Agriculture's Ecological "Foodprint"

By Gregory Zimmerman

THE 2010 STATE OF THE ROCKIES REPORT CARD

Agriculture's ecological footprint, or "foodprint," is a measure of the natural resources expended to produce a human's dietary requirements. Each Calorie we consume, every bite of food we take, carries hidden environmental costs. The following charts illustrate the effect of our diet on landscapes, water resources, ecology and climate in the Rocky Mountain Region and beyond.

Landscapes

An aerial view of the Rockies reveals the indelible "foodprint" that years of agriculture have left on the landscape. From above, you can see wide open rangelands and perfectly circular cropland. The view is neither developed, nor pristine, but it is classically Western.

The Rocky Mountain Region possesses 547.9 million acres, roughly 24 percent of the total United States land area. Just over 8 percent of the Region is cropland, constituting 46.3 million acres. This represents 10.5 percent of total cropland in the United States. Grassland pasture and range comprises 302.8 million acres in the Rockies, representing over 55 percent of the total land in the Region. **See Figures 1 and 2.**

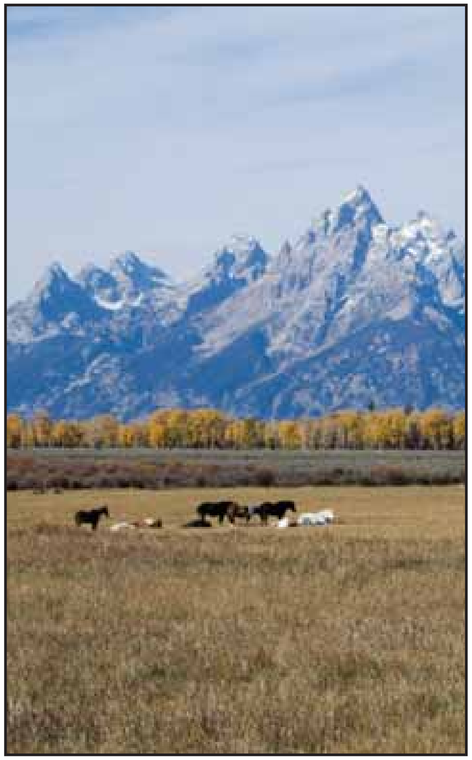

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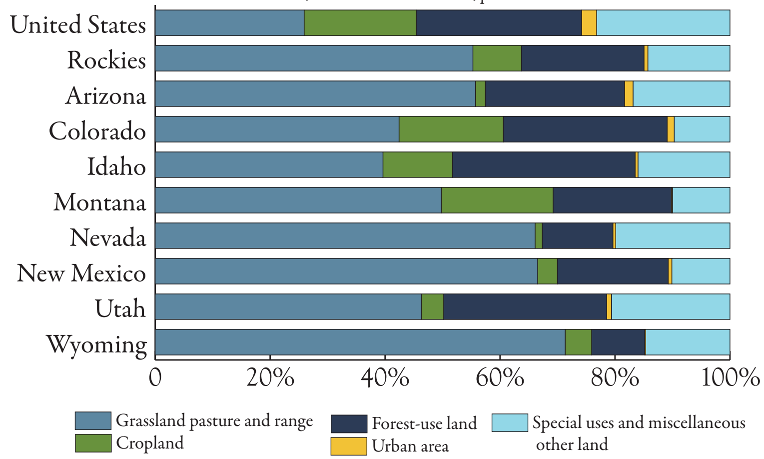
Figure 1:
Major Land Uses as a Percent of Total Land, 2002

Source: USDA, 2005

Note: Grassland, pasture and range: Grassland and other non-forested pasture and range in f
plus estimates of open or non forested grazing lands not in farms.
Cropland: Cropland used for crops, cropland idled, and cropland used for pasture.
Forest-use land: Forest-use land grazed and forest-use land not grazed.
Urban: Densely-population areas
Special use and other miscellaneous: Rural transportation, rural parks and wildlife, defense and industrial, miscellaneous farm uses, plus



Underlying Data Associated with Figure 1

	Grassland Pasture and Range	Cropland	Forest-use Land	Urban Area	Special Uses and Miscellaneous Other Land
United States	26%	20%	29%	3%	23%
Rockies	55%	8%	21%	1%	14%
Arizona	56%	2%	24%	1%	17%
Colorado	42%	18%	29%	1%	10%
Idaho	40%	12%	32%	0%	16%
Montana	50%	19%	21%	0%	10%
Nevada	66%	1%	12%	0%	20%
New Mexico	67%	3%	19%	1%	10%
Utah	46%	4%	28%	1%	21%
Wyoming	71%	5%	9%	0%	15%

Landscapes, continued.

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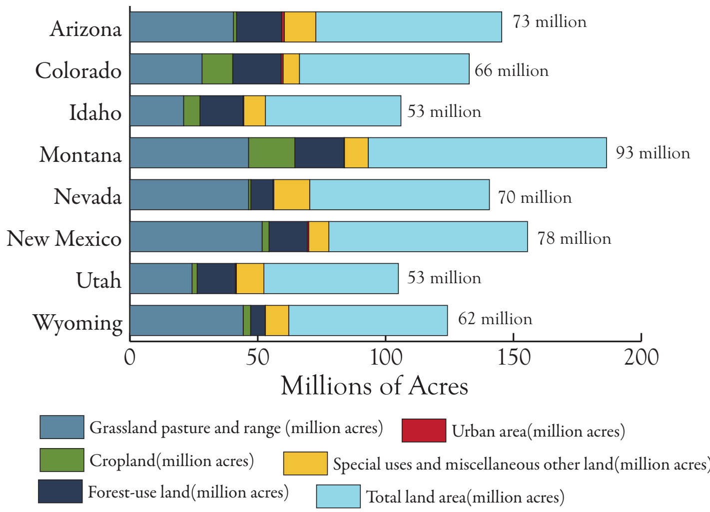
Figure 2:
Major Land Uses in the Rockies, by Millions of Acres, 2002
Source: USDA, 2005

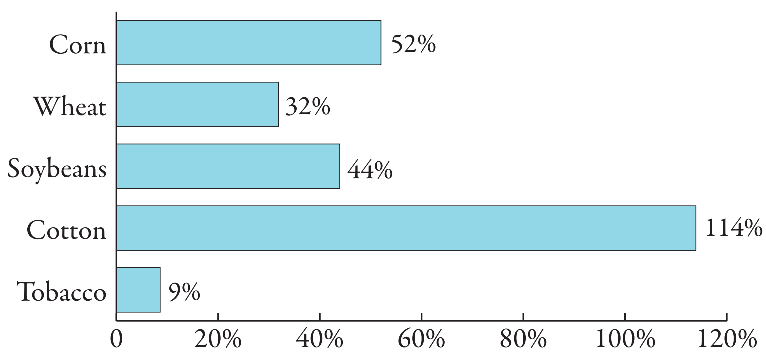


Underlying Data Associated with Figure 2

In Millions of Acres	Grassland Pasture and Range	Cropland	Forest-use Land	Urban Area	Special Uses and Miscellaneous Other Land	Total Land Area
United States	587	442	651	60	525	2,264
Rockies	303	46	117	4	78	548
Arizona	41	1	18	1	12	73
Colorado	28	12	19	1	6	66
Idaho	21	6	17	< 1	8	53
Montana	46	18	19	< 1	9	93
Nevada	46	1	9	< 1	14	70
New Mexico	52	3	15	< 1	8	78
Utah	24	2	15	< 1	11	53
Wyoming	44	3	6	< 1	9	62

Production efficiency on U.S. farms has increased substantially during the previous three decades, allowing farmers to grow more food on the same amount of land. Today, the same area of land can produce 44 percent more soybeans and 114 percent more cotton than it could in 1978. **See Figure 3.**

Figure 3:
Crop Yield Increases on U.S. Farms, 1978 - 2007
Source: USDA. *2007 Census of Agriculture*, 2009



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Water

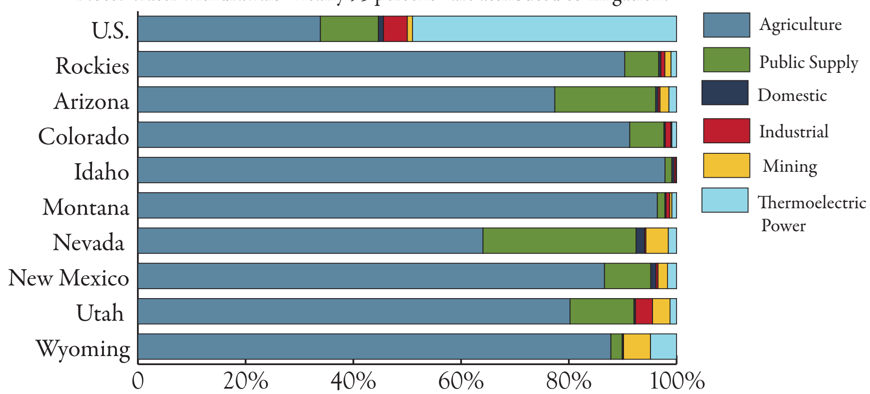
When a farm receives less than 20 inches of precipitation annually, irrigation water is required to grow crops. Much of the Rockies Region falls well below the 20 inch threshold.[1] As a result, farmers depend upon irrigation water from rivers, lakes, reservoirs and aquifers to function.

In 2005, agriculture was responsible for over 90 percent of all water withdrawals in the Rocky Mountain Region. In comparison, agriculture accounted for only 34 percent of withdrawals in the United States. In Idaho agriculture uses 19.13 billion gallons of water each day, representing nearly 98% of the state's total withdrawals. Agriculture in Nevada withdraws only 1.52 billion gallons per day, which makes up 64% of the states daily water withdrawals – the lowest proportion in the Rockies. **See Figures 4 and 5.**

Figure 4:
Water Withdrawals by Category as a Percent of Total, 2005

Source: Kenny, J.F. et al. *Estimated Use of Water in the United States in 2005.* U.S. Geological Survey Circular 1344. 2009.

Note: Water withdrawals - nearly 95 percent - are attributed to irrigation.



Underlying Data Associated with Figure 4

	Agriculture	Public Supply	Domestic	Industrial	Mining	Thermoelectric Power
United States	34%	11%	1%	4%	1%	49%
Rockies	90%	6%	< 1%	1%	1%	1%
Arizona	77%	19%	< 1%	< 1%	2%	1%
Colorado	91%	6%	< 1%	1%	< 1%	1%
Idaho	98%	1%	< 1%	< 1%	< 1%	< 1%
Montana	96%	1%	< 1%	1%	< 1%	1%
Nevada	64%	28%	2%	< 1%	4%	2%
New Mexico	87%	9%	1%	< 1%	2%	2%
Utah	80%	12%	< 1%	3%	3%	1%
Wyoming	88%	2%	< 1%	< 1%	5%	5%

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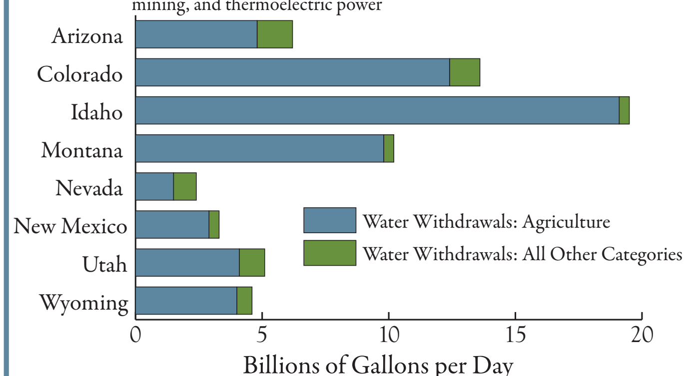
Figure 5:
Daily Water Withdrawals in the Rockies, in Billions of Gallons, 2005

Source: Kenny, J.F. et al. *Estimated Use of Water in the United States in 2005.* U.S. Geological Survey Circular 1344. 2009.

Note: Water withdrawals in "All Other Categories" includes: public supply, dometstic, industrial, mining, and thermoelectric power



Underlying Data Associated with Figure 5

	Agriculture (billion gallons per day)	Agriculture (percent of total)	All Other Categories (billion gallons per day)	All Other Categories (percent of total)
United States	139	34%	271	66%
Rockies	59	90%	6	10%
Arizona	5	77%	1	23%
Colorado	12	91%	1	9%
Idaho	19	98%	< 1	2%
Montana	10	96%	< 1	4%
Nevada	2	64%	1	36%
New Mexico	3	87%	< 1	13%
Utah	4	80%	1	20%
Wyoming	4	88%	1	12%

Water, continued.

Growing food requires large inputs of water. Globally, a pound of corn takes 168 gallons of water, while a pound of beef uses a whopping 1,857 gallons of water (including water to grow the feed, maintain forage, and water the cow). Beverage production is similarly water-intensive. A gallon of coffee requires an input of 1,120 gallons of water. **See Figures 6 and 7.**

Figure 6:
Water Foodprint, Food, 2009
Source: Gleick, P.H., et al. *The World's Water 2008 - 2009*. Washington: Island Press. 2009. and USDA. *2007 Census of Agriculture,* 2009.

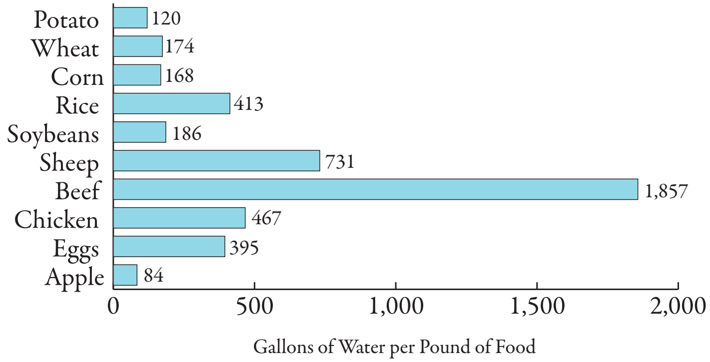
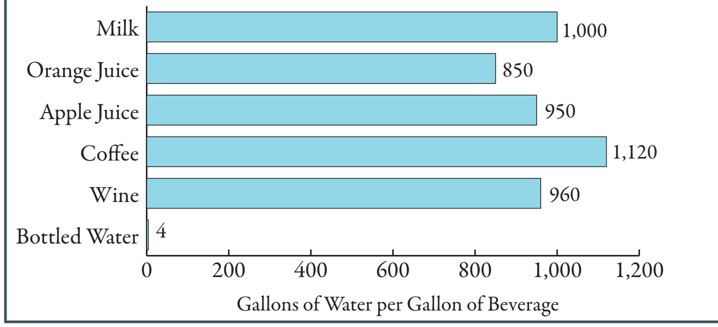


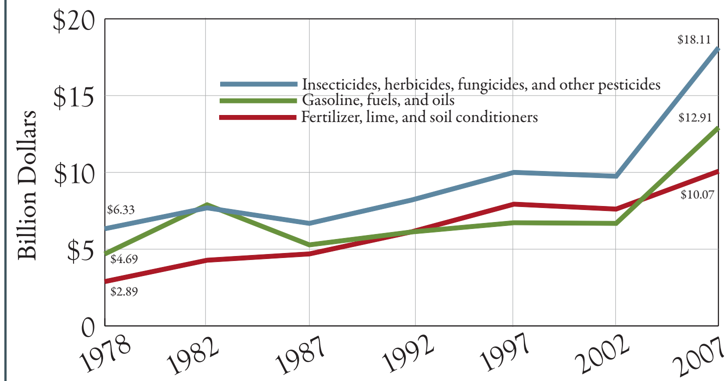
Figure 7:
Water Foodprint, Beverages, 2009
Source: Gleick, P.H., et al. *The World's Water 2008 - 2009*. Washington: Island Press. 2009.



Ecology

Farmers use pesticides, fertilizers and other chemicals that, when released into the environment, impact local ecology. During the latter half of the 20th century, farms across the United States increased their reliance on pesticides, fertilizers and fossil fuels. Expenditures on fertilizers, along with gasoline and oil, have nearly tripled since 1978. At the same time, expenditures on pesticides have more than tripled. While chemicals, fertilizers and fossil fuels have boosted productivity on U.S. farms, they also pollute terrestrial and aquatic resources when released into the environment.[2] **See Figure 8.**

Figure 8:
Total Expenditures on Chemicals, Fuels, and Fertilizers on U.S. Farms, 1978 - 2007
Source: Kenny, J.F., et al. *Estimated Use of Water in the United States in 2005*. U.S. Geological Survey Circular 1344. 2009.



Croplands are the largest contributor of nitrogen and phosphorus to U.S. surface waters as nutrient-laden manure and fertilizers runoff into rivers and lakes.[3] While water bodies require some nitrogen and phosphorus to be healthy, excess concentrations cause algal blooms that consume dissolved oxygen. Without adequate dissolved oxygen in the water, plants and animals die off in large numbers. In the United States, croplands alone release 3,204 thousand metric tonnes of nitrogen each year to surface waters, accounting for nearly 40 percent of all aquatic nitrogen pollution. Croplands release 615 thousand metric tonnes of phosphorus to U.S. surface waters each year, representing about 31 percent of all aquatic phosphorus pollution. **See Figures 9 and 10.**

Figure 10:
Phosphorus Discharges to U.S. Surface Waters, 1998
Source: Carpenter, N.F. et al. "Nonpoint Pollution of Surface Waters with Phosphorus and Nitrogen," Ecological Applications. Vol. 8. No. 3. p. 559 - 568. August 1998.

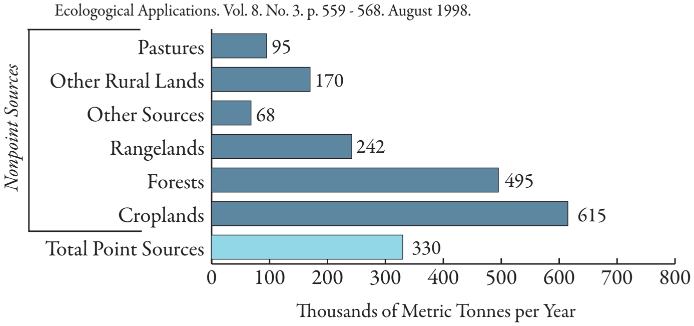


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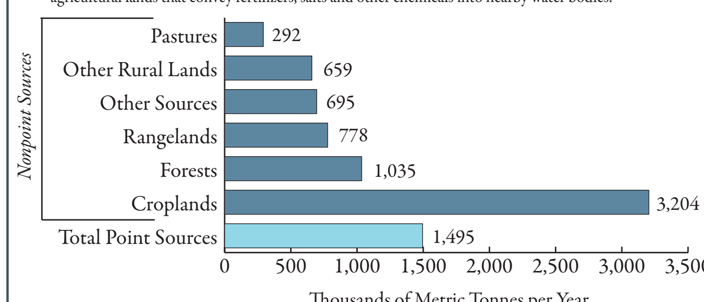
Figure 9:
Nitrogen Discharges to U.S. Surface Waters, 1998
Source: Carpenter, N.F. et al. "Nonpoint Pollution of Surface Waters with Phosphorus and Nitrogen," Ecological Applications. Vol. 8. No. 3. p. 559 - 568. August 1998.
Note: Point source pollution is pollution that originates from a single, discernible, source. For example, discharge from a sewage treatment facility is a point source of pollution. Nonpoint source pollution is pollution that originates from diffuse sources. A common nonpoint source pollution is runoff from agricultural lands that convey fertilizers, salts and other chemicals into nearby water bodies.



Climate

Climate foodprint is the summation of all greenhouse gases released from the farm to our dinner plate. Although calculating climate foodprint is relatively complex, one trend remains constant – animal products, especially red meat, are far more greenhouse gas intensive than vegetables. **Table 1** outlines the various sources of greenhouse gases in agriculture.

To demonstrate the difference between a meat and vegetable diet, compare equal Caloric portions of beef and vegetables with rice, and their respective CO_2e emissions. **See Table 2.** Both dishes have roughly 320 Calories. The beef steak requires 16 times more fossil energy to produce than the vegetables and rice. Overall, the six ounce steak generates 9.75 pounds CO_2e, which is 24 times greater than the vegetarian meal. The large difference in greenhouse gas emissions between the meals is explained by the additional fossil fuels burned in meat production, along with methane and nitrous oxide emitted in great quantities by cows and their manure.[4] [5] **See Figures 11 and 12.**

Table 1:
Sources of Common Greenhouse Gases in Agriculture

Carbon Dioxide	Nitrous Oxide	Methane
Fossil Fuel Consumption	Fertilizer Applications, Soil Management, Manure Management	Manure Management, Enteric Fermentation*

* Enteric fermentation is fermentation that occurs in the digestive system of cattle, sheep, pigs, and other ruminant animals. Methane is a byproduct of enteric fermentation.
Source: Weber, C.L. et al. "Food-Miles and the Relative Climate Impacts of Food Choices in the United States." *Environmental Science and Technology*. 42 (10), p. 3508 - 3513. 2008.

Table 2:
Global Warming Potential of Common Greenhouse Gases

Greenhouse Gas	Global Warming Potential (100 Years)	Carbon Dioxide Equivalent
Carbon Dioxide	1 ton of CO_2 is equivalent to 1 ton of CO_2	1 ton CO_2e
Methane	1 ton of methane is equivalent to 25 tons of CO_2	25 tons CO_2e
Nitrous Oxide	1 ton of nitrous oxide is equivalent to 298 tons of CO_2	298 tons CO_2e

Carbon Dioxide Equivalent
Carbon dioxide is the most prevalent greenhouse gas emitted by humans. Molecule-for-molecule, however, other common gases like methane and nitrous oxide are much more effective at trapping heat in the atmosphere and altering the earth's climate. A ton of methane traps 25 times more heat than a ton of carbon dioxide over a century. A ton of nitrous oxide traps 298 times more heat than a ton of carbon dioxide. In order to measure the global warming impact of human activity, scientist's measure carbon dioxide equivalent – or CO_2e – to account for the warming potential of each greenhouse gas. Table 2 provides the carbon dioxide equivalent for the most common greenhouse gases.

Figure 11:
Fossil Fuels Requred to Grow a Vegetarian Meal and a Steak Meal, 2008
Source: Bittman, Mark. "Rethinking the Meat Guzzler." *The New York Times*. January 27, 2008.

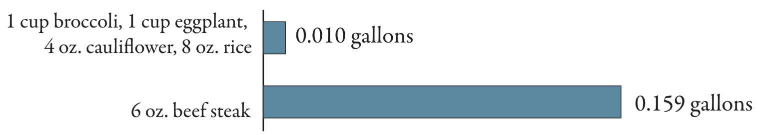
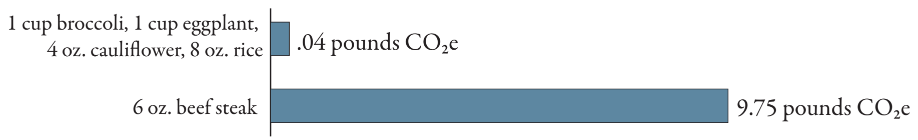


Figure 12:
Greenhouse Gases Emitted while Growing a Vegetarian Meal and a Steak Meal, 2008
Source: Bittman, Mark. "Rethinking the Meat Guzzler." *The New York Times*. January 27, 2008.



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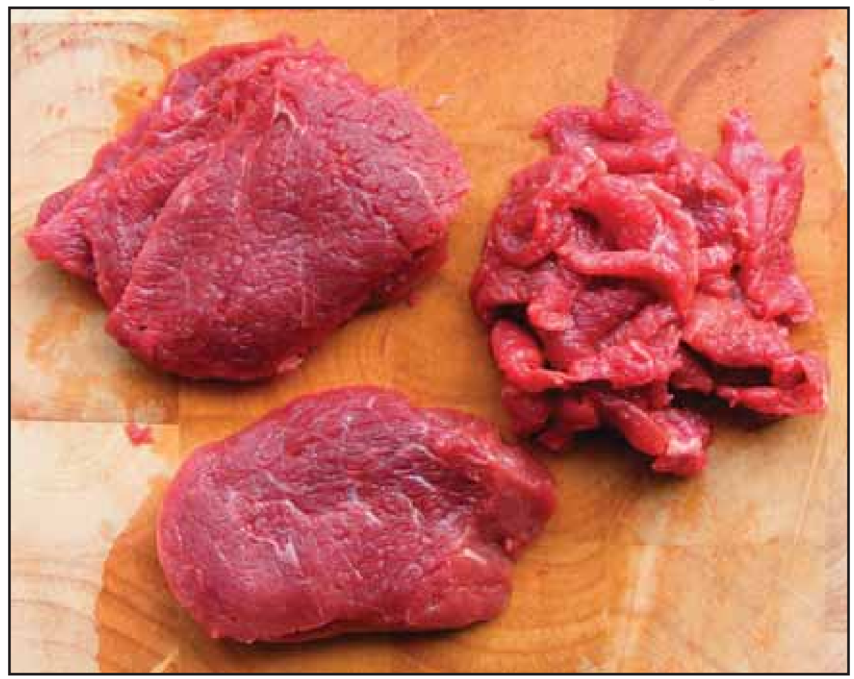

Climate, continued.

The climate impact of producing a half-pound of beef is similar to driving 9.81 miles. Producing a half-pound of potatoes is similar to driving 0.17 miles. **See Figure 13.**

Annually, global meat production is responsible for generating more greenhouse gases than transportation. Only energy production releases more atmospheric greenhouse gases than livestock production. **See Figure 14.**

Of the 11 pounds CO_2e generated in the production of a gallon of milk, 80 percent is released by growing feed and raising the cow. Preparation, transportation and sale of the gallon are responsible for the remaining 20 percent. **See Figure 15.**

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Figure 13:
Eating and Driving, Comparing the Climate Impact of Food Production and Driving, 2008

Source: Fiala, Nathan. "How Meat Contributes to Global Warming," *Scientific American*. Februray 2009.

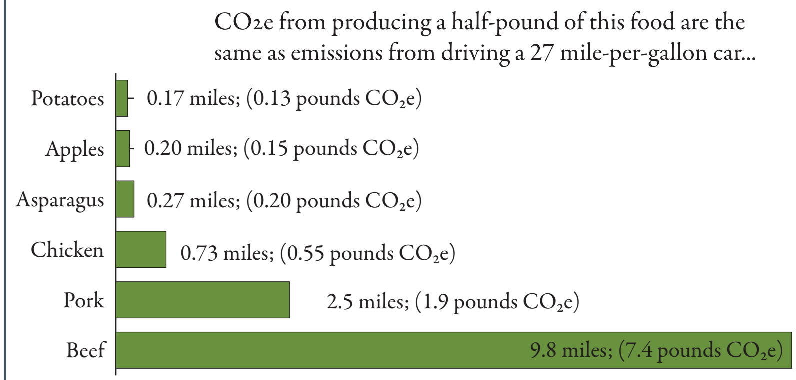


Figure 14:
Global Contribution of Greenhouse Gases by Sector, 2006

Source: Fiala, Nathan. "How Meat Contributes to Global Warming," *Scientific American*. Februray 2009.
Note: Total may exceed 100% due to rounding

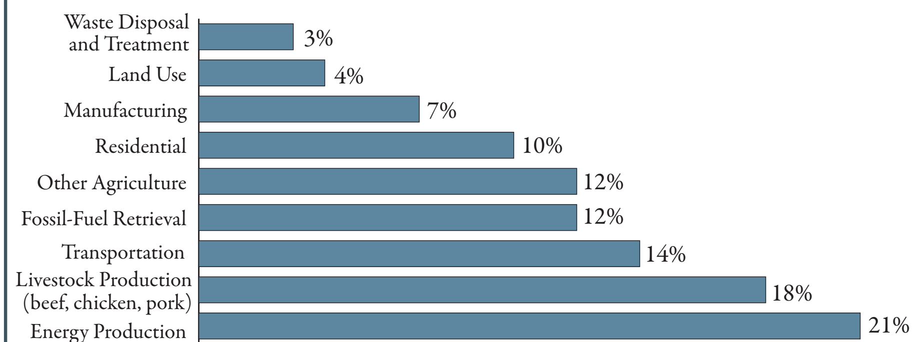
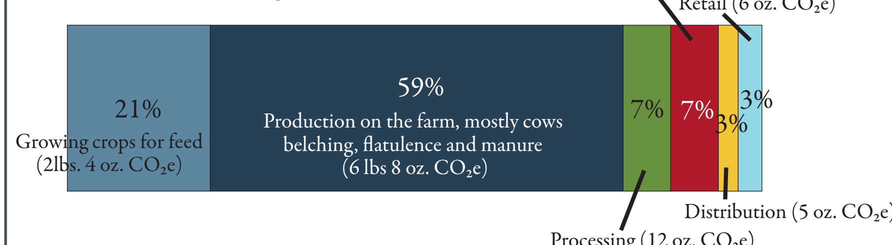


Figure 15:
Carbon Foodprint, A Gallon of U.S. Cow Milk

Source: Ball, Jeffrey. "Hate Calculus? Try Counting Carbon," *The Wall Street Journal*. September 18, 2009.



Climate, continued.

Geophysicist Gidon Eshel and Pamela Marten compared the climate impact of different American diets and relate those diet choices to the impact of various sized automobiles. Their research illustrates that the average American consumes 3,774 Calories every day: 1,047 Calories from animal products and 2,727 Calories from non-animal products. This average diet is responsible for 1.7 tons CO_2e annually, which is larger than the climate impact of driving a Toyota Prius for a year. The difference in greenhouse gas emissions between a vegan diet – one in which all 3,774 Calories are from non-animal sources – and the average American diet is 1.5 tons CO_2e annually. This is greater than the 1.0 ton CO_2e per year difference between driving a Camry and a Prius. **See Figures 16 and 17.**

Figure 16:
The Average American Diet, Caloric Composition, 2009
Source: Eshel, G. et al. "Diet, Energy, and Global Warming," *Earth Interaction*. Volume 10. Paper Number 9. 2006.

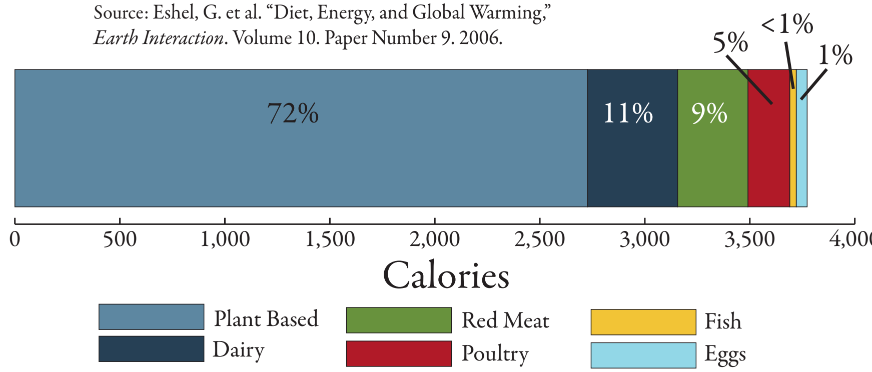
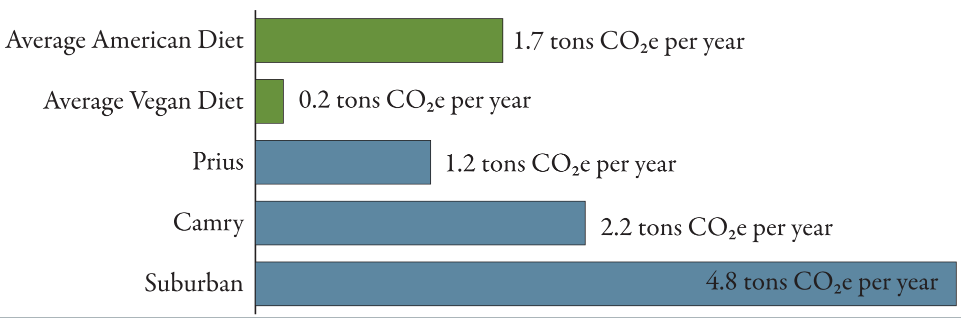


Figure 17:
Eating and Driving: Climate Impact of an Average Diet and a Vegan Diet versus Driving
Source: Eshel, G. et al. "Diet, Energy, and Global Warming," *Earth Interaction*. Volume 10. Paper Number 9. 2006.
Note: Assumes 8,332 per capita vehicle miles traveled, of which 65 percent are traveled on highways and the remainder are traveled in the city.



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Climate, continued.

A very common misperception is that “buying local” is the most effective method for reducing ones climate foodprint. Reducing food-miles – the distance food travels from farm-to-fork – does decrease greenhouse gas emissions. However, researcher Christopher Weber and Scott Matthews found that, of the 8.13 tonnes CO_2e released annually by American households, 83 percent of emissions occur at the farm, during production. As a result, the best technique for reducing climate foodprint is to reduce consumption of the most carbon intensive foods, namely red meat and dairy products. Weber and his colleague demonstrate that red meat and dairy are responsible for a combined 49 percent of an American household’s annual foodprint: 2.48 tonnes CO_2e per year from red meat and 1.47 tonnes CO_2e from dairy products. **See Figures 18 and 19.**

Figure 18:

Annual Climate Impact of Foods Consumed in U.S. Households by Supply Chain Tier

Source: Weber, C.L. et al. “Food-Miles and the Relative Climate Impacts of Food Choices in the United States,” *Environmental Science and Technology*. 42 (10), p. 3,508 - 3,513. 2008.

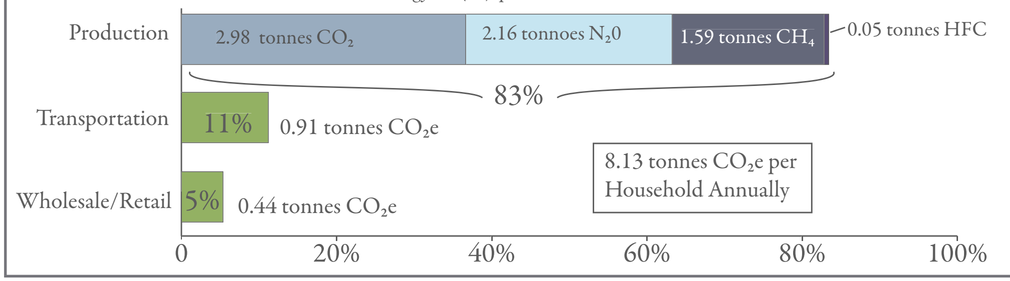

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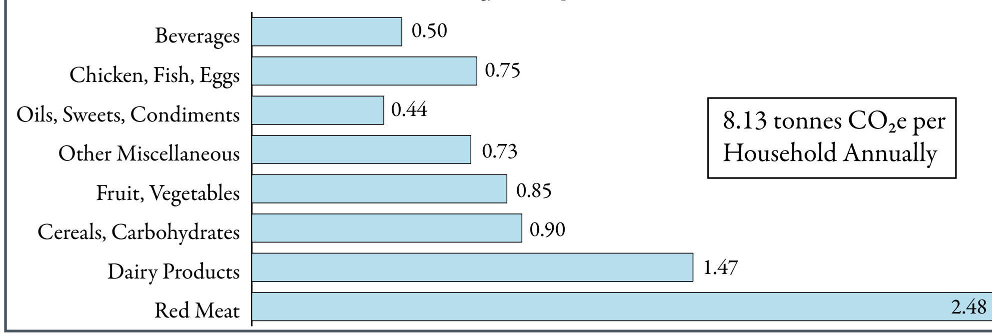
Figure 19:

Annual Climate Impact of Foods Consumed in U.S. Households by Food Group, in tonnes CO_2e per Year

Source: Weber, C.L. et al. “Food-Miles and the Relative Climate Impacts of Food Choices in the United States,” *Environmental Science and Technology*. 42 (10), p. 3,508 - 3,513. 2008.



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[1] McMahon, T. et al. “Water Sustainability in the Rockies: Agriculture to Urban Transfers and implications for Future Water Use.” In *The 2007 Colorado College State of the Rockies Report Card,* edited by Walter E. Hecox, Matthew K. Reuer, and Christopher B. Jackson, pg. 30. Colorado Springs: Colorado College, 2007.

[2] United States Department of Agriculture. *The 20th Century Transformation of U.S. Agriculture and Farm Policy.* Economic Information Bulletin Number 3. June 2005. http://www.ers.usda.gov/publications/eib3/eib3.htm#longrun. Accessed February 18, 2010.

[3] Carpenter, N.F. et al. “Nonpoint Pollution of Surface Waters with Phosphorus and Nitrogen,” Ecological Applications. Vol. 8. No. 3. pg. 559-568. August 1998. http://www.esajournals.org Accessed February 18, 2010.

[4] Bittman, Mark. “Rethinking the Meat Guzzler,” *New York Times.* January 27, 2008, http://www.nytimes.com/2008/01/27/weekinreview/27bittman.html. Accessed February 18, 2010.

[5] Greenhouse gas emissions are typically reported by the pound, the kilogram, the ton or the metric tonne (often just called the tonne). 1 ton is equivalent to 2000 pounds and 907 kilograms. 1 tonne is equivalent to 2205 pounds and 1000 kilograms.