculture, *National Agricultural Statistics Service: Quick Stats*, 2007. Web. 28 Feb. 2011. <http://quickstats.nass.usda.gov/>.

[199] U.S. Department of Agriculture, *National Agricultural Statistics Service: Quick Stats*, 2007. Web. 28 Feb. 2011. <http://quickstats.nass.usda.gov/>.

[200] calculated from USDA National Agricultural Statistics Service, *Agricultural Chemical Usage 2006 Vegetables Summary*, July 2007, p. 213. Web. Accessed 5 March 2011. <http://usda.mannlib.cornell.edu/usda/current/AgriChemUsVeg/AgriChemUsVeg-07-25-2007_revision.pdf>.

Bacon

Wellesley orders Sysco Reliance Layflat bacon. Dining services ordered 6,075 pounds of Layflat bacon in 2010. The College also orders other bacon products such as bacon bits and bacon pizza topping, but in this report we focus on the regular Layflat bacon since it is by far the most purchased form of bacon. Bacon is a cured pork product. An average pig produces 198 lbs of meat and we are estimated that 15% of that is bacon.[201]

Serving Size

The United States Department of Agriculture suggests a servings size of 1 oz as an appropriate serving of bacon.[202] Fresh Mark Foods provided Dining services with 5,655 pounds of the total 6,075 pounds of layflat bacon, which is approximately 90,480 serving sizes of bacon.

Farm Locations

Information about the farm locations for Fresh Mark Foods' Layflat bacon is not readily available. Therefore the farm locations used in this report are estimated based on general information about bacon production and trade. Currently, most of the swine in the United States are produced in North Carolina and the Midwestern and plains states, including Nebraska, Iowa, Minnesota, Missouri, Indiana and Illinois. Worldwide, China is by far the largest producer of pork, producing nearly four times as much as the U.S.[203] In 2010, pig exports only accounted for 19% of production.[204] We believe it is safe to assume that the Fresh Mark Foods' bacon sources are domestically produced. The following companies are suppliers to Fresh Mark Foods:

Sugardale Food Service
1600 Harmont Ave. NE, Canton, OH 44705-3302

Superiors Brand Meats Inc
1888 Southway Street SW Massillon, OH 44646-9429

Both of these suppliers are located in Ohio, which is one of the high pork producing states in the United States. We assume that these companies raise pigs in that area.

Fertilizer Use

The average bacon pig of 132 lbs consumes about 6lbs of feed every day.[205] The majority of the contents of pig feed are corn and soy along with food wastes, wheat, oats and grains.[206] Please see Feed Corn for information about fertilizer from pig feed.

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[201] Springer, Sandra . "Swine Production in the US." *University of Pennsylvania School of Veterinary Medicine* n.d. Web. 25 Feb. 2011. <http://cal.vet.upenn.edu/projects/swine/prod/hm.html>.
[202] U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Dietary Guidelines for Americans, 2010.* 7th Edition, Washington, DC: U.S. Government Printing Office, December 2010.
[203] U.S. EPA, "Background of Pork Production in U.S. | Ag 101 | Agriculture | US EPA." *US Environmental Protection Agency*. 9 Oct. 2009. Web. 21 Feb. 2011. <http://www.epa.gov/oecaagct/ag101/porkbackground.html>.
[204] Johnson, Rachel J. . "Livestock, Dairy and Poultry Outlook." *USDA Economic Research Service* 1 (2011): 1-19. *Economics, Statistics and Market Information System*. Web. 21 Feb. 2011.
[205] Smith, K.A., D.R. Charles, and D. Moorhouse. "Nitrogen Excretion By Farm Livestock With Respect To Land Spreading Requirements And Controlling Nitrogen Losses To Ground And Surface Waters. Part 2: Pigs And Poultry." *Bioresource Technology* 71 (2000): 183-194. Print.

Water Use

A 2,400 sow farm needs 40-50 gallons/min for drinking water and other farm requirements, compared to an irrigation pump which uses 2,000gal/min That means an average pig farm requires 72,000 gallons of water per day or 26, 280,00 gallons per year.[207] The average bacon pig requires approximately 1 gallon of water every day.[208]

Mechanization and Processing

Bacon production is a highly mechanized process done in factories. Before the factory pigs are slaughtered, dehaired and skinned, gutted and separated. Pork bellies are softened in tumblers, mechanically cut, brined, baked in an oven for 5 hours, blast freezed, microwaved and stored in a refrigerator.[209]

Transportation

Most pigs are raised in CAFOs on one site where they are bred and raised.[210] The pig products are transported from the farm to the processing plant and then distributed from there. They are most likely transported via refrigerated trucks because they must be kept at 85% humidity and, depending on the style of bacon, between the temperature ranges of 34-39 and 61-64 degrees Fahrenheit[211]

The headquarters of Fresh Mark Foods is: Fresh Mark, Inc 1735 S Lincoln Avenue Salem, OH 44460-4203, but it is unclear whether the bacon is processed or distributed from this location. For our estimations we assumed this location was the distribution center.

Emissions

Methane emissions from domesticated animals and animal wastes in the US are about 8,400,000 metric tons/yr, or about 30% of the total U.S. annual anthropogenic emissions. In 1988, there were about 55,300,000 swine (including all sizes and classes) in U.S. with estimated CH_4 emissions of about 1,100,000 metric tons/yr, primarily from their waste products.[212]

Scale

The average size of U.S. hog farm operations as of 2004 was 661 acres.[213] Advances in technology have allowed pig farmers to use less acreage while having more head per acre.[214]

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206 "Swine Feed and Nutrition." *EDIS - Electronic Data Information Source - UF/IFAS Extension*. n.d. Web. 25 Feb. 2011. <http://edis.ifas.ufl.edu/topic_swine_nutrition>.

207 Springer, Sandra . "Swine Production in the US." *University of Pennsylvania School of Veterinary Medicine*. n.d. Web. 25 Feb. 2011. <http://cal.vet.upenn.edu/projects/swine/prod/hm.html>.

208 Smith, K.A., D.R. Charles, and D. Moorhouse. "Nitrogen Excretion By Farm Livestock With Respect To Land Spreading Requirements And Controlling Nitrogen Losses To Ground And Surface Waters. Part 2: Pigs And Poultry." *Bioresource Technology* 71 (2000): 183-194. Print.

209 Gabriel Hoss. "How It's Made: Bacon,". *How It's Made*. Science Channel. Season 9, 12, Episode 116, 2007.

210 Springer, Sandra . "Swine Production in the US." *University of Pennsylvania School of Veterinary Medicine*. n.d. Web. 25 Feb. 2011. <http://cal.vet.upenn.edu/projects/swine/prod/hm.html>.

211 Ashby, B. Hunt. "Protecting Perishable Foods During Transport by Truck." *Transportation and Marketing Programs Handbook* 669 (2006): 1-100. Print.

212 Sharpe, R. R. "Methane Emissions From Swine Houses In North Carolina" *Chemosphere - Global Change Science* 3.1 (2001): 1-6. Print.

213 McBride, William D.,and Nigel Key. "Characterisitics and Production Costs of U.S. Hog Farms, 2004." *USDA Economic Research Service* 1 (2007): 1-41. Print.

214 McBride, William D. , and Nigel Key. "Characterisitics and Production Costs of U.S. Hog Farms, 2004." *USDA Economic Research Service* 1 (2007): 1-41. Print.

A 250-pound market hog yields about 150 pounds of pork.[215]

Toxicity Information

A variety of insecticides are used in swine production, some of which have been linked to cancer. Farmers who raise pigs have higher instances of rectal cancer and lymphosarcoma.[216] In addition, at least 11 different types of antibiotics are commonly mixed into pig feed. These compounds include various salts of bacitracin, chlortetracycline, dynafac, mycostatin, oxytetracycline, oleandomycin, penicillin, streptomycin, bambermycins, tilmicosin and tylosin.[217]

Biodiversity

Use of land used for raising pigs, especially by large CAFOs, limits the ability of plants and biodiversity to develop. The excessive amounts of nitrogen from pig manure also can limit plant growth on land and in water nearby.

Packaging

The bacon must be processed and packaged before it can be transported. Most bacon products are packaged in plastic and parchment paper wrappings and placed in 15 lb packages.[218] They must be kept refrigerated so as to prevent spoiling.

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[215] U.S. EPA, "Background of Pork Production in U.S. | Ag 101 | Agriculture | US EPA." *US Environmental Protection Agency*. 9 Oct. 2009. Web. 21 Feb. 2011.
[216] Stewart, Patricia Ann, Thomas Fears, Burton Kross, Linda Ogilvie, and Aaron Blair. "Exposure Of Farmers To Phosmet, A Swine Insecticide." *Scandanavian Journal of Work, Environment and Health* 25 (1999): 33-38. Print.
[217] Carlson, Marcia S. and Thomas J. Fangman. "G2353 Antibiotics and Other Additives for Swine: Food Safety Considerations | University of Missouri Extension." *University of Missouri Extension Home*. n.d. Web. 1 Apr. 2011. <http://extension.missouri.edu/publications/DisplayPub.aspx?P=G2353>
[218] Gabriel Hoss. "How It's Made: Bacon." *How It's Made*. Science Channel. Season 9, 12, Episode 116, 2007.

Bananas

In this report, we base our banana analysis on Chiquita bananas. AVI ordered 1,670 boxes of bananas in 2010, and each box contained 40 pounds of fruit. Bananas are served at all the dining halls, as well as the Emporium, El Table, and the Science Center café. They are not served at Collins Café or the Hoop. Wellesley dining services' orders account for essentially all the bananas served on campus.

We assume an average yield is the yield for bananas in Costa Rica as reported in 2002 in a paper by E.Serrano.[219] We choose Costa Rica because it is the largest banana exporter to the United States. E. Serrano reports the banana yield in Costa Rica in 2002 as 2,107 boxes per hectare. Each box holds 40 pounds of bananas, so this figure equates to 34,107 pounds per acre and 131,183 bananas per acre.

Serving Size

In our study we use the USDA serving size for bananas, which is one medium banana, which weights approximately 120 grams or 0.26 pounds.[220] There are approximately 150 bananas in one 40 pound box.

Farm Locations

In our report, we assume that of all the bananas served at Wellesley College, 25 percent are from Ecuador, 21 percent from Guatemala, 29 percent from Costa Rica, 13 percent from Columbia, 9 percent from Honduras, and 3 percent from Mexico, Nicaragua, and Panama combined. Because these countries are relatively small, we use the center of the country as the farm location from which bananas are transported to ports. Chiquita has operations in six continents, but most of its 23,000 employees are based in Central America. Chiquita's main sourcing locations are: Mexico, Guatemala, Honduras, Nicaragua, Costa Rica, Panama, Colombia, Equador,[221] the Philippines, and Ivory Coast.[222] According to FAO, bananas imported to the US originate almost entirely from Latin American countries, with imports from other parts of the world considered negligible. For this reason, we exclude the Philippines and Ivory Coast from our analysis. Central America is the largest supplier with a market share of 60 percent, and is almost exclusively in the hands of transnational corporations.[223] From 2000 to 2001, the US imported 25% of its bananas from Ecuador, 21% from Guatemala, 29% from Costa Rica, 13% from Columbia, 9% from Honduras, and 3% from other countries.[224] We base our calculations on these percentages.

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219 Serrano, Edgardo. "Relationship between Functional Root Content and Banana Yield in Costa Rica." *Musalit.inibap.org*. N.d. Web. 3 Mar. 2011. <http://musalit.inibap.org/pdf/IN050554_en.pdf>.
220 "Dietary Guidelines for Americans 2010." *USDA.gov*. N.d. Web. 20 Feb. 2011. <www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/PolicyDoc/PolicyDoc.pdf>.
221 " Where do Chiquita® Bananas Grow? Map of Banana Farms & Plantations." *Chiquita® Bananas*. N.d. Web. 20 Feb. 2011. <http://www.chiquitabananas.com/Banana-Information/find-banana-farm-map.aspx>.
222 "Our Experience of Partnerships: Methods, Risks and Benefits." *Chiquita® Bananas*. 16 Feb. 2003. Web. 20 Feb. 2011. <ftp://ftp.fao.org/paia/organicag/meet160203_4c.pdf>.
223 "The World Banana Economy, 1985-2002." *FAO*. N.d. Web. 20 Feb. 2011. <http://www.fao.org/docrep/007/y5102e/y5102e06.htm#bm06.3>.
224 "The World Banana Economy, 1985-2002." *FAO*. N.d. Web. 20 Feb. 2011. <http://www.fao.org/docrep/007/y5102e/y5102e06.htm#bm06.3>.

Fertilizer Use

We base our fertilizer calculations on figures from a paper by Noor-Un-Nisa Memon et al.[225] on banana fertilization practices around the world. This paper provides a range of fertilizer application rates; we assume that Chiquita uses the lowest rates in the paper because reducing agrochemical use is part of the company's mission. We assume that nitrogen fertilizer is applied at a rate of 250 kilograms of nitrogen per hectare per year, in four split applications. We assume that phosphorus is applied at a rate of 300 kilograms of P_2O_5 per hectare per year (130 kilograms of P per hectare per year). We assume that K_2O is applied at a rate of 100 kilograms per hectare per year.

Total nutrient uptake in bananas varies from 4 to 7 kilograms of nitrogen, 0.9 to 1.6 kilograms of P_2O_5, and 18 to 30 kilograms of K_2O per ton of whole bunches produced.[226]

Irrigation

Because most of the banana plantations we include in our analysis exist in regions with abundant year-round rainfall, we assume that no irrigation occurs during Chiquita banana farming. Because banana roots cannot be submerged in water, the lowlands that characterize the Caribbean coast of Central America (where banana plantations are heavily concentrated) must be drained using drainage canals to divert excess water from the fields. Streams must be diverted to prevent flooding during periods of high rain.[227]

Mechanization

Chiquita has adopted a zero-tolerance policy on deforestation and is actively reforesting land across Central America, so we do not include deforestation activities in our greenhouse gas emissions calculations. Bananas are harvested manually using a machete, so we ignore the harvesting process in our analysis because it has a relatively insignificant impact on the environment. We do not include the energy needed to run the overhead cableways to which freshly picked bananas are attached for transport to the packing shed.[228]

Processing

Because bananas are sold as whole fruits and relatively little energy and resources go into preparing bananas for sale, we assume that no energy is used during the "processing" step. Bananas are washed and packed manually.

Chiquita states that the harvest and packing process requires approximately 10 liters of water per kilo of bananas.[229]As part of its Rainforest Alliance certification, Chiquita has taken steps to reforest and protect the banks of natural waterways. It also monitors the quality of water

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[225] Memon, Noor-un-nisa, et al. "Status and Response to Improved NPL Fertilization Practices in Banana." *Pakbs.org*. Version 42 (4). Pak. J. Bot., n.d. Web. 21 Feb. 2011. <www.pakbs.org/pjbot/PDFs/42%284%29/PJB42%284%292369.pdf>.

[226] Memon, Noor-un-nisa, et al. "Status and Response to Improved NPL Fertilization Practices in Banana." *Pakbs.org*. Version 42 (4). Pak. J. Bot., n.d. Web. 21 Feb. 2011. <www.pakbs.org/pjbot/PDFs/42%284%29/PJB42%284%292369.pdf>.

[227] McCracken, Carrie. "Banana Plantations in Central America." *Tripod.com*. N.d. Web. 20 Feb. 2011. <http://members.tripod.com/foro_emaus/BanPlantsCA.htm>.

[228] "Banana." *UNCTAD.ORG*. N.d. Web. 21 Feb. 2011. <http://www.unctad.org/infocomm /anglais/banana/crop.htm>.

[229] "2008 Corporate Social Responsibility Report." *Chiquitabrands.com*. N.d. Web. 21 Feb. 2011. <www.chiquitabrands.com/content/corpres/AR%20reports/2007-2008-CRReport.pdf>.

in nearby streams and rivers.[230] At its packing plants, Chiquita has reduced water use by 80 percent by installing water filtration and recycling systems.[231]

Transportation

We assume that the fuel efficiency of Chiquita tractor trailers is 5.9 miles per gallon. This figure is based on the company's 2008 Corporate Social Responsibility report. The report states that the company's current tractor trailer fuel efficiency was 5.5 miles per gallon. In the report, the company outlined its plans to shift towards Single Wide Tires, idle reduction, and using Freight Wings, which together would achieve a fuel efficiency of 6.4 miles per gallon.[232] Information about the company's fuel efficiency in 2011 is not readily available, so we assume that the company has progressed halfway towards its goal of 6.4 miles per gallon since 2008.

We include greenhouse gas emissions from trucks shipping bananas from packing shed to port, ships transporting bananas from Central American port to US port, and trucks transporting bananas from US port to Wellesley College. We ignore the transportation from the US port to banana ripening rooms because we assume it is en route to the college.

We assume that bananas are transported by tractor trailer from banana farms to three ports: Port Barrios, Guatemala; Port Limon, Costa Rica; and Port Cortes, Honduras. We assume that the distance bananas travel from farm to port is equal to the distance from the center of country to nearest port. We use this distance because some banana plantations are close to ports while others are farther away, so using the middle distance will be close to an average distance. We use Google Map Directions[233] to obtain the distances travelled. By typing in the name of the country in the "To" box, Google automatically calculates the "To" location as the center of the country (ex. From: Costa Rica; To: Port Limon, Limon, Costa Rica).

Chiquita uses Great White Fleet Commercial Shipping to ship bananas from Central America to US ports.[234] Based on the shipping schedule provided on Great White Fleet's website,[235] we assume that the bananas AVI orders are shipped from ports in Guatemala, Costa Rica, and Honduras to Port of Wilmington, Delaware. The ship is refrigerated (temperature kept at 57 degrees Fahrenheit[236]) but we do not include refrigeration-related greenhouse gas emissions in our calculations.

From the Port of Wilmington, we assume that bananas are transported to Wellesley College via tractor trailer. We assume the truck travels along the route provided by Google Map Directions (From: Port of Wilmington, Wilmington, DE; To: Wellesley College, 106 Central Street, Wellesley, MA 02481).

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[230] "Being Green." *Chiquita.com*. N.d. Web. 20 Feb. 2011. <http://www.chiquita.com/#/BeingGreen>.
[231] "Chiquita Reaps a Better Banana." *Rainforest Alliance*. N.d. Web. 20 Feb. 2011. <www.rainforest-alliance.org/sites/default/files/publication/pdf/chiquita_profile_en_hz_jan09.pdf>.
[232] "2008 Corporate Social Responsibility Report." *Chiquitabrands.com*. N.d. Web. 21 Feb. 2011. <www.chiquitabrands.com/content/corpres/AR%20reports/2007-2008-CRReport.pdf>.
[233] "Get Directions." *Google Maps*. N.d. Web. 20 Feb. 2011. <http://maps.google.com/>.
[234] " About GWF." *Great White Fleet*. N.d. Web. 21 Feb. 2011. <http://www.greatwhitefleet.com/liner/About/AboutGWF.asp>.
[235] "Sailing Schedule." *Great White Fleet*. N.d. Web. 21 Feb. 2011. <http://www.greatwhitefleet.com/liner/Applications/SailingSchedule/SailingSchedule.asp>.
[236] "Banana." *UNCTAD.ORG*. N.d. Web. 21 Feb. 2011. <http://www.unctad.org/infocomm /anglais/banana/crop.htm>.

Toxicity Information

Chiquita uses Integrative Pest Management (IPM) methods on its company-owned farms in Latin America, which make up over 80 percent its banana suppliers.[237] In 1996, it was estimated that approximately 30 kilograms/hectare/year of pesticides were applied to Central American banana plantations (ten times the average amount used on US agricultural crops),[238] but Chiquita has made radical changes since 2000 to reduce its chemical use. Once they arrive in the US, bananas are sent to banana ripening rooms where they are ripened using ethylene gas.[239]

While banana growers in Central America have historically applied agrochemicals at application rates significantly higher than US farmers, Chiquita's toxicity impact has lessened drastically since all of its company-owned farms in Latin America became Rainforest Alliance certified in 2000. According to the Chiquita's Rainforest Alliance profile, Chiquita has "stopped using agrochemicals that pose risks to workers and aquatic life; and switched to low-toxicity alternatives to fungicides." It is also investigating the possibility of using biological controls to lessen the amount of toxic fungicides its workers must use.[240]

"Dirty Dozen" pesticides Paraquat and Parathion are among the most common pesticides used on banana plantations,[241] but Chiquita no longer uses "Dirty Dozen" pesticides on its company-owned farms in Central America as part of its Rainforest Alliance certification.[242] Despite these improvements, Chiquita bananas are by no means "organic" and are still grown with harmful pesticides. Not all of Chiquita's bananas come from company-owned farms; 20 percent of the company's suppliers are independent farmers who are not Rainforest Alliance certified[243] and may be using more toxic chemicals at higher application rates. All of Chiquita's banana suppliers still use highly toxic nematicides[244] such as Aldicarb,[245] a nematicide that the EPA just banned in the US in 2010.[246] Nematicides are applied directly to the soil around the base of the tree, most likely using manually-operated applicators. Chiquita applies fungicide in the lowest category of toxicity aerially,[247] up to 50 times per annual growth cycle.[248]

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237 "2008 Corporate Social Responsibility Report." *Chiquitabrands.com*. N.d. Web. 21 Feb. 2011. <www.chiquitabrands.com/content/corpres/AR%20reports/2007-2008-CRReport.pdf>.
238 McCracken, Carrie. "Banana Plantations in Central America." *Tripod.com*. N.d. Web. 20 Feb. 2011. <http://members.tripod.com/foro_emaus/BanPlantsCA.htm>.
239 "Banana." *UNCTAD.ORG*. N.d. Web. 21 Feb. 2011. <http://www.unctad.org/infocomm /anglais/banana/crop.htm>.
240 "Chiquita Reaps a Better Banana." *Rainforest Alliance*. N.d. Web. 20 Feb. 2011. <www.rainforest-alliance.org/sites/default/files/publication/pdf/chiquita_profile_en_hz_jan09.pdf>.
241 McCracken, Carrie. "Banana Plantations in Central America." *Tripod.com*. N.d. Web. 20 Feb. 2011. <http://members.tripod.com/foro_emaus/BanPlantsCA.htm>.
242 "Chiquita Reaps a Better Banana." *Rainforest Alliance*. N.d. Web. 20 Feb. 2011. <www.rainforest-alliance.org/sites/default/files/publication/pdf/chiquita_profile_en_hz_jan09.pdf>.
243 "2008 Corporate Social Responsibility Report." *Chiquitabrands.com*. N.d. Web. 21 Feb. 2011. <www.chiquitabrands.com/content/corpres/AR%20reports/2007-2008-CRReport.pdf>.
244 "2008 Corporate Social Responsibility Report." *Chiquitabrands.com*. N.d. Web. 21 Feb. 2011. <www.chiquitabrands.com/content/corpres/AR%20reports/2007-2008-CRReport.pdf>.
245 Mulcahy, Mark. "The Case for Buying Organic Bananas." *Rawfoodinfo.com*. N.d. Web. 20 Feb. 2011. <http://www.rawfoodinfo.com/articles/art_bananaspestic.html>.
246 "Aldicarb | Pesticides | US EPA." *US Environmental Protection Agency*. N.d. Web. 20 Feb. 2011. <http://www.epa.gov/oppsrrd1/reregistration/aldicarb/>.
247 "2008 Corporate Social Responsibility Report." *Chiquitabrands.com*. N.d. Web. 21 Feb. 2011. <www.chiquitabrands.com/content/corpres/AR%20reports/2007-2008-CRReport.pdf>.
248 McCracken, Carrie. "Banana Plantations in Central America." *Tripod.com*. N.d. Web. 20 Feb. 2011. <http://members.tripod.com/foro_emaus/BanPlantsCA.htm>.

Additionally, the plastic bags that growers place on banana bunches to protect the fruit from insect damage are coated in insecticides such as Chlorpyrifos.[249]

Biodiversity

As part of the company's effort to reduce herbicide use, 30 percent of Chiquita banana farms have achieved effective ground cover with the plant *Geophila repens.*[250] Banana plantations in Central America tend not to have other plant species growing along with the banana trees. Land preparation for a new banana plantation typically involves complete deforestation of tropical lowland forests. Herbicides are applied specifically to keep the ground free of any vegetation.[251] As part of Chiquita's Rainforest Alliance certification, the company has planted cover crops in all drainage ditches.

Chiquita has also reforested approximately 2,470 acres of land in the form of buffer zones, set aside 2,125 acres of forest for regeneration, and adopted a zero-tolerance policy on deforestation.[252] It prohibits hunting and fishing in endangered species zones, and protects existing forests, wetlands, and lagoons.[253]

Packaging and Waste

Sources of waste associated with the banana industry include polyethylene growing bags and cardboard shipping boxes. Chiquita bananas are shipped in cardboard boxes that hold 40 pounds. Chiquita now recycles or reuses the majority of plastic bags used in banana production.

Banana bunches are covered in plastic bags coated with insecticides to protect the fruit from insects and sun while it is maturing.[254] Disposal of these bags is often a problem at Central American banana plantations. They are commonly disposed of in open-air dumps, but the wind easily picks them up and blows them across the surrounding land. They often end up in local streams or even the ocean, where they may suffocate sea turtles and pollute the water.

Now that Chiquita is working with the Rainforest Alliance, it recycles or reuses almost 80 percent of the plastic bags and twine used on company farms.[255] Chiquita has also installed solid waste traps in packaging facilities to prevent fruit pieces from entering waterways, fortified chemical warehouses, and installed on-farm composting trenches for banana leaves and stems. It also gives bruised bananas to local farmers to use as cattle feed. It now recycles or reuses all plastics, which amounts to 3,000 tons of plastic per year.[256]

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[249] McCracken, Carrie. "Banana Plantations in Central America." *Tripod.com*. N.d. Web. 20 Feb. 2011. <http://members.tripod.com/foro_emaus/BanPlantsCA.htm>.

[250] "2008 Corporate Social Responsibility Report." *Chiquitabrands.com*. N.d. Web. 21 Feb. 2011. <www.chiquitabrands.com/content/corpres/AR%20reports/2007-2008-CRReport.pdf>.

[251] McCracken, Carrie. "Banana Plantations in Central America." *Tripod.com*. N.d. Web. 20 Feb. 2011. <http://members.tripod.com/foro_emaus/BanPlantsCA.htm>.

[252] "Chiquita Reaps a Better Banana." *Rainforest Alliance*. N.d. Web. 20 Feb. 2011. <www.rainforest-alliance.org/sites/default/files/publication/pdf/chiquita_profile_en_hz_jan09.pdf>.

[253] "Being Green." *Chiquita.com*. N.d. Web. 20 Feb. 2011. <http://www.chiquita.com/#/BeingGreen>.

[254] McCracken, Carrie. "Banana Plantations in Central America." *Tripod.com*. N.d. Web. 20 Feb. 2011. <http://members.tripod.com/foro_emaus/BanPlantsCA.htm>.

[255] "Chiquita Reaps a Better Banana." *Rainforest Alliance*. N.d. Web. 20 Feb. 2011. <www.rainforest-alliance.org/sites/default/files/publication/pdf/chiquita_profile_en_hz_jan09.pdf>.

[256] "Being Green." *Chiquita.com*. N.d. Web. 20 Feb. 2011. <http://www.chiquita.com/#/BeingGreen>.

Beef

We focus on ground beef produced by Green Bay Dressed Beef (GBDB), a manufacturing plant owned by American Foods Group. American Foods Group runs a business through its nine subsidiary companies, which together operate five beef harvesting and processing plants, two ground beef plants, and three case-ready processing plants. The company has locations across Wisconsin, Nebraska, South Dakota, Minnesota, and Ohio. It is the fifth-largest beef processing company in the United States.[257]

In 2010, dining services ordered 3,360 pounds of bulk ground beef from GBDB. The college purchases hundreds of beef products every year, but we choose to concentrate on ground beef because it is a main ingredient in other beef products, including hamburger patties and meatballs. Wellesley also purchases large amounts of beef cuts and franks, but these vary in brand and manufacturing procedures, making it difficult to analyze their environmental impact. Many of the foods served by dining services contain beef-derived products such as soup bases, sausages, and other blended meat foodstuffs, but we eliminate these from our analysis because they are processed differently from 100 percent beef products.

Serving Size

The United States Department of Agriculture (USDA) recommends a 3-ounce serving size of beef.[258] The daily recommendation for a 2,000-calorie diet is about 5 ½ ounces. In 2010, we purchased 17,920 servings of ground beef from GBDB.

Farm Locations

GBDB is a ground beef processing plant located in Green Bay, Wisconsin. American Foods Group has multiple locations in the Midwest where the cattle are raised and slaughtered. American Foods Group's main harvesting and fabricating plants are:

- Long Prairie Packing, Long Prairie, MN
- Dakota Premium Foods, South St. Paul, MN
- Cimpls Inc., Yankton, SD
- Gibbon Packing, Gibbon, NE [259]

It is likely that the cows are raised on a feedlot in Minnesota, South Dakota, or Nebraska, before being trucked in a padded trailer to one of the harvesting plants above. After slaughter, the beef is most likely shipped via refrigerated truck to the ground beef processing plant located at 544 Acme Street, Green Bay, Wisconsin. Figure 20 shows American Foods Group's eleven locations for farming, processing and packing, grinding, packaging, and other specialty treatments such as curing.

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[257] "Fresh Meats." *American Foods Group*. American Foods Group, LLC, n.d. Web. 20 Feb. 2011. <http://www.americanfoodsgroup.com/page.asp?pageid=12>.

[258] US Department of Agriculture. "Beef, Ground, Frozen." *Household Community Fact Sheet*. US Department of Agriculture, n.d. Web. 23 Feb. 2011. <www.fns.usda.gov/fdd/facts/hhpfacts/New_HHPFacts/Meats/HHFS_BEEF_GROUND_A609_Final.pdf>

[259] "American Foods Group Careers." *American Foods Group*. n.d. Web. 25 Feb. 2011. <http://www.americanfoodsgroup.com/page.asp?pageid=3>.

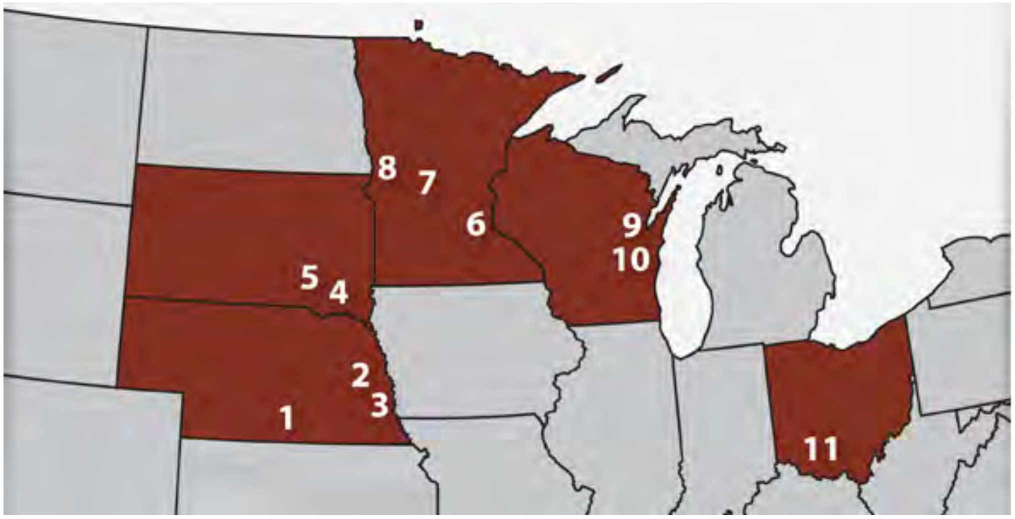

Figure 20: American Foods' Group locations[260]

Fertilizer Use

For this analysis, we focus on environmental impacts of corn in cattle feed, since it makes up the majority of the mixed-ration feed supplied to beef cattle. The average fertilizer consumption of corn in the corn-belt is 170 kg/ha of nitrogen, 84 kg/ha of P2O5, 78 kg/ha of K2O in the eastern part of the country.[261]

Animal Feed

The cattle are raised on large feedlots, usually consuming a mixture of grains, grass, and protein. Corn is the most predominant feed ingredient, with about 80 percent of the country's corn going towards the meat industry.[262] Corn silage is one of the most common ingredients in feedlots, followed by high moisture corn, dry corn, and corn gluten.[263] The grain products are mixed with raw protein, making the cows gain approximately two pounds per day. The cows are slaughtered around three years of age.

Water

Beef production is a water-intensive process, requiring water for irrigation of feedlots, drinking, and servicing. A cow slaughtered at three years old produces roughly 450 pounds of meat, but in its lifetime consumes 2,800 pounds of grains, 15,800 pounds of roughages, and 8,000 gallons of water for drinking and servicing.[264] Producing the necessary volume of feed requires about 4,000 gallons of water for every two pounds of beef, or 800,000 gallons per cow.

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260 "American Foods Group Careers." *American Foods Group*. n.d. Web. 25 Feb. 2011. <http://www.americanfoodsgroup.com/page.asp?pageid=3>.

261 "Maize / Corn: Fertilizer Best Management Practices - Crop Nutrition." *Crop Data,* Web. 25 Feb. 2011. <http://cropnutrition.wikidot.com/maize-corn>.

262 US Environmental Protection Agency. "Major Crops Grown in the United States." *US Environmental Protection Agency*. n.d. Web. 25 Feb. 2011. <http://www.epa.gov/oecaagct/ag101/cropmajor.html>.

263 Martin, Dennis. "Typical Beef Feedlot and Background Diets." *Ontario Ministry of Agriculture Food and Rural Affairs*. Government of Ontario, n.d. Web. 24 Feb. 2011. <http://www.omafra.gov.on.ca/english/livestock/beef/facts/06-017.htm>.

264 Water Footprint Network. "Water Footprint of Beef." *Water Footprint*. n.d. Web. 24 Feb. 2011. <http://www.waterfootprint.org/?page=files/productgallery&product=beef>.

Greenhouse Gas Emissions

The cattle industry is one of the largest factors contributing to global climate change, mainly through methane emissions. In the United States, cattle emit about 5.5 million tons of methane per year into the atmosphere, accounting for 20 percent of the country's total methane emissions.[265] Ruminant animals digest their food through a process called enteric fermentation that produces methane gas. The EPA estimates that cattle emit 80 to 110 kilograms of methane per cow per year. In our calculations we assume that one cow being raised for beef emits 95 kilograms of methane per year, or 285 kilograms of methane over its lifetime (assuming a lifetime of three years).[266] Manure management is also a major contributor to climate change. Farms that collect liquid animal waste in holding tanks or lagoons create significant methane emissions, but farms that spread dry manure on fields and pastures minimize methane.[267] GBDB's large size suggests that it uses feedlots rather than open pastures, and therefore probably does not spread manure as fertilizer on fields.

Processing

Ground beef production is a highly mechanized process, requiring energy-intensive machinery throughout the whole process. The mechanization begins on the kill floor, continuing through the grinding process, pasteurization for food safety, and on through packaging and labeling. Humans play a very small role in actual ground beef production; the total mechanization increases carbon emissions in the atmosphere. On average, beef cattle have a 62 percent average dressing percentage (the percent of the live animal that becomes carcass).[268] Disposal of the animal waste that is produced during processing is heavily regulated by the USDA.

Transportation

Since GBDB is located in Wisconsin, the beef travels far to get to Wellesley. The cow is most likely raised somewhere in Minnesota, South Dakota, or Nebraska. From the farm, the cows are transported by truck to the plant for slaughter. After slaughter, the raw meat is taken by refrigerated truck to Green Bay, Wisconsin, where it is run through a grinder and packaged. From there, it is transported to our main food supplier in Boston, then to Wellesley in a refrigerated truck.

Scale

American Foods Group is the fifth-largest beef processing company in the United States, shipping over 4 million pounds of beef a day and employing over 4,000 employees.[269] Given

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265 S Environmental Protection Agency. "Ruminant Livestock - Frequent Questions." *US Environmental Protection Agency*. 21 Mar. 2007. Web. 24 Feb. 2011. <http://www.epa.gov/rlep/faq.html>.
266 "Ruminant Livestock - Frequent Questions." *US Environmental Protection Agency*. 21 Mar. 2007. Web. 4 Mar. 2011. <http://www.epa.gov/rlep/faq.html>.
267 US Environmental Protection Agency. "Methane: Sources and Emissions." *US Environmental Protection Agency*. n.d. Web. 25 Feb. 2011. <http://www.epa.gov/methane/sources.html>.
268 Cornell Cooperative Extension. "Yields and Dressing Percentages." *Small Farms Program*. Cornell University, n.d. Web. 24 Feb. 2011. <http://www.smallfarms.cornell.edu/pdfs/Livestock%20Processing%20Guide/Yields%20and%20Dressing%20Percentages.pdf>.
269 "Fresh Meats." *American Foods Group*. American Foods Group, LLC, n.d. Web. 20 Feb. 2011. <http://www.americanfoodsgroup.com/page.asp?pageid=12>.

that Wisconsin ranks ninth in the country in terms of cattle quantity, it is safe to assume that GBDB is operating on a large, industrial-level processing scale.[270]

Animal Welfare

The size of GBDB suggests that the company probably uses concentrated animal feed operations (CAFOs) for its cattle farms. American Foods Group's website does not contain any information or statements on animal welfare, so we assume that it uses CAFOs, which are more efficient than feeding systems. However, CAFOs do not animal welfare into account, deeming the operations inhumane.

Labor

In February 2011, Green Bay Dressed Beef settled a gender discrimination case with the U.S. Department of Labor for $1.65 million.[271] The settlement followed an investigation by the Department of Labor's Office of Federal Contract Compliance Programs, which found that 970 female applicants had been rejected from general labor positions at the Green Bay plant in 2006 and 2007. In addition to the $1.65 million paid to the women, the company will extend 248 employment offers to women from the original class.

[270] US Department of Agriculture. "2007 Census of Agriculture State Profile: Wisconsin." *National Agricultural Statistics Service*. US Department of Agriculture, n.d. Web. 24 Feb. 2011. <www.agcensus.usda.gov/Publications/2007/Online_Highlights/County_Profiles/Wisconsin/cp99055.pdf>.

[271] "OFCCP News Release: US Labor Department settles gender discrimination case with Green Bay Dressed Beef on behalf of 970 female applicants for $1.65 million." *U.S. Department of Labor*. 3 Feb. 2011. Web. 5 Feb. 2011. <http://www.dol.gov/opa/media/press/ofccp/OFCCP20110146.htm>.

Bottled Water

We decided to examine the college's purchases of bottled water because of the volume that we purchase (at least 40,000 bottles annually) and the popular understanding that bottled water harms the environment more than tap water. Upon further examination, we found that the college purchases the vast majority of its bottled water from Crystal Geyser (over 38,000 bottles) and the second most from Poland Springs. The college tended to purchase flavored, sparkling water from Poland Springs and bulk water purchases (312 gallons of mineral water). However, the type of bottled water we are most concerned with evaluating is that serving as a substitute for tap water, which is single-serve mineral water. Ultimately, we present an examination for only Crystal Geyser's Alpine Spring Water, Flat Top because this item constitutes virtually the entire purchase made by the college.

Serving Size

Crystal Geyser generally accepts that one serving of bottled water is 8 fluid oz, or one cup.[272] This measurement is consistent with other bottled water companies like Poland Spring, but the USDA offers no standard serving size information for water. Alpine Spring Water, Flat Top comes in 16.9 oz containers, meaning that one individual bottle contains 2.1 servings of water.

Origins

Crystal Geyser mineral water is sourced from four different springs within the United States: Mt. Shasta and Olancha Peak in California; the Cherokee National Forest of Tennessee; Moultonborough, New Hampshire; and the Blue Ridge Mountains in South Carolina.[273] Of these sources, the plant at Mt. Shasta reportedly only serves exports to the west coast of the United States and Japan. Given that Crystal Geyser reports that Black Springs also serves regional customers, the most likely plant that serves Wellesley College is Moultonborough in New Hampshire. The Moultonborough plant is located on 5,200 acres in the Ossippee Mountains.

General Information

Crystal Geyser uses two types of filtration before bottling the extracted spring water: ozonation and 0.1 micron filtration. As a result of these stringent filtration processes – only one is required in the United States – Crystal Geyser is the only US bottled water brand authorized to sell in the France.[274] The quality of the water is regularly tested to ensure that it meets standards set by the US Food and Drug Administration. In the most recent examination, almost no contaminants were detected in the water, and all trace amounts detected were in compliance with FDA and EPA standards.[275]

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[272] "Calorie Counter, Calorie Tracker & Food Journal." *LiveStrong*. N.d. Web. 21 Feb. 2011. <http://www.livestrong.com/thedailyplate/nutrition-calories/food/crystal-geyser/://>.
[273] "Sources." *Crystal Geyser Alpine Spring Water*. N.d. Web. 21 Feb. 2011. <http://www.crystalgeyserasw.com/sources/index.php>.
[274] "Water Quality." *Crystal Geyser Alpine Spring Water*. N..d. Web. 25 Feb. 2011. <http://www.crystalgeyserasw.com/quality/
[275] "Analysis Report 2010: Moultonborough Plant." *Crystal Geyser*. N.d. Web. 2 Apr. 2011. <www.crystalgeyserasw.com/docs/Bottled_Water_Report_Moultonborough.pdf>.

Fertilizer

No fertilizer is used in the processing of this product (see Table 33).

Table 33: Fertilizer application in bottled water production

Units	Lbs fertilizer/serving	Grade
Bottled water	n/a	A

Water

Crystal Geyser water is sourced from 100% spring water. According to Dettore's life-cycle assessment, just less than 500 ml of water is used in the production, bottling, transportation and power production of one 500 ml bottle, not including the spring water contained within the bottle.[276] This number varies among bottling plants, and we determine that Dettore's assessment underestimated the water volume commonly used in bottle production. Still, only one gallon of water is required on average to produce one 8 oz serving of bottled water, making it one of the least water-intensive food items we analyzed.

Processing

Dettore demonstrated that container production is the largest contributor to the net energy consumption of bottled water, amounting to 1.83 MJ for a virgin PET bottle and approximately 75% of the total energy expenditure. The second largest consumer is distribution from bottling facility to kitchen. Finally, bottling and consumer transport make up approximately 5% of energy consumption. Our analysis agrees with Dettore's assessment, with the largest proportion of greenhouse gas emissions coming from processing, including water filtration and bottle production. As a result, bottled water receives a C Grade on the climate change metric.

Transportation

The Moultonborough bottling plant from which Wellesley sources its bottled water is located approximately 130 miles away from Wellesley. The finished bottled product is trucked to its final destinations in a single-unit diesel truck.[277]

Table 34: Greenhouse gas emissions from all stages of bottled water production

Units (g CE)	Transportation	Processing	Farming processes	Methane	TOTAL	Grade
Bottled water	2.100	22.26	0	0	24.36	C

Packaging

Flat Top spring water travels in 35-bottle packs in 16.9 oz bottles. Packs of 35 or 28 are contained in shrink-wrapped plastic with a tray of 100% recycled cardboard.[278] The 500 ml

[276] Dettore, Christopher. "Comparative Life-Cycle Assessment of Bottled vs. Tap Water Systems." *Center for Sustainable Systems* Report No. CSS09-11 (2009): 1-110. Print.
[277] Dettore, Christopher. "Comparative Life-Cycle Assessment of Bottled vs. Tap Water Systems." *Center for Sustainable Systems* Report No. CSS09-11 (2009): 1-110. Print.
[278] "Water Quality." *Crystal Geyser Alpine Spring Water*. N.d. Web. 25 Feb. 2011. <http://www.crystalgeyserasw.com/quality/>.

Crystal Geyser bottle leads the industry in containing only 10 grams of PET plastic– polyethylene terephthalate – reducing the normal PET amount by 25%. PET is the most commonly used plastic found in bottled drinks today, and is also ubiquitous in the textile industry under the name polyester. Based on this figure, 16.9 oz bottles contain approximately 10 grams of PET. Crystal Geyser does not indicate that it uses recycled material to produce its bottles, meaning that all PET used is virgin.

The Crystal Geyser Flat Top product differs mainly from its alternative, simply known as Alpine Spring Water, in its packaging contents. The FT product is designated as “flat top” in order to distinguish itself from the “sport” alternative model available for 500 ml bottles.

Biodiversity

Crystal Geyser conserves tracts of land surrounding each spring source in order to provide additional protection for the water it withdraws to bottle. In this way, Crystal Geyser helps to preserve the rich biodiversity in the California Floristic Province, home to the Giant Sequoia and California Redwood.[279]

Toxicity

All bottles produced by Crystal Geyser contain zero bisphenol A (BPA). In recent years, BPA has come under scrutiny for its estrogenic properties, and has been linked with cancer, abnormal fetal development, and obesity. Canada became the first country to declare BPA a toxic substance in 2010, and the European Union and Canada now ban its use in baby bottles.[280]

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[279] Conservation International. "California Floristic Province." *Biodiversity Hotspots*. N.d. Web. 1 Apr. 2011. <http://www.biodiversityhotspots.org/xp/hotspots/california_floristic/Pages/default.aspx>.
[280] von Reppert-Bismarck, Juliane. "EU to ban Bisphenol A in baby bottles in 2011 | Reuters ." *Reuters*. N.p., n.d. Web. 2 Apr. 2011. <http://www.reuters.com/article/idUSTRE6AO3MS20101125>.

Brown Rice

In this report, we base our brown rice LCA on Uncle Ben's Whole Grain Brown Rice (UB-BR). Dining services ordered 5,125 lbs of UB-BR in 2010, and this item ranks 24th out of 2825 on the list of 2010 foodstuff purchases by total cost. Dining services also orders brown rice from Riceland Food, but this rice was not included in our analysis because the Riceland Food purchases are relatively insignificant; we purchase 23 times as much UB-BR as we do Riceland Food's brown rice. The college also purchases other rice varieties such as basmati, white, and wild, but brown rice is by far the biggest purchase by both price and weight. It is possible that there is a significant difference in the environmental impact of UB-BR and that of Riceland Food's brown rice or other types of rice that dining services orders, but evaluating multiple rice brands is beyond the scope of this project.

The only dining facilities on campus that serve brown rice are the dining halls. El Table and the Hoop do not serve brown rice, and neither Collins Café nor the Science Center café serve brown rice as part of their regular menu. Brown rice is not grown locally, so it is unlikely that AVI purchases brown rice from a provider other than Uncle Ben's or Riceland Food.

The USDA reports that in the 2008/9 harvest, the total US rice harvest was 8,000 metric tons, harvested over 1,204 hectares.[281] We use this data to calculate UB-BR yield. The USDA figures equate to 5929 pounds per acre and 57,220 servings per acre.

Serving size

The serving size of UB-BR is 1/4 cup dry (47 grams or 0.1 lbs dry, or about one cup cooked). According to the nutrition facts on the UB-BR box, there are 19 servings of dry rice per two pound bag.[282] AVI purchased 5,125 pounds of UB-BR in 2010, which amounts to 48,688 servings.

Farm locations

The brown rice analyzed in this report includes rice grown in Grand Prairie counties of Arkansas and Missouri, Mississippi River Delta counties of Arkansas and Mississippi, the Bayou Prairies of Louisiana, the North Gulf Coast of Texas, and California's Sacramento Valley. We use national statistics in our calculations because these regions make up all the rice production regions in the country.

Information about the farm locations for Uncle Ben's domestically-sold rice is not readily available. Therefore the farm locations used in our analysis are estimated based on general information about rice production and trade. Because only 5 to 6 percent of total rice production is traded internationally,[283] we assume Uncle Ben's rice is grown in the US. The UB-BR the college purchases is long grain parboiled brown rice.[284] Long grain rice is grown almost

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281 "U.S. Grains Supply and Distribution: Wheat, Corn, Sorghum, Barley, Oats, Rye, and Rice." *USDA Foreign Agricultural Service (FAS)*. n.d. Web. 30 Mar. 2011. <http://www.fas.usda.gov/psdonline/psdReport.aspx?hidReportRetrievalName=U.S. Grains Supply and Distribution: Wheat, Corn, Sorghum, Barley, Oats, Rye, and Rice &hidReportRetrievalID=873&hidReportRetrievalTemplateID=13>.

282 "Instant & Long Grain Rice Recipes - Wild, White, & Brown Rice Recipes - Healthy Meal Solutions ." *UncleBens.com*. n.d. Web. 19 Feb. 2011. <http://www.unclebens.com/rice/natural-brown-rice.aspx>.

283 "Rice." *UNCTAD.ORG*. n.d. Web. 19 Feb. 2011. <http://www.unctad.org/infocomm/anglais/rice/market.htm>.

284 Instant & Long Grain Rice Recipes - Wild, White, & Brown Rice Recipes - Healthy Meal Solutions ." *UncleBens.com*. n.d. Web. 19 Feb. 2011. <http://www.unclebens.com/rice/natural-brown-rice.aspx>.

exclusively in the South and accounts for more than 70 percent of U.S. production.[285] Using USDA data on the area of long grain rice planted and harvested by state in 2010, we estimate the percent of UB-BR that is grown in each of the rice-growing states in each region. We use the percentages shown in Table 35 in the calculations for our LCA.

Table 35: Long grain rice- area and percent planted and harvested by state and United States, 2010

State	Region	Area (1,000 acres)[286]	% of US
AR	Grand Prairie Counties (Non-Delta); Mississippi	1,260	55
MS	Mississippi River Delta	245	11
LA	Gulf Coast (Bayou Prairies)	415	18
TX	Gulf Coast (North Gulf Coast of TX)	166	7
MO	Grand Prairie Counties (Non-Delta)	199	9
CA*	Sacramento Valley	5	0.2
US		2,290	

Fertilizer Use

Information about fertilizer use on rice crops in the US is provided in

[285] "ERS/USDA Briefing Room - Rice: Background." *USDA Economic Research Service*. n.d. Web. 19 Feb. 2011. <http://www.ers.usda.gov/Briefing/Rice/background.htm>.
[286] "Acreage." *National Agricultural Statistics Service (NASS)*. N.p., 30 June 2010. Web. 19 Feb. 2011. <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1000>.

Table 36.

Table 36: Brown rice fertilizer use[287]

Measurement	Units	Estimate	RSE[288]
Planted acres	1,000 Acres	2,838.20	0
Treated with manure	Percent of planted acres	1.985*	45.4
Ever treated with lime	Percent of planted acres	8.371	20.1
Treated with chemical fertilizer and manure	Percent of planted acres	1.130*	41.6
Nitrogen inhibitor used	Percent of planted acres	21.379	9.4
Soil tested for N,P2O5,K2O	Percent of planted acres	35.162	6.6
Soil tested for N	Percent of planted acres	26.39	8.5
Plant tissue test used	Percent of planted acres	7.472	21.6
Acres treated with N	Percent of planted acres	97.105	1.4
Acres treated with P2O5	Percent of planted acres	67.531	3.9
Acres treated with K2O	Percent of planted acres	54.462	4.2
N applied	Pounds per treated acre	186.393	2.8
P2O5 applied	Pounds per treated acre	53.351	2.7
K2O applied	Pounds per treated acre	65.246	2.9

* - The estimate is statistically unreliable due to the combination of a low sample size and high sampling error.

Irrigation

Table 37includes information about U.S. rice farm water use, water sources, and irrigation technology. All U.S. rice is produced in irrigated fields. We assume that the pumping rate for rice crop irrigation is 20 gallons per minute per acre, the average recommended pumping rate for rice crops given by the University of Arkansas Division of Agriculture.[289]

Table 37: Brown rice irrigation technology and water use[290]

Measurement	Units	Estimate	RSE [291]
Planted acres	1,000 Acres	2,838.33	0
Irrigated acres	1,000 Acres	2,838.33	0
Surface water source	Percent of irrigated acres	27.563	5.7
Ground water source	Percent of irrigated acres	69.786	2.7
Water applied per irrigated acre	Inches	30.031	4

[287] "ERS/USDA Data - ARMS Farm Financial and Crop Production Practices 2006." *USDA Economic Research Service*. 2006. Web. 26 Mar. 2011. <http://www.ers.usda.gov/Data/ARMS/CropOverview.htm>.
[288] The Relative Standard Error (RSE) is the standard error of the estimate expressed as a percent of the estimate. The larger the RSE, the less precise the estimate.
[289] "Rice Irrigation - Soil and Water Management." *Arkansas Agriculture*. n.d. Web. 20 Feb. 2011. <http://www.aragriculture.org/soil_water/irrigation/crop/Rice/default.htm>.
[290] "ERS/USDA Data - ARMS Farm Financial and Crop Production Practices 2006."
[291] The Relative Standard Error (RSE) is the standard error of the estimate expressed as a percent of the estimate. The larger the RSE, the less precise the estimate.

Methane

Rice agriculture is one of the largest sources of anthropogenic methane in the atmosphere. Methanogenesis rates are highest when rice paddy soil is fully waterlogged, which only occurs for approximately four months out of the year.[292] We assume that 88 pounds of CO2e are emitted per 100 pounds of rice per year, based on 2000 estimates from the USA Rice Federation.[293]

Mechanization

Table 4 provides the most recent information available on production practices and input use on rice farms in the U.S. by region. Most rice producers in the South drill seed, while most California producers seed by air into flooded fields. In our report we consider the impacts of drill seeding only, as California rice crops account for only 0.2 percent of total rice crops in the U.S. and thus the impact of air seeding rice in California is relatively insignificant. We consider the impacts of agricultural tillers in our LCA because approximately 94% of rice farm acres in the U.S. utilize conventional tillage systems. Table 38 also provides on-farm fuel usage for gasoline, diesel, LP gas, and natural gas on U.S. rice farms in volume per acre. It provides the electricity use in kilowatt hours per acre. These figures are used to calculate the CO_2e of UB-BR production.

Table 38: Production practices and inputs used on US rice farms, 2000[294]

Item		**All regions**
Method of planting seed (percent of acres)		
	Aerial	35
	Drilled (dry)	60
Tillage systems (percent of acres)		
	Conventional	94
	Reduced	?
	Conservation	?
Fuel usage		
	Gasoline (gal/acre)	3
	Diesel (gal/acre)	33.8
	LP gas (gal/acre)	2.1
	Natural gas (cubic	543
	Electricity (kilowatt	131.8

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[292] "Methane - Rice." *GreenHouse Gas Online*., n.d. Web. 20 Feb. 2011. <http://www.ghgonline.org/methanerice.htm>.
[293] USA Rice Federation. "Environmental Indicators Report." *USA Rice Federation*. 9 Dec. 2010. Web. 20 Mar. 2011. <http://www.usarice.com/doclib/233/4929.pdf>.
[294] Livezey, Janet , and Linda Foreman. "Characteristics and Production Costs of U.S. Rice Farms ." *USDA Economic Research Service*. n.d. Web. 20 Feb. 2011. <http://www.ers.usda.gov/publications/sb974-7/>.

Table 39 provides a list of agricultural machinery involved in rice production.

Table 39: Rice production machinery

Equipment	**Purpose**
Disk harrow	soil cultivation, weed/crop residue destruction
Cultivator	secondary tillage (stir and pulverize soil to
Drill seeder	seeding
Corrugated roller	flatten land, break up soil clumps
Levee disk	levee construction
Broadcast spreader	fertilizer and pesticide application
Water pump	irrigation
Mechanical combine harvester	harvest crop
Mechanical drier	dry the grain
Rice huller (husker)	remove chaff and outer husks of grain

Processing

At the processing plant, rice is milled, parboiled, and packaged for distribution.

Transportation

The percent of domestically grown rice that is shipped via freight rail is insignificant,[295] thus we assume all UB-BR is shipped via tractor trailer truck. We assume that rough rice is transported from the rice farm to Uncle Ben's main domestic processing plant, located at 1098 North Broadway, Greenville, Mississippi, 38701.[296] No information is available about the trucking routes from Mississippi to Massachusetts, so we use the truck route provided by Google Maps Directions[297] (To: Wellesley College, 106 Central Street, Wellesley, MA 02481. From: 1098 North Broadway, Greenville, Mississippi, 38701).

Scale

The average amount of cropland per rice farm in the US is 1,168 acres, and the average harvested rice acreage per farm is 380 acres (breakdowns by region are provided in Table 1).[298]

Packaging Information

In Europe, Uncle Ben's has switched to 100% recycled material for its outer packaging, which has resulted in annual savings of 230 tons of cardboard.[299] The company most likely uses the same packaging in the U.S. No further information is available about UB-BR packaging. It is likely that UB-BR is packaged using a bag similar to the most popular rice bag on

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295 "Railroads and Grain." *Association of American Railroads*. n.d. Web. 20 Feb. 2011. <www.aar.org/~/media/aar/backgroundpapers/railroadsandgrain.ashx>.

296 Perin, Monica. "Uncle Ben's closing old mill, moving operations to Mississippi." *The Business Journals*. n.d. Web. 20 Feb. 2011. <http://www.bizjournals.com/houston/stories/1998/10/12/story6.html>.

297 "Get Directions." *Google Maps*. N.p., n.d. Web. 20 Feb. 2011. <http://maps.google.com/>.

298 Livezey, Janet , and Linda Foreman. "Characteristics and Production Costs of U.S. Rice Farms ." *USDA Economic Research Service*. n.d. Web. 20 Feb. 2011. <http://www.ers.usda.gov/publications/sb974-7/>.

299 "Mars Switzerland - News Releases." *Mars.com*. n.d. Web. 20 Feb. 2011. <http://www.mars.com/switzerland/en/news-and-media/press-releases/news-releases.aspx?SiteId=73&Id=2623>.

Alibaba.com,[300] a global trade website for industrial suppliers and buyers. This bag, made in China, is a recyclable polypropylene woven rice bag with a drawstring. The UB-BR that AVI orders is likely packaged in the largest size bag, which is 700 mm by 120 mm.

300 "Search: 10kg rice packing bag." *Alibaba.com*. n.d. Web. 20 Feb. 2011. <http://www.alibaba.com/products/10kg_rice_packing_bag/--2302.html>.

Butter

As part of our individual foodstuff analysis we are including butter because it is widely used on campus and is fairly common as both an additive in foods and as a stand-alone condiment. For this analysis, we are only looking at the product bought as butter, not as an additive in pre-packaged foods. Additionally, we are excluding margarine because it is a separate product that involves very different inputs and production methods.

Serving Size

To compare butter against other foodstuffs, we use a single serving, which is one teaspoon or 0.17 ounces.[301]

Farm Locations

We buy most of our butter from Sommer Maid Creamery and Cabot Creamery, although there are a variety of other small suppliers from whom we buy specialty products. Sommer Maid Creamery is located in Bucks County, Pennsylvania,[302] and Cabot Creamery is located in Cabot, Vermont[303]. Sommer Maid Creamery does not list its source farms but likely sources from Pennsylvania, New York, and Ohio, which are the main dairy producing states in the area.(citation here?) Cabot sources its milk from a co-op of 1,200 farms across New England and upstate New York.[304] Given that Cabot is more forthcoming with information, we use their creamery as the sample for our analysis, understanding that we are slightly underestimating food miles.

Fertilizer Use

The main fertilizer input for butter is the fertilizer used on the corn and soybean crops that make up the vast majority of the feed given to dairy cows. This information can be found in the food analysis sections on tofu and corn.

Water Use

The main water inputs in making butter are the water required for growing the crops for animal feed and for providing drinking water for the cow, which can be found in the tofu, corn, and milk food analysis sections. Minor inputs could also come from the butter-making process and transportation.

Mechanization and Processing

The main greenhouse gas emissions involved in making butter come from growing the animal feed crops, raising the cow, and transporting the milk and butter from farm to processing to Wellesley. The greenhouse gas emissions from crops can be found in the corn and tofu food

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301 U.S. Dept. of Health and Human Services. *Dietary guidelines for Americans, 2010*. Washington, D.C.: U.S. Dept. of Agriculture, 2010. Print.
302 Sommer Maid Creamery. "Welcome to Sommer Maid Creamery." *Sommer Maid Creamery*, n.d. Web. 25 Feb. 2011. <http://www.sommermaid.com/index.html>.
303 Cabot Cheese. "Cabot Cheese - Award Winning Vermont cheddar." *Cabot Cheese*, n.d. Web. 25 Feb. 2011. <http://www.cabotcheese.coop/>.
304 Cabot Cheese. "Cabot Cheese - Award Winning Vermont cheddar." *Cabot Cheese*, n.d. Web. 25 Feb. 2011. <http://www.cabotcheese.coop/>.

analysis sections, while the dairy input can be found in the food analysis section for milk. The transport from processing plant to Wellesley and the information for calculating greenhouse gas emissions from the processing stage is listed under "Transportation" below. In order to examine the process from milk to finished butter, we must look at the processing steps in between. At the processing facility, the cream and skim milk are separated. The skim milk is taken for consumption as is, while the raw cream is then pasteurized and ripened through aging. Pasteurization requires temperatures of 95 °C or higher to destroy enzymes and microorganisms.[305] The cream is then held in a cool tank for 12-15 hours to crystallize the butterfat.[306] Once the butterfat has crystallized, it is heated and churned before being packaged and shipped out. It takes 10.5-11 quarts of milk to produce around one pound of butter.[307]

Transportation

Once the cow is milked, the milk goes to a separate creamery processing facility where it is turned into butter and then shipped out to Wellesley. Beginning with Cabot Creamery, the milk travels from our sample farm in Rutland, Vermont (see the food analysis section on milk) to the Cabot Creamery in Cabot, Vermont (85 miles), then more or less directly from Cabot to Wellesley (207 miles). It travels by shipping truck for both of these trips. Although the exact energy source for Cabot Creamery is not available, Vermont more generally gets 73% of its power from a single nuclear reactor and sources much of the rest from hydroelectric power and biomass.[308] Furthermore, Cabot Creamery has won awards for its energy-efficient operations and demand management.[309]

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[305] WebExhibits. "Overview of the Buttermaking Process." *Webexhibits*, n.d. Web. 25 Feb. 2011. <http://www.webexhibits.org/butter/process-steps.html>.
[306] WebExhibits. "Overview of the Buttermaking Process." *Webexhibits*, n.d. Web. 25 Feb. 2011. <http://www.webexhibits.org/butter/process-steps.html>.
[307] Wisconsin Cheese. "Butter FAQs." *Wisconsin Milk Marketing Board*. n.d. Web. 25 Feb. 2011. <http://www.eatwisconsincheese.com/wisconsin/other_dairy/butter/butter_faqs.aspx>.
[308] U.S. Dept. of Energy. " Vermont." U.S. Dept. of *Energy* , n.d. Web. 25 Feb. 2011. <http://www.energy.gov/vermont.htm>.
[309] EnerNOC. "Cabot Creamery Cooperative Wins Energy Project Award for DemandSMART Deployment." *EnerNOC,*, 27 Apr. 2010. Web. 25 Feb. 2011. <http://www.enernoc.com/press/releases/176/cabot-creamery-cooperative-wins-energy-project-award-for-demandsmart-deployment.php>.

Chicken

Wellesley College orders chicken from multiple vendors in various forms. Purchases are in the form of wings, tender, thigh, and breast in addition to breaded chicken products such as chicken nuggets. Whole chicken C-CVP ("Chicken CVP Whole w/OG Fresh") produced by the corporate vendor, Georges Food LLC, and distributed by Sysco Classic is analyzed in this report because it is the whole animal form and because it is purchased from Sysco, the supplier from which Wellesley purchases a majority of other chicken products (37, to be exact). This product is listed as number 474 on the list of AVI 2010 purchases by cost. The chicken comes in quantities of 16 per order; the college's 22 whole chicken purchases result in a total of **1056 total chickens** ordered in the year 2010. In addition to purchases of chicken for serving in dining hall, this foodstuff is served at El Table and the College Club – these purchases may not be listed on the college purchase list. Also, there may be special orders for student events such as Family Weekend that are not listed in the main AVI list.

Serving Size

The serving size of chicken is 1 oz of cooked meat according to USDA guidelines.[310] The average weight of a whole broiler chicken is 3-4 lbs,[311] so Wellesley purchased approximately **50,688 to 67,584 servings** of C-CVP last year.

Farm Locations:

The majority of broiler chickens are raised in the southeast region of the United States.[312] George's Food Company, LLC, the producer of Whole Chicken C-CVP is located in Edinburgh, Virginia and was assumed to be the representative producer for chicken.[313] Information about George's Food LLC regarding whether it is vertically integrated and whether it owns hatcheries and growhouses in addition to the slaughterhouse and processing plant, was not readily available.

Fertilizer

Fertilizer is applied to corn and soy, the primary ingredients in chicken feed; so analysis of fertilizer use for Whole Chicken C-CVP would consider the inputs of nitrogen, phosphorous, and potassium in feed. Chickens are fed corn pellets; it takes 11.4 lbs of feed and 3 gallons of water to raise a chicken to market weight of 6 lbs over their lifetime. Many major poultry companies produce their own feed; information about George's Farms feed production was not readily available. Corn and soybean meal represent 40% of the cost of producing chicken.[314]

Water Use

It is assumed that water for chicken consumption and for processing steps comes from the local groundwater system in Edinburgh, VA. Raising chickens is not water-intensive; water is

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310 U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2010. 7th Edition, Washington, DC: U.S. Government Printing Office, December 2010.
311 "Focus On: Chicken." *USDA Food Safety and Inspection Service Home* . USDA-ERS, 4 Apr. 2006. Web. 25 Feb. 2011. < http://www.fsis.usda.gov/factsheets/Chicken_from_Farm_To_Table/index.asp>
312 "ERS/USDA Briefing Room - Poultry and Eggs: Background." *USDA Economic Research Service - Home Page*. USDA-ERS, 16 Apr. 2009. Web. 25 Feb. 2011. < http://www.ers.usda.gov/Briefing/Poultry/Background.htm>
313 "EPA | Envirofacts Warehouse | LRT." *U.S. EPA Web Server*. U.S. EPA, n.d. Web. 25 Feb. 2011. <http://oaspub.epa.gov/enviro/lrt_viewer.map_page?sys_id=110000562766>.
314 "Investor Factbook." *Tyson Foods, Inc. 2005-2006*. n.d. Web. 25 Feb. 2011. <media.corporate-ir.net/media_files/irol/65/65476/reports/04_05_factbook.pdf>.

kept in the brooder rings, and food is kept in feeders or on the floor.[315] The steps of scalding for feather removal, and washing of the chicken carcass involve large amounts of water. Before chilling, the chicken carcass is washed from inside to out with hoses and sprayers. In addition, additives such as chlorine are often added to the water to reduce bacteria content.[316] Information about the size of water tanks and rate of water use for these processes was not readily available.

Carbon:

a. **Production and processing:**

Eggs are hatched in a hatchery, a ventilated and incubated facility with equipment for holding large numbers of eggs. Chicks must be incubated at this stage for about 21 days. Broiler hens, or hens raised for meat, are raised in hen houses that are heated (See Figure 21). "Brooder" units provide microclimates within these hen houses that are designed to keep chickens near each other and near sources of food and water.

Figure 21: Modern enclosed poultry building
Source: (Purdue University) in US-EPA.

Young chicks are kept in blackout houses, which allow growers to artificially control lighting provided to them. Broiler chicks are reared in enclosed buildings with on-demand feeding and watering equipment, thereby reducing the amount of feed and water waste. Most are raised on litter or manure floors, which is collected from hens and then stored or composted.[317] Large commercial hen houses use energy for ventilation to keep hens cool in both winter and summer, since hen houses are generally kept warm by their own body heat. This is natural ventilation by large fans that draw air out of the building.

In addition to energy required for heating and lighting facilities year-round, we consider carbon emissions from various steps in the transportation process. For delivery, whole birds are delivered fresh and refrigerated.[318]

b. **Transportation:**

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[315] "Poultry Production Phases | Ag 101 | Agriculture | US EPA." *US Environmental Protection Agency*. US EPA, 10 Sept. 2009. Web. 25 Feb. 2011. <http://www.epa.gov/oecaagct/ag101/poultryphases.html>.
[316] Small-scale Poultry Processing." *ATTRA - National Sustainable Agriculture Information Service*. n.d. Web. 25 Feb. 2011. <http://attra.ncat.org/attra-pub/poultryprocess.html#washing>
[317] "Poultry Production Phases | Ag 101 | Agriculture | US EPA." *US Environmental Protection Agency*. US EPA, 10 Sept. 2009. Web. 25 Feb. 2011. <http://www.epa.gov/oecaagct/ag101/poultryphases.html>.
[318] "Investor Factbook." *Tyson Foods, Inc. 2005-2006*. n.d. Web. 25 Feb. 2011. <media.corporate-ir.net/media_files/irol/65/65476/reports/04_05_factbook.pdf>.

1. **Transportation between breeder house, hatchery, broiler farm, and processing plant:** Contract growers usually simultaneously invest in feed mills, hatcheries, and processing facilities;[319] we assume that George's Food LLC is a complex where the feed mill, hatchery, and processing plant for broiler chickens are located in Virginia within 50 mi. of Edinburgh since more detailed company information is not readily available. Transportation would most likely occur by truck.
2. **Transportation from George's Food, LLC to Sysco Classic Distributor:** Use Google Maps to calculate distance from George's Food Company, LLC, 19992 Senedo Road, Edinburgh, VA is the producer located at coordinates (38.877575, -78.609361) to Sysco Boston LLC, 380 South Worcester Street, Norton, MA 02766 by truck.
3. **Transportation from Sysco Classic to Wellesley College Dining:** Use Google Maps to calculate distance from Sysco Boston LLC, 380 South Worcester Street, Norton, MA 02766 by truck to 106 Central Street, Wellesley, MA 02481.

Scale

Poultry production usually occurs on large farms with sales of $100,000 or more and accounts for one-third the total value of poultry and egg production. Smaller farms were the majority of farms delivering poultry but produced a relatively small amount of the total production of the US. Table 40 lists poultry production by farm size.

Table 40: Poultry farm operations, 1995[320]

Farm size	Number of Farms	Percent of Farms	Total value of poultry production ($ million)	Poultry value of production (%)	Average value of poultry production
49 or fewer acres	23,444	47.2	4,963	34.3	211,703
50-179	15,621	31.4	5,664	39.2	362,563
180-499	8,504	17.1	2,130	14.7	250,441
500-999	1,549	3.1	1,100	7.6	709,817
All poultry operations	49,716	100	14,463	100	290,907

[319] "Poultry Production Phases | Ag 101 | Agriculture | US EPA." *US Environmental Protection Agency*. US EPA, 10 Sept. 2009. Web. 25 Feb. 2011. <http://www.epa.gov/oecaagct/ag101/poultryphases.html>.
[320] "USDA Agricultural Resource Management Survey." *U.S. Department of Agriculture*. 1995. Web. 14 May 2011. <http://www.usda.gov>.

Coffee

As part of our individual analysis of foodstuffs we are examining coffee because it is so prevalent across campus, is incredibly visible to both college residents and visitors and is consumed in large quantities. Coffee is a fairly narrow category in that it is made up of a single commodity and we mostly buy from two major brands, Pura Vida and Starbucks. The college buys 1,482 pounds of coffee from Starbucks and approximately 2,624 pounds of coffee from Pura Vida. Both purchases are compromised of a mix of regular, decaffeinated and flavored coffees. Although there are many "accessories" to our coffee purchasing such as filters, instant coffee and flavor syrups, the actual coffee beans are the main foodstuff in this category that we examine. To simplify the analysis further, we examine the largest purchases from each brand: the House Blend Fair Trade Regular and Decaffeinated from Pura Vida and the Columbian blend from Starbucks. Although we purchase other types of coffee from both brands, many are flavored and involve a number of other inputs such as chemicals. Since the bulk of the environmental impact will come from the coffee beans and not the chemicals or other additives, our analysis of the main coffee purchases can be used to estimate the impact of all of our coffee purchases.

Serving Size

The general serving size for coffee is six ounces of brewed coffee. Looking backwards, a generally acceptable ratio is two tablespoons (1/8 cup) of ground coffee per six ounces of water. Every tablespoon of coffee grounds weighs around five grams, and the weight of the coffee beans and the ground coffee should be about equal. Therefore every six-ounce cup of brewed coffee requires around ten grams of coffee beans. For the purpose of this analysis, we use ten grams, or 0.36 ounces, of coffee beans as the serving size.

Farm Locations

Since we are examining two different brands, the coffee originates in two different locations. The Starbucks Colombian blend is grown in the Andes of Colombia.[321] Pura Vida's House Blend and Decaffeinated House Blend are a bit more complicated in their growing locations. Both types are grown in Central America and Indonesia, but the specific locations are not listed.[322] In Indonesia, the majority of coffee comes from the island of Sumatra,[323] while in Central America coffee production is more evenly distributed between Guatemala, Costa Rica, Honduras, El Salvador, Nicaragua and Panama.[324] All the Pura Vida Coffee we buy is also Fair Trade Certified, organic and shade-grown.[325]

Because specific information is hard to find, we use Colombia as the sample source of our coffee, understanding that extrapolating to our other sources involves some error. There are

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[321] Starbucks Coffee Company. "Colombia." Starbucks Corporation, 2011. Web. 25 Feb. 2011. <www.starbucks.com/coffee/whole-bean-coffee/latin-america/colombia>.

[322] Pura Vida Coffee. "Pura Vida Coffee - Coffee Difference." *Pura Vida Create Good, Inc.*, 2011. Web. 25 Feb. 2011. <http://puravidacoffee.e-beans.net/coffees/>.

[323] Owen, Thompson and Sweet Maria's Coffee, Inc. "The Coffees of Indonesia; Sumatra." *Home Coffee Roasting Supplies - Sweet Maria's*, n.d. Web. 25 Feb. 2011. <http://www.sweetmarias.com/coffee.indonesia.sumatra.php>.

[324] "Central America Coffee Beans." *Coffee - CoffeeResearch.org*. Web. 25 Feb. 2011. <http://www.coffeeresearch.org/coffee/mexicoca.htm>.

[325] Pura Vida Coffee. "Pura Vida Coffee - Coffee Difference." *Pura Vida Create Good, Inc.*, 2011. Web. 25 Feb. 2011. <http://puravidacoffee.e-beans.net/coffees/>.

also sample errors because Pura Vida Coffee is Fair Trade Certified, organic and shade-grown, while Starbucks Colombian coffee is not. The impact of the Pura Vida Coffee is likely less than that of the sample Starbucks Colombian coffee.

Coffee is grown in much of Northwest Colombia, so we use Medellín as a sample farm location.[326]

Fertilizer Use

Coffee requires inputs of nitrogen, phosphorus and potassium to grow. One source puts nutrient uptake by coffee of nitrogen at 53-172 kilograms per hectare per year, phosphorus pentoxide at 10.5-36 kilograms per hectare per year, and potassium oxide at 80-180 kilograms per hectare per year.[327] Fertilizer application rates for coffee are estimated at 150-300 kilograms per hectare per year for both nitrogen and potassium oxide and 0-150 kilograms per hectare per year for phosphorus pentoxide.[328]

Water Use

Coffee uses approximately 4000 cubic meters per hectare per year of water for irrigation purposes.[329] The wet processing also uses large amounts of water, as does the actual preparation of the coffee. Additionally, water impacts may result from the oil extraction methods used to procure the fuel for transport.

Mechanization, Processing, and Transportation

Coffee is generally picked by hand, although some farms use mechanized gear to pick more efficiently. After picking, the coffee can be processed in one of two ways – wet or dry processing. Much of the coffee from Colombia is processed using machine-assisted wet processing in order to separate the bean from the pulp.[330] After wet processing, the coffee is dried, milled and graded according to the quality of the bean. The coffee beans are then exported through the Colombian Coffee Federation, a federation of small coffee farmers across Columbia.[331] These beans are likely shipped by truck about 390 miles from Medellín to Cartagena before being put on a ship. The ship would have to go approximately 3,000 miles from Cartagena to Miami, where the beans would be loaded onto a truck and driven from Miami to the Starbucks processing plant in Calhoun County, South Carolina (650 miles).[332]

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[326] Owen, Thompson and Sweet Maria's Coffee, Inc. "The Coffees of Colombia." *Home Coffee Roasting Supplies - Sweet Maria's*, n.d. Web. 25 Feb. 2011. <http://www.sweetmarias.com/coffee.southamr.colombia.php>.

[327] Harding, P. "Coffee." in International Fertilizer Industry Association, "World Fertilizer Use Manual: Crop index – Type of crops." *International Fertilizer Industry Association (IFA),* 25 April 1992. Web. 25 Feb. 2011. <http://www.fertilizer.org/ifa/Home-Page/LIBRARY/Our-selection2/World-Fertilizer-Use-Manual/by-type-of-crops>.

[328] Harding, P. "Coffee." in International Fertilizer Industry Association, "World Fertilizer Use Manual: Crop index – Type of crops." *International Fertilizer Industry Association (IFA),* 25 April 1992. Web. 25 Feb. 2011. <http://www.fertilizer.org/ifa/Home-Page/LIBRARY/Our-selection2/World-Fertilizer-Use-Manual/by-type-of-crops>.

[329] Humbert, S., *et al.* Life cycle assessment of spray dried soluble coffee and comparison with alternatives (drip filter and capsule espresso). *Journal of Cleaner Production* 17 (2009): 1351-1358.

[12]Espresso & Coffee Guide. "Columbian Coffee." *Espresso & Coffee Guide, 2009-2011.* Web. 25 Feb. 2011. <http://www.espressocoffeeguide.com/gourmet-coffee/coffees-of-the-americas/columbian-coffee/>.

[331] Espresso & Coffee Guide. "Columbian Coffee." *Espresso & Coffee Guide, 2009-2011.* Web. 25 Feb. 2011. <http://www.espressocoffeeguide.com/gourmet-coffee/coffees-of-the-americas/columbian-coffee/>.

[332] Food Processing Technology. "Starbucks Coffee Roasting Plant.".*Net Resources International*, 2011. Web. 25

Once in the South Carolina processing plant, coffee beans are roasted, cooled, blended, grinded and packaged. Electrical energy is needed to power the equipment at all steps.[333] The roasting step probably takes up the most energy and involves putting the coffee beans in the roaster between three and thirty minutes at a temperature of 188 to 282 degrees Celsius.[334] Although information on the power source for the Starbucks power plant is not available, we can look at the electrical generation in South Carolina more generally. Around 36 percent of energy comes from coal, around 58 percent from nuclear, and just under 4 percent from hydroelectric, with other minor sources including petroleum, natural gas and wood-derived fuels.[335]

Once the beans are roasted, they are put on a truck and shipped more or less from South Carolina to Wellesley (920 miles), with a few stops in between that we assume are minor.

Scale

Coffee is grown on the slopes of the Andes at altitudes between 4,200 and 6,000 feet and mainly on farms of around fifteen acres.[336] Much of the work comes from human labor because of the difficult and steep terrain.

Feb. 2011. <http://www.foodprocessing-technology.com/projects/starbucks-roasting/>.

[333] Salomone, Roberta. "Life cycle assessment applied to coffee production: investigating environmental impacts to aid decision making for improvements at company level." *Food, Agriculture & Environment* 1.2 (2003): 295-300. Print.

[334] "LCA of coffee." *Appropedia*, n.d. Web. 25 Feb. 2011. <http://www.appropedia.org/LCA_of_coffee>.

[335] U.S. Energy Information Administration. "Electric Power Annual 2009 - State Data Tables.". *U.S. Department of Energy*, 24 Jan. 2011. Web. 25 Feb. 2011. <http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html >.

[336] Encyclopedia of the Nations."Colombia-Agriculture." *Advameg, Inc.,* 2011. Web. 25 Feb. 2011. <http://www.nationsencyclopedia.com/Americas/Colombia-AGRICULTURE.html#ixzz1Ew7DpHff>.

Chocolate Chip Cookie Dough

Our analysis of chocolate chip cookie dough focuses on Otis Spunkmeyer Inc. cookie dough sold in one ounce portions, as this makes up 95 percent of the chocolate chip cookies that the College purchases in dough form. We are focusing our analysis on five ingredients of the cookie dough: wheat flour (30 percent by weight), sugar (30 percent), unsweetened chocolate and cocoa butter (20 percent), and palm oil (20 percent). Proportion estimates are based on a recipe for homemade chocolate chip cookies, except that sugar content is higher and chocolate content is lower, based on the order of the ingredients in Spunkmeyer's nutrition facts.[337] Sugar is an ingredient in the dough itself and also in the chocolate chips, which also include unsweetened chocolate and cocoa butter. Palm oil is an ingredient in the dough, and is also the top ingredient in the margarine used in the dough. An acre of wheat produces enough grain for approximately 2740 pounds of flour,[338] an acre of sugarcane yields about 5085 pounds of sugar,[339] cocoa farming yields about 880 pounds of cocoa per acre,[340] and a hectare of oil palms produces about 5085 pounds of oil.[341] Based on the assumed proportions of each of these ingredients in the recipe, one acre of land is used to produce 43840 cookies.

Serving Size

Since the cookie dough in this analysis is sold in one ounce (28 gram) portions, we use 28 grams as the functional unit in our analysis. This serving size is within the 14 to 96 gram range accepted by the USDA for cookie serving sizes.[342]

Farm Locations

Each of the ingredients in the cookie dough could be produced in several different locations. For flour, the top three sources of wheat in the U.S. are North Dakota, Kansas, and Montana,[343] so we estimate that 40 percent of the flour is from North Dakota, 40 percent from Kansas, and 20 percent from Montana. Agricultural land use is high in all regions of North Dakota, all regions except the east in Kansas, and in Northern regions of Montana,[344] so we assume that wheat production is most likely occurring in west and central Kansas and northern Montana. For sugar, the likeliest source is Florida, since 70 percent of sugar used in the U.S. is

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337 "Value Zone Frozen Cookie Dough- Chocolate Chip." *Otis Spunkmeyer*. Otis Spunkmeyer, Inc., 2011. Web. 24 Feb. 2011. <http://www.spunkmeyer.com/Our-Products/Foodservice-Products/Frozen-Cookie-Dough/Value-Zone-/Chocolate-Chip-Cookies---58100/>.
338 "Wheat Facts." *Oklahoma Ag in the Classroom* . Oklahoma Cooperative Extension Service, n.d. Web. 23 Feb. 2011. <http://oklahoma4h.okstate.edu/aitc/lessons/extras/facts/wheat.html#growing>.
339 Legendre, Benjamin L. "Louisiana's Top Sugarcane Growers Recognized at the 50th Annual High Yield Awards Program ." *The Louisiana State University Agricultural Center* . LSU AgCenter, 11 Mar. 2009. Web. 1 Mar. 2011.
340 "Ivory Coast, Sustainable Cocoa Production." *Hanns R. Neumann Stiftung* . Hanns R. Neumann Stiftung, 2009. Web. 1 Mar. 2011. <http://www.hrnstiftung.org/project-reader/items/ivory-coast-sustainable-cocoa-production.42.html>.
341 Henson, IE. "Environmental Impacts of Oil Palm Plantations in Malaysia." PORIM 33 (1994): 1-23. Print.
342 "Serving Sizes in the Food Guide Pyramid." *Nutrition Insights*. USDA Center for Nutrition Policy and Promotion, December 2000. Web. 22 Feb. 2011. <www.cnpp.usda.gov/Publications/NutritionInsights/Insight22.pdf>.
343 "NASS - Data and Statistics - Quick Stats." *NASS - National Agricultural Statistics Service*. Version 1.0. NASS, n.d. Web. 22 Feb. 2011. <http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/index.asp>.
344 "NASS - Data and Statistics - Quick Stats." Version 2.0.

produced from cane in Florida.[345] Sugar used on the East Coast is even more likely to be from Florida, because of the expense involved in shipping sugar.[346] Within Florida, sugarcane is grown in the Everglades Agricultural Area, between Lake Okeechobee and the Everglades. Unsweetened chocolate and cocoa butter are likely to be produced from cocoa beans grown in three countries, which produce 68 percent of cocoa beans: Côte D'Ivoire (32 percent) Indonesia (19 percent), and Ghana (17 percent),[347] so we assume that, on average, 50 percent of our cocoa ingredients are from Côte D'Ivoire, 25 percent from Indonesia, and 25 percent from Ghana. For palm oil, 85 percent of production is in Malaysia (43 percent) and Indonesia (41 percent), so we estimate that, on average, 50 percent of the palm oil in the cookies is from Malaysia and 50 percent is from Indonesia

Fertilizer Use

Wheat is on average fertilized with 61 pounds per acre per year of nitrogen, 31 pounds per acre per year of phosphate, 39 pounds per acre per year of potash (potassium), and 11 pounds per acre per year of sulfur. Studies indicate that wheat takes up an average of 45 percent of nitrogen applied, when the optimum level of fertilizer is applied.[348] Fertilizer is applied to sugarcane at an average rate of 194 pounds per acre worldwide.[349] Nutrient uptake varies by location; nitrogen uptake varies from 0.5 to 0.9 kilograms per ton of cane, phosphorus uptake is 0.1 to 0.3 kilograms per ton, and potassium uptake is 0.8 to 1.3 kilogram per ton.[350] Cocoa in Indonesia is grown with an average of 85 pounds per acre nitrogen, 50 pounds per acre phosphorus (as P_2O_5), and 58 pounds per acre potassium (as K_2O), while in Ghana fertilizer is not commonly used.[351] One hectare, containing approximately 1000 plants, takes up about 35, 10, and 60 kilograms of nitrogen, phosphorus, and potassium, respectively.[352] Since Ghana and Côte D'Ivoire are in the same region, it is possible that Côte D'Ivoire does not use fertilizers as well. The average of fertilizer use in Indonesia and Malaysia is a rate of 68 pounds per acre nitrogen, 155 pounds per acre phosphorus (as P_2O_5), and 231 pounds per acre potassium (as K_2O), with higher quantities used in Malaysia.[353] A hectare of oil palms containing 148 palms

[345] Ettlinger, Steve. *Twinkie, deconstructed: my journey to discover how the ingredients found in processed foods are grown, mined (yes, mined), and manipulated into what America eats*. New York, NY: Hudson Street Press, 2007. Print.

[346] Ettlinger, Steve. *Twinkie, deconstructed: my journey to discover how the ingredients found in processed foods are grown, mined (yes, mined), and manipulated into what America eats*. New York, NY: Hudson Street Press, 2007. Print.

[347] "Food and Agricultural commodities production." *FAOSTAT*. Food and Agriculture Organization of the United Nations, 2008. Web. 22 Feb. 2011. <http://faostat.fao.org/site/339/default.aspx>.

[348] Foulkes, MJ, R Sylvester-Bradley, and RK Scott. "Evidence for differences between winter wheat cultivars in acquisition of soil mineral nitrogen and uptake and utilization of applied fertilizer nitrogen." *Journal of Agricultural Science, Cambridge* 130 (1998): 29-44. Print.

[349] "Fertilizer Use by Crop." *Food and Agricultural Organization of the United Nations*. FAO, n.d. Web. 22 Feb. 2011. <ftp://ftp.fao.org/agl/agll/docs/fpnb17.pdf>.

[350] Fageria, N. K., V. C. Baligar, and C. Allan Jones. *Growth and mineral nutrition of field crops* . 2nd ed. New York: Marcel Dekker, 1997. Print.

[351] "Fertilizer Use by Crop." *Food and Agricultural Organization of the United Nations*. FAO, n.d. Web. 22 Feb. 2011. <ftp://ftp.fao.org/agl/agll/docs/fpnb17.pdf>.

[352] "World Fertilizer Use Manual ." *IFA : International Fertilizer Industry Association*. IFA, n.d. Web. 24 Feb. 2011. <http://www.fertilizer.org/ifa/Home-Page/LIBRARY/Our-selection2/World-Fertilizer-Use-Manual/by-type-of-crops>.

[353] "Fertilizer Use by Crop." *Food and Agricultural Organization of the United Nations*. FAO, n.d. Web. 22 Feb. 2011. <ftp://ftp.fao.org/agl/agll/docs/fpnb17.pdf>.

takes up 191, 62, and 318 kilograms of nitrogen, phosphorus, and potassium, respectively, in Malaysia.[354]

Irrigation

The recommended level of irrigation for wheat varies from 0 to 16 acre-inches, depending on rainfall.[355] Cane is watered to prevent subsidence of the soil; one kilogram of sugarcane grown in Florida requires 88 to 118 kilograms of water.[356] There is no indication that oil palms and cocoa are irrigated, and it is likely that they are not due to the tropical climate where they are grown. Thus we assume that these crops are not irrigated.

Mechanization

Wheat production is a highly mechanized process; Carbon dioxide emissions are associated with all stages from soil preparation to milling. Soil preparation begins with plowing and cultivating with a disk harrow. Seeds are planted with a grain drill, and grain is harvested with a combine. The combine harvests enough grain to produce about 1.75 kilograms of flour in nine seconds. Sugar cane production in Florida involves the use of machinery, including planters that plant cane stems and a combine designed to work in wet soil for harvesting. Burning is used to control pests.[357] Cocoa is often grown using manual labor rather than machinery, so there are few carbon dioxide emissions, though there may be ethical issues associated with this form of production. Palm plantations are cleared, burned and replanted approximately every 25 years. Some plantations use machinery for planting and harvest, which results in some greenhouse gas emissions (Table 41).

Table 41: Energy usage and carbon dioxide equivalent emissions associated with oil palm cultivation[358]

Input	**Energy value (GJ/ha/year)**	**CO_2 equivalent (kg/ha/year)**
Fertilizers	11.22	730.2
Pesticides, herbicides, and rat baits	0.8	52.1
Machinery	5.14	334.5
Total	17.16	1116.8

[354] "World Fertilizer Use Manual ." *IFA : International Fertilizer Industry Association*. IFA, n.d. Web. 24 Feb. 2011. <http://www.fertilizer.org/ifa/Home-Page/LIBRARY/Our-selection2/World-Fertilizer-Use-Manual/by-type-of-crops>.
[355] Bauder, James W.. "Wheat Irrigation." *MSU Extension Water Quality Program*. MSU Extension , 12 May 2005. Web. 23 Feb. 2011. <http://waterquality.montana.edu/docs/irrigation/wheatirrigation.shtml>.
[356] Whitty, EB, DL Wright, and CG Chambliss. "Water Use and Irrigation Management of Agronomic Crops ." *University of Florida IFAS Extension*. 2009. Web. 23 Feb. 2011. <http://edis.ifas.ufl.edu/aa131>.
[357] Ettlinger, Steve. *Twinkie, deconstructed: my journey to discover how the ingredients found in processed foods are grown, mined (yes, mined), and manipulated into what America eats*. New York, NY: Hudson Street Press, 2007. Print.
[358] Henson, IE. "Environmental Impacts of Oil Palm Plantations in Malaysia." PORIM 33 (1994): 1-23. Print.

Processing

Wheat grain is transported to a grain elevator where machinery is used to move the grain upwards. From the grain elevator, wheat kernels are transported to mills, which use disks and water to separate dirt from the grain. Machines roll and shake the grain, blow air on it to remove the bran, and rollers grind it into flour.[359] Processing sugarcane includes washing, shredding and crushing in hot water, cleaning with lime and coagulant, filtering and evaporation, and centrifugation. Processing is often fueled by cane residues, so net carbon dioxide emissions are low. The raw cane sugar is then refined and dried, which involves boiling sugar syrup, vacuum drying the crystals, centrifugation, rotary drying, and additional drying under humidity controlled air for several days.[360] Cocoa beans are roasted and shelled in a winnower, and then ground. Grinding produces chocolate liquor which is turned into unsweetened chocolate through kneading or pressed to produce cocoa butter. The chocolate is pressed in rollers, kneaded in conches for a few hours to a week, and then heated, cooled, and reheated to temper it.[361] The refining process for palm oil, including extraction in a digester and refining, is often fueled by oil palm byproducts.[362] Production of the cookie dough entails mixing the ingredients, forming the dough into cookies, and freezing the dough. Once frozen, the cookies are transported in freezer trucks to Wellesley.

Transportation

Sugar produced in Florida is likely to be transported in barges or railcars to Yonkers, New York (1 Federal Street, Yonkers, NY 10705) for refining before being transported to the dough manufacturing plant.[363] After hand harvesting, cocoa beans are sun-dried and transported to the U.S. in 200-pound burlap sacks. The chocolate used in Spunkmeyer cookie dough may be produced by Nestle, since it is the top chocolate manufacturer in the world, excluding companies that mostly produce chocolate bars.[364] Since Nestle USA has a large concentration of factories in Illinois, we assume that the chocolate is produced there.

Assuming that the cookie dough sold to Wellesley College is made at the nearest Otis Spunkmeyer manufacturing plant, the cookie dough used at Wellesley is manufactured at 1001 Corporate Lane, Export, PA.[365] We make the simplifying assumption that all of the ingredients mentioned above are transported directly to the Spunkmeyer manufacturing plant, since we have no information to indicate otherwise. Flour is most likely transported by train since there is heavy use of rail for agricultural purposes from grain-producing states to Pennsylvania,[366] and

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[359] "Wheat Facts." *Oklahoma Ag in the Classroom* . Oklahoma Cooperative Extension Service, n.d. Web. 23 Feb. 2011. <http://oklahoma4h.okstate.edu/aitc/lessons/extras/facts/wheat.html#growing>.

[360] Ettlinger, Steve. *Twinkie, deconstructed: my journey to discover how the ingredients found in processed foods are grown, mined (yes, mined), and manipulated into what America eats*. New York, NY: Hudson Street Press, 2007. Print.

[361] "Harvest, Fermentation, Drying and Transport of the Cacao Bean." Hershey Company.

[362] Henson, IE. "Environmental Impacts of Oil Palm Plantations in Malaysia." PORIM 33 (1994): 1-23. Print.

[363] Ettlinger, Steve. *Twinkie, deconstructed: my journey to discover how the ingredients found in processed foods are grown, mined (yes, mined), and manipulated into what America eats*. New York, NY: Hudson Street Press, 2007. Print.

[364] O'Coughlin, Mary. "Top Ten Chocolate Manufacturers Worldwide." *GoArticles.com*. GoArticles.com , 6 Feb. 2009. Web. 24 Feb. 2011. <http://goarticles.com/article/Top-Ten-Chocolate-Manufacturers-Worldwide/1385494/>.

[365] "Our Locations." Otis Spunkmeyer. Otis Spunkmeyer Inc., 2011. Web. 21 Feb. 2011. <http://www.spunkmeyer.com/About-Us/Locations/Our-Locations/>.

[366] "Chapter 9: Rail Capacity." *United States Department of Agriculture- Agricultural Marketing Service*. USDA-AMS, 27 Apr. 2010. Web. 25 Feb. 2011.

the same is true for chocolate that is transported from Illinois, though chocolate would require refrigerated railcars for approximately half of the year. Sugar, on the other hand, is transported a fairly short distance from New York, so it is probably transported by truck. Palm oil, which is being transported from Southeast Asia, may be brought by ship to New York and transported by truck from there, or it could be brought to Los Angeles and transported by train to PA.[367]

Scale

A typical wheat farm size is 10,010 acres,[368] an oil palm plantation is about 10,000 hectares,[369] and a sugarcane farm in Florida is about 1,240 acres.[370] Most cocoa is grown on small farms that are 12 acres or less in area.[371]

Toxicity Information

The pesticides most commonly used on wheat include: the fungicide propiconazole, which is applied at a rate of 0.08 pounds per acre per year, the herbicide Glyphosate-isopropylammonium (ISO) salt at 1.16 pounds, and the insecticide chlorpyrifos at 1.1 pounds. Sugarcane is typically produced in California using these pesticides: the herbicide atrazine is applied at a rate of 1.13 pounds per acre, and the insecticide Orchex 796 oil at 1.45 pounds per acre.[372] Pesticide use on cocoa appears to be low; 25 percent of cocoa farm land is treated with pesticide in Côte D'Ivoire.[373] The most commonly used pesticides in oil palm plantations are glyphosate and paraquat, both herbicides.[374]

Biodiversity

Conventional wheat is generally grown in a monoculture with no crop rotation; about a third of wheat farmland is rotated to other crops.[375] Since cocoa is still shade grown in many

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<http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5084093>.

[367] "Chapter 14: Ocean Transport." *United States Department of Agriculture- Agricultural Marketing Service*. USDA- AMS, 27 Apr. 2010. Web. 25 Feb. 2011. <http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5084098>.

[368] Ettlinger, Steve. *Twinkie, deconstructed: my journey to discover how the ingredients found in processed foods are grown, mined (yes, mined), and manipulated into what America eats*. New York, NY: Hudson Street Press, 2007. Print.

[369] "The Rise of Large Farms: Drivers and Development Outcomes." *United Nations University-World Institute for Development and Economics Research*. UNU-WIDER, 2011. Web. 22 Feb. 2011. <http://www.wider.unu.edu/publications/newsletter/articles-2010/en_GB/article-11-12-2010/>

[370] "Sugar and Sweeteners: Background." *USDA Economic Research Service*. ERS USDA, 6 Aug. 2009. Web. 22 Feb. 2011. <http://www.ers.usda.gov/Briefing/Sugar/Background.htm>.

[371] "Harvest, Fermentation, Drying and Transport of the Cacao Bean." *Chocolate, the Natural Antioxidant - Recipes, History and More*. Hershey Company, n.d. Web. 22 Feb. 2011. <http://www.allchocolate.com/understanding/how_chocolate_is_made/tree_to_factory.aspx#harvest>.

[372] "PAN Pesticide Use Info for Sugarcane." *PAN Pesticide Database*. Pesticide Action Network, 2010. Web. 22 Feb. 2011. <http://www.pesticideinfo.org/DS.jsp?sk=25003>.

[373] Mark, Monica. "Ivory Coast May Boost Cocoa Output With Increased Pesticide Use - Bloomberg." *Bloomberg - Business & Financial News, Breaking News Headlines* . Bloomberg LP, 15 July 2009. Web. 22 Feb. 2011. <http://www.bloomberg.com/apps/news?pid=newsarchive&sid=aJKpS9KfvSbI>; "Food and Agricultural commodities production." FAO.

[374] Page, Bill, and Simon Lord. "The Oil Palm Industry's approach to the use of pesticides in Papua New Guinea." *New Britain Palm Oil Limited*. NBPOL, n.d. Web. 22 Feb. 2011. <www.nbpol.com.pg/downloads/Pesticides_in_Papua_New_Guinea.pdf>.

[375] "NASS - Data and Statistics - Quick Stats." Version 2.0.

areas, tree diversity on these plantations varies from 9 to 21 species per 0.25 hectares, at least in Indonesia, compared to 27 species in natural forest.[376] About 17 percent of oil palm plantations in Malaysia are planted as a monoculture on cleared forest land, while the rest replaced other agricultural uses.[377]

[376] Bos, Merijn M., Ingolf Steffan-Dewenter , and Teja Tscharntke. "The contribution of cacao agroforests to the conservation of lower canopy ant and beetle diversity in Indonesia." *Biodiversity and Conservation* 16.8 (2007): 2429-2444. Print.
[377] Henson, IE. "Environmental Impacts of Oil Palm Plantations in Malaysia." PORIM 33 (1994): 1-23. Print.

Corn

Corn for feed, though not a foodstuff analyzed in this report, is included in our calculations for animal products and byproducts purchased by Wellesley College. In the United States, field corn is grown on 99 percent of all farmland for corn, totaling to 88.2 million acres, most of which are located in the Heartland region (Illinois, Iowa, Indiana, eastern South Dakota, eastern Nebraska, western Kentucky, western Ohio, and northern Missouri).[378] Its primary uses are for livestock feed, ethanol production and other manufactured goods. Figure 22 provides information on the use of field corn in the United States in 2010. [379]

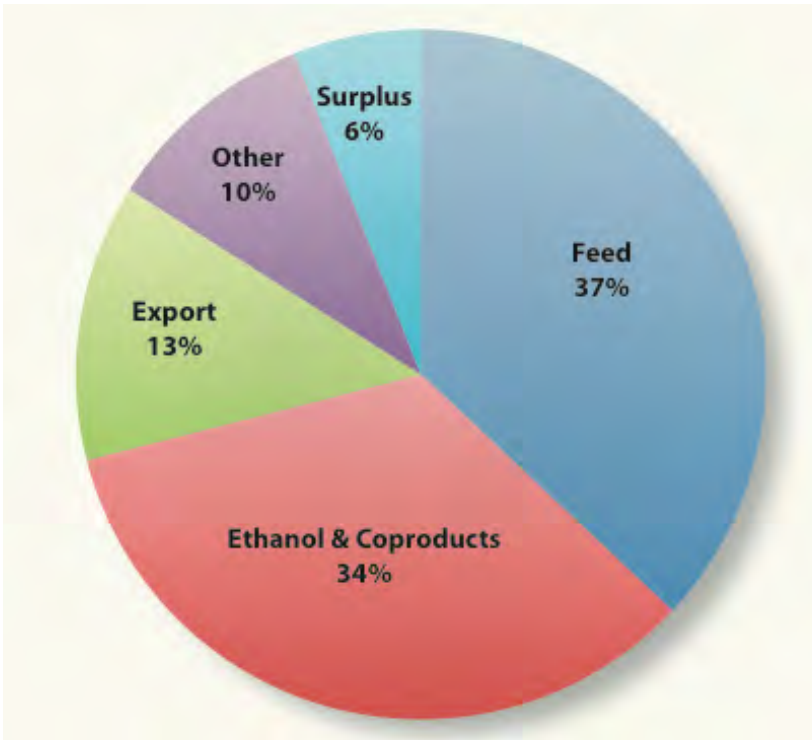

Figure 22: U.S. Corn use 2010

Corn is used in a range of concentrations in feed depending on the age of the animal consuming the feed, and can be supplemental in foraging diets.[380] In this study, field corn statistics were used in calculations for beef, pork, chicken and turkey, as well as their respective products (i.e. milk, eggs, cheese, etc.).

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[378] "ERS/USDA Briefing Room - Corn: Background." *USDA Economic Research Service - Home Page*. 18 Feb. 2009. Web. 05 Apr. 2011. <http://www.ers.usda.gov/Briefing/Corn/background.htm>.

[379] *Tale of Two Corns*. Publication. National Corn Growers Association, 2011. Web 04 Apr. 2011. <http://www.ncga.com/files/pdf/TaleofTwoCorns%201.2011.pdf>

[380] Lardy, Greg. "Feeding Corn to Beef Cattle." *NDSU Agriculture — NDSU*. Dec. 2002. Web. 08 Mar. 2011. <http://www.ag.ndsu.edu/pubs/ansci/beef/as1238w.htm>.

Serving Size

According to the USDA, in the 2009/2010 analysis of Feed Grain Data, a total of 130,574,000 metric tons of corn were fed to each grain-consuming animal unit (GCAU).[381] A grain-consuming animal unit is a standard unit used by the USDA to compare feed consumption across all animal types (livestock and poultry) and is based on the amount of feed consumed by the average milk cow during the base period. The base period is not defined by the USDA. Data for specific pounds of corn per day were sourced from sources other than the USDA, however, in an attempt to use more specific data for corn in feed ratios. Most of the data is in pounds per day for the finishing period of each animal.

Beef cattle eats between 25-30 pounds of corn silage per day when they are put out to pasture for the winter, and consume a supplement of 8-10 pounds of ground shelled corn per day during the finishing period.[382] Finishing pigs should consume about 5.25 pounds of corn per day for an average daily weight gain of 1.64 pounds.[383] Three quarters of feed used for finishing broiler chickens (chickens produced for meat) is grain based (a combination of cracked corn, soybean, rolled oats, and other ingredients) and the remaining quarter is added nutrients; about half of the total mix is corn. Mature chickens for slaughter should be fed at a rate of 3 lbs for every five hens per day.[384] Finally, turkeys are fed a diet of corn and soybean meal, supplemented by other nutrients.[385] Again, corn is about half of the feed mix,[386] and it is estimated that they chickens consume between 5-7 pounds of feed per week.[387] Other components of the feed are corn silage, soybean, dry distiller grain, wheat, sorghum, and other added nutrients.

Farm Location

The majority of corn for feed is grown in America's Heartland region, though corn farms exist in almost every part of the country (see Figure 2).[388] Iowa and Illinois produce roughly one third of all U.S. field corn.[389] Because determining the provenance of corn for feed is nearly impossible, we assume, for the purpose of this study, that all corn for grain comes from the Heartland region.

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[381] "Processed Feeds: Quantities Fed and Feed per Grain-consuming Animal Unit - USDA/ERS." *USDA Economic Research Service - Home Page*. 2011. Web. 17 Apr. 2011. <http://www.ers.usda.gov/data/feedgrains/Table.asp?t=29>.
[382] Lalman, David L., and Homer B. Sewell. "G2066 Rations for Growing and Finishing Beef Cattle | University of Missouri Extension." *University of Missouri Extension Home*. nd. Web. 06 May 2011. <http://extension.missouri.edu/publications/DisplayPub.aspx?P=G2066>.
[383] Cromwell, Gary L. *Corn - Is It Still the Best Feed Grain for Swine?* University of Kentucky - Animal Sciences. nd. Web. 3 May 2011. <http://www.uky.edu/Ag/AnimalSciences/pubs/ornisitstillthebestfeedgrainforswine.pdf>.
[384] "Feeding Broiler Chicks To Maturity | Chicken Keeping Secrets." *Chicken Keeping Secrets - How To Keep Chickens at Home*. nd. Web. 03 May 2011. <http://www.chickenkeepingsecrets.com/chicken-feed/feeding-broiler-chicks-to-maturity/>.
[385] "Let's Talk Turkey." *DEC - Department Welcome Page*. nd. Web. 03 May 2011. <http://www.dec.state.ak.us/eh/fss/consumers/allturk.htm>.
[386] Shepard, C. C., and Charles J. Flegal. "Want to Raise a Few Turkeys?" *Michigan State University Extension*, 21 Apr. 2000. Web. 01 May 2011. <http://web1.msue.msu.edu/imp/modpo/visuals/e1259t2.html>.
[387] CHS Nutrition. *Specialty Bird Feeding Guide*. Sioux Falls: CHS Nutrition, 2009. Web. 01 May 2011. <http://www.paybackfeeds.com/tag_book/documents/chs2255_FeedingGuidesLR_0211.pdf>
[388] "NASS - Statistics By Subject." *NASS - National Agricultural Statistics Service*. 2010. Web. 06 Apr. 2011. <http://www.nass.usda.gov/Statistics_by_Subject/result.php?182BEBE5-43CC-3395-AB40-946C9BAD36F2>.
[389] "ERS/USDA Briefing Room - Corn: Background." *USDA Economic Research Service - Home Page*. 18 Feb. 2009. Web. 05 Apr. 2011. <http://www.ers.usda.gov/Briefing/Corn/background.htm>.

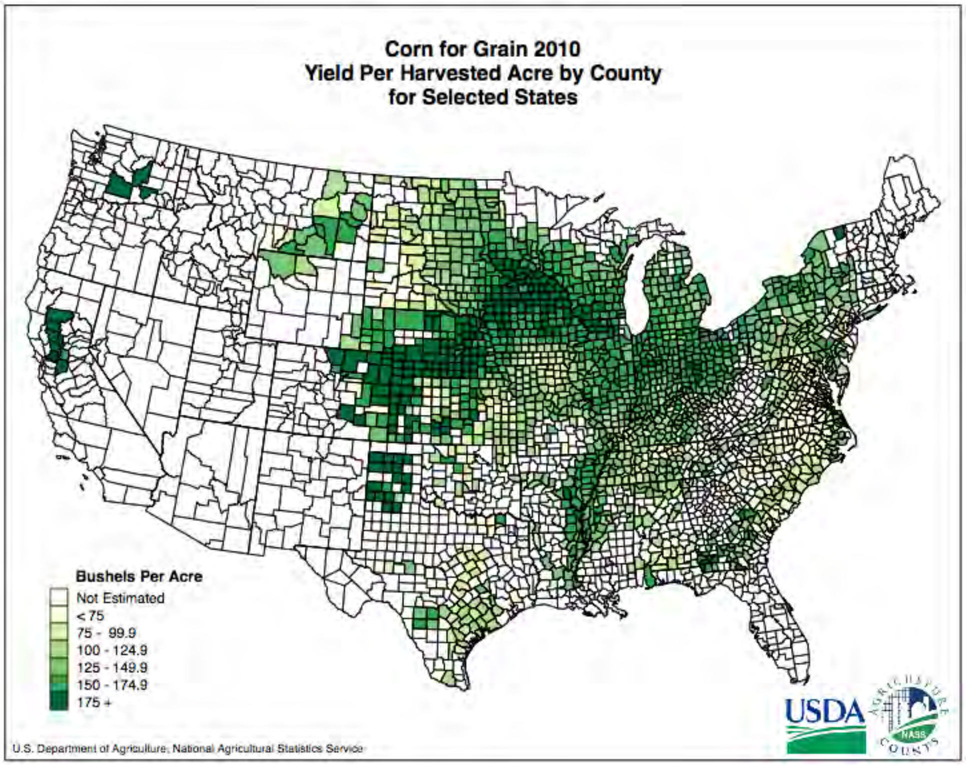

Figure 23: USDA map of yield per harvested acre by country for the year 2010

Fertilizer Use

Data provided by the Agricultural Resource Management Survey (ARMS) from 2005 on the application of fertilizer on corn in the United States are listed below. On average, 137.027 pounds of nitrogen (N), 57.627 pounds of phosphate (P_2O_5), and 82.626 pounds of potash (K_2O) per treated acre were applied. The recommended rates of fertilizer application for maximum yield are:

- Nitrogen: 170 kilograms per hectare (151.67 pounds per acre)
- Phosphate: 54 kilograms per hectare (48.17 pounds per acre)
- Potash: 78 kilograms per hectare (69.6 pounds per acre)

These values were used in our calculations because of their applicability to a broad range of environments in which corn is grown.

Irrigation

According to the 2005 ARMS report, roughly 9,539,000 acres of corn are on irrigated land currently. About ten percent of those acres are irrigated with surface water, the remaining ninety percent using a ground water source. The water applied per irrigated acre is about 12.5 inches.[390] An ERS report that uses 1996 ARMS data concludes that there is a wide range of irrigation practices used to bring water to field corn crops. These methods are grouped into four categories according to their potential for water conservation: gravity-flow application systems

[390] United States Department of Agriculture Economic Research Service. *ARMS Farm Financial and Crop Production Practices: Customized Data Summaries from ARMS*. United States Department of Agriculture, 10 Nov. 2010. Web. 14 Mar. 2011. <http://www.ers.usda.gov/Data/ARMS/app/default.aspx?survey=CROP#startForm>.

(42% of irrigated acres), basic sprinkler systems (19% of irrigated acres), improved sprinkler systems (39% of irrigated acres) and other technologies. Gravity-flow application systems consist of furrow systems, border (or flood) systems, and uncontrolled flooding. These systems rely on land contours to bring water down-slope in lined or unlined trenches or ridges. Improved gravity flow systems include field leveling (eliminating variation in topography), level basin systems (level, enclosed field that receives high volumes of water to ensure uniform infiltration rates). Other systems are surge flows, cablegation, alternate furrow irrigations, special furrows and tailwater reuse.[391]

Sprinkler systems include center-pivot sprinklers, hand move sprinklers, stationary or solid set sprinklers, big gun systems, and side-roll, wheel-move systems. Improved sprinkler systems include improved center pivots (which reduce water losses and energy needs), linear or lateral-move systems low-energy precision application methods (similar to center-pivot), low flow irrigation (drip and trickle systems), and micro sprinklers.[392]

As of 2005, 1,866,027 acres of corn were planted on farms that use gravity irrigation systems, 79,997,864 acres of corn were planted on farms that use pressure irrigation systems (sprinklers), and 66,606,106 acres of corn were planted on farms that use no irrigation system.[393]

Mechanization

Machinery used in the life cycle of corn consists of the following: tractor, plow (moldboard, disk, chisel, or a disk harrow), field cultivators, irrigation equipment, grain elevators and silos for storage, and trucks, barges, and railroad for transport.[394] The most recent data available regarding tillage practices for field corn was released in 2008 by the Conservation Technology Information Center. The data was published in an updated Crop Residue Management Survey from 2004. This update shows that of the total planted corn acreage in 2008 (83,085,042 acres), 21 percent used no-till methods, 1.4 percent used ridge-till methods, 17.8 percent used mulch-till methods, 24.3 percent used reduced-till methods, and the remaining 35.5 percent used intensive-till methods.[395]

Processing

Corn for grain can be processed in two different ways: wet-milling or dry-milling. The following processes for wet and dry-milled corn are taken from a report, coupled by a presentation given by the Minnesota Corn Growers Association at a technology symposium in 2001. Wet-milled corn has become an important ingredient in feed formulas. Beginning with a drop off at the corn facility, the corn is loaded into elevator bins through a cleaning system,

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[391] Christensen, Lee A. *Soil, Nutrient, and Water Management Systems Used in U.S. Corn Production*. Rep. no. AIB-774. Economic Research Service/United States Department of Agriculture. nd. Web. 19 Apr. 2011. <http://www.ers.usda.gov/publications/aib774/aib774.pdf>.

[392] Christensen, Lee A. *Soil, Nutrient, and Water Management Systems Used in U.S. Corn Production*. Rep. no. AIB-774. Economic Research Service/United States Department of Agriculture. nd. Web. 19 Apr. 2011. <http://www.ers.usda.gov/publications/aib774/aib774.pdf>.

[393] United States Department of Agriculture Economic Research Service. *ARMS Farm Financial and Crop Production Practices:Customized Data Summaries from ARMS*. United States Department of Agriculture, 10 Nov. 2010. Web. 14 Mar. 2011. <http://www.ers.usda.gov/Data/ARMS/app/default.aspx?survey=CROP#startForm>.

[394] "Soil Preparation | Ag 101 | Agriculture | US EPA." *US Environmental Protection Agency*. 9 Sept. 2009. Web. 02 May 2011. <http://www.epa.gov/agriculture/ag101/cropsoil.html>.

[395] Conservation Technology Information Center. *CTIC - CRM Results*. Rep. nd. Web. 6 May 2011. <http://www.ctic.purdue.edu/crm_results/>.

conveyed into steep tanks, where the stalks are soaked for 30-50 hours at 120-130 degrees Fahrenheit in a dilute sulfur dioxide solution. This results in the softening of the corn. During the soak, nutrients from the corn are absorbed into the water, which is later evaporated to concentrate the nutrient extracts. Following the removal from the steep tanks, corn germ is removed from the kernel and processed to recover the oil. The remaining portion of the germ is collected for feed use. Once the germ has been fully removed, the rest of the kernel is screened to remove the bran, which leaves starch and gluten proteins behind. The bran is then combined with other products to make Corn Gluten Feed. The Corn Gluten Feed is sent to centrifugal separators that cause a separation between light and heavy starches. In total, wet-milling produces four major co-products for feed: starch, gluten feed, gluten meal, and corn oil.[396]

The standard process for dry-milled corn starts the same way as wet-milled corn: by the arrival of shelled corn to the processing facility. After quality check procedures, the corn is cleaned and hammer milled to a medium-coarse to fine grind. The corn is now ready to be milled and fermented. The process of milling and fermentation, though mechanically quite simple, is chemically complex. For the purposes of this report, the chemical processes associated with dry-milling are not described in detail. The grind undergoes the process of liquefaction, wherein water with a pH of 5-6 and a temperature of 180-195 degrees Fahrenheit is added to turn the cornstarch into dextrin (long chain sugars). After liquefaction, corn is then cooked and cooled to ninety degrees Fahrenheit, and sent to a fermentation vessel that converts dextrin into dextrose (a simple sugar). Yeast species, *Saccharomyces cerevisiae*, are added to convert dextrose into ethanol and carbon dioxide. Fermentation is finished in 40-60 hours. The mix is sent to a distillation area to be stripped of ethanol. Protein, fat and fiber (now collectively called whole stillage) are also collected at this time, centrifuged, and separated by coarse solids and thin stillage (liquid). The stillage can be recycled to the beginning of the dry-milling process, or evaporated to collect the concentrated remains for *Corn Condensed Distillers Solubles*. These, and the remaining coarse solids, are mixed and dried in a rotary dryer to form feed.[397]

Transportation

Domestic transportation of corn is dominated by truck transport. Other modes of transportation include rail and barge. In 2004, 3,338,000 tons were transported by barge, nearly 60,000,000 tons by rail, and a staggering 125,214,000 tons by truck.[398] Because of the dramatic increases in harvested acreage, we assume that these numbers have subsequently risen as well. For the purposes of this study, and because the majority of domestic shipments are done in this way, we assume that the main form of transportation is done by truck. Grains can be transported

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[396] Davis, Kelly S. *Corn Milling, Processing and Generation of Co-products*. Proc. of Minnesota Nutrition Conference, Minnesota. St. Paul: University of Minnesota, 2001. Distillers Grains By-prodcuts in Livestock and Poultry Feeds, 11 Sept. 2001. Web. 28 Apr. 2011. <http://www.ddgs.umn.edu/articles-proc-storage-quality/2001-Davis-%20Processing.pdf>.

[397] Davis, Kelly S. *Corn Milling, Processing and Generation of Co-products*. Proc. of Minnesota Nutrition Conference, Minnesota. St. Paul: University of Minnesota, 2001. Distillers Grains By-prodcuts in Livestock and Poultry Feeds, 11 Sept. 2001. Web. 28 Apr. 2011. <http://www.ddgs.umn.edu/articles-proc-storage-quality/2001-Davis-%20Processing.pdf>.

[398] Marathon, Nick, Tamara VanWechel, and Kimberly Vachal. "Transportation of U.S. Grains A Modal Share Analysis, 1978-2004." United States Department of Agriculture, Agricultural Marketing Service, Transportation and Marketing Programs, Transportation Services Branch, 2006. Web. 29 Apr. 2011. <http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5049160&acct=atpub>.

in bags loaded onto pallets, in lined containers with canvas tops,[399] or in bulk using pneumatic trailers.[400]

Scale

According to the 2007 Census of Agriculture, corn farms in the U.S. constituted for 16% of all crops, and accounted for 259,065,885 acres of the total 922,095,840 acres of total U.S. farm land.[401] As seen in Table 42 below, the average size of a U.S. corn farm is 374 acres.

Table 42: U.S. Corn farm size, 2007

	UNIT	ALL FARMS	CORN FARMS
FARM NUMBERS			
Total Farms	#	2,204,792	347,760
Percent of All Farms	%	100	16
Land in Farms	Acres	922,095,840	259,065,885
Average Size of Farm	Acres	418	745
Average Land in Principal Crop	Acres		248
New Farms (began since 2003)	#	291,329	21,564
Percent of All Farms	%	13	6
Land in Farms	Acres	58,431,799	8,060,864
Average Size of Farm	Acres	201	374

Toxicity Information

As reported from ARMS aggregate data from 2005 the total percentage of planted acres treated with any sort of pesticide (herbicide or insecticide) was about 95 percent. The percentage of acreage treated with insecticide is 24.8 percent, with an average of .585 pounds per acre. This could be because of the increased use of Bt corn in the United States. The percentage of acres treated with herbicide is 94.8 percent with an average treatment size of about two pounds per acre.[402] The following pesticides are applied commonly to corn: acetohlor, atrazine, S-Metolachlor, Mesotrione, 2,4-D (all herbicides), Terbufos, Bifenthrin, Cyfluthrin, Zeta-

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[399] Frittelli, John F. *Grain Transport: Modal Transport and Infrastructure Implications*. Rep. no. RL32720. CRS Report For Congress, 5 Jan. 2005. Web. 26 Apr. 2011. <http://www.nationalaglawcenter.org/assets/crs/RL32720.pdf>.

[400] *Comprehensive Truck Size and Weight Study*. Rep. no. FHWA-PL-00-029. Vol. 2. United Stated Department of Transportation. *Comprehensive Truck Size and Weight Study*. US Department of Transportation, Aug. 2002. Web. 1 Apr. 2011. <http://www.fhwa.dot.gov/reports/tswstudy/tswfinal.htm>.

[401] "2007 Census of Agriculture Farm Numbers, Demographics, Economics." *http://agcensus.usda.gov*. n.d. Web. 21 Feb. 2011. <www.agcensus.usda.gov/Publications/2007/Online_Highlights/Custom_Summaries/Data_Comparison_Major_Crops.pdf>.

[402] United States Department of Agriculture Economic Research Service. *ARMS Farm Financial and Crop Production Practices:Customized Data Summaries from ARMS*. United States Department of Agriculture, 10 Nov. 2010. Web. 14 Mar. 2011.

cypermethrin, and Esfenvalerate, though the list is longer than demonstrated here.[403] The USDA Pesticide Data Program found 15 pesticide residues on corn for grain as well, including malathion, chlorpyrifos, permethrin, metalaxyl, and heptachlor epoxide.[404]

Biodiversity

The use of genetically engineered (GE) crops has been hotly debated since the Reagan Administration gave the USDA, the EPA and the FDA the liberty to set regulations for the use of GE crops in 1987.[405] Corn is one of the major U.S. crops that has seen a significant rise in the percentage of GE crops planted since they were made available to farmers in 1996 – herbicide tolerant (HT) corn reached 70 percent of U.S. corn planted in 2010 and insect-resistant (Bt) corn reached a total of 63 percent of all U.S. corn planted in 2010. In a 2001-2003 survey conducted by the USDA, between 59-79 percent of farmers said they used corn to increase crop yield through pest control, save time, and decrease pesticide costs. [406]

Although there have been no known ecological catastrophes as a result of using GE crops, there are concerns in the scientific community about the overall sustainability of their use. The greatest biodiversity concerns for using GE corn was addressed in 2000 when the worry that Monarch butterfly populations were declining because of pesticides contained in a particular strain called Event 176.[407] Although the toxins in this pollen were significant enough to harm monarch populations, it was not a popular strain, and was therefore easy to remove from the public market.

Another factor to consider is maintaining soil quality and biodiversity in the soil through crop rotation. Corn crops are rotated to improve fertility by including nitrogen-fixing legumes (often soybeans) into crop rotations to lower dependence on commercial nitrogen use, to control insects, diseases and weeds, reduce soil erosion and loss of soil nutrients, and to promote crop diversification.[408] A two-year corn-legume crop rotation is used heavily in the Corn Belt.[409] In 2005, nearly 45,986, 876 thousand acres of corn crops planted were preceded by soybean

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[403] Toxic Free NC, *Pesticides Commonly Used on Corn*. Toxic Free NC, nd. Wed. 01 May 2011. <http://www.toxicfreenc.org/informed/pdfs/corn_chems.pdf>.

[404] "What's On My Food :: Pesticides on Corn Grain." *What's On My Food? :: Pesticides On Food*. nd. Web. 06 May 2011. <http://www.whatsonmyfood.org/food.jsp?food=CO>.

[405] Mellon, Margaret, and Jane Rissler. "Environmental Effects of Genetically Modified Food Crops -- Recent Experiences." *Union of Concerned Scientists - Citizens and Scientists for Environmental Solutions*. 2003. Web. 19 Apr. 2011. <http://www.ucsusa.org/food_and_agriculture/science_and_impacts/impacts_genetic_engineering/environmental-effects-of.html#GENETICALLY_ENGINEERED_CROPS_ON_THE_MARK>.

[406] "ERS/USDA Briefing Room - Agricultural Biotechnology Briefing Room: Adoption of Biotechnology and Its Production Impacts." *USDA Economic Research Service - Home Page*. 1 July 2010. Web. 25 Apr. 2011. <http://www.ers.usda.gov/Briefing/Biotechnology/chapter1.htm>.

[407] Mellon, Margaret, and Jane Rissler. "Environmental Effects of Genetically Modified Food Crops -- Recent Experiences." *Union of Concerned Scientists - Citizens and Scientists for Environmental Solutions*. 2003. Web. 19 Apr. 2011. <http://www.ucsusa.org/food_and_agriculture/science_and_impacts/impacts_genetic_engineering/environmental-effects-of.html#GENETICALLY_ENGINEERED_CROPS_ON_THE_MARK>.

[408] Christensen, Lee A. *Soil, Nutrient, and Water Management Systems Used in U.S. Corn Production*. Rep. no. AIB-774. Economic Research Service/United States Department of Agriculture. nd. Web. 19 Apr. 2011. <http://www.ers.usda.gov/publications/aib774/aib774.pdf>.

[409] Karlen, D. L. "Crop Rotation Effects on Soil Quality at Three Northern Corn/Soybean Belt Locations." *Agronomy Journal* 98.3 (2006): 484-95. United States Deparment of Agriculture, National Agricultural Library, 11 Apr. 2006. Web. 19 Apr. 2011. <http://ddr.nal.usda.gov/bitstream/10113/3824/1/IND43865377.pdf>.

crops.[410] Other rotations are used in corn crops, such as cotton, small grain (oats, wheat, barley and rye), but soybean-corn rotation is the most common.

Packaging

Though there is not one standard way to ship or package grain, information taken from IOM Grain, LLC shares the following information, and we assume that these methods are commonly used throughout the Heartland region. IOM Grain LLC packages corn in one metric-ton tote bags, three ply paper or poly bags at varying weights, bulk domestic trucks, bulk rail, or custom order packaging.[411]

[410] "ARMS Farm Financial and Crop Production Practices: Customized Data Summaries from ARMS." *USDA Economic Research Service - Home Page*. 30 Nov. 2010. Web. 06 May 2011. <http://www.ers.usda.gov/Data/ARMS/app/default.aspx?survey=CROP>.

[411] "IOM Grain | Products." *IOM Grain | Quality Non-GMO Food Grade IOM Soybeans and Corn | Portland, Indiana*. nd. Web. 03 May 2011. <http://www.iomgrain.com/products.asp>.

Corn (Sweet)

We examine whole kernel corn (WKC) in the form of sweet corn because it is a common food item found in each dining hall. The reason we choose to examine whole kernel corn exclusively is in part due to the high number of purchases made by the college; in 2010 alone, AVI ordered a total of 6,383 pounds of whole kernel corn from Bondouelle North America. This is the largest amount of whole kernel corn purchased from one vendor; frozen WKC from Sysco Reliance and is ranked 29th out of 2825 and frozen WKC Grade A from Sysco Classic is ranked 438th and 876th out of 2825 on the list of AVI's 2010 foodstuff purchases by total cost. Wellesley Fresh also purchased 2,200 pounds from a United States vendor, Allen Canning; purchases of WKC and WKC Grade A from Sysco Reliance and Sysco Classic from Allen Canning rank 193rd and 516th out of 2825, respectively. The total amount of WKC purchased from AVI in 2010 is 8,583 pounds. Although AVI purchases ears of corn, petite corn, corn meal and a variety of other corn products, we will not be analyzing these items, or the U.S. sweet corn, because doing so would exceed the scope of this project.

WKC is served in each dining hall facility. Corn is not used in any of the student Co-ops, nor is it sold as an individual item in Collins Café or the Science Center Café. WKC is not sold locally, and, based on AVI's 2010 foodstuff purchasing list, the majority of corn is shipped from Quebec and/or Ontario.

Serving size

According to the USDA, corn is categorized as a starchy vegetable.[412] One serving of whole kernel corn is ½ cup (82g).[413] For women ages 19-30, 3 cups per week is the recommended intake amount.[414] One 30-pound case yields approximately 82½ cups ready-to-serve and tempered (unheated) and roughly 330 ¼-cup servings ready to serve as cooked vegetables.[415] In total, AVI purchased 41,153.75 servings of WKC in 2010.

Farm locations

Corn products ordered from Bonduelle Canada are grown near their plants in southern Quebec near their processing plants in (1) Bedford, (2) Saint-Denis-sur-Richelleu, (3) Saint-Césaire, and (4) Sante-Martine, and in Ontario near (5) Ingersoll, (6) Strathroy and (7) Tecumseh (see Figure 24). We choose to examine those located in Quebec (plants 1-4) because of their proximity to Boston (Figure 25).

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[412] "MyPyramid.gov - Inside The Pyramid - What foods are in the vegetable group?" *MyPyramid.gov - United States Department of Agriculture - Home* . 9 Feb. 2011. Web. 20 Feb. 2011. <http://www.mypyramid.gov/pyramid/vegetables.html#>.
[413] Ibid.
[414] "MyPyramid.gov - Inside The Pyramid - How many vegetables are needed daily or weekly?" *MyPyramid.gov - United States Department of Agriculture - Home* . N.d. Web. 20 Feb. 2011. <http://www.mypyramid.gov/pyramid/vegetables_amount.aspx#>.
[415] "USDA Commodity Food Fact Sheet for Schools & Child Nutrition Institutions." *http://www.fns.usda.gov/fdd/schfacts/FV/A130_CornFrzWholeKernel_30lb.pdf*. 27 Feb. 2009. Web. 21 Feb. 2011. <www.fns.usda.gov/fdd/schfacts/FV/A130_CornFrzWholeKernel_30lb.pdf>.

Figure 24: Image approximates proximity of farm to production plant in Ontario and Quebec

http://www.bonduelle.ca/en/groupe_bonduelle/on_pousse_ici/index.php.

Bonduelle Plants	
Location of Plant	**Distance to Boston (mi)**
Bedford	264
Saint-Denis	339
Saint-Césaire	295
Saint-Martine	233
Ingersoll	571
Strathroy	616
Tecumseh	697

Figure 25: Distance of plants from Boston (note the increased distance between Ingersoll, Strathroy and Tecumseh from Boston)
http://www.bonduelle.ca/en/groupe_bonduelle/on_pousse_ici/index.php.

Fertilizer use

For the purposes of this study, information on fertilizer application amounts from Ontario is used in place of application amounts from Quebec. Because a language barrier impacts the interpretation of Quebec's agricultural statistics and data, we choose to use data from Ontario. We assume that because of the relative proximity, and negligible variations in sweet corn production regionally, that these values are similar enough to justify using agricultural information from Ontario. The recommended amount of nitrogen (N) for sweet corn is 90 kilograms per hectare (80.73 pounds per acre). Depending on the phosphorus levels found in the soil, there recommendations for phosphorous (phosphate P_2O_5) application range from 20 -110 kilograms per hectare (17.86 – 98.23 pounds per acre, see Figure 26).[416] Likewise, recommended application rates for potassium vary depending on the level of potassium (K_2O) measured in the soil. The recommended application amounts for K_2O range is between 30 -170 kilograms per hectare (26.79-151.81 pounds per acre, see Figure 27).[417] These recommended application amounts are intended for maximum sweet corn production per acre.

Soil phosphorus (0.5 M sodium bicarbonate extract) mg P L[1] of soil (ppm P)	Corn, Sweet. corn, sorghum, sunflower
0-3	110 HR
4-5	100 HR
6-7	90 HR
8-9	70 HR
10-12	50 MR
13-15	20 MR
16-20	20 MR
21-25	20 LR
26-30	20 LR

Figure 26: Required phosphorous application levels in kg/ha. HR, MR and LR signify desired high, medium or low crop response levels

[416] "Fertilizer Recommendation Tables - 2010 Revision." *Ontario Ministry of Agriculture, Food and Rural Affairs / Ministère De L'Agriculture, De L'Alimentation Et Des Affaires Rurales De L'Ontario*. June 2010. Web. 01 Apr. 2011. <http://www.omafra.gov.on.ca/english/crops/facts/fert-rec-tables-7.htm>.
[417] Ibid. Fertilizer Recommendation Tables – 2010 Revision.

Soil Potassium (1 M ammonium acetate extract) mg K L^{-1} of soil (ppm K)	Spring barley, mixed grain, spring wheat	Corn, sweet corn, sorghum, sunflower
0-15	90 HR	170 HR
16-30	80 HR	160 HR
31-45	70 HR	140 HR
46-60	50 HR	110 HR
61-80	40 HR	80 MR
81-100	30 MR	50 MR
101-120	20 MR	30 MR
121-150	20 MR	0 LR
151-180	0 LR	0 RR
181-210	0 RR	0 RR
211-250	0 RR	0 RR
250+	0 NR*	0 NR*

Figure 27: Required potassium application rates in kg/ha. Hr, Mr and LR signify desired high, medium or low crop response levels

Application of fertilizer depends on farming practices. Where fall tillage is commonly practiced, phosphate and potassium are applied before tillage, and where spring tillage is practiced, fertilizer is applied in late winter or early spring. Nitrogen is applied in the spring prior to planting, and post emergence if crop loss potential is high. When farmers use irrigation, they often apply sixty percent of nitrogen before planting with subsequent applications of 20-25 kilograms per hectare. All nitrogen will have been applied by two weeks after pollination.[418]

Irrigation

According to research from the University of Minnesota, sweet corn uses different amounts of water throughout its lifetime. The amount of water used depends on air temperature, stage of growth and solar radiation. The greatest daily water use will occur from tassel to harvest, and might even use 0.25 inches over the course of several days (see Table 43).[419]

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[418] The Fertilizer Institute: Fertilizer Facts and Stats - About Fertilize - Maize." *The Fertilizer Institute*. N.d. Web. 26 Feb. 2011. <http://www.tfi.org/factsandstats>

[419] "Sweet Corn (vegetable Crop Management)." *University of Minnesota Extension*. 2011. Web. 01 Apr. 2011.

Table 43: Estimated daily crop water use in inches of evapotranspiration (ET) per day

	Week After Emergence (growth stage)				
	2	6	8	10	12
	(4 Leaf)	(12 Leaf)	(Tassel)	(Pollination)	(Milk)
Air Temperature (°F)	--inches of ET per day--				
50-59	.03	.06	.09	.10	.10
60-69	.04	.09	.12	.15	.14
70-79	.05	.12	.16	.19	.18
80-89	.06	.15	.20	.24	.22
90-99	.06	.18	.24	.28	.26

Canada has recently begun to track its irrigation practices, and little data is available. However, Table 44shows that,[420] despite a decrease in farms reporting for the 2006 census, there was an increase in total irrigation use throughout Canada.

Table 44: Canada total irrigation uses by province. Taken from Canada Agriculture Overview

Agriculture overview, Canada and the provinces - Total irrigation use for calendar year prior to the census, 2005 and 2000

	Total irrigation use					
	2005			2000		
	farms reporting	acres	hectares	farms reporting	acres	hectares
Canada	16,667	2,087,980	844,975	17,204	1,938,465	784,469
Newfoundland and Labrador	33	347	140	51	465	188
Prince Edward Island	55	4,376	1,771	38	1,827	739
Nova Scotia	255	7,949	3,217	300	8,627	3,491
New Brunswick	117	2,122	859	156	2,827	1,144
Quebec	1,305	61,403	24,849	1,307	55,792	22,578
Ontario	2,983	156,445	63,311	3,002	121,752	49,271
Manitoba	241	66,870	27,061	361	69,548	28,145
Saskatchewan	923	169,625	68,645	1,030	169,243	68,490
Alberta	3,817	1,325,929	536,584	4,098	1,233,649	499,240
British Columbia	6,938	292,914	118,538	6,861	274,735	111,181

<http://www.extension.umn.edu/distribution/cropsystems/dc7061.html>.

420 "Farm Data and Farm Operator Data: Agriculture Overview, Canada and the Provinces." *Statistics Canada: Canada's National Statistical Agency / Statistique Canada : Organisme Statistique National Du Canada*. 2010. Web. 02 Apr. 2011. <http://www.statcan.gc.ca/pub/95-629-x/2007000/4182409-eng.htm>.

Mechanization

Sweet corn uses a number of machines for production. Soil for sweet corn usually uses a low or no-till soil preparation. If a low till approach is used, the field is usually tilled only once, using a tractor. Seeds are planted at a shallow depth using a vacuum air planter and harvested using a field-harvester. The product is then transported to processing facilities using trucks.

Processing

When the corn arrives at the Bonduelle processing plants, all stalks are cleaned and washed. Following the cleaning process, they are sliced, trimmed according to need. Next, the corn is blanched at 93 degrees Celsius and quickly frozen to stop the development of its natural enzymes. All corn purchased from Bonduelle is frozen. The process Bonduelle uses is flash freezing. After the vegetables are blanched, they are sent to flash-freezing tunnels with temperatures ranging from -30 degrees Celcius to -35 degrees Celcius. They are then placed in bulk containers and stored in an environment at -18 degrees Celcius.[421]

Transportation

Sweet corn is transported from farms to production plants via truck and likewise distributed after processing and packaging.[422] Sweet corn is transported in refrigerated trucks. The desired transit temperature is 32 degrees Fahrenheit, and the highest freezing point should be 30.9 degrees Fahrenheit. It is recommended that they are loaded in wirebound crates or fiberboard boxes.[423]

Scale

In 2006, Canada reported having a total of 229,373 farms. Of those, 30,675 were located in Quebec, and a total of 10,931,000 hectares (27,011,089 acres) were for corn. Please see Table 45, Table 47, and Table 47 for details on Quebec farms for details regarding scale. In 2006, corn constituted for 6.0 percent of all crops in Quebec.[424]

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[421] "Bonduelle North America - World Leader in Processed Vegetable." *Bonduelle Amerique Du Nord - Leader Mondial Du Légume élaboré*. 2010. Web. 01 Apr. 2011. <http://www.bonduelle.ca/en/groupe_bonduelle/bonduelle/infotransformation-etapes.php#>.

[422] Ibid, Bonduelle North America

[423] Protecting Perishable Foods During Transport By Truck." *www.ams.usda.gov*. N.d. Web. 25 Feb. 2011. <www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3021003&ac

[424] "Farms, by farm type and province (Census of Agriculture, 2001 and 2006)." *Statistics Canada - Summary tables*. N.d. Web. 25 Feb. 2011. <http://www40.statcan.gc.ca/l01/cst01/agrc35f-eng.htm>.

Table 45: Total farm area in Canada, 1996-2006

Total farm area, land tenure and land in crops, by province (Census of Agriculture, 1986 to 2006)
(Canada)

	1986	1991	1996	2001	2006
	number				
Canada					
Total number of farms	**293,089**	**280,043**	**276,548**	**246,923**	**229,373**
Total farm area					
Area in hectares[1]	67,825,757	67,753,700	68,054,956	67,502,446	67,586,739
Farms reporting	293,089	280,043	276,548	246,923	229,373
Average area in hectares per farm reporting	231	242	246	273	295
Total area owned					
Area in hectares[1]	43,218,905	42,961,352	43,060,963	42,265,706	41,377,673
Farms reporting	273,963	264,837	262,152	235,131	220,513
Average area in hectares per farm reporting	158	162	164	180	188
Total area rented or leased from others[2]					
Area in hectares[1]	24,606,852	24,792,348	24,993,993	25,236,740	26,209,066
Farms reporting	118,735	111,387	111,718	103,484	97,989
Average area in hectares per farm reporting	207	223	224	244	267
Land in crops (excluding Christmas tree area)					
Area in hectares[1]	33,181,235	33,507,780	34,918,733	36,395,150	35,912,247
Farms reporting	264,141	248,147	237,760	215,581	194,717
Average area in hectares per farm reporting	126	135	147	169	184

1. Conversion factor: 1 hectare equals 2.471 054 13 acres.
2. Total area rented or leased from others includes land; leased from governments, rented or leased from others and crop-shared from others.
Source: Statistics Canada, Census of Agriculture.
Last modified: 2008-10-31.

Table 46: Total farm area, land tenure and land in crops in Quebec

Total farm area, land tenure and land in crops, by province (Census of Agriculture, 1986 to 2006)
(Quebec)

	1986	1991	1996	2001	2006
	number				
Que.					
Total number of farms	**41,448**	**38,076**	**35,991**	**32,139**	**30,675**
Total farm area					
Area in hectares[1]	3,638,801	3,429,610	3,456,213	3,417,026	3,462,935
Farms reporting	41,448	38,076	35,991	32,139	30,675
Average area in hectares per farm reporting	88	90	96	106	113
Total area owned					
Area in hectares[1]	3,166,015	3,000,832	2,958,514	2,852,881	2,831,857
Farms reporting	39,968	37,169	35,023	30,995	29,677
Average area in hectares per farm reporting	79	81	84	92	95
Total area rented or leased from others[2]					
Area in hectares[1]	472,785	428,778	497,699	564,145	631,078
Farms reporting	10,386	8,932	9,665	10,468	10,534
Average area in hectares per farm reporting	46	48	51	54	60
Land in crops (excluding Christmas tree area)					
Area in hectares[1]	1,744,396	1,638,453	1,738,811	1,849,938	1,933,274
Farms reporting	36,035	31,160	28,676	26,036	23,967
Average area in hectares per farm reporting	48	53	61	71	81

1. Conversion factor: 1 hectare equals 2.471 054 13 acres.
2. Total area rented or leased from others includes land; leased from governments, rented or leased from others and crop-shared from others.
Source: Statistics Canada, Census of Agriculture.
Last modified: 2008-10-31.

Table 47: Area of fruit, berries and nuts, vegetables, sod, nursery and greenhouse products in Quebec

Area of fruit, berries and nuts, vegetables, sod, nursery and greenhouse products, by province (Census of Agriculture, 1986 to 2006) (Quebec)

	1986	1991	1996	2001	2006
Que.					
Total number of farms	**41,448**	**38,076**	**35,991**	**32,139**	**30,675**
Total fruit, berries and nuts					
Area in hectares[1]	15,120	21,622	23,827	24,515	28,244
Farm reporting	2,946	2,399	2,212	1,883	2,013
Percentage of total farms	7.1	6.3	6.1	5.9	6.6
Average area in hectares per farm reporting	5	9	11	13	14
Total vegetables (excluding greenhouse vegetables)					
Area in hectares[1]	32,804	36,575	40,313	43,501	42,223
Farm reporting	3,015	2,634	2,505	2,114	2,052
Percentage of total farms	7.3	6.9	7.0	6.6	6.7
Average area in hectares per farm reporting	11	14	16	21	21

Toxicity Information

In a 2003 study, the Integrated Pest Management Center produced a study on the north central United States, listing critical pesticides for sweet corn. For the purposes of this study, we assume that the critical pesticides are used on a broad scale, including Canadian crops. The critical herbicide used on sweet corn is atrazine. The critical insecticides are pyrethroids. Critical fungicides include Fludioxonil and Mefenoxam (see Table 48). Herbicides are applied to combat three types of threatening weeds: grasses, broadleaves and sedges. Table 48 details the estimated application rates and areas for the United States in 2003. Insecticide is used to combat a number of insects including the European corn borer, the corn earworm, western bean cutworm, and the fall army worm. Insecticide application is dependent on region, local pest problems, and application of fungicides may vary on an annual basis (see Table 49). Fungicides are used to combat seedling diseases and blights, leaf blights, Stewart's wilt and blight, viruses, rust and smut. Table 50 outlines the fungicides, brand names, REI (Restricted Entry Interval – required time between an application and worker entry into a treated field) and PHIs (Pre Harvest Interval – the time required between a pesticide application to a commodity and the harvest of that commodity) and treatment estimations for the United States in 2003.[425] Despite the pesticides used during field crop time, no pesticide residues were found on frozen sweet corn in the United States.[426]

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425 Delahaut, Karen. *Sweet Corn Pest Management Strategic Plan*. Rep. Madison, 2003. Web. 1 Apr. 2011. http://www.ipmcenters.org/pmsp/pdf/NCSweetcorn.pdf

426 "What's On My Food :: Pesticides on Sweet Corn, Frozen." *What's On My Food? :: Pesticides On Food*. 2010. Web. 02 Apr. 2011. <http://www.whatsonmyfood.org/food.jsp?food=CS>.

Table 48: Estimates of application rate of herbicide and area treated in the United States in 2003

Herbicide	Area Applied (%)	Rate/ Application (Lbs/acre)
Atrazine	95	1.07
Metolachlor	35	2.14
Alachlor	10	2.06
Dimethenamid	40	1.17
Bentazon	15-20	.44
Glyphosate	1-5	.51
Nicosulfuron	25-45	.03
2,4-D	10	.35
Simazine	1	1.39
EPTC	<1	3.0
Butylate	<1	4.0
Carfentrazone	25 -45	.008

Table 49: Estimates of application rates of insecticide and area treated in United States in 2003

Insecticide	Area Applied (%)	Rate/ Application	# of applications
Chlorpyrifos	1	1.16	1
Permethrin	30	0.11	3
Tefluthrin	30	0.12	3
Terbufos	1	1.24	1
Cyfluthrin	30	0.006	3
Tebupirimphos	1	0.12	1
Imidacloprid	10	10oz/100# seed	1
Lambda cyhalothrin	50	.02	3
Bifenthrin	30	.02	3
Zeta-cypermethrin	50	.025	3

Table 50: Estimated fungicide application rates and percent of acres treated in 2003

Trade Name	Common Name	REI Hrs	PHI Days	Target Disease	Percent Acres Treated "2003"
Apron	metalaxyl	48	NA	soil borne diseases	99
Bravo	chlorothalonil	48	14		1
Captan 30-DD, Captan 400	captan	96	NA	seed rot, seedling blights, seedborne diseases	20
Gaucho Insecticide	imidacloprid			stewart's wilt	1-5
Maxim 4FS	fludioxonil	48	NA	seedling blights	80
Mancozeb Dithane	Mancozeb	24	7		0
Quadris	azoxystrobin	4	7	Leaf rust and N. Corn leaf blight	10
Tilt	propiconazole	24	14	leaf blights, rust	20

Biodiversity

Currently, many large-scale farming operations mass-produce only a few genetic varieties of each crop used for food. Since 1900, approximately 75 percent of the world's genetic diversity of agricultural crops has been eliminated. Pesticides and the effects of fertilizers on cropland soils contribute to a decrease in biodiversity.[427] Additionally, if sweet corn farms are rotated with leguminous crops, this can interrupt the lifecycle of pests so that they do not become established. In Canada, it is recognized that crop rotation is effective for combating some diseases and managing pests effectively, though it seems that without the added use of pesticides, crop rotation alone is insufficient.[428]

Packaging

Sweet corn from Bonduelle packaging plants is shipped in 30 lb bags, or shipped as a canned good. When it arrives at Wellesley, it is frozen, so we assume for the purposes of this study that the package is a bag. In transit, it is recommended that the packaged corn be loaded in wirebound crates or fiberboard boxes on the truck.[429]

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[427] "Biodiversity, Biodiversity and Mass Production - The Issues - Sustainable Table." *Sustainabletable*. Web. 02 Apr. 2011. <http://www.sustainabletable.org/issues/biodiversity/>.
[428] Howatt, Steve. *Crop Profile for Sweet Corn in Canada*. Rep. Ottawa, 2006. Web Access. 02 Apr. 2011. < http://dsp-psd.pwgsc.gc.ca/collection_2009/agr/A118-10-14-2006E.pdf>.
[429] Protecting Perishable Foods During Transport By Truck." *www.ams.usda.gov*. N.d. Web. 25 Feb. 2011. <www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3021003&ac>.

Section F, item 1

MACHINERY and IMPLEMENT CODES

PLOWS and DISKS

01 Chisel Plow (Big Ox)
02 Coulter Plow
(Coulter Chisel, Soil Saver, Soil Conserver)
03 Deep Ripper
(Knife, Bed knife, Slide)
04 Disk Plow

Moldboard
05 Regular
06 Two Way
07 Stubble-mulch
(Noble, Sweeps, Hoeme Plow, Muckeroy Plow)
08 Subsoiler
(Chisel, Ripper, V-ripper)
09 Disk-chisel
(Mulch Tiller)

Offset Disk
10 Heavy Disk
11 Light Disk
12 One-way Disk
(Disk Tiller)
13 Single Disk

Tandem Disk
14 Plowing
15 Regular
16 Paraplow

PACKERS

51 Culti-packer
(Pulverizer, Crow-foot, Serrated, Ring, Spiral)

Roller-packer
52 Attachment
53 Smooth & Flat

PLANTERS

111 Bedder-shaper Planter
112 Lister-bedder
113 No-till, Minimum Till, (Ripper Planter)
114 Conventional, Regular (Tye, Flex)
115 Air Delivery/vacuum
116 Ridge till

MISCELLANEOUS TILLAGE

61 Land-all, Do-all, Mix-n-till, Till-all
(Disk, Shovels, Reel & Spikes)
62 Mulch Treader, Picker, Treader, Skew
63 Roto-tiller
64 Roterra (Roto-spike, Lely)
65 Sand-fighter
66 Soil Finisher
(Finishing Tool, Mulch Finisher Tri-tiller, Task Master)
67 Root Crown Puller
68 Stalk Puller/Chopper

BEDDERS-SHAPERS

41 Bedder (Shaper)
(Bedshaper, Crowder)
42 Bed Shaper

Disk
43 Hipper
44 Row
45 Float
46 Lister (Middle-buster)
47 Rorovator-bedder
48 Seedbed Roller
(Flat Roller)
49 Sub-soil Bedder
(Ripper-hipper)
50 Discovator

FERTILIZER APPLICATORS

71 Aerial (Airplane)
72 Attachment to implement
73 Manure Spreader
74 Self-propelled
75 Truck Spreader

Tractor Mounted
76 Anhydrous
77 Dry
78 Liquid

Trailer Mounted
79 Anhydrous
80 Dry
81 Liquid

HARROWS (DRAGS)

30 Heavy Harrow
31 Field Conditioner
(Scratcher, Seed Bed Conditioner, Soil Conditioner, Ground Hog)
32 Finishing
(Harrogator, Spiral, Roller, Knives, Shanks, Pegs, Smoother)
33 Flex-tine Tooth
(Coil Tine)
34 Multi-weeder
(Cultivator & Harrow)
35 Rail, Pipe, Log, Plank
36 Rod Weeder
37 Roller (Culti-mulcher, Pulvi-mulcher, Crumbler, Packer-mulcher, Packer & Shanks)
38 Spike Tooth
39 Spring Tooth
40 Powered Spike Tooth Harrow

CULTIVATORS

21 Field Cultivator
(Regular Digger, Triple K, Danish Tined, Swedish Tined, Incorporated, S-tine, Cultivator, Vibra-shank Harrow, Lilliston Tiller
22 Furrow-out
23 Rotary Hoe
(Crust Buster)

Row
24 Disk Sweep, Shovel
25 Rolling, Rotary

Field Cultivator
26 Heavy Duty
(Duckfoot Cultivator)
27 Marker
28 Fallow Master

CHEMICAL APPLICATIONS

91 Aerial (Airplane)
92 Attachment to implement
93 Largest Self propelled
(or Large Truck)
94 Motocycle/atv Sprayer
95 Small Self-propelled
(Spra-coupe, Hi-cycle)
96 Small Truck (Skid Mounted)
97 Tractor Mounted
98 Trailer Mounted

DRILLS and SEEDERS

101 Aerial Seeding
102 Broadcast Seeder

Drill
103 Air Delivery
104 Lister Disk
105 No-till or minimum till
106 Plain
107 Press, Disk or Hoe

HARVESTING EQUIPMENT

Small Grains/Row Crops Combine

121 Hillside
122 Self propelled, 2wd
123 Self-propelled, 4wd
124 Track
125 PTO/motor Mounted

Windrower-swather
126 (Grain/hay)PTO
127 (Grain/hay) self-propelled

133 Corn Picker
134 Hand Harvesting

PTO Power Take-off
WD Wheel Drive

LAND FORMING EQUIPMENT

171 Backhoe
172 Disk Border Maker
173 Ditch Closer
174 Ditcher
175 Levee Plow Disk
176 Quarter Drain Machine
177 Rear Mounted Blade
178 Corrugator
(Furrow Dicer, Dammar Dicer, Dicer)
180 Land Plane Leveler
(Water Leveler)
181 Laser Planer, Laser Leveler
182 Gate Setter
183 Bull Dozer

For implement codes 171 – 183, enter Total Hours Operated in the column labeled Total Acres Covered. Total Acres covered is not meaningful for these implements.

MOWERS and BALERS

141 Amish Harvester

Bale Wagon
142 PTO
143 Self-propelled
144 Bale Loader

Baler
145 Motor Mounted
146 PTO (Large)
147 PTO (Small)
148 Self-propelled
149 Mower-chopper-Rotary
150 Conditioner/PTO
151 Self-propelled
152 Drum disk
153 Flail
154 Sickle

Rake
155 Dump
156 Side Delivery
157 Wheel
158 Stack Mower
159 Stacker, Automatic
160 Front End Loader

OTHER IMPLEMENTS

191 Burn Buggy
192 Chaff/straw Saver
193 Electric-discharge Weed Killer
196 Off-field Thresher
197 Rock Picker
198 Rock Windower or Rake
199 Rodent (Gopher) Killer
200 Roller Groover
201 Rubber-wheeled Weed Puller
202 Flail Shredder
203 Rotary Shredder
204 Silage Harvester
205 Stalk Shredder, Stalk Cutter
206 Swath Roller
207 Tractor or Truck–No attachments
223 Flame Thrower

HAULING EQUIPMENT

Trailers
194 General Purpose Wagon or Cart
195 Hay Wagon
208 Gravity Wagon
209 Grain Cart with Auger
221 Forage Wagon
222 Dump Wagon
220 Other Trailers

Trucks
301 Single Axle
302 Tandem Axle
303 Tri Axle
304 Semi
305 Other Trucks

Figure 28: Machinery and implementation code

Table 51: Production practices on 1996 ARMS corn farms, by region

Table 5–Production practices on 1996 ARMS corn farms, by region

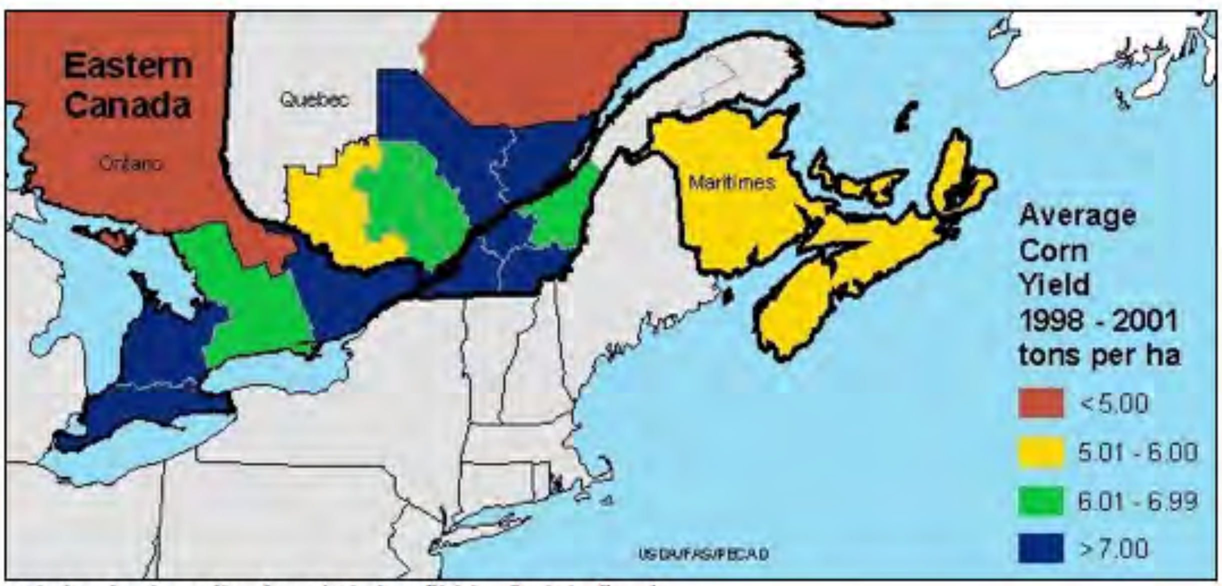
Item	Heartland (*a*)		Northern Crescent (*b*)		Prairie Gateway (*c*)		Southeast[1] (*d*)	
Seeding rate per acre (*kernels*)	27,527	*d*	27,591	*d*	27,264	*d*	24,828	*abc*
Row width (*inches*)	32.0	*d*	31.6	*d*	31.6	*d*	34.4	*abc*
Fertilizer use (*percentage of farms*):								
Nitrogen	96		89		96		94	
Phosphorous	81	*c*	86	*c*	31	*abd*	87	*c*
Potassium	86	*c*	86	*c*	69	*abd*	87	*c*
Manure	20	*bc*	58	*acd*	*7	*abd*	15	*bc*
Test nitrogen level (*percentage of farms*)	14	*bcd*	8	*ac*	41	*abd*	8	*ac*
Use recommended level (*percentage of farms*)	56	*bc*	75	*a*	81	*a*	71	
Fertilizer quantity on reporting farms:								
Nitrogen (*lbs/acre*)	134	*bc*	93	*ac*	159	*abd*	125	*bc*
Phosphorous (*lbs/acre*)	78	*c*	71	*c*	*20	*abd*	73	*c*
Potassium (*lbs/acre*)	60	*c*	52	*c*	36	*abd*	52	*c*
Chemical use (*percentage of farms*):								
Herbicides	97	*bcd*	94	*a*	92	*a*	77	*a*
Insecticides	25	*bcd*	16	*ac*	36	*ab*	15	*ac*
Chemically treated acres on reporting farms:								
Herbicides (*acre-treatments*)	2.7	*bd*	2.4	*a*	2.6		2.0	*ac*
Insecticides (*acre-treatments*)	1.1		1.0	*c*	1.3	*bd*	1.0	*c*
Custom operations (*percentage of farms*):								
Any custom operation	59	*bd*	39	*ac*	65	*bd*	33	*a*
Preparation, cultivation, or planting	9	*bcd*	6	*ad*	*5	*a*	#2	*ab*
Fertilizer/chemical	42	*bcd*	*12	*ac*	22	*ab*	14	*a*
Harvest	20		*18		22		20	
Drying	21	*bcd*	14	*ad*	*12	*ad*	*2	*abc*
Total labor hours per acre	2.5	*bd*	3.5	*ac*	2.4	*bd*	5.1	*ac*
Unpaid	2.4	*bcd*	3.2	*ac*	1.7	*abd*	4.4	*ac*
Paid	.2	*d*	.2	*d*	*.6		.7	*ab*
Farms with paid labor (*percent*)	17	*c*	13	*c*	28	*abd*	*16	*c*
Tillage systems (*percentage of farms*):								
Conventional	67	*c*	73	*c*	56	*abd*	71	*c*
Reduced	27	*bd*	10	*ac*	28	*bd*	*8	*ac*
Conservation	33	*c*	*27	*c*	44	*abd*	29	*c*
No-till	12	*b*	*7	*acd*	*15	*b*	*16	*b*
Machinery:								
Planter width (*rows*)	7.4	*bd*	5.0	*ac*	7.7	*bd*	4.1	*ac*
Harvester width (*rows*)	5.2	*bcd*	3.7	*ac*	6.6	*abd*	3.7	*ac*
Tractor horsepower (*largest used*)	152	*bd*	123	*acd*	163	*bd*	89	*abc*
Speed of tillage/planting operations (*acres/hr*)	8.0	*bcd*	4.9	*ac*	10.2	*abd*	4.2	*ac*
Speed of harvest operations (*acres/hr*)	4.7	*bcd*	2.9	*ac*	7.9	*abd*	2.8	*ac*
Total trips across field (*number*)	8.0		7.9	*c*	8.3	*b*	8.0	
Tillage and planting trips (*number*)	3.3	*bcd*	3.6	*a*	3.8	*a*	4.1	*a*
Drying:								
Bushels dried (*percentage*)	59	*bc*	48	*a*	*25	*ab*	*43	
Moisture removed (*percentage points*)	4.5	*bcd*	2.4	*acd*	*1.1	*ab*	0.8	*ab*

Coefficient of Variation = (Standard Error/Estimate)*100.
** indicates that CV is greater than 25 and less than or equal to 50.*
 # indicates that CV is greater than 50.
a, b, c, d indicates that estimates are significantly different from the indicated group at the 90 percent or better level using the t-statistic.
[1] Southeast includes Eastern Uplands and Southern Seaboard.

Map of Corn Area Distribution in Eastern Canada

agricultural region outlines from: Agriculture Division, Statistics Canada

Map of Corn Yield Distribution in Eastern Canada



agricultural region outlines from: Agriculture Division, Statistics Canada

Figure 29: Maps of corn yield distribution in Canada

Taken from http://www.fas.usda.gov/remote/Canada/can_crn.htm

Table 52: Area of commercial fertilizer, herbicides, insecticides and fungicides applied, by province

Area of commercial fertilizer, herbicides, insecticides and fungicides applied, by province (Census of Agriculture, 1996 to 2006)
(Quebec)

	1996	2001	2006	1996 to 2006	2001 to 2006
	number			% change	
Que.					
Commercial fertilizer					
Area in hectares[1]	991,062	1,001,733	1,043,634	5.3	4.2
Farm reporting	18,871	16,593	14,746	-21.9	-11.1
Percentage of total farms	52.4	51.6	48.1	-8.4	-7.0
Average area in hectares per farm reporting	53	60	71	34.0	18.3

Cracklin Oat Bran

Cracklin Oat Bran (Cracklin) is a popular food choice on campus. Cracklin appears seventh on AVI's 2010 food purchasing inventory by cost. In 2010, AVI purchased 43,193.4 ounces (1,224,501 grams) of the cereal. Cracklin is manufactured exclusively by Kellogg and is distributed in the United States.[430] This makes Cracklin unique from other cereal brands and other cereals purchased from Kellogg. Cracklin is only served in Wellesley's dining halls. Unlike other cereals that could be used in other dishes or desserts, Cracklin is probably only served as a cereal.

Cracklin is a hearty cereal made up of grains. The top six ingredients are whole oats, wheat bran, brown sugar, palm oil, oat bran and corn syrup.[431] Other ingredients include coconut, salt and vitamins.[432] The other ingredients are in small enough quantities that they will not be useful to include in an LCA of this magnitude. In order to distribute the ingredients and allocate inputs accordingly, we are going to assume that 40 percent (489800 grams) of the product is whole oats, 25 percent (306,125 grams) is wheat bran, 15 percent (183675 grams) brown sugar, 10 percent (122,450 grams) palm oil, 10 percent (122450 grams) oat bran.

Serving size

One serving size of Cracklin is ¾ cup or 49 grams (1.8 ounces).[433] AVI purchased 23,996 servings of Cracklin during the 2010 buying period. This equates to 17,998 cups of cereal, 7199 cups of whole oats (1428 pounds[434]), 4499 cups of wheat bran, 2700 cups of brown sugar (1080 pounds[435]), 1800 cups of palm oil and 1800 cups of oat bran. We were unable to find the conversions for wheat and oat bran. Using the conversion of rolled oats for oat and wheat bran[436] and dividing the number by two because bran is lighter than rolled oats, we obtain weights of 179 pounds of oat bran and 446 pounds of wheat bran.

Oats and Oat Bran

For the purposes of this report we will be evaluating oats and oat bran in the same growth and production process. It is nearly impossible to find information to distinguish the growth and production of oats from oat bran.

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430 "Kellogg's Cracklin Oat Bran." *Kellogg*. N.d. Web. 14 Feb. 2011. <http://www2.kelloggs.com/ProductDetail.aspx?id=559>.

431 "Kellogg's Cracklin Oat Bran." *Kellogg*. N.d. Web. 14 Feb. 2011. <http://www2.kelloggs.com/ProductDetail.aspx?id=559>.

432 "Kellogg's Cracklin Oat Bran." *Kellogg*. N.d. Web. 14 Feb. 2011. <http://www2.kelloggs.com/ProductDetail.aspx?id=559>.

433"Kellogg's Cracklin Oat Bran." *Kellogg*. N.d. Web. 14 Feb. 2011. <http://www2.kelloggs.com/ProductDetail.aspx?id=559>.

434 "Oats (rolled oats) amounts converter | Convert to units and culinary measures.." *Online converters for various units and culinary measures to different systems*. N.d. Web. 20 Feb. 2011. <http://convert-to.com/rolled-oats-amounts-converter.html>

435 Sugars - Joyofbaking.com." *Baking & Dessert Recipes & Videos - Joyofbaking.com *Fully Tested Recipes**. N.d. Web. 20 Feb. 2011. <http://www.joyofbaking.com/sugar.html>.

436 "Oats (rolled oats) amounts converter | Convert to units and culinary measures.." *Online converters for various units and culinary measures to different systems*. N.d. Web. 21 Feb. 2011. <http://convert-to.com/rolled-oats-amounts-converter.html>.

Farm Locations

The largest producers of oats internationally are the United Kingdom, Finland, Russian Federation, Sweden and Australia.[437] Canada is not listed as a top producer of oats but they are where the United States receives most of its oats.[438] Most of the oats in Canada are grown in Ontario, Manitoba and Saskatchewan, with the highest production in southern Manitoba.[439] We will assume that a centrally located city such as Winnipeg[440] will serve as an adequate approximation of where oat production occurs. Generally 2.6 tons per hectare are grown in this area.[441]

Fertilizer and chemicals

We assume that application rates are 20 pounds of nitrogen per acre, up to 20 pounds per acre of sulfur, 30 to 40 pounds of phosphate per acre and about 30 pounds per acre of potassium.[442] There are no weed control products on the market for oats in Canada.[443]

Water

Information about oat watering was not available, but rainfall is an important component of oat growing.[444] It seems unlikely that oats do not require any watering other than rainfall, thus we assume that oats are watered in a manner similar to wheat (1.5 to 2 inches on crop).[445]

Oat processing

Whole oats and oat bran production can be broken down into the following steps:[446]

a. Preparation of fields through tiling and possibly fertilizing and herbicide/pesticide
b. Irrigation infrastructure
c. Planting of crop

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[437] "Oats." *FAOSTAT*. N.d. Web. 22 Feb. 2011. <http://faostat.fao.org/site/339/default.aspx>
[438] "U.S. barley and oats imports by selected sources ." *USDA Economic Research Service - Home Page*. 9 Feb. 2011. Web. 23 Feb. 2011. <http://www.ers.usda.gov/data/feedgrains/Table.asp?t=25>.
[439] "Oats." *Agro-Maps*. FAO, n.d. Web. 21 Feb. 2011. <www.fao.org/landandwater/agll/agromaps/interactive/page.jspx >. and "Canada Crop Conditions: Variable across the Prairies." *Production Estimates and Crop Assessment Division Foreign Agricultural Service*. United States Department of Agriculture, n.d. Web. 22 Feb. 2011. <http://www.fas.usda.gov/pecad/highlights/2005/08/Canada_Aug2005/index.htm>.
[440] "Political Map of Manitoba, Canada." *Map of Canada* . N.d. Web. 24 Feb. 2011. <http://www.canadamaps.info/provincemaps/manitoba.htm>.
[441] "Canada Crop Conditions: Variable across the Prairies."
[442] "Oat Production and Management." *Manitoba Agriculture, Food and Rural Initiatives*. Government of Manitoba, n.d. Web. 22 Feb. 2011. <www.gov.mb.ca/agriculture/crops/cereals/bfc01s01.html>; Mask, Paul, Henk W. van Riessen, and Don Ball. "Production Guide For Oats." *Alabama Cooperative Extension*. N.d. Web. 23 Feb. 2011. <www.aces.edu/pubs/docs/A/ANR-0884/ >.
[443] "Oat Production and Management."
[444] Mask, Paul, Henk W. van Riessen, and Don Ball.
[445] Youts, C Dean, Dean Eisenhauer, and David Varner. "Managing Furrow Irrigation Systems." *NebGuide*. University of Nebraska: Lincoln, n.d. Web. 22 Feb. 2011. <www.ianrpubs.unl.edu/epublic/live/g1338/build/g1338.pdf>.
[446] Mask, Paul, Henk W. van Riessen, and Don Ball. "Production Guide For Oats." *Alabama Cooperative Extension*. N.d. Web. 23 Feb. 2011. <www.aces.edu/pubs/docs/A/ANR-0884/ >;Ransom, Joel , Michael S. McMullen, and Dwain Meyer. "Oat Production in North Dakota ." *North Dakota State University*. N.d. Web. 23 Feb. 2011. <www.ag.ndsu.edu/pubs/plantsci/smgrains/a891w.htm >.

d. Additional fertilization or pesticide
e. Watering
f. Harvest by equipment
g. Transportation to processing plant
h. Drying and oat extraction
i. Packaging of oats for transportation
j. Transportation to manufacturing plant

Oats are grown in large fields. Some crop rotation may occur.[447] Field tillage occurs first by a cultivator; usually using a disking method.[448] Chiseling or turning of the soil is next in preparation for direct planting.[449] Direct planting is done with a drill seeder.[450]

Oats are harvested once they reach a specific moisture and color. Oats are harvested with a combine and pickup cut.[451] The oats are then dried to ensure that mold does not grow and to retain a desirable color.[452] Oats can be stored for an extended period of time until they are needed for use. Oat bran is the outer husk of the oat.[453] The oats are husked and the whole oats are separated from the husk or oat bran. Both are moved into large storage units before they are shipped to the Kellogg production facility.

Wheat Bran

Wheat bran is another grain from wheat that is removed during normal production.[454] It is high in fiber and consists of the outer layers of the wheat.[455]

Farm location

The top producers of wheat are the European Union, China, India and the United States.[456] For the purposes of this report, we will assume that the United States is receiving its wheat domestically. According to the FAO, Nebraska, Iowa, Michigan and Ohio are the nation's top producers of wheat.[457] Other sources claim that Kansas, North Dakota, Montana, Oklahoma,

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447 Ransom, Joel , Michael S. McMullen, and Dwain Meyer. "Oat Production in North Dakota ." *North Dakota State University*. N.d. Web. 23 Feb. 2011. <www.ag.ndsu.edu/pubs/plantsci/smgrains/a891w.htm>.
448 Mask, Paul, Henk W. van Riessen, and Don Ball. "Production Guide For Oats." *Alabama Cooperative Extension*. N.d. Web. 23 Feb. 2011. <www.aces.edu/pubs/docs/A/ANR-0884/ >
449 Mask, Paul, Henk W. van Riessen, and Don Ball. "Production Guide For Oats." *Alabama Cooperative Extension*. N.d. Web. 23 Feb. 2011. <www.aces.edu/pubs/docs/A/ANR-0884/ >
450 Mask, Paul, Henk W. van Riessen, and Don Ball. "Production Guide For Oats." *Alabama Cooperative Extension*. N.d. Web. 23 Feb. 2011. <www.aces.edu/pubs/docs/A/ANR-0884/ >
451 Ransom, Joel , Michael S. McMullen, and Dwain Meyer. "Oat Production in North Dakota ." *North Dakota State University*. N.d. Web. 23 Feb. 2011. <www.ag.ndsu.edu/pubs/plantsci/smgrains/a891w.htm>.
452 Mask, Paul, Henk W. van Riessen, and Don Ball. "Production Guide For Oats." *Alabama Cooperative Extension*. N.d. Web. 23 Feb. 2011. <www.aces.edu/pubs/docs/A/ANR-0884/ >
453 Smith, S.E.. "What is Oat Bran?." *WiseGEEK*. N.p., 7 Feb. 2011. Web. 25 Feb. 2011. <http://www.wisegeek.com/what-is-oat-bran.htm>.
454 "WHFoods: Whole wheat." *The World's Healthiest Foods*. George Mateljan Foundation, n.d. Web. 23 Feb. 2011. <http://www.whfoods.com/genpage.php?tname=foodspice&dbid=66>.
455 "WHFoods: Whole wheat." *The World's Healthiest Foods*. George Mateljan Foundation, n.d. Web. 23 Feb. 2011. <http://www.whfoods.com/genpage.php?tname=foodspice&dbid=66>.
456 "Wheat." *Food Outlook- Global Market Analysis*. FAO, n.d. Web. 23 Feb. 2011. <http://www.fao.org/docrep/011/ai482e/ai482e03.htm>.
457 "Wheat." *Agro-Maps*. FAO, n.d. Web. 21 Feb. 2011.

Washington as well as Texas, Colorado, Nebraska, South Dakota and Minnesota are top producers.[458] Nebraska was listed as a top producer in both cases, and therefore we will assume that the wheat used to make Cracklin came from Nebraska. Most of the wheat comes from the south and southwest portions of the state.[459] The wheat is likely coming from near North Platte as that is centrally located between all wheat growing areas.

Fertilizers and Pesticides

Although weed control is not always necessary for wheat, the following products may be used: 2,4-D, Banvel (dicamba), Roundup (glyphosate), and Gramoxone Extra (paraquat).[460] Roundup can be used at 0.38lbs per acre, 2,4-D may be used at 0.62 pounds per acre and Gramoxone can be used at 1.5 to 3 pounds per acre.[461] Neonicotinoid is a popular insecticide to target grasshoppers.[462] Other treatments for insects include Asana, Warrior and Mustang MAX.[463] We assume fertilizer inputs are similar to oats since exact ratios for phosphorus, nitrogen and potassium were not found.

Irrigation

Artificial watering mechanisms must be in place for wheat production. Approximately 1.5 to 2 inches of water is necessary to keep roots moist at all times.[464] Assuming 1.5 to 2 inches of water are applied to 15 percent of an acre each day (607 square meters), 1,214 square inches of water is applied per acre per day.

Wheat processing

Wheat bran production can be broken down into the following steps:[465]

a. Preparation of field- (clearing, tilling, fertilizing, pesticides/herbicides)
b. Irrigation infrastructure
c. Planting by machinery
d. Harvesting of wheat using a combine harvester
e. Threshing to separate head from the rest of the plant
f. Transportation of wheat head to processing
g. Grinding wheat to make wheat bran
h. Packaging of wheat bran

<www.fao.org/landandwater/agll/agromaps/interactive/page.jspx>.

[458] Benson, Garren , and Lance Gibson. "Origin, History, and Uses of Oat (Avena sativa) and Wheat (Triticum aestivum)." *Department of Agronomy* . Iowa State University, n.d. Web. 24 Feb. 2011. <http://www.agron.iastate.edu/courses/agron212/readings/oat_wheat_history.htm>.

[459] Brauer, Caroline . "Nebraska Wheat Crop Report." *Nebraska Wheat*. N.p., 12 Aug. 2010. Web. 24 Feb. 2011. <http://www.nebraskawheat.com/pdfs/Nebraska%20Crop%20Report.pdf>

[460] Ransom, Joel , Michael S. McMullen, and Dwain Meyer. "Oat Production in North Dakota ." *North Dakota State University*. N.d. Web. 23 Feb. 2011. <www.ag.ndsu.edu/pubs/plantsci/smgrains/a891w.htm>.

[461] Ransom, Joel , Michael S. McMullen, and Dwain Meyer. "Oat Production in North Dakota ." *North Dakota State University*. N.d. Web. 23 Feb. 2011. <www.ag.ndsu.edu/pubs/plantsci/smgrains/a891w.htm>.

[462] "Defending New Winter Wheat and Alfalfa Fields from Grasshoppers." *CropWatch: Nebraska crop production & pest management information*. University of Nebraska: Lincoln, 6 Aug. 2010. Web. 25 Feb. 2011. <http://cropwatch.unl.edu/web/cropwatch/archive?articleID=4241640>.

[463] "Defending New Winter Wheat and Alfalfa Fields from Grasshoppers."

[464] Youts, C Dean, Dean Eisenhauer, and David Varner.

[465] Lamb, Robert. "Growing Wheat, the Organism." *Howstuffworks "Science"*. N.d. Web. 23 Feb. 2011. <http://science.howstuffworks.com/environmental/life/botany/wheat1.htm>.

i. Transportation of wheat bran to cereal facility such as Kellogg

Winter wheat is a popular type of wheat that is easily accessible and grown for human consumption.[466] Herbicides are applied with light tillage on a previously grown field.[467] Fields are tilled or plowed using rod wheelers or drag harrows.[468] Once planted, a series of herbicides, pesticides and fertilizers are used concurrently. Harvesting occurs when the grain achieves a desired color and certain moisture levels are obtained (22 percent).[469] Raw wheat is transported off of the field with a method similar to oats. It is then husked and transported to the Kellogg facility to be made into cereal.

Yield

Wheat yield is 50 bushels of wheat per acre.[470] Sixty pounds of wheat are in one bushel.[471]

Production of cereal

Factory location

Kellogg produces its products in 18 countries worldwide.[472] Some of the countries that produce Kellogg products include South Africa, Australia, most of Europe, Canada, Mexico, the United States, as well as most of Asia.[473] Unfortunately Kellogg does not release information about where its cereals are produced.[474] Therefore, we assume that the Cracklin served at Wellesley is produced in the United States and that its inputs are also produced in or near the United States. We assume that cereal production occurs at Battle Creek, Michigan, because this is the location of corporate headquarters and it is known that cereal was produced here in the past.[475] For the purposes of this report, we will assume that cereal production is still occurring there.

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[466] "Types Of Wheat." *Commodity Futures Seasonal Analysis for Traders*. N.p., n.d. Web. 23 Feb. 2011. <http://www.commodityseasonals.com/types_of_wheat.htm>.
[467] Lyon, Drew, and Robert Klein. "Getting Started in Ecofarming: Growing the Winter Wheat Crop." *University of Nebraska–Lincoln Extension Publications*. N.p., n.d. Web. 25 Feb. 2011. <http://www.ianrpubs.unl.edu/epublic/pages/publicationD.jsp?publicationId=555>
[468] Ransom, Joel , Michael S. McMullen, and Dwain Meyer. "Oat Production in North Dakota ." *North Dakota State University*. N.d. Web. 23 Feb. 2011. <www.ag.ndsu.edu/pubs/plantsci/smgrains/a891w.htm>.
[469] Ransom, Joel , Michael S. McMullen, and Dwain Meyer. "Oat Production in North Dakota ." *North Dakota State University*. N.d. Web. 23 Feb. 2011. <www.ag.ndsu.edu/pubs/plantsci/smgrains/a891w.htm>.
[470] rank, Gary . "Cost of Production versus Cost of Production." *University of Wisconsin-Madison*. N.p., 17 Aug. 1988. Web. 23 Feb. 2011. <cdp.wisc.edu/pdf/cstvscst.pdf>.
[471] "U.S. Commercial Bushel Sizes." *The University of North Carolina at Chapel Hill*. N.p., n.d. Web. 24 Feb. 2011. <http://www.unc.edu/~rowlett/units/scales/bushels.html>.
[472] "Our Company." *Kellogg Company*. N.d. Web. 13 Feb. 2011. <http://www.kelloggcompany.com/company.aspx?id=32>
[473] "Our Company." *Kellogg Company*. N.d. Web. 13 Feb. 2011. <http://www.kelloggcompany.com/company.aspx?id=32>
[474] "Kellogg's Cracklin Oat Bran." *Kellogg*. N.d. Web. 14 Feb. 2011. <http://www2.kelloggs.com/ProductDetail.aspx?id=559>.
[475] "Contact Us." *Kellogg Company*. N.d. Web. 14 Feb. 2011. <http://www2.kelloggs.com/ContactUs.aspx>.

We assume that all of the ingredients are shipped to the factory in Michigan. All of the ingredients, as described below, can easily shipped from within the United States or across its boarders. After the raw ingredients arrive at the factory the cereal is manufactured there.

Processing

Cereal production can be broken down into the following steps:[476]

a. Raw ingredients are delivered to factory
b. Ingredients cleaned
c. Oat is hulled (impact huller)
d. Groat processed
e. Steamed (oats stored in cylinder containers and are steamed to 200-212 degree. Goats need to be up to 10-12% water.)
f. Flaking
    i. Mixing
    ii. Cooking
    iii. Drying
    iv. Cooling/Tempering
    v. Dryer/Toaster
g. Dry cereal is put in plastic bags and bags are put into boxes.
h. Boxes are bundled together.
i. Shipped from plant to distribution center by truck.
j. Shipped from distribution center to intermediate locations and final location by truck.

Once ingredients enter the factory, they need to be cleaned. For washing the ingredients, we assume a 50:50 ratio for water to dry ingredients of oats, wheat bran and oat bran. The brown sugar and palm oil do not need to be washed. An impact huller separates the oat. A smaller sized huller used as an example does not require any water inputs but energy inputs.[477] The groat process includes separating out the groat by size. The groats are then steamed. Steaming groats is similar to cooking oatmeal. On the industrial level it is more of a steaming process to increase the moisture content.[478] All the ingredients are combined with the palm oil, brown sugar and other less abundant ingredients. They are mixed, cooked, dried through cooling and tempering. They are dried at approximately 250 degrees Fahrenheit.[479]

Packaging

Cereal is packaged into plastic bags which are then put into preprinted cardboard boxes. Cereal is available in 17 ounce bags which are then put into larger boxes with either one or two bags per box.[480] The cereal boxes are packaged together in crates or pallets and moved from their location to Wellesley via truck.

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[476] "Cereal Breakfast Food." *United States EPA*. N.d. Web. 22 Feb. 2011. <www.epa.gov/ttn/chief/ap42/ch09/final/c9s09-2.pdf>.
[477] "Model 15-D Impact Huller." *Forsberg*. N.d. Web. 23 Feb. 2011. <www.huntsmaninc.com/pdf/15-d-ih.pdf>.
[478] "Cereal Breakfast Food." *United States EPA*. N.d. Web. 22 Feb. 2011. <www.epa.gov/ttn/chief/ap42/ch09/final/c9s09-2.pdf>.
[479] "Cereal Breakfast Food." *United States EPA*. N.d. Web. 22 Feb. 2011. <www.epa.gov/ttn/chief/ap42/ch09/final/c9s09-2.pdf>.
[480] "Kellogg's Cracklin Oat Bran." *Kellogg*. N.d. Web. 14 Feb. 2011.

Energy use

All of the processes require the use of energy. We unfortunately do not know how energy intensive each step is for the desired amount of cereal.

Toxicity

It is not known what chemicals are involved in the packaging and process of making cereal. This past summer Kellogg had to remove some of its products from shelves due to food poisoning symptoms stemming from the use of 2-methylnaphthalene.[481] This product is on the market but it is not known how it impacts human health.[482] Other parts of the production of cereal can result in the emission of volatile organic compounds during drying, steaming or cooking. Air pollution problems can also occur during the hulling process.[483]

<http://www2.kelloggs.com/ProductDetail.aspx?id=559>.

[481] Layton, Lyndsey . "U.S. regulators lack data on health risks of most chemicals." *Washington Post*. N.d. Web. 25 Feb. 2011. <http://www.washingtonpost.com/wp-dyn/content/article/2010/08/01/AR2010080103469.html?hpid=topnews>

[482] Layton, Lyndsey . "U.S. regulators lack data on health risks of most chemicals." *Washington Post*. N.d. Web. 25 Feb. 2011. <http://www.washingtonpost.com/wp-dyn/content/article/2010/08/01/AR2010080103469.html?hpid=topnews>

[483] "Cereal Breakfast Food." *United States EPA*. N.d. Web. 22 Feb. 2011. <www.epa.gov/ttn/chief/ap42/ch09/final/c9s09-2.pdf>.

Cranberry Blast Concentrate

Dining services purchases 1,656 liters of Cranberry Blast Concentrate, produced by Sysco and distributed by Dispenser Services Inc. Sysco is a national producer and its distributor, Dispenser Services, is headquartered in Charleston, SC, and operates through its district office in Waltham. Although Sysco's recipe is not available, the major competitor in the cranberry market, Ocean Spray, which controls 65% of international cranberry production, makes a similar product. The Ocean Spray recipe consisted of: filtered water, cranberry juice, sugar, and ascorbic acid (Vitamin C). Sysco's recipe likely does not deviate significantly. For water, please see the analysis of bottled water, until the bottling step. For sugar, see the pertinent section in the cookie dough analysis. Ascorbic acid is not included in this analysis because it only composes 2.057^{-5} percent per serving of unsweetened juice, so sweetened juice contains even less per cup (.0057 grams per 227 grams).[484] The USDA-recommended serving size for juices of all kinds is one cup, so dining services purchases 6,999.5 servings total.[485]

Farm Location

The US produces 82% of the world's cranberries, most of which (56%) is grown in Wisconsin.[486] According to the Wisconsin State Cranberry Growers Association, three counties including Wood, Monroe, and Jackson lead in acreage devoted to cranberry cultivation.[487]

Fertilizer Use

While cranberries require much less input than most other agricultural crops, young shoots are supplied with around 10 pounds (or up to 20 pounds) of nitrogen per acre; 45 pounds of P205 and less than 200 pounds of potash per acre per year are also applied.[488] Cranberry nutrient uptake rates are highly variable, and growers usually submit tissue tests midseason to determine appropriate application rates for their particular crop.[489]

Irrigation

Cranberry cultivation requires access to significant quantities of water, approximately seven to ten feet of water per acre per year. When new fields are irrigated, they are usually supplied with surface water, diverted from nearby lakes, streams, etc, supplied by dikes and surface or buried sprinkler irrigation to maintain ideal growth conditions. Irrigation consumes an

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484 "Cranberry juice, unsweetened Nutrition Facts and Analysis for Cranberry juice, unsweetened ." *Nutrition facts, calories in food, labels, nutritional information and analysis* . Condé Nast Publishers, n.d. Web. 25 Feb. 2011. <http://nutritiondata.self.com/facts/fruits-and-fruit-juices/7678/2>.

485 US Department of Agriculture, and US Department of Health and Human Services. "Dietary Guidelines for Americans 2010." *Dietary Guidelines for Americans*. USDA Center for Nutrition Policy and Promotion, 31 Jan. 2011. Web. 20 Feb. 2011. <http://www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/PolicyDoc/PolicyDoc.pdf>.

486 Rieger, Mark. "Cranberry." *Fruit Crop Home Page*. Department of Horticulture, University of Georgia. N.d. Web. 20 Feb. 2011. <http://fruit-crops.com/cranberi/>.

487 Roper, T. R. "Cranberry Production in Wisconsin." *Wisconsin Cranberries*. Wisconsin State Cranberry Growers Association. N.d. Web. 20 Feb. 2011. <http://www.wiscran.org/user_image/pdf_files/CranProduction08.pdf>.

488 Roper, T. R. "Cranberry Production in Wisconsin." *Wisconsin Cranberries*. Wisconsin State Cranberry Growers Association. N.d. Web. 20 Feb. 2011. <http://www.wiscran.org/user_image/pdf_files/CranProduction08.pdf>.

489 Hart, John, Joan Davenport, Carolyn DeMoranville, and Teryl Roper. "Nitrogen for Bearing Cranberries in North America." North American Cranberry Research and Extension Workers, June 2000. Web. 20 Feb. 2011. <http://extension.oregonstate.edu/catalog/pdf/em/em8741.pdf>.

inch of water per week, and bogs are flooded for harvest and winter protection to the depth of one foot. Massachusetts cranberry production uses 41.3 to 44.9 billion gallons of water per year. Wisconsin produces more than twice as many cranberries as Massachusetts, so statewide water usage is likely to be around 100 billion gallons annually.[490]

Mechanization

Mechanized processes begin with clearing and leveling the field. Most cranberries are no longer grown in natural bogs, so fields are cleared to a depth of 18 inches above the water table, and covered with a 4-8 inch-deep layer of sand, requiring tractors and dump trucks. Once the sand substrate is established, it is tilled with a disking attachment. New cranberry plants are transplanted using a transplanter, another attachment. Depending on the scale of the bog, fertilizer can be applied by helicopter, by ground rig, through the irrigation system, or manually.[491] Contrary to popular conception, cranberries are not grown in water; the fields are flooded only at harvest, because cranberries float. A tractor-mounter beater and slipper remove berries from vines, and then the berries float to the surface and are corralled into a truck using a pump. (Although bogs spend little time flooded, decomposing organic material in cranberry bogs does produce some methane.)[492] Over the winter, the flooded field freezes, after which dump trucks deposit a thick layer of sand over the bog to insulate and re-root the crop in spring once the ice melts.[493]

Processing

Berries are cleaned, sorted, crushed, concentrated and frozen. According to the FAO, "A coarse chopping followed by paddle or screw finisher with ~5 mm screening will produce a thick seed and skin containing pulp suitable for juicing. A macerating enzyme treatment, hot press and water extraction of the press cake optimize yield. The extract can be combined with the press juice or concentrated separately."[494]

Transportation

Fresh cranberries, once pumped into trucks, are shipped to processing centers in 1000-pound boxes on wooden pallets. A truck can handle 6 to 8 pallets.[495] The average Wisconsin cranberry travels 35 miles to a processing plant.[496] Once combined with the other ingredients

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490 Cape Cod Cranberry Growers' Association. "Cranberry Water Use." Cape Cod Cranberry Growers' Association Cranberry Watershed Education Initiative, June 2001. Web. 20 Feb. 2011. <http://www.cranberries.org/pdf/wateruse.pdf>.

491 Cape Cod Cranberry Growers' Association. "Fertilizer Use in Cranberry Production." Cape Cod Cranberry Growers' Association, May 2005. Web. 20 Feb. 2011. <http://www.cranberries.org/pdf/soil_fertility.pdf

492 Cape Cod Cranberry Growers' Association. "Cranberry Crop Monitoring Program." K Laboratories, Inc, Oshkosh, WI. N.d. Web. 20 Feb. 2011. <http://www.kaglab.com/Services/cranberry/monitor.htm>.

493 Roper, T. R. "Cranberry Production in Wisconsin." *Wisconsin Cranberries*. Wisconsin State Cranberry Growers Association. N.d. Web. 20 Feb. 2011. <http://www.wiscran.org/user_image/pdf_files/CranProduction08.pdf>. 2.

494 Cape Cod Cranberry Growers' Association. "Berries." *Principles and Practices of Small-and Medium-scale Fruit Juice Processing*. Food and Agriculture Organization of the United Nations. N.d. Web. 21 Feb. 2011. <http://www.fao.org/Docrep/005/Y2515e/y2515e16.htm#TopOfPa>.

495 Hewitt, T. "Oregon Cranberry Harvest." *Port Orford, Oregon - Gateway to America's Wild Rivers Coast*. Town of Port Orford, OR. N.d. Web. 21 Feb. 2011. <http://www.portorfordoregon.com/bogtour.html>.

496 Colquhoun, Jed, and Heidi Johnson. "Sustainable Cranberry Production for a Vibrant Future: the Wisconsin Experience." Horticulture Department, University of Wisconsin-Madison. N.d. Web. 20 Feb. 2011. <http://www.cals.wisc.edu/downloads/SustainableCranberry.pdf>.

into Cranberry Blast, the concentrate is shipped frozen to the distributor in Waltham, and from there to Wellesley. According to the Brazilian Association of Citrus Exporters, the most efficient way to ship frozen juice concentrate via refrigerated container trucks.[497]

Scale

There are around 250 cranberry growers in Wisconsin, with 17,700 acres in cultivation. The average cranberry farm is 70.8 acres in total.[498]

Toxicity

Eighty-eight percent of cranberry growers use non-chemical pest management, including IPM. For the other 12 percent of producers, there is a long list of pesticides approved for use in cranberry production.[499] It does not appear that Sysco is certified organic, so it is likely that the cranberry growers from whom they source their juice use some of the many pesticides available to cranberry growers.[500]

Biodiversity

Because they rely so heavily on nearby surface and groundwater sources for water, traditional cranberry bogs have destroyed about 15,000 acres of former Wisconsin wetland through flooding, drainage, and pollution. Although many species of fish and birds continue to live in former or newly-created bogs, fluctuations in the water level are not conducive to stable wildlife populations, and the focus on a single species does not encourage biodiversity.[501] In response, the state has tightened restrictions on licenses required to expand cranberry cultivation. Additionally, management of surrounding land not used for cranberry cultivation has been effective in protecting natural habitats and biodiversity. According to the Wisconsin State Cranberry Growers Association, "Wisconsin cranberry growers also own and manage an additional 120,000+ acres, resulting in a ratio of roughly seven acres of support lands per acre of planted vines. Much of this acreage includes wetlands and woodlands which are inaccessible, providing undisturbed sites for birds and animals to feed, nest, and rear their young."[502]

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[497] Brazilian Association of Citrus Exporters. "Shipping Concentrated Juice in Bulk." *Transportation and Logistics*. Brazilian Association of Citrus Exporters, 2009. Web. 21 Feb. 2011. <http://www.citrusbr.com/en/citric-exporters/sector/transport-and-logistics-155688-1.asp>.
[498] Colquhoun, Jed, and Heidi Johnson. "Sustainable Cranberry Production for a Vibrant Future: the Wisconsin Experience." *Horticulture Department, University of Wisconsin-Madison*. N.d. Web. 20 Feb. 2011. <http://www.cals.wisc.edu/downloads/SustainableCranberry.pdf>.
[499] University of Wisconsin Cooperative Extension. Web. "Insecticide Profiles." *Wisconsin Cranberry Crop Management Library*. *University of Wisconsin Cooperative Extension.* N.d. Web. 20 Feb. 2011. <http://www.hort.wisc.edu/cran/>.; McManus, Patricia, Jed Colquhoun, and Roger Flashinski. "Cranberry Pest Management in Wisconsin." University of Wisconsin Cooperative Extension, 2011. Web. 20 Feb. 2011. <http://learningstore.uwex.edu/assets/pdfs/A3276.PDF>.
[500] For an extensive list of pesticides and associated toxities, please see McManus, Patricia, Jed Colquhoun, and Roger Flashinski. "Cranberry Pest Management in Wisconsin." University of Wisconsin Cooperative Extension, 2011. Web. 20 Feb. 2011. <http://learningstore.uwex.edu/assets/pdfs/A3276.PDF>.
[501] Wisconsin Department of Natural Resources. "Environmental Issues Related to Cranberry Production." *American Cranberry (Vaccinium Macrocarpon)*. Wisconsin Department of Natural Resources, 1999. Web. 20 Feb. 2011. <http://www.library.wisc.edu/guides/agnic/cranberry/documents/dnrpaper.html>
[502] Roper, T. R. "Cranberry Production in Wisconsin." *Wisconsin Cranberries*. Wisconsin State Cranberry Growers Association. N.d. Web. 20 Feb. 2011. <http://www.wiscran.org/user_image/pdf_files/CranProduction08.pdf>. 8.

Packaging

Fresh cranberries are shipped to processing centers in 1000-pound boxes on wooden pallets.[503] Frozen juice concentrate is shipped in steel drums in refrigerated container trucks.[504]

[503] Hewitt, T. "Oregon Cranberry Harvest." *Port Orford, Oregon - Gateway to America's Wild Rivers Coast*. Town of Port Orford, OR. Web. 21 Feb. 2011. <http://www.portorfordoregon.com/bogtour.html>.
[504] "Shipping Concentrated Juice in Bulk." *Transportation and Logistics*. Brazilian Association of Citrus Exporters, 2009. Web. 21 Feb. 2011. <http://www.citrusbr.com/en/citric-exporters/sector/transport-and-logistics-155688-1.asp>.

Cucumbers

We include cucumbers in our analysis because they are served almost every day at the salad bars in the dining halls, and according to the Bates manager they are one of the most popular choices among students. There are only 2 cucumber items listed on the 2010 AVI inventory, the first of which is Cucumber Select Fresh from Paradise Produce Distributors. We use this item for our analysis because it is the most frequently ordered cucumber item on the AVI purchasing list (although across all food items, it is the 2583rd largest order).[505]

Serving Size

According to the USDA food pyramid and guidelines, ½ cup of chopped vegetables counts as one serving. Therefore we consider a serving of cucumbers to be ½ cup.[506]

Farm Locations

Cucumbers are grown in many southern U.S. states where the climate is warm and wet, such as Georgia, Alabama, Florida, and Louisiana. Florida is the leading cucumber-producing state, so we assume that cucumbers are not only processed in Florida but grown on Florida farms as well.[507] The address of the processing facility for Paradise Produce Distributors is as follows: Paradise Produce Distributors, 5151 S Lakeland Dr Ste 1, Lakeland, Florida 33813.[508]

Background

The cucumbers are grown on industrial farms before they are sent to a large distributor. Cucumber plant population and spacing vary depending on the soil moisture of the cropland and the harvest method. Cucumbers can be grown in a wide range of soil types, but the soil must be well-drained. Heavy soils are often used for commercial crop production. Cucumber seeds are planted when soil temperatures at the two-inch depth that are around 55 to 60 degrees Fahrenheit. Planting dates vary with climatic conditions. Although cucumbers are fairly tolerant of acidic soils, best growth is obtained in the pH range of 6.0-7.0. Larger crops are harvested with destructive machines to maximize yield, but they require more intensive management. With irrigation and machine harvest, populations of over 150,000 plants per acre can be produced. On light-textures soils and no irrigation, machine-harvested plantings will have 30,000-60,000 plants per acre. For machine-harvested crops, precision seeders are used to plant the higher populations. Spacing of cucumber plants vary from 12 to 30 inches, with plants two to six inches apart.[509]

Cucumbers mature quickly, especially in warm weather, when they can have a 40 percent increase in weight in 24 hours. Once ripe, they should not be left on the vine. Fresh market

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505 AVI purchasing list 2010, AVI Fresh Wellesley.

506 "Serving Size." *Dietary Guidelines for Americans 2010*. USDA, n.d. Web. 24 Feb. 2011. <www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/PolicyDoc/PolicyDoc.pdf >.

507 "United States Department of Agriculture - Agriculture." *U.S. Department of Agriculture Home Page*. United States Department of Agriculture, n.d. Web. 25 Feb. 2011. <http://www.usda.gov/wps/portal/usda/!ut/p/c4/04_SB8K8xLLM9MSSzPy8xBz9CP0os_gAC9-wMJ8QY0MDpxBDA09nXw9DFxcXQ-cAA_2CbEdFAEUOjoE!/?navtype=SU&navid=AGRICULTURE>.

508 "Paradise Produce Distributors (Paradise Produce Distributors, Inc) - Lakeland, Florida (FL) | Company Profile." *Company Profiles & Company Information on Manta*. N.d. Web. 25 Feb. 2011. <http://www.manta.com/c/mmngprd/paradise-produce-distributors>.

509 "B's Cucumber Pages: Commercial Production." *The University of Arizona | Lunar and Planetary Laboratory*. N.d. Web. 25 Feb. 2011. <http://www.lpl.arizona.edu/~bcohen/cucumbers/commercial.html>.

cucumbers in the field are generally harvested every two to three days. When cucumbers are hand-harvested, their growing season in the field may last 100 to 120 days or more. Cucumbers grown in greenhouses may be harvested almost daily. The crops are normally hydro-cooled to remove field heat as soon as possible. Fruits ripen rapidly at temperatures above 50 degrees Fahrenheit, resulting in color change from green to yellow. They can be held for 10 to 14 days at 50 to 55 degrees Fahrenheit and 95 percent relative humidity.[510]

Fertilizer

Cucumbers grow quickly, and need essential nutrients and moisture for maximum growth. Fertilizer requirements vary depending on soil type, native fertility, previous cropping, cultural practices, and yield levels. Machine-harvested cucumbers grown for processing, which mature in 40 to 50 days, require less fertilizer than hand-harvested cucumbers grown for the fresh market. Cucumbers also use nitrogen fertilizer, ranging from about 75 pounds per acre on some heavy, dark-colored soils to 150 pounds per acre for lighter soils. Cucumbers also need phosphorus and potassium fertilizer, but application rates vary considerably. Where irrigation is used, nitrogen and potassium are sometimes applied through the irrigation system. The most important micronutrients for cucumber growth are zinc and manganese. Sometimes growers apply both manganese and zinc two to three weeks after seedlings emerge.[511]

Water

Cucumbers require a continuous supply of moisture during the growing season, especially during blossoming and fruiting. The most heavily irrigated cucumber crops are typically grown on sandy soil or on heavy-textured soil in dry climates, but irrigation will generally be required even on soils that are moist. Irrigation allows the crop to reach its maximum yield potential as plant populations increase to 100,000 plants per acre or more. Cucumber crop water requirements range from 15 to 24 acre-inches of water, depending on climate, soil type, plant populations, and market type. On average, cucumbers take in one inch of water per week, which may increase to two inches per week during hot and dry weather, or if plants are budding. In extremely dry areas, furrow irrigation is preferred because it reduces evaporation losses, while in humid regions, overhead sprinkler or gun-type systems are used.[512] Since we assume that the cucumbers served at Wellesley are grown in Florida, we assume that sprinkler systems are used on the cucumber crops since Florida has such a humid climate.

Mechanization

The cucumber process is mechanized during the planting and harvesting steps using cultivators and seed planters. Irrigation methods are also carried out with machines. Assuming that the cucumbers served at Wellesley do not grow in a greenhouse in Florida, but rather a farm, no other machinery is involved.

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[510] "B's Cucumber Pages: Commercial Production." *The University of Arizona | Lunar and Planetary Laboratory*. N.d. Web. 25 Feb. 2011. <http://www.lpl.arizona.edu/~bcohen/cucumbers/commercial.html>.
[511] "B's Cucumber Pages: Commercial Production." *The University of Arizona | Lunar and Planetary Laboratory*. N.d. Web. 25 Feb. 2011. <http://www.lpl.arizona.edu/~bcohen/cucumbers/commercial.html>.
[512] "B's Cucumber Pages: Commercial Production." *The University of Arizona | Lunar and Planetary Laboratory*. N.d. Web. 25 Feb. 2011. <http://www.lpl.arizona.edu/~bcohen/cucumbers/commercial.html>.

Processing

Grading and sorting of cucumbers can be done in the field or packing shed. Cucumbers are graded by fruit diameter, length, shape, and color. The average length is 6.0 to 8.5 inches, with a diameter of 1.5 to 2.5 inches. Standard grades include U.S. Fancy, U.S. Extra No. 1, U.S. No. 1, U.S. No. 1 Large, U.S. No. 1 Small, and U.S. No. 2. After cucumbers are harvested and sent to a processing facility, the fruits go through an inspection zone on conveyor belts and platforms. They also are brought through a washer that cleans off excess dirt and pesticides.[513] After they are free of debris, the cucumbers are usually waxed to reduce moisture loss and packaged in waterproof cardboard cartons prior to marketing.[514] The wax also enhances the shiny coat around the outside of the cucumber.

Transportation

Cucumbers are shipped to a processing facility where they are graded based on the rating system previously mentioned. It is unclear where the processing facility for cucumbers served at Wellesley would be located. Since cucumber farms are located primarily in Florida, it is reasonable to assume that cucumber processing facilities would be located close to that region. After processing, the fruits are shipped to a food provider that supplies Wellesley's campus. A lot of our produce comes from Costa in Boston, Massachusetts, so we assume that our cucumbers come from Costa.

Toxicity

Weed control among cucumber populations using herbicides usually fails due to the strong resistance of the weeds. Ethafluralin cannot control many broadleaf weeds and yellow nutsedge, and there are no herbicides that can selectively control these weeds in cucumbers. Bentazone is a postemergence herbicide that can control these specific weed populations in cucumbers. The little research that has been done on this chemical indicates that the first application decreases the harvest yield by almost 42 percent, increasing significantly afterwards during the second or third harvest.[515] The major diffuse sources of bentazone in the aquatic environment are likely to be from soil run-off or accidental over-spray on crops. Bentazone contamination of drinking water has become problematic in some areas.[516]

Biodiversity

Little research has been done on bentazone, but when addressing the issue of threat to biodiversity, studies concluded that bentazone has a low to moderate toxicity to freshwater and saltwater organisms. Bentazone affects algae and macrophytes through inhibition of photosynthesis. Therefore, these species are at the highest risk. Invertebrates and fish are much less sensitive to the herbicide by-product than these other organisms. The only other threat to biodiversity posed by cucumber production is destruction of natural habitats when clearing land

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513 "Hartung Brothers cucumber processing lines." *home*. N.d. Web. 25 Feb. 2011. <http://www.sormac.co.uk/en/cucumber_grading>.

514 "B's Cucumber Pages: Commercial Production." *The University of Arizona | Lunar and Planetary Laboratory*. N.d. Web. 25 Feb. 2011. <http://www.lpl.arizona.edu/~bcohen/cucumbers/commercial.html>.

515 Teasdale, John R. "Factors Affecting Bentazone Toxicity to Cucumber (cucumis sativus)." *Weed Science.* Vol 32, No 1. January 1984. 1 April 2011.

516 "Water Sanitation and Health (WHS)." *World Health Organization.* 2011. 1 April 2011.

to be used for planting crops. Other than pesticides and land clearing, cucumber crops do not pose a significant risk to biodiversity in Florida.[517]

[517] "Toxic substance profile: Bentazone." *UK Marine SACs Info Net*. N.d. Web. 1 Apr. 2011. <http://www.ukmarinesac.org.uk/activities/water-quality/wq8_16.htm>.

Eggs

The primary egg products Wellesley purchased are WHLFCLS brand liquid eggs and shell eggs. Michael Foods Co. is the vendor supplying the liquid eggs to food services and Southern New England Eggs supplies the shell eggs. Dining services purchased **30,312 pounds of liquid eggs** and **9,945 dozen whole eggs**. Although there are many different egg forms, we believe focusing on the liquid eggs and whole eggs are the most important considering these two constitute the vast majority of the egg products purchased.

Serving Size

The recommended serving size by the United States Department of Agriculture standards size for eggs is one large egg or about 2oz.[518]

Farm Locations

Information on the specific egg suppliers is unavailable. It has proven to be difficult to find the sources of the eggs purchased by the college. The primary egg supplier, Michael Foods Inc., is a huge company, so it may be hard to pinpoint the direct sources. Southern New England Eggs Inc. is the main supplier of fresh eggs to the college, however, they do not have a website so we were not able to find information regarding their sources of eggs. Most of the eggs consumed in the United States are also produced here. According to the USDA, Canada is the only exporter of eggs to the United States.[519] The top ten egg producing states ranked by number of laying hens are listed in Figure 30 .[520]

1. **Iowa** - 52,537
2. **Ohio** - 28,050
3. **Pennsylvania** - 23,876
4. **Indiana** - 22,898
5. **California** - 19,511
6. **Texas** - 14,240
7. **Michigan** - 10,119
8. **Minnesota** - 9,991
9. **Florida** - 9,407
10. **Nebraska** - 9,321

Figure 30: Top ten egg producing states ranked by number of laying hens

The five largest egg-producing states represent approximately 50 percent of all U.S. hen layers.[521] Michael Foods is located in Minnesota which is ranked 8th in the top ten producers, so we deduced that liquid eggs are sourced from within the state. On the other hand, Connecticut, where Southern New England Eggs is based, is not ranked as one of the top producers. Therefore, it remains unclear where the source of our dining services whole eggs come from.

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518 U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Dietary Guidelines for Americans, 2010.* 7th Edition, Washington, DC: U.S. Government Printing Office, December 2010. Print.
519 USDA Meat and Poultry. *Egg Products and Food Safety*. 2010. Web. 15 Feb 2011. <http://www.fsis.usda.gov/factsheets/Egg_Products_Preparation_Fact_Sheets/index.asp>
520 "American Egg Board - Egg Industry Facts Sheet." *Welcome to the American Egg Board*. n.d. Web. 25 Feb. 2011. <http://www.aeb.org/egg-industry/industry-facts/egg-industry-facts-sheet>.
521 "American Egg Board - Egg Industry Facts Sheet." *Welcome to the American Egg Board*. n.d. Web. 25 Feb. 2011. <http://www.aeb.org/egg-industry/industry-facts/egg-industry-facts-sheet>.

The processing plant locations for the two vending companies are:

Southern New England Eggs Inc
28 Under the Mountain Road
North Franklin, CT 06254[522]

Michael Foods, Inc
301 Carlson Parkway, Suite 400
Minnetonka, MN 55305[523]

Fertilizer Use

Most poultry chickens eat corn and soybean meal as part of their diet. For more information about animal feed, please refer to the *corn* food analysis, as it highlights much of the animal feed process. Laying chickens are fed much of the same diet as other chickens, however, they are treated in different ways and fed more precisely in order to produce quality eggs. Young birds are fed a high protein diet during the first few weeks of life, and as they grow, their consumption increases. In addition to monitoring dietary protein, producers must closely examine other ingredients. During the laying phase, lysine, methionine, calcium, and phosphorus are important to support maximum egg production.[524]

Mechanization

Egg production is a highly mechanized process from the lighting in the factories, housing the hens, the conveyor belts moving the eggs, etc. Most eggs are produced in large scale operations. The temperature, light and humidity are controlled in hen houses to encourage laying. Laying houses are heated at 57 to 79°F. The hens are kept in cages. Feeding and watering is mechanized. Once the eggs are laid, machines and conveyor belts move the eggs throughout all stages of production so that risk of contamination is minimized. The eggs are then washed in hot water, dried, inspected and packaged. As a result, a large amount of energy is required because there are many steps to the process. [525]

Most large-scale egg production facilities are vertically integrated, meaning the feed mill, hens, buildings, egg processing facility and transportation vehicles are all located in one area.[526] The fact that all facilities are located together may reduce emissions from transportation.

Processing

Eggs are packaged in plastic egg handlers and transported to the processing facility where they are washed and sanitized in 120 degree Fahrenheit water. Once they are processed they are packaged in Styrofoam or paper egg cartons. These cartons are stacked on cardboard flats to be

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[522] "Southern New England Eggs Inc, North Franklin, CT." *Company Profiles & Company Information on Manta*. n.d. Web. 10 May 2011. <http://www.manta.com/c/mm2v19q/southern-new-england-eggs-inc>.
[523] "Michael Foods - Contact Us." *Michael Foods - Home*. n.d. Web. 10 May 2011. <http://www.michaelfoods.com/contact-us/>.
[524] Meunier, Ryan A., and Mickey A. LaTour. "Commercial Egg Production and Processing." *Department of Animal Sciences*. n.d. Web. 25 Feb. 2011. <http://ag.ansc.purdue.edu/poultry/publication/commegg/>.
[525] Meunier, Ryan A., and Mickey A. LaTour. "Commercial Egg Production and Processing." *Department of Animal Sciences*. n.d. Web. 25 Feb. 2011. <http://ag.ansc.purdue.edu/poultry/publication/commegg/>.
[526] Meunier, Ryan A., and Mickey A. LaTour. "Commercial Egg Production and Processing." *Department of Animal Sciences*. n.d. Web. 25 Feb. 2011. <http://ag.ansc.purdue.edu/poultry/publication/commegg/>.

shipped to retailers.[527]

Eggs for liquid egg production have the same initial processing but must be removed from the shells. These eggs are cracked by a mechanical cracking machine, pasteurized and then placed in large plastic bins. The pasteurization of liquid eggs occurs at 145 degrees Fahrenheit for seven minutes, which creates 3,000 pounds of eggs. The liquid eggs are packaged in milk carton containers.[528]

Transportation

The eggs are shipped to retail locations via semi-trailers at 40-45 degrees Fahrenheit and 80-85% humidity.[529] The two processing plants of egg suppliers are Southern New England Eggs Inc, 28 Under the Mountain Road North Franklin, CT 06254 and Michael Foods, Inc 301 Carlson Parkway, Suite 400 Minnetonka, MN 55305. The eggs are then shipped to Wellesley College.

Emissions

Large amounts of ammonia are emitted from laying hen houses and is the major green house gas emitted as a result of egg production. 26.7% of ammonia emissions in the United States are from poultry production.[530]

Scale

95% of the egg-laying operations in the United States have at least 75,000 hens. There are 78 operations with 1 million or more laying hens.[531]

Packaging

Eggs are packaged in plastic, styrofoam or paper cartons and transported in cardboard boxes. These packaging materials require great energy use and create varying impacts on the environment.

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[527] Meunier, Ryan A., and Mickey A. LaTour. "Commercial Egg Production and Processing." *Department of Animal Sciences*. n.d. Web. 25 Feb. 2011. <http://ag.ansc.purdue.edu/poultry/publication/commegg/>.
[528] Meunier, Ryan A., and Mickey A. LaTour. "Commercial Egg Production and Processing." *Department of Animal Sciences*. n.d. Web. 25 Feb. 2011. <http://ag.ansc.purdue.edu/poultry/publication/commegg/>.
[529] Ashby, B. Hunt. "Protecting Perishable Foods During Transport by Truck." *Transportation and Marketing Programs Handbook* 669 (2006): 1-100. Print.
[530] H, Xin. "Environmental Impacts and Sustainability of Egg Production Systems." *Poultry Science* 90 (2011): 263-277. Print.
[531] "American Egg Board - Egg Industry Facts Sheet." *Welcome to the American Egg Board*. n.d. Web. 25 Feb. 2011. <http://www.aeb.org/egg-industry/industry-facts/egg-industry-facts-sheet>.

Hummus

Wellesley College purchases a half ton of one form of processed hummus in the form of frozen dip, produced and provided by Grecian Delight Foods, located at 1201 Tonne Road, Elk Grove Village, IL 60007. As El Table and the Hoop are supplied by our dining service, it seems likely that their contribution to campus hummus consumption is also covered by this order. Grecian Delight's hummus consists of: garbanzo beans [aka chickpeas], sesame tahini, lemon juice, and soybean oil. It contains less than 2% of "garlic puree with citric acid, salt, sugar, lecithin, natural flavors, cellulose, modified food starch, and spices".[532] We excluded these ingredients from our analysis, as they are too small to impact our overall findings. While lemons are likely sourced from Ventura, California, the following analysis relies on data from Italian citrus production, as a recent life cycle analysis for a highly mechanized cultivation and juice production process in a Mediterranean climate has already been performed in depth.[533] Please see the *tofu* assessment for more information on soybeans before the processing stage.

Serving Size

The USDA serving size for hummus is 2 tablespoons.[534]

Farm Locations

While no data on the source of Grecian Delight's chickpeas, and most chickpeas worldwide are grown in India,[535] the US is a net exporter of chickpeas, suggesting that Grecian Foods would be easily able to source its chickpeas domestically. According to the USDA, North Dakota, Michigan, Nebraska, Minnesota, and Idaho command the chickpea production market in the United States; North Dakota accounts for the largest share, producing 33 percent.[536] The US is a net importer of sesame oil, 75 percent of which was sourced from Japan, Taiwan, China, Thailand, and India between 1998 and 2007;[537] half of 2009 sesame imports were from India.[538] West Bengal produces the largest share of Indian sesame seeds, followed by Gujarat, Rajasthan, Madhya Pradesh and Uttar Pradesh.[539] While Brazil and China account for the largest share of global lemon production, and Mexico accounts for the largest share of lemon imports (32

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532 "Dips & Spreads: Traditional Hummus." Grecian Delights Foods, 2011. Web. 21 Feb. 2011. <(http://www.greciandelight.com/Grecian_Delight_Hummus.aspx>.

533 Beccali, Marco, Maurizio Cellura, Maria Iudicello, and Marina Mistretta. "Resource Consumption and Environmental Impacts of the Agrofood Sector: Life Cycle Assessment of Italian Citrus-Based Products." *Environmental Management* 43.4 (2009): 707-24. Print.

534 "Dips & Spreads: Traditional Hummus." Grecian Delights Foods, 2011. Web. 21 Feb. 2011. <(http://www.greciandelight.com/Grecian_Delight_Hummus.aspx>.

535 "Countries by Commodity- Chick Peas." *Food and Agricultural Commodities Production*. Food and Agriculture Organization of the United Nations. Nd. Web. 21 Feb. 2011. <http://faostat.fao.org/site/339/default.aspx>.

536 "Dry Beans: Questions and Answers." *USDA ERS Briefing Room*. United States Department of Agriculture Economic Research Service, 23 Mar. 2009. Web. 21 Feb. 2011. <http://www.ers.usda.gov/briefing/drybeans/faq.htm>.

537 Brooks, Nora, Anita Regmi, and Alberto Jerardo. "U.S. Food Import Patterns, 1998-2007." United States Department of Agriculture Economic Research Service, Aug. 2009. Web. 21 Feb. 2011. <http://www.ers.usda.gov/Publications/FAU/2009/08Aug/FAU125/FAU125.pdf>.

538 Hansen, Ray. "Sesame Profile." *Grains and Oilseeds*. Agricultural Marketing Resource Center, Aug. 2010. Web. 21 Feb. 2011. <http://www.agmrc.org/commodities__products/grains__oilseeds/sesame_profile.cfm>

539 "Sesame Seed Growing Areas in India." Agricultural Commodity Prices, 16 Feb. 2010. Web. 22 Feb. 2011. <http://www.agricommodityprices.com/futures_prices.php?id=436>.

percent), most US lemon production is consumed internally, suggesting it is likely that Grecian Delight sources its lemon juice domestically. California leads domestic lemon production, contributing either 72 or 89 percent, as noted from the USDA.[540] Within California, the lemons almost certainly come from Ventura County, which dominates, with over half the state's lemon production. Riverside, Imperial, Tulare, Kern, and San Diego counties produce the rest.[541] The USA is the world's major producer of soy, largely from the upper Midwest, making it extremely likely that the soybean oil used in Grecian Delights's hummus is semi-local for them.

Fertilizer

While no standard application rates of fertilizer are available, a University of Montana case study fertilized chickpeas with 6 pounds of nitrogen per acre, 30 pounds of P2O5 as mono-ammonium phosphate and 30 pounds per acre of potassium chloride.[542] Rates of nitrogen, compared to other nutrients are low, because chickpeas, which are legumes, fix their own nitrogen. Instead, seeds are inoculated with rhizobium to stimulate N fixation and seeded with an air drill.

Sesame is commonly grown in rotation with leguminous crops to supply its nitrogen.[543] It is recommended that five tons of manure be incorporated before planting sesame. A second application of fertilizer is applied by sidedressing 4-5 weeks after germination. Vietnamese sesame cultivators recommended in total 15 kilgrams of nitrogen, 45 kilograms of phosphorus, and 30 kilograms of potassium be applied per hectare.[544]

A lemon orchard is cultivated at the beginning of the season for weed control and to work in the fertilizer at 250 kilograms per hectare of nitrogen, 150 kilograms per hectare of P_20_5, and 200 kilograms per hectare of K_20.[545] These estimates are in agreement with figures for Florida citrus production.[546] Fertilizer can also be applied as a foliar spray with a boom sprayer, which is often highly diluted.[547]

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540 "Background Statistics: Citrus Market." United States Department of Agriculture Economic Research Service, 22 Jan. 2007. Web. 22 Feb. 2011. <http://www.ers.usda.gov/News/citruscoverage.htm>. or Boriss, Hayley. "Commodity Profile: Citrus." Agricultural Issues Center, University of California Davis, Feb. 2006. Web. 22 Feb. 2011. <http://aic.ucdavis.edu/profiles/Citrus-2006.pdf>.

541 "Background Statistics: Citrus Market." United States Department of Agriculture Economic Research Service, 22 Jan. 2007. Web. 22 Feb. 2011. <http://www.ers.usda.gov/News/citruscoverage.htm>.

542 Jackson, Grant, John Miller, and Perry Miller. "Response of Chickpea and Pea Cultivars to Irrigation and Planting Rates." Montana State University College of Agriculture, 2004. Web. 21 Feb. 2011. <http://ag.montana.edu/wtarc/Web2004/Soils/Chick/IrrChickpea2004.pdf>.

543 "Growing Sesame: Production Tips, Economics, and More." *Sesame : A High Value Oilseed*. The Jefferson Institute. Nd. Web. 21 Feb. 2011. <http://www.jeffersoninstitute.org/pubs/sesame.shtml>.

544 Bissdorf, Jewel K. "Field Guide to Non-chemical Pest Management in Sesame Production." Pesticide Action Network (PAN) Germany, 2007. Web. 21 Feb. 2011. <http://www.agmrc.org/media/cms/field_guide_sesame_8CBDCBAE271E8.pdf>.

545 Beccali, Marco, Maurizio Cellura, Maria Iudicello, and Marina Mistretta. "Resource Consumption and Environmental Impacts of the Agrofood Sector: Life Cycle Assessment of Italian Citrus-Based Products." *Environmental Management* 43.4 (2009): 707-24. Print.

546 Koo, R. C. J. "Citrus (Citrus Spp.)." *World Fertilizer Use Manual by Type of Crops*. International Fertilizer Industry Association. Web. 25 Feb. 2011. <http://www.fertilizer.org/ifa/Home-Page/LIBRARY/Our-selection2/World-Fertilizer-Use-Manual/by-type-of-crops>

547 Kuepper, George. "Foliar Fertilization." ATTRA - National Sustainable Agriculture Information Service. Web. 25 Feb. 2011. <http://attra.ncat.org/attra-pub/foliar.html#intro>.

Water

Chickpeas receive irrigation twice over the growing season.[548] As a dryland crop with a deep root structure, chickpeas do not require much irrigation; whatever is supplied may be through drip or sprinkler irrigation.[549] Sesame fields are irrigated before seeding, which is broadcast by hand. Over the course of the season, a sesame crop requires 16 to 18 inches of water.[550] Irrigation in Italy totals an average of 4.2 million kilograms per hectare, accounting for 45 percent of total water use in the process, or 141 kilograms of water per kilogram of lemons. Lemons are washed twice as part of the juice-making process.

Mechanization

The Midwestern production market uses highly mechanized techniques to plant and harvest the peas.[551] Chickpeas are raised in a monoculture and must be grown in fields free of chickpea cultivation for at least the previous three years to limit fungal infections. Fields are cultivated once.[552] According to the Indian Ministry of Agriculture, while mechanizing production of oilseeds (including sesame) is a high priority, the necessity of importing specialized machinery has hindered the adoption of mechanical techniques.[553] Chickpeas are harvested with a combine harvester and threshed to remove the peas from their stalks. The loose peas are sorted on conveyor belts and dried in fan-aerated bins.[554]

As specific information describing the process of traditional Indian sesame cultivation is not readily available, we used guidelines for organic sesame production in other developing nations. Weeding, slashing, winnowing, bundling, and drying are all manually performed. Sesame appears to be grown as a monocrop in tilled rows. The following excerpt from the FAO's summary of citrus juice processing refers specifically to Floridian oranges, which is the same process is used for lemons.[555] Presumably methods in Florida are similar to those in California.

> "Manual (hand harvesting) is used to harvest 99.9 percent of Florida's orange crop. Picked fruit, called grove run, moves directly from the grove

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548 Muehlbauer, F. J., and Abebe Tullu. "Chickpea (Cicer Arietinum L.)." Purdue University Center for New Crops and Plant Products, 23 Feb. 1998. Web. 21 Feb. 2011. <http://www.hort.purdue.edu/newcrop/cropfactsheets/chickpea.html#Crop Culture>.

549 Singh, Faujdar, and B. Diwakar. "Chickpea Botany and Production Practices." ICRISAT Training and Fellowships Online Resources. International Crops Research Institute for the Semi-Arid Tropics, 1995. Web. 21 Feb 2011. <http://www.icrisat.org/what-we-do/learning-opportunities/lsu-pdfs/sds.16.pdf>.

550 Bissdorf, Jewel K. "Field Guide to Non-chemical Pest Management in Sesame Production." Pesticide Action Network (PAN) Germany, 2007. Web. 21 Feb. 2011. <http://www.agmrc.org/media/cms/field_guide_sesame_8CBDCBAE271E8.pdf>.

551 McKay, Kent, Perry Miller, and Brian Jenks, Et Al. "Growing Chickpea in the Northern Great Plains." North Dakota State University Agriculture and University Extension, Nov. 2002. Web. 21 Feb. 2011. <http://www.ag.ndsu.edu/pubs/plantsci/crops/a1236w.htm>.

552 Muehlbauer, F. J., and Abebe Tullu. "Chickpea (Cicer Arietinum L.)." Purdue University Center for New Crops and Plant Products, 23 Feb. 1998. Web. 21 Feb. 2011. <http://www.hort.purdue.edu/newcrop/cropfactsheets/chickpea.html#Crop Culture>.

553 Department of Agriculture and Cooperation Frequently Asked Questions (Agricultural Implements and Machinery Division)." Indian Ministry of Agriculture, 1 Apr. 2005. Web. 21 Feb. 2011. <http://agricoop.nic.in/faq/machinery.htm>.

554 Goodwin, Mark. "Crop Profile for Chickpeas." Pulse Canada, Mar. 2003. Web. 21 Feb. 2011. <http://www.pulsecanada.com/uploads/z7/7x/z77xpozphnfLKGNMDxWaAg/Chickpea-Profile.PDF>.

555 "Practical aspects of citrus juice processing." *Principes and Practices of Small- and Medium-scale Fruit Juice Processing*. Food and Agriculture Organization of the United Nations. Nd. Web. 22 Feb. 2011. <http://www.fao.org/Docrep/005/Y2515e/y2515e13.htm#TopOfPage>.

> to the processing plants without ever being graded in a packinghouse. Hand harvested fruit is hand picked into harvesting sacks that are manually dumped into 400 kg bins in the grove. These bins are lifted by small trucks and taken to the edge of the grove where the bin is dumped into a semi-trailer. Each semi-trailer hauls about 22 MT of fruit to the processing plant that can be many kilometres away. In Florida, a single over-the-road-trailer load of grove run fruit usually represents one grower's fruit and is driven onto a scale where the gross weight is recorded. Elevating the entire truck hydraulically after opening the end gate unloads the fruit. It only takes about 15 minutes to unload about 22 MT, the capacity of the trailer."[556]

Processing

The only available information pertaining to the processing of sesame seeds is highly mechanized. We assume that seeds are shipped unprocessed to be cleaned and hulled in the United States. Seeds are cleaned with "air separation" and hulled by agitating them in water.[557] To become tahini, seeds are soaked in water, crushed to separate the bran from the kernels, then soaked again. The kernels, which float, and are easily removable, are toasted and crushed again.

According to the FAO:

> "The empty truck and trailer are re-weighed to determine the net fruit weight. Fruit is pulled out of the bin and the individual grower's load of fruit is blended with other loads of fruit to achieve the desired Brix and sugar/acid ratio of the final extracted juice.
>
> After the fruit is graded to eliminate unsound fruit... a plug is cut in the centre of the fruit and a strainer pushed up inside the orange. A mechanical hand presses the juice and pulp against this strainer keeping the juice away from the exterior of the fruit and strongly flavoured peel oils. The juice exits out the bottom of the FMC Extractor after being separated from the pulp and the peel is pushed up and out the front. . . Thus in one stroke five oranges are separated into juice, pulp, peel, peel oil, seeds and rag.
>
> After the juice is removed from the fruit and has gone through the finisher it is sent to an evaporator feed tank. Almost all orange juice is concentrated on Thermally Accelerated Short Time Evaporators, TASTE. These multi-stage, forward feed evaporators take juice that is 10 to 12 percent solids or ºBrix and remove the water to concentrate the juice to 62o to 65°Brix."[558]

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556 "Practical aspects of citrus juice processing." *Principes and Practices of Small- and Medium-scale Fruit Juice Processing*. Food and Agriculture Organization of the United Nations. Nd. Web. 22 Feb. 2011. <http://www.fao.org/Docrep/005/Y2515e/y2515e13.htm#TopOfPage>.

557 Hansen, Ray. "Sesame Profile." *Grains and Oilseeds*. Agricultural Marketing Resource Center, Aug. 2010. Web. 21 Feb. 2011. <http://www.agmrc.org/commodities__products/grains__oilseeds/sesame_profile.cfm>.

558 "Practical aspects of citrus juice processing." *Principes and Practices of Small- and Medium-scale Fruit Juice Processing*. Food and Agriculture Organization of the United Nations. Nd. Web. 22 Feb. 2011. <http://www.fao.org/Docrep/005/Y2515e/y2515e13.htm#TopOfPage>.

Juice is also pasteurized with steam for 15 to 20 seconds; some juice is then cooled to 2 degrees for fresh sale, while the rest is concentrated in a steam boiler.559

According to an EPA report on emissions from soybean oil production:

> "Conventional desolventizing takes place in a desolventizer-toaster (DT), where both contact and noncontact steam are used to evaporate the hexane. In addition, the contact steam "toasts" the flakes, making them more usable for animal feeds. The desolventized and toasted flakes then pass to a dryer, where excess moisture is removed by heat, and then to a cooler, where ambient air is used to reduce the temperature of the dried flakes. The desolventized, defatted flakes are then ground for use as soybean meal. Flash desolventizing is a special process that accounts for less than 5 percent by volume of the annual nationwide soybean crush. The production of flakes for human consumption generally follows the flow diagram in Figure 9.11.1-3 for the "conventional" process, except for the desolventizing step. In this step, the flakes from the oil extraction step are "flash" desolventized in a vacuum with noncontact steam or superheated hexane. This step is followed by a final solvent stripping step using steam. Both the hexane vapor from the flash/vacuum desolventizer and the hexane and steam vapors from the stripper are directed to a condenser. From the condenser, hexane vapors pass to the mineral oil scrubber and the hexane-water condensate goes to the separator, as shown in Figure 9.11.1-3. The flakes produced by the flash process are termed "white flakes". A process flow diagram for the flash desolventizing portion of the soybean process is shown in Figure 9.11.1-5. From the stripper, the white flakes pass through a cooker (an optional step) and a cooler prior to further processing steps similar to the "conventional" process. A plant that uses specialty or "flash" desolventizing requires different equipment and is far less efficient in energy consumption and solvent recovery than a plant that uses conventional desolventizing. Given these facts, solvent emissions are considerably higher for a specialty desolventizing process than for a similar-sized conventional desolventizing process."[560]

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[559] Beccali, Marco, Maurizio Cellura, Maria Iudicello, and Marina Mistretta. "Resource Consumption and Environmental Impacts of the Agrofood Sector: Life Cycle Assessment of Italian Citrus-Based Products." *Environmental Management* 43.4 (2009): 710. Print.

[560] "Vegetable Oil Processing." *Emissions Factors & AP 42, Compilation of Air Pollutant Emission Factors*. United States Environmental Protection Agency, 1995. Web. 25 Feb. 2011. <http://www.epa.gov/ttnchie1/ap42/ch09/final/c9s11-1.pdf>.

At the processing plant, presumably in Elk Grove, IL, the chickpeas, tahini, soybean oil, and lemon juice are combined into the finished hummus product.[561] Production steps at the processing plant probably include soaking, boiling, and mashing the chickpeas (especially as Grecian Delights boasts of soaking its chickpeas overnight]; blending all ingredients. According to a tour of a hummus factory in Massachusetts, industrial hummus production uses more or less the same steps as home production, only scaled up. Raw chickpeas are funnelled onto a conveyor belt to remove impurities, and from there are spilled into a washer. Chickpeas are soaked for a day in water, then drained. They are cooked, transported via conveyor belt, transferred to a grinder, combined with other ingredients, creamed, and pasteurized in heated tanks.

Transportation

Because sesame seeds store stably when dried (and therefore would not need to be flown), it seems likely that they are shipped to the United States via standard intermodal containers on cargo ships. Los Angeles is the US's busiest container ship port.[562] From there, the containers are probably transferred onto freight trains to the Chicago area for processing into tahini.

Total fuel consumption required for machinery and transport in lemon production averages 250 kilograms per hectare. In Italy, lemon juice was shipped on diesel trucks with an average cargo of 25,000 kilograms.[563] According to the FAO, juice is delivered in refrigerated tanks.[564]

Finished hummus is shipped frozen.[565]

Scale

Indian sesame production remains largely unaffected by Westernized industrial agriculture, so it is essentially organic by default. [566] The average farm in California in 2007 was 313 acres; 75 percent of farms fell in the 1 to 99 acres percentile. As only .05 percent of California agriculture is organic, it is safe to assume that the farms supplying Grecian Delight's lemon juice are large, monocropped, mechanized, and not organic.

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561 "How To Make Hummus Factory Tour!" *iFood.tv*. 2009. Web. 22 Feb. 2011. <http://www.ifood.tv/video/how-to-make-hummus-factory-tour>.

562 "Total Cargo Volume." *World Port Rankings 2008*. American Association of Port Authorities, 2008. Web. 22 Feb. 2011. <http://aapa.files.cms-plus.com/Statistics/WORLD%20PORT%20RANKINGS%2020081.pdf>.

563 Beccali, Marco, Maurizio Cellura, Maria Iudicello, and Marina Mistretta. "Resource Consumption and Environmental Impacts of the Agrofood Sector: Life Cycle Assessment of Italian Citrus-Based Products." *Environmental Management* 43.4 (2009): 712. Print.

564 Beccali, Marco, Maurizio Cellura, Maria Iudicello, and Marina Mistretta. "Resource Consumption and Environmental Impacts of the Agrofood Sector: Life Cycle Assessment of Italian Citrus-Based Products." *Environmental Management* 43.4 (2009): 711. Print.

565 "How To Make Hummus Factory Tour!" *iFood.tv*. 2009. Web. 22 Feb. 2011. <http://www.ifood.tv/video/how-to-make-hummus-factory-tour>.

566 Bissdorf, Jewel K. "Field Guide to Non-chemical Pest Management in Sesame Production." Pesticide Action Network (PAN) Germany, 2007. Web. 21 Feb. 2011. <http://www.agmrc.org/media/cms/field_guide_sesame_8CBDCBAE271E8.pdf>.

Toxicity

The University of Montana study provides recommendations for herbicides and pesticides for use on chickpeas, itemized in Table 53.[567]

Table 53: Application rates for chickpea insecticides and pesticides

Herbicide	Rate per acre
Assure II (quizalofop)	8-10 fl oz at 1
Dual II (metolachlor)	1-2 pt
Fargo (tritillate)	1.25 qt or 12.5
Poast (sethoxydim)	0.5-1.5pt
Prowl (pendimethalim)	1.2-3.6pt
Pursuit W DG (imazethapyr)	2 fl oz
Select (clethodim)	4-8 fl oz
Sonolan (ethalfluranlin)	1.5-2 pt or 5.5
Spartan (sulfentrazone)	2-5.33 fl oz
Tough (pyridate)	1.5 pt
Treflan (trifluralin)	1-2 pt or 5-10
Glyphosate	see label
Paraquat	see label

No herbicides, chemical pesticides or insecticides are applied for use with sesame.[568] While Californian citrus production tends to use integrated pest management, pesticides commonly applied to lemon trees in California are usually phosphorus-based and include: Acetamiprid (Assail); Abamectin (Agrimek/Zephyr); Bacillus thuringiensis; Buprofezin(Applaud); Chlorpyrifos (Lorsban); Diazinon; Dicofol (Kelthane); Fenbutatin Oxide (Vendex); Fenpropathrin; Formetanate HCL (Carzol); (Admire/Gaucho); Malathion; Metaldehyde; Methidathion; (Supracide); Methomyl; (Lannate); Propargite (Comite; Pyridaben; Pyriproxyfen (Esteem); (Veratran D), and Spinosad (Success).[569] Total pesticide application in lemon husbandry averages 3.26 kilograms per hectare.[570]

Packaging

Most bulk chickpea importers and exporters pack chickpeas in polypropylene bags, either in 100 pound or 250 kilogram units. Sesame seeds in Tanzanian production are stored in polypropylene bags for transport.[571] Lemons are packed in 55-pound field boxes for

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[567]Jackson, Grant, John Miller, and Perry Miller. "Response of Chickpea and Pea Cultivars to Irrigation and Planting Rates." Montana State University College of Agriculture, 2004. Web. 21 Feb. 2011. <http://ag.montana.edu/wtarc/Web2004/Soils/Chick/IrrChickpea2004.pdf>.

[568]Oplinger, E. S., D.H. Putnam, A.R. Kaminski, C.V. Hanson, E.A. Oelke, E.E. Schulte, and J.D. Doll. "Sesame." *Alternative Field Crops Manual*. Departments of Agronomy and Soil Science, College of Agricultural and Life Sciences and Cooperative Extension Service, University of Wisconsin- Madison, and the Department of Agronomy and Plant Genetics, University of Minnesota, May 1990. Web. 21 Feb. 2011. <http://www.hort.purdue.edu/newcrop/afcm/sesame.html>.

[569]"Crop Profile for Citrus in California." University of California Davis Cooperative Extension, Dec. 2003. Web. 25 Feb. 2011. <http://ucce.ucdavis.edu/files/datastore/391-261.pdf>.

[570]Beccali, Marco, Maurizio Cellura, Maria Iudicello, and Marina Mistretta. "Resource Consumption and Environmental Impacts of the Agrofood Sector: Life Cycle Assessment of Italian Citrus-Based Products." *Environmental Management* 43.4 (2009): 710. Print.

[571]Ton, Peter, and Ray Mjunguli. "EPOPA Organic Sesame Workshop (Singida, Tanzania)." *Development Through*

transportation to juice extraction processing centers.[572] According to Beccali et al, juice is stored in "low-density polyethylene bags", in tanks of low carbon steel.[573] Finished hummus is packaged in 4 half-liter containers per unit.[574]

Other Greenhouse Emissions

Methane is an output in processing lemon juice, in that it is used to heat washing water, steam pasteurization, and concentrator, accounting for about 6 percent of total energy. Total fuel consumption required for machinery and transport in lemon production averages 250 kilograms per hectare.

Sesame seeds are fumigated with CO2 before shipping.[575]

Organic Trade. Export Promotion of Organic Products from Africa, Dec. 2006. Web. 21 Feb. 2011. <http://www.grolink.se/epopa/publications/Sesame_Workshop_2006Feb08.pdf>.

[572] Klonsky, Karen, and Laura Tourte. "Production Practices and Sample Costsfor Fresh Market Organic Lemons: South Coast, 1997." UCDavis Agriculture and Resource Economics.University of California Davis Cooperative Extension, 1997. Web. 22 Feb. 2011. <http://www.ers.usda.gov/News/CAcitrus.htm>.

[573] Beccali, Marco, Maurizio Cellura, Maria Iudicello, and Marina Mistretta. "Resource Consumption and Environmental Impacts of the Agrofood Sector: Life Cycle Assessment of Italian Citrus-Based Products." *Environmental Management* 43.4 (2009): 712. Print

[574] "How To Make Hummus Factory Tour!" *iFood.tv*. 2009. Web. 22 Feb. 2011. <http://www.ifood.tv/video/how-to-make-hummus-factory-tour>.

[575]Ton, Peter, and Ray Mjunguli. "EPOPA Organic Sesame Workshop (Singida, Tanzania)." *Development Through Organic Trade*. Export Promotion of Organic Products from Africa, Dec. 2006. Web. 21 Feb. 2011. <http://www.grolink.se/epopa/publications/Sesame_Workshop_2006Feb08.pdf>.

Ice Cream

Wellesley dining services purchases over 800 three-gallon containers of ice cream every year from Hood creamery, which is based in New England and opened its first dairy in Derry, New Hampshire. Hood now operates from its headquarters in Lynnfield, Massachusetts – approximately 30 miles from Wellesley College – and manages 22 manufacturing plants throughout the United States. In order to assess the environmental impacts of ice cream, we assess the impacts of two primary ingredients in ice cream: milk and sugar. Additionally, we consider the impacts associated with processing and freezing the ice cream once the ingredients are mixed, as well as transportation of the product from its distributor in Suffield, Connecticut.

Serving Size

Although Hood considers ½ cup to be the standard serving size on its ice cream products, we decided to follow the USDA guidelines which consider one cup to be the standard serving size for ice cream.[576] A total of 48 cups are in every three-gallon container of ice cream purchased by the college. A recipe yielding three gallons of ice cream would contain approximately 18 cups of regular milk and 3 cups of white sugar.[577] So, each serving size would contain 0.375 cups of milk and 0.0625 cups of sugar.

Farm Origins

Hood has dairies located in New England, so it is likely that the ice cream is processed within a 200-mile radius of Wellesley College. However, Hood offers no information about where it sources its sugar and milk. The milk is most likely sourced from dairy farms in the Northeastern United States, given that Vermont, New York, and Pennsylvania are among the top dairy-producing states in the country.[578] We assume that the milk for ice cream is sourced from central Vermont in order to be consistent with our analysis for milk for drinking. Milkfat is a natural fat found in milk, and so is produced during the production of milk.

The sugar listed in the ingredients of ice cream is most likely conventionally grown cane sugar. India and Brazil are the two largest sugarcane producers worldwide,[579] but the 70 percent of the sugar used in the United States is produced in Florida.[580] So, it is more likely that sugar used in the United States comes from Florida, especially since the ice cream factory is located on the East Coast. Sugar produced in Florida is grown in the Everglades Agricultural Area on the southern tip of the state.

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576 "What's in a Serving Size?." *USDA*. N.d. Web. 24 Feb. 2011. <www.fns.usda.gov/tn/healthy/portions_kit/serving_size.pdf>

577 See traditional Vanilla Ice Cream recipe: http://allrecipes.com//Recipe/Vanilla-Ice-Cream-III/Detail.aspx.

578 "Facts And Figures." *Dairy Farming Today*. N.d. Web. 25 Feb. 2011. <http://web.archive.org/web/20080527041829/http://www.dairyfarmingtoday.org/DairyFarmingToday/Learn-More/Facts-And-Figures/#State%20Statistics>

579 IERE. "Environmental Comparison of Conventional and Organic Technological Routes for Sugar Obtaining Concerning to Greenhouse Gases Emissions." International Life Cycle Assessment & Management. International Environmental Research & Education. LCA VIII, Sao Paulo, Brazil. 2008. Lecture.

580 Ettlinger, Steve. *Twinkie, deconstructed: my journey to discover how the ingredients found in processed foods are grown, mined (yes, mined), and manipulated into what America eats*. New York, NY: Hudson Street Press, 2007. Print.

General Information

Approximately 90% of the environmental impacts of ice cream are a result of primary production on the farm. The remaining environmental impacts are limited to mixing, refrigeration, and transportation.[581] Hood does not indicate that any of its farmers adhere to organic standards, which would decrease the fertilizer applied to the feed eaten by the dairy cows.

Ice cream processing takes three main ingredients - dairy, sweeteners, and additives – to give the finished product the flavor and texture desired by the consumer. Traditional additives include stabilizers that prevent the growth of ice crystals and emulsifiers that reduce fat coalescence.[582] Once blended, the mix still must be pasteurized, homogenized, aged, frozen, cartooned, and hardened.

Ice cream mix is pasteurized at 155˚F for thirty minutes, which is a higher temperature than thinner milk products.[583] Then, the mix is homogenized at 2500 to 3000 pounds per square inch to ensure even distribution of ingredients to aid in smooth freezing.[584] Following this thorough blending, the mix is aged overnight at 40˚F to allow the milk fat to partially crystallize and the stabilizers time to hydrate.[585] Before packaging, flavoring is added and the mixture is whipped to increase the air content.[586] Finally, the ice cream is cartooned in three-gallon containers and quickly cooled to -13˚F to harden the product.[587] Now, the ice cream is ready for consumption.

Fertilizer

The fertilizer is mostly a concern in primary production of the feed provided to dairy cows and in sugar harvesting. See the analyses for corn and soybean feed, provided separately in this report, for more details. In our estimates we assume that each dairy cow consumes 82,125 pounds of corn and 82,125 pounds of soybeans over the course of its life. As for sugar, fertilizer is commonly applied in the agricultural stage at the following rate per hectare per year:[588] 60 kilograms of urea and ammonium nitrate, 8.3 kilograms of single superphosphate, and 13.3 kilograms of potassium chloride. We combine these estimates of fertilizer application to determine that 0.008772 lbs of fertilizer are applied per serving of ice cream produced, giving ice cream a grade of D (see Table 1). This is one of the worst grades given to any food we analyze, making ice cream a food to target if the College moves to reduce its fertilizer impact.

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581 "Environmental Impacts of Food Production and Consumption." *Department for Environment: Food and Rural Affairs*. University of Manchester, n.d. Web. 14 May 2011. <http://www.ifr.ac.uk/waste/Reports/DEFRA-Environmental%20Impacts%20of%20Food%20Production%20%20Consumption.pdf>.

582 West Virginia University. "Ice Cream Production." *College of Engineering and Mineral Resources Projects*. N.d. Web. 1 Apr. 2011. <www.che.cemr.wvu.edu/publications/projects/.../icecream.pdf>.

583 Cornell University. "Ice Cream Production." *Index*. N.d. Web. 2 Apr. 2011. <http://www.milkfacts.info/Milk%20Processing/Ice%20Cream%20Production.htm#ICPast>.

584 Cornell University. "Ice Cream Production." *Index*. N.d. Web. 2 Apr. 2011. <http://www.milkfacts.info/Milk%20Processing/Ice%20Cream%20Production.htm#ICPast>.

585 Cornell University. "Ice Cream Production." *Index*. N.d. Web. 2 Apr. 2011. <http://www.milkfacts.info/Milk%20Processing/Ice%20Cream%20Production.htm#ICPast>.

586 West Virginia University, Ice Cream Production.

587 Cornell University. "Ice Cream Production." *Index*. N.d. Web. 2 Apr. 2011. <http://www.milkfacts.info/Milk%20Processing/Ice%20Cream%20Production.htm#ICPast>.

588 IERE. "Environmental Comparison of Conventional and Organic Technological Routes for Sugar Obtaining Concerning to Greenhouse Gases Emissions." *International Life Cycle Assessment & Management. International Environmental Research & Education. LCA VIII*, Sao Paulo, Brazil. 2008. Lecture.

Water

Ice cream uses water at several critical stages in its production: farming the feed for dairy cows, providing drinking water for dairy cows, watering the sugarcane, and the water required for manufacturing. Our analyses of corn and soybean feed indicate that one dairy cow requires 36.5 gallons of water per day to produce the feed that it consumes. In addition, one kilogram of sugarcane grown in Florida requires 88-118 kilograms of water.[589] Finally, water is required during manufacturing to cool the mix at various points in the process. Since this salt water is recycled, however, we do not consider it as water that is expended during the manufacturing process. As a result, we estimate that ice cream production expends approximately 28.15 gallons of water per serving size, earning a grade of C.

Processing

Ice cream immediately contributes more to greenhouse gas emissions than many other food items because it is a dairy product. Dairy cattle not only demand large quantities of feed that must be harvested and processed, but they also emit methane gas through enteric fermentation that is a more potent greenhouse gas than carbon dioxide. Due to these factors, it is not surprising that ice cream earns a C grade in comparison to other food items that we analyze.

Processing the ingredients into ice cream contributes the largest percentage of total greenhouse gas emissions associated with ice cream production (see Table 3). The majority of these emissions come from the energy required to process sugarcane into granular sugar. Another large portion comes from the complex manufacturing process once the ingredients reach the processing plant, that includes cooling, adding emulsifiers and stabilizers, and injecting air into the ice cream mix to make it light and creamy.

Transportation

We assume that ice cream that Wellesley purchases is manufactured at the closest plant operated by HP Hood, located in Suffield, Connecticut. HP Hood acquired Crowley and Kemps in 2004, and subsequently sought to consolidate their frozen desserts manufacturing plants in the northeast to two locations: Suffield, Connecticut and Lancaster, Pennsylvania.[590] So, Hood ice cream delivered to Wellesley travels approximately 90 miles in refrigerated freight trucks. According to interviews with the dining hall staff, ice cream deliveries arrive at Wellesley as many as three times a week. All dining complexes order ice cream separately commensurate with demand.

Table 54: Greenhouse gas emissions from all stages of ice cream production

Units (g CE)	Transportation	Processing	Farming processes	Methane	TOTAL	Grade
Ice cream	1.623	92.98	0.01180	9	103.6	C

[589] Whitty, EB, DL Wright, and CG Chambliss. "Water Use and Irrigation Management of Agronomic Crops ." *University of Florida IFAS Extension*. 2009. Web. 23 Feb. 2011. <http://edis.ifas.ufl.edu/aa131>.
[590] CBS. "Hood consolidating ice cream ops, entering aseptic creamer market | Dairy Foods | Find Articles at BNET." *BNET*. N.d. Web. 1 Apr. 2011. <http://findarticles.com/p/articles/mi_m3301/is_11_105/ai_n7577121/>.

Toxicity

Hood reports that some of its dairy farmers have eliminated the use of artificial growth hormones (rBST, an abbreviation for recombinant bovine somatotropin) in their operations, but it does not report what percentage of farmers. These growth hormones increase milk output per dairy cow an estimated 5-8%.[591] On average, thirty percent of dairy farms in the Northeast use rBST to enhance their milk production.[592]

591 Foltz, Jeremy. "Bovine Growth Hormone (rBST) Adoption on Connecticut Dairy Farms." *Department of Agricultural and Resource Economics* (2001): n. pag. *University of Connecticut*. Web. 25 Feb. 2011.
592 Foltz, Jeremy. "Bovine Growth Hormone (rBST) Adoption on Connecticut Dairy Farms." *Department of Agricultural and Resource Economics* (2001): n. pag. *University of Connecticut*. Web. 25 Feb. 2011.

Milk

As part of our individual foodstuff analysis, we are examining milk because it is an individual food product that is consumed in large quantities and is very visible in our dining services. We buy various milk products from a number of suppliers, but the main suppliers are Hood and Garelicks Farms, subsidiary of Dean Foods. We order approximately 1,260 gallons of milk per year from Hood Farms and just under 10,000 gallons of milk from Garelick Farms. For simplification, we assume that all milk types are processed similarly, although there is some variation when fat skimming occurs. We assume that the bulk of the environmental impact of milk production occurs in growing the feed, raising the animals, and transporting the product, not in the different skimming methods.

Serving Size

To examine the impact of milk, we use a single serving of milk from each supplier. The U.S. Department of Agriculture and the U.S. Department of Health and Human Services define a serving of milk as one cup, or eight fluid ounces.[593]

Farm Locations

Hood Milk is headquartered in Lynnfield, Massachusetts and sources its milk from across New England.[594] Likewise, Garelick Farms is a New England-based dairy farming operation with farms across New England and New York State.[595] Neither company provides the exact locations or sourcing information for their farms. New England dairy farming is concentrated in Vermont but is also spread across Maine, New Hampshire, Massachusetts, Connecticut and Rhode Island. We use central Vermont as the largest supplier of milk in New England and as a middle point to generalize milk production. This generalization allows us to estimate the impact of our milk supply without having to analyze each farm individually. Additionally, we assume Garelick and Hood use similar methods throughout the lifecycle, and so will calculate a single analysis for New England milk.

Dairy Cow Feed, Water Consumption, and Milk Production

We need to examine the lifecycle from the production of the dairy cow feed through the transportation to Wellesley College. In order to get a sense of the impact of our milk supply, we look at a typical dairy farm and use those numbers to estimate the impact of a single cup of milk. The New England Dairy Promotional Board lists a number of facts on their website that inform these calculations. For instance, a cow produces over 2,400 gallons of milk per year or around 500,000 glasses of milk in her lifetime.[596] For a fully-grown Holstein, the most common dairy breed in the U.S., an average mature weight is around 1,400 pounds.[597] An average cow eats 90 pounds of food and drinks 25-50 gallons per day.[598] Over the course of a five-year lifetime, this

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[593] U.S. Dept. of Health and Human Services. *Dietary guidelines for Americans, 2010*. Washington, D.C.: U.S. Dept. of Agriculture, 2010. Print.
[594] HP Hood LLC. "Hood Home," 2009. Web. 25 Feb. 2011. <http://www.hood.com/>.
[595] Garelick Farms, "Garelick Farms," 2006-2011. Web. 25 Feb. 2011. <http://www.garelickfarms.com/>.
[596] New England Dairy Promotion Board. "New England Dairy Promotion Board - Dairy Facts," n.d. Web. 25 Feb. 2011. <http://www.newenglanddairy.com/page/dairy-facts>.
[597] New England Dairy Promotion Board."New England Dairy Promotion Board - Dairy Facts," n.d. Web. 25 Feb. 2011. <http://www.newenglanddairy.com/page/dairy-facts>.
[598] Richardson, Deborah Y. *All about dairy cows*. Beltsville, Md.: U.S. Department of Agriculture, 2003. Print.

amounts to 164,250 pounds of feed and 68,437.5 gallons of water (using 36.5 gallons per day average). This number may be slightly high, as it assumes that a baby cow eats and drinks the same amount as an adult cow, but the estimation is close enough.

To assess the environmental impacts of the cow feed, we use the food analysis sections for corn and tofu. Animal feed, including the food that cows eat, is approximately 70-90% corn and soybeans.[599] For this analysis we simplify the food equation and use 50% corn and 50% soybeans, thus assuming that a cow eats around 82,125 pounds each of corn and soybeans in its lifetime.

Fertilizer Use

Much, if not all, of the fertilizer inputs for milk come from growing the crops for cow feed. These figures can be found in the corn and tofu food analysis sections. For this analysis we estimate that each dairy cow consumes approximately 82,125 pounds each of corn and soybeans in its lifetime.

Water Use

The majority of the water usage from producing milk comes from raising the crops for feed and the drinking water for the cow. The information for water use in raising crops can be found in the corn and tofu food analysis sections. We assume that the cow eats 82,125 pounds each of corn and soybeans and drinks 68,437.5 gallons of water (an average of 36.5 gallons per day) in its lifetime.

Mechanization and Processing

For information about mechanization and processing associated with dairy cow feed, refer to the corn and tofu food analysis sections.

Methane

Another environmental impact of dairy farming is caused by methane emissions from enteric fermentation and manure management. Vermont dairy cows produce around 0.16 metric tons of methane per cow per year, just about the same as the national average.[600] For a five-year lifespan, this amounts to around 0.8 metric tons of methane per cow. Any methane emissions associated with growing dairy cow feed can be found in the corn and tofu food analysis sections.

Transportation

Another worry with greenhouse gas emissions and milk production comes from the transport from farm to processing plant and then to final consumer. Using Garelick Farms as the sample and assuming that Hood has a similar setup, we look at the food miles involved in transporting the milk from farm to Wellesley. Garelick Farms' main processing plants are in Lynn and Franklin, Mass., and in East Greenbush, NewYork.[601] Using Rutland, a central point in

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[599] *Consumer Reports.* "Animal feed and the food supply: Food safety, animal feed," Jan. 2010. Web. 25 Feb. 2011. <http://www.consumerreports.org/cro/food/food-safety/animal-feed-and-food/animal-feed-and-the-food-supply-105/overview/>.

[600] ProCon.org, "State by State Dairy Cow Emissions: The Fart Chart - Milk - ProCon.org," *n. d.*. Web. 25 Feb. 2011. <http://milk.procon.org/view.resource.php?resourceID=001154>.

[601] Gram, Dave. "Major milk buyer Dean Foods to pay $30 million to Northeast dairy farmers in proposed suit settlement | masslive.com." *Western Massachusetts Local News, Breaking News, Sports and Weather -*

Vermont, as the sample location for a dairy farm and the plant in Lynn as the sample processing location, we assume that the milk travels from Rutland to Lynn (172 miles), then from Lynn to Wellesley (37 miles). The milk likely stops once or twice more in storage facilities on the way to Wellesley, but generally goes from Rutland to processing plant to Wellesley. Both steps in the milk's transport from farm to Wellesley are likely in a large shipping truck. Information on transportation associated with dairy cow feed can be found in the corn and tofu food analysis sections.

Scale

According to a University of Vermont survey, in 2002 the average size of a herd of dairy cows in Vermont was 115.5 cows, while the median herd size was 70 cows.[602] This signifies some outliers on the upper end of the scale, so we use seventy cows per farm for our calculations, but these calculations indicate that there is a wide range of farm sizes in Vermont and a few extremely large farms. Vermont dairy farms often grow crops as well, such as hay and corn.[603] Although these crops may be grown differently than the industrial-scale corn we analyze in another food analysis section, we assume that the majority of the feed still comes from manufactured processes that use industrially grown corn.

Toxicity

One of the most prominent public issues with cows is the use of recombinant bovine growth hormone (rBGH), used to make cows gain weight faster. Fortunatelyneither Garelick nor Hood sources milk from farmers that use rBGH, so we do not have to worry about hormones for the vast majority of the milk at Wellesley.[604] Another common concern about milk is the antibiotics used on the dairy cows. Neither Garelick nor Hood has a specific policy on the use of antibiotics on their source farms . According to a study by the University of Minnesota, cows can be treated with antibiotics for disease treatment, disease control, or for production efficiency (to make the animal grow faster).[605] The most common antibiotics used are penicillin, cephalosporin and tetracyclines and were used to treat respiratory infections, mastitis and foot problems.[606] Unfortunately, the Union of Concerned Scientists and others have reported on the lack of information about the amount of antibiotics administered to livestock in the U.S.[607] A recent report from the U.S. Food and Drug Administration put the total around 29 million pounds of

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MassLive.com, 2010. Web. 25 Feb. 2011. <http://www.masslive.com/news/index.ssf/2010/12/major_milk_buyer_dean_foods_northeast_dairy_farmers_suit_settlement.html>.

602 Vermont Dairy Promotion Council. "Dairy Farm Numbers - Vermont Dairy." *Vermont Agency of Agriculture, 2011*. Web. 25 Feb. 2011. <http://www.vermontdairy.com/dairy_industry/farms/numbers>.

603 Vermont Dairy Promotion Council. "Dairy Farm Numbers - Vermont Dairy." *Vermont Agency of Agriculture, 2011*. Web. 25 Feb. 2011. <http://www.vermontdairy.com/dairy_industry/farms/numbers>.

604 Garelick Farms. "Garelick Farms FAQ," 2006-2011. Web. 25 Feb. 2011. <http://garelickfarms.com/newprod/faq.php>.; HP Hood LLC. "Hood Home," 2009. Web. 25 Feb. 2011. <http://www.hood.com/>.

605 Neeser, Nicole. "Antibiotic Use in Production Agriculture." College of Veterinary Medicine, University of Minnesota, May 2003: n. pag. From the Proceedings of the Minnesota Dairy Health Conference. Web. 25 Feb. 2011.

606 Kirk, John H. "Commonly Used Antibiotics on Dairies." *School of Veterinary Medicine, University of California Davis,* Sep. 2004: 1-3. Print.

607 Mellon, Margaret, and Steven Fondreist. "Hogging It." *The Magazine of the Union of Concerned Scientists,* Spring 2001: 25-30. Print.

antibiotics on all livestock raised in the U.S.[608] That number is not broken down by type of livestock or amount per animal.

[608] U.S. Food and Drug Administration. *2009 SUMMARY REPORT on Antimicrobials Sold or Distributed for Use in Food-Producing Animals*. Washington, D.C.: U.S. Department of Health and Human Services, 2009. Print.

Mozzarella Cheese

In the mozzarella cheese category, we are assessing Arezzio low moisture whole milk shredded mozzarella cheese, distributed by Olympia Cheese Company. This cheese makes up 3 percent of the mozzarella cheese purchased by Wellesley dining services. All shredded mozzarella cheese products, which would probably have a similar life cycle, make up 97 percent of mozzarella purchased.

Serving Size

We use a serving size of 1.5 ounces as the functional unit in our analysis.[609] Mozzarella cheese is produced from milk (93 percent by volume), water (7 percent), citric acid (0.1 percent), and rennet (0.03 percent). [610] A serving of cheese consists of 12 fluid ounces of milk.[611] Our analysis of the impacts of ingredients includes only milk, but we also consider the environmental effects of processing.

Farm Locations

Most domestic mozzarella cheese is produced in western U.S.,[612] and since our cheese is distributed by Olympia Cheese Company, which is located in Olympia, WA, it seems likely that the cheese is produced in Washington state.

Processing

Mozzarella is produced by adding citric acid and rennet to milk, and presumably all of the citric acid remains in the milk. The curds that form are warmed at 98°F. They are then kneaded in hot water, and cooled in cold water.[613] Machinery is probably used in the process of kneading and mixing. Most (97 percent) of the cheese used at Wellesley is shredded, and the shreds are then individually quick frozen.[614]

Transportation

Milk is most likely transported a short distance from the area where it is produced (see Milk LCA) to the processing plant, which we assume is located in Olympia. It is plausible that the cheese is transported in freezer railcars to Massachusetts,[615] and then is transported a

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[609] U.S. Department of Agriculture and U.S. Department of Health and Human Services. "Appendix 14. Selected Food Sources Ranked by Amounts of Calcium and Calories Per Standard Food Portion." *Dietary Guidelines for Americans*. Version 7th edition. Dec. 2010. Web. 24 Feb. 2011. <http://www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/PolicyDoc/PolicyDoc.pdf>.

[610] "Mozzarella Cheese Recipe." *New England Cheesemaking Supply Company*. 2010. Web. 24 Feb. 2011.

[611] Instructables, How to Make Great Fresh Mozzarella Cheese ." *Instructables* . 2010. Web. 1 Mar. 2011. <http://www.instructables.com/id/Great-Mozzarella-Cheese/step18/CHEESE/>

[612] "NASS - Data and Statistics - Quick Stats." *NASS - National Agricultural Statistics Service*. Version 2.0. NASS, n.d. Web. 22 Feb. 2011. <http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/index.asp>.

[613] "Making Mozzarella." *Mozzarella Cheese*. Mozzarella-Cheese.co.uk , 2010. Web. 24 Feb. 2011. <http://www.mozzarella-cheese.co.uk/making_mozzarella.html>.

[614] "Mozzarella Cheese - Products - Sysco Corporation." *Home-Sysco Corporation*. Sysco Corporation, 2009. Web. 24 Feb. 2011. <http://www.sysco.com/products/productpage.asp?prodID=64&ctID=49&ptID=1>.

[615] USDA- AMS. "Chapter 9: Rail Capacity." *United States Department of Agriculture- Agricultural Marketing Service*., 27 Apr. 2010. Web. 25 Feb. 2011. <http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5084093>.

relatively short distance by truck to 380 South Worchester Street, Norton, MA, where Sysco Boston is located,[616] since Arezzio cheese is a product of Sysco.

[616] "About Sysco - Location Map - Sysco Corporation." *Home-Sysco Corporation*. Sysco Corporation, 2009. Web. 24 Feb. 2011. <http://www.sysco.com/map/map.asp>.

Sunkist Orange Juice Concentrate

In 2010, AVI purchased 1872 liters of Sunkist Orange Juice Select (4x1 Concentrate), a juice concentrate produced by the brand Sunkist and distribute by Dispenser Services Inc. Sunkist is an international distributor whose headquarters is located in Sherman Oaks, California, and who has subsidiaries nationwide (including in Boston, Massachusetts). Dispenser Services Inc. is headquartered in Charleston, South Carolina, and operates through its district office in Waltham, Massachusetts. AVI purchases other brands of orange juice concentrate in addition to Sunkist, but we include only the Sunkist brand in our analysis because we assume that differences in production process across brands is negligible. Sunkist Orange Juice from Concentrate has no additives or other ingredients, and is 100 percent orange juice. Ingredients are not available online; the ingredient list was learned via personal inspection of products at Wellesley.

Serving size

The USDA-recommended serving size for juices is one cup.[617] AVI purchased 7912 servings of Sunkist Orange Juice Select in 2010.

Farm locations

No data specifying exact Sunkist farm locations is available. Florida is home to 82 percent of all oranges produced nationally, and California produces 16 percent.[618] Because Florida is the top producer of oranges used for juice and juice concentrate in the country by such a large margin, we examine oranges that are grown, harvested and processed in Florida. As shown in Table 55 and Figure 31 the highest orange production zone is in southern Florida.[619] Polk and Hendry Counties were ranked highest in production in the 2008-2009 crop year.[620]

Table 55: Citrus acreage by production area

Commercial Citrus Acreage by Production Areas by Variety – Florida: 2008-2009

Area	Oranges		Grapefruit		Specialty types		Total	
	2008	2009	2008	2009	2008	2009	2008	2009
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Indian River	50,007	45,826	42,145	40,059	3,704	3,482	95,856	89,367
Northern	23,233	22,728	1,076	1,057	3,883	3,799	28,192	27,584
Central	139,768	141,172	4,741	4,798	7,144	7,042	151,653	153,012
Western	133,293	135,989	1,667	1,713	2,749	2,729	137,709	140,431
Southern	150,217	146,814	7,252	6,236	5,698	5,370	163,167	158,420
Total	**496,518**	**492,529**	**56,881**	**53,863**	**23,178**	**22,422**	**576,577**	**568,814**

617 US Department of Agriculture, and US Department of Health and Human Services. "Dietary Guidelines for Americans 2010." *Dietary Guidelines for Americans*. USDA Center for Nutrition Policy and Promotion, 31 Jan. 2011. Web. 25 Feb. 2011. <http://www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/PolicyDoc/PolicyDoc.pdf>.

618 Rieger, Mark. "Cranberry." *Fruit Crop Home Page*. Department of Horticulture, University of Georgia. N.d. Web. 25 Feb. 2011. <http://fruit-crops.com/cranberi/>.

619 *Florida Citrus Statistics 2008-2009*. Tallahassee: Florida Department of Agriculture and Consumer Services, 210. N.d. Web. Feb 25, 2010. <http://www.nass.usda.gov/Statistics_by_State/Florida/Publications/Citrus/fcs/2008-09/fcs0809all.pdf>.

620 *Florida Citrus Statistics 2008-2009*. Tallahassee: Florida Department of Agriculture and Consumer Services, 210. N.d. Web. Feb 25, 2010. <http://www.nass.usda.gov/Statistics_by_State/Florida/Publications/Citrus/fcs/2008-09/fcs0809all.pdf>.

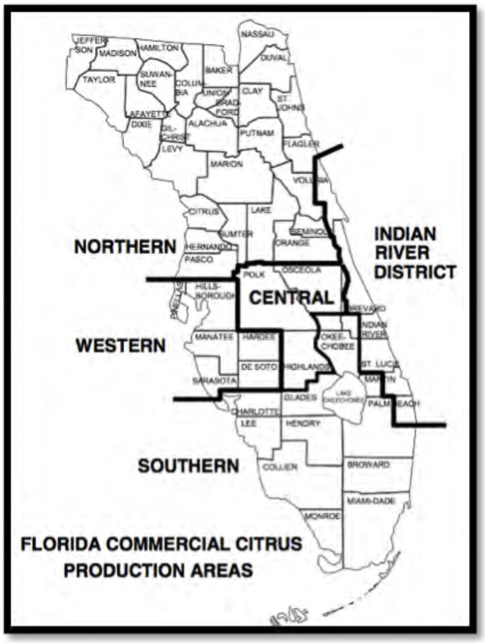

Figure 31: Florida citrus production areas

Fertilizer use

In comparison to other citrus producing regions, Florida has sandy soils with low water-retention capacity. These conditions require farmers to follow an intensive fertilizer program. The Fertilizer Institute reports that large amounts of nitrogen, potassium, and potash are applied (see Table 56) through a process called fertigation, where trees receive fertilizer 25 to 30 times a year during their first five years of growth through an irrigation system. Fertilizer is added in increasing amounts over the years of citrus trees production.[621]

Table 56: Recommended fertilizer use for young orange trees

Fertilizer programmes for young trees							
Country	Tree age in years	grams per tree					
		N	P2O5	K2O	MgO	Bone* meal	Wood** ash
USA, Florida	1	200	200	200	65		
	2	330	330	330	110		
	3	440	440	440	150		
	4	500	500	500	165		
	5	580	580	580	190		
	6	640	640	640	220		

621 The Fertilizer Institute: Fertilizer Facts and Stats - About Fertilize - Citrus." *The Fertilizer Institute*. N.d. Web. 26 Feb. 2011. <http://www.tfi.org/factsandstats>.

Irrigation

About two million of the 10.2 million acres of land used for farming practices in Florida requires irrigation.[622] Citrus crops in Florida use nearly half of irrigated water in the state—nearly 1.5 billion gallons per day. In 2000, citrus farms accounted for 48 percent of all ground and surface water withdrawals.[623] In Florida, the most common irrigation practices are drip, trickle or low-flow micro sprinklers (See Table 57).[624] Because oranges are the top crop in Florida,[625] and because citrus crops use a much greater amount of irrigation water than other crops, we assume that orange groves use drip, trickle or low-flow micro sprinklers as well. Ground and surface water for irrigation comes from the Surficial Aquifer system,[626] which is used for supplying commercial, domestic and large and small municipalities with water (see Figure 32).[627]

Table 57: Land irrigated by method of water distribution: 2008 and 2003

Table 4. **Land Irrigated by Method of Water Distribution: 2008 and 2003**

[Excludes institutional, research, and experimental farms and farms with horticulture. For meaning of abbreviations and symbols, see introductory text]

Geographic area	Acres irrigated	Gravity systems		Sprinkler systems		Drip, trickle, or low-flow micro sprinklers		Subirrigation	
		Farms	Acres irrigated	Farms	Acres irrigated	Farms	Acres irrigated	Farms	Acres irrigated
United States .... 2008 ..	54,929,915	89,646	22,017,757	114,348	30,877,057	43,368	3,756,134	1,292	199,993
2003 ..	52,492,687	100,626	23,106,280	103,154	26,888,528	41,802	2,963,742	614	279,522
2008 DATA									
Alabama	75,023	91	2,542	353	69,642	239	2,843	4	4
Alaska	1,589	1	(D)	16	1,707	7	22	-	-
Arizona	861,496	2,064	764,655	729	178,184	391	54,087	-	-
Arkansas	4,493,435	3,714	3,747,542	1,013	814,449	345	6,800	-	-
California	7,329,245	15,530	4,189,852	18,369	1,367,179	21,253	2,336,130	104	66,282
Colorado	2,865,840	10,252	1,547,072	4,337	1,402,688	524	23,061	13	2,495
Connecticut	2,337	-	-	76	1,397	89	959	-	-
Delaware	104,620	-	-	287	103,887	48	886	-	-
Florida	1,222,797	907	473,527	1,374	184,965	3,355	549,324	38	55,776
Georgia	1,007,763	447	52,599	2,892	943,612	1,051	97,930	52	520

622 "Agriculture and Water Use - Plant Management in Florida Waters ." *Welcome to the Center for Aquatic and Invasive Plants | Center for Aquatic and Invasive Plants*. N.d. Web. 26 Feb. 2011. <http://plants.ifas.ufl.edu/guide/agricul.html#lwuse>.

623 "Agriculture and Water Use - Plant Management in Florida Waters ." *Welcome to the Center for Aquatic and Invasive Plants | Center for Aquatic and Invasive Plants*. N.d. Web. 26 Feb. 2011

624 "Land Irrigated by Method of Water Distribution: 2008 and 2003." *2007 Farm and Ranch Irrigation Survey*. N.d. Web. 21 Feb. 2011. <www.agcensus.usda.gov/Publi>.

625 US Department of Agriculture and Florida Agricultural Statistics Service. "2007 Agriculture Census – State Profile, Florida." USDA National Agricultural Statistics Services, 2009. Web. 22, 2011. <http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/County_Profiles/Florida/cp99012.pdf>.

626 "SWAP: Aquifer Descriptions." *Welcome | Florida Department of Environmental Protection (DEP)*. N.d. Web. 26 Feb. 2011. <http://www.dep.state.fl.us/swa>.

627 "Agriculture and Water Use - Plant Management in Florida Waters ." *Welcome to the Center for Aquatic and Invasive Plants | Center for Aquatic and Invasive Plants*. N.d. Web. 26 Feb. 2011; "SWAP: Aquifer Descriptions." *Welcome | Florida Department of Environmental Protection (DEP)*. N.d. Web. 26 Feb. 2011. <http://www.dep.state.fl.us/swa>.

Figure 32: Florida aquifers

Mechanization

The process of planting and harvesting orange trees is labor intensive. Because it is rare that a fruit comes from a tree that is of true seed (most are from rootstock), fruits must be first propagated and then cultivated as seedlings before they are transplanted.

Land preparation requires tractors, roto-tillers, transplanters, sprayers for pesticide application, irrigation machinery, pruners, ladders for harvesting, harvesting machinery, canvas pick bags, fruit loader (‘goat’), boxes, and tractor trailers (holding roughly 45,000 pounds) for transporting boxes of oranges.[628] In Florida, nearly 96 percent of all oranges are hand-harvested.[629] There has, however, been a recent trend toward machine harvesting, using trunk and canopy shakers pulled by tractors.[630]

Processing

Sunkist Growers, Inc. provides no information regarding processing plant locations in Florida. At the processing plant, oranges are inspected, washed, processed and packaged in bulk.[631] The concentrate is packaged in 55-gallon drums or into special refrigerated tanker trucks and shipped to packaging plants as such. At the packaging plants, filtered water is added back to

[628] "The Story of Florida Orange Juice - From the Grove to Your Glass." *UltimateCitrus.com - The Ultimate Citrus Page*. N.d. Web. 26 Feb. 2011. <http://www.ultimatecitrus.com/>.
[629] "The Story of Florida Orange Juice - From the Grove to Your Glass." *UltimateCitrus.com - The Ultimate Citrus Page*. N.d. Web. 26 Feb. 2011. <http://www.ultimatecitrus.com/
[630] Rouse, Robert E., and Mongi Zekri. "HS-867/HS132: Citrus Culture In The Home Landscape ." *EDIS - Electronic Data Information Source - UF/IFAS Extension*. N.p., n.d. Web. 26 Feb. 2011. <http://edis.ifas.ufl.edu/hs132>.
[631] "The Story of Florida Orange Juice - From the Grove to Your Glass." *UltimateCitrus.com - The Ultimate Citrus Page*. N.d. Web. 26 Feb. 2011. <http://www.ultimatecitrus.com/

the concentrate, and packaged. Many dairies nationwide package orange juice using the same equipment used to package milk.[632]

Transportation

Sunkist Growers, Inc. does not provide information on shipment methods at any stage of the oranges lifecycle. Oranges in Florida are usually transported from the orange groves by truck-tractor to the processing plants. From the processing plant, the orange juice concentrate is then shipped in refrigerated trucks to packaging plants, where it is re-packaged for broader distribution.[633]

Scale

The United States produces 18 percent of the world's citrus supply, second to Brazil. According to the USDA 2009 Florida State Agricultural Overview, there were 47,500 citrus farms in operation in 2009, and the average farm size was 195 acres.[634]

Toxicity Information

According to the most recent Summary of Agricultural Pesticide Use in Florida, published in October 2010, orange crops use a high level of pesticides during production. In this time period, oranges used a total of 485,000 pounds/year of fungicides, 2,518,000 pounds/year of herbicides, 22,377,600 pounds/year of insecticides, and 53,500 pounds/year of other pesticides.[635]

Biodiversity

According to the World Wildlife Fund, the Florida Sand Pine Scrub, Florida's most distinct ecosystem, is currently and has historically been threatened by citrus crop development.[636] This species is currently rendered endangered, and only 10 to 15 percent of the scrub habitat remains in Florida. The most severe loss of the habitat is in the south of Florida.[637]

Packaging

Oranges go through a series of packaging stages in their lifecycle. From the harvest, they are put into plastic tubs that can hold up to 900 pounds, and then collected by goats to be brought to processing plants. From the processing plant, the concentrate is packaged in 55-gallon drums or into special food refrigeration trucks and sent to packaging plants where the concentrate is

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[632] "The Story of Florida Orange Juice - From the Grove to Your Glass." *UltimateCitrus.com - The Ultimate Citrus Page*. N.d. Web. 26 Feb. 2011. <http://www.ultimatecitrus.com/

[633] Ibid, The Story of Florida Orange Juice.

[634] US Department of Agriculture and Florida Agricultural Statistics Service. "2009 State Agricultural Overview." USDA National Agricultural Statistics Services, 2009. Web. 22, 2011. <http://www.nass.usda.gov/Statistics_by_State/Ag_Overview/AgOverview_FL.pdf>.

[635] Bronson, Charles H. *Summary of Agricultural Pesticide Use: 2007-2009*. Rep. Tallahassee: Florida Department of Agriculture and Consumer Services. Division of Agricultural Environmental Services, Bureau of Pesticides, 2010. N.d. Web. 31 Mar. 2011. < http://www.flaes.org/pdf/PUI_narrative_2010.pdf>.

[636] Dinerstein, E., A. Weakly, R. Noss, R. Snodgrass, and K. Wolf. "Terrestrial Ecoregions -- Florida Sand Pine Scrub (NA0513)." *World Wildlife Fund - Wildlife Conservation, Endangered Species Conservation*. World Wildlife Fund, 2011. Web. 01 Apr. 2011. <http://www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0513_full.html>.

[637] Dinerstein, E., A. Weakly, R. Noss, R. Snodgrass, and K. Wolf. "Terrestrial Ecoregions -- Florida Sand Pine Scrub (NA0513)." *World Wildlife Fund - Wildlife Conservation, Endangered Species Conservation*. World Wildlife Fund, 2011. Web. 01 Apr. 2011. <http://www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0513_full.html>.

then repackaged into cardboard, plastic or glass containers.[638] Wellesley receives its orange juice in plastic containers, which are most likely packaged inside of cardboard boxes.

[638] "The Story of Florida Orange Juice - From the Grove to Your Glass." *UltimateCitrus.com - The Ultimate Citrus Page*. N.d. Web. 26 Feb. 2011. <http://www.ultimatecitrus.com/>.

Pineapple

Wellesley dining services purchases fresh, canned and frozen pineapple. Approximately 140 pounds of frozen and 12,626 ounces of canned pineapple are purchased during the year. This equates to 685 pounds of canned drained pineapple or the equivalent of 395 individual, whole pineapples. Sysco is the major provider of frozen and canned pineapple and it orders from the brands Intlcys, Sys Rel and D'Allas.

Dining services purchases most of its pineapple as fresh pineapple in cases from Costa,[639] and in the past year the college purchased 688 cases of fresh pineapple. This equates to **4,128 individual pineapples** delivered to the College each year, which is **132,096 ounces** of fresh pineapple served annually.[640]

We use fresh pineapple for the LCA because we purchase significantly more fresh pineapple than canned or frozen pineapple. The location of production could differ between the fresh and canned pineapple, but for the purposes of this investigation it makes more sense to isolate fresh pineapple and evaluate it exclusively.

Pineapple is served in almost all dining locations on campus. It is found in the dining halls as a breakfast fruit or in desserts. Pineapple is served in fruit salads from the Emporium in the campus center to other locations on campus. Pineapple cannot be grown locally in temperate climates. Therefore, since this fruit is served at Café Hoop and El Table in special dishes and drinks, such as smoothies, it is likely purchased through the same supplier as the college.

Serving size

The serving size for pineapple is ½ cup of fresh cut up fruit.[641] This equates to 4 ounces or 113 grams.[642] Dining services purchased 33,024 servings of fresh pineapple in the 2010 purchasing year. There are approximately 8 servings in each individual pineapple.

Location of farm

Brazil (14.2% of the world's production of pineapple), Thailand (13%), Philippines (12.6%), Costa Rica (9.6%) and China (8%) are the top five producers of pineapples internationally.[643] Together they constitute 57.5% of the world's production of pineapple. The United States only accounts for 1% of total pineapple production. Although it is ambiguous where Costa receives its pineapple from, the United States Department of Agriculture's Marketing Service puts out news bulletins on prices of commodities and relevant news. The majority of the new releases on pineapple refer to imports from Costa Rica.[644] Although Brazil

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[639] Assume that Costa is the major distributor of fresh pineapple

[640] "Hawaiian Gifts and All Occasion Gift Baskets." *Doublebrush.com.*, n.d. Web. 21 Feb. 2011. <shopnow.secureonlinecart.com/estore/f/products.php?product_id=105&store_id=1198&affiliate=&sid=1af5723a064c43c65f2384bdcb63f25c&affiliate=%20%286%20pineapples%20per%20case%29%206x%20688>.

[641] Vilsack, Thomas, and Kathleen Sebelius. "Pineapple." *Dietary Guidelines for Americans 2010*. United States Department of Agriculture, n.d. Web. 22 Feb. 2011. <www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/PolicyDoc/PolicyDoc.pdf>.

[642] "Cooking Equivalent Measurements, U.S. vs. Metric vs. Imperial (U.K.) Measures, Substituting Cooking Measurements, Dry Measurements, Liquid Measurements." *What's Cooking America, Mardi Gras, New Orleans Mardi Gras, New Orleans Foods, New Orleans Recipes, History of New Orleans Food, Fat Tuesday*. n.d. Web. 21 Feb. 2011. <http://whatscookingamerica.net/Q-A/equiv.htm>.

[643] "Pineapple." *FAOSTAT*. n.d. Web. 20 Feb. 2011. <http://faostat.fao.org/site/339/default.aspx>.

[644] "Commodity Price-Pineapple." *Market Scope*. The Packer, n.d. Web. 25 Feb. 2011. <http://thepacker.com/Pineapple/MarketScope.aspx?cid=Pineapple>

actually produces more pineapple, it appears as though more of the pineapple imported into the Untied States is from Costa Rica. In 2000, Costa Rica accounted for 42% of the total pineapple exported.[645] We will assume for this report that the pineapple Wellesley purchases comes from Costa Rica.

Pineapples need to be produced in high altitudes but with warmer climates.[646] Most of pineapple production in Costa Rica occurs in the northern section of the country.[647] Judging from a map of the region, it is likely that pineapples originate closest to the city of agricultural land and cities it appears as though pineapples originate near the city of Alajueta or San Jose.[648] This part of the country has a higher altitude and is known for its agricultural and economic activity.

Fertilizer and other inputs

In addition to chemicals for the prevention of diseases and damage from pests, pineapples are treated with fertilizer to produce larger fruits. One hectare of pineapple receives 600 kg/ha (5 treatments) of nitrogen, 100 kg/ha (1 treatment) of phosphorus and 400 kg/ha (4 treatments) of potassium.[649]

Ethephon is used to encourage uniform flowering and is made of the chemical calcium carbide and is sprayed onto the plants.[650] Most commonly, nitrogen and iron are used as fertilizer, although the ratios are unclear.[651] The herbicide diuron has been used to keep weeds down. It is likely an herbicide that is used in the black fumigation plastic. According to one reference, approximately 6.4 kilograms can be used per hectare.[652] It is likely that the fumigant 1,3-dichloropropene (1,3-D) or methyl bromide is used in fumigation. 1,3-dichloropropene (1,3-D) used between 336 to 224 $l.ha^{-1}$.[653]

Water

Pineapples do not need extra water in most locations because they are grown in tropical climates to begin with.[654] A drip tube method of watering is used.[655] Water is also applied during fertilizing.

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645 "Intergovernmental Group on Bananas and Tropical Fruits." *Committee on Commodity Problem*. FAO, 12 Apr. 2001. Web. 25 Feb. 2011. <http://www.fao.org/docrep/MEETING/004/Y1982E.HTM>

646 "Pineapple Cultivation." *Dole Plantation*. n.d. Web. 20 Feb. 2011. <http://www.dole-plantation.com/Pineapple-Cultivation>.

647 "Climate of Costa Rica ." *Costa Rica Natural*. n.d. Web. 24 Feb. 2011. <http://organicfarmcostarica.wordpress.com/2009/09/26/climate-of-costa-rica-and-agricultural-production/>.

648 "Costa Rica Maps." *Perry-Castañeda Library Map Collection*. University of Texas Libraries, n.d. Web. 24 Feb. 2011. <www.lib.utexas.edu/maps/costa_rica.html>.

649 "Pineapple Farming Tips." *Startup Business - Innovative Business Ideas - Profitable Business Opportunities*. n.d. Web. 22 Feb. 2011. <http://www.startupbizhub.com/pineapple-farming-tips.htm>.

650 Ombrello, T. "Pineapple." *Union County College Faculty Web Site*. n.d. Web. 22 Feb. 2011. <http://faculty.ucc.edu/biology-ombrello/pow/pineapple.htm>.

651 "Questions & Answers." *Dole Plantation*. n.d. Web. 21 Feb. 2011. <http://www.dole-plantation.com/QA>.

652 "Pineapple Farming Tips." *Startup Business - Innovative Business Ideas - Profitable Business Opportunities*. n.d. Web. 22 Feb. 2011. <http://www.startupbizhub.com/pineapple-farming-tips.htm>.

653 "MANAGEMENT OF THE FUMIGANT 1,3-DICHLOROPROPENE IN HAWAII PINEAPPLE." *Acta Horticulturae*. n.d. Web. 24 Feb. 2011. <http://www.actahort.org/books/425/425_48.htm>.

654 Bradtke, Birgit . "How To Grow Pineapples? Growing Pineapples Is Ridiculously Easy." *Tropical Permaculture Gardens: Growing Fruits And Vegetables The Easy Way*. n.d. Web. 21 Feb. 2011. <http://www.tropicalpermaculture.com/growing-pineapples.html>.

655 "Questions & Answers." *Dole Plantation*. n.d. Web. 21 Feb. 2011. <http://www.dole-plantation.com/QA>.

There are 442 million acres of cropland in the United States.[656] Each day in the United States approximately 141 billion gallons of water are used for irrigation.[657] We can assume that this equates to 319 gallons per acre per day for irrigation. Regular sprinklers are 75-85% efficient while drip systems are 90% efficient.[658] Therefore, we can reduce our water estimate to 275 gallons per acre per day for pineapple harvests.

Climate Change Impacts

These steps in the production of pineapple are based on the Dole Pineapple Plantation[659]

1) Field preparation-banking and leveling ground, fumigating and laying down black plastic.
2) Hand planting pineapple crowns in hand dug holes
3) Installing irrigation between plants
4) Fertilization and watering if not done in the climate
5) Harvest- hand picking and then conveyor belt transported out of field
6) Transportation of whole pineapples to packaging if not on site
7) Packaging- removing any excess debris and putting into cases of 6, onto a truck

Scale

Pineapple production occurs at an altitude of normally 3,000 feet and in tropical temperatures of between 70-85°F. [660] Most farms are very large operations however, each pineapple is hand dug into the ground and the plants are killed and reseeded because they loose productivity.[661] Between 44,000-53,000 pineapple trees are produced on a farm.[662] Each plant only produces one pineapple fruit every 18 months.[663] This means that Wellesley requires almost 1/10 of a hectare to support our pineapple consumption.

Packaging

Once the pineapples are grown, they are packaged, presumably on site; most production is large enough where this can occur. Since the pineapples are handpicked and moved out of the

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[656] Lubowski, Ruben N., Marlow Vesterby, Shawn Bucholtz, Alba Baez, and Michael J. Roberts. "Major Uses of Land in the United States, 2002." *USDA Economic Research Service - Home Page*. n.d. Web. 23 Feb. 2011. <http://www.ers.usda.gov/Publications/EIB14/>.

[657] "FAQs-Water Supply, Sources & Agriculture Use ." *Agricultural Water Conservation Clearinghouse*. n.d. Web. 23 Feb. 2011. <http://www.agwaterconservation.colostate.edu/FAQs_WATER%20SUPPLYSOURCESAGRICULTURALUSE.aspx>

[658] Stryker, Jess. "Drip Irrigation System Design Guidelines." *Irrigation tutorials; sprinkler & drip systems, design, install and repair.*. n.d. Web. 24 Feb. 2011. <http://www.irrigationtutorials.com/dripguide.htm>.

[659] "Pineapple Cultivation." *Dole Plantation*. n.d. Web. 20 Feb. 2011. <http://www.dole-plantation.com/Pineapple-Cultivation>.

[660] "Pineapple Cultivation." *Dole Plantation*. n.d. Web. 20 Feb. 2011. <http://www.dole-plantation.com/Pineapple-Cultivation>.

[661] "Pineapple Cultivation." *Dole Plantation*. n.d. Web. 20 Feb. 2011. <http://www.dole-plantation.com/Pineapple-Cultivation>.

[662] "Pineapple Farming Tips." *Startup Business - Innovative Business Ideas - Profitable Business Opportunities*. n.d. Web. 22 Feb. 2011. <http://www.startupbizhub.com/pineapple-farming-tips.htm>.

[663] Ombrello, T. "Pineapple." *Union County College Faculty Web Site*., n.d. Web. 22 Feb. 2011. <http://faculty.ucc.edu/biology-ombrello/pow/pineapple.htm>.

field by a conveyor belt, few transportation emissions occur in production. Since we are looking at fresh pineapple, we assume each pineapple does not need to be cut, but rather packaged with paper and put into boxes.

Transportation

Pineapple is packaged near the city of Alajueta and travels by truck to a port on the Gulf of Mexico. Moin or Limón are the most populous locations on the coast, so it is likely that pineapples ship from either of these locations to the United States via oceanic transportation. [664]

Most of the news surrounding pineapple imports shows that pineapples are imported to Florida.[665] Miami is one of the top ports in Florida, so it is safe to assume that the pineapples would be shipped from Costa Rica to Miami. [666] Once they arrive in Florida, they are likely distributed throughout the country. Given the volume of fresh pineapples distributed to the northeast, it is likely that the fruit would travel again by ship up to Boston where they would be unloaded.

In all stages of production, pineapples should be kept between 45-55 degrees Fahrenheit and at 85-90% relative humidity.[667]

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664 "Costa Rica Maps." *Perry-Castañeda Library Map Collection*. University of Texas Libraries, n.d. Web. 24 Feb. 2011. <www.lib.utexas.edu/maps/costa_rica.html>.

665 "Commodity Price-Pineapple." *Market Scope*. The Packer, n.d. Web. 25 Feb. 2011. <http://thepacker.com/Pineapple/MarketScope.aspx?cid=Pineapple>

666 "Florida Seaports : Home." *Florida Seaports : Charting our future*. n.d. Web. 25 Feb. 2011. <http://www.flaports.org/Default.aspx>.

667 "Pineapple." *Protecting Perishable Foods*. United States Department of Agriculture, n.d. Web. 25 Feb. 2011. <www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3021003&acct=atpub>.

Potatoes

Wellesley orders over seventy potato products in various forms. While products are sold to the college from a number of corporations (the main corporate vendors are Conagra Foods, Mc Cain USA Foodservice, and Michael Foods), these corporations generally carry only a few major brands (Sysco, Mc Cain, and Lamb Weston). Smaller providers are present, but by far the largest proportion of Wellesley's potatoes and potato products come from Sysco. The Red, White and Yukon potatoes carried by Sysco are recommended for "broiling, boiling, or slicing and using as home fries" or as "a nice side dish."[668] Since most of the products ordered are not full potatoes but variations of fries, hash browns, tater tots, or diced potatoes, we analyzed the Red, White and Yukon potatoes from Sysco to get a sense of the baseline environmental impacts common to all potato products. Specifically, we analyze the Potato Fry Str 3/8" XL product, ordered from Conagra Foods and provided by Sysco Imperial, because it is the potato product we most frequenty order (276 packages with six packs of five pounds each were ordered during the 2009-2010 school year) and is representative of the most common production methods for potatoes consumed at Wellesley College. Potato crop yields for conventional farming are generally around 40,500 pounds per acre.[669]

Serving Size

The United States Department of Agriculture suggests a serving size of about one cup, or half a pound, for baked or mashed potatoes.[670] The process of frying potatoes doubles the number of calories,[671] and introduces more salts and fats. For this study, a serving size of French fries is defined as half a cup, or a quarter pound.

Farm Locations

Information on the specific producer locations for Sysco is unavailable. The United States is the fifth largest producer of potatoes in the world, following China, the European Union, Russia and India.[672] The United States exports six percent of its potatoes and imports only about 5 percent.[673] Therefore, it is a safe assumption that the potatoes delivered to Wellesley through Sysco are domestically grown. The largest proportion of U.S. potatoes is grown in Idaho (28 percent).[674] Since potatoes are grown all over the country, but with the largest percentage produced in Idaho, this state is used as the representative for all production calculations.

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[668] Sysco Corporation. "About Sysco - Location Map - Sysco Corporation." *Home-Sysco Corporation*. Web. 15 Feb. 2011. <http://www.sysco.com/map/map.asp>.
[669] University of Idaho Extension. "Idaho Nutrient Management - Potato." *University of Idaho Extension*. n.d. Web. 19 Feb. 2011. <http://www.extension.uidaho.edu/nutrient/crop_nutrient/potato.html>.
[670] U.S. Department of Agriculture and U.S. Departments of Health and Human Services. *Report of the Dietary Guidelines for Americans, 2010*. 7 ed. Washington, DC: U.S. Government Printing Office, 2010. 87
[671] U.S. Department of Agriculture and U.S. Departments of Health and Human Services 47.
[672] Foreign Agricultural Service. "The U.S. and World Situation: Potatoes (Fresh and Processed)." USDA, 2007. Web. 19 Feb. 2011. <http://usda.mannlib.cornell.edu/usda/fas/potatwm//2000s/2009/potatwm-01-14-2009.pdf> 2.
[673] Foreign Agricultural Service. "The U.S. and World Situation: Potatoes (Fresh and Processed)" 5,7.
[674] United States Department of Agriculture. *Fact Finders for Agriculture: Idaho*. Washington, D.C.: NASS, 2002. Web. 19 Feb. 2011. < http://www.fas.usda.gov/htp/horticulture/misc%20reports/US%20POTATOES.pdf>

Fertilizer Use

The University of Idaho published a report, *Managing Nutrients for Potato Production*, outlining recommended fertilizer use and concentrations as well as the expected yield per acre. Depending on the composition of the soil, potatoes generally require between 100 and 320 pounds nitrogen per acre. For average soil composition of 15 parts per million NO_3N+NH_4N, nitrogen application is 220 pounds per acre. Phosphorus application ranges from 0 to 440 pounds P_2O_5 per acre where average soils with 15 parts per million P_2O_5 require 140 pounds P_2O_5 per acre. Finally, potassium application ranges from 0 to 700 pounds K_2O_4 per acre and, with average soil composition of 100 parts per million of potassium per acre, 325 pounds K_2O_4 per acre are required. Proper application has an expected yield of 40,500 pounds per acre.[675] It should be noted that the recommended amounts of fertilizer are reported based on the expected uptake of the plant and therefore, the actual poundage of application used by commercial farmers may be higher than these estimates. A report by Bryan Hopkins *et al*. states that, based on a 400 to 500 hundred-weight per acre yield (40,000 to 50,000 pounds), total plant uptake in pounds per acre are 200 to 240 for nitrogen, 25 to 35 for phosphorus and 280 to 320 for potassium.[676] Methods for fertilizer application vary based on the time of growing season and producer preferences. In-ground methods include banding at mark-out or planting phase and side-dressing after planting. Pre-plant broadcasting sprays fertilizer onto fields. Additionally, folial nutrient sprays are used and liquid fertilizers (generally for nitrogen) can be injected into water and applied through the irrigation system.[677]

Irrigation

Over 95 percent of Idaho farmers use sprinkler systems to irrigate potato fields.[678] Most farms require 1.5 to 3.5 acre-feet (325,851.4 gallons) of irrigation water per year. Some farmers are beginning to use techniques such as tensiometers, evapotranspiration data or variable rate management practices for more precise irrigation and, as a result, use less water. Over 50 percent of producers are using less than 2.5 acre-feet of irrigation per year as a result of these practices.[679]

Mechanization

Commercial potato production requires the use of a number of machines. First, stubble from the preceding crop is chopped, the field is irrigated, and a disk harrow is used to break up

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[675] University of Idaho Extension. "Idaho Nutrient Management - Potato." *University of Idaho Extension*. N.p., n.d. Web. 19 Feb. 2011. <http://www.extension.uidaho.edu/nutrient/crop_nutrient/potato.html>.

[676] Hopkins, Bryan G., Jeffrey C. Stark, Dale T. Westermann, and Jason W. Ellsworth. "Nutrient Management Efficiency." *Nutrient Management*. University of California Agriculture and Natural Resources, n.d. Web. 20 Feb. 2011. <groups.ucanr.org/nutrientmanagement/files/79379.pdf> 1.

[677] Hopkins, Bryan G., Jeffrey C. Stark, Dale T. Westermann, and Jason W. Ellsworth. "Nutrient Management Efficiency." *Nutrient Management*. University of California Agriculture and Natural Resources, n.d. Web. 20 Feb. 2011. <groups.ucanr.org/nutrientmanagement/files/79379.pdf> 6-7.

[678] Bechinski, E.J.. "Potato IPM." *Pest Management Center*. University of Idaho College of Agriculture and Life Sciences, n.d. Web. 19 Feb. 2011. <http://www.uihome.uidaho.edu/default.aspx?pid=113888>.

[679] USDA National Institute of Food and Agriculture (NIFA), Environmental Protection Agency, Water Resource Research Institutes, and Land Grant Universities. "Water Management in Idaho Potatoes." *Pacific Northwest Region Water Quality Program*. N.p., n.d. Web. 20 Feb. 2011. <http://www.pnwwaterweb.com/initiatives/pnw_177.htm>.

the soil. Next, the field is plowed, cultivated using a basin tillage tool and then harvested using a harvester, windrower, and large trucks to carry produce.[680]

Processing

After being harvested, potatoes are shipped to a processing facility in refrigerated trucks. The locations of specific processing facilities are unavailable, so it is assumed that the facility is located en route to the product distributor, SYGMA Boston. Potatoes are washed and then steamed to soften the skins, which can then be peeled off with ease. The peeled potatoes are sliced and heated at 90 to 95 degrees C for 7 to 12 minutes. Next the potatoes are fried, using vegetable oil, and cooled.

Transportation

Throughout the total production process of the potato products ordered by Wellesley, the potatoes pass through numerous locations. From a field in Idaho, the potatoes are transported via refrigerated truck to a processing site (assumed to be en route to the next location). From there, the potatoes are driven to the distributor for AVI. In this case, SYGMA Boston, a food distributor owned by Sysco, supplies our region. The facility is located in Westborough, MA (191 Flanders Road, Westborough, MA 01581).

Scale

Commercial potato farms usually plant between 500 and 1000 acres. Potatoes require nutrient rich soil, ample rainfall or irrigation, and can be prone to pests.[681] The production process is also fairly mechanized.

Toxicity Information

Many commercial farms follow Integrated Pest Management practices such as destroying cull potatoes to reduce sources of late blight, planting certified seed, or adjusting fertility and irrigation practices to inhibit disease, but these are done in combination with the application of pesticides and fertilizers.[682] The Pesticide Action Network (PAN) provides a list of the top pesticides used on California potato crops for 2008. It has also identified “PAN Bad Actor” pesticides, based on designations by the International Agency for Research on Cancer (IARC), U.S. EPA, U.S. National Toxicology Program, and the World Health Organization (WHO). These chemicals are known to be or have at least one of the following: a known or probable carcinogen; reproductive or developmental toxicant; neurotoxic cholinesterase inhibitors; groundwater contaminants; or high acute toxicity. Table 58 shows the top 5 pesticides used in potato production.

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[680] University of Idaho College of Agricultural and Life Sciences, Department of Agricultural Economics & Rural Sociology, and Paul E. Patterson. *2007 Cost of Potato Production Comparisons for Idaho Commercial Potato Production*. Eagle: The Idaho Potato Commission R&E Committee, Potato Processors, and Grower Organizations, 2007. Web. <http://industry.idahopotato.com/assets/industry_research_articles_file/12.pdf> 23.

[681] "National Potato Council: Consumer Information." *National Potato Council*. N.p., n.d. Web. 19 Feb. 2011. <http://www.nationalpotatocouncil.org/NPC/potato_consumerinformation.cfm?cache=191102120441&faq_id=17>.

[682] Bechinski, E.J.. "Potato IPM." *Pest Management Center*. University of Idaho College of Agriculture and Life Sciences, n.d. Web. 19 Feb. 2011. <http://www.uihome.uidaho.edu/default.aspx?pid=113888>.

Table 58: Top 5 pesticides used on potato crops 2008[683]

Chemical Name	Chemical Class	Chemical Use	PAN Bad Actor	Application Rate (lb/acre treated)
Metam-sodium	Dithiocarbamate	Fumigant, herbicide, fungicide, microbiocide, algaecide	Yes	158.6
Metam-potassium	Dithiocarbamate	Fumigant, fungicide, microbiocide, algaecide, menaticide	Yes	196.1
1,3-Dichloropropene	Halogenated organic	Fumigant, nematicide	Yes	88.7
Chlorothalonil	Substituted Benzene	Fungicide	Yes	1.02
Mancozeb	Dithiocarbamate, Inorganic Zinc	fungicide	Yes	1.09

Biodiversity
Potatoes grown in Idaho are on farms with established field area so no additional clearing is required. Many small to medium sized farms grow multiple crops--generally other grains--with only 51 percent of the farm devoted to crop production (the remaining acreage is divided between pasture and other uses).[684] However, large commercial farms may have as much as 500 to 1000 acres of potatoes planted and it is unclear if these farms perform crop rotation, grow multiple crops, or carry out other sustainable practices.

Packaging
The fries are packaged in foil bags, which are subsequently placed in two- or three-layer bags or cardboard boxes of 10 to 25 kilogram capacity.[685] At this point the boxes of French fries are transported to a food distributor, again in refrigerated trucks. At the distribution center, it can be assumed that the fries are taken out of the primary (foil) and secondary packaging (bags or boxes) and repackaged in boxes to fit client orders (this is how the fries reach Wellesley). Each box ordered from Sysco contains six five-pound packages, meaning that there are six plastic or foil bags in one cardboard box.

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[683] Kegley, S.E., B.R. Hill, S. Orme, and A.H. Choi. "PAN Pesticide Use Info for Potatoes." *PAN Pesticide Database*. Pesticide Action Network, n.d. Web. 20 Feb. 2011. <http://www.pesticideinfo.org/DS.jsp?sk=14013>.
[684] United States Department of Agriculture. *Fact Finders for Agriculture: Idaho*. Washington, D.C.: NASS, 2002. Web. 19 Feb. 2011. <http://www.agcensus.usda.gov/Publications/2002/County_Profiles/Idaho/cp99016.PDF>.
[685] "French Fries Production Line." *Beijing Time Progress Technology Development Co., Ltd*. China Light Industry Machinery Association, n.d. Web. 20 Feb. 2011. <http://eng.clima.org.cn/Machine/Potato-Processing-Line/Frech-Fries-Equipment.html>.

Raspberries

Our analysis of raspberries is based on individually quick frozen (IQF) raspberries purchased from Jasper Wyman & Son. Dining services ordered 1,690 pounds of whole frozen raspberries in 2010, making frozen raspberries 39th out of 2,825 items purchased by the college in 2010. We also purchased 110 pounds of whole raspberries from Sysco Classic, but since Wyman's is by far the biggest supplier, we focus on their berries over any other brand. The college also orders raspberry puree, frozen raspberry bits and pieces made by other brands, but Wyman's whole frozen raspberries comprise a much larger share of Wellesley's raspberry purchases. Although dining services purchases frozen danishes with raspberries in them, they contain a blend of other fruits and bread that makes them difficult to compare to whole raspberries.

Serving Size

The United States Department of Agriculture recommends a serving size of ½ cup.[686] The college ordered 1,690 pounds of Wyman's frozen raspberries in 2010, which is equal to 6,760 servings.

Farm Locations

Wyman's has farms and facilities in Maine and Prince Edward Island, Canada. Farm headquarters and cold storage are in Deblois, Maine. The berries are processed twelve miles away at a facility in Cherryfield, Maine. The company's secondary processing facility is located in Morell, Prince Edward Island, Canada.

- Farm headquarters: 601 Route 193, Deblois, ME 04622
- Processing and manufacturing: 178 Main Street, Cherryfield, ME 04622 [687]

Fertilizer Use

Table 59 provides information on chemical fertilizer use on red raspberries in 2009. Application of nitrogen, phosphate, and potash fertilizers was generally equal. The University of Idaho College of Agriculture recommends an annual application of 50 to 65 pounds of nitrogen per acre for red raspberries, or up to 75 pounds per acre in the case of a low yield, which is consistent with the USDA's data on fertilizer use.[688] We assume that Wyman's uses a similar amount of fertilizer on its farms.

Depending on the time of year, raspberries only take up approximately 26 to 37 percent of nitrogen applied, requiring annual fertilizer reapplication.[689] Some nitrogen remains in the soil when the plant fails to absorb the fertilizer, while the rest of the excess nitrogen is lost in leaf fall or during end-of-season pruning.

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[686] U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Dietary Guidelines for Americans*, 2010. 7th Edition, Washington, DC: U.S. Government Printing Office, December 2010. Print.

[687] "Jasper Wyman & Son." *Jasper Wyman & Son*. n.d. Web. 10 May 2011. <http://www.wymans.com/about/index.php>.

[688] Mahler, R.L., and D.L. Barney. "Blueberries, Raspberries, and Strawberries." *Northern Idaho Fertilizer Guide*. University of Idaho College of Agriculture Cooperative Extension System, n.d. Web. 20 Feb. 2011. <www.cals.uidaho.edu/edComm/pdf/CIS/CIS0815.pdf>.

[689] Strik, Bernadine. "Nitrogen Fertilization of Berry Crops." *Ontario Ministry of Agriculture Food and Rural Affairs*. Government of Ontario, 1 Apr. 2003. Web. 20 Feb. 2011. <http://www.omafra.gov.on.ca/english/crops/hort/news/allontario/ao0403a2.htm>.

Table 59: Fertilizer use on red raspberries in 2009[690]

Type of Fertilizer	Fertilizer use (lbs)	Fertilizer use (average lbs per acre per year)
Nitrogen	355,000	66
Phosphate	324,000	64
Potash	300,000	59

Irrigation

Raspberries are usually irrigated through a drip irrigation system, which supplies water directly to the plant's shallow roots.[691] Wyman's relies on a network of water storage impoundments for its irrigation system. Surplus water is captured and stored to reduce demand on rivers and the local aquifer during drought periods. The company also reprocesses over 90 percent of the water to clean the berries during the processing season.[692]

Tilling and harvesting

Wyman's mows their berry fields in the fall and returns the carbon material to the ground. The company does not till their fields as an erosion control method, but the no-tillage system has an added benefit of not creating excess greenhouse gas emissions.

Some raspberry farms harvest by hand, but Wyman's size means it probably uses harvesting machines. These machines require diesel engines, which emit 22.2 pounds of carbon dioxide per gallon.[693] The harvesting machines often require multiple passes through the field to harvest all of the berries.[694]

Processing

After harvesting, the raspberries are transported to Wyman's processing and manufacturing facility. The raspberries are then cooled using forced air, washed, and passed through a quick-blast freezing tunnel. The entire freezing process is completed within hours of

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690 National Agricultural Statistics Service. "2009 Fertilizer Use on Raspberries." *Quick Stats Database*. USDA, n.d. Web. 20 Feb. 2011. <http://quickstats.nass.usda.gov/results/0389B943-D096-3072-9C2F-21E3D0C58BB2#9C695C35-4C86-338C-8794-CB94C14AA22E>.

691 Demchak, Kathleen, Jayson K. Harper, and Lynn F. Kime. "Agricultural Alternatives: Red Raspberry Production." *Penn State College of Agricultural Sciences*. The Pennsylvania State University, n.d. Web. 20 Feb. 2011. <agalternatives.aers.psu.edu/Publications/RedRaspberry.pdf>.

692 "Sustainability." *Jasper Wyman & Son*. n.d. Web. 20 Feb. 2011. <http://www.wymans.com/about/sustainability.php>.

693 "Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel." *US Environmental Protection Agency*. US Environmental Protection Agency, n.d. Web. 20 Feb. 2011. <http://www.epa.gov/oms/climate/420f05001.htm>.

694 Deuel, Charlotte, and Anne Plotto. "Strawberries and Raspberries." *Processing Fruits: Science and Technology*. 2nd ed. Hoboken, NJ: CRC Press, 2004. 531-560. Print.

harvesting to preserve freshness. Once they are frozen, the berries are laser-sorted for uniform quality.[695]

Packaging

After being checked for standards, the frozen raspberries are packed into plastic bags and sealed. The bags are put into cardboard boxes and shipped in refrigerated trucks to Wellesley. Wyman's recycles and reuses cardboard as much as possible; in 2009, it recycled 332,000 pounds of cardboard.[696]

Transportation

Wyman's raspberries do not travel very far during the production process. After they are harvested at the farm in Deblois, Maine, they are trucked approximately 12 miles to the processing plant in Cherryfield, Maine, where they are stored until they are ready to be shipped to Wellesley.

Scale

Wyman's is the largest supplier of wild blueberry products in the United States, and one of the largest suppliers of raspberries, boysenberries, cranberries, and strawberries. Despite being such a large producer, Wyman's is still family-owned and locally operated. The company does not provide information on its size, but it only has two facilities, which suggests that it probably operates at a relatively small scale.

Toxicity

Wyman's has successfully practiced full Integrated Pest Management (IPM) for over 20 years, reducing chemical use on the farm by 67%.[697] IPM is a pest management approach that considers the environmental impact of applying pesticides and other chemicals to crops.

Biodiversity

Wyman's produces blueberries, raspberries, blackberries, cranberries, and strawberries. Since it is not a large farm, it likely does not have a significant effect on local biodiversity. As part of its sustainability initiative, Wyman's supports biodiversity research on honeybee Colony Collapse Disorder (CDC) and sponsors the restoration of the Fullerton Marsh freshwater wetland on Prince Edward Island. The farm also composts its entire processing line shrink (2 million pounds of leaves, green berries, crushed berries, and other natural waste) and re-spreads it in the fields to limit erosion and to promote growth in bare spots.[698]

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695 Deuel, Charlotte, and Anne Plotto. "Strawberries and Raspberries." *Processing Fruits: Science and Technology*. 2nd ed. Hoboken, NJ: CRC Press, 2004. 531-560. Print.

696 "Sustainability." *Jasper Wyman & Son*. n.d. Web. 20 Feb. 2011. <http://www.wymans.com/about/sustainability.php>.

697 "Sustainability." *Jasper Wyman & Son*. n.d. Web. 20 Feb. 2011. <http://www.wymans.com/about/sustainability.php>.

698 "Sustainability." *Jasper Wyman & Son*. n.d. Web. 20 Feb. 2011. <http://www.wymans.com/about/sustainability.php>.

Wild-Caught Shrimp

Wellesley orders Arista Food's PORTBTY brand raw shrimp. We ordered 920 pounds of PORTBTY raw shrimp. Dining services also orders cooked shrimp, buttered shrimp and popcorn shrimp, but these are purchased in much smaller amounts compared to the PORTBTY brand raw shrimp. The yield of meat from a whole shrimp ranges from 20 to 45 percent of an individual. The head constitutes about 40 per cent of the weight of whole raw shrimp, and the tail shell and legs a further 15 per cent; yield of raw meat is thus about 45 percent.[699]

Serving Size

The serving size of shrimp is 1-3 oz based on the United States Department of Agriculture recommended serving size of other seafood and fish. [700]

Farm Locations

We could not find the specific sources of shrimp so we are using general information on shrimp production and consumption in the United States. Arista foods has expanded its seafood division from primarily Asian and South American imports to a strong position in the American domestic shrimp production of the Gulf of Mexico, with packing plants in several locations from the gulf coast.[701] Arista asserts they purchase shrimp from the Gulf of Mexico but does not make it clear how much domestic and international shrimp they purchase. From the language on the website it appears that they are purchasing mainly from the United States. However, according to the National Oceanic and Atmospheric Administration, shrimp is the primary seafood imported and consumed in the United States. Only 10% of the shrimp consumed in the United States actually originated in the United States, the rest is imported. The main suppliers of seafood to the United States are China, Thailand, Canada, Indonesia, Vietnam, Ecuador, and Chile.[702] Based on the following graphs and the information from NOAA we believe it would be best to investigate the shrimp produced in the United States. In the United States 86% of shrimp are wild-caught in the Gulf of Mexico, not farmed.[703] In our report we only investigated the environmental impacts of wild-caught shrimp by trawling in the Gulf of Mexico.

Fertilizer Use

Shrimp are either caught in the wild or farmed. Most shrimp caught in the United States are caught with trawling vessels and most shrimp produced abroad are farmed.

Water Use

Farmed shrimp requires extensive water use from creating feed, hatching, culturing, processing, storing and circulating water in the constructed pond farms. The average shrimp farm

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[699] "Handling and Processing Shrimp." *FAO: FAO Home*. n.d. Web. 21 Feb. 2011. <http://www.fao.org/wairdocs/tan/x5931e/x5931e01.htm>.
[700] U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Dietary Guidelines for Americans, 2010.* 7th Edition, Washington, DC: U.S. Government Printing Office, December 2010. Print.
[701] "Arista Foods." *Arista Foods*. n.d. Web. 21 Feb. 2011. <http://www.aristaindustries.com/AboutUS.asp>.
[702] NOAA, . National Marine Fisheries Service. *FishWatch- U.S. Seafood Facts: Pink Shrimp*. 2010. Web. 15 Feb 2011. <http://www.nmfs.noaa.gov/fishwatch/species/pink_shrimp.htm>.
[703] Harvey, David. "U.S. shrimp imports, volume by selected sources (1,000 pounds) - Aquaculture Data - USDA/ERS." *USDA Economic Research Service - Home Page*. 14 Feb. 2011. Web. 25 Feb. 2011. <http://www.ers.usda.gov/Data/Aquaculture/ShrimpImportsVolume.htm>.

in Thailand consumes 101.87 gallons of water for every 2oz serving size of shrimp. In the United States, a conventional shrimp farm consumed 31.46 gallons for every serving of shrimp.[704] The Oceanic Institute of the Hawaii Pacific University conducted an experiment in a biosecure raceway to farm fish in a safe and environmentally friendly manner. They were able to only consume 5.44 gallons of water per 2 oz serving of shrimp.[705] Considering wild-caught fish do not require the same inputs of farmed fish because the majority of the fish in the United States is caught with trawling ships, the amount of water consumed is much lower. The processes that require water consumption for wild-caught shrimp are washing, cooking and storage. We are going to assume the water consumption for a serving size of wild-caught shrimp is 1 gallon of water.

Mechanization

As noted, most shrimp in the United States are caught using trawling vessels, which are more fuel intensive than other shrimping methods such as farming. Fishing trawlers drag nets through the water either on the sea floor or at other depths. Trawling ships can vary in size from smaller personal ships to ships with thousands of horsepower. Fuel use by shrimp trawling is large in comparison to other fisheries, but other types of shrimp fishing such as stow nets are much more energy-efficient. The amount of fuel used is dependent on the distance traveled to retrieve the fish.[706] Emissions from ships are difficult to measure, but diesel fueled trawls emit nitrogen oxides and carbon dioxide.[707]

Processing

Shrimp can be processed on board or on land. Onboard shrimp can be frozen in 10-15 minutes by immersing them in brine at -20°C. Shrimp can also be frozen in blocks 50 mm thick in a vertical plate freezer; the shrimp are poured into a polyethylene bag between the freezer plates, and the spaces between the shrimp are filled with water. Freezing time for a 50 mm block in a plate freezer operating at -35°C is 90 minutes.[708]

If the shrimp are handled in a factory, the shrimp should be processed as quickly as possible in a factory near the port so as to prevent spoilage. Cooking and processing can better be done ashore seeing as there are fewer materials onboard a ship. Land facilities are also more hygienic. It does not matter if the shrimp are going to be processed on the ship or on land; they must be put on ice immediately after capture.

Transportation

The shrimp is caught in the Gulf of Mexico, processed on board or in facilities on land nearby, then transported to Arista's main processing center at Arista Industries, Inc. 557 Danbury

[704] Sun, Wenting. "Life Cycle Assessment of Indoor Recirculating Shrimp Aquaculture System." *Center for Sustainable Systems University of Michigan* CSS09-15 (2009): *University of Michigan CSS*. Nd. Web. 4 Mar. 2011.
[705] Moss, Shaun. "Oceanic Institute." *Shrimp Institute*. n.d. Web. 8 Mar. 2011. <http://www.oceanicinstitute.org/research/shrimp/index.html>.
[706] Gillett, R.. "Global Study of Shrimp Fisheries." *FAO FIsheries Technical Paper* 475 (2008): 1-359. Print.
[707] Clarke, Tom. "New estimate doubles shipping emissions." *Nature* 10 Nov. 2003: *Nature.com*. Web. 31 Mar. 2011.
[708] "Handling and Processing Shrimp." *FAO: FAO Home*. n.d. Web. 21 Feb. 2011. <http://www.fao.org/wairdocs/tan/x5931e/x5931e01.htm>.

Rd. Wilton, CT 06897. From there the products are then transported to Wellesley College. Shrimp must be kept frozen at 31 – 34 degrees Fahrenheit with 95-100% relative humidity.[709]

Scale

The average amount of shrimp caught in the Gulf of Mexico between 1999 and 2003 was 245.6 million pounds.[710] The number of shrimping vessels working in the Gulf of Mexico is approximately 3500 to 4000, according to estimates by the Gulf of Mexico Fishery Council.[711]

Biodiversity

Biodiversity loss is of great concern due to the large amounts of bycatch and seafloor destruction caused by trawls. Animals other than shrimp are frequently caught in the net as it is dragged and cannot escape. Often it is seabirds, marine mammals, larger fish, sea turtles and other marine life. In the Gulf of Mexico almost 1 billion pounds of bycatch are discarded, meaning that 57 percent of what was caught in trawlers was bycatch. Both biodiversity and other fishing industries are threatened by the bycatch caught by shrimp trawlers.[712]

Packaging

Shrimp do not require very much packaging. They are placed in plastic bags or paper wrapping, then fiberboard carton boxes, and frozen.[713]

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[709] Ashby, B. Hunt. "Protecting Perishable Foods During Transport by Truck." *Transportation and Marketing Programs Handbook* 669 (2006): 1-100. Print.

[711] Gillett, R.. "Global Study of Shrimp Fisheries." *FAO FIsheries Technical Paper* 475 (2008): 1-359. Print.
[712] Gillett, R.. "Global Study of Shrimp Fisheries." *FAO FIsheries Technical Paper* 475 (2008): 1-359. Print.
[713] "Handling and Processing Shrimp." *FAO: FAO Home*. n.d. Web. 21 Feb. 2011. <http://www.fao.org/wairdocs/tan/x5931e/x5931e01.htm>.

Tofu

Wellesley orders Moonrose® brand Firm and Extra Firm tofu, which is supplied and owned by Vitasoy USA. Moonrose is actually a Sysco brand but in this case is carried by Vitasoy. Tofu firm and tofu extra firm only differ at the end of the production process (extra firm tofu is compressed more than regular or firm tofu to get rid of excess moisture). Since Wellesley ordered much more extra firm tofu during the 2009-2010 school year, all analysis is completed using Moonrose Extra Firm Tofu as the model. Tofu is made from coagulated soymilk and the only ingredients are soybeans and water. Soy crop yields in 2010 were 3,060 pounds per ace in Iowa and 3,090 pounds per acre in Illinois.[714]

Serving Size

The United States Department of Agriculture suggests a servings size of a half-cup (or about 4 ounces) as an appropriate serving of tofu.[715] In the 2009-2010 school year, Wellesley purchased 19,992 servings of tofu.

Farm Locations

Specific information about the production sites of Moonrose® brand tofu soy crops are not available. The United States is the world's leading producer and exporter of soybeans and, nationally, Iowa and Illinois produce the most soybeans.[716] For this study, it is assumed that the soybeans were produced in either of these states.

Fertilizer Use

The USDA publishes information on the crop production practices of different states and regions. Table 60 provides the estimated fertilizer use, broken down between nitrogen, phosphorus and potash, for soybean production in Iowa and Illinois in 2006.

Table 60: Estimated fertilizer use on soybean crops 2006[717]

	Application rate of fertilizer (lb/acre)		
	Nitrogen	**Phosphate**	**Potash**
Iowa	14	54	85
Illinois	16	58	94

Soybeans require less nitrogen than other crops because legumes can accumulate nitrogen from the air. Nitrogen uptake is 219 kilogram per hectare with 1.21 percent nitrogen content in residues.[718] Phosphate and potash fertilizer should be applied prior to planting or at planting time

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[714] National Agricultural Statistics Service. "National Statistics for Soybeans." *National Agricultural Statistics Service*. USDA, n.d. Web. 20 Feb. 2011. <http://www.nass.usda.gov/Statistics_by_Subject/result.php?0DB967AF-4F8E-32ED-9D5D-D150ADE7D838&sector=CROPS&group=FIELD%20CROPS&comm=SOYBEANS>.
[715] U.S. Department of Agriculture and U.S. Departments of Health and Human Services. *Report of the Dietary Guidelines for Americans, 2010*. 7 ed. Washington, DC: U.S. Government Printing Office, 2010. Print.
[716] Economic Research Service. "Briefing Rooms: Soybeans and Oil Crops." *USDA Economic Research Service*. USDA, 9 Mar. 2010. Web. 20 Feb. 2011. <http://www.ers.usda.gov/Briefing/SoybeansOilCrops/>.
[717] Economic Research Service. "Fertilizer Use and Price." *USDA Economic Research Service - Home Page*. USDA, 30 June 2010. Web. 20 Feb. 2011. <http://www.ers.usda.gov/Data/FertilizerUse/>.
[718] Salvagiotti, F, Kenneth G. Cassman, James E. Specht, Daniel T. Walters, Albert Weiss, and Achim R. Dobermann. *Agronomy and horticulture* . Lincoln, NE: Department of Agronomy and Horticulture, Institute of

either through broadcasting, in which the fertilizer is sprayed onto the ground, or incorporated into the soil.[719]

Water Use

Most farms use center pivot sprinkler irrigation systems[720] and the water comes from ground water sources.[721] On average, soybean crops require 0.7 acre-feet of water per year.[722] During production, tofu is run under water for up to several hours as part of the cooling process.[723]

Mechanization and Processing

The production process of soybeans for commercial growth requires a number of machines. First, a combine threshes the fields to retrieve the beans from the plants and separate the beans. The beans are transported to a drying site. In dryer regions, drying can be done naturally by spreading the beans out in thin layers on the ground and periodically stirring them for uniform drying. A cleaner-separator machine will then shake off any remaining residue from the beans. The machine includes a reception hopper, fan and vibrating sieves. Next, the beans are transported to a storage location until they are shipped to a processing site.[724] At the processing facility, beans are cracked and then rolled.[725] For soymilk production, water is added. For tofu production, soymilk is boiled, the protein-lipid film on the surface is removed and a coagulant (gypsum powder or magnesium salts) is added. The curd is pressed into blocks, and run under cold water for several hours.[726]

Transportation

From the field, beans are transported via non-refrigerated truck to the drying site,[727] storage warehouse, processing facility and finally to a distribution center or, in this case, Wellesley College. The processing facility used by Vitasoy is located in Ayer, Massachusetts (1 New England Way, Ayer, MA 01432).

Agriculture and Natural Resources, University of Nebraska, 2008. Print.

[719] Dahnke, W.C., C. Fanning, and A. Cattanach. "Fertilizing Soybean." *NDSU*. Version SF-719. North Dakota State University, n.d. Web. 21 Feb. 2011. <http://www.ag.ndsu.edu/pubs/plantsci/soilfert/sf719w.htm>.

[720] Natural Resources Conservation Service. "Ground & Surface Water Conservation." *Iowa Natural Resources Conservation Service*. USDA, 8 June 2009. Web. 20 Feb. 2011. <http://www.ia.nrcs.usda.gov/programs/GSWC.html>.

[721] Economic Research Service. "Soybean Industry Statistics."

[722] O'Connor, Tom. "Water Usage in Biodiesel Production." *National Biodiesel Board*. California Environmental Protection Agency Air Resources Board, n.d. Web. 20 Feb. 2011. <http://www.arb.ca.gov/fuels/lcfs/workgroups/lcfssustain/oconnor.pdf>.

[723] Berk, Zeki. "Tofu, Tempeh, Soysauce and Miso." *Technology of production of edible flours and protein products from soybeans* . Rome: Food and Agriculture Organization of the United Nations, 1992. 56-79. Print.

[724] National Soybean Research Laboratory. "About Soy: Soybean Processing." *National Soybean Research Laboratory*. University of Illinois at Urbana-Champaign, n.d. Web. 21 Feb. 2011. <http://www.nsrl.uiuc.edu/aboutsoy/soyprocessing.html>.

[725] National Soybean Research Laboratory. "About Soy: Soybean Processing." *National Soybean Research Laboratory*. University of Illinois at Urbana-Champaign, n.d. Web. 21 Feb. 2011. <http://www.nsrl.uiuc.edu/aboutsoy/soyprocessing.html>.

[726] Berk, Zeki. "Tofu, Tempeh, Soysauce and Miso." *Technology of production of edible flours and protein products from soybeans* . Rome: Food and Agriculture Organization of the United Nations, 1992. 56-79. Print.

[727] Berk, Zeki. "Tofu, Tempeh, Soysauce and Miso." *Technology of production of edible flours and protein products from soybeans* . Rome: Food and Agriculture Organization of the United Nations, 1992. 56-79. Print.

Scale

While the average size of a farm in Iowa is 350 acres and in Illinois 374 acres, the majority of soybean production takes places on larger commercial farms that range from 500 to over 1000 acres.[728] Soybeans can grow in a variety of soils and need relatively small amounts of irrigation. Conventional farming requires the application of fertilizers and pesticides.

Toxicity

The Pesticide Action Network (PAN) provides a list of the top pesticides used on California potato crops for 2008. It has also identified "PAN Bad Actor" pesticides, based on designations by the International Agency for Research on Cancer (IARC), U.S. EPA, U.S. National Toxicology Program, and the World Health Organization (WHO), which are known to be or have at least one of the following: known or probable carcinogen; reproductive or developmental toxicant; neurotoxic cholinesterase inhibitors; groundwater contaminant; or high acute toxicity.[729] Table 61 shows the top 5 pesticides used in soybean production.

Table 61: Top 5 pesticides used on soybean crops 2008[730]

Chemical name	**Chemical Class**	**Use**	**PAN Bad Actor**	**Application Rate (lb/acre treated)**
Mineral oil	Petroleum derivative	Insecticide, adjuvant	Yes	.47
Polyoxyethylene ester of rosin	Polyalkyloxy compound	Adjuvant, soap/surfactant	Not listed	.10
Calcium hypochlorite	Inorganic	Algaecide, water treatment	Not listed	--
Magnesium phosphide	Inorganic	Fumigant, rodenticide	Not listed	--
Spinetoram (XDE-175-J)	Unclassified	Insecticide	Not listed	.02

[728] United States Department of Agriculture. *2002 Census Publications: State and County Profiles*. Washington, D.C.: NASS, 2002. Web. 19 Feb. 2011. <http://www.agcensus.usda.gov/Publications/2002/County_Profiles/index.asp >.
[729] Kegley, S.E., B.R. Hill, S. Orme, and A.H. Choi. "PAN Pesticide Use Info for Potatoes." *PAN Pesticide Database*. Pesticide Action Network, n.d. Web. 20 Feb. 2011. <http://www.pesticideinfo.org/DS.jsp?sk=14013>.
[730] Kegley, S.E., B.R. Hill, S. Orme, and A.H. Choi. "PAN Pesticide Use Info for Potatoes." *PAN Pesticide Database*. Pesticide Action Network, n.d. Web. 20 Feb. 2011. <http://www.pesticideinfo.org/DS.jsp?sk=14013>.

Table 62 gives the rate of application by state for general pesticides and the number of treatments used.

Table 62: Treatment rates of general pesticides and number of treatments[731]

		Iowa	Illinois
Pesticides	**Treatment rate (lb/acre)**	1.434	1.399
	Number of treatments	2.083	2.264
Insecticide	**Treatment rate**	.144	.133
	Number of treatments	1.094	1.066
Herbicide	**Treatment rate**	1.389	1.388
	Number of treatments	1.95	2.197
Fungicide	**Treatment rate**	.091	.104
	Number of treatments	1	1.036

Biodiversity

Soybean production in Iowa and Illinois occurs on farms with established field area so no additional clearing is required. These farms devote 85 to 89 percent of the land to crop production, with the remaining portion divided between pasture and other uses.[732] This percentage means there is very little land left fallow or used for anything other than crop production. It is unclear, however, if these farms participate in crop rotation or other sustainable farming practices.

Packaging

Throughout the harvesting and transportation process, beans are stored in plastic bags. Post-production packages for tofu are plastic containers.[733] Wellesley is provided with boxes of twelve fourteen-ounce packages.

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[731] Economic Research Service. "Soybean Industry Statistics." *USDA Economic Research Service*. USDA, 30 June 2010. Web. 20 Feb. 2011. <http://www.ers.usda.gov/News/soybeancoverage.htm>.
[732] United States Department of Agriculture. *2002 Census Publications: State and County Profiles*. Washington, D.C.: NASS, 2002. Web. 19 Feb. 2011. <http://www.agcensus.usda.gov/Publications/2002/County_Profiles/index.asp >.
[733] Berk, Zeki. "Tofu, Tempeh, Soysauce and Miso." *Technology of production of edible flours and protein products from soybeans* . Rome: Food and Agriculture Organization of the United Nations, 1992. 56-79. Print.

Tomatoes

Dining services purchases a variety of fresh tomatoes and processed tomato products. We focus our analysis on fresh tomatoes for simplicity. Of the fresh tomatoes the College purchases, it spends the most money and orders the most units of cherry tomatoes: 395 cases total (ID #00880). Information on the specific brands and vendors is not available, and is likely to vary depending on factors like season and price, so we assume that our apples are distributed by Costa Fruit and Produce like the majority of other produce that dining services purchases. The weight of each case is unknown and may vary depending on factors such as season and size of cherry tomatoes. In order to estimate the total amount of cherry tomatoes we buy, we can assume that each case weighs 25 pounds, as this is the weight of a case used in a report by the Florida Tomato Committee.[734] Assuming each case weighs 25 pounds, we purchase a total of 9,875 pounds of cherry tomatoes.

Serving Size and Yield

We use a serving size of ½ cup for cherry tomatoes, which is the USDA's serving size for raw or cooked vegetables.[735] This serving size is equivalent to one-sixth of a pound, or 0.167 pounds. Conversely, there are six servings (three cups) in a pound of cherry tomatoes.[736] If we purchase a total of 9,875 pounds of cherry tomatoes, this amounts to 59,132 servings. In 2009, California tomatoes grown in the open yielded 43.23 tons per acre,[737] or 86,460 pounds per acre. We assume our cherry tomatoes have the same yield, which equates to 518,759 servings per acre.

Farm Locations

Fresh tomatoes in the U.S. come mainly from Florida, California, and Mexico. Most of Mexico's tomatoes are imported to western states. Together, Florida and California account for two-thirds to three-fourths of U.S. fresh tomatoes. Since Florida's tomatoes are shipped mostly to eastern states and its growing season aligns with our academic school year,[738] we assume that our tomatoes are grown in Florida. Fresh market tomatoes grown in the open in Florida are concentrated in the southern region, in Collier, Miami-Dade, Palm Beach, and Hendry counties,[739] so we assume that our tomatoes come from these counties specifically.

Fertilizer Use

Recommended fertilizer applications for Florida tomatoes are 10 pounds of 6-8-8 or similar fertilizer for every 100 square feet of most irrigated soils.[740] This equates to 4,356 pounds of 6-8-8 fertilizer per acre (1 acre = 43,560 square feet). We assume our tomatoes receive these

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[734] Florida Tomato Committee, *2009-2010 Annual Report.* N.d. Web. 27 Feb. 2011. < http://www.floridatomatoes.org/annualreport10.pdf>.

[735] U.S. Department of Agriculture and U.S. Department of Health and Human Services, *Dietary Guidelines for Americans 2010*, 2010, p. 83. Web. 26 Feb. 2011.

[736] Graham, Douglas *The 80/10/10 Diet*, Decatur, GA: FoodnSport Press, 2008, p. 175. Print.

[737] U.S. Department of Agriculture, *National Agricultural Statistics Service: Quick Stats*, 2007. Web. 27 Feb. 2011. <http://quickstats.nass.usda.gov/>.

[738] Economic Research Service. "Vegetables and Melons: Tomatoes," *ERS/USDA Briefing Room*, Economic Research Service, United States Department of Agriculture, 5 Oct. 2009. Web. 27 Feb. 2011. <http://www.ers.usda.gov/briefing/vegetables/tomatoes.htm>.

[739] U.S. Department of Agriculture, *National Agricultural Statistics Service: Quick Stats*, 2007. Web. 27 Feb. 2011. <http://quickstats.nass.usda.gov/>.

[740] Stephens, James, "Tomatoes in the Florida Garden," University of Florida IFAS Extension, May 2003 (April 1994). Web. 27 Feb. 2011. <http://edis.ifas.ufl.edu/pdffiles/VH/VH02800.pdf>.

recommended applications. Thus, they receive six percent of 4,356 pounds of N and eight percent each of 4,356 pounds of N and K, or 261.36 pounds of N per acre, 348.48 pounds of P per acre, and 348.48 pounds of K per acre.

Water Use

Florida fresh tomatoes are grown with drip or seep irrigation and receive supplemental irrigation during the growing season.[741] After harvest, water is used to clean and fill dump tanks daily and to wash and rinse the tomatoes. Wash water is generated during tomato packing operations.[742]

Methane

Although our tomatoes do not produce significant methane in production, discarded tomatoes and tomato plant debris ("cull") can be converted into biogas – a mixture of methane and carbon dioxide – through anaerobic digestion.[743]

Mechanization

Florida tomatoes are planted by seedling transplant from greenhouses[744] (more than half) or direct seeding; most are grown on plastic mulched, raised beds using stake culture.[745] While tomatoes grown for processing are harvested by machine, fresh-market tomatoes are handpicked, not mechanized.[746]

Processing

After they are harvested fresh, Florida tomatoes are bathed in chlorine, rinsed, graded by size and color, and shipped to market.[747]

Transportation

We assume that our tomatoes are transported to a distribution center in southern Florida after harvesting, and that from there they are transported to Costa's distribution center in Boston

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[741] U.S. Environmental Protection Agency. "Florida Tomato (Vegetables): MetaData," *Pesticides: Science and Policy*, U.S. Environmental Protection Agency, 16 Feb. 2011. Web. 27 Feb. 2011. <http://www.epa.gov/oppefed1/models/water/met_fl_tomato.htm>.

[742] Sargent, Steve, "Reduce Disposal Costs," *American Vegetable Grower, August 2008,* Meister Media Worldwide, 2011. Web. 27 Feb. 2011. < http://www.growingproduce.com/americanvegetablegrower/?storyid=282>.

[743] Sargent, Steve, "Reduce Disposal Costs," *American Vegetable Grower, August 2008,* Meister Media Worldwide, 2011. Web. 27 Feb. 2011. < http://www.growingproduce.com/americanvegetablegrower/?storyid=282>.

[744] Florida Tomato Committee. "Tomato 101." N.d. Web. 27 Feb. 2011. <http://www.floridatomatoes.org/facts.html>

[745] U.S. Environmental Protection Agency. "Florida Tomato (Vegetables): MetaData," *Pesticides: Science and Policy*, U.S. Environmental Protection Agency, 16 Feb. 2011. Web. 27 Feb. 2011. <http://www.epa.gov/oppefed1/models/water/met_fl_tomato.htm>

[746] Economic Research Service. "Vegetables and Melons: Tomatoes," *ERS/USDA Briefing Room*, Economic Research Service, United States Department of Agriculture, 5 Oct. 2009. Web. 27 Feb. 2011.

[747] Florida Tomato Committee. "Tomato 101." N.d. Web. 27 Feb. 2011. <http://www.floridatomatoes.org/facts.html>

before traveling to us.[748] We assume that they are transported by truck at all stages. When stored along the way, they are likely kept in refrigerated "cold rooms."[749]

Scale of Operation

Fresh-market tomatoes are grown in the open air in Florida on farms ranging in size from less than one acre to over one thousand acres, but we calculate that 70 percent of the farms grow tomatoes on less than five acres, with 50 percent on less than one acre. From data on the number of farms of each size category, we calculate an average size of 87 acres per operation.[750] We assume our tomatoes are grown on farms of this size, keeping in mind that they could be much smaller (less than one acre) or larger (more than one thousand acres).

Pesticide Use

Florida fresh tomatoes received the following average pesticide applications in 2006, which we assume our fresh cherry tomatoes receive per year: 0.47573 pounds per acre of herbicide; 37.352 pounds per acre of fungicide; 5.7403 pounds per acre of insecticide; and 144.03 pounds per acre of other pesticides.[751]

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748 Costa Fruit and Produce, "Company Profile." N.d. Web. 25 Feb. 2011. <http://www.freshideas.com/aboutus/comp_profile.html>.

749 Sargent, Steve. "Reduce Disposal Costs." *American Vegetable Grower, August 2008,* Meister Media Worldwide, 2011. Web. 27 Feb. 2011. < http://www.growingproduce.com/americanvegetablegrower/?storyid=282>

750 U.S. Department of Agriculture. *National Agricultural Statistics Service: Quick Stats*. 2007. Web. 27 Feb. 2011. <http://quickstats.nass.usda.gov/>.

751 calculated from USDA National Agricultural Statistics Service. *Agricultural Chemical Usage 2006 Vegetables Summary*. July 2007, p. 248. Web. 5 March 2011. <http://usda.mannlib.cornell.edu/usda/current/AgriChemUsVeg/AgriChemUsVeg-07-25-2007_revision.pdf>.

Turkey

We are researching turkey because it is a top food product ordered by dining services. There were roughly thirty different turkey items on the AVI purchasing list, and we picked the product "Turkey Breast Boneless Raw Foil". The brand is Purdue and the vendor is Sysco. This particular item was number 18 on the AVI purchasing list, and the top turkey item that the college receives. The pack size is 2/8-#10. [752]

Serving Size

According to the USDA food pyramid, one ounce of lean meats, poultry, and fish constitutes as one serving size. This includes turkey, so the average serving size of turkey is *1 ounce.*[753]

Farm Locations

The largest processing plant for Perdue turkey is in the US, in Washington, Indiana.[754] We assumed that since this is where most of the turkey is processed, the local farms that Perdue gets its turkey from are close to this area as well. Therefore, we will use the address of the processing facility (below) as the main farm for turkey in the United States that AVI gets this product from.
Perdue Farms, 65 South 200 West, Washington, IN 47501[755]

Background

There are the multiple steps of turkey slaughtering and processing. The steps as follows are a direct quotation from the USDA.

"Turkeys are hauled to the plant on truck beds or trailers in crates, fixed coops, or batteries. When the turkeys are readied and unloaded for slaughter, the veterinarian (or a food inspector under his/her supervision) performs ante mortem inspection by observing the turkeys on a lot basis. The turkeys are hung by the shanks in shackles hooked to an overhead moving chain that conveys the live turkeys toward the stunning area prior to the neck cutting and bleeding areas. Scalding of the bled turkeys occurs when the shackles pass through an immersion scalder filled with heated water, which is agitated by recirculation pumps. In place of an immersion scalder, some turkey slaughter plants shower carcasses with hot water and then convey them through humidity cabinets where they are sprayed with steam. This system avoids the community bath of the immersion scalder. Picking is done mechanically; usually there are several pickers used and each concentrates on a different area of the turkey to insure complete feather removal. The shackled dressed turkeys sometimes are singed by a gas flame following picking. This burns the fine hair or feathers off the skin. The carcasses then pass through a wash cabinet, which is equipped with sprayers. The hock joints are severed and the shanks are removed from the carcass prior to transfer of the carcasses to the evisceration line. The carcasses

[752] AVI purchasing list, AVI Fresh Wellesley. 17 Feb. 2011.
[753] "Serving Size." *Dietary Guidelines for Americans 2010*. USDA, n.d. Web. 24 Feb. 2011. <www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/PolicyDoc/PolicyDoc.pdf >.
[754] "Perdue Foodservice : FacilitiesMap ." *Perdue Foodservice*. N.d. Web. 25 Feb. 2011. <http://www.perduefoodservice.com/OurCompany/FacilitiesLocator/>.
[755] "Perdue Foodservice : FacilitiesMap ." *Perdue Foodservice*. N.d. Web. 25 Feb. 2011. <http://www.perduefoodservice.com/OurCompany/FacilitiesLocator/>.

may be hung by the hocks or by the necks to make the subsequent removal of the crop and trachea (windpipe) easier. Poultry Slaughter Inspection Training is performed. The neck and both hocks of each carcass are placed in the shackle. This three-point suspension of the carcass facilitates the evisceration process. Before the viscera can be removed, some cuts have to be made into the carcass. The vent area is cut free by a circular incision. Next, if a modified J-cut is used, a cut is made to the point of the keel. If a bar-cut is used, a transverse cut is made caudal to the point of the keel. Either method is approved for use provided the requirements of uniform presentation are accomplished in a sanitary manner. Drawing, or viscera removal, is accomplished by pulling the viscera free from the body cavity and placing it consistently either to the right or left of the tail. Generally the esophagus will be the only natural body attachment remaining inside the body cavity. The USDA food inspector inspects the eviscerated carcasses for wholesomeness. The viscera and the outside and inside of the carcass are manipulated in a manner that insures that only wholesome product is passed. Unwholesome carcasses and parts are condemned for human consumption and are positively controlled until proper disposal is completed. Removal of the heart and liver from the viscera is part of the giblet harvest and trimming, which occurs next. The heart cap is removed from the heart, and the gall bladder is removed from the liver. Next the liver and heart are sent to an ice-and-water chiller. The removal of the gizzard finishes the giblet harvest from the viscera. The gizzard is removed by cutting anterior and posterior to its attachment to the gastrointestinal tract. The gizzards are placed in a machine which splits (peels) and cleans their surfaces. The surfaces are then flushed, and the gizzards are chilled in ice and water. After the viscera is removed, the lungs can be vacuumed from the chest cavity. The crop and trachea are pulled free from the slit in the neck. If the oil sacs have not already been removed, they are cut off the tail. The heads are removed and a final check of the carcasses is made to ensure all eviscerating processes have been properly completed. Then the carcasses pass through a final wash. After the wash, the neck bones are cut. The necks may be placed inside the body cavity or chilled separately from the carcasses in vats of slush ice. Next, the tails are cut, and, if they are used by the plant, hock lock wires are inserted in those carcasses that will be trussed. Tucking and trussing the legs of the carcasses is usually done prior to chilling. Ice-and-water chillers are used to lower the product temperature. Carcasses and giblets are chilled separately. Poultry Slaughter Inspection Training occurs. After the initial chilling, the carcasses are hung on a drip line and drained. Grading, if requested, is done next. Grading is a voluntary service performed at an additional expense to the plant. Some carcasses are sent to the cut-up line. Carcass parts are packed in tray packs with plastic overlay, boxed, or bagged. The giblets are wrapped and stuffed into the whole carcasses. At the bagging station, the carcass is placed in a plastic bag. The air is vacuumed out of the bagged carcass and the bag is closed with a clip. The bagged carcass then passes through a shrink tunnel, where it is sprayed with hot water. This procedure shrinks the plastic bag to conform to the shape of the carcass and results in an appealing consumer package. The whole bagged carcasses and containers of cut-up parts are weighed to confirm, adjust, or mark the net weigh of the product. In some plants the price per pound and the total price of the product may be applied to the outside of the product package. An immersion freezer is used by some plants to put a crust or quick chill on the product. This process helps prevent freezer burn on the carcass surfaces. Most immersion freezers contain solutions of propylene glycol or brine. As the bagged carcasses exit an immersion freezer, they must be sprayed with water in order to remove any freezing solution from the package. The product is sorted and packed prior to entry in to the blast freezer.

Usually the air blast or plate-type freezer is used to freeze the product solid. It is not usual for turkey plants to thaw frozen carcasses and cut-up or further process them some time after slaughter. Once frozen, the product is ready to be shipped to food markets."[756]

Animal Feed

According to Perdue, the turkeys are fed natural grain products including yellow corn, soybean meal, marigolds, vitamins and mineral supplements. Although we could not find any information regarding how much factory farm turkeys eat, wild turkeys eat an estimated amount of 1 cup of food per day.[757] Therefore, we will assume that factory farm turkeys get the same amount. Turkeys who are 1 -3 weeks old drink 7.8 – 18 gallons of water total. 9-13 week old turkeys consume 60 -96 gallons. And 15 – 19 week old turkeys consume 120 gallons of water throughout their lives. [758] The daily water consumption for 100 turkeys was averaged from the statistics. Turkeys consume an average of 0.7 gallons of water daily.

Calculations: Average of 60 and 96 = 78, 7.8 and 18 = 12.9.
(120 + 78 + 12.9)/3 = 70.3
70.3 gallons/100 turkeys = .703 gallons = .7 gallons

Fertilizer

For the animal feed, we will focus on corn since it is the major crop that turkeys eat. Potash fertilizer for corn has consistently been in the 90th percentile for the majority of the time in the state of Indiana. Therefore, this type of fertilizer is probably the most abundant in terms of corn production. The average fertilizer consumption of corn in the corn-belt is 170 kg/ha of nitrogen, 84 kg/ha of P2O5, 78 kg/ha of K2O in the eastern part of the country.[759]

Water

Corn is generally not irrigated, but if it is, it uses light irrigation techniques such as drip or sprinkler on scheduled timers that are able to detect the moisture of the soil. [760] Judging by this, the water usage for corn is very efficient. Also, we will assume that since turkeys drink about 0.7 gallons of water per day, and they live for roughly 15 weeks (or 105 days), their lifetime water consumption is 73.5 gallons. During processing, hot water washers, steam valves, and scalders are used. Once turkeys are slaughtered and emerged into a freezing process of chemicals, the bags are sprayed with water.

Mechanization

The process is mechanized, and machines are used for processing the turkeys. There are conveyor belts, steam and hot water washers, emersion scalders, stunning areas, and cutting

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[756] "Turkey Slaughter." *Poultry Slaughter Inspection Training*. USDA, n.d. Web. 24 Feb. 2011. <www.fsis.usda.gov/pdf/psit_turkey.pdf >.
[757] "Guidlines for winter feeding of wild turkeys." *NH Fish and Games*. NH Fish and Game Department, n.d. Web. 24 Feb. 2011. <www.wildlife.state.nh.us/Wildlife/turkey_feed_guidelines.htm>.
[758] Extension, University of Missouri. "EQ378 Selecting a Site for Livestock and Poultry Operations | University of Missouri Extension." *University of Missouri Extension Home*. N.d. Web. 25 Feb. 2011. <http://extension.missouri.edu/publications/DisplayPub.aspx?P=EQ378>.
[759] "Maize / Corn: Fertilizer Best Management Practices - Crop Nutrition." *Crop Data,* Web. 25 Feb. 2011.
[760] "Corn Irrigation." *Irrigation Scheduling*. N.d. Web. 24 Feb. 2011. <corn.agronomy.wisc.edu/Management/pdfs/NCH20.pdf>.

areas that are all mechanically operated (refer to the background information above for more mechanization techniques).

Processing

After the turkey leaves the farm in Indiana, it travels to the processing plant. The address of the processing plant was mentioned in section 3, and so far the turkey has traveled approximately 0 food miles if the farm and processor are right next to each other (this is purely estimated). After the processing plant, it goes to a distribution center, which is the supplier for Wellesley. In the AVI inventory list, this turkey product was listed under Sysco. The Sysco distributor for this region is located in Boston, Massachusetts. [761] (Refer to background information above for more processing information).

Transportation

Because the turkey comes to Wellesley frozen, it is assumed that the transportation conditions are for "hard-chilled" poultry. Hard-chilled poultry has a shelf life of several weeks if it is cooled below 26 degrees F soon after it is killed. They are wrapped then secured with firm pallets. We are assuming that the turkey is shipped from Indiana to Massachusetts by truck and from Boston to Wellesley by truck. [762]

Animal Welfare

The turkey farms are commercial and industrial sized. In these commercial farms, there are as many as 25,000 turkeys on a farm at any given time in cages.[763] Perdue makes a commitment to poultry welfare though, and claims that the turkeys are treated with care. [764] However, there is no evidence to back this up, so we will assume that the turkeys are in factory farm environments. Furthermore, there is no evidence that Perdue turkeys are raised range or cage free, so it is assumed that the operations use CAFOs, since the majority of massive poultry industries do.

Waste and Packaging

Regarding waste after processing, because turkey is often packaged with whole parts, except for the heads and the feet, it is estimated that roughly 10% of the turkey by weight is thrown away. Packaging is extensive, however, because parts are often separated. For example, breasts are packaged individually from thighs. During the holidays, more turkeys are sold whole, which drastically cuts down on waste and packaging.

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[761] AVI purchasing list, AVI Fresh Wellesley. 17 Feb. 2011.
[762] "Poultry and Eggs." *Protecting Perishable Foods During Transport by Truck*. N.d. Web. 24 Feb. 2011. <www.bts.gov/publications/national_transportation_statistics/] o http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3021003&acct=atpub >.
[763] "Turkey | Poultry & Livestock | Agricuture and Food Processing | Manitoba Trade and Investment | Entrepreneurship, Training and Trade." *Province of Manitoba - Province du Manitoba*. N.d. Web. 25 Feb. 2011. <http://www.gov.mb.ca/trade/globaltrade/agrifood/po_livestock/turkey.html>.
[764] "Our Commitments." *PERDUE® Chicken Recipes, Turkey Recipes, Tips and More*. N.d. Web. 25 Feb. 2011. <http://www.perdue.com/company/commitments/>.

Vegan Nuggets

The analysis of vegan nuggets is based on Vegan Breaded Nuggets produced by Mon Cuisine (MC-VBN), a brand supplied by Alle Processing. This product was 22nd on the list of 2010 AVI purchases by cost, and the college purchased approximately **2,057 lbs** of MC-VBN in 2010. AVI also purchases other vegan chicken products such as Vegan Breaded Cutlet by Mon Cuisine, but we examine vegan nuggets because AVI purchases five times as much by weight as the cutlet (only 492 lbs in 2010). In addition, vegan chicken nuggets are the most purchased chicken substitute at Wellesley and it represents a popular vegetarian alternative to chicken nuggets. The college also purchases vegan chicken strips, vegan chicken breast, and vegan chicken breaded filet, but these purchases were insignificant when compared to MC-VBN. Chicken substitutes are not served at Collins Cafe, El Table or the Hoop, and are only served in campus dining halls.

Other ingredients in Mon Cuisine's vegan nuggets include: water, soy protein concentrate, wheat gluten, torula yeast, corn meal, breadcrumbs, onion powder, garlic powder, expeller pressed canola oil, natural spices and flavorings, tapioca starch, cellulose gum, and carrageenan (seaweed)[765]. In this LCA we consider the ingredients soy protein and wheat gluten because these are the chief ingredients in each nugget.

Serving Size

The serving size for vegan nuggets was not available by the manufacturer, but a comparable serving size was that of Trader Joe's Soy Nuggets, which is 3 oz. or 4 nuggets[766]. One pack contains 188 nuggets, which amounts to **47 servings per package**. AVI purchased 206 packages or **9,682 servings in 2010**.

Farm Location

Because soy and wheat are the two most prominent ingredients in vegan nuggets, we will use soybean and wheat farm information for this analysis. We assume that soy protein concentrate is extracted from soybeans produced in the United States (the leading soybean producer and exporting country in the world).**[767]** Soybean acreage in the U.S. is concentrated in the upper Midwest, especially Iowa, Illinois, Minnesota, Indiana, and Nebraska. Therefore, we choose to narrow our focus to soybeans produced in these states. Table 63 shows percentages of total U.S. soybean production by state of interest.

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[765] "Vegetarian Nutritional Information and Ingredients." *Welcome to Alle Processing!*. Alle Processing Co., n.d. Web. 22 Feb. 2011. <http://www.alleprocessing.com/alle/MonCuisineV/food_serv_info.htm#nuggets>.

[766] "Calories in Trader Joe's Soy Nuggets - Nutrition Facts, and Healthy Alternatives | LIVESTRONG.COM."*LIVESTRONG.COM - Lose Weight & Get Fit with Diet, Nutrition & Fitness Tools*. Livestrong.com, n.d. Web. 21 Feb. 2011. <http://www.livestrong.com/thedailyplate/nutrition-calories/food/trader-joes/soy-nuggets/>.

[767] "ERS/USDA Briefing Room - Soybeans and Oil Crops." *USDA Economic Research Service - Home Page*. 9 Mar. 2010. Web. 22 Feb. 2011. <http://www.ers.usda.gov/Briefing/SoybeansOilcrops/>.

[4] "NASS-Statistics By Subject." *NASS-National Agricultural Statistics Service*. n.d. Web. 11 May 2011. <http://www.nass.usda.gov/Statistics_by_Subject/result.php?9D5F2C2B-331F-31F9-99E9-EE8D69415D1C&sector=CROPS&group=FIELD%20CROPS&comm=SOYBEANS>.

Table 63: Chief soybean producing states, 2009[768]

State	Bushels (millions of bushels)	% of US Total
IA	486	14.5
IL	430	12.8
MN	285	8.5
IN	267	7.9
NE	259	7.7
US Total	3,359	51.4

Fertilizer Use

Fertilizer is generally applied at a lower rate for soybeans than for row crops such as corn. Soybeans can fix their own nitrogen, minimizing the amount of nitrogen that needs to be applied.[769] Recommended application rates of nitrogen, phosphate, and potash (potassium) for soybeans are 0, 12.4, and 16.5 kg/ton of yield respectively. The recommended application rates of nitrogen, phosphate, and potash for winter wheat are 19.0-22.9, 5.1, and 5.1 kg/ton of yield respectively. Excess fertilizer application can result in leaching into groundwater, while a deficiency in fertilizers could lead to a reduced crop yield.[770]

Irrigation

Water use for growth of soybean crops varies depending on soil type and irrigation method. Generally, soybean crops are partially irrigated, with one crop producing 2 bushels per acre (bu/ac) for every inch of water used throughout the season. Most irrigated yields range from 45-50 bu/ac yield, while non-irrigated crops have a lower yield of 25-30 bu/ac. Surface and sprinkler are usually the types of irrigation methods used.[771] Soybean processing requires heavy water usage, especially during initial cleaning and during concentrate extraction, which is commonly an aqueous alcohol extraction process.[772]

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[5] "NASS-Statistics By Subject." *NASS-National Agricultural Statistics Service*. n.d. Web. 11 May 2011. <http://www.nass.usda.gov/Statistics_by_Subject/result.php?9D5F2C2B-331F-31F9-99E9-EE8D69415D1C&sector=CROPS&group=FIELD%20CROPS&comm=SOYBEANS>.

[769] "ERS/USDA Briefing Room - Soybeans and Oil Crops." *USDA Economic Research Service - Home Page*. 9 Mar. 2010. Web. 22 Feb. 2011. <http://www.ers.usda.gov/Briefing/SoybeansOilcrops/>.

[770] "Corn and the Environment- Corn and Soil Fertility." *Grain Farmers of Ontario*. N.d. Web. 1 Apr. 2011. <http://www.ontariocorn.org/envt/envfert.html>.

[771] "Soybeans - Crop Irrigation."*Arkansas Agriculture*. University of Arkansas: Division of Agriculture, 28 Jan. 2011. Web. 24 Feb. 2011. < http://www.aragriculture.org/soil_water/irrigation/crop/soybeans.htm>

[772] "Soy Processing (Illini SAND) — University of Illinois Extension." *Illinois Livestock Trail — University of Illinois Extension*. University of Illinois Extension, n.d. Web. 24 Feb. 2011.

Mechanization

For agricultural machinery, we should consider energy used in the operation of machinery for soil cultivation, planting, fertilizing, irrigating, harvest and loading. For processing, we should consider the surge bin (washing of beans), cracking meal, meal conditioner, flaking mill, meal cooler and grinder, flake elevator, toaster, vapor scrubber, evaporator, and multiple stages of condensers.[773]

Processing

Soybeans are usually crushed to extract soybean meal and oil; 50-75% of the soybean's value is in the meal.[774] In the case of texturized vegetable protein, nuggets are formed through an extrusion process in which soy concentrate made from soy flour is shaped into chunks.[775] Raw soybeans are first cleaned, heated and conditioned, hulled and shaved to a smaller size before any oil is extracted. After the oil extraction process, the remaining soybean undergoes meal handling, a process during which the leftover product from oil extraction is cooled, ground, and stored. Meal is processed again to extract remaining oil, and is compacted into a cake in a series of presses. Alternately, solvent extraction is used to chemically remove remaining oil from soybean meal.[776] Soy protein concentrate is a residue from the oil extraction process, made by treating soy flakes with an alcohol extraction process (Figure 33).[777]

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[773] "Soy Processing (Illini SAND) — University of Illinois Extension." *Illinois Livestock Trail — University of Illinois Extension*. University of Illinois Extension, n.d. Web. 24 Feb. 2011.

[774] "ERS/USDA Briefing Room - Soybeans and Oil Crops." *USDA Economic Research Service - Home Page*. 9 Mar. 2010. Web. 22 Feb. 2011. <http://www.ers.usda.gov/Briefing/SoybeansOilcrops/>.

[775] "Textured Vegetable Protein."*Recipes*. Illinois Center for Soy Food, n.d. Web. 24 Feb. 2011. <www.soyfoodsillinois.uiuc.edu/>

[776] "Soy Processing (Illini SAND) — University of Illinois Extension." *Illinois Livestock Trail — University of Illinois Extension*. University of Illinois Extension, n.d. Web. 24 Feb. 2011. <http://www.livestocktrail.illinois.edu/sand/soyprocessing.cfm>

[777] "Soy Protein Concentrate for Aquaculture Feeds: Technical Bulletin." *www.ussec.org*. The Solae Company, n.d. Web. 24 Feb. 2011. <www.ussec.org/resources/SPCforaquaculture.pdf>

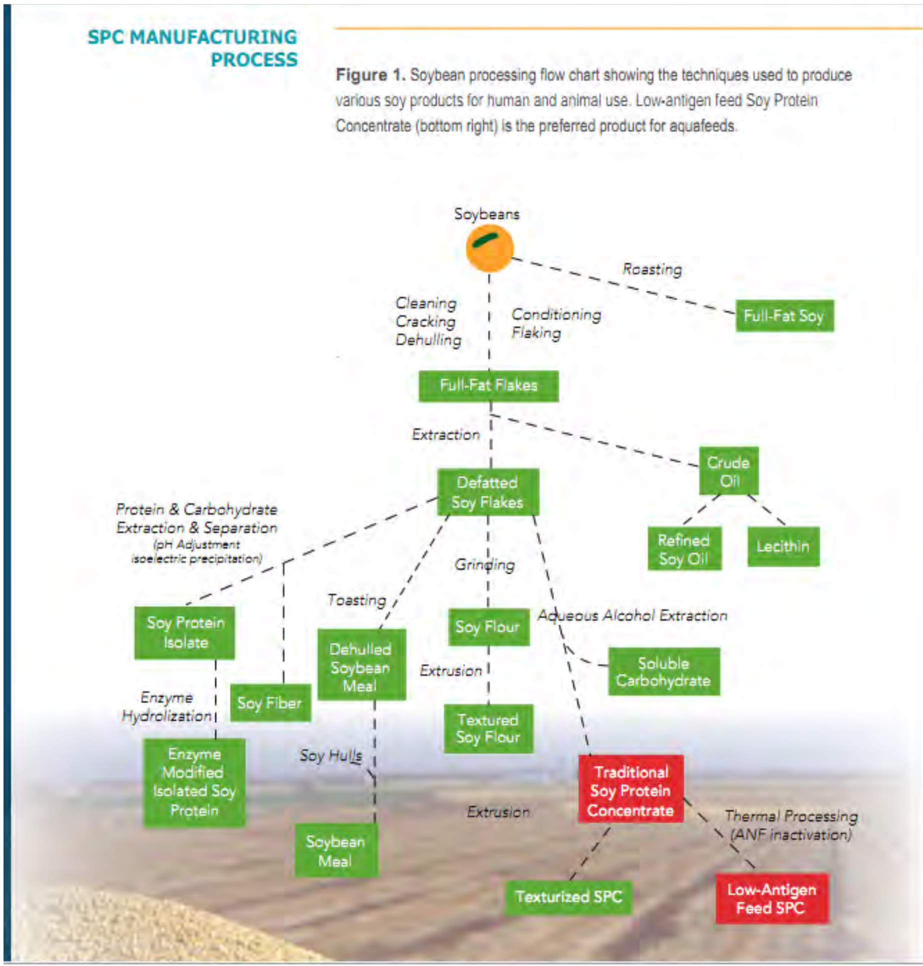

Figure 1. Soybean processing flow chart showing the techniques used to produce various soy products for human and animal use. Low-antigen feed Soy Protein Concentrate (bottom right) is the preferred product for aquafeeds.

Figure 33: Steps in soybean processing to Soy Protein Concentrate

Transportation

After leaving the farm, soybeans travel to processing plants, which are usually located near major production regions with good access to rail and barges for export.[778] For transportation and processing, we would assume that soybeans are being transported by railroad, the major transportation method for soybeans (See Table 5 and 6), from major farms in Indiana, the top soybean growing state, to Alle Processing in Maspeth, NY. It is not clear whether Alle processes soybeans on site or receives processed meal from elsewhere. Vegan chicken nuggets are most likely transported from Alle Processing to Wellesley College via truck, a distance of approximately 200 miles.

Scale

In 2007, 279,100 farms in the United States raised soybeans, and the average harvest area was 229 acres per farm. Small farms less than 250 acres accounted for the majority of soybean farms, but only produced 26 percent of the US crop. Small farms are usually individual or

[778] "ERS/USDA Briefing Room - Soybeans and Oil Crops." *USDA Economic Research Service - Home Page*. 9 Mar. 2010. Web. 22 Feb. 2011. <http://www.ers.usda.gov/Briefing/SoybeansOilcrops/>.

family farms, while large farms greater than 250 acres were partnerships and small family-held corporations.[779]

Biodiversity

Soybeans are commonly grown in crop rotation with corn. This combination reduces erosion and controls disease, insects, and weeds. Approximately 80 percent of soybean acres in major producing states used this rotation system in 2002.[780] As of 2000, soybean acreage in conventional tillage has been increasing. Complementary soil conservation activities, such as grassed waterways and terraces, were only in minor use for soybeans, with 65-86% of the soybean crop being conventionally grown.[781]

Toxicity

See Table 64for information about toxicity in soybean crops.

Table 64: Top agricultural chemicals applied to soybeans in program states, 2004[782]

Table 1- Top agricultural chemicals applied to soybeans in program states, 2004		
Type	Active Ingredient	Mean application (lbs/acre)
Herbicide	Sulfosate	1.49
	Glyphosate iso. Salt	1.08
	Gyphosate	0.91
	Pendimethalin	0.87
	Trifluralin	0.84
Insecticides	Chlorpyrifos	0.45
	Lambda-cyhalothrin	0.02

II. Wheat Gluten:

Location

Wheat gluten provides a high-protein substitute for high-protein wheat, and is derived from a wet milling process. Additionally, wheat gluten is taken from a different source than regular wheat. Gluten imports primarily come from the countries in Figure 34:

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779 "ERS/USDA Briefing Room - Agricultural Chemicals and Production Technology: Nutrient Management" *USDA Economic Research Service - Home Page*. 4 Oct. 2005. Web. 22 Feb. 2011. <http://www.ers.usda.gov/Briefing/AgChemicals/nutrientmangement.htm>.

780 "4.2 Soil Management and Conservation." *Agricultural Production Management: AREI, 2006 Edition*. 2006. Web. 22 Feb. 2011.

781 "ERS/USDA Briefing Room - Agricultural Chemicals and Production Technology: Nutrient Management" *USDA Economic Research Service - Home Page*. 4 Oct. 2005. Web. 22 Feb. 2011. <http://www.ers.usda.gov/Briefing/AgChemicals/nutrientmangement.htm>.

782 "Agricultural Chemical Usage Field and Vegetable Crops Chemical Distribution Rate." *USDA*. Dec. 2005. Web. 14 May 2011. <usda.mannlib.cornell.edu/usda/nass/AgChemUsDistRate//2000s/2005/AgChemUsDistRate-12-23-2005.pdf>.

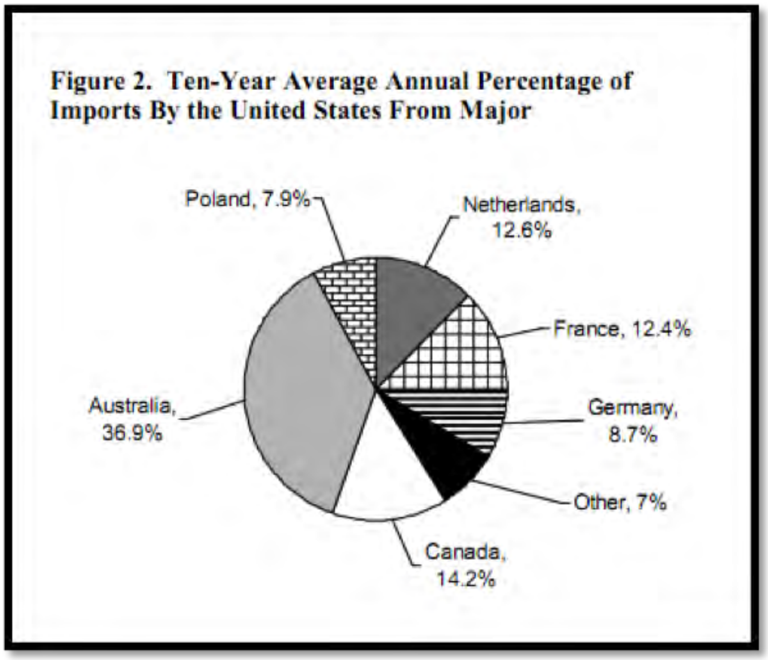

Figure 34: Sources of wheat gluten imports to the United States[783]

Domestic gluten production only occurs at three manufacturers: Manildra Milling, ADM, and Midwest Grain Products, which compete with international imports. These plants are located in Iowa, Kansas, and Illinois. Although the US does produce gluten domestically, the majority (25,000 tons) is imported from the European Union. For this metric we should consider gluten production as a percent of total US imports, which were 25,000 metric tons in 2004.[784]

Fertilizer

Although most wheat gluten is imported from Australia, statistics for the application rates of fertilizers were inconclusive. Data from the United States ARMS program are used in this case. In 2009, a total of 62.12 pounds/acre of nitrogen, 31.82 pounds/acre of phosphorous, and 38.82 pounds/acre of potash were applied to wheat crops in the United States.[785]

Processing and Water Use

In the wet milling process, wheat flour is suspended in a water and alkaline solution to soften. The resulting mix is run through a series of screens to collect flour proteins, which are dried and separated from the water/alkaline solution. About 80% of the dried protein is wheat gluten. This is extracted from the protein, along with other specialty

[783] Boland, Michael, Gary Brester, and Mykel Taylor. "Global and U.S. Wheat Gluten Industries: Structure, Competition, and Trade." *Briefing* 76 (2005): *Agricultural Marketing Policy Center*. 2005. Web. 26 Feb. 2011.
[784] Boland, Michael, Gary Brester, and Mykel Taylor. "Global and U.S. Wheat Gluten Industries: Structure, Competition, and Trade." *Briefing* 76 (2005): *Agricultural Marketing Policy Center*. 2005. Web. 26 Feb. 2011.
[785] "Crop production practices for winter wheat – National." USDA ARMS Farm Financial and Crop Production Practices. 30 Nov 2010. Web. 9 May 2011.
<http://www.ers.usda.gov/Data/ARMS/app/default.aspx?survey=FINANCE#startForm>

protein products.[786] It is assumed that groundwater local to processing plants is used for the wet milling process. See Figure 35 for a summary of this process.

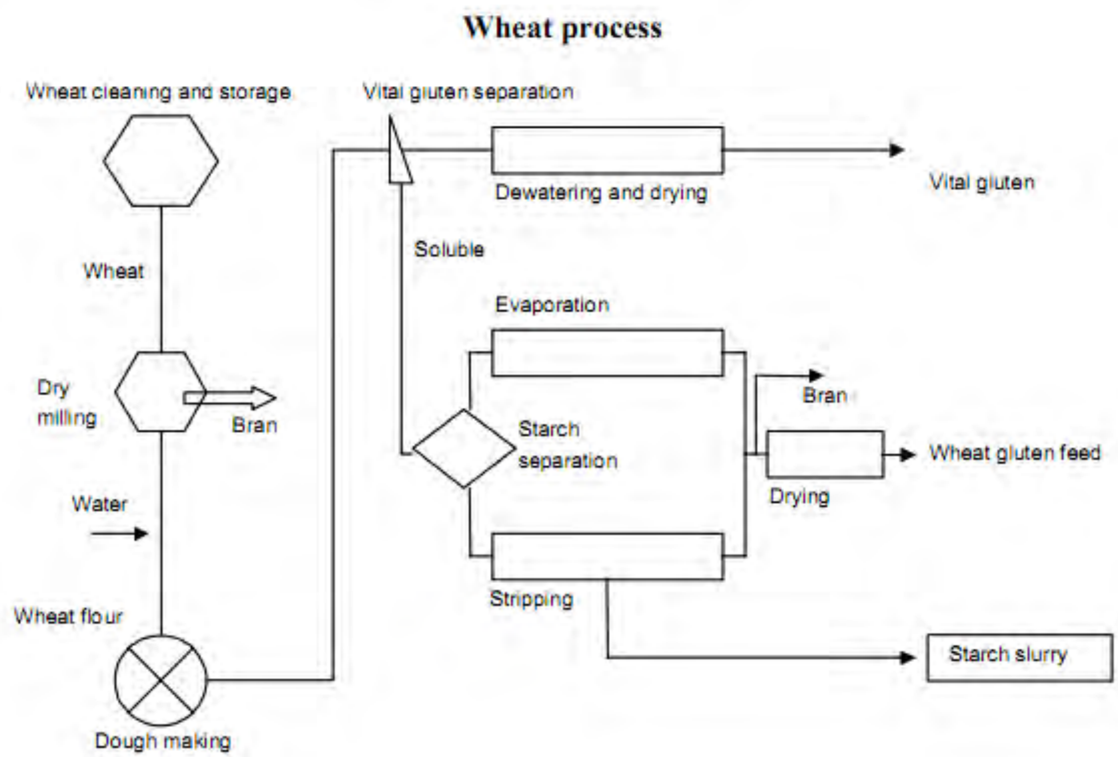

Figure 35: Wheat processes[787]

Transportation

Transportation locations we should consider are transportation by ocean vessel from the European Union to the United States, transportation from an east coast shipping port by rail or truck to Alle Processing in Maspeth, NY and transportation by truck from Alle Processing to Wellesley, MA. Ocean vessels use different fuel amounts depending on the size of the ship. We could calculate the distance travelled by choosing a standard cargo ship for fuel use, and use the distance of transport from a major exporting port in the EU to Boston, New York City or a nearby east coast port.

[786] Boland, Michael, Gary W. Brewster, and Mykel R. Taylor. *An Overview of the Wheat Gluten Industry*. Issue brief no. 75. Montana State University, June 2005. Web. 11 May 2011.
[787] Boland, Michael, Gary Brester, and Mykel Taylor. "Global and U.S. Wheat Gluten Industries: Structure, Competition, and Trade." *Briefing* 76 (2005): *Agricultural Marketing Policy Center*. 2005. Web. 26 Feb. 2011.