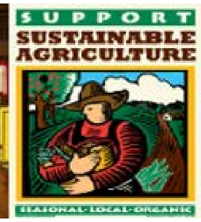
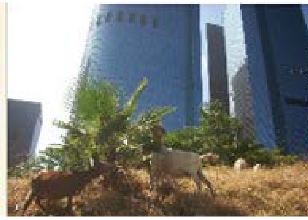
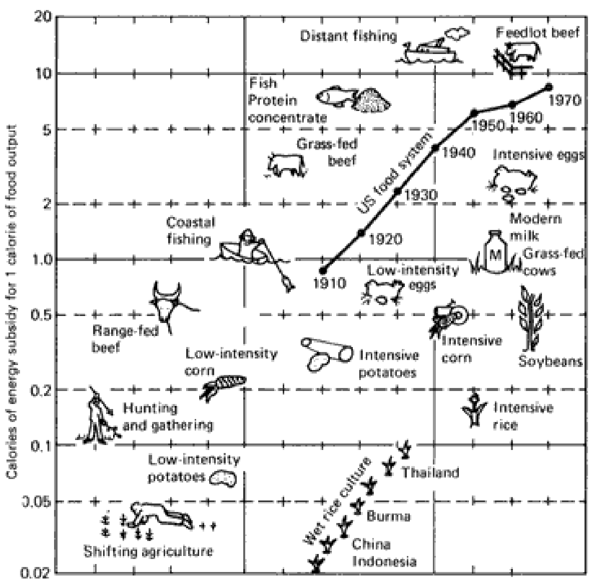
Sustainable Sustenance







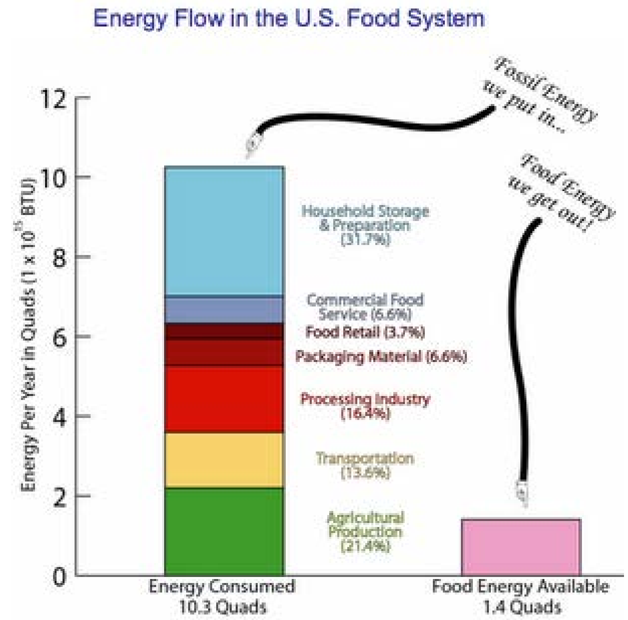
Origins of Energetic Inefficiency

The chart to the left shows how energy in food production has increased throughout human history (Clark). We have moved from the lower left-hand corner, where less than one calorie of input was needed to provide one calorie of food output, to the upper right hand corner, where twenty calories or more are needed to produce one food calorie. Humans first hunted and gathered to obtain food. This method required about one tenth of the energy in as it gained in energy out.

During the Neolithic Revolution, hunters and gatherers started to control their environment to provide a stable food supply. Over time, innovations such as crop rotation and seed selection increased output and decreased human energetic input. Though human energy input decreased, overall input increased due to the use of work animals and simple machinery. When New World explorers brought crops back to Europe, easy to cultivate potatoes and corn became important staples for a growing population.

Since the Industrial Revolution, farming techniques have become more economically efficient out of the need to provide for growing populations; however, the new farming techniques, based on cheap fossil fuels, are not sustainable. Mechanization of farming equipment has made production faster and requires less workers. However, our entire agricultural system is now based on the use of fossil fuels. At first, coal was the fossil fuel of choice in mechanized farming. Today, petroleum is required to run large, factory style farms. Some changes in farming techniques that increased production due to fossil fuels were man-made fertilizers, pesticides, increased irrigation, farming and processing machinery, and transportation of food over long distances.

In order to meet demand in the U.S., current food production uses about 50% of the country's land area, 80% of its fresh water, and 17% of its fossil energy (Pimentel *Sustainability of meat...*). The graph on the right shows our current system, where much more energy goes into production than we get out in calories. On average, the caloric input to output ratio for animal protein is 28:1 and 3.3:1 for plant protein (Pimentel *Sustainability of meat...*). This amount of energy input is not sustainable and needs to be changed to ensure future food security. This web page exists to provide information on status quo food production practices and lead consumers towards more sustainable sustenance systems.



Food Production Over Time

Hunting and Gathering | Neolithic Revolution | Developments up to the Industrial Revolution

Industrial Revolution to the 19th century | The 19th and 20th Centuries

Modern Farming and the Status Quo

Mass food production goes hand in hand with increased energy input, primarily in the form of fossil fuels.

Our modern system of intensive agriculture averages an input of 50 times more energy than traditional agriculture (Pimentel *Food and energy...*). A hectare of maize grown in the United States today has a 7,219,200 kcal input in a horse-based system and a 6,958,250 kcal input in a mechanized system (Pimentel *Food and energy...*). The mechanized system utilizes fossil fuels in place of horse power. In addition to mechanization, fossil fuels support the high use of fertilizer and pesticides, the need for processing, and the long distance transportation that comes with mass farming. For example, between 1.4 and 1.8 liters of diesel fuel are needed to produce 1 kilogram of nitrogen for fertilizer (Pfeiffer). Between 2001 and 2002, the U.S. used around twelve million tons of nitrogen fertilizer, which translates to 96.2 million barrels of diesel fuel (Pfeiffer).

The energy output for both horse-based systems and mechanized systems is 24.5 million kcals per hectare (Pimentel *Food and energy...*). The energy flow ratio of kcals in for kcals out is 3.4:1 for the horse-based system and 3.5:1 for the mechanized system (Pimentel *Food and energy*). The total energy input is similar for both systems, but the mechanized system's input comes from machines and agricultural products run off of and based on fossil fuels, while the horse-based system uses mainly animal and human energy. Traditional farming represents more of a closed loop: the farmer and the animals raise the food that then provides them with the energy to continue raising the food; therefore, horse-based systems are more sustainable. Mechanized systems need fossil fuels in order to function, creating a feed-in loop based on a finite energy source.

One of the most energetically expensive systems of our time is factory farmed meat. The production of beef is particularly inefficient, with an input to output ratio of 35-50:1 kcals. This extreme energetic expense is rarely recognized by consumers, because it is not reflected in the price at the supermarket. Instead, the Farm Bill subsidizes the production and even overproduction of grains used for feed such as corn, wheat, and soybeans. These crops are generally grown on mono-crop farms requiring fossil fuels in the form of fertilizer, irrigation, pesticides, and which then must be transported to the feedlot. These are then fed to cattle in confined animal feeding units (CAFOs) in order to fatten them as quickly as possible, even though cattle are meant to eat grass and forage. Feedlots themselves also receive government subsidies, diminishing the price further. These subsidies provide funds for running the CAFO and processing the animals, as well as "waste removal," which is often little more than dumping. There are also hidden energetic costs in this system. Waste from CAFOs pollutes important watersheds, causing eutrophication and making human drinking water unsafe. CAFOs also produce more CO_2 per year than all of the cars in the U.S. and release other harmful chemicals into the air. Because of dirty conditions, cattle feed in a CAFO generally includes antibiotics. This consistent use of antibiotics can lead to mutation of bacteria and strains of antibiotic resistant diseases. Another risk of dirty conditions that taxes health care is the spread of food borne illness. Factory farmed meat is also less nutritious than traditionally produced grass-fed meat. It contains more harmful fats, including those that contribute to heart disease, and less healthy Omega-3 fats. It also includes less vitamins and anti-oxidants than grass fed meat. Grass fed beef production is a much less energetically expensive system. Grass and forage is produced on-site and fertilized by manure, and cattle are kept outside in healthy conditions that do not require them to eat antibiotics. It is time that the true energetic costs of factory farmed beef became common knowledge. Consumers must become aware of what their consumption habits truly cost before becoming motivated to change them.

Similarly secretive, egg production in the U.S. mainly takes place behind closed bars. Literally. 95% of the 280 million chickens in the U.S. live in battery-cages; only five percent of egg producing hens live in an alternative, cage-free system. High demand for eggs and a work-for-profit attitude has made the barren battery cage system the most economically efficient method for keeping hens while meeting demand. However, the environment and confinement of the chickens produces severe health problems and the industrialization of the system and the distances necessary to transport the feed and the product is based on finite resources, fossil fuels. While smaller farms and cage-free farms require more land and might not be capable of producing enough eggs to meet demand, in terms of animal welfare and sustainability, there is no other viable option!

While animal production has become extremely focused on mono-cropping, so has produce production. Genetically uniform crops, such as large farms planted with just one type of corn, increase short-term yields (Understanding Evolution team). However, genetic uniformity makes the overall yield highly susceptible to food borne illness and environmental change. In the event of a disaster, large monetary losses or starvation are possible if the crop represents a society's main staple. Examples include Ireland in the 1800s, where the majority of the population survived off of one type of potato grown around the country; when a blight struck, one out of eight persons starved in the resulting famine. More recently, in 1970, the Midwestern U.S. corn crop was struck heavily by a fungus that had first appeared two years before, but went mostly unnoticed until it reached pandemic proportions, causing a loss of over a billion dollars. In 2003, the mad cow disease outbreak in the United States caused US beef exports to drop by almost 70%, roughly one million metric tons. The dangers of mass food production have been evident for centuries, and yet we are only now beginning to develop the systems necessary to address these problems, most recently in the form of the Food Safety and Modernization Act. Potential energy savings are an added benefit of streamlining the process of food inspection.

The system obviously needs to change and many changes are in process and being realized. One of the ways it is changing is the move towards small scale urban farming. Urban agriculture is not a new concept. In the 16th century, the Incan city Machu Picchu was terraced with produce to provide a portion of the city's food supply (x). It was also common in Persia and became popular in the 1940s as victory gardens/allotment gardens provided essential food during the world wars. In 1942 and 1943, victory gardens provided 40% of the vegetables consumed in the United States (Green For All). The benefit of urban gardens is greater than just war security, they also create food security. In the face of food deserts and the upcoming oil peak urban agriculture will create a sustainable food system for the future.

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Subpages (5): Developments up to the Industrial Revolution Hunting and Gathering Industrial Revolution up till the 19th century Neolithic Revolution The 19th and 20th Centuries

Comments

Alexandra Rempel - Oct 26, 2011 1:58 PM

Hi everyone - I'm running into some navigational glitches on the sidebar, with some "Page not found" warnings. Just wanted to let you know.

Alexandra Rempel - Nov 10, 2011 11:17 AM

Hi everyone - this is great progress! You have the makings of a wonderful story here, with lots of solid supporting material. Your research is excellent. The next step is to intensify your story line: what are the most important parts of your message, and why? What do you most want to impress upon your reader? This is your opportunity to convince him/her of the importance of your individual transition issues. You have the supporting facts; the next step is a matter of how you use them. Let's talk about this today.

Great new title! And this new diagram is *very* interesting - is it missing a horizontal axis? Where did it come from? It could even be moved higher in your discussion; it's got a lot to think about and could pull someone in by itself.

Alexandra Rempel - Dec 1, 2011 11:35 AM

Your graph at the bottom presents a truly astounding truth: that most American protein, and indeed most American food altogether, requires far more energy to produce it than it yields! It's a stunning statement of non-sustainability. Despite this, your story takes a rather quiet, matter-of-fact approach to setting forth a chronology of agriculture that could easily lose readers after a paragraph or two. It doesn't have to be this way. Your reader will be keenly interested to know how food got to be so dependent on fossil fuel that we now invest 10-20 calories for every calorie we get out, if you explain that to them first and then trace the food energy-in/ energy-out path for them through the rest. You have all the information you need; it's now a matter of framing it so that it's fascinating!

Alexandra Rempel - Dec 7, 2011 7:50 PM

The new introduction section is great!! Having the diagram right on top, and a clear and concise written explanation (nice job!), strengthens your message considerably. Do be sure to add citations in its text, as well. I would consider applying the same editing rigor to your paragraph underneath the photos - what do you really *need* to say there?

Then, rather than presenting the history as a long string below your fabulous intro, what would you think of linking the words "hunted and gathered" (in the first paragraph) to a sub-page with just the hunting and gathering paragraph (and maybe an image), then linking the phrase "Neolithic Revolution" (second paragraph) to its own subpage with the existing paragraph (and maybe an image), etc.?

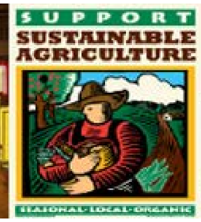
Then, you could use your fabulous introduction to lead directly into contemporary alternatives, thereby setting up your individual topics as logical extensions to this problem (and allowing you to take that part out of your text below your photo bar.)

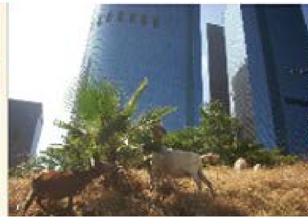
Alexandra Rempel - Dec 7, 2011 7:52 PM

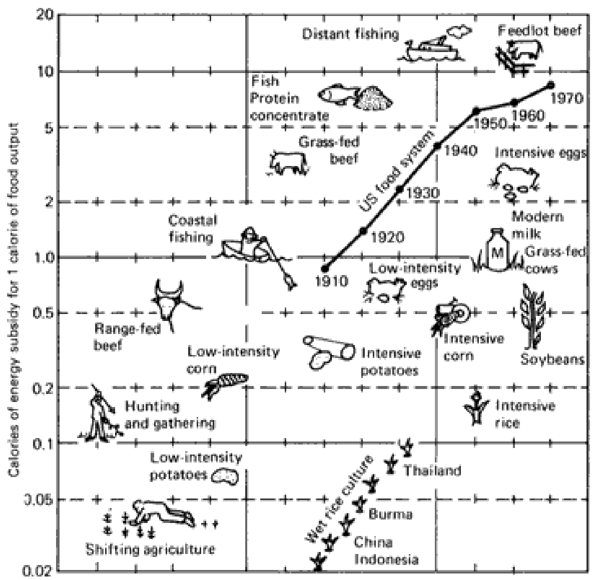
p.s. The history sub-pages wouldn't have to show up on the main title tab bar; also, you could use your intro + lead-in to contemporary issues to link to the Roundup-Ready story too. Could you call that page "Roundup Ready" rather than "Case Study"? It might get more attention that way. Good work!


PUBLIC MARKET
FARMERS MARKET
SUPPORT
SUSTAINABLE AGRICULTURE
SEASONAL·LOCAL·ORGANIC

Sustainable Sustenance







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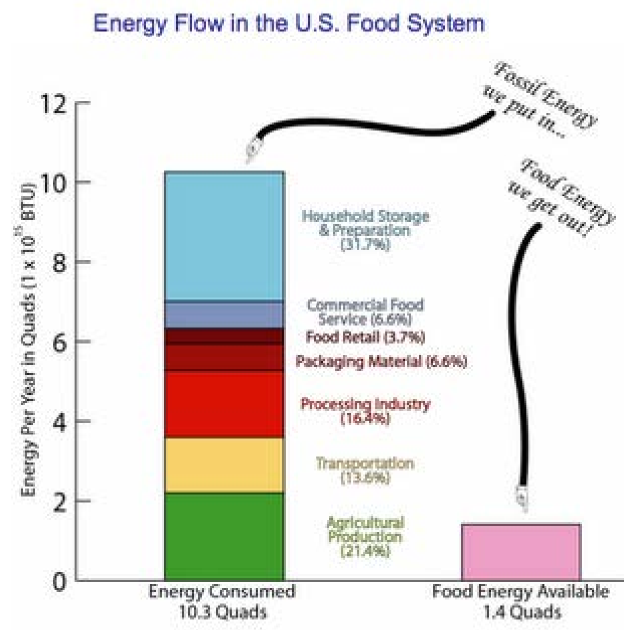

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Subpages (5): Developments up to the Industrial Revolution Hunting and Gathering Industrial Revolution up till the 19th century Neolithic Revolution The 19th and 20th Centuries

Comments

Alexandra Rempel - Oct 26, 2011 1:58 PM

Hi everyone - I'm running into some navigational glitches on the sidebar, with some "Page not found" warnings. Just wanted to let you know.

Alexandra Rempel - Nov 10, 2011 11:17 AM

Hi everyone - this is great progress! You have the makings of a wonderful story here, with lots of solid supporting material. Your research is excellent. The next step is to intensify your story line: what are the most important parts of your message, and why? What do you most want to impress upon your reader? This is your opportunity to convince him/her of the importance of your individual transition issues. You have the supporting facts; the next step is a matter of how you use them. Let's talk about this today.

Great new title! And this new diagram is *very* interesting - is it missing a horizontal axis? Where did it come from? It could even be moved higher in your discussion; it's got a lot to think about and could pull someone in by itself.

Alexandra Rempel - Dec 1, 2011 11:35 AM

Your graph at the bottom presents a truly astounding truth: that most American protein, and indeed most American food altogether, requires far more energy to produce it than it yields! It's a stunning statement of non-sustainability. Despite this, your story takes a rather quiet, matter-of-fact approach to setting forth a chronology of agriculture that could easily lose readers after a paragraph or two. It doesn't have to be this way. Your reader will be keenly interested to know how food got to be so dependent on fossil fuel that we now invest 10-20 calories for every calorie we get out, if you explain that to them first and then trace the food energy-in/ energy-out path for them through the rest. You have all the information you need; it's now a matter of framing it so that it's fascinating!

Alexandra Rempel - Dec 7, 2011 7:50 PM

The new introduction section is great!! Having the diagram right on top, and a clear and concise written explanation (nice job!), strengthens your message considerably. Do be sure to add citations in its text, as well. I would consider applying the same editing rigor to your paragraph underneath the photos - what do you really *need* to say there?

Then, rather than presenting the history as a long string below your fabulous intro, what would you think of linking the words "hunted and gathered" (in the first paragraph) to a sub-page with just the hunting and gathering paragraph (and maybe an image), then linking the phrase "Neolithic Revolution" (second paragraph) to its own subpage with the existing paragraph (and maybe an image), etc.?

Then, you could use your fabulous introduction to lead directly into contemporary alternatives, thereby setting up your individual topics as logical extensions to this problem (and allowing you to take that part out of your text below your photo bar.)

Alexandra Rempel - Dec 7, 2011 7:52 PM

p.s. The history sub-pages wouldn't have to show up on the main title tab bar; also, you could use your intro + lead-in to contemporary issues to link to the Roundup-Ready story too. Could you call that page "Roundup Ready" rather than "Case Study"? It might get more attention that way. Good work!

The Team

Tabit Xthona

Senior at the University of Oregon
Project: Urban Agriculture
Major: Human Physiology

Sarah Shindelman

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Energetic Efficiency of Genetically Modified Roundup Ready Soy

Question:

Is it more energetically efficient for large scale soybean farms to use genetically modified Roundup Ready soybeans (GM RR soy) or traditional soybeans?

Contents

Introduction

Within the last couple decades, the demand for soybeans, in addition to other staples such as wheat, corn and rice, has increased substantially with the expansion of the global market. The Monsanto Co.'s genetically modified soybeans resist harmful chemicals found in their herbicide product known as Roundup Ready, a combination of glyphosphate herbicide and fertilizer. The soybeans' resistance to the herbicide has allowed the Monsanto to build and maintain a monopoly in the soybean market. Though the partnership of GM RR soy and Roundup has been marketed as responsible and sustainable, the combination of the modified soy with the weed killer is energetically inefficient throughout the production process. In addition, according to a three year study conducted by Iowa State University, GM RR soy has a 5.4-7.6% lower yield than conventional soybeans for a variety of reasons, including an increased susceptibility to disease and a reduced ability to take in micro-nutrients. In spite of all of these detracting factors, Monosanto Co. retains its monopoly through a combination of patents, government subsidies, and underhanded business practices, making it the perfect case study of energetic inefficiency and lack of sustainability in agriculture.

History of Monosanto Co.

Founded in 1901, Monosanto began as a producer of the artificial sweetener saccharine. The company then bought its way into other chemical industries, becoming one of the leading producers of plastics by the 1940s. Monosanto Co. began producing herbicides and insecticides in 1944 with DDT, and, later, Agent Orange. Their scientists developed and patented the glyphosate molecule in 1970 and have been heavily marketing Roundup ever since. They retained exclusive rights to the molecule in the U.S. until its patent expired in 2000, yet have still maintained a predominant market share by enforcing related patents. Monosanto Co. pioneered the first genetically modified plant cell in 1982; five years later they conducted the first field tests of genetically engineered crops. To this day, they are the leading producer of genetically modified seed, maintaining their hold through patent lawsuits against other seed companies and requiring that farmers repurchase GM RR soy seed each season.

Nitrogen fixation in soy

Unmodified soybeans receive half of their required nitrogen from soil and the other half from the atmosphere through nitrogen fixation. The soy absorbs N2 gas through structural nodules in the roots, which work in tandem with the soil bacterium Bradyrhizobid Japonicum (BJ bacteria). The plant then converts this N2 gathered from its various sources to NH3, or ammonia, which it uses to sustain itself. Traditional soy therefore requires little fertilizer compared with corn or wheat (Figure 1).

If soy is deprived of its natural nitrogen fixation process, however, as in the case of GM RR soy, it requires just as much fertilizer as the other two grain staples, corn and wheat. Monosanto Co.'s patented triple combination of fertilizer, herbicide, and pesticide, known as Roundup, actually inhibits nitrogen fixation. Glyphosphates, the herbicides in Roundup, also kill the helpful BJ bacteria; the genetically modified Roundup Ready soybean's natural process of nitrogen fixation is replaced with the nitrogen from the Roundup fertilizer. Unmodified soybeans do not require supplemental nitrates, making them sustainable and energetically efficient compared to GM RR soy, which depends upon the continued presence of Roundup.

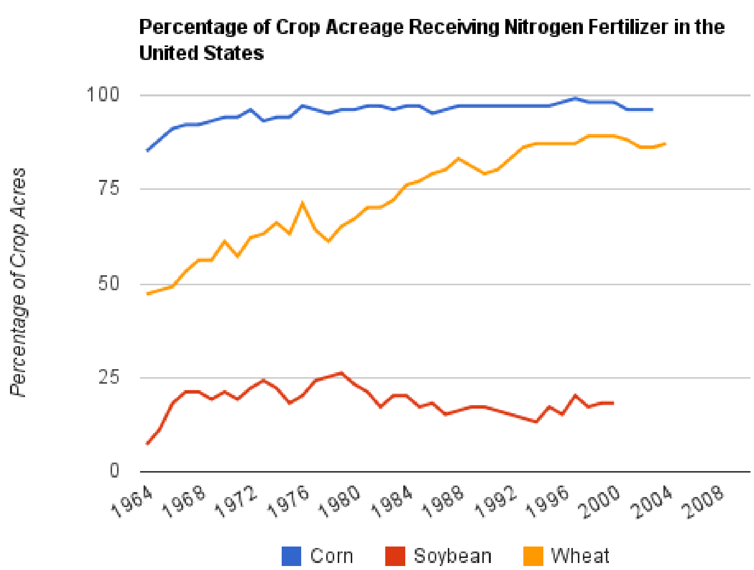
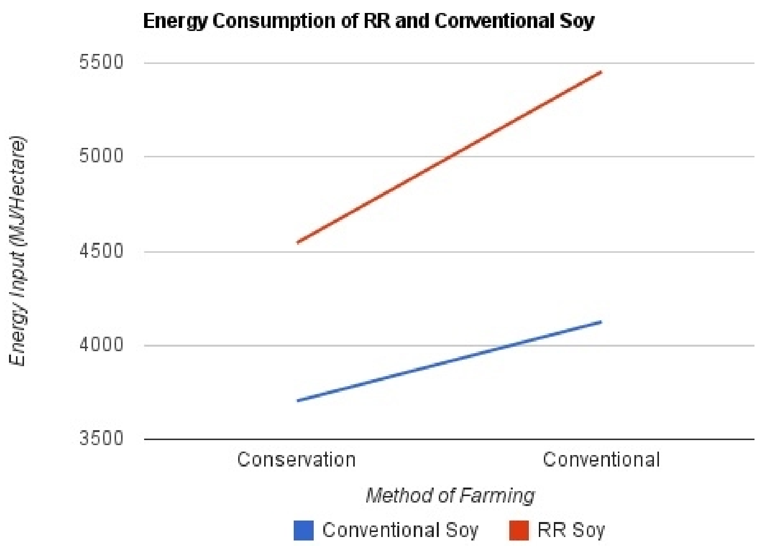


Figure 1 compares the percent of natural nitrogen-fixating soybean crop-acres to those crop-acres dedicated to corn and wheat (both of which require the application of fertilizer).

No-till farming and GM RR soy

Monsanto Co. claims that GM RR soy is superior to its natural counterpart because farmers do not need to till their fields prior to planting. GM RR soy saves energy through no-till farming by leading to a decreased use of machinery and fossil fuel energy input. No-till farming also prevents topsoil erosion, as less disturbance of the topsoil results in less nutrient runoff. However, no-till farming also leads to a sharp increase in the presence of invasive plants and pests later on, necessitating the frequent use of Roundup for its glyphosphates. In addition, weeds and other pests build up resistance to Roundup's pesticides and herbicides over time, requiring more frequent applications of Roundup products. As the production costs of Roundup far outweigh the energy saved by reduced equipment usage, the process becomes less efficient.



Costs of using GM RR soy

Unlike conventional soybeans, GM RR soy cannot use the natural method of delivering nitrogen and thus requires artificial fertilizers. Artificial fertilizers, in this case Roundup Ready, typically use ammonia in their production because it contains 82 percent nitrogen. The production of ammonia, which in some forms can serve as a fertilizer itself, necessitates consumption of energy in great quantities. It requires approximately 34.8 billion joules of natural gas per ton of ammonia (Huang, Wen-yuan). As a result of this energy intensive process, global ammonia production accounts for 2% of the world's total energy consumption. Though the numbers on how much ammonia is required to produce one ton of Roundup fertilizer were not found, the high energy cost of ammonia makes every ton not produced a substantial energetic saving (Quantum Sphere).

In addition to costing energy to produce, GM RR soy also has unnecessary monetary costs. Though Monosanto Co.'s patent on Roundup as an herbicide expired in 2000, their patent on the GM RR soy seed itself is still in effect. Farmers must repurchase soy seed each year, whereas conventional seed could be harvested and replanted, requiring only the initial investment cost.

Figure 2 displays the contrast in energy used by conventional soybean plants and Roundup Ready soy plants.

Energy costs of alternative methods

The use of cover crops presents a viable alternative to the combination of Roundup products and GM RR soy. Cover crops, planted during the off season of the cash crop, prevent soil erosion, improve soil quality, and keep down weeds and pests. Cover crops trade frequent application of fertilizers, herbicides, and pesticides for more tilling and labor, but the system still cuts the overall energy requirements and necessary resources. A study in *BioScience* found that when corn and soybean farms planted organic legume-based cover crops, they used 32% less energy than conventional herbicide and pesticide corn and soybean farms (Douds). On a conventional soybean farm, every kcal of energy put into the farm generates 3.2 kcals of soybean food energy; to contrast, on a cover crop farm, the outcome is 3.8 kcals of food energy per kcal put into the farm (Douds).

Conclusion

Roundup Ready soy may address the problem of soil erosion in the short term, but it fails in the long run. It causes a host of other environmental and farming efficiency problems, including mineral-depleted soil, pesticide resistance weeds, disease susceptible soy plants, and smaller yields than conventional soy farms. As an alternative to conventional farming techniques, GM RR fails to conserve energy, incurs higher costs, and negatively impacts the environment. Conversely, the more traditional approach of using cover crops creates farms with better soil quality, comparable crop yields, and is beneficial to the biodiversity of the farm and its surroundings. Farms planted with cover crops need less energy due to the fact that fertilizers and pesticides are either not required or are required in much smaller amounts, thereby avoiding or lessening the energetic costs and resources necessary for producing the chemical compounds.

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Comments

Alexandra Rempel - Oct 26, 2011 1:57 PM

Hi everyone - for some reason I don't have permission to access this page. Hm! Is it fixable? Thanks!

Alexandra Rempel - Nov 2, 2011 2:28 PM

1. Where is the group narrative? Is it this page? The group work doesn't need its own issue; it just needs to tell the story of how things got to where they are now.

2. In the spirit of conciseness, create every title to mean exactly what you want it to. What do you really want this title to say to the reader?

3. We know this is a work in progress, but it's not too early to use concrete, specific, referenced facts to support your positions. Sentences like "Within the last couple decades, the demand for soybeans has increased substantially with the expansion of the global market," sound as though you may not actually know what you're talking about. Tell us exactly what the time frame is, specifically how much the demand has increased, and what aspect of the global market increased it. Then cite the source in the text.

For example: "Since 1995, global demand for U.S. soybeans has tripled; the World Bank attributes much of this increase to declining supplies from competing South American producers^1." This level of specificity will ultimately be required in ALL sentences.

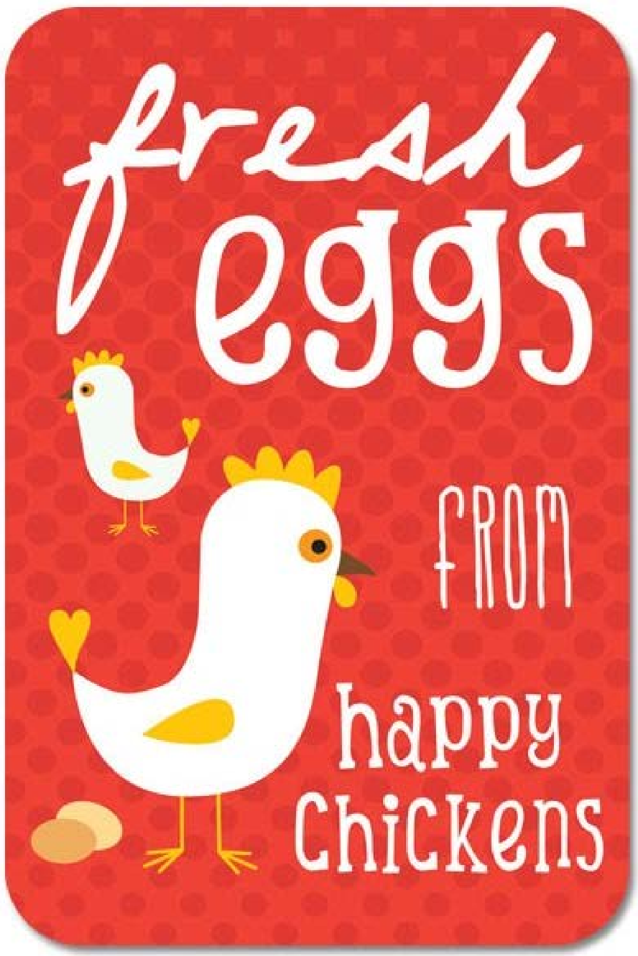
4. Write in a way that's easy to read. Can you tell that the first paragraph sounds disjointed and awkward? In your second sentence, can you see that the "combination" to which you refer is not at all clear? Rather than "harmful chemicals found in their herbicide product known as Roundup", a value judgment, be specific and impartial: "glyphosate, the herbicidal agent in Roundup."

5. Evaluate the value of the graph in comparison to its size. Then resize accordingly.

6. Visually, it's improving! At this point, the font seems large, the reference list takes up a lot of space, and the scrolling distance seems long. But the organizational structure is working and it's visually appealing.

Battery cages, cage-free, or small-scale chicken farms? A question of efficiency, animal welfare, and environmental impact.

Battery-cage farms Cage-free farms Small-scale farms Normal chicken behaviors Bibliography



Return of the small-scale chicken farm:

The chickens are once again cutting loose! For the last 60 years, the world egg production industry has crammed laying hens into tiny cages in order to boost profits. The U.S. consumer enthusiastically responded to the increase in supply by making eggs a staple of the American diet and a necessity at the American breakfast table. Now, as more people begin to appreciate not only the quality of products produced on smaller, more traditional farms but also the welfare of the animals the eggs come from, small-scale egg producing farms are making a comeback.

In the 1960s, the British Parliament commissioned the Brambell Report to lay out guidelines for the welfare and treatment of animals raised on intensive production farms. The authors of the report concluded that there are five specific freedoms animals should have for their mental and physical wellbeing:

1. freedom from hunger and thirst;
2. freedom from discomfort;
3. freedom from pain, injury, or disease;
4. freedom to express normal behavior;
5. freedom from fear and distress.

It has taken over thirty years for the Brambell Report's guidelines to actually find its way into policy. The European Commission passed Directive 1999/74/EC in 1999, a measure that will make battery cages in egg laying facilities illegal by 2012; member-states of the EU with large, factory style farms must switch over to cage-free or aviary systems. In 2008, California voted yes on Proposition 2, a statute that will ban battery cages by 2015 as part of the Standards for Confining Farm Animals Initiative. In Europe and the U.S., the push for cage-free eggs comes on behalf of the mental and physical welfare of the chickens. The laptop-sized amount of space given to each chicken in the battery cages prevents the hens' from stretching their wings, much less engaging in normal chicken behavior.

The small-farm setting and backyard chickens present alternative options. Both systems allow the chickens to live more naturally and engage in normal chicken behavior. The small scale of the two methods also means that the eggs are not traveling long distances between producer, processor, and retailer, cutting down on the environmental effects of long distance travel.

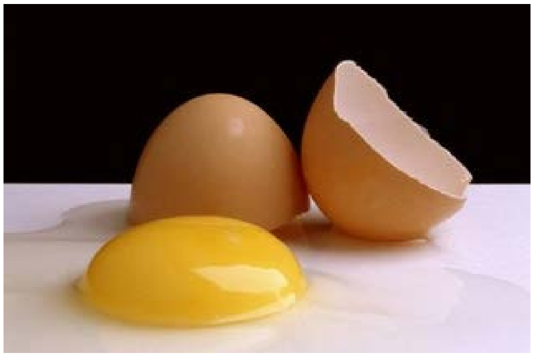
Currently, intensive egg production is necessary to meet U.S. demand for eggs. It seems unlikely that the bottom-up approach of small-farm chickens could meet the demand for eggs; producers are already struggling to meet the demand for cage free eggs from major businesses such as Ben and Jerry's, Whole Foods supermarket chain, and Wolfgang Puck's (Severson). However, the entire intensive egg production industry fails on every standard on the Brambell Report: chickens do not receive either the physical or emotional freedoms described. To put the issue in perspective, in many states it is considered a felony to treat dogs as cruelly as chickens are treated; punitive measures are a prison term and substantial fine.

United Egg Producers and the Humane Society of the United States recently agreed to push for legislation at the federal level that seeks to raise living standards for laying chickens and to afford chickens at least some protection from maltreatment. If the proposal were to become law, it would require, among other things, that producers use enriched cages and meet standards for euthanasia practices, that each chicken receive 67 square inches of space, and it would prohibit forced molting, battery-cages, and the sell of eggs or egg products that do not meet production standards (Oregonians for Humane Farms). The law would certainly push the U.S. on a national level to meet the physical welfare standards established by the Brambell Report, and it would better the chickens' psychological welfare. However, are the standards in the proposed legislation good enough for the two million chickens living in Oregon right now, or should Oregonians and the Oregonians for Humane Farms continue pushing for stronger policy at the state level?

Yes! Chickens do not belong in cages for their entire lives. Oregonians should push for legislation that would downsize chicken farms and free the hens from their cages. Cage-free and free-range farms require significantly more land use and the chickens produce fewer eggs than battery-cage farms and chickens do, but the trade-offs are healthier chickens, a locally focused business, and a dependence on more sustainable human energy rather than fossil fuel energy.

Why are the eggs themselves important?

For many people in the U.S., eggs provide a cheap source of protein.



An average sized egg, about 2 ounces, has:

- 7 grams of protein (Structure of the Egg), or 12 grams of protein (Poultry Your Way...)
- vitamins A, D, thiamin, riboflavin, and niacin
- minerals – iron, phosphorus
- unsaturated to saturated fat ratio, 2:1
- is easily digestible

From 2009-2011, one dozen eggs cost an average of $1.50 (USDA). For $1.50, the consumer gets 168 grams of protein.

2 ounce egg (12 egg carton) = 24 ounces of egg

24 ounces of egg (7 grams of protein) = 168 grams of protein / dozen eggs

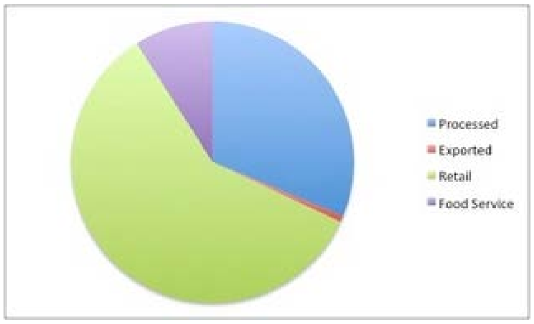
In comparison, the average price of ground beef from 2009-2011 was $2.40 / pound. There are 21 grams of protein per 3 ounces of ground beef; therefore, at $2.40 / pound, the consumer gets 112 grams of protein.

U.S. production and consumption of eggs:

After China, the U.S. has the second largest egg production industry in the world. In 2010, people and food industries in the U.S. consumed 91.4 billion eggs, valued at $6.52 billion; only 5% of those eggs came from cage-free systems, the other 95% of chickens live in battery cages (Promar). Industrial egg-producing farms maintain millions of chickens: Cal-Maine Foods, the largest producer of eggs in the U.S., has 29 million layer chickens, with Rose Acre Farms a second with 21 million layers (U.S. Poultry and Egg Association). Flocks vary in size from 20,000 layers to as many as 400,000. Most large egg production facilities are vertically integrated: the company that owns the chickens also owns the hatcheries, feed mills, and processing plants (Brewer).

Nearly 60% of the eggs produced in the U.S. are sold in retail stores to consumers as table eggs, that is, eggs still in their shells. Another 30% of eggs are broken to be used in the packaged foods. Less than 1% of those eggs are exported to other countries, mainly to Canada, Mexico, and Japan.

Figure 1: End uses for the eggs produced.



Processed - 31.3%
Exported - .7%
Retail - 59%
Food Service - 9%

Source: United Egg Producers

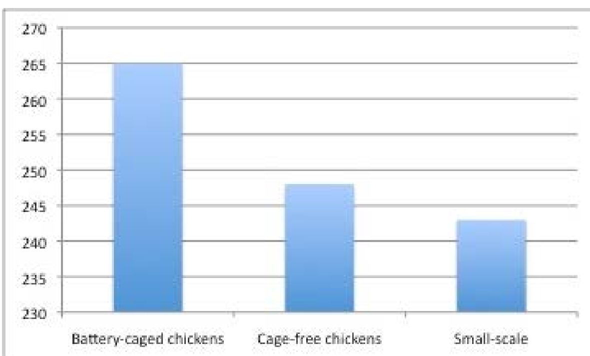
Defining the many different terms found on egg cartons and animal welfare posters:

- Battery-cages – The chickens live in cages that, on average, give each chicken the amount of space equal to the size of three quarters of a sheet of printer paper. The small size prevents natural behaviors: dustbathing, scratching, foraging, nesting, and perching; and the cages prevent exercise, which leads to severe osteoporosis and incredibly weak bones. The cages also prevent infectious diseases, the buildup of manure, and starvation.
- Cage-free, or barn – The chickens live on the farm floor, are allowed to move around, and have access to litter and nesting boxes. The increased exercise and freedom keep the chickens healthier in terms of bone structure, and psychologically healthier given the opportunities to engage in normal behaviors. However, the contact spreads disease, manure, and can cause pecking behavior. The chickens also do not necessarily have access to the outdoors.

· Aviary – The same as a cage-free system, but with multi-tiered perches.
· Small-scale farming, free-range – A business that keeps less than a thousand chickens and only sells the eggs to local businesses.
· Organic – The USDA label 'organic' means that the animals cannot receive antibiotics or hormones and must be treated humanely. Farmers cannot grow crops using pesticides, irradiation, or bioengineering, and they must follow certain regulations on water and soil conservation.

Comparisons of the different production methods:

Figure 1: Single chicken average annual egg production:

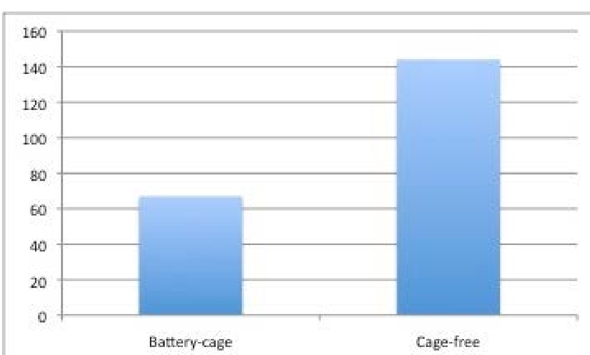


Battery-caged chickens: 265

Cage-free chickens: 248

Free-range (on a small farm) chickens: 243

Figure 2: Space allocated to each chicken:



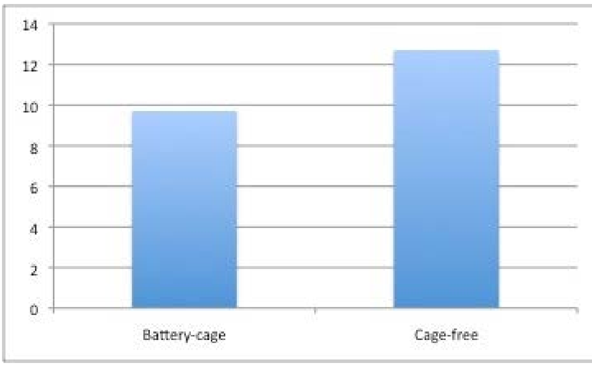
Battery-caged : 67 inches^2

Cage-free: guidelines from United Egg Producers specifies 144-216 inches^2

Small-scale: the U.S. does not have specific guidelines; however, the EU requires 1 acre for 1,000 chickens.

Figure 3: Annual feed needed to produce the 4.5 million metric tons of eggs for meeting consumer demand:

Battery-caged: 9.7 million metric tons
Cage-free: 12.7 million metric tons*
Small-scale: N/A



* If battery-cages were to be banned in the U.S., the estimated increased amount of chicken feed needed to meet demand would be 3 million metric tons (Promar).

Figure 4: Comparative summary of the physical and mental well-being of the chickens. The mental welfare of the chickens is measured by their freedom to carry out normal chicken behaviors such as foraging, nesting, and perching. The opportunity to nest in a sheltered location is especially important; hens instinctually need to feel secure while they nest. Large barns do in fact shelter the chickens from predators, but the hens do not know this.

	Physical welfare of the hens:	Mental welfare of the hens:
Battery-cage:	· Severe bone weakness; · Each chicken has about ¾ of a piece of printer paper for space; · Prevents manure buildup, spread of disease, and starvation; · Chickens can be individually monitored. · Disposal of the spent hens.	· The lack of space prevents the hens from acting like chickens: not able to forage, nest, or perch. · The close proximity and lack of activity requires the hens to be de-beaked in order to prevent incessant pecking.
Cage-free:	· Greater potential for spread of disease and manure buildup. · Increased level of exercise leads to healthier, stronger hens. · Do not necessarily have outdoor access.	· Able to carry out more behavioral norms. · More active chickens tend to pick on the less active hens.
Small-scale:	· Not as genetically inbred – less deformities, stronger bones. · Predator threat must be addressed.	· Outdoor access: foraging, nesting in a sheltered area, perching.

Bibliography:

Subpages (5): Battery-cage systems Bibliography Cage-free chickens Normal chicken behaviors Small-scale farming

Comments

Alexandra Rempel - Oct 26, 2011 1:56 PM

Is your new topic question in here, on another page, somewhere? If not, the first priority is to define the energy transition option that you will advocate for or against. California passed Proposition 2 in 2008, which will take effect in 2015, banning battery cages (http://en.wikipedia.org/wiki/California_Proposition_2_%282008%29#Similar_legislation_attempted_in_California_and_other_states), and efforts in Oregon and Washington were underway when egg industry leaders signed an agreement to support national legislation banning battery cages within 18 years (http://www.unitedegg.org/homeNews/UEP_Press_Release_7-7-11.pdf). It's far from law, though! Fortunately, Rep. Blumenauer (D-OR) has a very responsive office - by phone or email (https://forms.house.gov/blumenauer/webforms/issue_subscribe.html) - and his staff would readily fill you in on the status, I'm sure. Nothing has been introduced in Congress yet, so that would be something to ask - is anyone in Oregon or Washington planning to introduce legislation? Also, take a look at this report: http://www.unitedegg.org/information/pdf/Promar_Study.pdf, which goes through the energy costs of a cage ban fairly comprehensively and could help you evaluate the question of whether or not to support the new legislation when it arrives. This seems like a promising route to defining your topic.

The Promar Study should also be helpful as you revise your energy flow / thermodynamics section, which is now a bit behind schedule. There's no grade penalty, just a reminder. Please email us if you get stuck!

Alexandra Rempel - Nov 10, 2011 12:21 PM

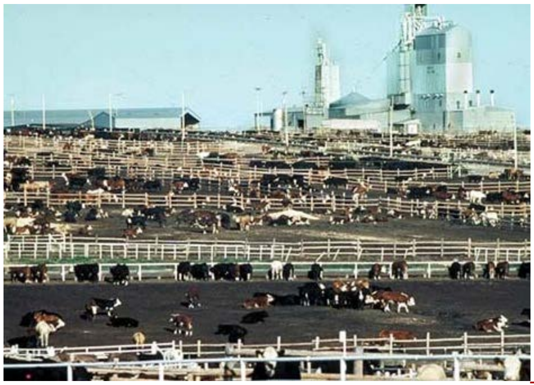
Hi Sarah - do you have a specific topic in mind yet? Do feel free to post your work in progress so we can check in with you. Did you have a chance to look at the Promar study? Let's talk today about what you want your main messages to be. It's time to start working pretty diligently on your topic, if you aren't already.

Alexandra Rempel - Nov 17, 2011 1:13 PM

I like the emerging focus of your question; is your frame of reference now the US, or just California? Or Oregon or the Pacific northwest? Is it possible to pick a reference that hasn't yet decided what to do? Let's talk about this today.

Individual Projects >

Should Confined Animal Feeding Operations (CAFOs) Stop Recieving Government Subsidies?



Current Beef Production Methods Meet Demand & Provide Cheap Protein, But is it Worth the Energetic Cost?

Confined Animal Feeding Operations (CAFOs) are facilities that profit from mass producing animals or animal products. A large cattle CAFO is defined by the Environmental Protection Agency as a facility with over 1000 cattle confined for 45 days or more in a 12 month period without grass or vegetation in the confinement area during the normal growing season. Also the facility pollutes water passing through or near the property.[1] In the CAFO system, cattle are raised on grass for the first months of their lives before being moved to the feedlot. At the feedlot they are fed a combination of corn, soybeans, and other cereal grains mixed with growth hormones, extra vitamins, and antibiotics. This feed allows the cattle to reach slaughter weight as quickly as possible, increasing production rates. While this may seem like a positive solution to meeting the demands of a growing population, in reality the system is quite energetically inefficient.

The Farm Bill allocates $30 billion a year directly to agricultural subsidies; without these status quo beef production would not be profitable.[2] The energy transition of CAFOs in kilo-calories (food calories) has been estimated to be **35-50:1**. This means it takes the energetic input of between 50-35 calories to produce a single edible calorie.[3,4] The grains that make up feed in a CAFO account for a large portion of this inefficiency, yet the consumer never sees the cost because it is covered by subsidies. Currently, most grains are produced on large mono-crop farms, due to incentives specified in the Farm Bill. Mono-crop farms deplete topsoil and therefore require artificial fertilizer, which requires fossil fuels to produce. Grains produced for CAFOs also require pesticides, herbicides, irrigation, farm machinery, and transportation to the feedlot, all of which use fossil fuels. The CAFO itself also receives subsidies, including "waste management" subsidies with lax pollution standards. This money goes towards running the facility (heat, electricity, labor, waste removal, ect.). CAFOs also have hidden energy costs, which will be covered in more detail later. Contrarily, grass-fed cattle require a much smaller energetic input. Their feed is produced on site and manure is used to fertilize the fields.[5] Although this system would require current production rates to decrease, it is more sustainable.

The Farm Bill is up for revision in 2012. It should be altered to provide incentives for energetically efficient and responsible farming. This includes shifting subsidies away from mono-crop farms that produce corn, soybeans, cereal grains, and CAFOs, towards more sustainable multi-crop farms that consume less fossil fuels. Monetary incentives should also encourage small and midsized farmers, and discourage the current trend towards fewer larger farms and monopolies. Waste-management subsidies should be eliminated and CAFOs should be required to report their waste removal practices to the E.P.A., in compliance with the Clean Air and Clean Water Acts. To fully understand the choices we currently face, we must first examine how we arrived at modern day beef production.

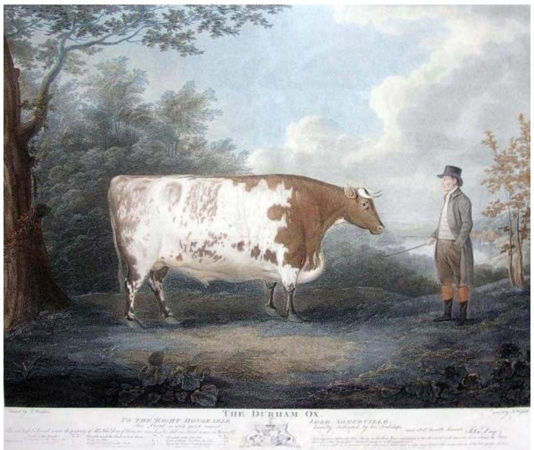
Contents

From the Evolution of Cattle to CAFOs

The ancestral species of modern day cattle was the auroch, which was present in the Lascaux cave paintings in the hall of bulls, dated to 17,000 B.C.E.[6] The species was present along with the domesticated species until it became extinct in 1627. Evidence from D.N.A. comparisons show that domesticated cattle and aurochs inter-bred

and that aurochs were probably used to replenish cattle populations in hard times. The taurine species of cattle was domesticated in the Fertile Crescent between 8,800 and 8,300 B.C.E., during the Neolithic Revolution. The zebu species of cattle was domesticated separately in the Indus Valley around 7,000 B.C.E.[7] There is debate about a third domestication in Africa around 9,000 B.C.E., but there is good evidence for domesticated African cattle by 6,000 B.C.E. The fossil record shows humans keeping cattle in Europe between 7,000 and 6,000 B.C.E. and in Asia around 3,000 B.C.E.[8]

Up until the Medieval period, cattle, primarily oxen, were used as work animals in Europe. Oxen pulled carts, logs, and simple farming implements, including the plow. They were used as beasts of burden for about 10 years and then were slaughtered for food. Cows were kept a similar length of time for milk and breeding before being slaughtered. Around the 11th and 12th centuries C.E., horses became the primary animal in both warfare and farm work and **oxen became more available for the production of meat**.

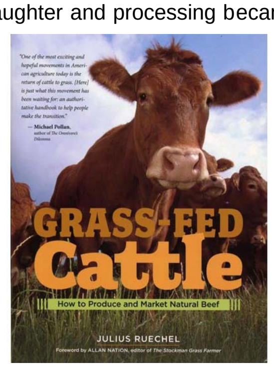


In England, beef consumption grew between the 16th and 18th centuries. Increased demand pushed farmers to produce larger cattle in a short amount of time. Before this time, cattle breeds were not formally recognized, although variation existed. The **first official breeds** started with intensive breeding programs among very small herds. Subsequently, inbreeding was common. In the mid 18th century, Benjamin Tonkins, Richard Bakewell, and Charles Colling started "systematic improvement" by deliberately selecting cattle with desirable traits. Bakewell started with a small herd that eventually became the longhorn cattle breed. Colling visited Bakewell's farm and then started his own herd, which eventually became the shorthorn cattle breed. In 1802 the "**Durham Ox**," an early member of the shorthorn breed, became famous for its gigantic size. It toured England and Scotland and many people payed to see it. Cattle became symbols of prestige, affluence, power, and the importance of good breeding. Among the English elite, portraits of favorite cattle became popular, with the size and proportions of the ox or cow often being exaggerated.[9,10]

Cattle first arrived in the Americas with Columbus' second voyage in 1493. Small numbers of cattle continued to accompany explorers, including Vera Cruz, who introduced cattle to Mexico in 1521. Descendants of these cattle accompanied missionaries who founded Christian missions along the west coast of the United States. The English also brought cattle to the Americas when the Jamestown colony was founded in 1611, however cattle ranching took place primarily in the West.[11] The Mexican government promoted cattle ranching in Texas in the early 19th century by offering land to anyone wishing to take up the industry. During this time period, **cattle had to be "driven,"** or walked to the location that they were to be sold and slaughtered. During the Californian gold rush, Texan ranchers would engage in 5 to 6 month long "drives" to transport cattle to miners. Cattle drives in the west reached their peak after the Civil War from about 1866 into the 1880s. A herd of between 2,000 and 3,000 cattle could be driven to western and northern markets by a team of about twelve men.[12]

The beginnings of **today's beef industry emerged during the second half of the 19th century**. With the invention of mechanical refrigerators and expansion of American railroads, long cattle drives became unnecessary. Ranchers would bring their **cattle to railroad stations** and send them elsewhere for processing and distribution. Though slaughterhouses had existed in America since the early 1800's, large slaughterhouses resembling factories started to be built and concentrated in a few cities by the end of the century. Chicago became the meatpacking capital of America. **The Union Stock Yard** opened there in 1865 and was the first slaughterhouse complex of its time. A slum of factory workers living in dirty, crowded conditions, as depicted in Upton Sinclair's *The Jungle*, developed next to the factory. As demand for beef increased, new technologies such as the conveyor belt were introduced at the Yard to speed up production.[13]

In the twentieth century, **monopolies in production and technological innovations** directed the American cattle industry towards larger companies encompassing more sectors of the business. **Feedlots** supporting many heads of cattle near the sites of slaughter and processing became increasingly common. Due to improvements in farming technologies and government subsidies during the **Green Revolution** (1940-1980), corn and other cereal grains were over-produced and fed to cattle. In 1940, a farmer could expect 70-80 bushels of corn per acre. By 1980, a farmer could expect 200 bushels of corn from the same acre. This huge increase in productivity can be attributed to the production of artificial fertilizer, genetic modification, pesticides, mechanization and irrigation.[14] Grains, being more calorically dense than grass, allowed cattle to become fatter faster. They also eliminated the necessity to graze, making it possible to raise more cattle in a smaller space. The modern **confined animal feeding operation** (CAFO) emerged around 1970.[15] CAFOs usually graze cattle for the first six to nine months of their lives and then move them to feedlots to be "finished," or fattened to market weight, as quickly as possible. Their feed is generally some blend of corn, soybeans, and other grains. Also, their feed often includes growth hormones and vitamins, and antibiotics to combat infection in dirty and confined conditions. Throughout the 20th century, the trend moved away from small and midsized farms towards fewer, larger operations. Between 1982 and 1997 the number of units with 1000 animals or less decreased substantially.[16] Today, the vast majority of beef in America is produced by a large CAFO and affiliated factory system. Increased public awareness about CAFO practices and health concerns have recently led to a small increase in the market for grass fed beef. **Grass fed beef** makes up about 3% of the current market, as opposed to nearly zero twenty years ago.[17]



Though there is a movement to return to more natural and traditional methods of cattle farming, industrialization and mechanization still push forward. **The Bovine genome** was sequenced between 2004-2009 at the Human Genome Sequencing Center at Baylor College of Medicine. The data is published and easily accessible for public use. Since it makes favorable cattle traits traceable and recognizable, it has the potential to make breeding selection more specific and further enhance traits that are favorable for human purposes. In theory, this would make beef and dairy production in large facilities even faster.[18]

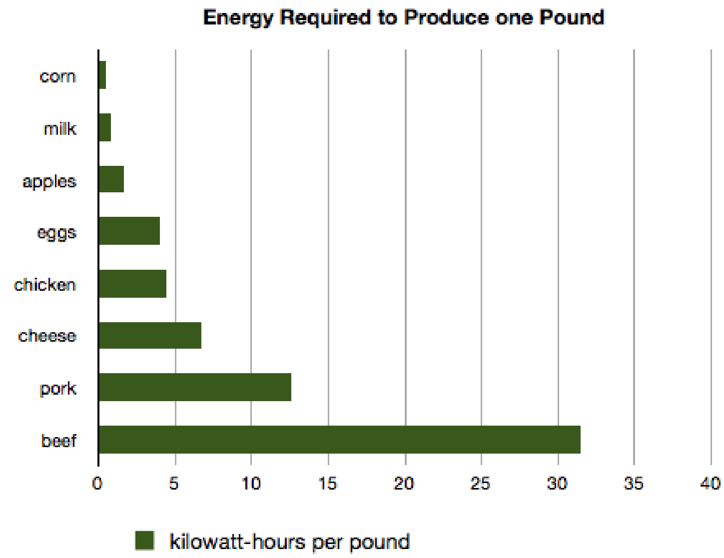
Energetic Costs of Factory Farmed Beef:

Inputs to Outputs in the Current System

Direct Energetic Costs:

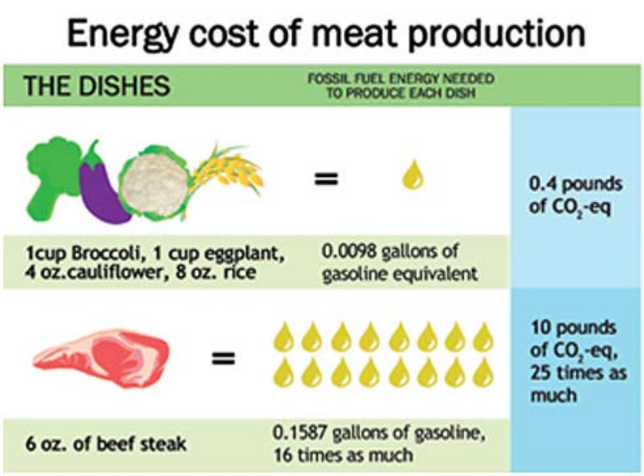
~35-50 kcals (fossil fuels): 1 kcal (beef)~

Feedlots use 63% of all fossil energy needed for beef production in the status quo system. Of that, **83% goes towards feed production** and the rest goes towards running the facility and processing the animals. It is estimated that fossil fuel use would be **diminished by 24% if no feedlot feed were used**.[19] One major contributor to the energy intensiveness of feed production is artificial fertilizer. One kilogram of nitrogen for fertilizer requires the energetic equivalent of 1.4 liters of diesel fuel. From 2001-2002, the U.S. produced 12,009,300 tons of nitrogen fertilizer, which required the equivalent of **96.2 million barrels of oi**l.[20] Since oil is a limited resource, this system is clearly not sustainable. Other fossil fuel contributors include transportation of feed to CAFOs, running farm machinery, the production of pesticides, electricity and heating for indoor facilities, irrigation, and waste removal. The graph to the right shows the energetic cost of beef per pound measured in kilowatt hours compared to other foods.



> "To produce one pound of beef, it takes 2,500 gallons of water, 12 pounds of grain, 35 pounds of topsoil and the energy equivalent of one gallon of gasoline. If all these costs were reflected in the price of the product, without subsidies, the least expensive hamburger in the US would cost US$35." -John Robbins[21]

How is this possible when supermarket prices are comparatively so low? Many CAFO expenses are paid for by tax dollars allocated by The Farm Bill, discussed in detail later. Though fossil fuel use is unsustainable in and of itself, there are other consequences of CAFOs that may be even more energetically costly.



Indirect Energetic Costs:

Air and Water Pollution

CAFOs are not required to pay for the cl ean up and proper disposal of the approximately **300 million tons of manure** they produce each year. The Environmental Quality Incentives Program (EQIP), which is funded by tax dollars, covers some clean up, but the majority of CAFO waste is release untreated into the environment. CAFO manure is leaked into important watersheds and contaminates human drinking water. It also causes eutrophication, or oxygen depleted "dead zones" in nearby rivers and oceans, destroying important ecosystems.[22]

CAFOs also release CO2, methane, nitrous oxide and organic acid compounds (mostly containing nitrogen and sulfur) into the air. These contribute to global warming as well as acid rain. A 2006 U.N. report found that worldwide, CAFOs contribute to 18% of all anthropogenic (human generated) green house gas emissions. **This exceeds the amount produced by the entire transportation sector**.[23] The chart to the left shows how much gasoline is used and CO2 results from the production of 6 oz. of meat versus three servings of vegetables and a serving of rice.[24]

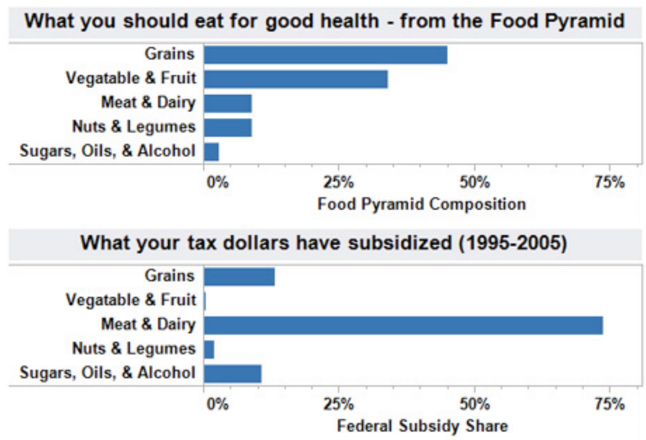
Antibiotic Resistant Bacteria

Due to crowded and unsanitary conditions, CAFOs include antibiotics as a regular part of animal feed to prevent disease and promote faster growth. It is estimated that **70% of all antibiotics produced in the U.S. go into animal feed**.[25] The overuse and constant presence of antibiotics causes mutations in bacteria and the emergence of new strains of antibiotic-resistant diseases. Diseases caused by antibiotic-resistant bacteria are much harder to treat and put strains on U.S. health care systems. **Resistant strains of salmonella have hospitalization rates 2.5 times higher** than non-resistant strains, and have higher mortality rates.[26]

Though the risk of contracting anti-biotic resistant food borne illness is very real for all consumers, farm workers in close proximity to mutating bacteria are put at risk simply by going to work. In one such case, 37 farm workers at a poultry processing plant and adjacent hatchery in Batesville, Arkansas became infected with methicillin resistant staph infection (MRSA). Similar cases have also been documented in other CAFOs that use antibiotics for non-therapeutic reasons. The University of Iowa did a study spanning several hog farms that routinely use antibiotics. The study found that 70% of hogs and 64% of farm workers carried MSRA.[27]

To legally address this issue, Congresswoman Louise Slaughter proposed a bill called The Preservation of Antibiotics for Medical Treatment Act in 2009.[28] It was introduced to a committee during the 111th session of Congress, but was never voted on. In 2011 the bill was proposed again, this time by both Slaughter and Congresswoman Dianne Fienstein, and is still in the committee referral stage of the legislative process.[29]

Human Nutrition



Because ruminants (cattle and other cud-chewing quadrupeds) are meant to digest grass and forage, not corn and grains, and because CAFOs provide enclosed conditions where exercise is often impossible, cattle raised in CAFOs are less healthy than traditionally raised grass-fed cattle. Since CAFO cattle are less healthy, CAFO beef is **less nutritionally beneficial** for human consumption than grass-fed beef. Grain fed beef has more saturated fat and Omega 6 fats, which contribute to heart disease and clogged arteries if over-consumed, and fewer healthy Omega 3 fats.[30] This difference in fat profiles accounts for the extra 92 calories per 6 oz. in grain fed beef compared to 6 oz. of grass-fed beef. While this difference may seem small, the average American consumes approximately 67 pounds of beef per year, **a difference of 16,642 calories**.[31] This equates to around 4.7 pounds of human body weight per year, since each pound has an energy potential of 3,500 calories. Considering that **33.8% of adults and 17% of children and adolescents in the U.S. were considered obese in 2010**, any caloric reduction would be helpful.[32] Grass fed beef also has more vitamin A and E, antioxidants, and up to 7 times the beta carotene of grain fed beef.[33]

Most Americans are aware that current rates of obesity are staggering and unhealthy, and that related diseases put pressure on the U.S. health care system. What most are not aware of is that this trend is in part caused by the disproportionate subsidization of unhealthy food. The figure above shows the **discrepancy between what is healthy and what is subsidized**. Fruits and vegetables, which should make up between 30-40% of a healthy diet receive less than 1% of government subsidies. Meat and dairy, which should make up about 10% of a healthy diet receive about 75% of subsidizes allocated to food. Because the foods currently being subsidized do not reflect good health, **unhealthy food is cheaper**. Because of this price difference, the number of over-weight individuals in our country continues to grow.[34]

Other Important Issues:

Since this argument comes from an energetic perspective, I will not go into detail on **humanitarian issues** regarding animal treatment or how CAFOs affect **rural communities**. These issues are, however, important when considering the overall cost of CAFOs to society. For more information, see the documentary "Food, Inc." (http://www.foodincmovie.com/), and the PEW Commission on Industrial Farm Animal Production website (http://www.ncifap.org/).

More Efficient Alternatives:

Grass Fed Beef

~20 kcals input: 1 kcal of beef~

Energetic inputs of grass-fed beef are cut in half by the reduction of fossil fuels needed to produce grain.[35]

Although all cattle are raised on grass for the first few months of their lives, feedlot cattle are then fed corn, soybeans and grains that are energetically costly, hard for them to digest, and which result in less nutritious beef. Although grass-fed cattle take longer to raise, their food is much less energetically costly to produce, they do not require anti-biotics or added nutrients in their food, their manure is used as fertilizer, and their meat is ultimately more nutritious for human consumption. **Many options exist** for farmers to profitably and responsibly raise grass-fed cattle. The region and climate, size of the farm, and other issues should be taken into account when planning a sustainable cattle ranch/farm.

Smart Pasture Operations

:

CAFO	SPO
-Massive (thousands of animals)	-Mid-sized (hundreds of animals) or smaller

-Extremely Crowded Facilities	-Less Crowded Facilities
-Unhealthy Conditions= Excess Antibiotic Use and Drug Resistant Bacteria	-Healthier Conditions Reduce Antibiotic Use
-Cattle Eat a Diet (corn and soy) that They Cannot Digest Properly	-Cattle Eat Their Normal, Digestible Diet (vegetation such as grass)
-Feed is Purchased and Shipped to the Site	-Low-cost Feed Produced On Site (pasture)
-Usually Isolated from Crop Farming	-Integrated with Crop Farming
-Unmanageable Concentrations of Untreated Manure Create Air and Water Pollution	-Manure is Put to Immediate Use as Fertilizer for Crops and Pasture, Minimizing Pollution

(figure replicated from "The Hidden Costs of CAFOs")

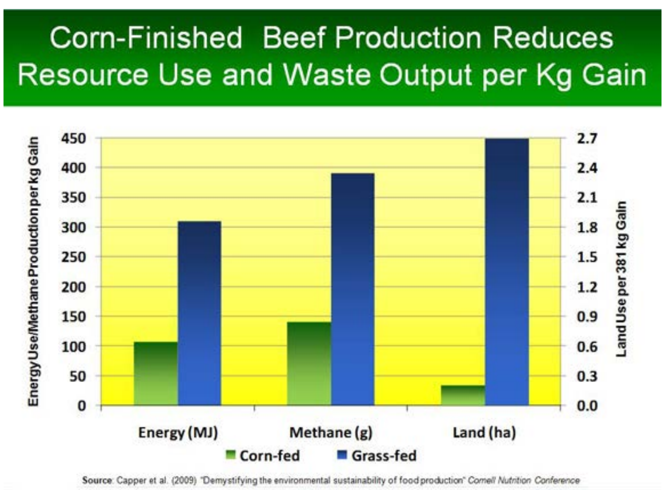
The Union of Concerned Scientists have come up with a viable alternative to CAFOs that is more efficient and sustainable. "Smart Pasture Operations" work with nature to decrease energetic input and pollution, and benefit human and animal health. In a SPO, cattle **eat grass and forage** grown onsite, greatly diminishing the amount of energy used to produce feed. Since the cattle eat what they are biologically meant to digest, they produce less methane per cow per day and meat is more nutritious for human digestion. **Manure is used productively to fertilize** fields and crops, minimizing pollution and reducing the need for artificial fertilizer. Pastures also require **less irrigation and pesticides** than grains. Since the cattle live primarily outside in clean conditions, the need for antibiotics is also greatly reduced. Also, **fossil fuels needed to run farm machinery are reduced** as well as heat and electricity to run large indoor facilities.[36]

Some groups and scientists have begun to invest in technological "fixes" for issues that CAFOs face, such as feed that reduces nitrogen and phosphorus in manure. While such solutions fix isolated problems, they tend to still be energy intensive. Many of these "fixes" are not necessary when **farmers work with nature to improve efficiency**, as is done in the SPO.[37]

Country Natural Beef:

Country Natural Beef is a collective of small to midsized ranches. The collective started in 1986 with 14 families in Oregon. It now includes 120 families and spans the West Coast and Hawaii. Though all together Country Natural Beef is large, it is managed on a small scale level. Each family is required to meet standards of animal welfare, land quality and biodiversity, to never use antibiotics or growth hormones, and to allow regular third party evaluations. The cattle spend the majority of their lives in pastures and then are finished for 90 days on a combination of grain, potatoes, and alfalfa before being slaughtered. While this practice may not be ideal, it is still much preferred energetically to CAFO practices. The cattle are never fed anti-biotics or growth hormones, the potatoes are discarded from a nearby potatoes farm, and the period of finishing is much shorter than that of most cattle.[38]

Opposition: Argument for the Status Quo



There is certainly strong support for continuing status quo beef production in favor of more sustainable alternatives. Critics of grass-fed beef cite **increased land use** as one reason that it is not a viable option for the majority of beef production. It is true that grass-fed cattle require much more land than feedlot cattle. Yet, if fields used for feed production were converted to pasture, some of this need for more land could be met. Another objection is that grass-fed cattle produce **more methane** during their longer lives than feedlot cattle. Though they produce less methane per day due to better digestion, grass-fed cattle do produce more methane over their lives than feedlot cattle. The graph to the right also makes an argument for increased energy input, yet more specific inputs were no where to be found in its source. [39] Consumers are often hesitant to purchase grass-fed beef because, due to a lack of subsidization, it is often **more expensive**. Consumers have also grown to enjoy the marbled more fat-dense texture of grain-fed beef as opposed to the **leaner, "tougher" texture** of the grass-fed alternative.[40]

Truthfully, beef production in an entirely grass-fed system would not be able to meet current demand or production rates. It is estimated that if the entire beef industry in the U.S. switched to grass-fed, **it could produce approximately half** of what feedlots currently produce.[41]

Why a Decrease in Production Would be Beneficial: We are Eating Almost Double What We Need

Currently 75 grams of animal protein are available per capita per day in the U.S. This plus the 34 grams of available plant protein equals 109 grams of protein per day. **The recommended daily allowance (RDA) of protein in a mixed diet (plant and animal based) is 56 grams per day.** If all cattle production became grass-fed, the drop in available meat would cause per capita consumption to drop to 29 grams of animal protein per day. This plus the same 34 grams of plant protein comes to 63 grams per day, still higher than the RDA suggests. A drop in beef consumption due to a switch to grass-fed beef would not only help address America's obesity issue, it would also cut energy inputs for beef production in half.[42]

How Can We Make These Changes?

The Farm Bill:

Background and Current Status

The Farm Bill was created during the Great Depression to alleviate economic strains on farmers. It was meant to be temporary, yet it was never terminated.[43] The latest Farm Bill, updated in 2008, allocated **$284 billion dollars** over 5 years to food related programs. Although this bill includes 15 titles, the top four receive 97% of available funds. 67%, or $189 billion, has been allocated to nutrition programs such as food stamps and school lunches. **Commodity crops were slotted to receive 15%, or $42 billion**. Conservation programs received 9%, or $24 billion, and crop insurance received 8%, or $22 billion. For the purposes of this argument, we will concern ourselves with the funds allocated to commodity crops, conservation, and crop insurance.[44]

Beef CAFOs receive financial assistance, both directly and indirectly, so that their energy intensive practices can remain profitable. Indirectly, feedlots benefit from subsidies to grain production, primarily corn and soybeans. These subsidies create artificially low prices, often below the price of production. Between 1997-2005, grain subsidies **saved beef CAFOs and diary farms approximately $35 billion in feed costs**.[45] Pasture and grass-fed alternative production methods do not benefit from these subsidies, giving CAFOs the illusion of being more economically efficient. Directly, CAFOs receive subsidies from the Environmental Quality Incentives Program; $100 million per year to reduce some waste and pollution. While reducing pollution is a positive, CAFO waste is still released into the environment untreated. Such a large sum of money funded by tax dollars also raises the question of whether the government should have to fund CAFO clean up at all.[46]

Current subsidies are based on production quantity, not need or methods. The more a farmer produces, the more subsidies they are eligible for. This system does not take into account need on a year by year basis, or income. It also not consider sustainability of practices or energy input. Because of this, wealthy owners of large farms receive funds they do not need, while many small to mid-sized farmers struggle.[47] Over half of the funds for direct subsidy payments go to the largest 7% of farms.[48] Another trend that needs to be reversed is that with each passing generation, fewer Americans become farmers. **The average age of the current American farmer is 55**. The Farm Bill should provide incentives for beginning farmers so that fewer farms will be taken over by big agribusiness such as CAFOs and commodity crops.

Another issue that needs to be addressed within the Farm Bill is crop insurance. Currently, insurance policies favor large, mono-crop farms that are energy intensive. Under this policy, it is difficult for more sustainable multi-crop farms to get insurance at all. The Farm Bill should create incentives for sustainable practices such as multi-crop farming, not disincentives. **The Conservation program is also underfunded**. Over 1,000,000 acres are currently waiting, due to lack of funds, to be enrolled in the Wetlands and Grasslands reserve programs.[49]

2012 Revision

The new 2012 Farm Bill includes an agricultural subsidy allocation of $30 million, $5 million of which is slated to go primarily to the commodity crop "big five": corn, soybeans, wheat, cotton, and rice. Mark Bitteman of the New York Times suggests that **instead of removing this fund, we should shift it to provide incentives for more sustainable, more beneficial farming practices**. Subsidies should be shifted to promote multi-crop farms, which require this fertilizer and therefore less fossil fuels, instead of the large, mono-crop farms that deplete soil and currently make up the basis of the beneficiaries.[50]

Also, **subsidies should be shifted towards fruits, vegetables, (which currently receive <1%) and beans** to be more aligned with suggestions for good nutrition. Nutritional education should also be supported to reduce obesity and related strains on U.S. health care. Shifting subsidies in this way would also help small to midsized farmers become more competitive with large agribusiness. The funds for research of sustainable farming methods should also be increased.[51]

The Farm Bill should provide incentives for small to medium sized farms with sustainable, responsible practices and stop funding environmentally harmful, energetically intensive CAFOs. This includes removing or reducing grain subsidies and waste removal subsidies, and instead using that money to fund less energy intensive practices that work with nature and improve human health. Money from these subsidies should be used to fund food proportionately to suggested daily intake values, allow for important research, help new farmers, conserve more wetlands and grasslands, ensure that small to midsize multi-crop farmers have equal access to crop insurance, and provide incentives for environmentally friendly practices. CAFOs in particular should have to pay for their true energetic costs, both direct and indirect, and **grass-fed alternatives that consume less fossil fuels should be supported.**

2011 Proposed National Pollutant Discharge Elimination System CAFO Reporting Rule-

The Environmental Protection Agency has proposed a rule that would require CAFOs to submit basic operational information, including waste management practices, for review. It is estimated that the rule will go in to place by July 2012, but two versions of the rule are still up for debate. In one version, only CAFOs near important watersheds would have to report their practices. In the second version, all CAFOs would have to report their practices. Since many CAFOs are not currently in compliance with laws made to protect human health and the environment, they should all be held accountable. If all CAFOs had to report their practices, they would have to alter their behavior to align with the Clean Air and Clean Water Acts. This would benefit rural communities, society as a whole, and ecosystems by decreasing pollution from cattle farming.[52]

The Good News and What You Can Do

The general public is becoming more educated and interested in proper nutrition and responsible food production. **In 2011 farmers markets grew by 17% and in 2010 they grew by 16%**.[53] Although the current market share of grass-fed beef is only 3%[54], in 2006 it was less than 1%.[55] It may seem as if agribusiness is too big too challenge, however it is the consumer who decides what is in demand. Each of us has **the power to choose** what we eat and what kind of agriculture we choose to support. As responsible, educated citizens, we should realize the energetic inefficiency and unsustainable practices of CAFO beef production and **take our business elsewhere.** We have the power to change what is in the supermarket.

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Comments

Alexandra Rempel - Oct 25, 2011 1:28 PM

The organization looks great! And now we can comment! Yea!!

Alexandra Rempel - Nov 10, 2011 11:49 AM

Wonderful! Your topic is great. Let us suggest phrasing the question as a neutral one, then examining both sides objectively and also sympathetically (a lot of people rely on cheap protein these days), and then arriving at your position. If you wish to state your position up front, which could also work (and is completely appropriate for many types of advocacy), then you have a somewhat greater burden in giving every single statement bulletproof support. You then have even less room for generalization, because your audience knows your position and may not trust you to evaluate both sides with equal attention. Either way can work, just be aware of the dynamic you establish with your choice.

Your outline looks like an excellent roadmap, too! Do be sure to compare energy use quantitatively, as it seems you're preparing to do. We can help if it gets complicated, but we know you can handle it, as well. This quantitative comparison will be an extremely powerful tool in your argument, so it's worth the effort!

Alexandra Rempel - Nov 17, 2011 1:28 PM

The top of your page is now *highly* effective!! Good job! The question's phrasing and images really drive the point home. In your introduction, open with factual statements that support the *importance* of your question, e.g. "Confined animal feeding operations now produce 90% of the beef consumed by Americans and consume 90% of US corn production...", without yet calling CAFOs "inefficient" - you need some time to present facts that show that, first.

Then - we know the writing is in progress - do be sure to show the reader your logical path with section headings and images. You're a good writer already; this is just extra encouragement. Good luck and let us know when we can help.

Alexandra Rempel - Nov 28, 2011 10:57 AM

The history looks great! And good for you for not calling it "history" :-). So - I think additional signposting might help, in the form of a bold-typeface phrase at the beginning of certain paragraphs, for the "skimming" reader. If these can convey a whole idea, so much the better; for example: "The Rise of Slaughterhouses", "Cattle Arrive in the

Americas with Columbus", etc. Alternatively, you can structure the first sentence of a paragraph so that you can simply boldface that sentence or part of it. Many of your paragraphs already have such a sentence, so that's what I've shown above (sorry for editing your page but it seemed the easiest way to show you what I meant.) Good work!

Should Detroit Be Exempt from Michigan's Right to Farm Act (RTFA)?

Many cities are expanding their urban zoning policy to allow some urban agriculture in some areas of the city. I believe that farm patches should be allowed to be anywhere and have any crop the farmer is interested in. While I understand the necessity of regulations preventing large livestock in the city, I believe that the more local food people have access to the better.

Arguments for Urban Agriculture include improved quality of food, decreased energy consumption, and improved nutrition for families with less access to organic (from the earth, not the factory) goods. Urban agriculture also provides a method for small income families to sell their wares at local markets.

My goal is to explore the benefits of urban agriculture. Detroit is currently big on urban agriculture in empty lots, but bigger for profit farms are meeting resistance. In 1995, Michigan's Right to Farm Act went into effect. This act protects farmers from their neighbor's complaints. As of December 2011 a second attempt will be made on the Right to Farm Act's jurisdiction in Detroit.

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Contents

Development of Urban Agriculture in Detroit

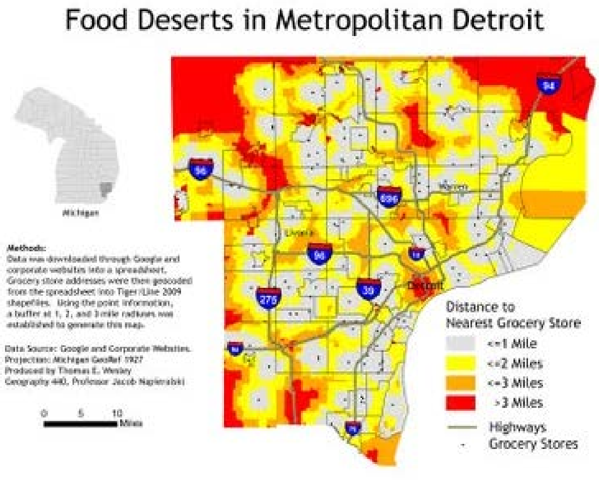
Urban Agriculture in Wayne county (home of Detroit) grew from the population decrease. The population dropped 25% between 2000 and 2010 alone (x). The max flux of people from the city meant much of land was left unused (left hand image). Detroit was considered to have "more vacant land than it knows what to do with". Taja Seville, creator of Urban Farming, decided to use the vacant plots for non-profit farms (right hand image). The city donated 20 derelict properties to her cause and pitched in free water utility. Overall the urban farms don't cost the city anything. Volunteers worked the land. The result is urban farm pods, which provide free vegetables to anyone who wants them. The remaining crops are donated to food banks.

As well as providing food security, these urban farms provide a major city service in reducing blight. While foreclosed building can house criminal activity, the vandals leave the gardens alone. These farms also attract people, as opposed to the concern that they might attract pests. People are brought together on a project that benefits the entire community and revitalizes the sense of neighbordom (Farms Take Root in Detroit's Foreclosures - NPR).

These original farms sparked the development of other urban farms through groups such as Detroit Agriculture Network and Detroit Black Community Food Security Network. Even wealthy, money manager John Hantz is joining the movement, albeit with a twist. Rather than starting a non-profit, Hantz wants to begin a farming enterprise within Detroit's city limits. He plans on committing $30 million to the project, which he hopes will turn into several 300 acre farm "lakes" throughout Detroit. One clear point Hantz dwells on is that these "lakes" will not turn Detroit into farm country, but help Detroit display a new type of city, (Can Farming Save Detroit - Whitford).

Why Urban Agriculture?

Counter food deserts



Many parts of the US are currently suffering from an inability to access healthy food. While the problem is more than just access, this is the issue urban agriculture can solve. The CDC currently defines "food deserts" as "areas that lack access to affordable fruits, vegetables, whole grains, low-fat milk, and other foods that make up the full range of a healthy diet" (http://www.cdc.gov/features/fooddeserts/). A study showed that only 19% of low-income zip codes have a minimal "healthy food basket" or products based on the food pyramid's recommended diet. This is in part due to the exodus of people, since many supermarkets have moved from the inner-city to find larger audiences. This means even when the families have cash, they might not have the option of buying healthy food.

Without essential nutrients, the poor quality of the calories in people's diets leads to a variety of preventable diseases. Inadequate nutrition is associated with school/work absences, fatigue, difficulty concentrating, and increased incidence of virulence and infectious diseases. Also, children who experience consistent malnutrition to have higher instance of anxiety, depression, and behavior problems (Brown). This continues on to create risk factors for obesity, early onset diabetes, heart disease, and high blood pressure (x). Michigan alone spends $5,426,000,000 on diabetes costs every year (x) and approximately 8.3% of the nation is said to have this illness (x).

Urban agriculture has the ability to reduce the severity of food deserts by providing local food that not only doesn't have to enter the city, but are in the food deserts. Urban farming has the potential to provide more healthful food than industrial farms and supermarket chains. It provides fresh produce, free-range poultry, and grass-fed lamb, which are good sources of nutrition and ease concerns about excessive use of antibiotics and treatment of animals in the industrial food system (Brown). For more information on this topic see "The Beef Story" or "A Chicken's Lifestyle". Detroit is one of the cities suffering from food deserts (image to the right), but they are starting to combat them with urban agriculture and the veggie-mobiles.

Detroit's veggie-mobiles are actually trucks run by a company called Peaches and Greens. The company started trucking their produce through neighborhoods, when the vegetable stands they set up were not widely attended. After that they started driving their produce through the neighborhoods with an ice-cream style truck (song and all). Lisa Johanon, who runs Peaches and Greens, says "at first people didn't know it was for them.... And then when we started flyering and talking to people, they became very excited. And they get to come on the truck and actually pick out what they want." The project has been very successful at helping to counter food deserts and one of the driver's, Marvin Jenkins, says the children are as happy to see him as the ice cream truck because "all they want is strawberries and grapes and peaches" (http://www.npr.org/player/v2/mediaPlayer.html?action=1&t=1&islist=false&id=131000846&m=131000707).

Decrease food miles

Food miles are the distance food has to travel before it reaches the dinner plate. It also includes the distance required to dispose of waste foods (http://www.organiclinker.com/food-miles.cfm). The food miles argument is trying to explain that local food is better for the world because it reduces fossil fuel consumption.

An example of the increased mileage is from lettuce's growth site to consumption site. Most lettuce is grown in California, Arizona, or Florida and is shipped to the other states. This requires a large amount of energy for transportation. Looking at gas alone, shipping lettuce from Florida to Michigan (Detroit) requires 31 GJ of energy (x)(x). On the other hand, urban agriculture eliminates these costs or at least decreases them. A city farmer will be driving approximately 25 miles (maximum) within the city (110 MJ) compared to the 1,220 miles driven (Florida to Detroit). This means large scale farms use 282 times as much energy for transport as small urban farms. This small amount of energy can be further decreased if farmers bike their products to the market, or carpool.

While transport is a small portion of the energy required for food production, production energy is also important to consider. A study done in 2001, compared the efficiency of small farms to large farms. They found that large crop farms (revenue > $100,000) are on average 25% more efficient than small crop farms (Lall). Of course another study says that urban commercial gardens have the potential to produce yields that are 13x greater than rural farms. While the large farms may have that 25% more efficient, the 282x more fossil fuel energy for transport is notable. This is especially since fossil fuels are running out and their use is destroying the environment.

Benefit the Environment

To understand the green quality of urban farms, it is necessary to understand the effects of large scale farms. Industrial agriculture creates a large amount of air pollution through use of mechanized machinery and large scale transport. But the air is not the only place being polluted in large scale agriculture. The chemicals used to produce such dense, and similar crops, pollute the soil and the groundwater (Brown). The manure from factory farm animals is mixed with water and stored in "lagoons". This is then sprayed on cropland, but the "lagoons" don't always hold or are over applied leading to runoff into surface water. While, a little animal manure doesn't sound too scary, it is usually contaminated with antibiotics and growth hormones. The runoff can change the environment enough to lead to fish death, degradation of aquatic habitats, and decrease the quality of drinking water.

The industrial farm system also leads to decreased soil fertility. When nutrients are over applied to the soil, the build up decreases the soils fertility instead of increasing it. Since it is difficult to unfertilize land, these plots are put out of use (http://www.sustainabletable.org/issues/environment/). Urban farming can help. Since most urban farms are in the city they distribute to, the energy of transport and air pollution due to it is decreased. Studies by the National Research Council of Canada showed that if 1% of Toronto's land area were greened, the city would reduce its greenhouse gas emission by 2.18 tons per year (Brown).

Of course it is necessary to make sure the food people are eating is safe. Cities have a bad habit of collecting unwanted lead concentrations in the soil. This can be counteracted by removal of polluted soils or photo-remediation (using plants to remove metals from the soil). Farming practices can also be practically applied to prevent food contamination. Raised beds with clean soil have become very popular in urban farming environments (http://www.foodsecurity.org/urbanag.html#V).

Socioeconomic aka other reasons

Urban agriculture is especially important in Detroit because it decreases blight. One urban farming promoter said "City revitalization efforts which include urban agriculture have a regenerative effect when vacant lots are transformed from eyesores- weedy, trash-ridden, dangerous gathering places--into bountiful, beautiful and safe gardens that feed peoples' bodies and souls" (Brown). In 2004, Detroit had between 40,000 and 65,000 vacant lots.

These vacant lots can also cause health and safety problems. In Detroit people would use the vacant lots as garbage dumps or toxic waste dumps, which cost the city $2.2 million a year to clean. Similarly, costs of maintaining city park space are much higher than those of urban farming. The urban agriculture groups pay for the upkeep of the land they use cutting the citys input to almost zero; "the City saves 100 percent on maintenance costs of the parcels in question," (Lachance).

As well as decreasing city costs, urban agriculture also provides valuable job security by creating jobs in the city. It also trains young people in skills like horticulture, marketing, leadership, and the benefits of fresh air (Lachance 7-9). Urban farmers in Philadelphia listed "recreation (21%), mental health (19%), physical health (17%), produce quality and nutrition (14%), spiritual reasons (10%), cost and convenience (7%), self-expression/self-fulfillment (7%) and other (5%) as reasons for community gardening" (Brown).

Michigan's Right to Farm Act

Detroit has shown that urban agriculture is more than people's personal garden's, but actual multi-acre farms within the city. Currently, both types of farms are protected by Michigan's Right to Farm Act (see below), but this is changing. Hundreds of Detroit citizens are currently involved in urban agriculture projects, but the government has not yet acknowledged urban farming as legitimate land use through its Master Plan of Policies or in its Official Zoning Ordinances. Therefore, "Since urban agriculture is neither officially encouraged nor forbidden by the City, it continues in a policy vacuum" (Lachance).

Urban agriculture's only clear guidelines are provided by Michigan's Right to Farm Act. The Right to Farm Act (RTFA) was created to protect the agricultural industry in Michigan. While much of it mainly applies to rural farms, a few sections are commonly applied to urban farms.

One section of the act states " (1) A farm or farm operation shall not be found to be a public or private nuisance if the farm or farm operation alleged to be a nuisance conforms to generally accepted agricultural and management practices according to policy determined by the Michigan commission of agriculture". Unfortunately, finding these "generally accepted agricultural and management practices" on the Department of Agriculture website is exceedingly difficult (www.michigan.gov/mda). This makes the zoning laws the major limiting factor for farming in the city.

Another section includes "(3) A farm or farm operation that is in conformance with subsection (1) shall not be found to be a public or private nuisance as a result of any of the following: (a) A change in ownership or size. (b) Temporary cessation or interruption of farming. (c) Enrollment in governmental programs. (d) Adoption of new technology. (e) A change in type of farm product being produced," which gives urban farmers a defense from their neighbors complaints. This section is the most complained about by those who live next to Detroit's urban farms, who occasionally wake up to a rooster-clock in the morning.

2010 House Bill 6458: Excludes "urban agriculture" from Right to Farm Act

In 2010 (at the very end of his term) Michigan representative Gabe Leland introduced House Bill 6458. In words the bill was very simple. It only said "SEC. 3A. (1) THIS ACT DOES NOT APPLY TO A CITY WITH A POPULATION OF 900,000 OR MORE," where "this act" refers to the Right to Farm Act. Recently, this act specifically applied to Detroit, but currently would not apply to any Michigan cities due the population requirement. The issue with bill's simplicity was that its intention was unknown and therefore distressed many urban farmers.

While the bill was meant to support urban agriculture, two interpretations of the bill's possible effect emerged. One group felt the bill would allow urban agriculture to be restricted within Detroit by countering section 3 (shown above). Others felt the bill would allow Detroit to make specific laws that encourage urban agriculture separate from the Right to Farm Act, which was originally intended for rural farms.

Personally, I believe the Right to Farm Act does not need to be modified for urban agriculture. While much of the information against the bill are urban farmers' rants. One of the few well-written articles about the bill (attempting to support it) actually swayed me against it (http://greatlakesecho.org/2010/10/28/bill-would-exempt-detroit-from-right-to-farm-act-allow-stricter-regulation-of-urban-agriculture/). The article explains that the bill will allow for stricter rules and allow more opportunity for neighbors to complain about farms near them. This sounds more like an attack on urban agriculture than support for it. After all the good urban farming has done for Detroit, why would you want to challenge it in any way?

As of September 2010, the bill did not pass into action (x).

Virgil Smith's Urban Farming Bill

While I was not expecting Michigan to try to revive HB 6458, they have (x). On December 14, 2011, Michigan Senator Virgil Smith is proposing another amendment to the RTFA. This one is similar except it now applies to cities 600,000 or larger (properly including Detroit). Senator Smith has done a better job of explaining his intent with the new legislature. The argument for the bill is that exempting Detroit from the RTFA will allow regulations to be put in place to both legalize zoning laws and increase the number of larger scale farms. While I like the intent of the new senate bill, I still have some disagreements.

First, the senator does not address any protections that will be given to urban farmers from their neighbors sensitive noses. On one of Senator Smith's pages it says if "a neighbor had 20 chickens in their backyard, some might find the smell and noise as a nuisance and the animals and their waste as a health hazard. But under Michigan's Right to Farm Act, the City could not regulate what is happening at that property," which indicates the neighbor should have the power to shut down their neighbor's operation (http://www.virgilksmith.com/vks/blog/article/188). Farmer's main argument against bills exempting urban agriculture from the RTFA is fear that they will be shut down.

Second, I disagree with the Senator's position that people need to be protected from urban farms. Reporter Jonathan Oosting quotes the senator saying "The biggest problem is that we do not want folks having, say, pigs right next door to somebody trying to raise a normal family" (http://www.mlive.com/news/detroit/index.ssf/2011/11/state_legislator_looks_to_amen.html). As someone raised on a farm (including pigs), I find this insulting. Does he mean to insinuate that growing up on a farm decreases one's potential for success?

I believe that the senator is doing a better job of stating his public intent, but I want to see the exact bill before I am willing to support it. Urban farmers need to be reassured that they will be protected during the agriculture expansion, not threatened.

Comments

Alexandra Rempel - Nov 3, 2011 4:11 PM

Since land use zoning is usually a municipal issue, why don't you pick a city that is currently undergoing a major soul-searching about this, and investigate its specific issue? Detroit is one that comes to mind, that is really wrestling with it, and Kansas City is another; there are surely many more though. Seattle & San Francisco can serve as examples of success! Try to pin this down soon.

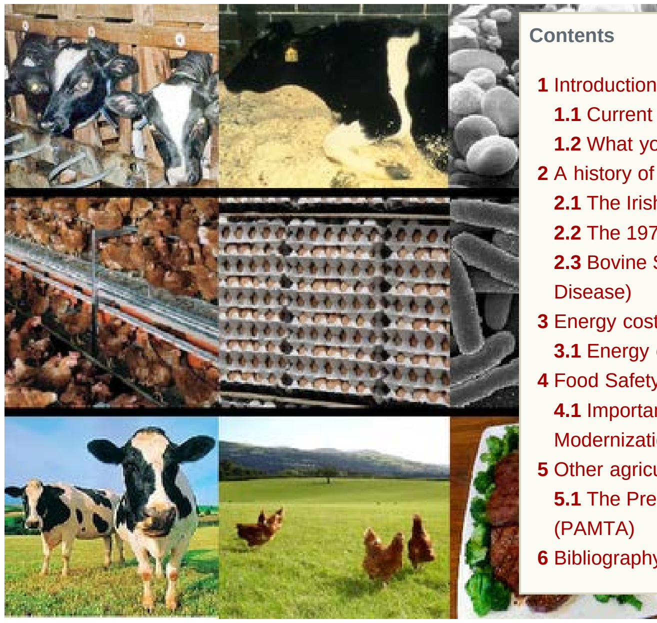
Alexandra Rempel - Nov 10, 2011 12:30 PM

This seems the same as it did last week; have you thought about a more location-specific issue, with two valid opposing sides, to investigate? That's the first step, and it would be good to establish that as soon as possible. Then, think about a logical structure for your investigation: what is the most important information to discover, in order to create an informed, well-supported position? Within that structure, you can integrate your description of ways that energy moves through the system of interest; it's probably time to dispense with the "work" and "heat" subtopics. The urban agriculture movement is fascinating and you have a great area to work within; it's time, though, to start developing your ideas into a concrete story. Let us know when we can help.

Alexandra Rempel - Nov 17, 2011 1:04 PM

The Detroit focus is very promising! I'm not sure the story is clear to me yet, but I know it's a work in progress. Do be sure to make the central logical flow of the story clear eventually, though! See the writing page on the course wiki for ideas and examples of clear, concise writing.

Should Congress amend food regulation policies to help prevent food borne illness?



Contents

Food Borne Illness and Energy

Dylan G. Carter

Introduction: Food borne illness and you

Current effects

Table 1. Estimated annual number of domestically acquired, foodborne illnesses, hospitalizations, and deaths due to 31 pathogens and unspecified agents transmitted through food, United States

Foodborne Agents	Estimated annual number of illnesses (90% credible interval)	%	Estimated annual number of hospitalizations (90% credible interval)	%	Estimated annual number of deaths (90% credible interval)	%
31 known pathogens	9.4 million (6.6–12.7 million)	20	55,961 (39,534–75,741)	44	1,351 (712–2,268)	44
Unspecified agents	38.4 million (19.8–61.2 million)	80	71,878 (9,924–157,340)	56	1,686 (369–3,338)	56
Total	47.8 million (28.7–71.1 million)	100	127,839 (62,529–215,562)	100	3,037 (1,492–4,983)	100

Food borne illness is defined as any illness resulting from the consumption of food contaminated by pathogenic bacteria, viruses, or parasites, as well as chemical or natural toxins. It is still a serious threat today; the Center for Disease Control estimates that each year roughly 1 in 6 Americans (or 48 million people) gets sick from food borne illness, 128,000 are hospitalized, and 3,000 die of foodborne diseases. Their estimates are divided into two major groups of foodborne illnesses: known foodborne pathogens and unspecified agents. There are currently 31 pathogens known to cause foodborne illness; most of these pathogens are tracked by public health systems that follow diseases and outbreaks. Unspecified agents are those cases with insufficient data to estimate what the CDC calls the agent-specific burden. These include known agents that are not yet identified as causing foodborne illness; microbes, chemicals, or other substances known to be in food whose ability to cause illness is unproven; and agents not yet identified. Table 1 above gives a full break down of the CDCs estimates for the effects of food borne illness within the United States.

What you can do

As seen in the table above, the CDC estimates roughly 3,000 people die from food borne illness within the United States each year. You as a consumer can also help to bring this number down by following these simple steps, as recommended by the CDC. Click the image to enlarge.

Clean: hands, foodstuffs, tools and utensils, surfaces.
Wash all produce. Rinse fresh fruits and vegetables in running tap water to remove visible dirt and grime. Remove and discard the outermost leaves of a head of lettuce or cabbage.

Because bacteria can grow well on the cut surface of fruit or vegetable, be careful not to contaminate these foods while slicing them up on the cutting board, and avoid leaving cut produce at room temperature for many hours. Don't be a source of foodborne illness yourself. Wash your hands with soap and water before preparing food.

Separate: raw meat and poultry, vegetables and fruits.
Don't cross-contaminate one food with another. Avoid cross-contaminating foods by washing hands, utensils, and cutting boards after they have been in contact with raw meat or poultry and before they touch another food. Put cooked meat on a clean platter, rather back on one that held the raw meat.

Cook: meat, poultry and eggs THOROUGHLY.
Using a thermometer to measure the internal temperature of meat is a good way to be sure that it is cooked sufficiently to kill bacteria. For example, ground beef should be cooked to an internal temperature of 160^{o} F. Eggs should be cooked until the yolk is firm.

Chill: Refrigerate leftovers promptly.
Bacteria can grow quickly at room temperature, so refrigerate leftover foods if they are not going to be eaten within 4 hours.

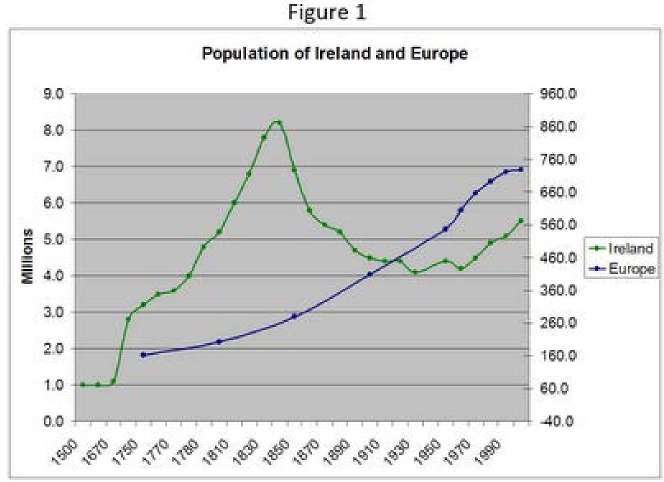
Report:
Report suspected foodborne illnesses to your local health department. The local public health department is an important part of the food safety system: often calls from concerned citizens are how outbreaks are first detected. If a public health official contacts you to find our more about an illness you had, your cooperation is important.

A history of food borne illness

The Irish potato famine

Mass production of any foodstuff can allow on to reap great rewards, but there are many hazards associated with it, as history has proven many times. With a monoculture crop, one can produce food to amply feed a population; however, a rampant disease can uniformly infect and devastate the entire food supply. Such was the case in the Irish potato famine in the mid 19th century. The potato was bro ught back to Europe from the Americas and introduced to Ireland as early as the late 1500s. The result, as can be seen in Figure 1 (click to enlarge), was Ireland's population growing at almost an exponential rate, such that at their peak in 1845, the 8 million denizens of Ireland comprised a whopping 3% of Europe's total population. However, 1845 also marked the onset of the potato blight, which infected and corrupted Ireland's prized tubers, leaving a third of the population without a food source. In the fallout, it is estimated that Ireland lost almost half of its population to starvation and emigration elsewhere.

Figure 1



Dependence upon a single, cheap food source can support a great many people and is obviously convenient, but when the potential hazards associated with such quick and easy consumption come to pass, they are typically devastating, as the Irish can attest. However, humanity continues to employ mass production extensively, as the ability to support a much larger population outweighs the potential losses should the worst come to pass.


Figure 2: Maize with Southern Corn Leaf Blight

The 1970 US corn blight

In the centuries since the Great Famine, as it is known in Ireland, humankind has realized the dangers posed by mass production of foodstuffs and as a result applied itself to mitigating these problems or avoiding them entirely. To this end, humankind has placed focus on reducing the health risks posed by mass production in the agricultural sector, which to its benefit has seen exceptional new advances. The solution was thought to be found during the Green Revolution as the genetic modification of plants and seeds took off; scientists now know tha t although genetic alteration does guar antee some disease resistance, it also comes with its own host of pitfalls.

In 1970, the Midwestern U.S. corn crop was struck heavily by a fungus that, though it had made its first appearance two years before, went mostly unnoticed until it reached nigh pandemic proportions, causing a loss of 15% of the US corn crop and over a billion dollars. Farmers had initially ignored the slight discolorations found on leaves, as shown in figure 2, assuming that their genetically modified crop was safe from microbes. Sadly, the same folded protein that kept most serious crop diseases away from maize and corn, when confronted with a new mutation of leaf blight, welcomed it in. Genetic modification had allowed humanity to take a great leap forward in the fight against food borne illness, but to this day, humanity still has not even come close to complete prevention.

Bovine Spongiform Encephalopathy (BSE aka Mad Cow Disease)

In the modern world, it seems rare that we find ourselves eating foodstuffs that haven't been genetically modified; that is, if it was ever a plant or animal in the first place. And though standardization of food safety, further mechanization and antibiotics have relegated diseases such as dysentery and cholera to being nigh unheard of in the developed world, this has only brought other food borne illnesses to the fore. Fortunately, these diseases have so far affected relatively few individuals, but there are realistic fears that any one of these small outbreaks could quickly become an epidemic. This is especially true in the case of diseases that affect plants and animals and have the potential to mutate to become communicable to humans.

The first discovered case of BSE in a cow occurred in 1986 in the United Kingdom. During the 1980s, it is estimated that as many as 400,000 cattle with BSE in the UK entered the human food chain undetected, accounting for most human cases, including those in Ireland, Canada and the United States. The current statistics from the Center for Disease Control (CDC) have just three cases of humans with BSE in the United States on record, sources of which were all traced back to foreign meat. By culling all suspect cattle populations, Britain brought the disease under control, but not before it had spread to several other countries and accrued enough fatalities to gain worldwide attention.

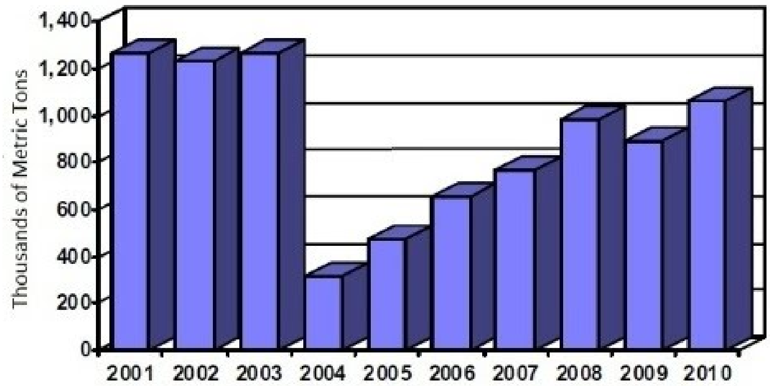


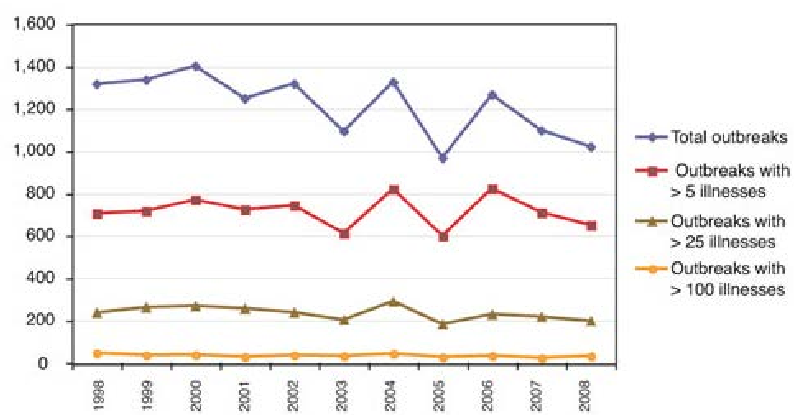
Figure 3: US Beef Exports

The first reported case of BSE in cattle in North America occurred in 1993 in Alberta, Canada. Another case reported later in May 2003. In December of 2003, a single cow in Washington state was discovered to have BSE; it was later confirmed that it was a cow of Canadian origin and imported to the U.S. Japan responded by instantly cutting off all US beef. Other countries quickly followed suit, significantly reducing or entirely eliminating US beef imports. Total beef exports dropped by almost 70% over the next year, roughly a million metric tons, all because of a single diseased cow, discovered even before it was slaughtered.

Energy costs of food borne illness

The easiest way avoid loss from food borne illness, whether that loss is in the form of human life, energy, or money, is to prevent these outbreaks from ever occurring in the first place: as the age old expression goes, an ounce of prevention is worth a pound of cure. The best way to prevent food borne illness from even reaching the outbreak stage is to ensure that food production and distribution are properly regulated. In the past there have been massive losses as a result of lax food regulation, both in terms of foodstuffs discarded or destroyed and in the economic sector; thus these are areas of greatest potential savings. In the United States, most all food regulation is passed through legislation; there is no way to guarantee that new pieces of legislation might prevent or help to slow the spread of food borne illness such as mad cow disease or e coli in spinach, but according the graph at the right, the total number of outbreaks does exhibit a downward trend.

TRENDS IN THE NUMBER OF OUTBREAKS, BY NUMBER OF ILLNESSES PER OUTBREAK



Energy cost of BSE in the US

Energy Cost of a Hamburger (90 grams)

	Low, MJ	High, MJ
Crop production, drying, fodder production	3.5	5.0
Stable, slaughtering, cutting	0.23	1.4
Grinding, freezing	0.12	0.16
Storage	0.45	2.3
Frying	0.79	1.0
Transportation	0.44	0.59
Total	**5.6**	**10**

The factors for conversion of beef to to energy comes from a report done by the Environmental Strategies Research Group of the Department of Systems Ecology at Stockholm University, based on on the following: "In our example, we assumed that the meat came from a spring born calf that eats 2,728 kg of feed before attaining a carcass weight of 265 kg. The feed consumption per kg live weight is 6.4 kg with a dressing yield of 62 %." They concluded that the average energy cost of one hamburger, or 90 grams of beef, was between 5.6 and 10 MegaJoules. This equates to between 62 million and 111 million MegaJoules per metric ton of beef, from birth til death and then from farm to table. Considering that the cow in Washington cost the United States 952,131 metric tons of beef exports, the equivalent of relatively 3 billion dollars, this cost over 59 trillion MegaJoules. By comparison, in 2006, the worldwide transport sector consumed 97 trillion Mega Joules. We cannot say that necessarily say that 59 trillion MegaJoules was the actual cost of that single contaminated cow, as that would imply that that beef was still produced without demand, but many thousands of cattle were slaughtered and their meat discarded to ensure that the disease not spread and that a second contaminated cow never be found. And though we cannot quantify the energy cost of most food epidemics, it is obvious that it is far more efficient to address food borne illness through prevention rather than by responding to outbreaks. Worldwide governments have accepted this and had food safety regulations in place for decades now, but there are always improvements to be made. With BSE and other food borne illnesses making headlines in the news, in 2009 the Food and Safety Modernization Act was passed, although not without controversy.

Food Safety Regulations

Important provisions of the unamended Food and Safety Modernization Act (FSMA)

As food production has evolved over time, so have our regulations. Prior to the FSMA, the most recent major update to food safety regulations was the Public Health Security and Bioterrorism Preparedness Response Act, which was passed as part of the PATRIOT Act. However, it was intended to address concerns over deliberate contamination of food by those seeking to harm Americans, rather than the safety of the food itself, making the FSMA the largest overhaul of food safety regulations in the last decade. The less controversial provisions include:

- The Food and Drug Administration (FDA) the power to directly issue a mandatory food recall.
    - Previously, the agency had to arrange a voluntary recall with the company in question. This new provision is designed to expedite negotiations between the FDA and the food company, and in some cases circumvent the process all together
- Every two years at minimum, the FDA will identify the most significant food threats and disperse new science-based outlines and regulations for food production companies.
- The FDA must establish offices in at least five foreign countries that export food to the United States to improve food oversight
- The FDA will gain expanded access to food production facility records.
    - Upon request, the agency may obtain records for tracking purposes or if there is reason to suspect a potential public health risk.
- The FDA may suspend a food production facility if a possible health risk is suspected.
- The FDA will issue regulations that prevent food companies from knowingly including illegal additives, chemicals or other substances in their food products
    - Stunningly, before the passage of the FSMA, it was illegal for companies to manufacture such substances, but not for production facilities to add them to foods,
- Health and Human Services, along with the Department of Education, will develop food allergy management guidelines.
    - Schools and early childhood programs may then voluntarily implement them.
    - Programs deemed successful by the Secretary of Health And Human Services will be eligible for federal grants.
- Health and Human Services will have to prepare a specific response outline in case of a food-borne illness outbreak.
    - In addition, grocery stores will now be responsible for actively alerting customers of latest product recalls.
- The FDA must increase the frequency of its inspections.
    - High-risk food production facilities will be inspected every three years.
    - Low-risk facilities will be visited within seven years of the law's passage, and then every three years after that.
    - Each year the FDA must report to Congress the frequency and cost of inspections.
- The FDA may require certification or other forms of assurance for high-risk food imports.
    - The FDA may then refuse to import food products that are lacking the required certification.
- The FDA will have the authority to review the current food safety practices of countries importing products into America.
- Any food production company employees will be protected when providing information regarding potential violations to the FDA.
- The new law mandates that FDA inspections of foreign food facilities must double each year for the next five years.

All of these provisions passed through the legislature without generating much feedback. However, two elements stood to impact small farmers and farmers market in drastic ways:

- The FDA will institute new regulations regarding standards for fruits and vegetables.
    - Tracking and tracing fruits and vegetables will be a priority in order to quickly locate the source of contamination, requiring facilities to provide the FDA with tracking information for all fruits and vegetables.
    - Additionally, the FDA will publish updated safety guidelines for specific fruits, vegetables and designated high-risk produce.
- Food production facilities must alert the FDA, through writing, of all identified hazardous practices currently in place and their plans to implement preventive measures going forward.

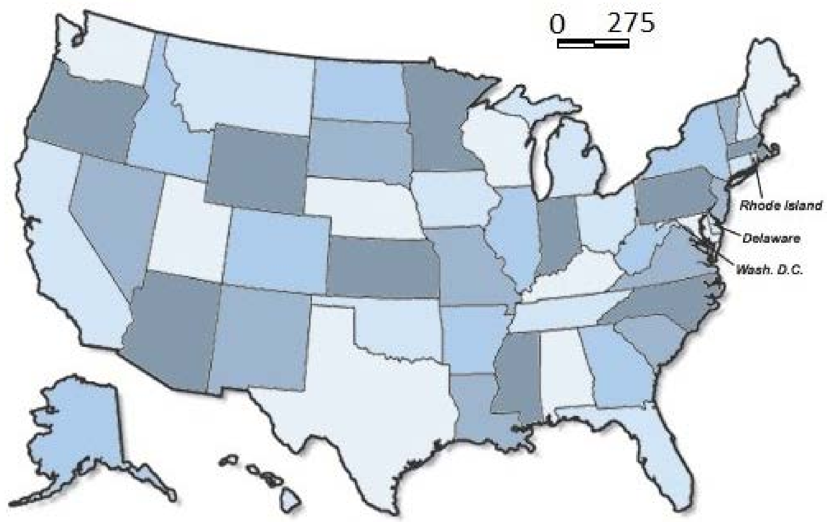
Both of these regulations stood to have significant impact on smaller farms, due to fears that the cost of producing such records would drive some businesses to bankruptcy. Among these, the hardest hit would be the smallest farmers, whose primary source of income is farmers markets and other sources of local distribution.

The Tester Amendment

In response, senator Jon Tester, D-Mont. (pictured at right), added an amendment to the FSMA that added exemptions for such small farms and facilities.

- Food facilities would qualify for an exemption from the preventive control/HACCP provisions (documentation of food safety hazards) and the produce safety standards (documentation of fruits and vegetables for tracking purposes) under certain conditions:
    - They are either a “very small business” as defined by FDA in rulemaking or
    - The average annual monetary value of all food sold by the facility during the previous 3 year period was less than $500,000
        - Additionally, businesses only qualify so long as the majority of the food sold by that facility was sold directly to consumers, restaurants, or grocery stores (as opposed to 3rd party food brokers)
        - The food must sold within the same state where the facility grew or produced the food or within 275 miles of the facility. (see map below for detail, Alaska and Hawaii not to scale)
- Facilities that qualify would be exempt from the preventive control/HACCP provisions (documentation of food safety hazards) , but would still have to comply with one of the following:

  - They would have to demonstrate that they have identified potential hazards and are implementing preventive controls to address the hazards.
  - They would have to demonstrate to FDA that they are in compliance with state or local food safety laws.
- Any food sold by a facility that opts for compliance with the listed options must provide the name and address of the facility that produced it on the food packaging label, or at the point of purchase (such as a farmers market), as appropriate.
- In the event of an active investigation of a foodborne illness outbreak that is directly linked to a facility or farm exempted under this section, or if the Secretary determines that it is necessary to protect the public health and prevent or mitigate a foodborne illness outbreak, the Secretary may withdraw the exemption provided to such facility under this section.
- No activities under this limitation expand existing FDA authorities to inspect farms.



The Tester Amendment addressed both provisions of the FSMA that raised concerns with small farmers. It introduced a 'size' requirement for a facility to be exempt from both the safety and fruit and vegetable documentation provisions, while still holding such facilities accountable should there be an outbreak of food borne illness. Unfortunately, this turns the regulation from implementing preventative measures to instead responding to outbreaks, but considering that the new 'smaller' facilities have a small distribution area, their impact in case of an outbreak is far more limited. In addition, requiring such smaller farms and facilities to provide their address either on the label of their product or at the source of their distribution (in most cases, a farmers market) sets a noteworthy precedent; several failed bills in the last decade have tried to set regulations for food product labeling.

Interestingly enough, large agribusiness focused on fruits and vegetables refrained from weighing in on the issue until after the addition of the Tester Amendment, at which point several large companies addressed a letter to Congress: 'As organizations representing the vast majority of fresh produce grown and consumed in this country – from small, medium and large-sized farms – the Tester amendment utterly fails to protect consumers by including blanket exemptions from the rest of the bill's strong safety net, without regard to risk.' However, though these concerns are legitimate in some cases, the bill will already have a fundamental impact upon the safety of small farms, which, considering their small area of distribution, is an appropriate compensation. In fact, the bill will even promote smaller farms and facilities over their larger counterparts, which gears the bill towards promoting locavorism, another large energy saver.

With the passage of just the FSMA, complete with the Tester Amendment, the likelihood of such epidemics should be diminished, to the point where the declining trend in the number of food borne illness outbreaks will hopefully continue. However, only time will tell.

Should Congress amend food regulation policies to help prevent food borne illness?

Yes, Congress has done so in the past and in the present, and should continue to do so in the future. As our system of food production and distribution continues to develop, expand and modernize, there are still many areas where food safety could be improved. The FSMA is a massive leap in the right direction, but there is still much more than can be done. Key among these further reforms would be an overhaul of the United States Department of Agriculture, which monitors the meat industry, including oversight of chicken and cattle farms, two other areas directly addressed by our website (links can be found under the tabs at the top of the page).

Other agricultural bills currently under consideration

The Preservation of Antibiotics for Medical Treatment Act (PAMTA)

Antibiotics are excellent for wiping out almost every trace of bacteria (whether they're harmful or not), but the key word there is 'almost'. Those few bacterium that do survive have a miniscule resistance to the antibiotic, and they will be the breeding ground for the next generation. Thus, applying frequent small doses of antibiotics to animal feed, as is commonly done in confined animal feeding organizations (CAFOs), simply accelerates the development of the super germ that can resist anything we throw at it. In the worst of worst case scenarios, we are also accelerating the rate at which it can mutate to then communicate itself to humans, as in the case of BSE.

Effects of PAMTA:

- Phases out the non-therapeutic use of medically important antibiotics in livestock.
- Requires new applications for animal antibiotics to demonstrate the use of the antibiotic will not endanger public health.
- Does not restrict the use of antibiotics to treat sick livestock or to treat pets.

First proposed by Rep. Louise Slaughter, D-NY28 in the '09-'10 session, it was reintroduced by Senator Dianne Feinstein (D-CA), to address "the rampant overuse of antibiotics in agriculture that creates drug-resistant bacteria, an increasing threat to human beings." Senators Susan Collins (R-ME), Jack Reed (D-RI), Barbara Boxer (D-CA), all collaborated on the legislation.

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Comments

Alexandra Rempel - Oct 26, 2011 2:15 PM

Good investigative work! The FSMA does have impacts on small farms, too; I could put you in touch with our local CSA farm that advocated strongly against applying factory-farm-level record keeping laws to small local farms. However, advocating to include something new in an existing bill does not help you identify specific counterarguments; those emerge most clearly when you look at a real controversy. It looks like the *labeling* of GMOs is now a real controversy, in California at least, and GMOs do have a very real energy-based reason for existence: they help more biomass grow from a given amount of land and fertilizer. Much of the anti-GMO literature has become sensationalized, however, so be sure to support both sides with solid scientific studies.

Alternatively, the locavore aspect is still valid as well. And, the reference formatting you used for the locavore section is great! The direct link from a word to a source, and from a citation note to its source, is a winning combination.

Keep working on this! We'll check in frequently until you get your topic firmly defined.

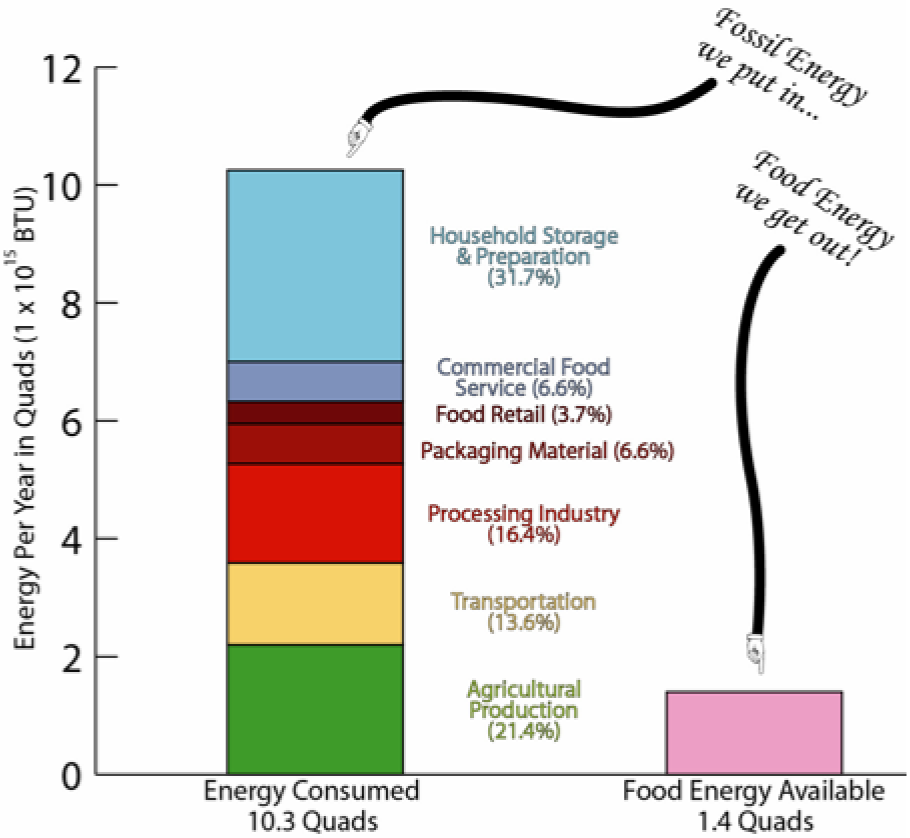
Alexandra Rempel - Nov 10, 2011 11:33 AM

Good improvements! Your topic now seems firmly linked to current issues. And, you show a good appreciation of the connection of the immediate issue (food safety standards) to the energy transition issue (should we promote small local farms to diminish the miles that food is transported?). This topic covers a lot of ground; your challenge will be to organize it and package it so that the opposing arguments are clear, and are supported by the facts without getting too bogged down in them. Think of presenting it in manageable bites. And, remember that it's awkward to read too many numbers and symbols, and that sometimes a map or a diagram or a graph can convey the same information more easily.

Alexandra Rempel - Nov 17, 2011 1:22 PM

The central focus of your exploration is quite obscure at this point: what is your energy transition question? Put that at the top so we can find it. You'll need to make the connection from the FSMA to local farming *explicitly*, using diagrams and headlines, or your readers will stay confused. Also make the arguments for and against this question *abundantly* clear. Point fingers and name names; use citations to your advantage! And edit, edit, edit - jettison any word that is not absolutely essential to your case. Replace others with images. Be ruthless! You can do this, we're confident!

Energy Flow in the U.S. Food System



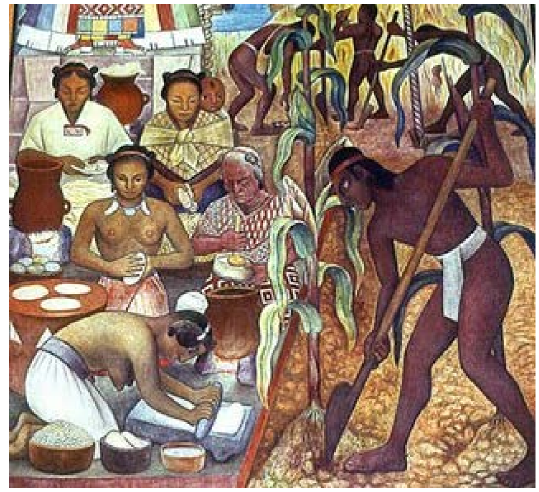
Hunting and Gathering

Before humans used farming and animal husbandry to ensure a steady food supply, hunting and gathering was the primary method used to obtain necessary calories. Though the energetic input of this system came entirely from the human body, it was actually quite efficient in terms of energy in to energy out. In a hunter-gatherer society, the caloric needs of an average man are estimated at 2,680 kilo-calories (food calories) per day. With this, a man could collect 10,500 k-cals of nuts per day. The energetic flow in this system is 1:3.9; one kcal of energy in for 3.9 kcals of energy out.

The cave art at right comes from the Lascaux cave paintings in southwestern France. The paintings in the cave date back 15,000 years and shows the importance of hunting during this time.

→→Neolithic Revolution

Neolithic Revolution



"Farming maize" - Diego Rivera

During the Neolithic Revolution, hunters and gatherers in the Fertile Crescent began domesticating plants and animals. Plant cultivation and the increased use of animals led to significant population growth and greater food production efficiency. When agriculture developed, the energy ratio of inputs to outputs increased favorably, though variably. The energy flow for maize produced in Mexico includes an input of 642,338 kcals and an output of 6,901,200, which can be represented in a ratio as 1:11. The input includes human effort, tool production (axe and hoe), and seed production and distribution. On less productive land, there is a kcal input of 770,253 and output of 6,901,200, a ratio of 1:4. In this case, the land is less productive because of reduced soil fertility, and animal power replaced human power. Even though the yields do not seem that much greater than those of the hunter-gatherer, human effort greatly decreased with the use of animals.

Slash-and-burn and irrigation methods were among the first agricultural practices to develop. Slash-and-burn methods helped to support population densities of ten to thirty people per square kilometer. Irrigation began in 6,000 BCE in the Zagros Mountains, modern day Iran, and then spread to Mesopotamia (Timeline - Ancient History). The development of irrigation supported several hundred people per square kilometer (Mazoyer, Roudart 65). Dogs were domesticated around 10,000 BCE, and goats, sheep, and pigs were domesticated in 7,000 BCE (Timeline - Ancient History). The first plow, a significant technological advance, was invented around 4,500 BCE (Mazoyer, Roudart 236).

Ever since shifting to farming, humans have modified plants to meet production needs (Evolution in Agriculture). One of the crops originally planted in the Fertile Crescent was wheat. Farmers would save the seeds from plants with certain desirable traits and plant them in the next growing season. These favorable traits included seeds that stayed on the plant after ripening, and seeds that could be more easily separated from the hull (Evolution in Agriculture).

→→Developments Up to the Industrial Revolution

Developments up to the Industrial Revolution

Agricultural advances such as irrigation, slash and burn, the plow, and animal domestication directly contributed to population growth; estimates of the world population in 10,000 B.C.E. are between one and five million, in 1000 B.C.E. between 50 million and 100 million, and in 1000 C.E. around 250 million (World History). As the population grew, more food was needed to support the people. To meet that demand, more efficient methods of farming were required.

Europeans began making improvements in both farming methods and technology starting around the eighth century. Northern Europe began using the three-field crop rotation system around 700 C.E. (Backer). The peasants divided the fields into three sections: in one section they planted a fall crop, in the second a spring crop, and the third they let lie fallow in order to rejuvenate its soil. In the earlier two-field rotation system, only half the field produced food; with the three-field system, the production rate rose to two-thirds.

Improvements to the horse collar in the Middle Ages allowed for increased work production. The Europeans developed a horse harness in which the traces attached to the horse's shoulders and moved the yoke to around the horse's breast; previously, the Romans used a harness with a strap that cut across the horse's neck. This development moved the load from the back and neck to the shoulders and breast and increased the amount of work the horse could do (Gans).

In the Middle Ages, people began using oxen to pull their plows (Backer). This innovation allowed the farmers to till the heavier, wetter soils of Northern Europe more efficiently. These improvements on the plow, the start of three-field crop rotation, and better horse harnesses all helped increase agricultural productivity and caused population growth.

Beginning in the 1500s, Spanish and Portuguese explorers brought crops from the New World back to Europe. Potatoes and corn served as inexpensive, easy to grow crops for poorer communities and caused population growth in Europe, Africa, and Asia. Other crops became luxury items for the wealthy: tomatoes, peanuts, vanilla, chocolate, pineapples, and peppers (Hannon).

During the Middle Ages, over half of England's farm land was used for the open field system. The manor or village would be surrounded by large fields divided into strips and tended by individual families. The fields were regulated according to the needs of the community and divided into rotating crop fields and pastures. The community would work together during harvest season to bring in the crops, but otherwise farmers tended their respective fields, even if they did not technically own them (Knox).

→→Industrial Revolution to the 19th Century

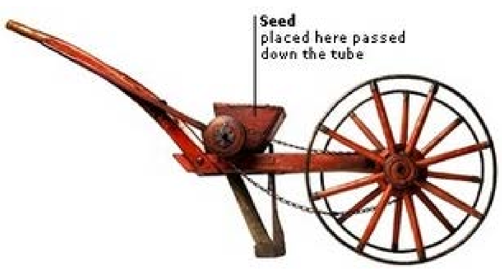
Industrial Revolution up till the 19th century

With the Industrial Revolution came a redistribution of farm land; England passed more than a dozen enclosure acts between 1773 and 1882. The enclosure acts kicked a majority of England's peasantry off their rented land, creating a free floating, poverty stricken population that would later provide the labor for the industrialized factories. The peasantry's loss of land meant they lost their means of eking a small-scale subsistence existence: the acts denied the peasantry use of the land for grazing, hunting, harvesting timber, or fishing. Similar acts were passed all over Europe as the landowners consolidated their tracts of land to be used at their own discretion. Now, new innovations could be implemented faster since a group consensus was not required (Montagna). The enclosure movement also led to the conversion of six million acres of forests, commons, parks, and land considered “waste,” into arable land, which became private property.

The four-field crop rotation system emerged in the years leading up to the Industrial Revolution. Cereals, such as wheat and barley, require a steady supply of nitrates in a closed system. Legumes, including clover and radishes, have nodules on their roots which contain nitrogen-fixing bacteria that return nitrates to the soil. In this situation, the legumes act as a fertilizer. Used in a rotating pattern, the legumes raised the fertility of fields that would otherwise have been left fallow. The improved yield of the agricultural sector during the Industrial Revolution can be attributed to increases in nitrogen in the soil from the cultivation of clover and other legumes (Montagna).

In addition to its nitrate fixing properties as a legume, clover was an ideal fodder crop for cattle; the improved grain production simultaneously increased livestock production. With more food available to sustain livestock throughout the winter, spring herd sizes increased steadily. This lead to greater slaughter sizes, which put more energy-rich red meat on the table. Additionally, the manure of legume-consuming cattle is an excellent fertilizer, leading to even more productive crops.

Cattle production also boomed in England during the Industrial Revolution due to the advent of more sophisticated breeding techniques. Robert Bakewell and Thomas Coke developed both selective breeding, involving mating two animals with desirable traits, and inbreeding, mating two close relatives to ensure such traits were preserved. This yielded much more robust and hearty cattle, in addition to dependable draft horses and woollier sheep.



One of many key factors of the Industrial Revolution was the advent of mechanization; Jethro Tull ‘invented’ the seed drill in 1701 (it had been present in Indo-China for centuries already), which replaced manual planting. The drill spaced seeds into rows, allowing for easier weeding, and ensured that they were always positioned deep enough in the soil, increasing germination rate (Jethro Tull the Inventor). Iron ploughs had no commercial success in Europe until 1730, when Joseph Foljambe's Rotherham plough combined an earlier Dutch design with other technological innovations. This design was followed by the Scots Plough, invented by James Small in 1763, which remained in wide use for the better part of a century. In 1786, the Swing Riots were sparked by the spread of Andrew Meikle's threshing machine, which would ultimately deprive many of the participating laborers of their livelihoods. In the 1850s and '60s John Fowler, an agricultural engineer, pioneered the use of steam engines for ploughing and digging drainage channels.

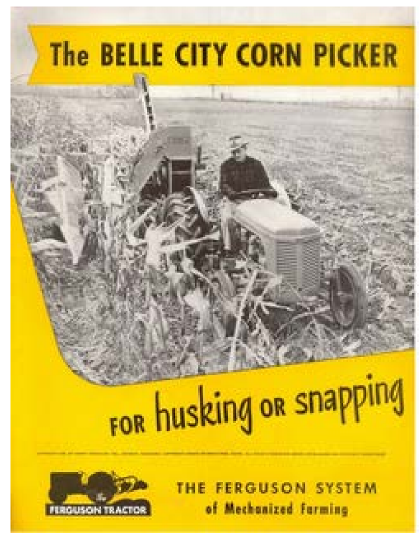
In 1809, Nicolas Appert of France discovered preservation of food by canning, which involves heating food to sterilize it and sealing it in a container. Appert opened the first commercial cannery, the House of Appert, in 1812 (Nicolas Appert). In 1810 Peter Durand received a British patent for the use of a variety of containers for canning, and in 1822 preserved food in tin cans became available in the United States (Food Preservation). In 1862, Louis Pasteur discovered a process that destroys harmful organisms without damaging the food (Chew). Pasteur's process became known as pasteurization, and it is applied to the production of beer, wine, and milk (Cohen).

→→The 19th and 20th Centuries

The 19th and 20th Centuries

Although greenhouses were initially used for cultivation of exotic plants imported by explorers from the New World, greenhouses came to provide a springboard for the science of plant hybridization over the next few centuries. Dependence on monoculture crops increased as the understanding of plant genetics grew. Though beneficial in providing large quantities of food to burgeoning populations, dependence on one type of specific crop has its drawbacks, especially when it comes to disease. The Irish Potato Famine (1845-1849) presents a notable case of the risks of a monoculture crop. Roughly one third of Ireland's population depended on the potato as a primary food source when their crop was struck by a fungus commonly known as potato blight; it is estimated that one million people died of starvation and another million emigrated.

Mass production led to new systems of storage for the grain and new machines for making production faster and easier. The grain elevator and silo stored large quantities of cereals. They appeared first in the U.S. during the second half of the 19th century: grain cultivation of the Midwest with its swaths of nutrient rich soil yielded wheat, barley and other grains. In 1917 Henry Ford's first mass produced tractor caught on so quickly that by the 1920s gas powered tractors had become the norm. Tractors and new storage devices, partnered with advances in combine harvesters, revolutionized grain manufacture around the world and made mass production by a small workforce commonplace.



As mechanized agriculture became firmly entrenched in the economies of the world, developments in shipping and transport of foodstuffs also arose. Networks of rails and highways spanned much of America, with container shipping quickly and conveniently bringing grain to the coast to be shipped. Though artificial refrigeration was invented in 1756 and commercial applications were wide spread by the mid 19th century, it was not until the early 20th that such devices were installed in train cars by meat packing companies such as Armour and Swift. Both meat and produce could now be sent long distances without fear of all of the goods spoiling.

The four-field-crop-rotation system, mentioned earlier, was the first practical application of fertilizer in the form of manure and dead plant material; since that the time, the process had only been refined further. Fritz Haber demonstrated a method for synthesizing ammonium nitrate from the air itself in 1909, which was adjusted to industrial proportions by Carl Bosch in 1913. The ability to produce megatons of fixated nitrogen helped Germany produce explosives during World War I in addition to maximizing their agricultural output.

The Green Revolution occurred between 1950-1984 and caused major changes in the energetic inputs and outputs of agriculture. It increased world wide grain production by 250%. This was possible because of the use of fossil fuels in the form of fertilizers (natural gas), pesticides (oil), hydrocarbon fueled irrigation, and genetic modification. Norman Borlaug has been called the father of the Green Revolution for his development of high-yield, disease-resistant wheat in the early 1940s, which were introduced to grain exporting countries. By 1963, Mexico had become a net exporter of wheat and India and Pakistan, on the brink of famine in 1961, began exporting wheat in 1964. They then had their wheat exports double between 1965 and 1970.

→→Modern Farming

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