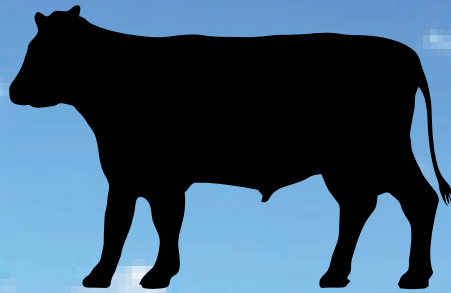


**MEAT  
EAT LESS.  
EAT GREENER.**



# **MEAT EATER'S GUIDE**

**TO CLIMATE CHANGE + HEALTH**

**July 2011**

**By Kari Hamerschlag, EWG Senior Analyst**

[www.ewg.org/meateatersguide](http://www.ewg.org/meateatersguide)

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By *Kari Hamerschlag*, EWG Senior Analyst

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## **A Meat Eater's Guide to Climate Change + Health: What You Eat Matters**

### **Eat Less Meat + Cheese and Buy Greener When You Do**

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Americans' appetite for meat and dairy – billions of pounds a year from billions of animals – takes a toll on our health, the environment, climate and animal welfare. Producing all this meat and dairy requires large amounts of pesticides, chemical fertilizer, fuel, feed and water. It also generates greenhouse gases and large amounts of toxic manure and wastewater that pollute groundwater, rivers, streams and, ultimately, the ocean. In addition, eating large quantities of beef and processed meats increases your exposure to toxins and is linked to higher rates of health problems, including heart disease, cancer and obesity.

U.S. meat consumption has held steady for the past several years, but Americans consume 60 per cent more than Europeans (FAO 2009) and the global appetite for meat is exploding. From 1971 to 2010, worldwide production of meat tripled to around 600 billion pounds while global population grew by just 81 percent (US Census Bureau, International Data Base). At this rate, production will double by 2050 to approximately 1.2 trillion pounds of meat per year,

requiring more water, land, fuel, pesticides and fertilizer and causing significant damage to the planet and global health (Elam 2006).

It doesn't have to be this way. You can do something about it. By eating and wasting less meat (especially red and processed meat) and cheese, you can simultaneously improve your health and reduce the climate and environmental impact of food production. And when you do choose to eat meat and cheese, go greener. There are many environmental, health and animal welfare reasons to choose meat and dairy products that come from organic, pasture-raised, grass-fed animals. It may cost more, but when you buy less meat overall, you can afford to go healthier and greener.

EWG's Meat Eater's Guide to Climate Change + Health can help you green your diet. It provides useful information about the [climate, environmental and health impact of your protein choices](#). We hope it also inspires you to advocate for public policies that will make our food system healthier for our bodies and the planet, since improving our personal food choices is just one part of the solution.

## **WHAT WE DID: Lifecycle Assessments**

To assess climate impacts, EWG partnered with CleanMetrics, an environmental analysis and consulting firm, to do lifecycle assessments of 20 popular types of meat (including fish), dairy and vegetable proteins. Unlike most studies that focus just on

production emissions, our assessment calculates the full “cradle-to-grave” carbon footprint of each food item based on the greenhouse gas (GHG) emissions generated before and after the food leaves the farm – from the pesticides and fertilizer used to grow animal feed all the way through the grazing, animal raising, processing, transportation, cooking and, finally, disposal of unused food. The analysis also includes the emissions from producing food that never gets eaten, either because it’s left on the plate or because of spoilage or fat and moisture loss during cooking. About 20 percent of edible meat just gets thrown out (EWG/CleanMetrics analysis of 2011 USDA data) ([see EWG’s Meateater’s Guide Methodology and Results / PDF](#)).

The lifecycle assessments are based on conventional rather than pasture-based or organic systems of food production. We focused on conventionally produced, grain-fed meat because that is mostly what Americans eat. Also, we were unable to identify definitive studies and widely accepted methodologies assessing greenhouse gas emissions from pasture-raised, organic or other meat production systems that make use of more environmentally sound management practices (such as cover cropping and intensive grazing). Because climate is just one of many factors to consider, our report also assesses other environmental and health impacts of all kinds of meat and dairy, including conventional, organic and pasture-raised. The analysis included salmon and tuna but focuses mostly on livestock and much less on seafood due to data and resource constraints.

## WHAT WE FOUND: All Meat is Not Created Equal

Different meats and different production systems have varying health, climate and other environmental impacts.

Lamb, beef, cheese, pork and farmed salmon generate the most greenhouse gases. With the exception of salmon, they also tend to have the worst environmental impacts, because producing them requires the most resources – mainly chemical fertilizer, feed, fuel, pesticides and water – and pound for pound, they generate more polluting manure. On the health front, the scientific evidence is increasingly clear that eating too much of these greenhouse gas-intensive meats boosts exposure to toxins and increases the risk of a wide variety of serious health problems, including heart disease, certain cancers, obesity and, in some studies, diabetes.

Meat, eggs and dairy products that are certified organic, humane and/or grass-fed are generally the least environmentally damaging (although a few studies of the impact on climate show mixed results for grass-fed versus confined-feedlot meat) (Pelletier 2010, Gurian-Sherman 2011). Overall, these products are the least harmful, most ethical choices. In some cases, grass-fed and pasture-raised products have also been shown to be more nutritious and carry less risk of bacterial contamination.

Greenhouse gas emissions vary depending on the quantity of chemical fertilizers, fuel and other “production inputs” used, differences in soil conditions

and production systems and the extent to which best practices (cover cropping, intensive grazing, manure management, etc.) are implemented along the entire supply chain. While best management practices can demonstrably reduce overall emissions and environmental harm, the most effective and efficient way to reduce greenhouse gas emissions and environmental impacts from livestock is simply to eat, waste and produce less meat and dairy.

## Climate and Environmental Impacts

The chart below shows the lifecycle total of greenhouse gas emissions for common protein foods and vegetables, expressed as kilograms (kg) of carbon dioxide equivalents (CO<sub>2</sub>e) per kg of consumed product. We compared our production emissions data for the main meat proteins to several mostly [peer-reviewed or government-sponsored studies in the U.S. and Europe](#) that assessed greenhouse gas emissions from animal production systems. Only a handful of other studies showed lower emissions, and these were within 25 percent of EWG's figures, indicating that our results may be conservative.

### Key Findings from the Lifecycle Assessments: Lamb, beef and cheese have the highest emissions.

This is true, in part, because they come from ruminant animals that constantly generate methane through their digestive process, called

enteric fermentation. Methane (CH<sub>4</sub>) – a greenhouse gas 25 times more (CH<sub>4</sub>) potent than carbon dioxide (CO<sub>2</sub>), accounts for nearly half the emissions generated in this study's Nebraska beef production model (**see chart on the next page**). Pound for pound, ruminants also require significantly more energy-intensive feed and generate more manure than pork or chicken (**see figure 2**).

- Lamb has the greatest impact, generating 39.3 kg (86.4 lbs) of carbon dioxide equivalents (CO<sub>2</sub>e) for each kilo eaten – about 50 percent more than beef. While beef and lamb generate comparable amounts of methane and require similar quantities of feed, lamb generates more emissions per kilo in part because it produces less edible meat relative to the sheep's live weight. Since just one percent of the meat consumed by Americans is lamb, however, it contributes very little to overall U.S. greenhouse gas emissions.
- Beef has the second-highest emissions, generating 27.1 kilos (59.6 lbs) of CO<sub>2</sub>e per kilo consumed. That's more than twice the emissions of pork, nearly four times that of chicken and more than 13 times that of vegetable proteins such as beans, lentils and tofu. About 30 percent of the meat consumed in America is beef.
- Cheese generates the third-highest emissions, 13.5 kilos (29.7 lbs) of CO<sub>2</sub>e per kilo eaten, so vegetarians who eat a lot of dairy aren't off the hook. Less dense cheese (such as cottage) results in fewer greenhouse gases since it takes less milk to produce it.

Figure 1. Full Lifecycle Greenhouse Gas Emissions from Common Proteins and Vegetables

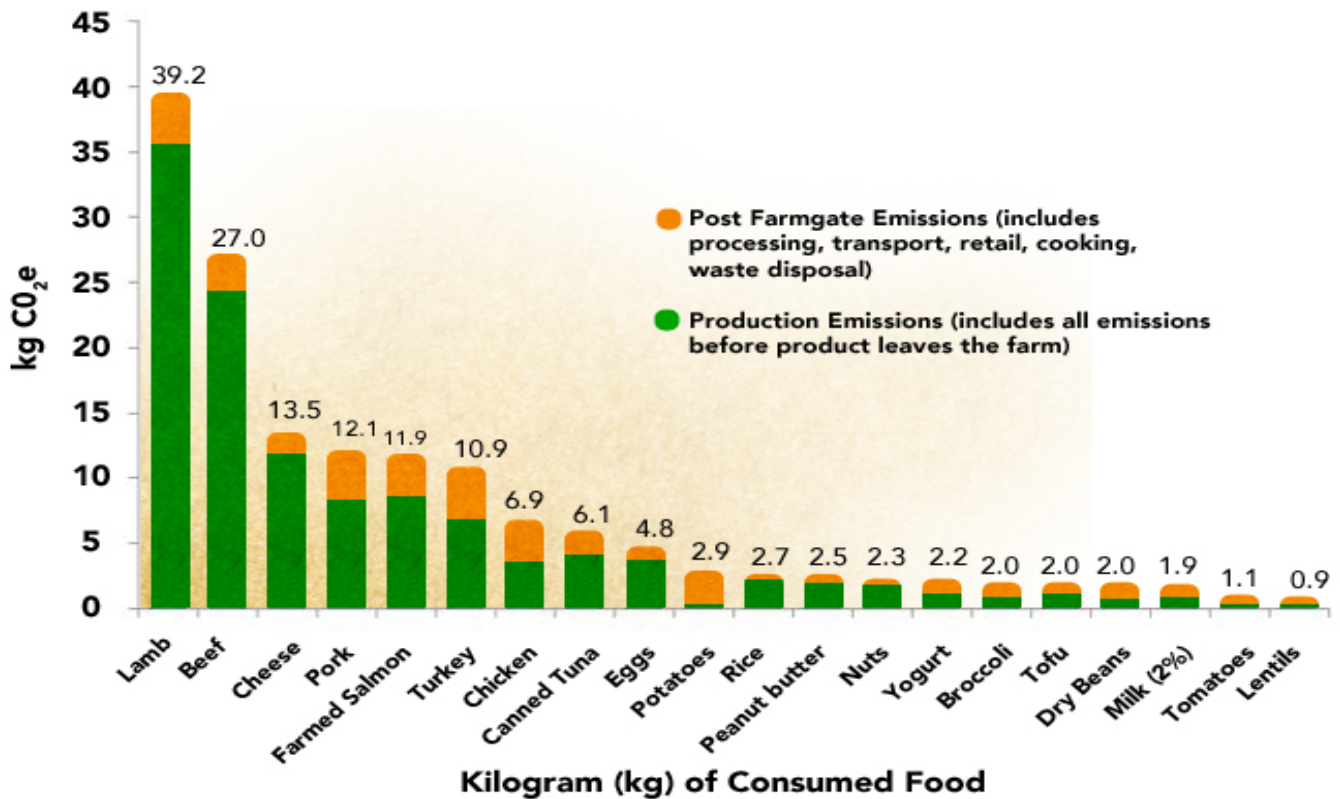
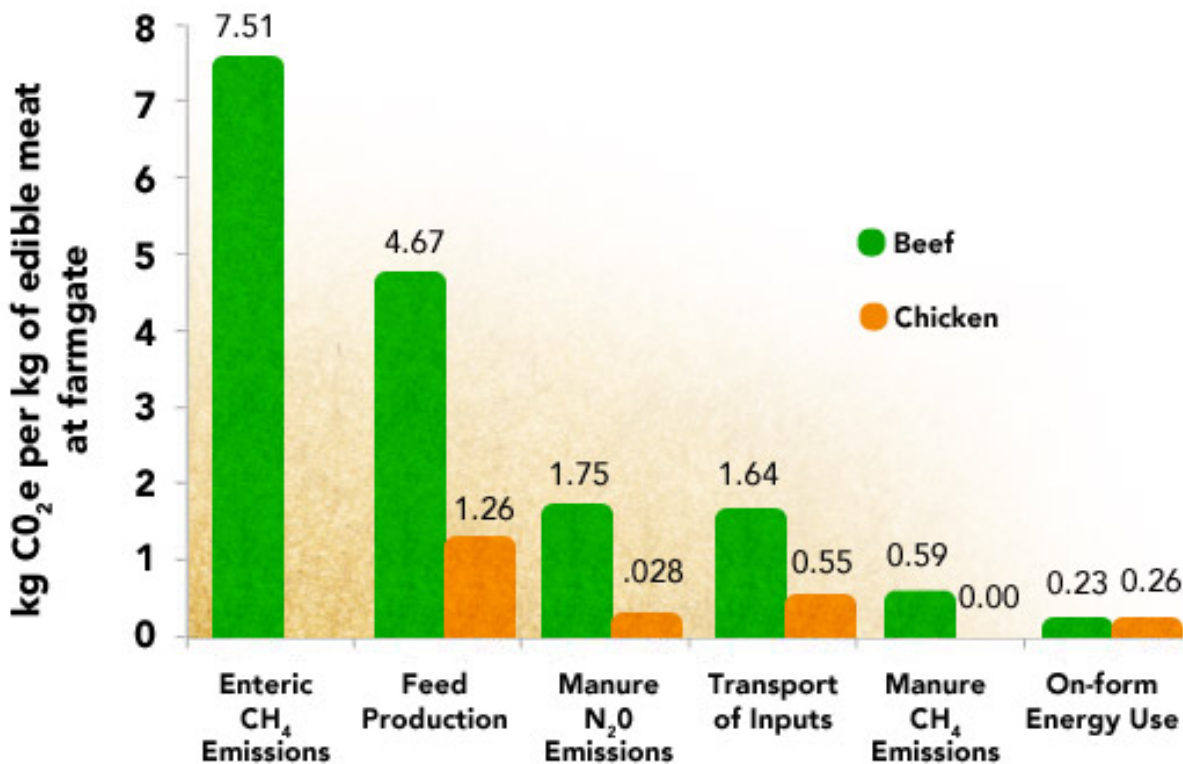


Figure 2. Sources of Emissions from Beef and Chicken Production



# How feed production and manure generate greenhouse gases and harm the environment

## Feed production:

Most U.S. livestock are fattened on fishmeal, corn, soybean meal and other grains. Grain production, in particular, requires significant quantities of fertilizer, fuel, pesticides, water and land. It takes 149 million acres of cropland, 76 million kilos (167 million lbs) of pesticides and 7.7 billion kilos (17 billion lbs) of nitrogen fertilizer to grow this feed. Fertilizer applied to soil generates nitrous oxide (N<sub>2</sub>O), which has 300 times the warming effect of carbon dioxide. Irrigation pumps, tractors and other farm equipment also release carbon dioxide, but in relatively small amounts. Pesticides and fertilizers often end up in runoff that pollutes rivers, groundwater and oceans. Feed crops are heavily subsidized by taxpayers through the federal Farm Bill, to the tune of \$45 billion over the past 10 years. Fertilizer and pesticide production requires a significant amount of energy, but our model found that together they account for just 12 percent of the emissions from growing feed. The biggest impact is from the nitrous oxide emissions resulting from fertilizer application

## Manure:

Animal waste releases nitrous dioxide and methane and pollutes our water and air, especially when it is concentrated. In 2007, U.S. livestock in confined feeding operations generated about 500 million tons of manure a year, three times the amount of human waste produced by the entire U.S. population (EPA 2007). Manure is the fastest growing major source of methane, up 60 percent from 1990 to 2008 (EPA 2010). While manure is a valuable nutrient for plants, it can leach pollutants – including nitrogen, phosphorus, antibiotics and metals – into groundwater when storage facilities leak or too much is spread on farm fields. More than 34,000 miles of rivers and 216,000 acres of lakes and reservoirs in the U.S. have been degraded by waste from confined feeding operations (EPA 2009). Decomposing waste releases dust, smog odors and toxic gases, including ammonia and hydrogen sulfide, which degrade air quality and can cause itching, dizziness and discomfort to workers and nearby residents.

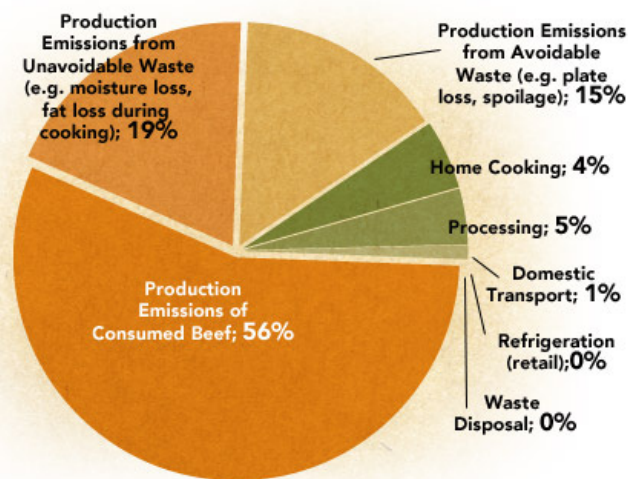
## Most Emissions from Meat, Dairy and Fish Consumption Occur during Production

EWG’s analysis found that 90 percent of beef’s emissions, 69 percent of pork’s, 72 percent of salmon’s and 68 percent of tuna’s are generated in the production phase. In the case of beef and dairy, this is due to the high methane (CH<sub>4</sub>) emissions from the ruminants’ digestion and manure, as well as the nitrous oxide generated from growing feed. Chickens, in contrast, generate no methane and have far fewer emissions during production. In the case of farmed salmon, the primary emissions in the production phase come from feed. Emissions for farmed salmon are also high because consumers throw away a lot of what they buy. This means that a lot of additional salmon is produced for every pound that gets eaten.

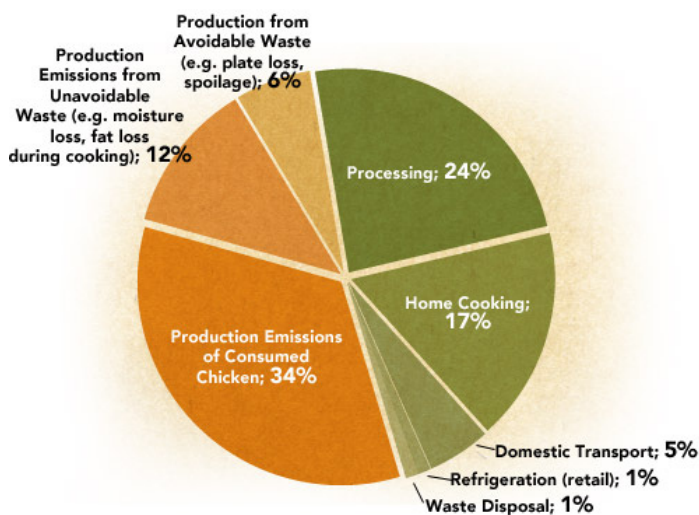
- Just half of chickens’ emissions are generated during production. That’s because pound for pound, chickens require far less feed than hogs and beef or dairy cattle, and chickens generate no methane. However, chicken processing is more energy- and water-intensive than other meat processing.
- Sources of greenhouse gases are different for farmed and wild fish. Feed production dominates emissions from salmon farming, while diesel combustion from fishing boats accounts for most of the emissions from wild-caught fish, including salmon and tuna. Overall, canned tuna has lower emissions. This is partially due to the fact that tuna and other wild-caught fish live on food that they consume directly from the ocean, in contrast

to farmed fish that are fed energy-intensive feed (such as sardines, menhaden, soybean meal and wheat) that must be grown and/or caught. Also,

**Figure 3. Beef: Most Emissions occur during Production**



**Figure 4. Chicken: Production and Post-Farmgate Emissions are Roughly Equal**



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this analysis considered canned tuna vs. fresh (farmed) salmon, keeping tuna emissions lower because there is less waste and no cooking in the canning process.

- In contrast to meat, most of plant proteins' emissions are generated after crops leave the farm (processing, transport, cooking and waste disposal). For example, post-farmgate emissions account for 65 percent of dry beans' total emissions and 59 percent of lentils', primarily because of the energy needed to cook them. Using a pressure cooker that cuts cooking time in half reduces beans' emissions by 25 percent. Ninety percent of potato emissions occur after the crop leaves the farm, primarily from cooking.

## Wasted Food is a Major Source of Emissions

EWG's analysis found that discarded food accounts at least 20 percent on average of the emissions associated with producing, processing, transporting and consuming meat and dairy products. Reducing waste and buying only as much as you can eat is the easiest way to reduce greenhouse gas and other environmental impacts of food.

Most of the emissions attributed to waste come from producing food that is ultimately discarded – from fertilizer and pesticide production, growing feed, transportation, etc. Foods with higher waste rates such as farmed salmon (44 percent is thrown away by retailers and consumers) have much higher emissions during production since it takes a lot more salmon to produce the amount that is actually consumed. Some of the waste-related production emissions are

unavoidable, such as moisture and fat loss during cooking. These must be accounted for in the lifecycle analysis, but there is very little consumers can do to minimize these losses (See **Figure 5 on page 11**).

## Waste disposal accounts for a small fraction of emissions from meat, a larger portion of emissions from plant food.

The source of these emissions is the methane produced during decomposition. In some landfills, a portion of these emissions are captured and used for energy. In EWG's model, less than 1 percent of beef, lamb and chicken, 2 percent of pork and 3 percent of turkey and salmon emissions are attributed to the waste disposal process.

Waste disposal accounts for roughly 22 percent of broccoli's total emissions, 20 percent of tomatoes' and 5 percent of potatoes'.

Composting meat (at home or through a service) reduces emissions by only small amounts: less than 0.01 percent for most meats. It has a bigger impact for vegetables: 10 percent in the case of broccoli and tomatoes.

## Transportation: Small portion of meat and dairy's emissions, more of vegetables' and plant proteins'

Although transportation-related emissions don't vary much among different kinds of food, transportation accounts for a much higher fraction of the overall

footprint of vegetable proteins because they have much lower emissions overall. According to this analysis, buying locally can significantly reduce the climate impact of vegetable production (10-30 percent), but has a relatively smaller impact for meat (1-3 percent). Nevertheless, supporting local ranchers is important for other reasons.

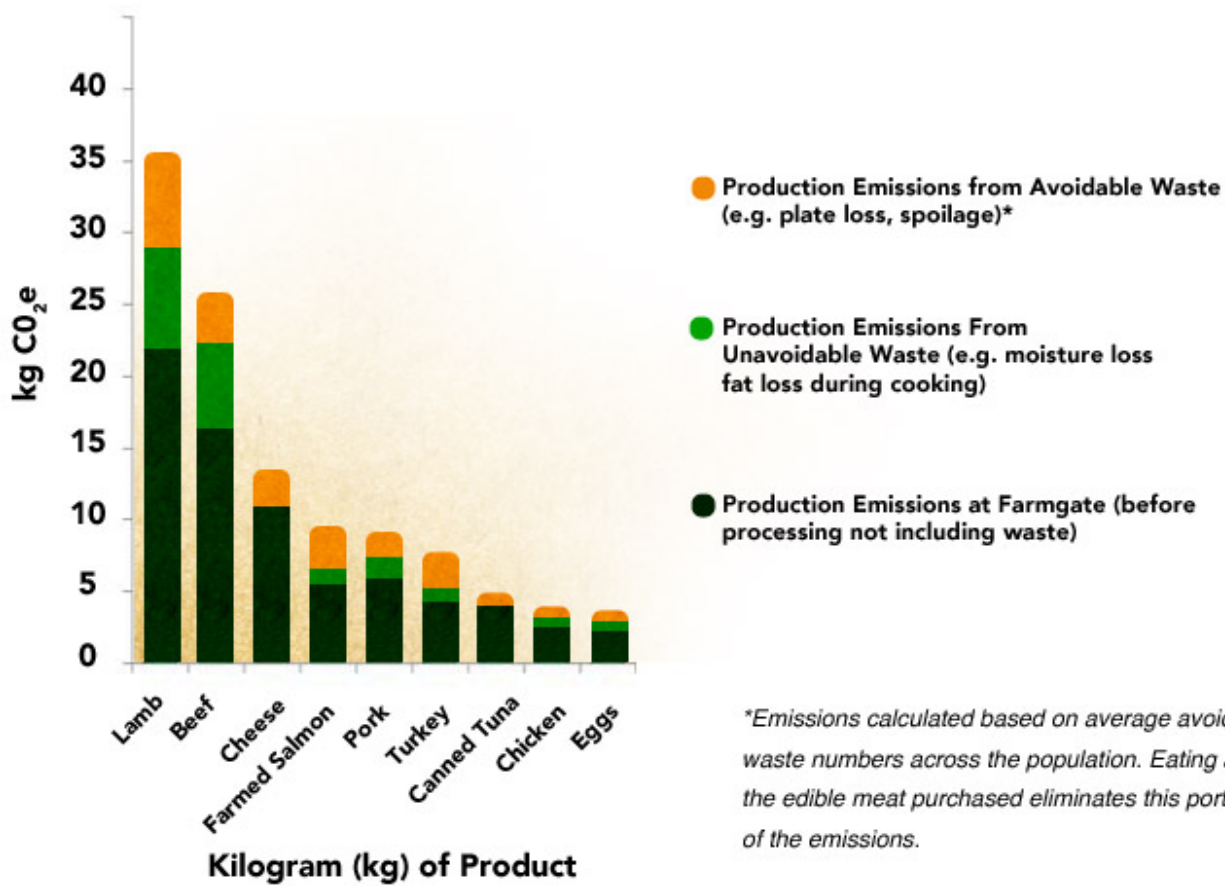
- EWG's analysis found that transporting animals, supplies and retail food products domestically to and from farms, slaughterhouses and stores produces only about 10 percent of meat's carbon footprint; transportation from the processor to retail generated just 1 percent of beef's footprint, 3 percent of pork's and 5 percent of chicken's and salmon's (including shipping in the case of salmon, since most salmon is imported by boat).
- By contrast, transportation to retail generates 30 percent of tomatoes' footprint, 23 percent of broccoli's, 15 percent of lentils' and tofu's, 12 percent of nuts', 9 percent of potatoes' and 7 percent of eggs'.
- Buying locally can reduce the overall footprint by as much as 20 percent for broccoli and 25 percent for tomatoes; local purchasing reduces meat's carbon footprint by just 1-3 percent.
- Emissions are much higher for airfreighted food. Cheese imported by air has a 46 percent larger footprint than domestically produced cheese. Most imported meat and dairy products, however, are shipped by sea, adding less than 1 percent to their carbon footprint.

## **Emissions from meat processing, including freezing and packaging, vary considerably.**

Processing accounts for just 5 percent of lamb and beef's overall carbon footprint, compared to 12 percent of pork's and 24 percent of chicken's.

Electricity to run the plants and pump huge quantities of wastewater is the main source of greenhouse gases from slaughterhouses. Emissions from chicken processing are relatively higher because it requires a high volume of water, and overall production emissions are lower.

Figure 5. Production Emissions from Eaten and Wasted Meat, Eggs and Cheese



The amount of food consumers throw away varies considerably. Consumers throw out about 40 percent of the fresh and frozen fish they buy, but only 12 percent of the chicken, 16 percent of the beef, 25 percent of the pork, and 31 percent of turkey is discarded at home or in restaurants. On average, retailers throw out about 5 percent of the meat they sell.<sup>8</sup>

## Slaughterhouses dump millions of pounds of toxic pollutants –

Primarily nitrogen, phosphorus and ammonia – into waterways. Eight slaughterhouses are consistently among the nation’s top 20 industrial polluters, responsible for discharging 13.6 million kilos (30 million lbs) of contaminants – primarily nitrates – in 2009 (EPA 2009). Nitrates are a significant source of drinking water contamination in agricultural communities nationwide. Excessive amounts of these pollutants lead to massive fish kills and oxygen-deprived “dead zones” where no marine life can survive.

## Reducing Your Footprint Take the Meatless Monday Pledge.

Across the country, thousands of people and dozens of schools and other institutions are going meatless on Mondays. Just like reducing home energy use or driving less, skipping meat once a week can make an important difference if everyone does it. By itself, eating less (or no) meat won't stop climate change or eliminate environmental damage, but it is very important for improving personal health and reducing your environmental footprint.

If everyone in the U.S. chose a vegetarian diet – the equivalent of taking 46 million cars off the road or not driving 555 billion miles, according to EWG's calculations, it would only make a moderate dent in overall carbon emissions, about a 4.5 percent reduction. Other estimates of meat's overall contribution to US emissions are higher, but not as high as many estimates for the world as a whole (Weber 2010). That's because the U.S. has other very large other industrial sources of greenhouse gases, making the meat slice of carbon emissions comparatively smaller. Also, U.S. livestock production does not depend on cutting down carbon-rich rain forests in order to import or grow feed crops and raise animals, as is true in Europe (which imports significant amounts of feed from Brazil) or in some tropical countries, where livestock emissions are a much larger slice of the overall emissions pie.

While important, it is clear that making significant cuts in US emissions will not come solely from individual action. It will take political action to bring

about comprehensive policies that put the nation on a path to green energy. Similarly, reducing meat production's negative impact on soil, air and water quality will require better policies and regulatory enforcement as well as curbing meat consumption.

### Here's how eating less meat measures up against other climate-saving actions:

#### Over a year:

- ✓ If you eat one less burger a week, it's like taking your car off the road for 320 miles or line-drying your clothes half the time. <sup>10</sup>
- ✓ If your four-person family skips meat and cheese one day a week, it's like taking your car off the road for five weeks – or reducing everyone's daily showers by 3 minutes. <sup>11</sup>
- ✓ If your four-person family skips steak once a week, it's like taking your car off the road for nearly three months. <sup>12</sup>
- ✓ If everyone in the U.S. ate no meat or cheese just one day a week, it would be like not driving 91 billion miles – or taking 7.6 million cars off the road. <sup>13</sup>

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## Meat and your Health

There is no question that meat in moderation can be a good source of complete protein and key vitamins and nutrients such as iron, zinc and vitamins B-12, B-6 and niacin. For many, meat is an important aspect of their diets. At the same time, the scientific evidence is increasingly clear that eating too much meat – particularly red and processed meat – is associated with a wide variety of serious health problems.

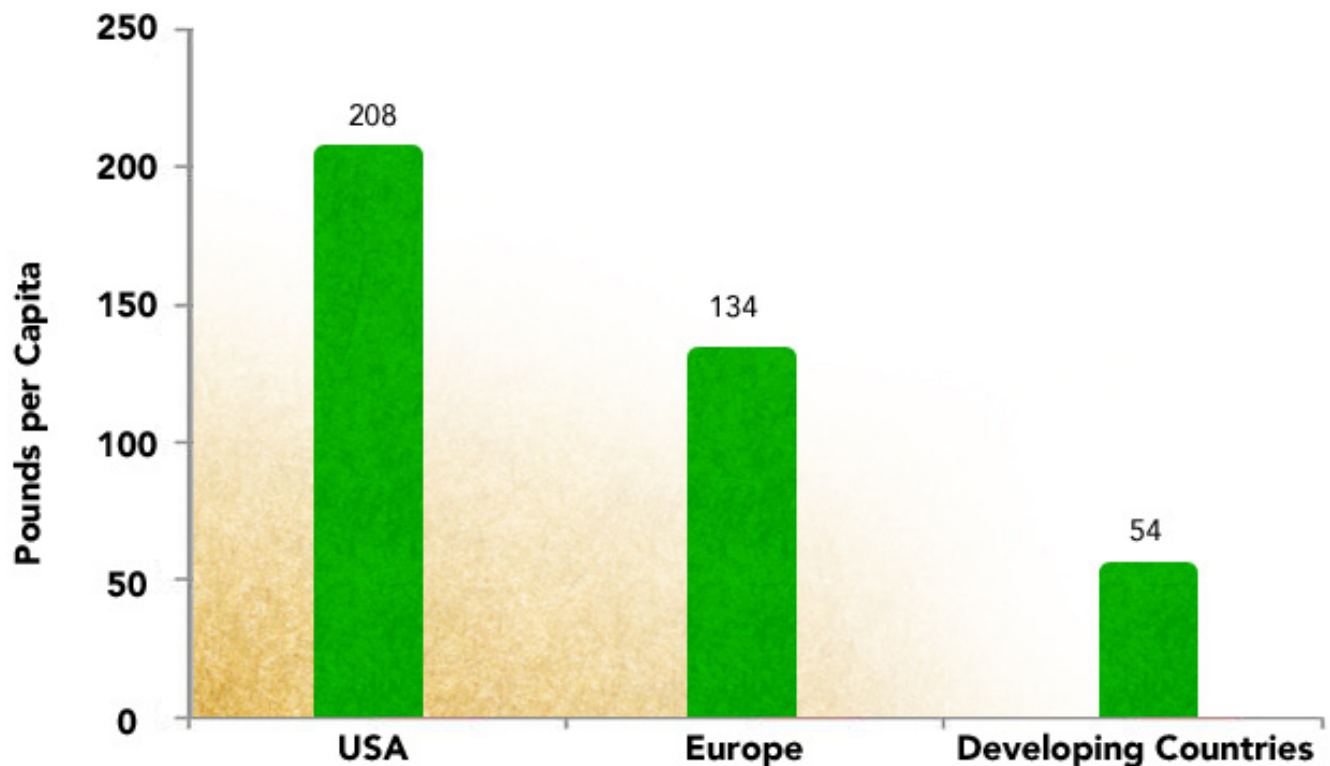
Americans eat more meat than most other developed nations. In 2009, the U.S. produced 94 kilograms (208 lbs) of meat per person for domestic consumption, not including seafood. That's nearly 60 percent more than Europe produced (61 kg, or 134 lbs person), and nearly four times as much as developing countries (EWG analysis of 2009 FAO data).

Recent research suggests that eating all this meat is contributing to the U.S. obesity epidemic. Several major epidemiological studies have found an association between high meat consumption levels and being overweight. A 2009 Johns Hopkins University study found that those who consumed the most meat consistently ate an average of 700 calories more per day and had a 27 percent greater likelihood of being obese than meat eaters who consumed the least (Wang 2009). Another large-scale European study found that men and women who ate the most meat consumed an average of 900 and 600 more calories per day, respectively, than those who ate the least. The study attributed weight gain to the high fat content and calories in many meats and concluded that “a decrease in meat consumption may improve weight management” (Vernaud 2010).

Some people may wonder whether they can reduce their meat intake and still get enough protein. The fact is that the protein intake for most age groups far exceeds the government's recommended dietary allowance (RDA) (CDC 2009). The RDA for men ages 19-70+ is 56 grams per day of protein, and the most recent National Health and Nutrition Examination Survey (NHANES) showed that men in this age group consumed almost twice this much on average: 88.3-109.2 grams per day (Fulgoni 2008). By contrast, only 1 percent of children and 4 percent of adults ate their recommended daily intake of fruits and vegetables (Kimmons 2009).

While vegetarian diets are not for everyone, some research suggests that eliminating all or most meat from one's diet may be good for health. A number of studies have found that people who eat vegetarian diets have lower rates of chronic disease and often live longer than those on predominantly meat-based diets (Fraser 2009, Jacobs 2009). The American Dietetic Association, the world's largest organization of nutrition experts, maintains that vegetarians have less obesity and lower rates of chronic medical conditions such as heart disease, diabetes and hypertension (Craig 2009).

Most Americans aren't going to give up meat entirely, of course, but it is not difficult to cut down a bit. Some research has shown that a diet abundant in plant foods partnered with servings of lean meats and seafood confers many of the health benefits of a purely vegetarian diet (Jacobs 2009).

**Figure 6. 2009 Per Capita Meat\* Production**

Source: FAO 2009; \* not including fish

## Red and Processed Meats Linked to Chronic Disease

Red meat (beef, pork and lamb) and processed meats (such as bacon, sausage, salami, hot dogs, lunch meats) are some of the most popular types of meat. According to the United Nations' Food and Agriculture Organization and the National Cancer Institute, more than half of the meat Americans eat is red meat and nearly a quarter of it is processed (FAO 2009, Daniel 2010). Abundant scientific research now links consumption of these kinds of meats with a wide array of chronic diseases and serious health problems.

High consumption of red meat is also linked to increased mortality. A 2009 National Cancer Institute (NCI) study of 500,000 Americans found that people who ate the most red meat were 20 percent more likely to die of cancer and at least 27 percent more likely to die of heart disease than those who ate the least. In women who consumed the most meat, the risk of dying from cardiovascular disease was 50 percent higher (Sinha 2009).

The study authors concluded that "11 percent of deaths in men and 16 percent of deaths in women could be prevented if people decreased their red meat consumption to the level of intake" of the group who ate the least. (Sinha 2009).

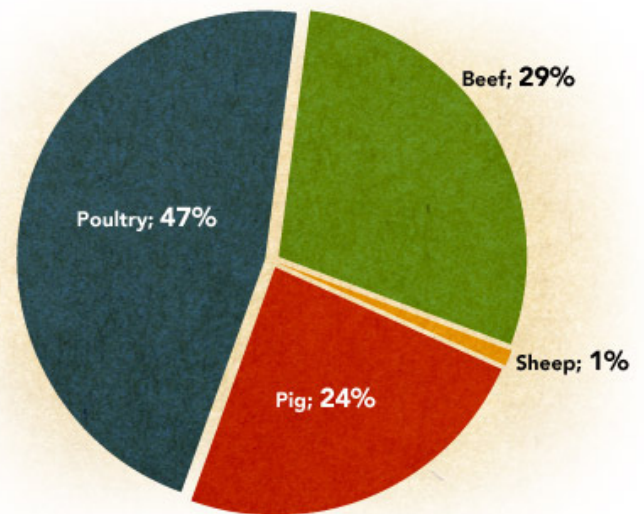
Similarly, a 10-year study by the Karolinska Institutet in Sweden found that women who consumed more than 3.6 ounces of red or processed meat a day were 42 percent more likely to suffer a stroke than those who ate less than one ounce (Larsson 2011).

Scientists at the University of Hawaii found that the risk of type-2 diabetes was 43 percent higher among men and 30 percent higher among women who consumed the most red meat, compared to those who ate the least. Men who ate the most processed meat had a 57 percent higher risk of developing type-2 diabetes, and women had a 45 percent higher risk, compared with those who ate the least (Steinbrecher 2010).

A separate seven-year study of almost 200,000 people conducted by the University of Hawaii found that those who ate the most processed meats had a 67 percent higher risk of pancreatic cancer than those who ate little or no processed meat (Nöthlings 2005). In a review of more than 7,000 clinical studies of the links between diet and cancer, the World Cancer Research Foundation (WCRF) found “convincing evidence” that red meats and processed meats are a cause of colorectal cancer (WCRF 2007).

This research is just the tip of the iceberg. In 2009 and 2010 alone, the National Cancer Institute published studies linking red and/or processed meat to esophageal, bladder, breast and lung cancer (Ferrucci 2009, 2010, Lam 2009, Cross 2010). The evidence linking red and processed meat to colon and prostate cancer is so strong that the American Cancer Society advises people to limit consumption of these meats.

**Figure 7. US Meat Consumption, 2009**



**The American Cancer Society (ACS) advises people to limit intake of processed meats and red meats in order to decrease risk of colon and prostate cancer. The American Institute for Cancer Research (AICR) and the American Dietetic Association recommend limiting red meat to 18 ounces (ADA 2010) a week. AICR further recommends cutting out all processed meat (ACS 2010, AICR 2010).**

## Other Meat Concerns: Antibiotics, Hormones and Toxins

### Antibiotics

In the unsanitary conditions typical of confined feedlots used to fatten livestock, animals are routinely given continual low doses of antibiotics in feed to prevent sickness, promote faster growth and boost profits. The sheer volume of antibiotics being used may pose serious risks to public and environmental health, primarily because it may contribute to antibiotic resistance in pathogens that cause illness in people (Chee-Sanford 2009, Shea 2004).

Antibiotics used this way get into the environment via soil and water, often from animal waste that is either stored or spread on fields. Once in the water, these drugs can get into people (Chee-Sanford 2009). A 2007 study by scientists at the University of Illinois found that genes that conferred resistance to the widely used antibiotic tetracycline had transferred from bacteria in waste pools of hog manure into the bacteria in nearby water wells (Koike 2007). Groundwater is an important source of public drinking water. Lead researcher Dr. Roderick Mackie commented, “At this stage, we’re not really concerned about who’s got these genes. If the genes are there, potentially they can get into the right organism at the right time and confer resistance to an antibiotic that’s being used to treat disease” (University of Illinois 2007).

According to an analysis of U.S. Food and Drug Administration data by the Johns Hopkins University’s

Center for a Livable Future, 80 percent of the antibiotics sold in 2009 were for use on livestock and poultry, and only 20 percent was for human medical use (Center for a Livable Future 2010). In 2010, the FDA said in a non-enforceable “guidance” that because “antimicrobial drug use contributes to the emergence of drug-resistant organisms, these important drugs must be used judiciously in both animal and human medicine.” It urged strict limits on antibiotic use in livestock (FDA 2010).

The FDA has tried for decades to restrict the use of antibiotics for non-therapeutic uses but has been stymied repeatedly by Congress (Harris 2010). At a 2010 press conference, former Principal Deputy Commissioner Joshua M. Sharfstein said the FDA believes “this is a public health issue of some urgency” (Harris 2010).

### Hormones

Residues of artificial hormones that are widely used to promote growth in beef cattle, dairy cows and sheep may also increase the risk of cancer in humans and lead to higher rates of infection in animals. Many studies have found increased risk of breast, prostate and colorectal cancer associated with higher levels of insulin-like growth factor-1 (IGF-1) in blood and serum (Yu 2000, Hansen 1997). Recombinant bovine somatotropin (rBST), also known as rBGH, causes a significant increase in IGF-1 levels in milk from treated cows (Hansen 1997). Further, rBST-treated cows suffer higher rates and more severe cases of udder tissue inflammation and infection (mastitis), which requires increased use of antibiotics (Craven 1991, Pell 1992, FDA 1993, Monsanto 1993, Kronfeld 1997).

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Using hormones this way is banned in most European countries and in Australia, Japan, and New Zealand and is not permitted in U.S. pork or poultry products, but it is common in U.S. beef cattle, dairy cows and sheep (Clancey 2006, USDA 2011).

More than a decade ago, scientists in Europe raised serious concerns about a wide range of potential health effects related to hormone use in livestock, particularly in the U.S. In 1999, the European Union's Scientific Committee for Veterinary Measures Relating to Public Health said in a press release that six commonly used growth hormones had the potential to cause "endocrine, developmental, immunological, neurobiological, immunotoxic, genotoxic and carcinogenic effects," adding that "even exposure to small levels of residues in meat and meat products carries risks, and no threshold levels can be established for any of the six substances" (EU 1999). The EU subsequently banned imports of U.S. beef because of scientific concerns about hormones, but the U.S. government successfully challenged the ban in the World Trade Organization.

## Toxins

A number of widespread environmental toxins build up in animal tissues and are found in meat, sometimes at high levels. According to the FDA, "studies suggest that exposure to dioxin-like compounds (DLCs) may lead to a variety of adverse health effects, including reproductive and developmental problems, cardiovascular disease, increased diabetes and increased cancer. Because DLCs tend to accumulate in the fat of food-producing animals, consumption of animal-derived foods (e.g., meat, poultry, eggs, fish and

dairy products) is considered to be the major route of human exposure to low levels of DLCs." (FDA 2004a) According to the FDA, most human exposure to dioxins comes from food, with 95 percent of that coming from animal fats (FDA 2004a).

Among fish, tuna and farmed salmon are of particular concern. A 2004 analysis of two metric tons of farmed and wild salmon purchased from stores around the world showed consistently and significantly higher concentrations of PCBs, dioxins, and the widely banned insecticides toxaphene and dieldrin in farmed salmon (Hites 2004). EWG's tests of farmed salmon from U.S. stores support this finding. On average, the farmed salmon had 16 times the dioxin-like PCBs found in wild salmon, four times the levels of beef, and 3.4 times the levels found in other seafood (EWG 2000). Mercury contamination of seafood is also a well-documented problem. According to the FDA, "Nearly all fish and shellfish contain traces of methyl mercury. However, larger fish that have lived longer have the highest levels of methyl mercury because they've had more time to accumulate it. These large fish (swordfish, shark, king mackerel and tilefish) pose the greatest risk" (FDA 2004b).

*"The best way to reduce your personal dioxins level and your potential risks from dioxins is to reduce dietary exposures to dioxins."*

- U.S. Food and Drug Administration

## Why Go Organic, Grass-Fed and Pasture-Raised?

### Health Benefits

A considerable number of studies show that grass-fed beef has less fat and more nutrients than far more common and less expensive grain-fed beef (Duckett 1993, 2009; Rule 2002; UCS 2006). A 2009 study comparing both types found that grass-fed beef had lower total saturated and mono-unsaturated fat, more heart healthy omega-3 fatty acids, a lower (and healthier) ratio of omega-6 to omega-3 fatty acids, and higher levels of vitamin E, beta-carotene and B-vitamins (Duckett 2009). Choosing certified organic and/or grass-fed products reduces your exposure to traces of sub-therapeutic antibiotics and artificial hormones that are given to conventionally raised animals. Going organic also reduces exposure to toxins from pesticides that might accumulate in animal fat.

### Lower Risk of Disease

Food from free-range, pasture-raised animals may also reduce the risk of bacterial contamination. A 2007 study found that the prevalence of fecal salmonella in open-pasture chicken farms was about half that of conventional farms (16 percent versus 30 percent) (Siemon 2007). Other studies have found that grass-fed cattle carry less E. coli overall than grain-fed, confined animals (Russell 2000, Bailey 2003). Organically raised meat may also be safer. A recent USDA-funded study found that salmonella prevalence

in fecal samples from organic poultry farms was significantly lower than in samples from conventional farms (6 percent versus 39 percent). Similarly, only 5 percent of organic feed samples were contaminated with salmonella, versus 28 percent of conventional feed samples (Alal 2010).

### Environmental Benefits

Well-managed grazing and grass-fed operations are better for the environment. They use fewer energy-intensive inputs and, by regularly moving animals to fresh pasture and keeping them away from streambeds, they spread the manure more evenly and improve the quality and quantity of forage growth. This helps to conserve soil, reduce erosion and water pollution, increase carbon sequestration and preserve biodiversity and wildlife (Johnson 2002, FAO 2009, Pelletier 2010). Organic feed production and grazing practices are also better for the environment. They reduce fertilizer and pesticide runoff into waterways, and the use of compost, cover-cropping and rotational grazing helps build healthy, productive and water-conserving soils. Organic methods also enhance pest and weed resistance without the use of chemicals and ultimately foster greater resiliency in the face of extreme weather and climate change.

*“Exposure to antibiotics, growth hormones, and toxic run-off from livestock feed lots can be minimized by eating free-range meat raised without these medications if it is available.”*

- President’s Cancer Panel,  
Annual Report 2008-09.

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## Climate Impact

There are few definitive studies of the net amount of greenhouse gas emissions from grass-fed versus confined-feedlot, grain-fed meat. Since pasture-raised cattle gain weight more slowly than grain-fed animals (an average of 25 percent slower in one recent study (Gurian-Sherman 2011), those animals take longer to reach slaughter weight and consequently emit more methane and nitrous oxide. Confined cattle gain weight much more quickly on their high-starch corn feed.

These higher emissions may be offset, however, by the carbon sequestration benefits that well-managed pasture systems can provide (Pelletier 2010). Rotational grazing and the application of organic soil treatments can have a significant impact on building up soil carbon in pastureland (Follet 2001, Conant 2001). Far fewer energy-intensive inputs are used in grass-fed beef production.

The climate impact of grass-fed animals depends on factors that vary greatly from one production system to another. They include: average weight gain and quality of forage (the slower the animals gain weight, the more methane they emit); the rate of soil carbon sequestration; and crowding (greater density of animals means more concentrated manure deposits and higher methane and nitrous oxide emissions).

Much more research is needed to determine the comparative climate impact of pasture-based versus confined feedlot systems.

## Conclusion

### **Eating Less, Greener and Healthier Meat is Good for Your Health and the Planet**

Climate impacts are just one factor in choosing what to eat. There are many compelling health, environmental and animal-welfare reasons to eat less meat and to opt for meat from organic, pasture-raised, grass-fed animals. It may cost more, but when you buy less meat overall you can afford healthier, greener meat.

Eating and wasting less meat (especially red meat) and cheese can simultaneously improve our health and reduce the climate and environmental impact of food. Choosing grass-fed, free-range, pasture-raised and/or organic products also helps to expand market demand. As the market grows, more farmers and ranchers will choose more sustainable and humane production methods, which in turn will make these products more affordable and available.

Choosing healthier, greener food is important, but significantly cutting the greenhouse gas emissions that contribute to climate change will also require governmental action. We all need to get engaged to push for comprehensive public policies that put the nation on a path to greener energy. Reducing meat production's negative impacts on soil, air and water will take stronger regulatory enforcement and better policies – in addition to significant changes in meat consumption habits.

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– Kari Hamerschlag

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## Footnotes

1- The analysis calculated the carbon dioxide equivalents of methane and nitrous oxide emissions based on their global warming potential (GWP), the warming effect relative to carbon dioxide over a 100-year time frame.

2- EWG analysis based on data from: <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?jsessionid=39589A84B623FB18D319BF97277F79C?documentID=1560>. Application rates for hay are based on California rates of pesticide application from: <http://www.pesticideinfo.org/DS.jsp?sk=23001#TopRegions>

3- EWG analysis based on data from: Table 2 @ <http://www.ers.usda.gov/Data/FertilizerUse/>, hay application rates from <https://cru84.cahe.wsu.edu/ItemDetail.aspx?ProductID=15009&SeriesCode=&CategoryID=131&Keyword>, and nutrient application rates at: <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?jsessionid=39589A84B623FFB18D319BF97277F79C?documentID=1560> for sorghum, barley and oats.

4- EWG analysis based on EWG farm subsidy database. Accessed at <http://www.farm.ewg.org>

5- US EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008. US Environmental Protection Agency. 430-R-10-006. April 2010. Accessed at: [http://www.epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010\\_Chapter2-Trends](http://www.epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010_Chapter2-Trends)

6- EWG analysis of “EPA data in Specific State Probable Sources that make up the National Agriculture Probable Source Group,” accessed on Nov. 30, 2010 at [http://iaspub.epa.gov/tmdl\\_waters10/attains\\_nation.cy.source\\_detail?p\\_source\\_group\\_name=AGRICULTURE](http://iaspub.epa.gov/tmdl_waters10/attains_nation.cy.source_detail?p_source_group_name=AGRICULTURE)

7- CleanMetrics calculations are based on retail and consumer waste on ERS loss-Adjusted Food Availability data accessed at: <http://www.ers.usda.gov/Data/FoodConsumption/FoodGuideSpreadsheets.htm> as well as recently revised consumer food loss estimates from USDA’s January 2011 Technical Bulletin “Consumer-Level Food Loss Estimates and Their Use in the ERS Loss-Adjusted Food Availability”

8- Ibid

9- According to EWG calculations, if everyone in the US went vegetarian and there was a corresponding reduction in meat production of that same amount, it would be the equivalent of removing about 255 million metric tons of carbon from the atmosphere. That represents 4.5 percent of total 2009 US emissions (5,618 million metric tons) (EPA 2011). EWG calculations are based on recently revised

per capita meat consumption estimates from USDA’s January 2011 Technical Bulletin, “Consumer-Level Food Loss Estimates and Their Use in the ERS Loss-Adjusted Food Availability Data, and daily meat intake. Calculation assumes the following: US population 309,050,816 (2010 Census data); weighted average of 1 kg of meat = 15.34 CO<sub>2</sub>e; weighted average of 1 kg of vegetable protein = 2.14 CO<sub>2</sub>e. Average daily meat consumption of 6.4 ounces (USDA 2011) is replaced by a vegetarian meal with equivalent protein content. 2.80 kg CO<sub>2</sub>e - .53 kg CO<sub>2</sub>e = 2.27 CO<sub>2</sub>e saved per day. 2.27\*52 = 118 kg (0.118 metric tons) CO<sub>2</sub>e saved per person for going meatless one day week. Total US population going meatless 7 days a week is calculated as follows: 0.118\*309,050,816\*7 = 255,275,974 metric tons = 554,947,769,600 miles driven. Miles are calculated based on assumption of 20 mpg, 12,000 miles a year and 0.46 kg CO<sub>2</sub>/mile driven as per EPA guidance: <http://www.epa.gov/OMS/climate/420f05004.htm>

10- The line dry calculation is based on average single household energy consumption, EPA website. [http://www.epa.gov/climatechange/emissions/ind\\_calculator2.html#c=waste&p=reduceAtHome&m=calc\\_WYCD](http://www.epa.gov/climatechange/emissions/ind_calculator2.html#c=waste&p=reduceAtHome&m=calc_WYCD); Accessed February 2011:

11- Ibid

12- EWG calculation assumes replacing the consumption of an 8-ounce steak with 8 ounces of vegetable protein as follows: 6.1 (CO<sub>2</sub>e of 8 ounces beef) - .48 (8 ounces of vegetable protein) = 5.62 kg CO<sub>2</sub> saved per person for each day of replacing meat with protein. 5.6\*52 = 292 kgs = .29 metric tons saved replacing steak one day a week over one year. 29 metric tons = 639 miles (see above)\*4 = 2,557 miles (nearly three months of driving) if family of four skips steak once a week.

13- EWG assumes replacement of average per capita meat and cheese consumption with a vegetable meal of equivalent protein content. The calculation is as follows: 3.19 CO<sub>2</sub>e - .60 CO<sub>2</sub>e = 2.59 kg saved per day. 2.59\*52=135 kg CO<sub>2</sub>e = 0.135 metric tons. Entire US population going meatless and cheese-less one day a week over a year: 0.135\*309050816 = 41,421,860 metric tons = 90,699,696,000 miles driven = 7,558,308 cars off the road.

## References

- ACS (American Cancer Society). 2010. Learn About Cancer. Diet and Physical Activity: What's the cancer connection? <http://www.cancer.org/Cancer/CancerCauses/DietandPhysicalActivity/diet-and-physical-activity-whats-the-cancer-connection>
- ADA (American Dietetic Association). 2010. Diet and Cancer Prevention. Accessed online on 7/12/11 <http://www.eatright.org/Public/content.aspx?id=9904&terms=red+meat+intake>
- AICR (American Institute for Cancer Research). 2010. Red and Processed Meats: the Cancer Connection. Accessed online on 7/12/11. [http://www.aicr.org/site/PageServer?pagename=elements\\_red\\_processed\\_meat](http://www.aicr.org/site/PageServer?pagename=elements_red_processed_meat)
- Alali WQ, Thakur S, Berghaus RD, Martin MP. 2010. Prevalence and Distribution of Salmonella in Organic and Conventional Broiler Poultry Farms. *Foodborne Pathogens and Disease*, 7(11):1363-71.
- CDC (Centers for Disease Control and Prevention). 2009a. State Indicator Report on Fruits and Vegetables, 2009. Accessed online on 7/12/11 [http://www.fruitsandveggiesmatter.gov/health\\_professionals/statereport.html#Background](http://www.fruitsandveggiesmatter.gov/health_professionals/statereport.html#Background)
- CDC (Centers for Disease Control and Prevention). 2009b. How to Use Fruits and Vegetables to Help Manage Your Weight. Accessed online on 7/12/11 [http://www.cdc.gov/healthyweight/healthy\\_eating/fruits\\_vegetables.html](http://www.cdc.gov/healthyweight/healthy_eating/fruits_vegetables.html)
- Center for a Livable Future. 2010. New FDA Numbers Reveal Food Animals Consume Lion's Share of Antibiotics. December 23, 2010. Accessed online on 7/12/11 <http://www.livablefutureblog.com/2010/12/new-fda-numbers-reveal-food-animals-consume-lion%E2%80%99s-share-of-antibiotics/>
- Chee-Sanford JC, Mackie RI, Koike S, Krapac IG, Lin YF, Yannarell AC, Maxwell S, Aminov RI. 2009. Fate and Transport of Antibiotic Residues and Antibiotic Resistance Genes
- Following Land Application of Manure Waste, *J Environ Qual*. Apr 27;38(3):1086-108.
- Clancy K, 2006. Greener Pastures: How Grass-fed Beef and Milk Contribute to Healthy Eating. Union of Concerned Scientists. [http://www.ucsusa.org/assets/documents/food\\_and\\_agriculture/greener-pastures.pdf](http://www.ucsusa.org/assets/documents/food_and_agriculture/greener-pastures.pdf)
- Conant RT, Six J, Paustian K. 2002. Land Use Effects on Soil Carbon Fractions in the Southeastern United States I: Management intensive versus extensive grazing. *Biology and Fertility of Soils*. 38(6):386-92.
- Craig WJ, Mangels AR. 2009. Position of the American Dietetic Association: Vegetarian Diets. *Journal of the American Dietetic Association* 109(7):1266-82.
- Craven N. 1991. Milk Production and Mastitis Susceptibility: genetic relationships and influence of bovine somatotropin treatment. Pages 55-59. In: J. Espinasse (Ed.) *Mammites des Vaches Laitieres*. Toulouse, France: Polygone.
- Cross AJ, Freedman ND, Ren J, Ward MH, Hollenbeck AR, Schatzkin A, Sinha R, Abnet CC. 2011. Meat Consumption and Risk of Esophageal and Gastric Cancer in a Large Prospective Study. *Am J Gastroenterol* 106(3):432-42.
- Daniel CR, Cross AJ, Koebnick C, Sinha R. 2011. Trends in meat consumption in the USA. *Public Health Nutr*. 14(4): 575-83.
- Duckett, SK, Wagner DG, et al. 1993. Effects of Time on Feed on Beef Nutrient Composition. *J Anim Sci* 71(8): 2079-88.
- Duckett SK, et al. 2009. Effects of Winter Stocker Growth Rate and Finishing System on: III. Tissue proximate, fatty acid, vitamin and cholesterol content. *J. Anim Sci*. 87(9): 2961-70.
- Elam TE. 2006. Projections of Global Meat Production Through 2050. Center for Global Food Issues. <http://farmecon.web.officelive.com/Documents/Projections%20of%20Global%20Meat%20Production%20Through%202050.pdf>
- EPA (US Environmental Protection Agency). 2011. Inventory of US Greenhouse Gas Emissions and Sinks 1990 – 2009. [http://www.epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Complete\\_Report.pdf](http://www.epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Complete_Report.pdf)

EPA (US Environmental Protection Agency). 2009. The Facilities with Total TRI On- and Off-site Disposal or Other Releases, 2009: Food/Beverages/Tobacco

(NAICS 311/312). <http://www.epa.gov/tri/tridata/tri09/nationalanalysis/tablesandcharts/2009TRIWorkbookSectionC.pdf>

EPA (US Environmental Protection Agency). 2007. FY08–FY10. Compliance and Enforcement National Priority: Clean Water Act, Wet Weather, Concentrated Animal Feeding Operations (CAFOs). <http://epa.gov/compliance/resources/publications/data/planning/priorities/fy2008prioritycwa.pdf>

EPA (US Environmental Protection Agency). 1994. Estimating Exposure to Dioxin-Like Compounds, Vol. II: Properties, Sources, Occurrence and Background Exposures. Review Draft. U.S. EPA, Office of Research and Development. EPA/600/6-88/005Cb, June 1994.

EPA (US Environmental Protection Agency). 2010. EPA Water Quality Assessments and Maximum Daily Loads Information: Probable Sources that make up the National Agriculture Probable Source Group. [http://iaspub.epa.gov/tmdl\\_waters10/attains\\_nation.cy.source\\_detail?p\\_source\\_group\\_name=AGRICULTURE](http://iaspub.epa.gov/tmdl_waters10/attains_nation.cy.source_detail?p_source_group_name=AGRICULTURE)

European Union. 1999. Abusive Use and Difficulties of Controls of Growth Hormones Increase Risks. May 3, 1999. Brussels. Accessed online 7/12/11 <http://www.trade.ec.europa.eu/doclib/html/114722.htm>

European Union Health and Consumer Protection Directorate – General. 1999. Growth Hormones in Meat Pose Risk to Consumers – Different Levels of Evidence. Accessed online 7/12/11 [http://ec.europa.eu/dgs/health\\_consumer/library/press/press24\\_en.html](http://ec.europa.eu/dgs/health_consumer/library/press/press24_en.html)

FAO (Food and Agriculture Organization). 2009. The State of Food and Agriculture. Food and Agriculture Organization of the United Nations. Rome. Accessed online 7/12/11 <http://www.fao.org/docrep/012/i0680e/i0680e00.htm>

Gurian-Sherman D. 2011. Raising the Steaks: Global Warming and Pasture-Raised Beef Production in the United States. Union of Concerned Scientists, Washington DC.

Hansen M, Halloran, JM, Groth E III, and Lefferts L. 1997. Potential Public Health Impacts of the Use of Recombinant Bovine Somatotropin in Dairy Production. (Prepared for a Scientific Review by the Joint Expert Committee on Food Additives). Consumers Union. Accessed online 7/12/11 <http://www.consumersunion.org/pub/>

[core\\_food\\_safety/002272.html](http://www.fda.gov/oc/ohrt/core_food_safety/002272.html)

Harris G. 2010. “Antibiotics in Animals Need Limits, F.D.A.” New York Times. June 28 2010. Accessed online 7/12/11 <http://www.nytimes.com/2010/06/29/health/policy/29fda.html>

Hites R, et al. 2004. Global Assessment of Organic Contaminants in Farmed Salmon. *Science* 303(5655): 226-229.

Houlihan J. 2003. PCBs in Farmed Salmon. Environmental Working Group. Accessed online 7/12/11 <http://www.ewg.org/reports/farmedpcbs>

Ferrucci LM, Sinha R, Ward MH, Graubard BI, Hollenbeck AR, Kilfoy BA, Schatzkin A, Michaud DS, Cross AJ. 2010. Meat and Components of Meat and the Risk of Bladder Cancer in the NIH-AARP Diet and Health Study. *Cancer*. 15;116(18):4345-53.

Ferrucci LM, Cross AJ, Graubard BI, Brinton LA, McCarty CA, Ziegler RG, Ma X, Mayne ST, Sinha R. 2009. Intake of Meat, Meat Mutagens, and Iron and the Risk of Breast cancer in the Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial. *Br J Cancer*. 101(1):178-84.

Follett RF, Kimble JM, Lal R. 2001. The Potential of U.S. Grazing Lands to Sequester Carbon and Mitigate the Greenhouse Effect. Lewis Publishing, Washington, DC.

FDA (Food and Drug Administration), Center for Veterinary Medicine. 2010. Draft Guidance: The Judicious Use of Medically Important Antimicrobial Drugs in Food-Producing Animals. Issued June 28, 2010. Accessed online 7/12/11 <http://www.fda.gov/downloads/AnimalVeterinary/GuidanceComplianceEnforcement/GuidanceforIndustry/UCM216936.pdf>

FDA (Food and Drug Administration). 2010. Questions and Answers about Dioxins. Accessed online 7/12/11 <http://www.fda.gov/Food/FoodSafety/FoodContaminantsAdulteration/ChemicalContaminants/DioxinsPCBs/ucm077524.htm#g4>

U.S. Department of Health and Human Services,

FDA (Food and Drug Administration). 2009. Summary Report on Antimicrobials Sold or Distributed for Use in Food-Producing Animals. Accessed online 7/12/11 <http://www.fda.gov/downloads/ForIndustry/UserFees/AnimalDrugUserFeeActADUFA/UCM231851.pdf>

- FDA (Food and Drug Administration). 2007. Updated Dioxin Analysis Results/Exposure Estimates. Accessed online 7/12/11 <http://www.fda.gov/Food/FoodSafety/FoodContaminantsAdulteration/ChemicalContaminants/DioxinsPCBs/ucm077444.htm>
- FDA (Food and Drug Administration). 2004b. What You Need to Know About Mercury in Fish and Shellfish. Accessed online 7/12/11 <http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/Seafood/FoodbornePathogensContaminants/Methylmercury/ucm115662.htm>
- FDA (Food and Drug Administration). 1993. Freedom of Information Summary. POSILAC (sterile sometribove zinc suspension) for increasing production of marketable milk in lactating dairy cows. November, 1993.
- Fraser GE. 2008. Vegetarian diets: what do we know of their effects on common chronic diseases? *American Journal of Clinical Nutrition* 89(5): 1607S-1621S.
- Fulgani V. 2008. Current protein intake in America: analysis of the National Health and Nutrition Examination Survey, 2003–2004. *Am J Clin Nutr.* 87(Suppl):1554S–7S.
- Jacobs DR, Haddad EH, Lanou AJ, Messina MJ. 2009. Food, Plant Food, and Vegetarian Diets in the US Dietary Guidelines: Conclusions of an Expert Panel. *American Journal of Clinical Nutrition* 89(5): 1549S-1552S.
- Johnson DE, Phetteplace HW, Seidl AF, Schneider UA, McCarl BA. 2003. Management Variations for U.S. Beef Production Systems: Effects on greenhouse gas emissions and profitability. Proceedings of the 3rd International Methane and Nitrous Oxide Mitigation Conference; 17–21 November 2003; Beijing, China. Beijing: China Coal Information Institute. 953-61. <http://www.coalinfo.net.cn/coalbed/meeting/2203/papers/agriculture/AG047.pdf>
- Johnson DE, Phetteplace HW, Seidl AF. 2002. Methane, Nitrous Oxide and Carbon Dioxide Emissions from Ruminant Livestock Production Systems. In *Greenhouse Gases and Animal Agriculture* (eds J. Takahashi & B. A. Young). Amsterdam, The Netherlands: Elsevier. <http://www.agron.iastate.edu/courses/agron515/Johnson-methane.pdf>
- Koike S, Krapac IG, Oliver HD, Yannarell AC, Chee-Sanford JC, Aminov RI, Mackie RI. 2007. Monitoring and Source Tracking of Tetracycline Resistance Genes in Lagoons and Groundwater Adjacent to Swine Production Facilities over a 3-Year Period. *Applied and Environmental Microbiology*. 73(15):4813-23.
- Kimmons J, Gillespie C, Seymour J, Serdula M, Blanck HM. 2009. Fruit and vegetable Intake Among Adolescents and Adults in the United States: Percentage meeting individualized recommendations. *Medscape J Med.* 11(1):26.
- Kronfeld, DS. 1994. Health Management of Dairy Herds Treated with Bovine Somatotropin. *Journal of the American Veterinary Medical Association*, 204(1): 116-130.
- Kümmerer, K. 2004. Resistance in the environment. *J. Antimicrob. Chemoth.* 54, 311–320.
- Lam TK, Cross AJ, Consonni D, Randi G, Bagnardi V, Bertazzi PA, Caporaso NE, Sinha R, Subar AF, Landi MT. 2009. Intakes of Red Meat, Processed Meat, and Meat Mutagens Increase Lung Cancer Risk. *Cancer Res.* 69(3):932-9.
- Larsson SC, Virtamo J, Wolk A. 2011. Red Meat Consumption and Risk of Stroke in Swedish Women. *Stroke.* 42: 324-329.
- Lorson BA, Melgar-Quinonez HR, Taylor CA. 2009. Correlates of Fruit and Vegetable Intakes in US children. *Journal of the American Dietetic Association* 109(3): 474-78.
- Monsanto. 1993. Technical Manual for Posilac. Monsanto Company, St. Louis, Missouri.
- Muth M, Karns SA, Nielsen SJ, Buzby JC, Wells HF. 2011. Consumer-Level Food Loss Estimates and Their Use in the ERS Loss-Adjusted Food Availability Data. Technical Bulletin Number 1927, US Department of Agriculture, Economic Research Service. January 2011.
- Nöthlings U, Wilkens LR, Murhhy SP, Hankin, JH, Henderson BE, Kolonel N. 2005. Meat and Fat Intake as Risk Factors for Pancreatic Cancer: The Multiethnic Cohort Study, *Journal of the National Cancer Institute.* 97 (19): 1458-1465.
- Pell AN, Tsang DS, Howlett BA, Huylet MT, Meserole VK, Samuels WA, Hartnell GF, Hintz RL. 1992. Effects of a Prolonged-Release Formulation of Sometribove (n-Methionyl Bovine Somatotropin) on Jersey cows. *Journal of Dairy Sciences*, 75: 3416-3431.
- Pelletier N, Pirog R, Rasmussen R. 2010. Comparative Life Cycle Environmental Impacts of Three Beef Production Strategies in the Upper Midwestern United States in Agricultural Systems. [http://www.leopold.iastate.edu/research/marketing\\_files/Pelletier\\_Agricultural\\_Systems\\_beef.pdf](http://www.leopold.iastate.edu/research/marketing_files/Pelletier_Agricultural_Systems_beef.pdf)

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Rule DC, Broughton KS, Shellito SM, Maiorano G. 2002. Comparison of Muscle Fatty Acid Profiles and Cholesterol Concentrations of Bison, Beef Cattle, Elk, and Chicken. *J Anim Sci* 80(5):1202-11.

Yu H, Rohan T. 2000. *Journal of the National Cancer Institute*. Role of the Insulin-Like Growth Factor Family in Cancer Development and Progression. 92 (18): 1472-1489.

Shea KM. 2004. Nontherapeutic Use of Antimicrobial Agents in Animal Agriculture: Implications for Pediatrics. *Pediatrics* 114:3 862-868.

Sinha R, Park Y, Graubard BI, Leitzmann MF, Hollenbeck A, Schatzkin A, Cross AJ. 2009. Meat and Meat-related Compounds and Risk of Prostate Cancer in a Large Prospective Cohort Study in the United States.

*Am J Epidemiol.* 1;170(9):1165-77.

Steinbrecher A, Erber E, Grandinetti A, Kolonel L, Maskarinec G. 2011. Meat Consumption and Risk of Type 2 Diabetes: the Multi-ethnic Cohort. *Public Health Nutrition.* 14(4):568-74.

UCS (Union of Concerned Scientists). 2006. Greener Pastures: How Grass-fed Beef and Milk Contribute to Healthy Eating. [http://www.ucsusa.org/assets/documents/food\\_and\\_agriculture/greener-pastures.pdf](http://www.ucsusa.org/assets/documents/food_and_agriculture/greener-pastures.pdf)

US Census Bureau, International Data Base, <http://www.census.gov/population/international/data/idb/worldpopgraph.php>

USDA (US Department of Agriculture). 2010. Livestock and Poultry Slaughter Tables. <http://www.ers.usda.gov/publications/ldp/LDPTables.htm> and <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do;jsessionid=92943DD4F9903FDAD302C6296C983D74?documentID=1097>

USDA (US Department of Agriculture). 2010. Loss Adjusted Food Availability Data Series. <http://www.ers.usda.gov/Data/FoodConsumption/>

USDA (US Department of Agriculture). 2010. USDA Fact Sheet: Meat and Poultry Labeling Terms. [http://www.fsis.usda.gov/factsheets/Meat & Poultry Labeling Terms/index.asp](http://www.fsis.usda.gov/factsheets/Meat%20&%20Poultry%20Labeling%20Terms/index.asp)

Weber CL, Matthews HS. 2008. Food-Miles and the Climate Impacts of Freight Transportation in American Food Consumption. *Environmental Science & Technology* 41(14): 4875–4881

World Cancer Research Foundation. 2007. Food, Nutrition, Physical Activity and the Prevention of Cancer: a Global Perspective. <http://www.dietandcancerreport.org/>