Greenhouse Gas Emissions of the U.S. Diet: Aligning Nutritional Recommendations with Environmental Concerns

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ABSTRACT

Dietary choices – the overall food consumption patterns displayed by a population – can, and do, influence greenhouse gas emissions (GHGE) of the food system. Here, we consider the GHGE associated with production of the current U.S. diet, and various dietary recommendations. USDA's loss adjusted food availability dataset is used to represent current consumption. GHG emission factors were compiled from published LCA sources. Production of the current U.S. diet has GHGE of 5.0 kg CO_2eq capita^{-1}day^{-1}, 28% of which is due to food losses; a diet based on USDA's *Dietary Guidelines* has similar or greater GHGE as this current diet. Lacto-ovo vegetarian, vegan, and Harvard's Healthy Eating Plate guidelines show 33%, 53%, and 33% lower GHGE, respectively, than their USDA omnivore counterpart. Official USDA food plans at four cost levels show increasing emissions with rising food costs, but decreasing emissions per unit cost. This paper suggests aligning environmental and health objectives through dietary recommendations policy.

Keywords: sustainable diet, carbon footprint, diet shift, consumption, cost-based food plan

1. Introduction

Opportunities to reduce the greenhouse gas emissions (GHGE) associated with food and agriculture exist throughout the food production chain, but researchers warn that technological improvements in agriculture alone – enhanced yields, resource use efficiencies, etc.– will likely be insufficient to keep pace with population growth and rising demand for meat and dairy (Garnett 2011). Behavioral choices, including shifts in diet and minimizing food waste, particularly in developed countries, can have large influences. With transportation, housing and food (in that order) as the largest contributors to the carbon footprint of the typical U.S. household, often the most economically effective abatement options for consumers are dietary changes (Jones and Kammen 2011). In addition, more than 40% of food waste in industrialized countries happens at the retail and consumer levels (Gustavsson et al. 2011). In this study, we explore in detail the GHGE associated with current and recommended diets in the U.S.

Changes in both the quantity and quality of the American diet may hold potential to affect the carbon footprint of food production. The current obesity epidemic, in the U.S. as well as other developed nations, garners broad academic, political and media attention; the most recent statistics claim that 69% of U.S. adults are overweight and 36% are obese (CDC 2013). Food overconsumption and obesity contribute not only to human health dangers, but also translate directly and indirectly into increased agricultural demand, excess resource utilization, and concomitant environmental impacts (Blair and Sobal 2006; Cafaro et al. 2006). Not only are Americans over-consuming, they are not eating properly: repeated assessments find that Americans do not meet the Federal dietary recommendations (Krebs-Smith et al. 2010; Wells and Buzby 2008). Dietary choices influence the environmental cost of food consumption (Carlsson-Kanyama and Gonzalez 2009; Marlow et al. 2009), and research from Germany (Meier and Christen 2013) and Austria (Fazeni and Steinmuller 2011) suggests that a shift from current consumption patterns to German Nutrition Society dietary recommendations can result in reduced environmental impacts from the agri-food sector. Dietary choices are complex and influenced by a myriad of factors; dietary recommendations presented by governments are but one avenue to influence policy and consumer choices to move toward a more nutritionally healthy diet. However, if multiple objectives (e.g., health and sustainability) are not aligned in recommendations, undesirable outcomes are possible. Here, we explore the implications on food related GHGE of U.S. dietary recommendations and policy-related food patterns.

2. Methods

2.1. U.S. food consumption and losses

The Loss Adjusted Food Availability (LAFA) data series (USDA ERS 2012) serves as a useful proxy for per capita food consumption in the U.S. The food availability series measures the use of basic food commodities (e.g., wheat, beef, fruit, vegetables) by tracking their "disappearance" in the U.S. marketplace. For most commodities, the available supply is the sum of production, imports and beginning stocks, minus non-food use (feed and seed, industrial uses), exports, and ending stocks for a given calendar year. In the Loss Adjusted data series, the food availability data for over 200 commodities are modified by percent loss assumptions at the primary level, retail/institution level, and consumer level. Retail losses include dented cans, unpurchased holiday foods, spoilage, and the culling of blemished or misshaped foods. Consumer losses include spoilage, cooking shrinkage, and plate waste. Nonedible food losses (bones, peels, pits, etc.) are accounted for separately in the data series and not included in the results presented here. We use LAFA data from 2010 in this study to represent current food consumption patterns in the U.S., shown in Table 1. Percent losses for individual foods were assumed to be unchanged in considering a shift to dietary recommendations, thus allowing an assessment of how food losses might be affected by a dietary shift. Further detail and report of per capita availability and loss estimates for various foods are presented in (Heller and Keoleian 2014).

2.2. Dietary recommendations and food plans

The 2010 *Dietary Guidelines for Americans* contains food pattern recommendations (Appendix 7, 8 and 9 of (USDA 2010)) that provide recommended average daily intakes of different food groups (assumed to be in nutrient dense forms and lean or low-fat) for a range of Calorie levels, depending on individual caloric intake needs. The *Dietary Guidelines* also provide estimated caloric needs by age, gender and physical activity level (Appendix 6 of (USDA 2010)). Weighting these estimated caloric needs with U.S. age and gender demographics from 2010 (U.S. Census Bureau 2011) suggests that the weighted average caloric need for a moderately active U.S. population is 2093 Calories[1] (1867 Calories and 2361 Calories for sedentary and active, respectively). For the purpose of this paper, we explore recommended food patterns at two caloric levels (see Table 1): the current caloric intake (according to the LAFA series) of 2534 Calories, representing an iso-caloric diet shift, and the often used reference point of 2000 Calories, representing a weighted average target intake for the average U.S. citizen, assuming moderate activity. We also evaluate lacto-ovo vegetarian and vegan food pattern recommendations at 2000 Calories, as defined by the *Dietary Guidelines* (USDA 2010).

The Healthy Eating Plate (HEP) diet is a food pattern designed to represent the Alternative Healthy Eating Index (AHEI) developed by nutrition experts at the Harvard School of Public Health. AHEI is based on foods and nutrients predictive of chronic disease risk, and has demonstrated a stronger association with chronic disease risk, particularly coronary heart disease and diabetes, than USDA's Healthy Eating Index (which quantifies adherence to *Dietary Guidelines*) in prospective cohort studies (Chiuve et al. 2012). The HEP is characterized by high quality grains (whole vs. refined), healthy proteins (fish, poultry, beans and nuts vs. red meat and processed meat), greater intake of poly unsaturated fatty acids (healthy oils), reduced intake of sugar-sweetened beverages, and reduced dairy (Harvard School of Public Health 2014). The HEP food pattern at 2000 Calories examined here is defined in Table 1 and is from (Willett 2014).

USDA also maintains official food plans designed to meet required dietary standards and specified cost levels, which are used for various policy implementation purposes. The Thrifty Food Plan (Carlson et al. 2007b) serves as a national standard for a nutritious diet at a minimal cost and is used as the basis for maximum food assistance allotments. Bankruptcy courts often use the value of the Low-Cost Food Plan (Carlson et al. 2007a) to determine the portion of a bankrupt person's income to allocate to necessary food expenses; the U.S. Department of Defense uses the value of the Liberal Food Plan to determine the Basic Allowance for Subsistence rates for all service members; many divorce courts use the values of the USDA Food Plans to set alimony payments, and they are also used to set child support guidelines and foster care payments.

These food plans reflect the consumption patterns and eating habits of U.S. citizens as determined by the

[1] 1 Calorie = 1 food calorie = 1 kilogram calorie = 4,186.8 Joules

2001-2002 National Health and Nutrition Examination Survey (NHANES); the U.S. population is divided into quartiles of food spending by combining NHANES food intake data with the 2001-2002 Food Price Database (Carlson et al. 2007a). The Thrifty Food Plan corresponds with the first quartile of food expenditure, the Low-Cost plan with the second quartile, the Moderate-Cost Plan with the third quartile, and the Liberal Food Plan with the upper quartile. A mathematical optimization model is used to identify food market baskets representing a diet as close as possible to actual food consumption patterns within a given quartile group while also meeting USDA dietary standards and the cost limits for that quartile. Within each Food Plan, diets for 15 age-gender groups are identified; for simplicity's purposes, we consider here only the male and female diets in the 19-50 year old group. Purchasing costs at the four quartile levels are updated monthly (USDA 2014); costs from June 2013 (assigned by USDA to represent the annual average) are used here in order to present GHGE per dollar for the four food plans. Note that updated Food Plans reflecting the (most recent) 2010 Dietary Guidelines have not yet been published; the Food Plans reported in (Carlson et al. 2007a; Carlson et al. 2007b) are based on the 2005 Dietary Guidelines for Americans.

Table 1. Per capita daily intake definitions for the current US diet and recommended food patterns.

	Food pattern equiva-lents units	Cur-rent US diet[a]	Food Pattern Recommendations from 2010 Dietary Guidelines (USDA)[c]				Healthy Eating Plate food pattern[j]	GHGE of repre-sentative food(s)[l]
			omnivore		Lacto-ovo vegetarian	vegan		
		Per capita per day						kg CO_2eq. (food pattern unit)$^{-1}$
Total Calories	Cal.	2534	2534[e]	2000	2000	2000	2000	
Fruits	Liter eq.	0.19	0.47	0.47	0.47	0.47	0.47	0.76
Vegetables	Liter eq.	0.38	0.78	0.59	0.59	0.59	0.59	-
dark green veg	Liter eq.	0.050	0.071[d]	0.047[d]	0.047[d]	0.047[d]	0.085[d]	0.12
red & orange veg	Liter eq.	0.059	0.24[d]	0.19[d]	0.19[d]	0.19[d]	0.20[d]	0.40
beans & peas	Liter eq.	0.028	0.071[d]	0.047[d]	0.047[d]	0.047[d]	0.069[d]	0.25
starchy veg	Liter eq.	0.15	0.24[d]	0.17[d]	0.17[d]	0.17[d]	0.069[d]	0.14
other veg	Liter eq.	0.10	0.19[d]	0.14[d]	0.14[d]	0.14[d]	0.17[d]	0.40
Grains	kg-eq.	0.21	0.25	0.17	0.17	0.17	0.20	0.49
Protein foods	kg-eq.	0.21	0.18	0.16	0.16	0.16	0.18	-
seafood	kg-eq.	0.012	0.040[d]	0.031[d]	0	0	0.031[d]	6.4
meat, poultry, eggs	kg-eq.	0.17	0.12[d]	0.10[d]	0.016[d]	0	0.077[d]	-
beef	kg-eq.	0.054	0.040[f]	0.031[f]	0	0	0.0082[d]	26
pork	kg-eq.	0.037	0.026[f]	0.023[f]	0	0	0.0082[d]	6.7
poultry	kg-eq.	0.068	0.048[f]	0.040[f]	0	0	0.048[d]	4.9
eggs	kg-eq.	0.014	0.011[f]	0.0085[f]	0.016[d]	0	0.012[d]	6.3
nuts & seeds	kg-eq.	0.024[b]	0.020[d,g]	0.017[d,g]	0.054[d]	0.059[d]	0.043[d]	0.85
soy products	kg-eq.	-[b]	-[g]	-[g]	0.048[d]	0.040[d]	0.031[d]	3.5
beans & peas	kg-eq.	-[i]	-[i]	-[i]	0.040[d, i]	0.054[d, i]	-[i]	2.1
Dairy	Liter eq.	0.35	0.71	0.71	0.71	0.71[k]	0.24	1.69 (0.85[k])
Oils	g	46.2	33.0	27	19	19	50	0.0063
Max. SoFAS[h]	Cal.	513	351.4	258	258	258	120	0.00035

[a]from: (USDA ERS 2012) http://www.ers.usda.gov/datafiles/Food_Availabily_Per_Capita_Data_System/LossAdjusted_Food_Availability/servings.xls; reported in cup eq. and oz. eq.

[b]source dataset only gives nuts and does not explicitly differentiate seeds or soy products.

[c] Appendix 7,8 & 9 (USDA 2010).; reported in Cup eq. and oz. eq.

[d] presented in guidelines as weekly recommendations. Averaged here to daily intakes.

[e] Food pattern for 2534 Calories derived by linear interpolation between 2400 and 2600 Calorie pattern from (USDA 2010).

[f] *Dietary Guidelines* only report the aggregated "meat, poultry & eggs" category. Subcategory distributions presented here are based on current consumption patterns.

[g] Subcategories are combined in *Dietary Guidelines* (as "nuts, seeds & soy products"), and this combined category is presented here under "nuts & seeds."

[h] max. SoFAS = maximum solid fats and added sugars, but is composed only of added sugars in the Healthy Eating Plate guidelines (HEP does not set a maximum limit of calories from healthy fats).

[i] this "beans & peas" category represents *additional* intake for vegetarian and vegan diets, on top of the beans & peas recommended as part of vegetable consumption.

[j] Healthy Eating Plate food pattern from Walter Willett, personal communication (Willett 2014).

[k] The vegan "dairy group" is composed of calcium-fortified beverages and foods from plant sources. Soy milk is used as a GHGE proxy for the entire group.

[l] GHGE factors for food groups were calculated as described in (Heller and Keoleian 2014), Supporting Information.

2.3. Food GHGE data

While numerous LCA-based studies of food production have been published, there currently is not a comprehensive and authoritative database of food environmental impact. Thus, we have chosen a meta-analysis approach of published LCA data to arrive at representative GHGE factors for the diversity of foods considered in this study. Results are drawn from a variety of sources (referenced in (Heller and Keoleian 2014), Supporting Information (SI)), compiled by food type, and averaged across comparable food type. These sources include studies representing a variety of countries of origin, climatic conditions, transportation distances, and production methods and therefore are intended to provide a reasonable range of expected values rather than a definitive result for each food type. U.S. based data is limited, and thus this meta-analysis includes data from other developed countries. The average GHGE values for the ~100 foods considered in this study, along with minimum and maximum GHGE values from the meta-analysis, are given in (Heller and Keoleian 2014), SI. In some cases where insufficient data on individual foods exist and where small differences in GHGE are expected between foods (such as, e.g., added sugars and sweeteners), available examples are used to represent the entire food category.

The emission factors for broad food categories and subcategories shown in Table 1 are averages of representative foods, weighted by current consumption patterns in the U.S. as dictated by the LAFA dataset. Conversions to food pattern equivalents units are based on grams per food pattern equivalents contained in the LAFA dataset (USDA ERS 2012).

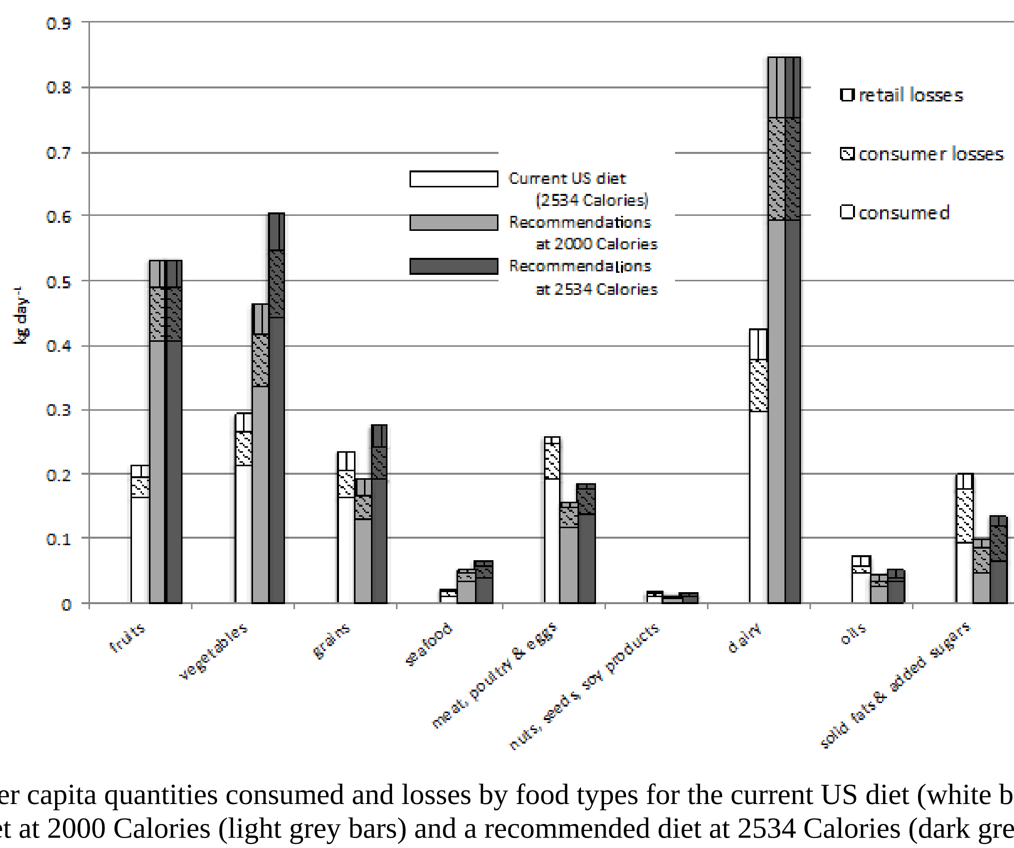

Figure 1. Per capita quantities consumed and losses by food types for the current US diet (white bars), a recommended diet at 2000 Calories (light grey bars) and a recommended diet at 2534 Calories (dark grey bars).

3. Results

Figure 1 summarizes the average daily per capita diet in the U.S. as well as food patterns corresponding with the USDA dietary recommendations. To shift their diet to meet recommendations, the average U.S. citizen would need to significantly increase fruit, vegetable and dairy intake while decreasing intakes of meats, oils and solid fats and added sugars. Figure 1 also shows the retail- and consumer-level food losses, as specified by the LAFA dataset, and expected food losses with a recommended diet, assuming the same loss percentages for individual food types. The total weights of food consumed and wasted are reported in Table 2. In Figure 2, the same diets are shown but with individual food weights multiplied by GHGE factors, providing a distribution of GHGE associated with producing the U.S. diet. Not surprisingly, meats and dairy dominate the carbon footprints of both current and recommended diets. As can be seen in Table 2, the total diet-related GHGE is greater for dietary recommendations at the same caloric intake compared with the current diet, whereas a shift to recommendations accompanied by a 20% decrease in caloric intake shows the same GHGE as the current diet. This appears to be primarily due to the balance between decreased meat and increased dairy in the recommended diets. The total weight of food losses associated with a recommended diet at 2534 and 2000 Calories is nearly 50% and 30% greater than the current diet, respectively, whereas GHGE associated with those food losses only increase 20% and 7%, respectively. The weight of food losses increases primarily due to increased consumption of fruits, vegetables and dairy – all foods with relatively high loss percentages but low GHGE factors; decreases in meat consumption also contribute to the disproportional increase in food loss GHGE.

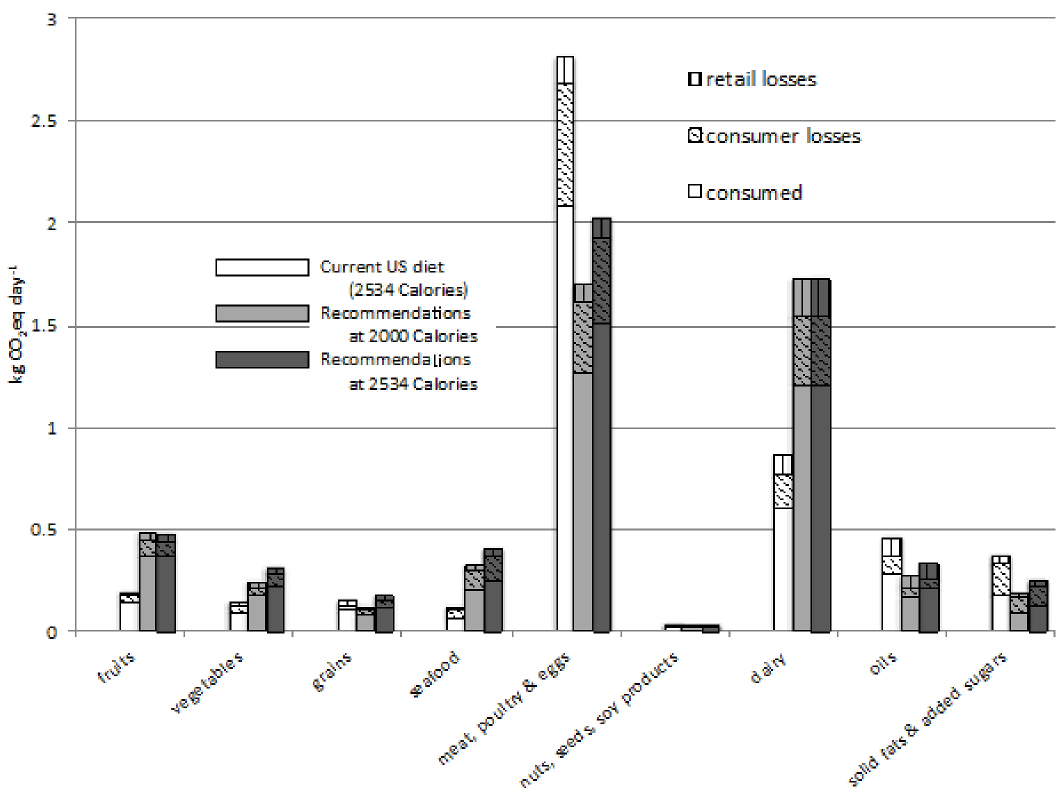

Figure 2. Per capita greenhouse gas emissions associated with producing consumed food and losses by food types for the current US diet (white bars), a recommended diet at 2000 Calories (light grey bars) and a recommended diet at 2534 Calories (dark grey bars).

Table 2. Total per capita weights and GHGE associated with consumed food and estimated food losses of the diets shown in Figures 1 and 2.

	weight (kg day^{-1})				GHGE (kg CO_2 eq day^{-1})			
	consumed	Retail losses	Consumer losses	Total losses	consumed	Retail losses	Consumer losses	Total losses
Current US diet (2534 Cal.)	1.19	0.17	0.36	0.53	3.60	0.40	1.0	1.4
US dietary recommendations at 2000 Cal.	1.70	0.24	0.46	0.69	3.57	0.45	1.1	1.5
US dietary recommendations at 2534 Cal.	1.91	0.27	0.53	0.79	4.02	0.51	1.2	1.7

Figure 3 compares the GHGE associated with food patterns for four recommended diets all at 2000 Calories: the USDA recommended diet shown in Figures 1 & 2, lacto-ovo vegetarian and vegan adaptations of this diet (also offered by USDA), and a food pattern representing the HEP recommendations made by Harvard School of Public Health. As expected, limiting or eliminating animal products in the vegetarian and vegan diet significantly reduces GHGE. Interestingly, the HEP diet, which recommends reduced (but not eliminated) levels of animal proteins and dairy, demonstrates GHGE equivalent to the lacto-ovo vegetarian diet.

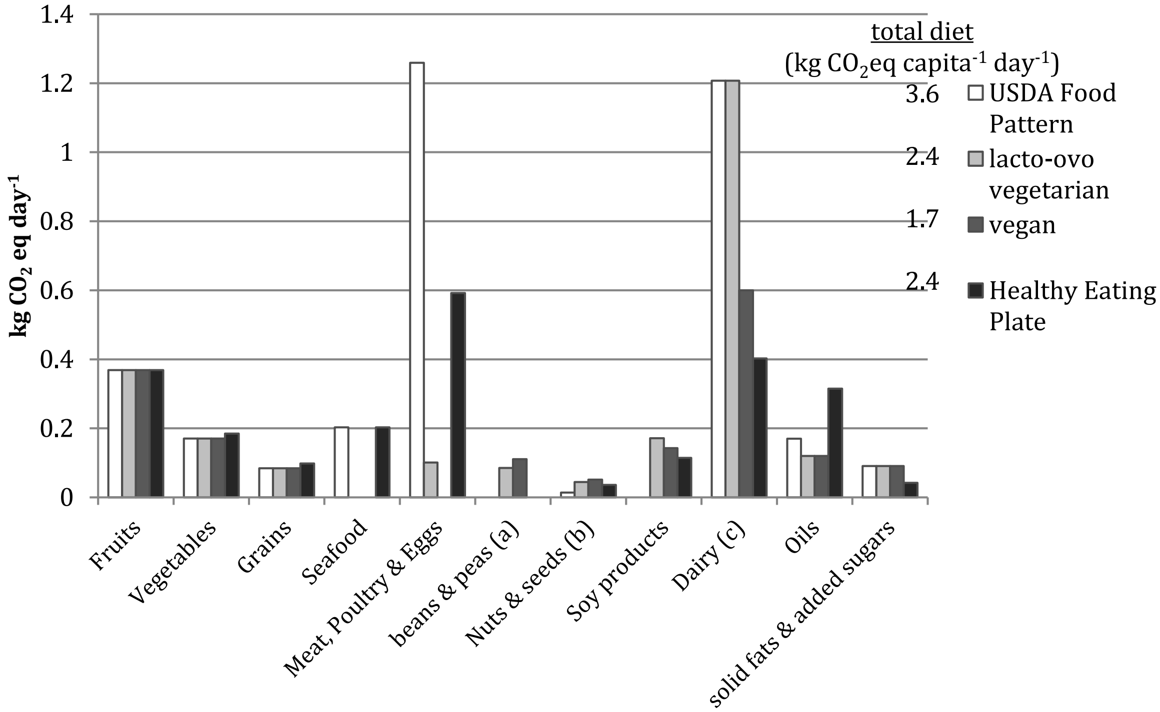

Figure 3. Comparison of the per capita greenhouse gas emissions associated with various 2000 Calorie recommended food patterns. Diets are as described in Table 1. Notes: (a) this category represents beans and peas added to the vegetarian and vegan diet *in addition* to those included in “vegetables”. (b) nuts, seeds & soy products are combined into the same category in the USDA food pattern, presented here as a bar only in “nuts & seeds”. (c) “dairy” category in the vegan diet contains calcium-fortified beverages and foods from plant sources.

Figure 4 offers a high-level summary of the GHGE associated with USDA cost-based food plans. These food plans are based on the food expenditures of surveyed U.S. citizens. Food expenditure distributions for each of 15 age and gender categories are divided into quartiles; the average share of food consumption in each quartile is used to represent the group. An optimization is then performed to arrive at a food plan (collection of food items) that meets nutritional requirements, does not exceed the expenditure cut-off for the group, and minimizes change in consumption from the average food consumption for the group. Figure 4 shows that the food-plan-associated GHGE for 19-50 year old men and women rise with food expenditures, but apparently at a slower rate than the increasing cost, as the GHGE per $ cost decreases. Table 3 gives the distribution of both food expenditures and GHGE across broad food categories for all four food plans. Interestingly, the dominant cause of the increase in GHGE from the Thrifty to the Low-cost food plan is due to the introduction of soft drinks and sodas: these beverages are absent from the Thrifty food plan for 19-50 year olds. Additional trends are more difficult to identify: increasing red meat consumption with increased cost plays a role, often buffered by decreasing poultry consumption. Vegetable consumption tends to move away from starchy vegetables like potatoes to dark green and other vegetables with increasing costs. Surprisingly, legumes (beans, lentils, peas), which might be considered low cost protein sources, actually increase with expenditure in these food plans.

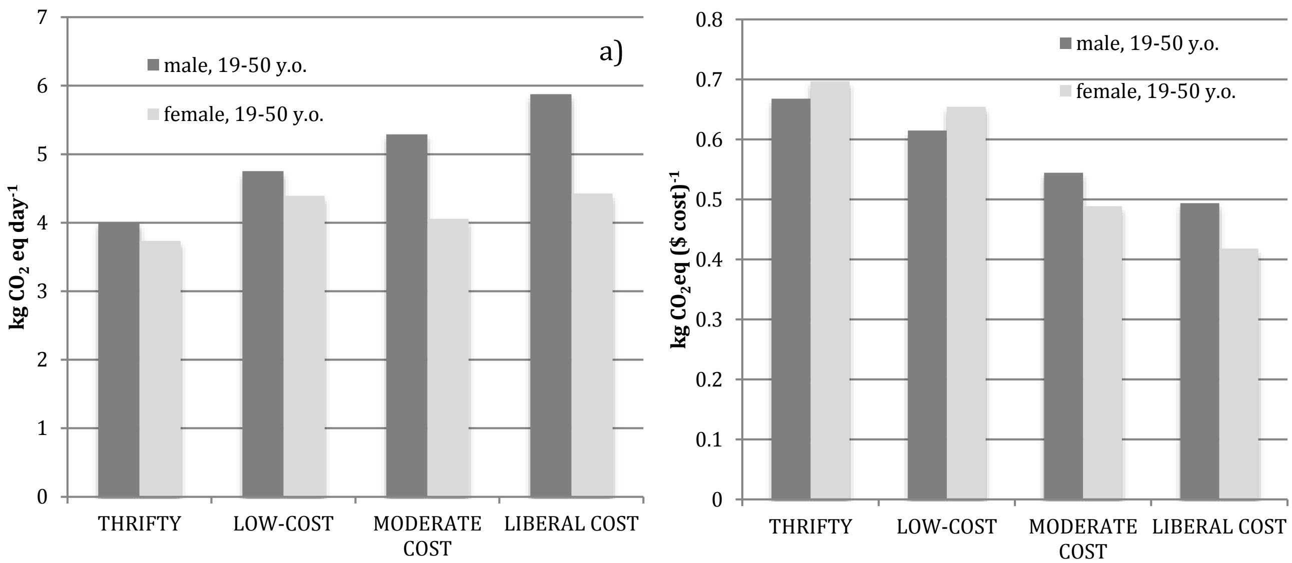

Figure 4. Comparison of GHGE associated with USDA food plans developed at meal cost quartiles, shown for diets developed for 19-50 year old males and females.

Table 3. Expenditure (cost) and GHGE shares across food categories for Thrifty, Low-cost, Moderate-cost and Liberal cost food plans. Food plans for 19-50 year old males and females are shown. Expenditure shares from (Carlson et al. 2007a; Carlson et al. 2007b).

	THRIFTY		**LOW**		**MODERATE**		**LIBERAL**	
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**
% COST								
grains	14.4	16.6	15.1	12.2	21.4	18.3	19.8	16.4
vegetables	27.1	21.9	23.9	23.3	24.0	30.8	28.1	27.1
fruits	19.8	17.9	17.9	20.6	14.9	14.6	13.4	18.4
milk products	14.1	16.4	13.5	15.3	12.4	14.1	11.5	14.3
Meat[a]	16.5	20.8	20.5	21.6	21.8	19.0	21.4	19.3
other foods[b]	8.1	6.4	9.0	7.2	5.6	3.3	5.8	4.4
% GHGE								
grains	4.7	3.1	2.9	2.7	3.7	3.5	3.7	3.5
vegetables	8.3	6.6	7.5	6.4	7.4	10.0	8.4	10.1
fruits	9.4	6.3	7.4	8.1	7.3	7.4	7.2	10.9
milk products	26.7	28.4	24.8	27.5	23.9	31.1	24.3	30.6
Meat[a]	44.4	50.6	39.3	39.3	47.5	42.4	45.3	36.7
other foods[b]	6.4	5.0	18.1	16.0	10.2	5.5	11.1	8.3

[a]"Meat" include beef, pork, veal, lamb, poultry, fish, sausages and luncheon meats, nuts, nut butters and seeds, and eggs and egg mixtures.
[b]"Other foods" include table fats and oils, gravies, sauces and condiments, coffee and tea, soft drinks and sodas, sugars sweets and candies, ready-to-serve, condensed and dry soups, and frozen or refrigerated meals.

4. Discussion

Better understanding the environmental implications of dietary food patterns is a critical step toward a more sustainable food system. Here, we provide an approach to estimating the GHGE associated with the current U.S. diet. The LAFA dataset on which our estimate is based is a top down approach, starting with *disappearance* of (primarily) agricultural commodities and, through a series of loss estimates, arriving at a proxy for per capita consumption. Some impacts of food processing and distribution are missed in this approach, and we acknowledge that the GHGE factors used for individual foods are limited in their specificity and geographic accuracy. While our estimate for GHGE associated with the average U.S. diet of 5.0 kg CO_2eq capita^{-1} day^{-1} (consumption plus losses) is within the range of other national average diet carbon footprints reported in the literature (see Table 3 in (Heller et al. 2013)), reported economic input-output LCA based estimates for the U.S. diet are higher (8.4 kg CO_2eq. capita^{-1}day^{-1} from (Weber and Matthews 2008) and 8.5 kg CO_2eq. capita^{-1}day^{-1} from (Jones and Kammen 2011)).

Despite the limitations, the approach presented here is valuable in comparing the relative effects of dietary shifts. A USDA recommended dietary pattern at the same caloric intake as the current diet is associated with 12% greater GHGE. While a 20% reduction in caloric intake at a constant dietary pattern would result in a 20% decrease in GHGE, a 20% reduction in caloric intake combined with a shift to dietary recommendations results in no change in GHGE.

Food losses represent a significant impact for the U.S. food system. By our estimates, the GHGE associated with retail- and consumer-level losses totaled 160 MMT CO_2 eq. in 2010, roughly equivalent to the emissions of 33 million average passenger vehicles (Heller and Keoleian 2014). Interestingly, this is also roughly equivalent to the GHGE difference between the omnivore recommended USDA food pattern and the lacto-ovo vegetarian food pattern (Figure 3). A population-wide shift to vegetarianism is highly unlikely in the U.S., but comparisons with the HEP guidelines suggest that similar reductions are possible without completely giving up meat. Reduced dairy consumption is a primary driver of the carbon footprint differences seen with the HEP food pattern. While the scientific debate over the health implications of dairy in our diet (e.g., (Ludwig and Willett 2013)) are beyond the scope of this paper, clearly the trade-offs between the health and environmental impacts of dairy deserves further attention, and is a focus of our future work. Of course, in order to infer actual change in climate impact from the dietary shifts considered in this paper, a consequential LCA analysis is needed, as market-mediated and other indirect effects are likely significant. Still, the attributional approach presented here suggests the potential for reduction in food system GHGE through changes in diet.

Analysis of the USDA cost-based food plans offers an initial glimpse at consideration of a triple bottom line objective for dietary recommendations. It should be noted that these food plans are based on a different approach to defining current U.S. consumption patterns than the diet presented in Figures 1 and 2, and therefore may not be directly comparable. The influence of current consumption patterns on these food plans should also not be underestimated: they do not represent an optimal low-cost nutritious diet, but instead a nutritious diet within a given cost constraint that *minimally deviates from current consumption*. That said, the results in Figure 4 further demonstrate the effect that dietary composition can have on GHGE of food plans that are (roughly) nutritionally equivalent. In addition, it raises questions as to what the ideal optimization objective might be when including environmental concerns in nutritional policy and recommendations: minimizing overall environmental impact? Impact per unit cost? Impact per unit nutritional benefit? Such questions echo the perennial challenge of functional unit definition in food LCA, and are at the heart of the additional work needed to permit meaningful incorporation of environmental indicators into nutritional policy.

5. Conclusion

The GHGE associated with production of the food consumed by the U.S. population is significant: 8% of total U.S. GHGE in 2010, based on our estimates (Heller and Keoleian 2014). Yet, the results presented here suggest that these emissions could be reduced by upwards of 30%, not by eliminating all animal products from the diet, but by shifting to a healthy diet based on foods and nutrients that are predictive of lowered chronic disease risk. According to our analysis, a diet based on the food patterns recommended by the *Dietary Guidelines for Americans 2010* would have the same or greater GHGE as the current U.S. diet. Absent of additional interventions, greater food losses can be expected with a shift to dietary recommendations, but the relative GHGE impact of those losses are diminished. While policy-level food plans designed to supply ample nutrition at limited cost show increasing GHGE with increasing cost, they also demonstrate the highest emissions per unit of food cost at the lowest expenditure food plan, suggesting that further optimization of the health/ environment/ affordability triple bottom line is possible. Policy-level discourse regarding sustainable food consumption and the inclusion of environmental factors in nutritional guidelines has emerged in various European countries as well as in Australia (Lang and Barling 2013), but such conversation is at a nascent stage in the U.S. This study provides much needed quantitative evidence to the emerging U.S. sustainable diet debate, and suggests the need to align environmental and health objectives of the U.S. food system through dietary recommendations.

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