Environmental Impacts of Increasing Alternative Protein Intake in the Diet

Zach Conrad, PhD, MPH

Assistant Professor, Department of Kinesiology, William & Mary
Faculty Affiliate, Global Research Institute, William & Mary

zsconrad@wm.edu

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Agenda

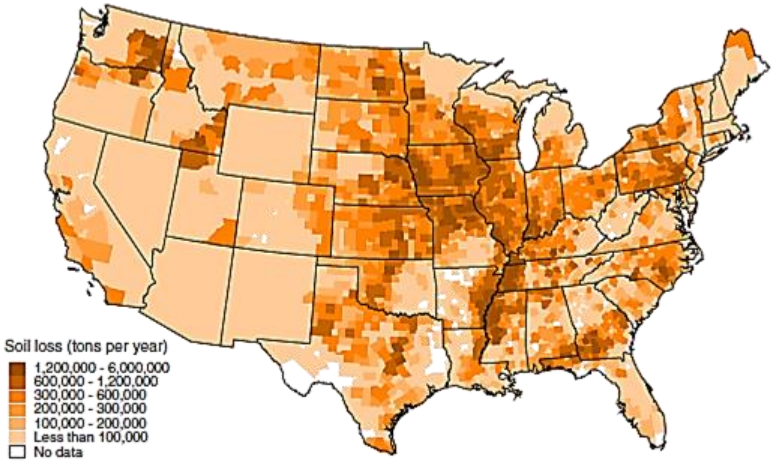
Diet-sustainability hypothesis

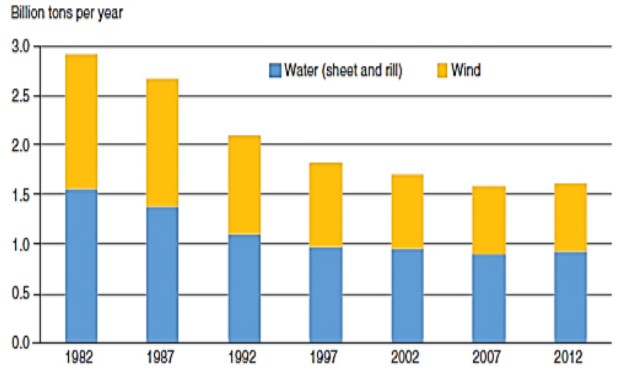
- -Are healthy diets more environmentally sustainable?
- -A brief timeline of the evidence
- -Implications for alternative protein sources

Lingering questions

Environmental indicators

Soil erosion
GHG emissions
Energy use
Air pollution
Water pollution
Nutrient loss
Eutrophication
Fertilizer use
Pesticide use
Water use
Water scarcity
Biodiversity





USDA, NRCS Photo Gallery; USDA, ERS, 2019.

Sustainable diets

The hypothesis that healthy diets are more environmentally sustainable is not new.

But the seminal article by Gussow and Clancy (1986) was pivotal in introducing this concept to scientific discourse.

This hypothesis has become conventional wisdom.

Extraordinary claims require extraordinary evidence.

Dietary Guidelines for Sustainability

JOAN DYE GUSSOW[1] AND KATHERINE L. CLANCY[2]

[1]Department of Nutrition Education, Teachers College, Columbia University, New York, New York 10027; and [2]Department of Human Nutrition, Syracuse University, Syracuse, New York 13210

In the last few years, nutrition educators have begun asking increasingly sophisticated questions related to *how* to teach nutrition. Seeking to learn why people eat what they do and how better to teach them what we think they need or want to know, the profession has turned to models and theories from a variety of fields (1–3). By contrast, new questions and understandings about *what* to teach have been generated almost entirely at the interface between nutrition and medicine by a concern over the relationship between diet and health. This is not surprising, since as Contento (4) has reminded us, the explicit goal of nutrition education has been to produce healthy and productive citizens.

We wish to argue here, however, that information on the relationship between human health and food choices is not a sufficient basis for nutrition education. In our time, educated consumers need to make food choices that not only enhance their own health but also contribute to the protection of our natural resources. Therefore, the content of nutrition education needs to be broadened and enriched not solely by medical knowledge, but also by information arising from disciplines such as economics, agriculture, and environmental science.

It is important to note that discussion of the implications—environmental, macroeconomic, and agricultural—of individuals' food choices has been widespread outside the nutrition community for a number of years, among groups with interests in subjects as diverse as vegetarianism, organic agriculture, community building, "natural healing," cooperatives, bioregionalism, and social justice. But while individual nutritionists have worked with such groups, there appears as yet to have been no recognition by the profession that food choices might regularly be made not merely in terms of their nutritional impact on the individual but in terms of their impact on the long-term stability of the food system.

Nutritionists and the food system. The notion that nutrition education ought in some way to be linked to agriculture and global resource issues is a very old one. Although most present-day professionals are young enough to be surprised by the fact, the earliest U.S. food guides, as Haughton (see Note 1) has pointed out, clearly reflected a concern with the food supply as well as with consumer health. In the early part of the century, pioneer nutritionist Henry Sherman was urging the purchase of locally produced fruits and vegetables to save energy and transportation costs, the use of grains to feed humans rather than livestock, and the substitution of dairy products for meat since the former were less wasteful of resources (5).

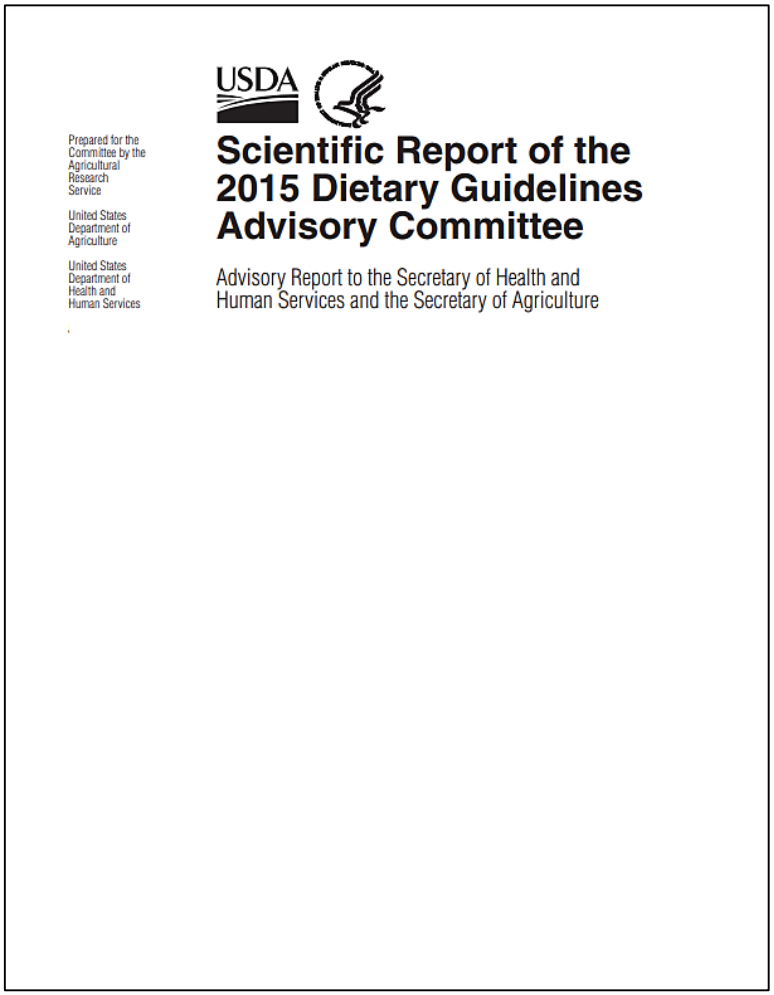
Concern for the resource costs of our food choices is validated not only by our own history but by another traditional interest of nutritionists—world hunger. We are all familiar with the existence of hunger in various parts of the world, as we are with the conviction that—at least in emergencies—the U.S., with all its abundance, ought to be feeding the poor. It is our lack of attention to global resource issues that has allowed us to ignore the fact that the poor, especially in the developing countries, are actually feeding us (6). Since we are rich enough to outbid the citizens of the Third World for the products of their own soils, we have become the largest food importer in the world. Moreover, our food demands are having an increasingly adverse effect on the natural resource base and the food self-reliance of poor countries (7).

The concern that our diets may inadvertently contribute to the hunger of others is also not a new idea among some U.S. nutritionists; in fact, thirty-six years ago Sherman commented on this subject. Urging that consumers spend less of their food money on resource-intensive meat, he noted that "wide disparities of purchasing power and the willingness of many consumers to compete at high prices . . . tend to put serious strains upon good will and social justice between the 'haves' and 'have nots,' both within the nation and among the nations. With increasing knowledge . . . increasing numbers of people may give more open-minded thought to the possibility of some moderation of (demand) for foods which are inherently expensive of resources to produce" (8). It is sobering to note that in the twenty years following Sherman's admonition, U.S. per capita beef consumption almost doubled, and the disparities between the world's haves and have-nots increased (9, 10).

Conclusion

Consistent evidence indicates that, in general, a dietary pattern that is higher in plant-based foods, such as vegetables, fruits, whole grains, legumes, nuts, and seeds, and lower in animal-based foods is more health promoting and is associated with lesser environmental impact (GHG emissions and energy, land, and water use) than is the current average U.S. diet. A diet that is more environmentally sustainable than the average U.S. diet can be achieved without excluding any food groups. The evidence consists primarily of Life Cycle Assessment (LCA) modeling studies or land-use studies from highly developed countries, including the United States. **DGAC Grade: Moderate**

US studies (n=2): Pimental and Pimental (2003); Peters et al. (2007)

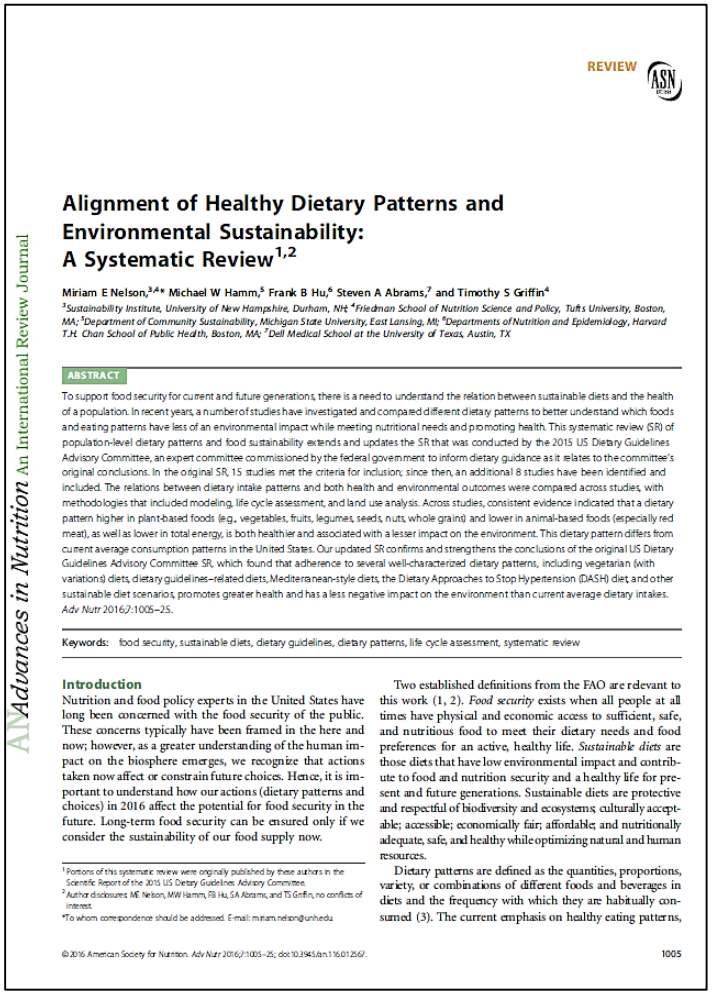


Conclusions

The 2015 DGAC concluded "Consistent evidence indicates that, in general, a dietary pattern that is higher in plant-based foods, such as vegetables, fruits, whole grains, legumes, nuts, and seeds, and lower in animal-based foods is more health promoting and is associated with lesser environmental impact (GHG and energy, land, and water use) than is the current average US diet. A diet more environmentally sustainable than the average US diet can be achieved without excluding any food groups. The evidence consists primarily of LCA modeling studies or land use studies from highly developed countries, including the United States" (3). Our update further supports and strengthens the original conclusions.

Overall, the studies in this updated SR were consistent with the original review in showing that higher consumption of animal-based foods was associated with higher estimated environmental impact, whereas increased consumption of plant-based foods was associated with an estimated lower environmental impact. Assessment of individual foods within these broader categories showed that meat—sometimes specified as RPM or ruminant meat (beef and lamb)—was consistently identified as the single food with the greatest impact on the environment, most often in terms of GHG emissions and/or land use.

The evidence demonstrates that health-promoting dietary patterns also improve environmental sustainability indicators; dietary patterns that adhered to dietary guidelines (in total, not in part) were more sustainable than the population's current average amount of dietary pattern intake. Well-characterized dietary patterns with known health



REVIEW

Alignment of Healthy Dietary Patterns and Environmental Sustainability: A Systematic Review[1,2]

Miriam E Nelson,[3,4]* Michael W Hamm,[5] Frank B Hu,[6] Steven A Abrams,[7] and Timothy S Griffin[4]

[3]Sustainability Institute, University of New Hampshire, Durham, NH; [4]Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA; [5]Department of Community Sustainability, Michigan State University, East Lansing, MI; [6]Departments of Nutrition and Epidemiology, Harvard T.H. Chan School of Public Health, Boston, MA; [7]Dell Medical School at the University of Texas, Austin, TX

ABSTRACT

To support food security for current and future generations, there is a need to understand the relation between sustainable diets and the health of a population. In recent years, a number of studies have investigated and compared different dietary patterns to better understand which foods and eating patterns have less of an environmental impact while meeting nutritional needs and promoting health. This systematic review (SR) of population-level dietary patterns and food sustainability extends and updates the SR that was conducted by the 2015 US Dietary Guidelines Advisory Committee, an expert committee commissioned by the federal government to inform dietary guidance as it relates to the committee's original conclusions. In the original SR, 15 studies met the criteria for inclusion; since then, an additional 8 studies have been identified and included. The relations between dietary intake patterns and both health and environmental outcomes were compared across studies, with methodologies that included modeling, life cycle assessment, and land use analysis. Across studies, consistent evidence indicated that a dietary pattern higher in plant-based foods (e.g., vegetables, fruits, legumes, seeds, nuts, whole grains) and lower in animal-based foods (especially red meat), as well as lower in total energy, is both healthier and associated with a lesser impact on the environment. This dietary pattern differs from current average consumption patterns in the United States. Our updated SR confirms and strengthens the conclusions of the original US Dietary Guidelines Advisory Committee SR, which found that adherence to several well-characterized dietary patterns, including vegetarian (with variations) diets, dietary guidelines–related diets, Mediterranean-style diets, the Dietary Approaches to Stop Hypertension (DASH) diet, and other sustainable diet scenarios, promotes greater health and has a less negative impact on the environment than current average dietary intakes. *Adv Nutr* 2016;7:1005–25.

Keywords: food security, sustainable diets, dietary guidelines, dietary patterns, life cycle assessment, systematic review

Advances in Nutrition An International Review Journal

Introduction

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Two established definitions from the FAO are relevant to this work (1, 2). *Food security* exists when all people at all times have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active, healthy life. *Sustainable diets* are those diets that have low environmental impact and contribute to food and nutrition security and a healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems; culturally acceptable; accessible; economically fair; affordable; and nutritionally adequate, safe, and healthy while optimizing natural and human resources.

Dietary patterns are defined as the quantities, proportions, variety, or combinations of different foods and beverages in diets and the frequency with which they are habitually consumed (3). The current emphasis on healthy eating patterns,

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*To whom correspondence should be addressed. E-mail: miriam.nelson@unh.edu.

US studies (n=3): Pimental and Pimental (2003); Peters et al. (2007); Soret et al., (2014)

Study	Location
Pimentel and Pimentel, 2003	**USA**
Peters et al., 2007	**USA**
Soret et al., 2014	**USA**
Aston et al., 2012	UK
Macdiarmid et al., 2012	UK
Scarborough et al., 2012	UK
Scarborough et al., 2014	UK
Milner et al., 2015	UK
Monsivais et al., 2015	UK
Baroni et al., 2006	Italy
Barosh et al., 2014	Australia
Hendrie et al., 2014	Australia
Wilson et al., 2013	New Zealand
Biesbroek et al., 2014	Netherlands
Saxe et al., 2014	Netherlands
van Dooren et al., 2014	Netherlands
De Carvalho et al., 2013	Brazil
Vieux et al., 2013	France
Masset et al., 2014	France
Meier and Christen, 2013	Germany
Saez-Almendros et al., 2013	Spain
Pradhan et al., 2013	Global
Tilman and Clark et al., 2014	Global

REVIEW

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Study	Attributes
Pimentel and Pimentel, 2003	• National • Vegetarian vs. average diet • Food balance sheets used to construct theoretical vegetarian diet • Outcomes: land use, energy use, and water use
Peters et al., 2007	• New York State • Diets differentiated by meat and fat content • Food balance sheets used to construct theoretical diets • Outcomes: land use
Soret et al., 2014	• National • Vegetarian, semi-vegetarian, and non-vegetarian • Actual diets (n=73,308), not nationally representative • Outcomes: GHG emissions

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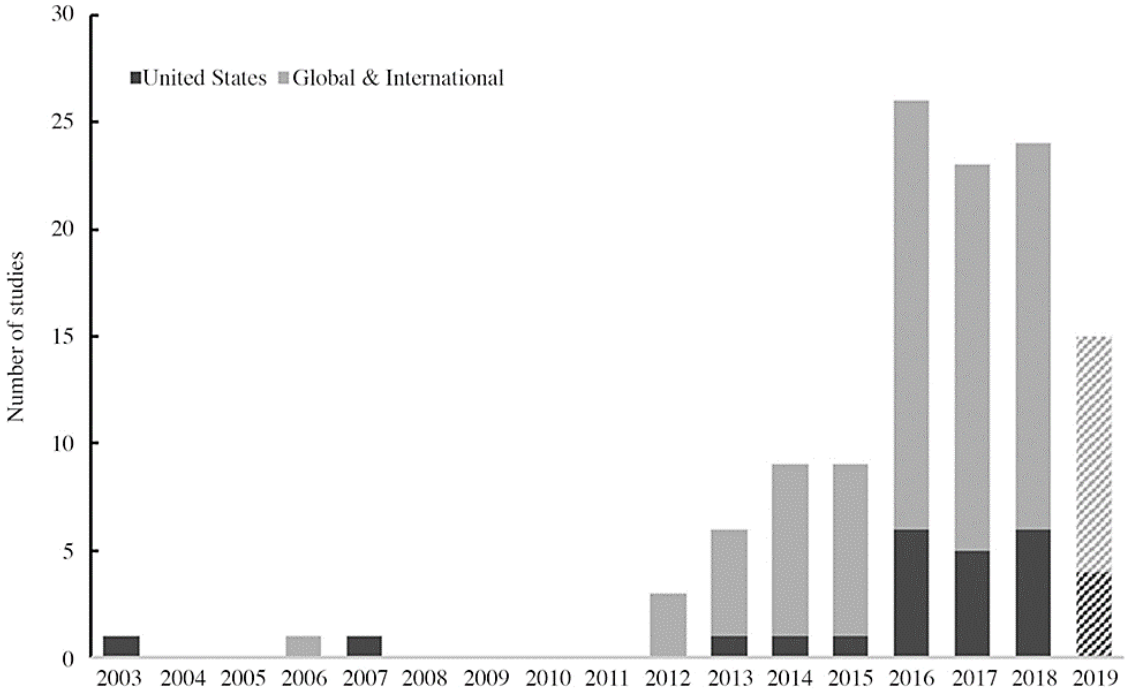


US studies: n=23

REVIEW

Systematic Review of Dietary Patterns and Sustainability in the United States

Sarah L Reinhardt,[1] Rebecca Boehm,[1] Nicole Tichenor Blackstone,[2] Naglaa H El-Abbadi,[3] Joy S McNally Brandow,[4] Salima F Taylor,[3] and Marcia S DeLonge[1]

[1] *Food and Environment Program, The Union of Concerned Scientists, Washington, DC, USA;* [2] *Division of Agriculture, Food, and Environment, Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA, USA;* [3] *Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA, USA; and* [4] *Research Support, The Union of Concerned Scientists, Cambridge, MA, USA*

ABSTRACT

Improving awareness and accessibility of healthy diets are key challenges for health professionals and policymakers alike. While the US government has been assessing and encouraging nutritious diets via the Dietary Guidelines for Americans (DGA) since 1980, the long-term sustainability, and thus availability, of those diets has received less attention. The 2015 Dietary Guidelines Advisory Committee (DGAC) examined the evidence on sustainable diets for the first time, but this topic was not included within the scope of work for the 2020 DGAC. The objective of this study was to systematically review the evidence on US dietary patterns and sustainability outcomes published from 2015 to 2019 replicating the 2015 DGAC methodology. The 22 studies meeting inclusion criteria reveal a rapid expansion of research on US dietary patterns and sustainability, including 8 studies comparing the sustainability of DGA-compliant dietary patterns with current US diets. Our results challenge prior findings that diets adhering to national dietary guidelines are more sustainable than current average diets and indicate that the Healthy US-style dietary pattern recommended by the DGA may lead to similar or increased greenhouse gas emissions, energy use, and water use compared with the current US diet. However, consistent with previous research, studies meeting inclusion criteria generally support the conclusion that, among healthy dietary patterns, those higher in plant-based foods and lower in animal-based foods would be beneficial for environmental sustainability. Additional research is needed to further evaluate ways to improve food system sustainability through both dietary shifts and agricultural practices in the United States. *Adv Nutr* 2020;0:1–16.

Keywords: Dietary Guidelines for Americans, sustainability, sustainable diets, dietary patterns, dietary recommendations, sustainable food systems, public health, environmental health

Introduction

Nutrition and public health professionals increasingly recognize that a systems approach is needed to address the complex and interconnected challenges facing population health (1). Two of the leading threats to global health are climate change and noncommunicable diseases, both of which are inextricably linked to diet (2). Dietary patterns directly drive health outcomes via the relation between nutrition and chronic disease, and indirectly influence health by way of the social, economic, and environmental consequences of food production systems (3).

The environmental impacts of current food production and consumption patterns are substantial, threatening the future availability of natural resources such as land, healthy soil, and clean water. Agriculture has been estimated to account for 70% of global freshwater use and ~37% of the world's land (4, 5). In total, the agricultural sector has accounted for an estimated 11% of global greenhouse gas emissions (GHGs) during the last decade, while the broader food system, including manufacturing agricultural inputs, food processing, and transportation, has accounted for up to an estimated 37% of global emissions (6).

In the United States, agricultural production systems and consumption of foods from the global food system contribute

The research was conducted and the manuscript was written while SLR, RB, JSMB, and MSD were employed by the Union of Concerned Scientists, a nonprofit organization. Funding for the project was provided by The Lumpkin Family Foundation, The Martin Foundation, the WK Kellogg Foundation, and the Union of Concerned Scientists members. Author disclosures: The authors report no conflicts of interest. None of the funding sources were involved with the study design, data analysis, writing, or submission of this manuscript. Supplemental Material are available from the "Supplementary Material" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/advances/.

Address correspondence to SLR (e-mail: sreinhardt@ucsusa.org).

Abbreviations used: DGA, Dietary Guidelines for Americans; DGAC, Dietary Guidelines Advisory Committee; EIO-LCA, Economic Input-Output Life Cycle Assessment; GHG, greenhouse gas emission; HEI, Healthy Eating Index; LCA, Life Cycle Assessment; PLCA, Process Based Life Cycle Assessment.

 Adv Nutr 2020;0:1–16; doi: https://doi.org/10.1093/advances/nmaa026.

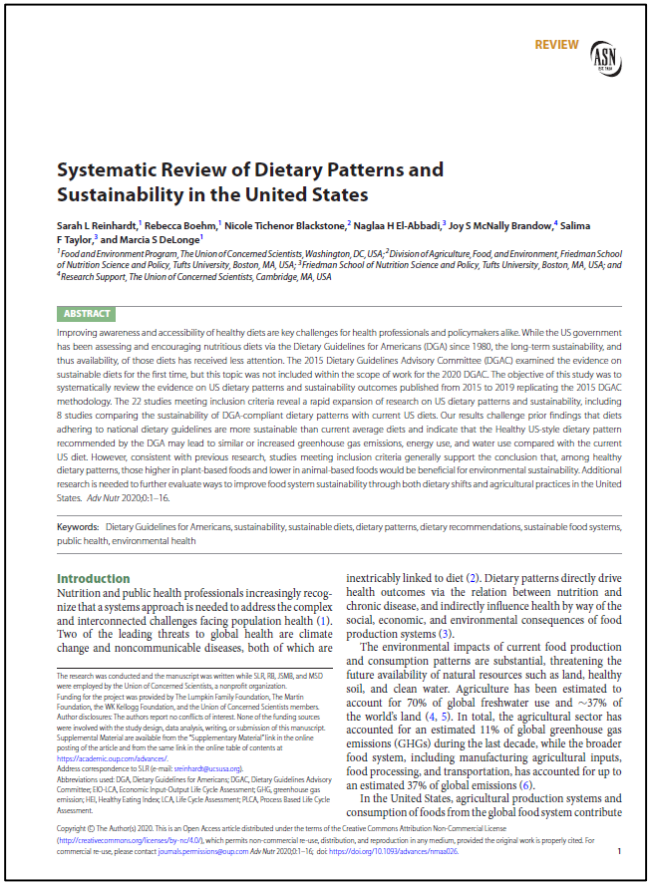
Recent US research does not support prior findings that diets adhering to national dietary guidelines are necessarily more sustainable than current average diets

Nelson et al. (23) concluded that "dietary patterns that adhered to dietary guidelines (in total, not in part), were more sustainable than the population's current average dietary pattern intake." This conclusion was based on available evidence from primarily non-US studies. Yet, our findings indicate that the Healthy US-style dietary pattern, as currently recommended by the DGA, generates GHGs and energy and water use at levels higher than or indistinguishable from the current average US diet. (Studies reporting <10% difference in GHGs or 30% difference in energy or water use between dietary patterns, and whose actual differences are therefore uncertain, are indicated in Table 2.)

Limited research on other DGA-compliant dietary patterns also suggests that the environmental impacts of the Mediterranean-style diet are comparable to the US Healthy-style diet across multiple environmental indicators. Nevertheless, additional US-based research is needed to evaluate the environmental impacts of DGA-compliant diets, including the influence of cost constraints and minimized differences from current diets.

Research continues to support previous findings that, among healthy dietary patterns, those higher in plant-based foods and lower in animal-based foods benefit environmental sustainability

Studies comparing Healthy Vegetarian diets with other DGA-compliant patterns reported environmental benefits such as reduced energy and land use and air and water pollution (24, 33, 37). Among all included studies, those finding that lower consumption of animal-based foods generated lesser environmental impacts attributed these effects primarily to changes in the type and amount of meat (e.g., beef, pork, lamb) or dairy in the diet. (8, 9, 24, 26–28, 30–34, 37, 38, 40, 41, 35). Broadly, our findings are consistent with other recent reviews of dietary sustainability (12, 20, 55–57). However, more research may be required to better quantify the water use associated with higher proportions of plant-based foods such as fruits, vegetables, and nuts in the diet, and evaluate potential tradeoffs with other dietary shifts (24, 39).



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The environmental impacts of current food production and consumption patterns are substantial, threatening the future availability of natural resources such as land, healthy soil, and clean water. Agriculture has been estimated to account for 70% of global freshwater use and ~37% of the world's land (4, 5). In total, the agricultural sector has accounted for an estimated 11% of global greenhouse gas emissions (GHGs) during the last decade, while the broader food system, including manufacturing agricultural inputs, food processing, and transportation, has accounted for up to an estimated 37% of global emissions (6).

In the United States, agricultural production systems and consumption of foods from the global food system contribute

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Address correspondence to SLR (e-mail: sreinhardt@ucsusa.org).

Abbreviations used: DGA, Dietary Guidelines for Americans; DGAC, Dietary Guidelines Advisory Committee; EIO-LCA, Economic Input-Output Life Cycle Assessment; GHG, greenhouse gas emission; HEI, Healthy Eating Index; LCA, Life Cycle Assessment; PLCA, Process Based Life Cycle Assessment.

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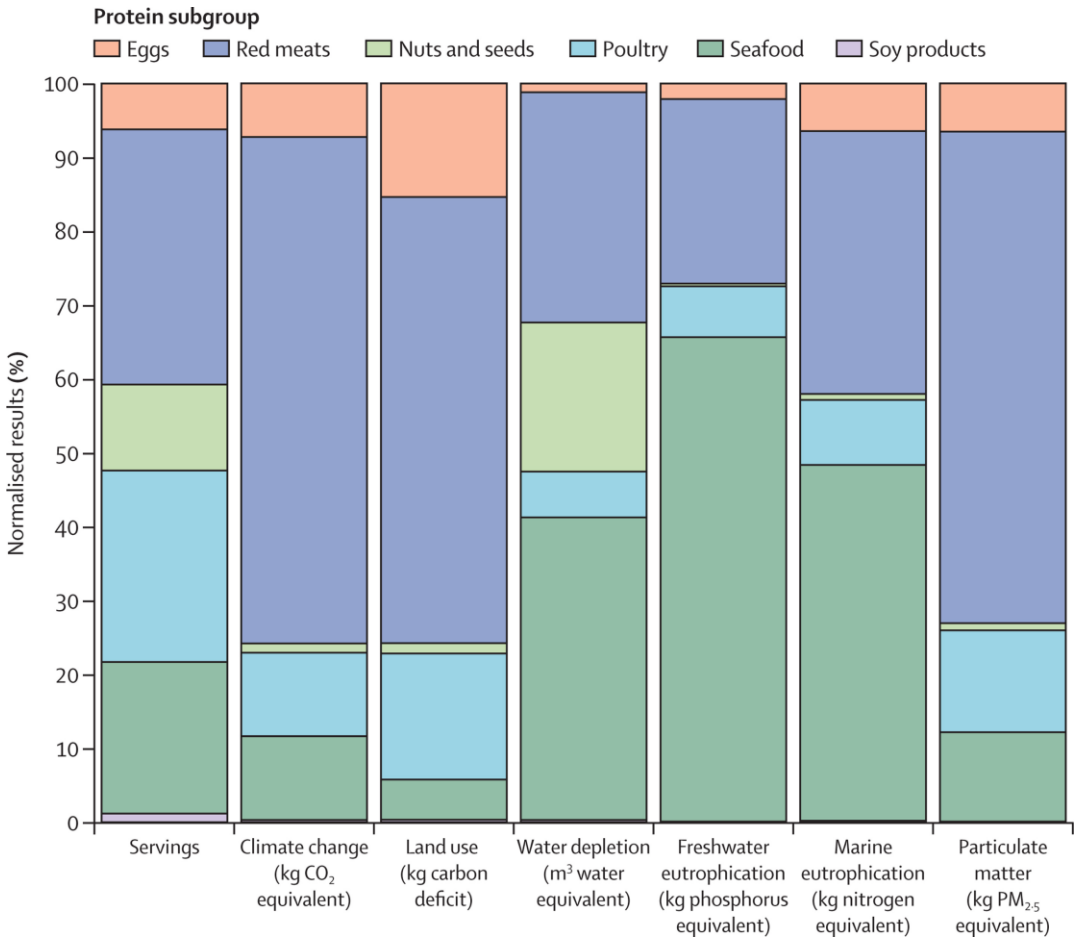

Linking sustainability to the healthy eating patterns of the Dietary Guidelines for Americans: a modelling study

Nicole Tichenor Blackstone, Naglaa H El-Abbadi, Margaret S McCabe, Timothy S Griffin, Miriam E Nelson

Summary

Background Evidence-based nutrition policy is a key mechanism to promote planetary health. In the USA, the Dietary Guidelines for Americans are the foundation of nutrition policy and guide more than US$80 billion in federal spending. Recent attempts have been made to incorporate sustainability into the development of the Dietary Guidelines. However, the sustainability of the 2015–20 Dietary Guidelines remains unclear; research has not yet assessed the environmental impacts of the distinct healthy patterns recommended by the policy.

Methods In this modelling study done at the University of New Hampshire (Durham, NH, USA), we analysed the healthy US-style (US), healthy Mediterranean-style (MED), and healthy vegetarian (VEG) patterns recommended in the 2015–20 Dietary Guidelines for Americans. Food groups and subgroups consisted of 321 commonly consumed foods, with group composition predetermined by the US Department of Agriculture. We compiled and used multiple datasets to assign environmental burdens to foods, focusing on six impact categories of policy importance: global warming potential, land use, water depletion, freshwater and marine eutrophication, and particulate matter or respiratory organics. We did life cycle impact assessments for each of the three diet patterns and compared the six impact categories between the patterns. We also analysed the proportion contribution of the food groups to each impact category in each of the diet patterns.

Findings The US and MED patterns had similar impacts, except for freshwater eutrophication. Freshwater eutrophication was 31% lower in the US pattern than the MED pattern, primarily due to increased seafood in the MED pattern. All three patterns had similar water depletion impacts, with fruits and vegetables as major contributors. For five of the six impacts, the VEG pattern had 42–84% lower burdens than both the US and MED patterns. Reliance on plant-based protein and eggs in the VEG pattern versus emphasis on animal-based protein in the other patterns was a key driver of differences, as was a lower overall protein foods recommendation in the VEG pattern.

Interpretation The recommended patterns in the Dietary Guidelines for Americans might have starkly different impacts on the environment and other dimensions of human health beyond nutrition. Given the scale of influence of the Dietary Guidelines for Americans on food systems, incorporating sustainability into their development has the potential to have great benefit in terms of long-term food security.

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See Comment page e331

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Sustainability Institute, The University of New Hampshire, Durham, NH, USA (N Tichenor Blackstone PhD, Prof M E Nelson PhD); Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA, USA (N Tichenor Blackstone, N H El-Abbadi MPH, T S Griffin PhD, Prof M E Nelson); School of Law, The University of New Hampshire, Concord, NH, USA (Prof M S McCabe JD); and Hampshire College, Amherst, MA, USA (Prof M E Nelson)

Correspondence to: Dr Nicole Tichenor Blackstone, Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA 02111, USA
nicole.tichenor@tufts.edu

Introduction

Human health, environmental sustainability, and food security are linked in complex and multidirectional ways. One important intersection occurs between food production and the natural environment. At present, agriculture is the largest consumer of fresh water and the second largest contributor to anthropogenic greenhouse gas emissions worldwide (including land use change).[1,2] Agriculture is also the driving force behind the disruption of global nitrogen and phosphorus cycles, with particular burden coming from increases in the quantity and intensity of livestock production.[3] Planetary boundaries for biogeochemical flows (of nitrogen and phosphorus) and climate change are estimated to already be exceeded.[4]

Disrupted planetary systems produce effects that will continue to feed back into agricultural and food systems if left unchanged. Rising atmospheric carbon dioxide (CO_2) levels, for example, are projected to reduce the nutritional value of key food crops under climate change.[5] Ensuring a safe operating space for humanity,[4] therefore, requires shifts in what, how, and how much food is produced. Food production is driven by policy choices and consumer demand, among other factors. Developing policy that catalyses shifts to sustainable food consumption patterns, therefore, is a key way to mitigate negative effects.

The concept of long-term food security takes into account these current and projected future dynamics, positing a fundamental connection between the health of human and earth systems. Agricultural, environmental, and nutrition policy must converge to reflect this interconnection. For example, some nations are incorporating sustainability into their dietary guidance. According to the UN Food and Agricultural Organization (FAO), "sustainable diets are those diets with low environmental

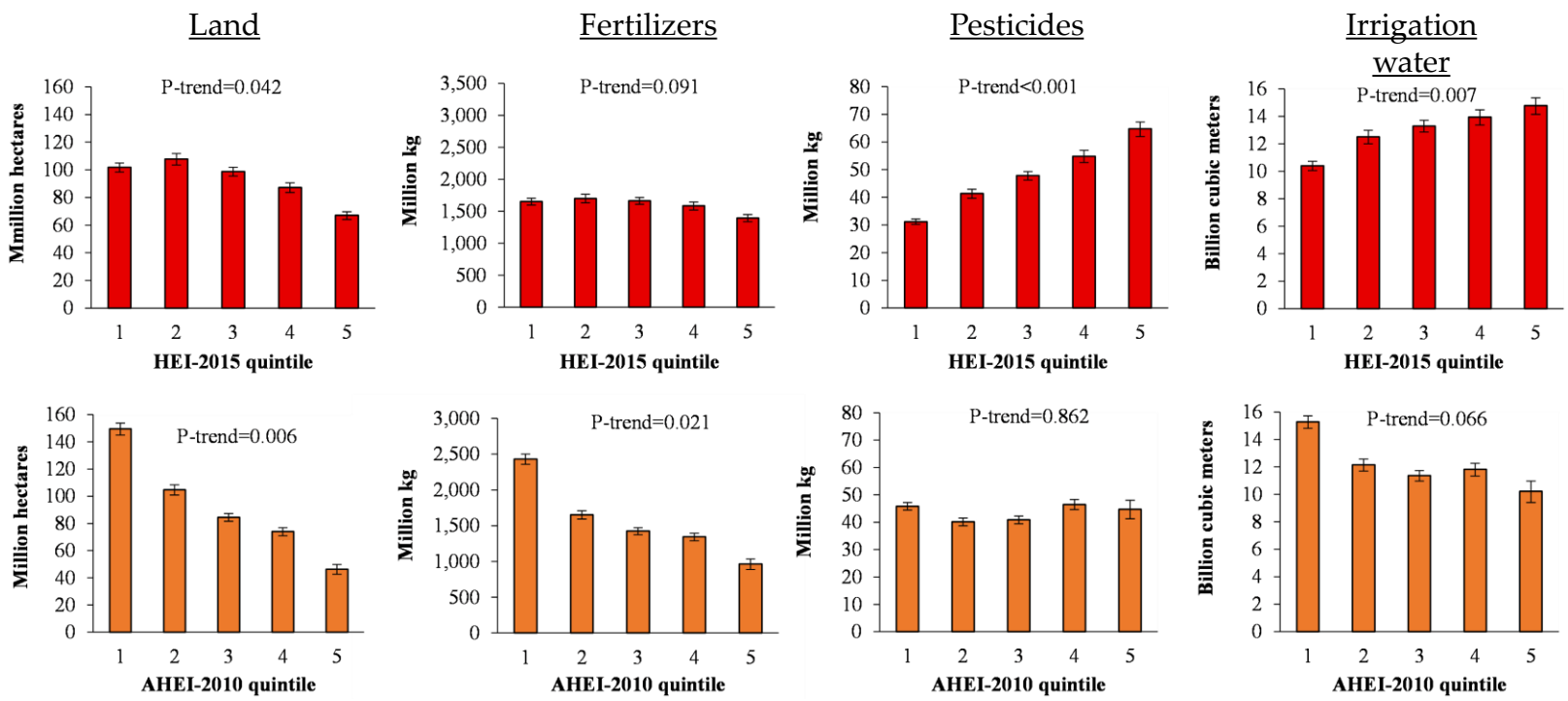
Lingering questions

Can we link sustainability indicators to actual diet patterns (rather than theoretical diet patterns)?

Are we using nationally representative samples to make national dietary guidance?

Does the diet-sustainability hypothesis hold when we evaluate incremental shifts toward meeting guidelines (rather than ideal vs. average)?

Are sustainability outcomes consistent across different measures of healthy eating?



Conrad et al. (2020). Healthy diets can create environmental trade-offs, depending on how diet quality is measured. *Nutrition Journal*, 19:117.

Lingering questions

How useful is it to isolate protein sources from diet patterns?

Can we create composite measurements of sustainability that include multiple indicators?

Are we accounting for impacts at all stages of the food system?

How can we measure and control bias/error when integrating data and methods from different disciplines?

Do we need to establish reporting guidelines for sustainability studies (e.g., CONSORT, STROBE, PRISMA)?

How do we provide sustainable dietary guidance when there are trade-offs between achieving nutrition and sustainability outcomes? And trade-offs between sustainability indicators?

Lingering questions

Are we preparing the next generation of scientists with the interdisciplinary tools and institutional support they will need to lead the way?

- Education (multi- and interdisciplinary)
- Training (assistantships, fellowships, internships)
- Tools and analytic methods (accessibility)
- Professional positions (traditionally departmental)
- Leadership positions (availability, purpose, and traction)
- Professional societies (legitimacy and collective leadership)
- Funding (true interdisciplinarity)
- Outlets for dissemination (expanding scope)

Environmental Impacts of Increasing Alternative Protein Intake in the Diet

Zach Conrad, PhD, MPH

Assistant Professor, Department of Kinesiology, William & Mary
Faculty Affiliate, Global Research Institute, William & Mary

zsconrad@wm.edu