Assessing the Role of Cattle in Sustainable Food Systems

Donald K. Layman, PhD

Food production has a global link to the environment. As the world population increases, there are ever expanding demands on agriculture, but there are also increasing concerns about the impact of agriculture on the environment. Initial attempts to measure the impact of agriculture on the environment used a metric of greenhouse gas emissions/kcal of food produced to assess the relative impact of different foods and agriculture practices. This metric highlights the differential costs for production of grains versus livestock and led to conclusions that livestock have disproportionate negative impacts on the environment, leading many researchers and policy makers to call for a shift toward more plant-based diets. However, this metric implies that production of calories is the most important diet criterion and has been criticized for ignoring diet quality. One of the nutrients that must be considered in formulation of a sustainable diet is protein. Currently, livestock produces more than one-third of the world's protein, and ruminant animals (ie, cattle, sheep and goats) have the unique capacity to convert nondigestible biomass (ie, grasses and forages) into high-quality protein. These factors highlight the need for prudent use of ruminants to optimize land use for production of adequate quantity and quality of protein. Any recommendations for changes in agriculture should consider impact on climate but must also focus on making optimal use of natural resources for creating healthy diets. Nutr Today. 2018;53(4):160–165

Understanding the roles of ruminant animals in creating nutritionally balanced diets and their relationships to agriculture and climate change are challenging issues confronting scientists, policy makers, and consumers. The interrelationships form a complex "trilemma" that must integrate diet-environment-health.[1] The link between the diet and the environment is the role of agriculture in food production and its impact on the planet ranging from land and water use to greenhouse gas emissions (GHGEs). Some claim that agriculture produces more than 30% of total GHGE,[2] and major changes within agriculture are needed to achieve a sustainable environment, whereas others claim that agriculture accounts for less than 9% of GHGE[3] and that farmers in the United States have demonstrated that modern agriculture can improve production efficiency to keep pace with population growth while also balancing environmental impact. Embedded within the agriculture debate are claims about the impact of livestock, and specifically cattle, on the environment and suggestions that humans should move toward a more plant-based diet with reduced use of animal products.[4] These recommendations reduce the availability of both the quantity and quality of protein in the diet.

Dietary protein is an often-ignored factor within the sustainable diet debate. Most efforts to quantify the impact of agriculture on the environment use metrics focused on production of calories, but some investigators have emphasized that these metrics are too simplistic, ignoring diet quality.[1,5] The most challenging nutrient for agriculture is protein. This commentary examines the impact of agriculture on climate change and the role of livestock in providing a sustainable diet with emphasis on meeting the protein needs of world populations.

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DOI: 10.1097/NT.0000000000000286

PRINCIPLES AND ASSUMPTIONS UNDERPINNING THE SUSTAINABLE DIET DEBATE

There are 3 questions that must be addressed within the sustainable diet debate:

1. What measurements should be used to evaluate the impact of agriculture, and specifically cattle, on the environment?
2. What constitutes an optimal diet?
3. What is the optimal pattern of land use that balances nutrition goals and sustainability?

The principal metric for assessing the impact of agriculture on the environment has been estimates of GHGE/kcal of food produced. This metric is conceptually simple to grasp, but interpretation of both the numerator and denominator has limitations. Greenhouse gas emission is certainly a factor that impacts the environment, but it does not capture other components such as energy use, the water footprint, or soil and water contaminations with pesticides and herbicides. Likewise, the denominator suggests that the most limiting component of a sustainable diet is calories, but this factor ignores diet quality. In a world where obesity and diabetes are more widespread than undernutrition, improving diet quality should be at least as important as producing more calories.

Assessing the Environmental Impact of Agriculture

The metric of GHGE/kcal attempts to define the total emissions of carbon dioxide (CO_2) associated with the generation of food calories beginning with on-farm activity and extending through processing, transportation, and ultimately to consumer use. This approach uses an elaborate statistical model called Life Cycle Assessment (LCA) and demonstrates that raising livestock is a relatively inefficient practice for producing calories[6]; however, the impact of agriculture on the environment requires a deeper dive into the data beyond just comparing the efficiency of livestock versus plants to produce calories.[1] A first step is to understand the fundamental currency of climate change—GHGE. Greenhouse gases include CO_2, methane (CH_4), and nitrous oxide (N_2O). These gases can arise from animals, particularly ruminant animals such as cattle and sheep, but CO_2 also comes from gasoline burned in automobiles and fossil fuels used for residential heating and to produce electricity to charge cell phones or power computers; CH_4 also comes from fermentation of food wastes in landfills and from wetlands such as rice paddies and swamps; and N_2O comes from nitrification in the soil (both natural processes such as growing beans and legumes that fix nitrogen or agricultural use of petroleum-based fertilizers). Collectively, these gases are referred to as GHGEs. For convenience, CH_4 and N_2O values are converted into CO_2 equivalents, and the total is expressed simply as CO_2 emissions.

The contribution of agriculture to GHGE remains controversial. There are numerous reports claiming that agriculture is the largest single source and accounts for 18% to 30% of global GHGEs[1,2]; however, values in the United States provide a different picture. The US Environmental Protection Agency reports GHGE in the United States as 31% from electricity production, 27% from transportation, 21% from industry, 12% from commercial and residential buildings, and 9% from agriculture (Figure 1).[3] The agriculture number can be further dissected as 4.2% from livestock, with approximately 2.2%, 1.4%, 0.5%, and 0.1% from beef, dairy, swine, and poultry, respectively. By contrast, in New Zealand, with only 4.6 million people and 10 million cattle, agriculture produces 47% of their GHGE, with energy production, transportation, and industry yielding 26%, 19%, and 6%, respectively.[7] Further, to put the US livestock numbers into historical perspective, in 1800 there were approximately 80 million

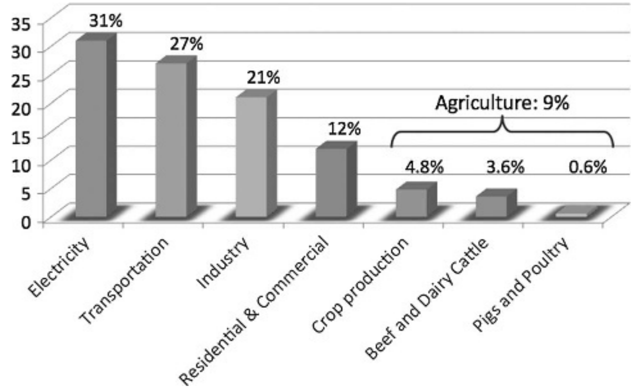

FIGURE 1. Environmental Protection Agency estimates of GHGEs from individual sectors of the United States expressed as percentages (%) of total emissions.[3]

ruminant animals in the United States (ie, buffalo), and today there are approximately 90 million cattle; whereas in 1800, there were zero cars and trucks, and today there are more than 260 million vehicles on US highways. It is unlikely that cattle in the United States account for global climate change. So what is the origin of the conflicting numbers and the contradictory arguments?

The controversy arises from generating global conclusions by averaging data from around the world while ignoring regional differences. The top 6 countries with the largest carbon footprint measured as total GHGE are China, United States, European Union (EU), India, Russia, and Japan. New Zealand ranks 62. Not surprising, the top countries are largely developed countries with large populations.

For agriculture, there are also large differences comparing across countries. Four countries, the United States, India, Brazil, and China, illustrate some of the country-specific issues and the risks of using global averages. Focusing on cattle because they are at the center of the sustainable diet debate, India, Brazil, and China have the largest cattle populations, with 30.1%, 22.6%, and 10.1%, respectively (Table 1). These 3 countries account for two-thirds of the world cattle population. The United States ranks fourth with 9.4%.[8]

The United States has made major strides in increasing the efficiency of agriculture, improving both crop and livestock production. In 1950, the United States had 22 million dairy cows producing 117 million tons of milk. In 2015, the herd size had dropped to 9 million (−59%), whereas milk production increased to 209 million tons (+79%). In the United States, a single cow produces 22 248 lb of milk per year. By contrast, India has more than 100 million dairy cows, and a single cow produces only 2500 lb of milk, 9-fold less efficient production.[9] Likewise, in 1950, there were 140 million beef cattle producing 24 million tons of meat in the United States, and in 2015, meat production remained the same but with approximately 87 million head (−38%). By contrast, Brazil has more than 220 million cattle, with 80% being raised for export to China and the EU. Agriculture in Brazil is a major concern because

TABLE 1 World Cattle Inventory (2017)[8]

Country	No. of Cattle (× Million)	% of World Total
1. India	303	30.4
2. Brazil	226	22.6
3. China	100	10.1
4. USA	93	9.4
5. Europe (EU)	89	8.9
—	—	—
13. New Zealand	10	1.0

of deforestation. Since 1970, Brazil has cleared more than 230 000 square miles of rainforest (ie, roughly the size of Texas), with the majority of the deforested land being used for soybean production for export to China and the EU for animal feed and biodiesel. The clearing and burning of the rainforests in Brazil are estimated to contribute more than 30% of the total human contributions to GHGE.[2] While trends in global averages of GHGE are important to monitor climate change, solutions need to be applied appropriately to individual countries and regions.

Defining a Sustainable Diet

Proposals to change the environmental impact of agriculture must also be balanced with maintaining and improving diet quality and health. Numerous LCA studies report that plants produce less greenhouse gas than animals; however, the plants with the lowest GHGE are sugar beets, corn, wheat, and tropical fruits that have low nutritional value (ie, low nutrient density).[1,5] The solution to the environmental debate cannot be simply to generate more empty calories, but to create healthy diets with the least environmental impact.

One of the most fundamental decisions in developing sustainable diets must be defining the importance of protein in the diet. Protein is perhaps the most controversial of all nutrients and should be at the center of the debate about animal- versus plant-based foods.

While protein is popular with consumers, there is a general lack of emphasis on dietary protein within dietary guidelines and among policy makers because of the simple fact that most adults consume more protein than the Recommended Dietary Allowance (RDA) of 0.8 g/kg of body weight.[10] However, evidence is mounting that this RDA, based on nitrogen balance and designed to prevent inadequacies, may not be optimal to maintain health for adults facing increasingly sedentary lifestyles, increasing life expectancy, and increasing risks of obesity, diabetes, and sarcopenia.[11]

The current narrative for reducing use of animal-derived foods and shifting toward a more plant-based food system relies on the assumption that adults consume more protein than they need. Most of the plant-based diet models rely on reducing the average daily protein intake to 50 to 60 g/d and increasing carbohydrate intake for all adults.[5,12,13] Contrary to this assumption, there is substantial evidence that the RDA for protein may not provide adequate protein for optimum adult health,[11] and most adults are already consuming more carbohydrates than required for energy balance.[10,14] Research studies focused on aging, bed rest, postsurgery, diabetes, obesity, and athletic performance have shown that diets with protein greater than the RDA are beneficial to protect and strengthen skeletal muscle and maintain metabolic health.[11]

In 2010, the Dietary Guidelines Advisory Committee highlighted the concerns about obesity and overconsumption of calories and carbohydrates especially in the form of processed grains with low nutritional value.[14] Following the Dietary Guidelines report, the US Department of Agriculture discontinued use of the Food Guide Pyramid that emphasized grains as the foundation of the diet and replaced it with the image of *MyPlate* that emphasized consumption of vegetables, lean protein, dairy, and whole grains. In 2013, an international consortium known as the PROT-AGE Study Group published a position paper recommending adults consume daily protein of 1.2 to 1.5 g/kg.[11] The 2015 Dietary Guidelines Advisory Committee reaffirmed the emphasis on protein. The committee illustrated multiple ways to create healthy diets using *MyPlate* with 3 specific diet patterns: a healthy US-style pattern, a Mediterranean pattern, and a vegetarian pattern. These 3 meal patterns recommended protein at 198%, 194%, and 155% of the RDA, respectively.[10]

Protein is one of the most limiting nutrients in our environment.[15] Meats are protein-dense, nutrient-dense foods that are not easy to replace with plant-based foods. Some plants such as bean and lentils are good sources of protein, but all plants have low protein density and are limiting in 1 or more of 5 of the essential amino acids (EAAs) (ie, lysine, methionine, tryptophan, threonine, and leucine).[15]

Lysine is a good example for comparing plant- versus animal-derived foods. The requirement for lysine based on the Indicator Amino Acid Oxidation method is approximately 45 mg/kg.[16] Assuming a 75-kg body weight, the daily lysine requirement is approximately 3.4 g. The amount of protein required to obtain this amount of lysine varies greatly among foods. Wheat protein (gluten) is particularly limiting in lysine containing only 2.6% (wt/wt: grams lysine per 100 g protein). To obtain 3.4 g of daily lysine would require an individual to consume 131 g/d of wheat gluten. Common wheat cereals or flour contains approximately 3.5 g of protein per 100 kcal.[17] Hence, to obtain the lysine requirement would require consuming more than 3700 kcal/d from wheat-based foods such as breads or cereals (Table 2). Similar analyses can be done for corn, containing lysine at approximately 4.0%, and legumes, such as soy, containing lysine at approximately 5.1%. Animal proteins including dairy, eggs, and beef (and fish) are rich sources of lysine. Beef, for example, contains at least 9.0% lysine and would provide the daily lysine requirement with approximately 240 kcal. Currently, the American diet derives approximately 70% of daily protein from animal protein, and daily lysine intake is between 5 to 6 g/d. Recommendations that alter diet patterns and lower both the quantity and the quality of dietary protein create risk for EAA deficiencies.

While individual proteins differ significantly in EAA content, people seldom exist on single foods or single proteins. The imbalance of EAA in a single food can be corrected by use of a complementary protein. Use of 2 or more proteins at a meal can balance the EAA limitations of 1 protein with the strength of another protein. A simple example is the combination of a wheat cereal with milk. Wheat protein is deficient in lysine, whereas milk is a rich source of lysine. The combination provides a balanced protein meal. However, the complementary meal contains more total protein and more total calories to reach the lysine requirement. Another example may be more important to the plant-based diet philosophy. If an individual uses soy milk in combination with a wheat cereal, it requires 6.2 g of soy protein to balance 1 g of wheat gluten because both proteins are limiting in lysine, whereas it requires only 1.6 g of milk protein.[18] Combinations of 2 or more proteins may provide an approach to reduce use of animal proteins; however, protein blends always require more total protein and more total calories to achieve similar metabolic outcomes.[19]

Protein digestibility and bioavailability of EAA are additional factors that must be considered with increased use of plant proteins. In the native plant structure, proteins are often associated with nondigestible fiber structures that inhibit digestion and absorption of the protein. An example is pea protein, a legume considered to be a high-quality plant protein. The digestibility of pea protein in the native plant form can be compared with isolated and processed pea protein using the PDCAAS (protein digestibility corrected amino acid score) measure of protein quality. In the isolated form, pea protein concentrate has a PDCAAS score of 0.860; however, pea protein in the native plant food matrix has a PDCAAS score of 0.575, representing a 35% reduction in bioavailability.[20]

While protein is clearly a central component of a healthy diet, and guidelines are beginning to reflect the new knowledge about protein needs, protein recommendations remain a controversial issue within public policy. This commentary is not intended to resolve the debate about optimum protein intake, but simply to highlight that environmental models that ignore the debate and rely on reducing daily protein intake and reducing production capacity through fundamental changes in agriculture create the risk of unintended and unexpected health consequences.

Optimizing Land Use for Sustainable Diets

Strategies that seek to balance the trilemma of food production, environmental impact, and healthy diets must also consider land use. Current suggestions to reduce use of cattle in favor of more plant-based diets rely on 2 assumptions about land use: (1) calories used by cattle can be equally utilized by humans and/or (2) land that is suitable for raising cattle can be directly converted to cultivating plants. These assumptions are deeply flawed.

A central doctrine of the plant-based sustainability theory is that the plant calories fed to beef and dairy cattle would be better utilized if consumed by humans. However, cattle are ruminant animals with the unique capacity to utilize fibrous materials such as grasses, hay, and corn silage. Although these plant materials contain calories (ie, "metabolizable energy"), the calories are mostly nondigestible by humans or other monogastric species including pigs and poultry. The ruminant digestive tract contains bacteria with the ability to utilize energy contained in grasses and other biomass and, more important, convert these calories into EAAs. In the United States, more than 85% of the calories fed to cattle

TABLE 2 Lysine (Lys) Contents of Food Proteins[a] and Calories Required to Meet Daily Amino Acid Need

	Lys Content,[b] %	Protein Required,[c] g/d	g Protein,[d] 100 kcal	kcals Consumed[e]
Wheat	2.6	131	3.5	3700
Maize	4.0	88	2.5	3500
Soy	5.1	69	7.5	920
Beef	9.0	40	16.7	240

[a]Data from US Department of Agriculture Food Composition Database.[17]
[b]Lysine density expressed as grams of Lys/100 g of total protein.
[c]Amount of protein required to achieve the daily lysine requirement of 3.4 g/d.
[d]Grams of protein present in 100 kcal of common food sources.
[e]Total calories consumed to meet lysine requirement with common food sources.

come from grasses, forages, and plant materials not suitable for human consumption. Ruminant animals are uniquely capable of extracting metabolizable energy from crop residues (ie, wheat and oat straw and sugar cane tops) and wastes generated from biofuel production (ie, gasohol and biodiesel) and plant processing (ie, wheat and cotton milling) that would otherwise end up in landfills.[21] Further, cattle produce 1.0 g of high-quality protein from every 0.6 g of poor-quality proteins obtained from these wastes and forages.[21]

Global estimates are that approximately one-third of grains (ie, corn, barley, and wheat), and more than 50% of corn is used to feed livestock. However, world averages once again are not uniform across all countries and obscure important differences. Values for the United States provide additional insight. Using Iowa as a specific example, Iowa ranks number 1 in the United States for production of corn, with approximately 2.51 billion bushels in 2015.[22] Of the Iowa corn crop, approximately 25% is fed to livestock, with the majority going to pigs and poultry, and only 5% used for beef and dairy[23] (Figure 2). The majority of Iowa corn (53%) is used for making ethanol as a fuel for cars, with only 12% of corn actually processed to human food, with the majority of that converted into high-fructose corn syrup. With 1.6 billion bushels per year (63%) of Iowa corn going to ethanol production for cars or sugar production, the criticism of grain use for cattle seems misplaced.

The Iowa example of corn uses illustrates the risk of simplistic LCA extrapolations that assume all corn calories are used for human consumption. Likewise, the LCA models limit the value of the beef carcass to only the 40% of the weight that produces edible calories. This limited perspective ignores the economic value of other parts of the carcass such as leather. What would be the economic cost and environmental impact of producing alternatives for leather shoes, belts, purses, jackets, and furniture?

Ultimately, decisions about land use also need to recognize the characteristics of the land. Land can be partitioned into specific production types. The simplest classification is croplands versus grazing land. Currently, approximately 11% of the world's land mass is used as cropland, and approximately 30% is grazing land usable only for ruminant animals. Reducing use of grazing land does not translate into increased cropland for cultivation. Looking within the United States, Peters et al[12] provided an interesting evaluation of the population "carrying capacity" of US land mass. Based on US Department of Agriculture's Agriculture Research Services data, these authors defined the agricultural land in the United States as 299 million hectares (m. ha.) of grazing land, 39 m. ha. of perennial forages, and 95 m. ha. of croplands. These authors make the important point that while there is some potential for conversion of perennial forages to cropland, the sustainability is low; hence, nearly 80% of US agricultural land mass is suitable for use only by ruminant animals that can metabolize grasses and forages. They concluded that the US land mass can sustain the largest population using an omnivore diet with a balance of plant- and animal-derived foods.

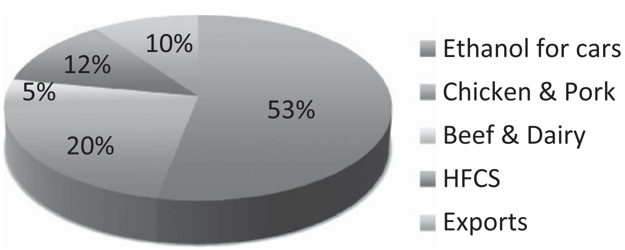

FIGURE 2. Distribution of Iowa corn uses.[16,17] The majority is used for production of ethanol ("gasohol") as a fuel for gasoline engines. Abbreviation: HFCS, high-fructose corn syrup.

Finally, there is general consensus that healthy diet patterns should emphasize increased use of vegetables, fruits, fish, and high-quality protein sources. These potential diet changes may simply shift the environmental risks. Increasing production of vegetables and fruits requires reevaluating land use, growing season, water availability, transportation, and food wastes. For example, shifting to the US Dietary Guidelines that promotes increased consumption of vegetables and fruits and reduces consumption of red meat is estimated to increase energy use associated with the diet pattern by 43%, the water footprint by 16%, and GHGE by 11%.[24] Increasing vegetable and fruit consumption also impacts transportation. Based on current consumption patterns, more than 19% of vegetables and 50% of fruits are imported into the United States. Transportation is a major source of GHGE accounting for 27% of GHGE in the United States. Further, fresh produce is associated with the highest amount of food wastes and GHGE from landfills. Outcomes of the trilemma debate must carefully consider and avoid unintended consequences.

SUMMARY

Balancing agriculture production with nutrition goals and environmental concerns forms a complex trilemma for food policy decisions. Critical questions within the trilemma debate revolve around (1) what is the optimal measure of environmental impact, (2) what is the optimal target for diet quality, and (3) what constitutes optimal land use? For each of these questions, the essential information remains incomplete and controversial.

The current environmental debate about agriculture is focused on the cost and impact of producing grains versus meats. This is an overly simplistic view of both agriculture and nutrition. Grains appear beneficial in LCA models because they produce lower GHGE/kcal, but they also have low nutrient density, whereas meats have comparatively high GHGE, but also have high nutritional value and are rich sources of protein and EAAs.

Sustainable production of protein needs to be a foundation of a sustainable diet, and livestock have a critical role in production of high-quality protein. Livestock currently produces more than one-third of world's protein, and ruminant animals have a unique capacity to convert nondigestible biomass into proteins providing the optimal balance of EAAs. These factors call for prudent use of ruminant animals to optimize land use for production of high-quality protein. Any recommendations for changes in agriculture production should consider the impact on climate but must also focus on maximizing use of natural resources for creation of healthful diets.

REFERENCES

1. Tilman D, Clark M. Global diets link environmental sustainability and human health. *Nature*. 2014;515:518–522.
2. FAO; Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, de Haan C. Livestock's Long Shadow. *Food and Agriculture Organization of the United Nations*. 2006. http://www.fao.org/docrep/010/a0701e/a0701e00.HTM. Accessed July 18, 2017.
3. US Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks. Accessed July 13, 2017.
4. Perignon M, Vieux F, Soler LG, Masset G, Darmon N. Improving diet sustainability through evolution of food choices: review of epidemiological studies on the environmental impact of diets. *Nutr Rev*. 2016;75(1):2–17.
5. Drewnowski A, Rehm CD, Marin A, Verger EO, Voinnesson M, Imbert P. Energy and nutrient density of foods in relation to their carbon footprint. *Am J Clin Nutr*. 2015;101:184–191.
6. de Vries M, Boer IJ. Comparing environmental impacts for livestock products: a review of life cycle assessments. *Livest Sci*. 2010;128:1–11.
7. Science Media Center. https://www.sciencemediacentre.co.nz/2014/04/11/greenhouse-gas-inventory-takes-stock-of-emissions/. Accessed August 29, 2017.
8. USDA. *World Cattle Inventory*. Ranking of countries, 2017. http://beef2live.com/story-world-cattle-inventory-ranking-countries-0-106905. Accessed August 29, 2017.
9. Mitloehner F. Livestock's contributions to climate change: facts and fiction. http://blogs.ucdavis.edu/egghead/2016/04/27/livestock-and-climate-change-facts-and-fiction/. Accessed August 29, 2017.
10. USDA. *Scientific Report of the 2015 Dietary Guidelines Advisory Committee*. Washington, DC: USDA and Department of Health & Human Services; 2015. www.health.gov/dietaryguidelines/2015-scientific-report/. Accessed June 20, 2017.
11. Bauer J, Biolo G, Cederholm T, et al. Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE Study Group. *J Am Med Dir Assoc*. 2013;14:542–559.
12. Peters CJ, Picardy J, Darrouzet-Nardi AF, Wilkins JL, Griffin TS, Fick GW. Carrying capacity of U.S. agricultural land: ten diet scenarios. *Elementa: Sci Anthropocene*. 2016;4:000116.
13. Pimentel D, Pimentel M. Sustainability of meat-based and plant-based diets and the environment. *Am J Clin Nutr*. 2003;78(suppl):660S–663S.
14. USDA and Department of Health and Human Services (HHS). *Dietary Guidelines for Americans 2010*. 7th ed. Washington, DC: US Government Printing Office; 2010. www.health.gov/dietaryguidelines. Accessed June 20, 2017.
15. Wu G, Fanzo J, Miller DD, et al. Production and supply of high-quality food protein for human consumption: sustainability, challenges, and innovations. *Ann N Y Acad Sci*. 2014;1321:1–19.
16. Elango R, Ball RO, Pencharz PB. Indicator amino acid oxidation: concept and application. *J Nutr*. 2008;138:243–246.
17. US Department of Agriculture, Agriculture Research Service. *USDA Food Composition Database*. Beltsville, MD: Nutrient Data Laboratory; 2015. https://ndb.nal.usda.gov/ndb/. Accessed September 01, 2017.
18. Schaafsma G. The protein digestibility-corrected amino acid score. *J Nutr*. 2000;130:1865S–1867S.
19. Reidy PT, Walker DK, Dickinson JM, et al. Protein blend ingestion following resistance exercise promotes human muscle protein synthesis. *J Nutr*. 2013;143:410–416.
20. Rutherfurd SM, Fanning AC, Miller BJ, Moughan PJ. Protein digestibility-corrected amino acid scores and digestible indispensable amino acid scores differentially describe protein quality in growing male rats. *J Nutr*. 2015;145:372–379.
21. Mottet A, de Haan C, Falcucci A, Tempil G, Opio C, Gerber P. Livestock: on our plates or eating at our table? A new analysis of the feed/food debate. *Glob Food Sec*. 2017;14:1–8.
22. Iowa Corn. Iowa Corn Producers Board. https://www.iowacorn.org/resources/faqs/. Accessed September 12, 2017.
23. Lammers PJ, Honeyman MS. Corn use as livestock feed in Iowa. Animal Industry Rep 2009; AS 655, ASL R2462. http://lib.dr.iastate.edu/ans_air/vol655/iss1/84. Accessed September 12, 2017.
24. Tom MS, Fischbeck PS, Hendrickson CT. Energy use, blue water footprint, and greenhouse gas emissions for current food consumption patterns and dietary recommendation in the US. *Environ Syst Decis*. 2016;36(1):92–103.

CHICAGO REGISTERED DIETITIAN NUTRITIONIST MARY RUSSELL BECOMES 2018–2019 PRESIDENT OF ACADEMY OF NUTRITION AND DIETETICS

Registered dietitian nutritionist **Mary Russell** begins her 1-year term on June 1 as the 2018–2019 President of the Academy of Nutrition and Dietetics. Russell is senior manager of US nutrition medical affairs at Baxter Healthcare and a lecturer at the Rosalind Franklin School of Medicine and Science. Previously, she was director of the Department of Clinical Nutrition at the University of Chicago Medical Center and worked at Duke University Hospital in positions including director of nutrition services, trauma/surgery dietitian clinician, and adult nutrition support team dietitian. A past member of the Academy's House of Delegates and a member of numerous committees, Russell served on the Academy's Board of Directors for 5 years as treasurer-elect, treasurer, and immediate past treasurer. She is a past member of the Academy Foundation's Board, past chair of the Dietitians in Nutrition Support dietetic practice group, and past president of the North Carolina Dietetic Association.

Russell was named the 2018 Outstanding Dietitian by the Illinois Academy of Nutrition and Dietetics. She is the author or coauthor of numerous articles in the area of nutrition support. Russell is a graduate of Marquette University and earned a master's degree from the University of Wisconsin–Madison.

DOI: 10.1097/NT.0000000000000291