A Superbug in Every Bite: Eliminating Antibiotic Overuse in US Livestock Production

Senior Honors Thesis

Presented to

The Faculty of the School of Arts and Sciences
Brandeis University

Undergraduate Program in Environmental Studies
Dr. Dwight Peavey, Advisor

In partial fulfillment of the requirements for the degree of Bachelor of Arts

by

Tasneem Afreen Islam

May 2015

Copyright by
Tasneem Islam

Committee members:

Name: __Dwight Peavey__     Signature: ____________________
Name: __Charles Chester__    Signature: ____________________
Name: __Laura Goldin__      Signature: ____________________
Acknowledgements

First and foremost, I would like to express my deepest gratitude to my advisor Dr. Dwight Peavey for his continuous support of my academic passions throughout my Brandeis career. Dwight first convinced me to write a thesis as we were processing rotten lab specimens at work for the EPA a year ago, and since then has challenged me in countless ways and made me a stronger student. His patience, faith and commitment to my project have kept me motivated and confident throughout this journey.

Next, I would like to thank my academic advisor Laura Goldin for first welcoming me to the Environmental Studies department and for inspiring me to turn this major into a life passion. Her guidance and dedication over the past 3 years has helped me accomplish a lot of volunteer work, two research projects, and much more in my undergraduate career and I am very grateful.

I would also like to thank Professor Charles Chester for guiding me in the final stages of this project with his extensive revisions and comments. His commitment to helping me finish this project was invaluable, and my work would not be where it is without his help.

Last but not least, I would like to thank my parents Mohammed and Rezina Islam and every Brandeis friend who has supported me in completing this project. From reminding me to eat, sleep, and shower, to staying up past sunrise to work with me, providing emotional support with cookies, and listening to me rant for nine months straight about the livestock industry. This would not have been possible without their collective support.
Table of Contents

I. Executive Summary Page 4

1) Introduction Page 5

2) History and Rise of the Modern Food Animal Industry Page 12
   a. Part 1: History and Development of the Cattle, Chicken,
      and Swine Industries from the 17th Century to the 20th Century Page 12
   b. Part 2: The Modern Industry—CAFOs and Current Cattle,
      Chicken, and Swine Production Page 19

3) History of Antibiotics and Their Environmental Impacts Page 31

4) Current State of the Issue in the US Page 45

5) My Proposal to Protect Human Health and the Environment by
   Producing Safer and Healthier Meat Page 57

6) Conclusion Page 81

II. Appendix Page 82

III. Bibliography Page 107
I. Executive Summary

Antimicrobial resistance is rising to a level that is a threat to human health. Industrial food animal production in the US is dependent on antibiotic-use, and is the single largest contributor to this problem. Effectively addressing this problem requires immediate action and industry change. The President’s Council of Advisors on Science and Technology (PCAST) developed a National Action Plan in March 2015 to recommend strategies to reduce incidents of antibiotic-resistant bacterial infections. The 5 goals are to slow the spread of antibiotic resistance, improve surveillance, complete more diagnostic tests to better understand resistant bacteria, conduct research into new drugs, and collaborate with the international community. However, the recommendations do not include specific changes to reduce antibiotic-use in the livestock industry. My thesis deals with the creation of a government agency, which functions by statute to regulate the food animal industry to produce healthier and safer meat. It will increase transparency with electronic record keeping systems to track antibiotic-use and animal locations, labeling for consumer right-to-know, increased testing and reporting, and regulating animal by-products and waste management. Applying these changes to the food animal industry is necessary to reduce the development and spread of antibiotic resistant bacteria.
Chapter 1 – Introduction

“We’ve just touched the corner of understanding the diversity of microbes out there—we’ve barely scratched the surface. And we need to understand this because, again, they regulate the world around us in many ways.... Viewing them as important players in our ecosystem in the same way that people have viewed forests and grassland, the oceans, and things like that would probably make us treat the world in a better way.”
– Graziano 2014

Once upon a time, there lived Tiny: a bacterium existing in a world with only other types of bacteria. They all lived happily and replicated constantly resulting in a conglomerate of bacterial species. Genetic mutations are what defined individuality in the community of bacteria, as some were stronger and more resilient, whereas others fell to minor changes in the environment. Zooming out of the microcosm of Tiny’s world to better describe where he was in the context of the human world, he lived in the gut of a cow. This cow lived on a factory farm with thousands of other cows. Every day these cows would be given a low dose of antibiotics that would wipe out many of Tiny’s friends and family. But Tiny always survived because he had mutated to resist the daily toxic flush. Replicating himself to increase his resilient kind, Tiny was a part of a bacterial strain that was not impacted by the lethal effects of the antibiotics. Antibiotics have been around for less than a century and they battled well with bacteria, winning for decades until more recently when strong strains like that of Tiny defeated them. Compared to Tiny’s ancestors, who were the first life forms on planet Earth and have been around for millions of years, antibiotics were eventually going to be beat. But the speed at which antibiotics are being rendered obsolete because of Tiny and his gangs of “superbugs” is alarming.
In just the span of 3 days in 2015, various cases of antibiotic resistance headline top news articles, revealing the growing national issue. The New York Post reported “7 infected, 2 dead after ‘superbug’ outbreak at LA hospital.” Reuters reported “US FDA knew devices spread fatal ‘superbug’ but does not order fix.” The International Business Times reported “Infections of Deadly Superbug Reported in North Carolina.”

Total antibiotic use has reached an all-time high in the US. The Center for Disease Control (CDC) estimates that 50% of antibiotics prescribed to people, or 10% of total antibiotic-use, are not necessary (CDC 2013, 11). This includes situations where patients may not have had a condition that warranted the use of an antibiotic, such as a viral infection. Often times, antibiotics are prescribed to appease sick patients who expect a quick medicinal fix upon every visit to the doctor. This further increases the chances of the development of antibiotic resistance inside a person. The stronger, drug-resistant microorganisms that survive spread through fecal waste to the environment (CDC 2013, 25).

It is true that society is significantly contributing to the problem of antibiotic resistance. However, humans account for only 20% of total antibiotics consumption in the US. What about the other 80%? (NRDC 2014)

Food animals. This 80% of antibiotics produced in the US goes to the production of food animals: the livestock and poultry meats that the US—one of the world’s largest meat consumers—eats. The pharmaceutical industry is heavily invested in food animal production and in some cases ownership of animal feed companies. The various antibiotics traditionally administered to livestock animals are the same ones that have protected the human population since their discoveries in the 20th century. Utilized under
the umbrella term “therapeutic,” antibiotics are routinely given to animals to promote prophylactic measures, animal welfare, and feed efficiency. This widespread use of antibiotics has created a new breeding ground for “superbugs” to emerge and profligate.

Charles Darwin explained it best with his theory of natural selection. Superbugs are simply those strains of bacteria that have naturally developed genetic mutations to survive the lethal effects of antibiotics. Today, these microorganisms have become so resistant that many antibiotics are being rendered useless as people around the world succumb to their genetically advantageous resilience. The CDC reports that resistant bacteria infect 2 million Americans, and approximately 23,000 die each year (CDC 2013). Antibiotics would have once successfully protected the population from these thousands of deaths, but now some antibiotics are useless in curing infected people. Public health is suffering from the spread of antibiotic resistant microorganisms and their prevalence must be curtailed before all antibiotics are beat.

Rising antibiotic consumption in the US unnecessarily creates an army of superbugs that public health is succumbing to. Economically, antibiotic resistant strains cost the US healthcare system about $20-35 billion in 2013 (CDC 2013, 11). The CDC reports that 1 in 5 emergency department visits are caused by antibiotic adverse drug events such as side effects, accidental drug interference with other substances, and allergic reactions (CDC 2013, 25).

One solution that many countries like the US are focusing on is new drug development; however, this is inherently expensive and time consuming because of the high costs associated with the research process and resultanty increased labor. All antibiotics undergo a long, arduous process to go from the research phase, to being
synthesized, tested, approved by the Food and Drug Administration (FDA), mass-produced, marketed, and sold. Moreover, global research does not guarantee that drugs approved in certain countries will be widely accepted due to variance in governing agency rules of different nations.

Antibiotic resistance is not new, but has gained national importance. Most recently, in 2014 President Barack Obama issued Executive Order 13676, titled *Combating Antibiotic-Resistant Bacteria*. The President’s Council of Advisors on Science and Technology (PCAST) compiled this report, and outlined 5 goals to stop the spread of these superbugs: slowing the spread of antibiotic resistance, improving surveillance, increasing diagnostic tests to better understand resistant bacteria, conducting research into new drugs, and working with the international community (PCAST 2014). To accomplish these goals, PCAST released a *National Action Plan* in March 2015 recommending strategies to reduce incidents of antibiotic-resistant bacterial infections. It calls for the elimination of growth-promoting antibiotics, increasing veterinary oversight, developing monitoring systems for the livestock production process and retail meats, and a number of other strategies to reduce resistance for humans and animals (PCAST 2015).

The growing use of antibiotics in the food animal industry and demand for meat is not just a problem the US is dealing with. This problem also affects the human population at the global level where the demand for meat is growing at a faster pace than in the US. Approximately 18% of annual global greenhouse gas (GHG) emissions come from livestock production, including direct methane and carbon dioxide from the animals, from housing and processing facilities, and from transportation (Goodland 2009). The US livestock industry must change and adopt more sustainable practices to reduce its impact
on global antibiotic resistance and overarching climate change issues. Restructuring the industry to increase efficiencies is imperative for local environmental and public health benefits, and also for the planet. Small and medium sized farms are not to blame for the increase in antibiotic-use. The advent of corporate animal factory farms in the 20th century—the largest contributors to the GHG emissions in the US agricultural industry—has caused antibiotic-use to likewise grow.

Attempting to limit or reduce the power and growth of the livestock industry is challenging because the food animal sector is economically important. While demanding and consuming less meat would reduce GHG emissions, modern society and developing nations are increasingly consuming more meat per capita. Reversing this trend is nearly impossible without dramatic governmental efforts and consumption reductions.

Previously, consumers did not have many choices to afford and demand antibiotic-free or organic meats because supermarkets did not commonly supply them. But now specialty markets and industry competition towards more wholesome products provide this supply by driving prices down. Pew Charitable Trusts finds that consumers favor organic, drug free meat as a result of increased consumer awareness and concern about health (Antibiotic Resistance Project, 2010). By regulating the livestock industry and changing practices, prices for antibiotic-free meat will decrease and become the status quo for meat production. My proposal focuses on increasing transparency throughout the industry to achieve this.

Average consumers are kept in the dark about industry practices. Yes, consumer purchasing power controls demand, but this power is limited within the context of what the industry supplies. On average, antibiotic-free meat is more expensive than meat
produced on factory farms that employ pharmaceutical drugs. Driven by the financial aspect, most consumers opt for meat sold at lower prices. Due to the economic and operational efficiencies of US factory farm corporations, the cost of meat in the US is lower than in any other nation. Global reports prove meat consumption is on the rise, especially in developing nations, who employ intensive practices similar to the US’ to supply that demand. The US does not have a transparent food animal industry, and international trade further reduces consumer knowledge. Do consumers have the right-to-know how their meat was treated and where their meat is coming from? Would they change their consumption patterns if they did know?

Just as consumption is increasing, a number of health conditions associated with that trend are as well—obesity, heart disease, high blood pressure, and high cholesterol, to name a few. The US is experiencing an obesity epidemic and there is little to no education on food nutrition in schools. 35% of American adults and 17% of American children suffer from obesity (CDC 2011-2012).

In the global meat market, the US is one of the largest consumers and producers of meat both nationally and internationally. With developing nations following the ways of developed nations, it is our national responsibility to change our system and inspire developing nations to adopt similar systems. The European Union has been a global leader in terms of sustainable food animal production for over two decades. Scandinavian nations such as Denmark as well as the Netherlands have succeeded in eliminating virtually all non-essential antibiotic-use while also maintaining competitive yields in the global market. The US industry needs to implement similar changes to their production methods to protect public health.
In this thesis, I will begin with an analysis of the US food animal industry and the history of antibiotics in relation to that. Then I will discuss national legislative efforts starting with the President’s Executive Order and those of the Food and Drug Administration (FDA), and other government agencies. I then propose the development of a safer and healthier livestock production system in the US that is based upon elements of European models. Titled the SHAPA—Safer and Healthier Animal Production Agency—its mission is to regulate a more transparent and sustainable food animal industry. It is imperative to note that I will not be delving into animal welfare issues for the purposes of this thesis.

The US must re-structure its food animal production system to protect public health nationally and globally. If antibiotic resistant bacteria defeat our current antibiotic reserves, millions of people will be adversely affected. Frighteningly, this is a world that society might soon encounter if the current large antibiotic-users do not reduce their consumption. My thesis targets the livestock industry, the largest contributor to antibiotic resistance in the agricultural sector, and strives to construct a new system with increased monitoring, tracking, and transparency, to ensure a reduction in antibiotic overuse.
Chapter 2 – History and Rise of the Modern Food Animal Industry

Society has long possessed animals for their utilitarian uses and nutritional contribution. In domesticating livestock and housing chickens over the past millennia, civilizations have expanded and were supported via the flesh of cows, pigs, and chicken (and the eggs of the latter.) The development of commercial factory farms and industrial food production in the 20th century contributed to the significant rise in antibiotic-use and environmental degradation across the US and the world. How did food animal production reach the point where antibiotic-use was so embedded in the industry that it now accounts for up to 80% of all antibiotic-use in the US? (NRDC 2014) And how did society reach the point where consumerism and an insatiable hunger for meat were guiding the unsustainable growth of the food animal industry?

In Part 1 of this chapter, I will explicate how cattle, chickens, and pigs were raised in North America from when they arrived with colonists up to the beginning of the modern, industrialized system, while in Part 2, I will detail accounts of current cattle, chicken, and pig production methods.

Part 1: History and Development of the Cattle, Chicken, and Swine Industries from the 17th Century to the 20th Century

Cattle made their debut in North America in the 15th and 16th centuries, disembarking from Spanish ships from Christopher Columbus on. They slowly flooded the southern reaches of North America from South America and provided utilitarian support to people. In 1598, Don Juan de Oñate organized an exploration across the Rio
Grande River to the North American Southwest. Being one of the four wealthiest Mexican men at the time, he paid over $1 million and introduced approximately 7,000 animals to the area (Haeber 2013). In the East, the next influx of domesticated cattle arrived with European settlers in 1620. These large animals were highly prized commodities as they satisfied multiple uses: they were able to pull heavy loads on carts and wagons, plow fields, and also supplied milk, meat, and hides. Easy to breed and tend to since cattle subsisted on pasture grasses, they were low-maintenance and literally helped develop our nation on their backs. Hogs and chickens also disembarked in the New World, but because of their low physical utility, they were brought as food sources. Together these three animals were highly adaptable to changing environments and thus ideal to help develop the New World.

Thanks to Don Juan de Oñate’s expedition and introduction of longhorn cattle into the Southwest, cattle populations multiplied and supported new settlement. For the next 200 years until the 1800s, vaqueros—Mexican settlers who drove cattle between Mexico and Texas—inhabited this Southwest area of North America. They were rough around the edges and hardworking men who defined the “cowboy” way of life. Traversing the long distances from Mexico City to Texas on horseback, vaqueros guided longhorn cattle with pride (Haeber 2013).

The first English settlers out on the “wild west” arrived in 1821, eager to herd all the longhorn cattle that had multiplied and taken over the Southwest of North America. They too lived the iconic southwestern cattle culture that people today attribute to life on the western home front. Approximately 5 million head of cattle roamed the Texas range and contributed to the vision English colonists had for over two centuries of the New
World being expansive and full of life ready to be consumed (Newman 2010, 313).

American cowboys battled *vaqueros* and other settlers over claim of the land and cattle (Haeber 2013).

By the early 19\textsuperscript{th} century, cattle had become an integral part of the life, diet, and culture of the Southwest. Cowboys who had herded hundreds or thousands of cattle did not have a convenient, accessible market at which they could profit off selling their assets. There was demand in the East for cattle, but no means of easily capitalizing on it.

Industrialization in the early 1800s significantly influenced the development of the cattle industry. Railroad construction enabled long-distance transport for live cattle, and as tracks were generously laid out across the nation, markets and demand for cattle likewise grew. Processing plants and food distribution centers dotted the country, popping up alongside the railroads.

Joseph G. McCoy, a livestock trader from Illinois, realized this economic void and set out to create a central market between Texas and Chicago—from where transcontinental railcars could then transport cattle to the East. McCoy also knew that railroad companies wanted more freight to increase their profits. Putting both the needs of the Southwestern cattlemen and the railroad owners together, he established one of the first cow towns in the 1860s: Abilene, Kansas. With its centralized location, Abilene went from being a small town to a bustling center for cattle trade. The stockyards here served as a collection point and loading zone for cattle to be shipped out to Chicago (Newman 2010, 313). McCoy advertised the economic successes of his business all over the American west and drew in thousands of ranchers excited to finally reap the benefits of their hard work. It is estimated that McCoy transported over 2 million cattle from
Abilene to Chicago between 1867 and 1881 (History On The Net 2014). His entrepreneurial success allowed both ranchers to profit off their steer and eastern demands to be met.

McCoy wrote *Historic Sketches of the Cattle Trade of the West and Southwest*. In it, he describes the state of the cattle business from the 1860s to the 1880s. He writes how the largest livestock owners had approximately 25,000 to 75,000 head of cattle, who survived mostly by grazing on grasses (McCoy 1874). Moreover, ranchers would only set up stock ranches in areas that had plenty of pastureland and running water sources. Today, with advanced irrigation, intensive agricultural practices, this idyllic scene of organic cattle raising is atypical in the modern industry (McCoy 1874).

The traditional practices associated with cowboys and open-range ranching started to come to a close in the 1880s. The adoption of barbed wire in 1874 changed the way cattle were raised and herded (Newman 2010, 313). Now, cattle roamed within the constraints of private property rather than out in the wild, a process that only increased with the arrival of increasingly more settlers and reduced the area of land devoted to cattle raising. Cowboys were slowly rendered obsolete, as they did not need to herd longhorn cattle over long distances anymore. By this point, the railroad industry had significantly expanded and cow towns that cropped up along their route eased the transportation problems that slowed the growth of the livestock industry in the early half of the 19th century. Cattle industries had developed in Kansas, Nebraska, Colorado, Wyoming, Montana, and North and South Dakota due to the availability of open space and railroads and access to markets via the railroads. Indeed, markets up North and in the East reaped the benefits of the centralized industry (History On The Net 2014). As a
result of the growing national agrarian economy, the US established the US Department of Agriculture (USDA) in 1862.

Overgrazing and extreme weather patterns also contributed to the end of the cattle drive tradition. The millions of cattle unsustainably consumed grass, thus depleting it quicker than it could regenerate. Moreover, many cattle did not survive a bad winter blizzard in 1877-1878, which was later followed by a drought in 1885-1886 (Newman 2010, 313). It is estimated that severe weather conditions decimated 90% of the cattle and slowly marked the end of the cattle drive system (Newman 2010, 313). Even though the cattle frontier had ended, the livestock industry continued to grow, as did the nation’s hunger for beef.

In the 1850s, Chicago, Illinois became the home of the Union Stockyards and the chief meatpacking metropolis of the world. Approximately 40,000 people labored in the unregulated, unsanitary, mechanized work environment producing various cuts and types of beef for shipment by railcar to the rest of the nation. Chicago’s meatpacking district contributed to the end of live shipments of cattle. With the advent of refrigerated railroad cars in the 1850s, slaughtered meat could be transported over long distances without fear of spoilage. Centralized production in the Union Stockyards was highly economical because it allowed all the slaughtering, processing, and packing to occur in the same area, which reduced costs in transportation, labor, and time. Similar to how the modern food animal industry functions today, the meatpacking district of Chicago relied on a poor and easily replaceable, low paid labor force.

By employing the use of assembly lines, cattle processing was very mechanized and sped up the slaughtering and processing of meat. Work was simplified such that an
individual would have one specific job for their entire shift that they would repeat over
and over again. Although production methods were highly efficient and made the
livestock industry increasingly more profitable, they significantly decreased animal
welfare. This was the first time in US history that cattle were so rapidly processed in this
way. As such, legislation protecting animal welfare and the rights of workers was slow to
materialize.

Upton Sinclair’s novel *The Jungle* illuminated the hostile work environments,
unfair labor practices, and gross negligence inside these Chicago slaughtering houses. It
also helped inspire President Theodore Roosevelt in 1906 to sign and enact the Pure Food
and Drug Act and the Federal Meat Inspection Act. Covering different aspects of food
safety, these acts have been managed under two separate federal agencies: the former was
overseen by the Bureau of Chemistry, a part of the US Department of Agriculture that in
1930 officially became known as the Food and Drug Administration (FDA); the latter
was headed by a division/section/office of the US Department of Agriculture known
today as the Food Safety and Inspection Service. “The Pure Food and Drug Act forbade
the manufacture, sale, and transportation of adulterated or mislabeled foods and drugs.
The Meat Inspection Act provided that federal inspectors visit meatpacking plants to
ensure that they met minimum standards of sanitation (Newman 2010, 431).”

The livestock industry and the pharmaceutical industry were highly influential in
shaping federal food safety laws and regulations and the modern food animal industry.
Treating animals as commodities allowed for the industry to grow and contribute to the
national economy, as it was a profitable albeit unsustainable business. The industrialized
cattle production method also influenced the swine and chicken industries much later in
the 20th century with advancements in science and technology. Prior to that chicken and swine were raised in natural ways on family farms in and provided food.

Pigs came to North America with Columbus in the 15th century and again with European colonists in the 17th century, and were widely consumed as the primary meat of choice (EPA 2012, Pork). Neither beef nor poultry was valued as food as much as pigs. This was due to the greater utilitarian role that cattle played and the conception that chickens were predominantly used for egg production. Pigs not only provided meat, but also lard, which had numerous uses from cooking to lamp oil to making candles and soap (EPA 2012, Pork). They were owned by individual families or on small farms and housed outdoors on pastureland, but protected from predators.

Chickens arrived in the New World along with the European colonists in the 17th century. They thrived on a small-scale, roaming around the homes and plantations of the early settlers. Often times these animals were free-ranging on the farm and thus were easy to maintain in the warmer months of the year; however, un-sheltered poultry did not survive well during the winter months. As such, chickens were primarily kept and used for egg production, and chicken meat that was consumed was as a subsidiary to egg production. The value of chickens lay in egg consumption and some sales of surplus eggs (McMahon 1985, 34). Farm wives would sell some of the eggs for “pin money,” which would be a sort of allowance that they could use down at general stores (McMahon 1985, 34).

For over two hundred years, from the end of the 18th century and into the 20th century, chicken production in the US remained static. It was local, family-run, focused primarily on egg production, and the demand for chicken and poultry meat did not
increase. Chickens rarely fattened up because they typically, “ate table scraps or scavenged,” which was insufficient to allow them to become plump (Crews 2009). Eating poultry occurred only on special occasions like holidays or Sunday supper and was planned in advance so that the birds would be well fed for weeks and nice and meaty for the event (McMahon 1985). The industry had been incapable of expanding because of natural limitations. Egg-laying hens could produce only so much under natural conditions, and the market could only grow with scientific advancements. These discoveries came about in the 1920s, after which increased control over poultry production created a market demand for chicken products.

In 1923, Mrs. Wilmer Steele of Sussex County, Delaware housed and raised a flock of 500 chicks. This was a dramatic break from the backyard systems that had predominated chicken production in the US until this decade in both scale and purpose of production. Steele’s focus was to raise them for meat consumption, not egg production (National Chicken Council 2012). As a result of her intensive production, Steele demonstrated the large supply potential of the broiler industry. All it required was consumer demand to meet and surpass the supply, which did not occur until the second half of the 20th century (US DOI NPS 1969).

Part 2: The Modern Industry—CAFOs and Current Cattle, Chicken, and Swine Production

A. Introduction

The food animal industry today is unlike the organic, intensive systems of the past. The largest meat producing industries are those for beef, dairy, broiler chickens,
egg-layers, and pigs, versus the comparably smaller turkey, veal, fish and shellfish industries. Figure 1 depicts the major consumption changes that have occurred from 1910 to 2010. It confirms the trends discussed above: beef, pork, and eggs were primarily consumed until the middle of the 20th century when broiler meat rose in popularity.

Figure 1: Meat Consumption from 1910-2010

To better understand how the industries grew to the point where they developed a large dependency on the pharmaceutical industry, we must envision the industry as a three legged stool supported and controlled by three major sectors. The first of these legs or industries is intensive agriculture, the second is fast food, and the third is pharmaceutical corporations. They collectively influence the modern industry for beef, chicken, and pig production.

The US is currently on an unsustainable trend of productivism (Belasco 2008) in
which the US promotes intensive agricultural production in an attempt to maximize output per unit area and without concern over the environmental degradation. The entire livestock production system must be analyzed holistically and improvements in the system should come from a combination of factors that would make every step as sustainable as possible. European nations have already established more environmentally sound and sustainable meat production that has eliminated antibiotic overuse and ensured the production of safer healthier meat.

On a global scale, the United Nations Food and Agriculture Organization (UN-FAO) estimates that the livestock industry alone accounts for 18% of annual greenhouse gas (GHG) emissions, primarily contributing methane, nitrous oxide, and carbon dioxide (Goodland 2009). The US is the world’s largest producer of beef and thus the largest emitter of carbon dioxide (CO₂) and methane (CH₄) from livestock production (USDA Economic Research Service 2014). The US is one of the top four countries that have been the largest contributors of CH₄ emissions since 1990; the others include China, Brazil, and India (US EPA 2006, 70). Therefore, changes in US policies on meat production will result in significant reductions in global GHG emissions.

CH₄ in the agricultural sector is emitted primarily from enteric fermentation, a process by which microbes ferment food in the animal’s intestines and produce CH₄ as a byproduct that the animal releases into the environment. In 1990, CH₄ from enteric fermentation accounted for 34% of all agricultural emissions, and is expected to increase by 32% by 2020—while maintaining its relative share of the total agricultural emissions at 34% (US EPA 2006, 66). CH₄ has an atmospheric lifetime of about 12 years, whereas CO₂ is variable and between 50 and 200 years (UNFCCC 2014). Moreover, the global
warming potential (GWP)—a measure of the heat-trapping capability of a GHG—reveals that CH₄ traps heat 56 times more intensely than CO₂ over the course of 20 years (UNFCCC 2014). Thus, targeting and changing agricultural practices will in a reduction in GHG emissions and the greenhouse effect.

Understanding the scope of the industry on a global-scale is important because it proves the urgent need for improvement beyond just the issue of antibiotic-use. The industrial animal production system is complex and results in many other adverse environmental and public health effects that are time-sensitive. Change is not happening fast enough to combat these problems. Therefore, the US must take action to institute a more holistically sustainable production system that is not reliant upon antibiotic overuse.

Through the second half of the 20th century, large factory farms dominated the industry with high financial and economic value. See Appendix Figure 25 to see map of all CAFOs in the US. Their economic productivity contributed to the subsequent failure and sale of numerous small family farms. Further consolidation in the number of large corporate farms increased their corporate influence and they have been characterized as resistant to change. “Big Ag,” as they are collectively nicknamed, is known to exert its control over the industry to ensure its economic success over concerns regarding antibiotic-use and other environmental issues. The livestock industry has developed symbiotic relationships with feed industries, as well as with the pharmaceutical industry, thereby perpetuating a complex environmentally damaging system.

The agricultural sector is the largest contributor to global non-CO₂ emissions, with an expected increase of 57% by 2020 (US EPA 2006, 66). As of 2008, “American farmers planted 85.9 million acres of corn and 75.7 million acres of soy (USDA 2012).”
Referencing Figures 2 and 3 in the Appendix, it is clear that the vast majority of maize and soybean feed crops for livestock is concentrated in the US. Furthermore, these crops are produced using intensive monoculture farming, which strips the land of nutrients, leaves it vulnerable to erosion, and reduces local biodiversity, while also polluting it with chemical fertilizers and pesticides (US-UCS, 2012). Not only is the agricultural industry spurring on global warming, but also it is responsible for destroying nearly one-third of the world’s arable land in the last 40 years (Spitzer, 2008). The fact that much of this sector is devoted to unsustainably mass-producing grains for livestock consumption rather than for human consumption is alarming. Environmental impact exponentially increases once food that could be fed to humans goes to livestock (Fairlie 2010, 35).

Growing animal feed is an unsustainable practice and can be easily curtailed with a dramatic reduction in livestock production, and ultimately consumption demands.

B. CAFOs – Industry Practices and Environmental Impacts

The US EPA defines Confined Animal Feeding Operations (CAFOs) as those where: “Animals (other than aquatic animals) have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period (EPA 2011).” Their primary function is to rapidly fatten up animals to meet market weight for slaughter with the most efficient use of inputs such as feed, antibiotics, and water.

The high animal density in unsanitary conditions is the primary factor contributing to the increased use of antibiotics. Such environmentally destructive systems only account for about 5% of all US animal operations; however, they produce more than 50% percent of food animals in the US (Gurian-Sherman 2008, 2). CAFOs function on
taxpayer-supported subsidies to pay for pollution cleanup programs, antibiotics for the animals, and to purchase low-cost feed. CAFOs use subsidies to pay for two expensive on-site problems: antibiotic overuse and manure disposal—since 65% of the total manure from animal operations in the US comes strictly from CAFOs (Gurian-Sherman 2008, 1). Furthermore, CAFOs are indirectly subsidized through feed production subsidies; as a result, they have escaped responsibility for the environmental harm they cause. As Gurian-Sherman (2008, 17) states: “If CAFOs were required to remediate or prevent the cost of these externalities, they would incur higher production costs and thus be considered less efficient than they currently appear.” It is estimated that the total cost of soil remediation on pig and dairy cow CAFOs is nearly $4.1 billion; however, no one is owning up to the costs (Gurian-Sherman 2008, 4).

The amount of environmental damage that CAFOs caused through the middle of the 20th century had become a significant concern for the federal government, and so, by the mid-1970’s, CAFOs were regulated under the National Pollutant Discharge Elimination System (NPDES) (Hribar 2010, 1). The NPDES controls point source water pollution sources including CAFOs. But even with governmental oversight on waterways, CAFOs continue to pollute the land with chemical pollution from cleaning solvents, pharmaceutical use, and excess feces production, and the air with carbon dioxide, methane, and nitrous oxides (FAO Poultry).

One major aspect that the NPDES does not regulate is the manure waste from cattle, chicken, and swine that is often lawfully spread on nearby agricultural fields year-round. This manure adds nutrients to the soil for plant growth, and reduces factory farm disposal costs. But an adverse effect associated with this practice is the release of these
nutrients in the spring or during large rainfall into surface waters and groundwater. Moreover, antibiotics that remain in manure waste likewise get added to the soil and create environments where microbial resistance can develop.

CAFOs can also evade requirements to get NPDES permits depending on their animal per unit area size and other loopholes in the fine print. The Pew Charitable Trusts confirms this, citing that not all CAFOs are currently mandated to acquire Clean Water Act permits. The intensive, high-waste production on all CAFOs, regardless of size, routinely pollutes water, land, and air, without repercussions, and disrupts local communities (Reforming Industrial Animal Agriculture 2013). The integrated management of solid and liquid waste from cattle, dairy cows, chicken, and swine is an on-going problem and deserves further attention.

The economics of production shifted during the 1950s after the huge collective impact efficient production practices, supermarkets, advertising, and fast food franchises had on the meat industry. In order to continue increasing profits, individual companies adopted a new method of production called “vertical integration.” This system let a single company control all stages of production, processing, and marketing, thereby allowing the company to profit off of every step of poultry production from farm to plate. This continued to allow individual companies to assume massive control over their specific industries, leading to modern day production where fewer companies house thousands of cattle and swine and hundreds of thousands of poultry birds, and make high profits (US Poultry).

C. How Beef and Dairy Cows are Raised

The EPA states that the large, mass-produced cattle farms of today are primarily
located in the Corn Belt, Southwest, and Pacific Northwest (US EPA 2013). Feed today focuses on fat content rather than nutritional value since the purpose of raising livestock is for meat. Moreover, with increased intensive production methods, consolidation across the industry resulted in fewer operations producing more cattle and beef, as proven by the graph below. See Appendix Figures 20 and 21 for locations of beef and dairy CAFOs.

![Graph of Number of All Cattle and Beef Cow Operations, United States, 1992-2012](http://www.sdstate.edu/vs/extension/beef-procedures-antibiotics.cfm)

**Figure 4: Number of All Cattle and Beef Cow Operations, US, 1992-2012**

*D. How Chickens Are Raised*

By the 1940s, poultry was a $3 billion industry in the US and was the nation’s third largest agricultural crop (YouTube 2013). With the changing national market favoring the market economy and urban migration away from farms to cities, egg, broiler, and turkey farmers were forced to change their practices to meet the growing demand for poultry products. Seeking to increase their business profits, farmers shied away from
raising free-range egg-layers, broilers, and turkeys. The 1950s are the crossover point when modern poultry production was instituted. During this decade, the steady rise in broiler chicken consumption began. Mechanized advancements in housing and raising birds, slaughtering, and exporting to outside markets supported the growing demand. Fast food restaurants came into existence and the rise of this new industry correlated with increased rates of chicken consumption. Production systems changed making broiler production more efficient and profitable for individual companies.

Caging the egg-laying birds increased chicken density on the farms, which subsequently increased antibiotic-use. The close confinement also decreased animal health as it facilitated the spread of fecal-related diseases, which were common killers of bird flocks in the 1940s (United Egg Producers 2010). Furthermore, the intensive production system created a large waste stream that collected in pools on-site spurring an increase in populations of antibiotic resistant bacteria.

In the middle of the 20th century, supermarkets coupled with the growth of advertising media from newspapers and other physical forms to virtual advertising on televisions, supported egg and broiler meat consumption. Companies like Tyson Foods, Pilgrim’s Pride, Sanderson Farms, Perdue Farms, and Foster Farms, grew during this time and are still top broiler producers today (US Poultry 2014). Brand name recognition not only supported market companies, but also fast food restaurants. The convenience and speed of the fast food industry appealed to the average consumer and it likewise economically grew hand-in-hand with the meat industry.

Today, Perdue Farms, Tyson Foods, and McDonald’s have made the switch to committing to antibiotic-free chicken production. They have utilized their market power
to urge large supermarket chains like Costco and Wal-Mart to supply only antibiotic-free chicken. This collective effort from key industry players is starting to drive the industry in the right direction. I will return to this and elaborate more about this in Chapter 5.

Back to the late 1960s, chicken production routinely used pharmaceuticals due to intensive production and high chicken density. Added to feed and water under the loosely veiled category of “therapy,” antibiotics controlled the spread of disease throughout bird flocks. The USDA states that from 1970 to 2000, chicken consumption increased by 34 pounds and accounted for 37% of all meat consumed per capita in the US (Haley 2001, 42). Changing attitudes towards the American diet contributed to this significant shift towards increased poultry consumption. Chicken consumption continued to increase and even “surpassed beef consumption in the United States in 1992,” after “[surpassing] pork consumption in 1985 (National Chicken Council 2012).”

By the 2000s, consumers became more concerned about the quality of their meat and added ingredients. Today, there is a rise in American dietary preferences for “organic” and “free-range” and “antibiotic-free” and “rBST-free.” Americans want to eat healthier and increased per capita consumption of broiler chicken reflects this trend.

The US’ power in the poultry industry was not limited to national trade, as the USDA reports that the US was and still is the world’s largest exporter of poultry products including both chicken broilers and turkeys (Haley 2001, 42). Not only this, but consolidations across the poultry industry gave private companies increasingly more power and reliance on antibiotic-use. See Appendix Figures 22 & 23 for CAFO locations.

**E. How Pigs Are Raised**

The EPA outlines modern pig production. The simplest method of swine
production is called the continuous flow barn, where pigs of different age groups are housed and raised together. This engenders an environment for disease to flow between older and younger pigs, which complicate the amounts of antibiotics needed to maintain their health since drug doses are dependent on the age and weight. Moreover, continuous flow facilities are never empty as recently weaned piglets can replace older pigs ready for the grow-out and slaughter phases. This maintains a consistently high yield of pigs in-house, and maximizes space efficiency (EPA 2012, Pork). Due to pig density, industrial swine farms are increasingly reliant upon antibiotics. In 2013, Reuters reported a massive outbreak of Porcine Epidemic Diarrhea Virus that wiped out a large portion of the population. The weaker offspring were mostly affected and they effectively died, raising the price of pork products 2 years ago. More worrisome is the fact that it was most commonly contracted from pigs ingesting contaminated feces. The production of swine at these densities and unsanitary conditions increases the losses from individual viruses such as this (Reuters 2013).

At the cost of all of this, continuous flow barns continue to engender stressful and unsanitary environments for the pigs. By housing swine of various age groups together, the younger animals can feel intimidated and stressed. The age differences also contribute to the problem of varying degrees of disease resistance among the pigs. For instance, younger pigs would be more vulnerable to contracting a disease that an older pig with a stronger immune system might already be immune to. Plus, they live in close proximity to one another so diseases spread more rapidly. Furthermore, the EPA describes the difficulties with maintaining continuous flow barns since “adequate cleaning and disinfecting are not feasible, and higher levels of antibiotics and other medications are
normally required to control disease.” Antibiotic resistant pathogens become a potential problem if the swine waste is used on agricultural fields, accidentally overflows, or is not properly treated (EPA 2012, Pork).

Today, swine are typically industrially produced in “all-in, all-out” (AIAO) systems similar to CAFOs. The concept in AIAOs is that all of the pigs in the same age group are raised together in isolated pens and subsequently slaughtered together, so they are stay together throughout this growing phase in their lives and leave the system together. Such physical separation allows producers to clean and sanitize the pens before cycling in new groups. It also ensures that diseases do not spread as easily. The pigs are also less stressed in AIAOs because they reside with the same group of pigs throughout their time there. The only drawback to this structure of swine production is that it is less space efficient, which factors into the costs of production (EPA 2012, Pork).

By 1990, production methods changed to favor two-site or three-site systems because it reduced health concerns related to diseases spreading between pigs of different age groups, and manure build-up on site. One-site systems are more convenient because they require less transportation. The two-site systems separate the production phase into breeding and gestation, and farrowing and nursery, whereas, the three-site separates the nursery phase at another site (EPA 2012, Pork). See Appendix Figure 24 for CAFO map.

In the 2000s, some switched to “wean to finish” barns where pigs are kept in one location from when they are weaned until they go to market. This method is more energy, transportation, and space efficient. The EPA states that this reduces stress for the animals; however, the buildings are not cleaned regularly, but only after the pigs are removed from the facilities, which creates a breeding ground for diseases to spread (EPA 2012, Pork).
Chapter 3 – History of Antibiotics and Their Environmental Impacts

“The future of humanity and microbes will likely evolve…as episodes of our wits versus their genes.” – Nobel Laureate Dr. Joshua Lederberg

Homo sapiens have inhabited planet Earth for approximately 200,000 years. (Natural History Museum) But only in the past couple centuries has the population grown exponentially, to the point where every few decades it reaches another billion. In 1804, the year the human population finally reached 1 billion. After 199,800 years of countless civilizations rising and falling, slow technological developments, and the eventual abandonment of more primal ways of life, humans had begun pervading Earth by the billions. The 20th century is marked with a multitude of important factors that contributed to global population growth. Continued industrialization, improved transportation, urban sprawl, major technological advancements, intensive agricultural practices generating an overabundance of food, and the development of powerful antibiotics. In 1927, it hit 2 billion. 1960, 3 billion. 1974, 4 billion. 1987, 5 billion. 1999-6 billion. 2011, 7 billion.

The Birth of Antibiotics in the Early 1900s

The discovery of antibiotics in the early 20th century revolutionized modern medicine as people became resilient to common killers. These medicines allowed developed nations to nearly eradicate many diseases that were once deadly.

In 1909, the year the once almost incurable syphilis was deemed treatable, and the beginning of the modern antibiotic era. Paul Ehrlich was the lead scientist researching a cure to this endemic sexually transmitted disease. Now called the “systematic screening
“approach,” the research process methodically synthesized and tested hundreds of derivatives of Atoxyl, a highly toxic drug. After 5 years of painstaking research, Ehrlich and his team of scientists found one compound that fought against the bacterial threats of syphilis. Although they had strong side effects since they were derivatives of organoarsenic, these drugs cured lab rabbits. Sold under the name Salvarsan and Neosalvarsan, these antibiotics were the most prescribed drugs for over 30 years until the discovery of the next powerful antibiotic (Rustam 2010).

Although these drugs were extraordinary finds, what was more influential on the pharmaceutical industry was the research method. Systematically screening derivatives of compounds theorized to work ensures that every potential option has been tried. This systematic screening approach is what changed pharmaceutical research forever, and allowed many antibiotics to be discovered. Prontosil, a sulfa drug, is an example of one discovered in this way. The active ingredient, sulfanilamide, had low production costs and thus pharmaceutical companies flocked at the opportunity to mass-produce sulfonamide derivatives. Discovering the great marketing potential of this product, pharmaceutical companies went beyond distributing them to people. They realized the massive market for the livestock industry. Soon enough, sulfa drugs were utilized on large farm operations and subsequently, sulfa drug resistance became a threat to public health. It became one of the first instances of mass antibiotic resistance (Rustam 2010).

Alexander Fleming’s accidental discovery of penicillin in 1928 launched the next major stage in antibiotic-use. From its inception, penicillin underwent heavy research as it needed further processing to be effectively usable in humans. For 14 years, Fleming and other researchers he inspired, attempted to purify the Penicillium strain, but the
instability of the active substances proved it to be a difficult feat. Eventually in 1942, researchers succeeded in creating an antibiotic safe for humans from the Penicillium strain and mass production and distribution ensued. Even at this early stage in the antibiotic era, Fleming recognized the potential for resistance to develop (Rustam 2010).

Antibiotics continued to be discovered through the 20th century. Figure 2 neatly displays when major antibiotics reached the market. Prontosil and Penicillin are shown, as well as all the antibiotics that are still being used in livestock production today. In just four decades, 13 different antibiotics were discovered. But by the 1970s, antibiotics discoveries slowed down. Each novel discovery was made possible by extensive funding and research time, luxuries that make it very difficult to continuously produce new antimicrobials. The discovery and mass-production of penicillin described above took over a decade. Even with advanced medicine and technology today, developing new antibiotics is painstakingly difficult because defeating bacterial strains and microbes that have adapted to survive extraordinary environmental conditions created by mass antibiotic overuse.
Figure 5: USDA Timeline of Class and Antimicrobial First Marketed for Use

This figure “depicts the timeline of antimicrobial exposure available to humans, animals, and, by default, the ecosystem/environment. The timeline starting in 1935 describes the early development and marketing of the major classes and first antimicrobial within the class. Antimicrobials were largely introduced for human use with the exception of Chlortetracycline in 1948, which was and is still used in veterinary medicine. Resistance to all classes of antimicrobials emerged in human medicine after introduction, primarily among target pathogens. Veterinary applications for some classes of antimicrobials have been approved for use against veterinary pathogens. As observed in human medicine, resistance also emerges in target pathogens. Ancillary resistance also
appears in both human and veterinary non-target commensal and foodborne bacteria (USDA Antimicrobial Resistance Action Plan).”

**Importance of Antibiotics and How They Function**

To explain why antibiotics are so important to public health, one needs to understand why people need these drugs if human civilizations have survived without them for centuries. Prior to the advent of antibiotics, bacterial infections were commonplace killers. Encouraged to protect people from these microscopic killers, scientists and researchers studied these microbes to determine how they could be overcome. The invention of the microscope and plating lab techniques enabled them to see and learn about how these microorganisms function at a cellular level. Using this knowledge they were able to synthesize chemical compounds in labs that would counteract or interfere with these bacterial strains.

Even though penicillin was discovered in 1929, it was not widely distributed until the 1940s. The lengthy process from the discovery to when a drug goes to market is why it is unreliable to focus all efforts on researching to find new antibiotics. By the time an antibiotic can be prescribed to and used by people, millions will have fallen ill to antimicrobial resistant strains. Furthermore, it is difficult to collect and share data and to detect resistant bacteria. The CDC provides a detailed explanation of how antibiotics function, which can be found in Appendix Figure 6.

**Resistance**

Nearly all antibiotics function by targeting specific chemical and cellular processes to inhibit further growth of the microbe inside the human body. Antibiotics are specific to these pathogens and are composed of specific chemicals that can interfere with
metabolic pathways to destroy them. In this way they successfully stop bacterial infections and protect public health. In the same way that harmless bacteria outlived their kin and mutated into deadly bacterial strains, dangerous bacterial strains can adapt to survive even the most powerful of antibiotics.

Figure 7: Developing Resistance—Timeline of Key Antibiotic Resistance Events (CDC 2013, 28)
Overexposure to antibiotics allows bacteria to grow stronger. Across the population, these environments exist in all organisms using antibiotics, and areas where antibiotics enter waste streams such as municipal sewage systems and agricultural systems. Globally, antibiotics are regulated according to national laws and often times this leads to their misuse and overuse. In countries that do not have regulations and where antibiotics are over-the-counter, self-diagnosis leads to their improper use including, misdiagnosis, incorrect dosages, prophylactic uses, and no follow-up monitoring. All of these situations are optimal grounds for resistance to develop.

One of the first publications describing antibiotic resistance relayed the lack of concern on the issue. Since, “Syphilis has now been treated with arsenicals for about 40 years without any indications of an increased incidence of arsenic-resistant infections, and this work gives grounds for hoping that the widespread use of penicillin will equally not result in an increasing incidence of infections resistant to penicillin (Rollo et al., 1952).”

So understanding the vast importance of antibiotics to public health and the limitations of discovering new antibiotics, why have they been so rampantly overused? The answer is, there has been a general lack of concern that such widespread use was breeding serious resistance until more recently.

**Antibiotic-use in the Livestock Industry**

The livestock industry accounts for 80% of all pharmaceutical-use in the US. But how can one industry be using so much of the industry and why are they consuming more than humans, the primary organisms antibiotics were designed to protect? Antibiotics were initially introduced to the livestock industry to protect them from the rapid spread of
diseases within the high animal density of CAFOs. The inability to treat and track individual animals on factory farms supported the mass-distribution of antibiotics to all animals. Across the nation, antibiotic-use on farms increased as farmers assumed they would achieve significantly higher yields from fewer animal deaths; however, case studies of Europe in Chapter 5 invalidate this assumption. This rise contributes to the misuse and overuse of antibiotics in the livestock industry, to the point where the livestock industry is the #1 contributor to the development of antibiotic resistance, according to the CDC (Union of Concerned Scientists, Prescription).

But what ended up happening was that these antibiotics were given to animals for prophylactic reasons, which the FDA still currently includes on some antibiotic labels. The FDA has a lot of power since it is the agency in charge of regulating drug labels. Farmers opted to routinely feed these antibiotics to their animals on a daily basis, rather than only when an animal fell sick. But what is “sick” defined as? Due to the high labor and financial costs of individual veterinary visits, it seemed easier to therapeutically give them to animals in a preventative way. There was little regulation on this in the 1940s when antibiotic-use began on the animal industry. Moreover, they were given to improve “feed efficiency,” meaning that the drugs would fatten the animals more per unit of feed, thus increasing yields (Union of Concerned Scientists, Prescription). The USDA had found that antibiotics can sometimes increase meat yields by up to 3%, a percentage that further motivated farmers to use antibiotics for profit gains. Farmers incorporated antibiotics in animal feed, water, through direct injection or pill consumption, to achieve higher yields. Regardless of economic gains, they should not outweigh the rising threat antibiotic resistant bacteria pose to public health.
Environmental Remediation and Subsidies

It is well known that an increase in government subsidies leads to an increase in environmental degradation. For example, farmers in Florida who grow subsidized sugar cane have polluted the Everglades water system with excess phosphorus from overusing fertilizers on marginal lands to increase production (Ostria 2013). When farmers are supported by the government and pressured to meet high demands, they sacrifice environmental concerns to stay afloat. Therefore, it is no surprise government subsidies are highest for the US broiler and egg-layer sectors, considering the deplorable state US broiler and egg-layers, as well as cattle and swine, are living in. According to the Union of Concerned Scientists, the average annual subsidy for animal feed (grain, corn, and soy) received by the broiler sector trumps all other meat industry subsidies at $1.25 billion, and the egg sector receives $432 million (Gurian-Sherman 2008, 34). There have been many recalls and health related incidents involving industrial meat production especially in the chicken sector.

Robert Paarlberg elaborates on this claiming, “when subsidies go up, input use often goes up in lockstep (Paarlberg 2010, 121).” Essentially, the higher the subsidy or governmental support, the higher the pressure on the farmer, “to use too many fertilizers and pesticides and too much irrigation water in efforts to boost crop yields as high as possible (Paarlberg 2010, 121).” He cites an example of how South Korean rice farmers, who are heavily protected by the government and guaranteed a price about five times the world market price, employ 12.8 kg of pesticide per hectare; whereas the US rice farmers, who are much less protected, use only 2.3 kg per hectare (Paarlberg 2010, 121).
Mitigation and cleanup strategies are effective when maintained properly but are several times the cost. However, when practices stray from cleanup strategies and they are not implemented, environmental damage occurs. In practice, mitigation strategies are not always followed accordingly, so even in the best facilities and farms, environmental damage occurs from the use of antibiotics through soil contamination, water body pollution, and air pollution, all of which facilitate the spread of antibiotic resistant bacteria. In theory, mitigation proves to be a reliable method of reducing environmental damage. The most trusted way to ensure that environmental damage will not occur is if antibiotics are not rampantly used. It is the most trusted way that antibiotics will not be released into the environment, and that antibiotic resistance will not spread (Pruden 2013).

Appendix Figure 8 displays the levels of concern for current antibiotic resistant threats, and Figures 9 and 10 display charts for the various classes and types of antibiotics and their characteristics and resistance.

Establishing and proving the connection between antibiotic resistance and antibiotics breeding in the environment: “Correlations have been identified between antibiotic use and sulfonamide and tetracycline ARG abundance in cattle waste lagoons in the United States (McKinney et al. 2010) and in Dutch soil (Knapp et al. 2011), supporting the relationship between antibiotic use and environmental reservoirs of resistance (Pruden 2013).”

**Environmental Solutions**

Antibiotics from livestock production percolate through the environment, as they are in manure and urine, get mixed in with soil from manure deposits, and enter
waterways through waste discharges. Ways to reduce the presence of antibiotics in the natural world include improved waste treatment facilities, stricter and more numerous pollution discharge permits, and general elimination of non-essential uses. The figure below describes the numerous ways that resistance can develop and spread to humans and animals year-round.

Figure 11: USDA Human/Animal Exposure to Development of Resistance

Waste treatment plants significantly reduce environmental damage because they process manure before discharging it into the environment. These facilities process manure from large animal feeding operations to prevent harmful pollution from direct manure discharges into the local environment and reduce antibiotic potency. Researchers
in China discovered that manure treatment degrades antibiotics and reduces the chance of antibiotic resistant genes to develop and spread into the environment (Yong-Guan 2012). China, a nation that does not have strict regulations on pig farms or manure treatment but has one of the largest swine industries in the world, provided the ideal setting for this study. The research paper states, “Diverse, abundant, and potentially mobile antibiotic resistant genes (ARGs) in farm samples suggest that unmonitored use of antibiotics and metals is causing the emergence and release of ARGs to the environment.” A major problem is that farms typically do not employ the use of just one antibiotic; rather, the presence of multiple antibiotics such as tetracyclines and sulfonamides breeds an antibiotic resistance pool. As a result, treating manure eliminates target-specific methods of remediation. It goes beyond the lifecycle of the antibiotic inside the animal and degrades all antibiotics present in the waste. Given ample time and kept at the appropriate temperature, antibiotics in manure can degrade and diminish the chances of resistance to develop. This manure can then be more safely used to fertilize agricultural lands (Yong-Guan 2012).

Composting is another way that manure-containing antibiotics can be effectively managed to reduce the occurrence of ARGs in the environment. Simply allowing manure to sit in stockpiles before releasing it into the soil and water significantly reduces antibiotic potency. Research by Ranjana Sharma in 2009 focused on the survivability of *E.Coli*, *E.Coli* resistant to ampicillin and tetracycline, and erythromycin resistant methylase genes, after composting. The study discovered that composting can eliminate approximately 50-70% of certain antibiotics such as antimicrobial resistant *E.Coli* in livestock manure (Sharma 2009). Composting allows antibiotics to naturally degrade,
especially in the first two weeks during the thermophilic phase when bacteria are most active. Composting is highly affected by time and temperature controls. Degradation can also be accelerated by water treatment, and aeration and turning of the manure. (Pruden 2013) Biogas production from manure effectively kills pathogens and destroys antibiotics, and is a viable solution to reduce the spread of antibiotic resistance. These efforts focus on source reduction rather than waste management

**Public Health Impacts of Eliminating Non-essential Antibiotic-Use**

Antibiotic consumption should be restricted to treat only immediate health threats, those reasons that antibiotics were intended to overcome. The public will only gain from legislation with enforcement provisions and efforts to eradicate non-essential uses of antibiotics, especially in the livestock sector. Drug-resistant superbugs are difficult to combat once they invade an organism’s immune system. As stated before, 23,000 Americans die from antibiotic resistant bacteria every year. This coupled with the 2 million Americans hospitalized each year puts a financial strain of $20-35 billion on the healthcare system (CDC 2013, 11).

The National Research Council estimated that eliminating antibiotic-use for non-therapeutic use would increase per capita costs by $5-10 annually (Union of Concerned Scientists, Prescription). With such a small per capita economic cost, it seems like a straightforward decision to push for the elimination of antibiotic overuse. In the US, state and national efforts are moving in this direction. Many governmental officials and environmental organizations are working to inspire industry change, but nothing significant has been achieved yet. The threat of antibiotic resistance is a major global concern and as the population reaches 9 billion by 2050, the demand for meat will go up
in lockstep. More agricultural lands devoted to raising livestock treated with antibiotics means more breeding grounds for ARGs to develop. In order to move forward and delve into the paramount chapter revealing solutions, we must analyze what the US is currently doing to combat antibiotic resistance.
Chapter 4 – Current State of the Issue in the US

Founded in 1862 to manage the national agricultural sector, the USDA of today overlaps with many other sectors as agricultural practices heavily involve the pharmaceutical industry, chemical industry, EPA, FDA, and more. For instance, in terms of the food animal industry, they oversee livestock production; however, meat testing and antibiotic-use monitoring falls under the jurisdiction of the FDA (USDA 2014). The division of industry management increases the difficulty of regulating antibiotic-use. As such, the USDA has thus far not succeeded in eliminating antibiotic overuse.

In June 2014, the USDA published an action plan to combat antimicrobial resistance through a number of proposed changes including the creation of voluntary programs, extended research and studies, and education and training initiatives. This table outlines current efforts (in gray) and proposed efforts (in green). With three main objectives: “1) Determine and/or model patterns, purposes, and impacts of antibiotic use in food-producing animals; 2) Monitor antibiotic drug susceptibilities of selected bacterial organisms in food-producing animals, production environments, and meat and poultry; and 3) Identify feasible management practices, alternatives to antibiotic use, and other mitigations to reduce AMR associated with food-producing animals and their production environments (USDA 2014).” These goals of identifying issues surrounding antibiotic-use in food animals, monitoring the development of resistance, and recognizing alternative production methods to reduce the spread of antimicrobial resistance are exactly what my proposal achieves.
The USDA recognizes the weaknesses in its action plan, highlighting how due to time, labor, and financial constraints many of the proposed changes will be difficult to effectively execute. Pushing “judicious use training” is ineffective.
Moreover, all of the proposals are voluntary measures, which limits the widespread effectiveness and accountability to only those food animal companies that want to improve, leaving the companies who disagree with the changes to continue business as usual. Yes, some argue that allowing companies to voluntarily adopt proposals such as this result in faster industry improvements because competition amongst companies is a more natural driving force to inspire change. However, they can resultantly become weaker proposals as companies find loopholes in the diction to evade changing their practices. Such an occurrence is precisely why many efforts to eliminate antibiotic overuse in the food animal industry have not been as widely successful as their implementation was mandated.

In September 2013, the FDA implemented a voluntary measure for pharmaceutical companies to restrict the use of critically important antibiotics by changing the labels to not include the phrase “growth promotion in animals” as a listed use of the drug. In an attempt to curtail antibiotic-use for non-essential purposes, the FDA believed this measure would succeed; however, in reality, it was not. What subsequently happened was that companies removed the phrase from their labels, but because the drugs were mostly over-the-counter, farmers could continue purchasing the same amounts of antibiotics and claiming to distribute them to their animals for other reasons: therapeutic purposes, prophylactic uses, and of course, for disease treatment. Although it eliminates “growth promotion” as a use it does not eliminate “preventing disease,” a vague reason that antibiotics were never intended for and allows farmers to continue widely disseminating them to animals. Pharmaceutical companies continue to supply these antibiotics to farms who simply deny that they use them for growth promotion (Mercola
An attorney at the Natural Resource Defense Council (NRDC) states, “The voluntary approach is not likely to work... There’s a huge loophole: The FDA’s guidance endorses the use of antibiotics for disease prevention... although it urges that such use be ‘judicious’ (Levy 2014).” Disease prevention is the same as prophylactic uses of antibiotics. Until FDA reviews and bans the use of antibiotic via the label, the US will be stuck with more of the same. The FDA allows antibiotics to be given to animals for disease prevention.

The lack of monitoring and detailed record keeping contributed to the ill enforcement and knowledge about the truth behind individual farm practices. Only national figures confirm the total amounts of antibiotics used on farms. There have been political efforts to make meat producers report their antibiotic usage. Representative Henry Waxman of California created a bill titled “Delivering Antimicrobial Transparency in Animals Act,” which would require large farms to make detailed annual reports of their antibiotics usage in animal feed for the FDA; however, it unfortunately never progressed.

“The National Antimicrobial Resistance Monitoring System for Enteric Bacteria (NARMS) was established in 1996. NARMS is a collaboration among state and local public health departments, CDC, FDA, and USDA. This national public health surveillance system tracks changes in the antimicrobial susceptibility of certain enteric (intestinal) bacteria found in ill people (CDC), retail meats (FDA), and food animals (USDA) in the United States (CDC 2014).” NARMS publishes annual retail meat reports through the FDA, which provides non-specific figures on resistance in retail meats. It is ineffective because there are no statistics on location variance for where the meat was
purchased and tested, where processing and packaging occurred, or where the meat itself lived. In order to successfully reduce the development of antibiotic resistance, there must be information on location in addition to total amounts used.

NARMS has graphs from 1997 to 2011 on antibiotic resistance of various strains of *Salmonella* and *Campylobacter* in testing humans, retail meats, and chicken. The graphs prove that resistant bacteria persist in all three and even show percentages of antimicrobial resistance to specific antibiotics; however, what they fail to explain is the background on the testing. Without information on amounts of antibiotics that these samples were exposed to, or where all the samples were taken from over the 14 years of studies, it is impossible to develop conclusions about the exact reasons for the various amounts of resistance or how to combat the spread and development of resistance (US FDA 2011). The existence of NARMS is important, as it is one of the only governing bodies directly studying antimicrobial resistance; however, it is not doing enough. Antibiotic-use in the nation is continuing to grow as proven by the FDA’s latest report published in April 2015 titled “2013 Summary Report on Antimicrobials Sold or Distributed for Use in Food-Producing Animals.”
### Figure 12: Medically Important Antimicrobial Drug Sales and Distribution for Food-Producing Animals from 2009-2013

(FDA 2015)

This data proves that the total amount of antibiotics used in food animal production has increased by over 2 million kgs over the course of 4 years. Furthermore, this upward trend confirms that current efforts to reduce antibiotic overuse are not working. Comparing 2009 and 2013 figures, 8 out of 10 drug classes witnessed increases in domestic sales and distribution of antibiotics; 7 of which, are considered medically
important by the FDA. These medically important drugs not only increased in usage across the nation’s food animals, but also contributed to the problem of resistance development through routes of administration.

Figure 13: Medically Important Antimicrobial Drug Sales by Route of Administration 2009-2013

Antibiotics are most effective when injected or given to animals less target-specific applications. However, figures for antibiotic administration routes reveal that injections, intramammary, topical and oral (excluding feed and water routes), experienced a decrease from 2009 to 2013. Administering antibiotics via feed and water were the only two routes that witnessed an increase in kg totals. This means that their effectiveness to treat sick animals was diminished as most feed and water antibiotics do
not get fully digested by the body and therefore contribute to environmental pollution through waste and water ways.

Figure 14: Graph of Medically Important Antimicrobial Drugs and Routes of Administration 2009-2013

Administration via feed is by far the most common method as its total amount is nearly 4 times that of water, the second highest administration route, for all medically important drugs given to food animals in 2013. It accounts for 70% of all drugs
administered via feed. 94% of all antibiotics administered in 2013 of this FDA report were given via feed or water. This graph displays the same figures in the table to visually show how dramatic the routes of administration variance are. Low figures for injection and oral and topical routes are easily explained by the simple fact that they require the most human labor and veterinary input; two aspects that hinder the movement to eliminate antibiotic overuse. Increased veterinarian support and human labor increases costs, which is why farmers are reluctant to care so much about how and how much they administer to their animals. But if antibiotics were not so easily purchased or were prohibited for use in animal production, then antibiotic-use would decrease. As the governing body in charge of pharmaceutical regulation across the US, the FDA must implement stricter policies on antibiotic overuse for non-human purposes.

In September 2014, the Obama administration formed the President’s Council of Advisors on Science and Technology (PCAST) and ordered the nation’s top researchers and scientists on the council to develop a national action plan to combat antibiotic resistance. In March 2015, the action plan was published and it outlined 5 major goals:

1. “Slow the Emergence of Resistant Bacteria and Prevent the Spread of Resistant Infections
2. Strengthen National One-Health Surveillance Efforts to Combat Resistance
3. Advance Development and Use of Rapid and Innovative Diagnostic Tests for Identification and Characterization of Resistant Bacteria
4. Accelerate Basic and Applied Research and Development for New Antibiotics, Other Therapeutics, and Vaccines
5. Improve International Collaboration and Capacities for Antibiotic-resistance
Prevention, Surveillance, Control, and Antibiotic Research and Development.” (PCAST 2015)

In focusing on these primary goals, they hope to reduce urgent superbug threats from carbapenem-resistant *Enterobacteriaceae* (CRE) and *Clostridium difficile*, and serious superbug threats from methicillin-resistant *Staphylococcus aureus* (MRSA), by 2020. Implementation of the *National Action Plan* by the governing Task Force will lead to, “improved antibiotic stewardship in healthcare settings, prevention of the spread of drug-resistant threats, elimination of the use of medically-important antibiotics for growth promotion in food animals, and expanded surveillance for drug-resistant bacteria in humans and animals (PCAST 2015).” Moreover, there are plans for the, “creation of a regional public health laboratory network, establishment of a specimen repository and sequence database that can be accessed by industrial and academic researchers, development of new diagnostic tests through a national challenge, and development of two or more antibiotic drug candidates or non-traditional therapeutics for treatment of human disease (PCAST 2015).” Successful implementation will result in the following:
Figure 15: Table of PCAST National Action Plan Targets to Combat Antibiotic-Resistant Bacteria (PCAST 2015)

The action plan details specifics on how all these goals will be implemented; however, it focuses a lot on preventing antibiotic resistance in the healthcare setting rather than in the food animal industry—the sector that uses almost 80% of all antibiotics distributed in the US. The one important point they distinguish is that they hope to eliminate antibiotic-use for animal growth promotion by increasing veterinary input when assessing sick animals. But even this point is not one of the top 5 goals of the report, and reveals how ineffective the action plan is in addressing food animal drug usage. US Representative Louise Slaughter (D-NY), who realized the problem of antibiotic resistance and has been advocating for policy and industry change for over 2 decades, is disappointed with the National Action Plan. She states, “Once again, the administration
has fallen woefully short of taking meaningful action to curb the overuse of antibiotics in healthy food animals… trusting a voluntary policy that lets industry police itself will not bring about real change (Silverman 2015).”
Chapter 5 – My Proposal to Protect Human Health and the Environment by Producing Safer and Healthier Meat

I have defined six areas in the industry that need immediate improvement. To put my six suggested changes in context of other production systems, I compare them to current US, Cattlemen’s Associations, Denmark/EU, and “Strictly Organic.” Current industrial production in the US is the most important column because my proposal identifies the factory farm inefficiencies and how unsustainable it is. Denmark and European case studies represent more sustainable production systems that have reduced or eliminated antibiotic-use and associated environmental problems while maintaining and sometimes increasing production yields. Their successful implementation supports the practical achievability of my proposal. The “strictly organic” is the opposing method to current US production that represents the small and medium sized farms that produce livestock without the addition of any antibiotics except under dire situations as prescribed by a veterinarian. Although ideal, this system would require more industry changes to the current feedlot and CAFO practices and take longer to implement. I also include some information on what the cattlemen’s associations—the ones whose missions are to protect the rights and interests of the cattlemen themselves—are doing. They are responsible for voicing what the cattlemen want and support; however, they have not done enough to change production methods for the betterment of the cattlemen over the past century.

My proposal involves the creation via federal law of the Safe and Healthy Animal Production Agency (SHAPA), whose sole mission is to ensure safer and healthier food animal production to ensure the protection of the environment and public health.
<table>
<thead>
<tr>
<th></th>
<th>Current US</th>
<th>Cattleman’s Association</th>
<th>Denmark/EU</th>
<th>My Proposal</th>
<th>“Strictly Organic”</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Labelling</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Origin of animal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Include labels for Origin of animal (as they do for produce)</td>
</tr>
<tr>
<td>- Locations of where they lived</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Smiley face</td>
</tr>
<tr>
<td>- “Grow-out” Processor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Many confusing eco-labels</td>
<td></td>
<td>Many confusing eco-labels</td>
<td></td>
<td></td>
<td>Include labels for every location the animal ever lived if antibiotics were prescribed, which ones were</td>
</tr>
<tr>
<td>- Labels for cut and grade of meat</td>
<td></td>
<td>Labels for USDA certified organic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Organics label/Healthy label</td>
<td></td>
<td>Organics label/Healthy label</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Include labels for Origin of animal (as they do for produce)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Smiley face</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- None</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Antibiotic-use</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- What constitutes “drug-free”?</td>
<td></td>
<td>Allowed?</td>
<td></td>
<td>As prescribed by veterinarian</td>
<td>As prescribed by veterinarian</td>
</tr>
<tr>
<td>- CAFO/AFO: used</td>
<td></td>
<td>Allowed?</td>
<td></td>
<td>No antibiotic-use allowed if the drug is crucial to human use</td>
<td>No use</td>
</tr>
<tr>
<td>- Organic: none</td>
<td></td>
<td>Allowed?</td>
<td></td>
<td>No antibiotic-use allowed if the drug is crucial to human use</td>
<td>No use</td>
</tr>
<tr>
<td>- Government access</td>
<td></td>
<td>Government access</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Every site must be registered</td>
<td></td>
<td>Every site must be registered</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- GPS Public access to location information</td>
<td></td>
<td>GPS Public access to location information</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Location Registration</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Determines range of environmental impact</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Important information for communities nearby</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Hydrology maps/water sources</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- CAFO/AFO: NPDES permit</td>
<td></td>
<td>CAFO/AFO: NPDES permit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Organic: None</td>
<td></td>
<td>Organic: None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Government access</td>
<td></td>
<td>Government access</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Every site must be registered</td>
<td></td>
<td>Every site must be registered</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- GPS Public access to location information</td>
<td></td>
<td>GPS Public access to location information</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Electronic Record Keeping</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- For animals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- For antibiotic-use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Right-to-know/Who has access?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- What locations?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Ranch/CAFO/Distributor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- None</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Yes-both</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Yes-both</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Yes-both per animal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Testing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Where? Distributor/Processor/Raiser</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Of meat?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Of live animals?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Of waste streams?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Per label</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- ???</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Monthly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Every herd pre-process and at process</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Per animal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Animal by-products/waste Treatment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Do they get put in feed?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Where does it go?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- None</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- ???</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Per site, (with every herd) 3 times a year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Each herd twice</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SHAPA

SHAPA is a regulatory agency that oversees the 6 areas I have outlined in Table 1 and provides recommendations for a more sustainable livestock production system. Combating antibiotic resistance in the livestock industry has thus far not been successful because of the overlapping jurisdictions of the USDA, FDA, EPA, and the vested interests of large corporations. The industry needs a new agency that centers on every aspect of livestock production from cradle to grave including all inputs and outputs of the life cycle of the animal in production. The creation of the Safe and Healthy Animal Production Agency (SHAPA) is mandated to address and eliminate the inefficiencies of the livestock production system as well as stopping antibiotic overuse.
The SHAPA would have an advisory board that includes representatives from many stakeholders. Similar to the Danish Ministry of Food, Agriculture and Fisheries (MFAF) programs that monitor Denmark’s food animal industry that involves experts from veterinary sciences to policy-making to the meat producers themselves, the SHAPA would ensure all key players are heard and decision-making is collaborative rather than dictatorial. Especially since the SHAPA would be a regulatory agency that provides guidance, regulations and set policy consistent with its mission for an improved, safer & healthier food animal production system. By involving stakeholder representatives in the advisory board, it would be easier to engage their constituents and ensure their commitment to the goals of the SHAPA throughout its implementation. For example, transitioning to the electronic record systems of the SHAPA would be a challenging task; however, utilizing the existing systems and relationships in place by the USDA, FDA, and EPA, would facilitate this switch. The industry would be responsible to implement and maintain the electronic record keeping system with oversight by SHAPA. The industry association(s) would also assist with the increased monitoring and testing outlined in Table 1. The when, what and how of monitoring and testing would be regulated by the SHAPA based on recommendations from the board and also comments during the promulgation of the regulations.

The SHAPA would regulate and enforce the final rules governing the industry changes. The Netherlands, whose agricultural exports are second to that of the US even though it’s 200 times smaller, achieved its antibiotic-free meat campaign (Economist 2014). Realizing that after banning the use, pharmaceutical-use stayed the same and even increased, the Netherlands cracked down on its surveillance of the industry. Keeping
detailed records of antibiotic use, veterinarians prescribing them, and of pharmaceutical sales, they were able to pinpoint those individuals who were non-compliant and subsequently fined. After they did this, they were able to significantly reduce their usage of prophylactic antibiotics in food animal production. Similarly, based on statutory authority (federal law) the SHAPA would employ (federal) regulations punishable by fines to ensure that no one cheats the system. Charging substantial fines for non-essential uses of antibiotics pressures meat producers to abide by the SHAPA regulations and eliminate non-essential applications of antibiotics—this is achieved my monitoring, record keeping and enforcement. Non-compliant parties would be penalized.

Voluntary measures—such as the FDA voluntary directive—to date are not effective in changing the industry given the magnitude of the problem with antibiotic resistance. Without requiring all factory farms to have reliable data, one would not be able to interpret the resulting data and reports. They would falsely exemplify the figures of antibiotic-use in the livestock industry, and make it difficult to conclusively understand if efforts to reduce antibiotic-use are working. It also would be difficult to hold companies accountable and to enforce regulations without a rigorous and timely monitoring, testing and record system. Typically, industries want to avoid change and maintain business-as-usual, and that explains why voluntary measures will be slow and ineffective to change the industry compared to the fast rates at which antibiotic resistance is spreading. The time is now for a “New Approach” to industrial animal production in the US.

By realigning the federal budget, the statutory creation of the SHAPA by Congress would regulate the food animal industry in a way that mirrors many of those
already successfully implemented programs in several European nations. It would further the global effort to reduce antibiotic misuse and overuse since the US is the number one exporter of meat and meat products. With a more efficient, sustainable, and safer meat production system, the US could achieve the 5th goal of the President’s National Action Plan to make the antibiotic-overuse movement a concerted international effort (Hollis 2013).

The European Union has been spearheading antibiotic-free meat campaigns since the late 1980s when research identified and proved the dangers of bacterial resistance. Sweden was the first to ban all growth-promoting antibiotics use in the animal production sector, which included the importation of meat in 1986 (Casewell 2003). In 1994, Stuart Levy conducted an experiment on a small chicken farm to understand resistance and the impacts antibiotics have on them. According to one synopsis of the study:

“Levy’s team found that drug-resistant bacteria quickly came to dominate the intestinal flora of chickens following the introduction of feed commercially laced with oxytetracycline. Within six months, the people living on the farm also carried tetracycline-resistant coliform bacteria, which made up more than 80% of their intestinal microbes. The bacteria carried by both chickens and farmers contained plasmids that conferred traits creating resistance to multiple antibiotics, not only the original drug. One need not speculate that the waste from these chickens contained both antibiotic residue and antibiotic resistant bacteria. Several research papers have now documented the presence of antibiotic resistant pathogens from animal wastes in all media—land, air and water. The researchers also observed that
six months after antibiotics were removed from the chicken feed, most of the workers no longer carried tetracycline-resistant bacteria (Levy 2014).”

This influential study and the risks antibiotic resistance posed to public health pushed Denmark to issue a similar ban in 1995 on avoparcin and in 1998 on virginiamycin. These efforts were so effective that by 2000, Denmark had virtually eliminated all antibiotic-use in meat production (Casewell 2003, 159). Similarly influenced, the European Union (EU) banned all antibiotics crucial to human medicine that were being used for growth promotion in 1999 on the basis of the “precautionary principle” (Casewell 2003, 159). Today, the European Union maintains these strict regulations and continues to have profitable meat production. The USDA reports that the European Union production of pork is second in the world, beef and veal is third, and broiler chicken is fourth (USDA 2015).

Pork production in the European Union is larger than it is in the US, where growth-promoting antibiotics are still in widespread use on factory farms. Moreover, the World Health Organization (WHO) conducted a study on the Impacts of antimicrobial growth promoter termination in Denmark in 2002, and found that the antibiotics ban in Denmark did not negatively impact swine production and alternative methods actually increased productivity. Denmark realized that, “knowledgeable animal husbandry is cited as the most important factor in reducing antibiotic use (Pruden 2013).” By improving animal husbandry for swine, which included “more frequent cleaning of housing, improved ventilation, later weaning, additional space for animal movement, as well as experimenting with feed quality and additives made up for the lack of routine antibiotics on most farms,” they maintained and later exceeded previous yields (Pew 2010).
WHO study analyzed swine and broiler production in the entire nation of Denmark, which also included large-scale intensive production facilities such as “all-in-all-out” (AIAO) barns. The WHO concluded that if Denmark could economically raise animals in factory farms without antibiotic-use, then nations such as the US, which have “similar animal production conditions,” could likewise successfully eliminate growth-promoting antibiotics (WHO 2003).

Denmark’s economic success in the food animal industry did not come without initial challenges. In the first year after the ban, Denmark suffered an increase in diarrhea-related piglet deaths for 7 months, but returned to pre-ban levels by the end of the year. The strong commitment to maintain improved animal husbandry and hygiene practices in intensive meat production systems ensured this success. Furthermore, Pew Charitable Trusts found that production costs drop when growth-promoting antibiotics are eliminated, and similar findings were made in individual studies by Johns Hopkins University and the WHO (Pew 2010). The Danish case study demonstrated that in employing strict regulations on antibiotic-use and utilizing science research to inspire and execute the changes, food animal production can be safer and healthier and maintain economic growth.

**Electronic Record Keeping: Antibiotic and Animal Location Registries**

By regulating antibiotic-use and animal recording, Denmark’s MFAF has ensured success and honesty in reporting. The SHAPA mission would be to provide safer and healthier meat to protect the environment and human health. To achieve its goals, the SHAPA would need regulations governing the use of antibiotics and the electronic record keeping systems as modeled after Denmark’s current meat production system. The
industry associations for cattle, chicken, and swine, would help develop the systems, since they know what information is crucial to record to best determine animal health. As a regulatory agency, the SHAPA would oversee the two registries denoted in Diagram 1 above: Antibiotic Registration (AR) and Animal Location Registration (ALR).

The AR would collect data from veterinarians about the type, amount, date, and route of administered antibiotic drugs, along with the date when it is then safe to slaughter as established by FDA. This information would ensure that veterinarians are prescribing the antibiotics. It also would afford the SHAPA oversight on the veterinary practice and frequency of prescribing antibiotics. The record keeping system also would provide data on which antibiotics were prescribed for what illness. Pharmacies would also contribute to the AR by reporting antibiotic sales and distribution for what place (i.e. ranch, CAFO, etc.), which veterinarian, the amount, and type. Feed mills would be the last important player that would input data into the AR. Since some types of antibiotics are administered orally via the feed, regulating feed mills via AR would be imperative. Their reporting coupled with the data the AR would receive from veterinarians and pharmacies would conclusively determine if sales and usage are equal. Meat product testing data would also be included in the registration. Thus, the total amount of antibiotics administered to the animal production system would be recorded and accessible to the SHAPA and the public under an open and transparent online database.

The AR would be based off a Danish monitoring system called VETSTAT. Since its mandatory implementation in 1995, VETSTAT has collected and provided animal antibiotic-use to the Danish Ministry of Food, Agriculture and Fisheries (MFAF). The four purposes were to: “1) monitor veterinary usage of drugs in animal production; 2)
help practitioners in their work as farm advisors; 3) provide transparency as a basis for ensuring compliance with rules and legislation; and 4) provide data for pharmaco-epidemiological research (Stege 2002).” VETSTAT specifically collects detailed information on: date of medicine administration, identification of the reporting person/practice/pharmacy/feed mill, the animal identification number, drug product number, the amount administered, and the codes for animal species, age-group and diagnostic grouping (Stege 2002). It accurately accounts for almost 100% of Denmark’s pharmaceutical usage because all veterinarians, pharmacies, and feed mills, are required to report monthly figures. The Danish government can monitor and guarantee that antibiotic usage has in fact dropped based on these figures.

In relation to the SHAPA, VETSTAT was established as a result of the Danish Integrated Antimicrobial Resistance Monitoring and Research Program (DANMAP), which was founded as a result of rising concerns with livestock antibiotic-use. Since its conception in 1996, DANMAP has published annual reports detailing pharmaceutical antimicrobial sales to wholesalers; however, the program realized its limitations with surveillance. VETSTAT fulfilled this void and serves as the vessel providing insight into specific antibiotic-use on farms. Similar to the collaborative advisory board for SHAPA, VETSTAT is overseen by many stakeholders: the Danish Veterinary Institute, the Danish Medicines Agency, the Danish Veterinary and Food Administration, food-animal producers, and veterinarians. VETSTAT has been successful in maintaining the significant reduction in Denmark’s livestock antibiotic-use for nearly two decades, and indicates that if effectively enforced, the AR would likewise ensure compliance with SHAPA regulations involving the safe and healthy production of meat in the US.
Monitoring systems are imperative to the success of the SHAPA and the elimination of prophylactic and preventative antibiotic-use. Initially, after the EU ban was in effect, the Netherlands unexpectedly saw an increase in antibiotic sales based on monitoring data. Enforcement began closely monitoring and tracking drug sales and use and by 2009, they identified and issued fines to non-compliant companies and people. The result of this acute tracking and distribution of fines was that “veterinary consumption of the drugs subsequently dropped by more than 50% in the course of three years (Levy 2014).” Consumer right-to-know would also aid the effort, especially if the info is included on the label.

*Figure 5. Development of antibiotic use per species in the period 2009-2012 in % of ADDD/Y in 2009 (LEI, 2012).*

![Figure 16: Netherlands Antibiotic-use per Food Animal Species 2009-2013](image-url)
The above figures reveal that the Netherlands not only achieved a significant decrease in individual antimicrobial uses—most notably for tetracyclines, trimethoprim/sulfonamides, and penicillins/cephalosporins; but also major reductions in antibiotic-use for the pig, broiler, veal, and dairy industries. Under the SHAPA, the AR would work similarly to hold non-compliant parties accountable and ensure significant antibiotic-use reduction in a matter of a few years, as proven by the European examples.
Currently, the US reports for antibiotic-use in livestock production show total figures rather than detailed amounts. This is due primarily to the fact that no transparent record keeping system exists that can specifically pinpoint who is overusing or distributing antibiotics. The US needs to begin today to achieve the Denmark standards given its status as one of the highest antibiotic consumers in 2008, but with the implementation of the SHAPA, the US would successfully change livestock production for the safety of public health (Levy 2014). The President’s *National Action Plan* does little to address how antibiotic-use will specifically eliminated from the livestock industry.

*Figure 18: Antibiotic Usage Compared to the World, Pew Charitable Trusts*

(Pew Charitable Trusts)
The Animal Location Registration (ALR) would require that cattleman’s associations and all animal operations document where livestock are transported in their lives. Typically, animals are transported from their birth on ranches to industrial feedlots to the slaughterhouse and distributor. Tracking this location information via an automated/electronic system is critical, as it would increase transparency in the industry. Point-of-origin data on all livestock would assure that in case of a bacterial outbreak, the source of the problem could be quickly determined and addressed especially if a meat recall is needed. The ALR would collect important data, which many consumers need to understand about the lifecycle of the meat, and would also improve the SHAPA’s ability to ensure to safer and healthier meat production. This data would also allow large corporations to quality assure that the meat and meat products meet their standards.

Denmark has had an animal tracking system in place since 1992 called the Central Husbandry Registrar (CHR) that oversees cattle, pigs, sheep, and goats, as well as commercialized poultry, fur animals, deer, game birds, and fish. The CHR was constructed and managed by the Danish MFAF. The Danish online database records: the holding’s number and address and geographical position; the keeper and owner’s name, address, contact number and VAT/CPR number; number of animals; and veterinary events. It also has very specific data on every animal through ear tags, movement documents, and on-the-spot-inspections: individual movements by the livestock animals; results from TSE and salmonella testing; veterinary practitioners; use of medicine; and results from the on-the-spot inspections (Ministry of Food, Agriculture and Fisheries 2015).
Similarly, the SHAPA’s ALR would track livestock movement and data on the health of the animals as well as the owners of the various location at which the animals are raised. Randomized bacterial testing, as mandated by the SHAPA, would provide important information that should be registered on a per herd basis both before and after processing. This data would reveal general herd health and would track animal health throughout their lives, and again would be critical to the FDA and CDC if there were an illness outbreak caused by bacterial contamination of meat. It is known that, “keeping animals healthy is an important way of reducing the usage of antibiotics. Best management practices, such as lower animal density, improved sanitation, and improved nutritional programs, can be developed and adopted to control infectious diseases on farms (Pruden 2013).” As such, systems that reveal how healthy these animals are is vital to the mission of the SHAPA. Dairy farms already employ increased testing to monitor daily milk production. Cattle tracking technology on the farm can be as simple as employing ear tags. Approximately 50.4% of animal operations currently utilize personal plastic ear tags as animal identification systems in the US (Robb 2014). Utilizing the technology already in use, the ALR would go a step further to collect detailed information on animal health farm-to-feedlot-to-slaughter which would close the loop as to when and where antibiotics may have been used. The ALR would provide animal health reports per herd and include specifically where the animals have been raised.

“My CowHerd” is an online identification system that the National Cattlemen’s Beef Association (NCBA) developed to encourage ranchers to maintain electronic records of their herds. John Paterson of the NCBA reveals there is a need for electronic record-keeping systems if cattlemen are to meet the demands for increasing sustainability
and productivity. He describes how even a rudimentary system could easily identify calving distributions and weaning rates, both of which are key pieces of information that ranchers use to determine the health of their herds. “My CowHerd” has not been successfully applied as older, well-established ranchers who are reluctant to change stick to their own systems. Moreover, the NCBA reveals that a significant portion of cattlemen, not including factory farm owners, maintains handwritten livestock records on paper. The SHAPA would go beyond “My CowHerd” to collect quantifiable data on animal health and location and antibiotic-use to more accurately identify inefficient companies. The SHAPA would work with these companies to ease the transition to the online registries, and establish a more sustainable beef industry (Robb 2014). Since the industry is already utilizing “My CowHerd”, electronic record keeping under the SHAPA would not be a difficult transition.

Cattlemen’s associations function as do any other group working to improve the lives of its workers. There are many on the national and state levels, all with a general commitment to protect the beef industry and cattle ranchers and farmers and provide quality meat to the consumer. For example, the National Cattlemen’s Foundation raises funds to encourage youth to pursue agriculture careers and establish investments in the industry to ensure the fate of the beef industry. On their website, they claim to “[support] educational and research activities that will ensure a wholesome and economical supply of beef to the public (National Cattlemen’s Association, 2015).” But what they have blatantly failed to do is protect cattlemen from being taken over by powerful beef corporations. The SHAPA mission would be in harmony with the Cattleman’s
Association to improve animal husbandry to produce safer and healthier meat even if the company is a factory farm.

Records on animal health including location would improve industry facilities standards from the inside, as selective regulatory requirements would weed out those that have failing health standards. It would also help meat producers identify areas on their land that cause recurring health problems for the animals (i.e. location near manure storage.) Evidenced by animal health documentation on-site, the transparent system would generate a movement to maintain cleaner farms throughout the industry. From an economic standpoint, competition is the most effective way to inspire change at the industry level and open new markets for antibiotic free meats such as now required by McDonald’s. The press release can be found in the Appendix Figure 19.

The purpose of the AR and the ALR would be to help achieve the mission of the SHAPA for consumer safety and health. But in order to ensure accurate reporting, the registries must be third party verified as well as direct oversight by SHAPA. Denmark contracted a private company called Landbrugets EDC Center (LEC) to check data for VETSTAT and the CHR. Similarly, the SHAPA would utilize private consultants to maintain transparency in its actions. Delegating various stakeholders to manage different aspects of the SHAPA’s proposals would reduce the risk of influence and or corruption from singular groups regulating everything. The reason why meat production has not succeeded in eliminating antibiotic overuse may be due to a conflict of interest for agencies like the FDA or USDA who hold such a large stake in livestock production and pharmaceutical-use. Third party verification accomplishes the task of ensuring honesty in reporting for the AR and ALR to maintain transparency.
Consumer Right-to-Know and Labeling

The public, each citizen, has the right-to-know exactly where the food they are consuming is coming from, what it contains and who has control over the production. Collaborative efforts amongst the key players will increase transparency in the livestock industry for the benefit of the entire population because we are all stakeholders in this. With the centralized, industrial production that drives current food production in the US, knowledge about meat point-of-origin is lost and not revealed to the consumer. Centralized and regulated surveillance will increase transparency only if the data is open and transparent. Publicly posting information from the Antibiotic Registration (AR) and the Animal Location Registration (ALR), which consumers have online access to would satisfy and decrease this knowledge gap. The Safe and Healthy Animal Production Agency (SHAPA) would regulate and require a labeling system that provides information on antibiotic-use and point-of-origin, which are two of the most important facts that directly impact the health of the consumer. This food labeling would be done in partnership with the FDA or under the SHAPA’s statutory authority.

The AR would notify meat processors and distributors about any pharmaceuticals that were given to the animal during or after its lifetime. If a drug were administered, the date when the animal has completely digested or eliminated the antibiotic given would be posted in the records—according to standard FDA recommendations—and would ensure that the animal can be safely slaughtered. It then would fall under the distributor’s jurisdiction to complete the last stage of the SHAPA’s plan: to provide this information on the consumer via a product label.
Antibiotic-use could be revealed as simply as *antibiotic-free* or *antibiotics-used*. Point-of-origin labeling could include every general location (i.e. city, state, or nation depending on how local the meat is to the consumer) that the animal lived in throughout its life. This two-part label would bring the lifecycle of the animal to the forefront of consumer knowledge and provides large corporation additional information on the meats they procure.

The power of the SHAPA-approved labeling system would ensure consistency in the confusing world of brand name products. Eco-labeling has been shown to increase sales as consumer assumptions about the wholesomeness of the product inspire them to purchase labeled products over non-labeled ones. It drives market demand for the label and the associated products. However, the main problem with eco-labels is that there are too many with varying meanings. The SHAPA label would not be an eco-label; rather it would be a government label intended to make it convenient for consumers to know if antibiotics were used in the production of the meat they are purchasing. What the SHAPA would do is regulate a simple, uniform labeling system to ensure safer and healthier meat products. The SHAPA would enforce the regulations to relay information on antibiotic-use and point-of-origin to customers.

It would take some time before the AR and the ALR are in complete implementation, since it would be dependent on when enforcement takes action to regulate the veterinarians, pharmacies, feed mills, cattlemen, and meat producers, who must comply. The associations, extension, corporations and NGOs may help increase the compliance rate via training on what is required and how to use the systems. As such, my proposal advocates phasing in the electronic record keeping registries, first requiring the
largest industry players to adopt these changes and ending with the smallest groups. The Netherlands and Denmark systems proved that rapid antibiotic-use reductions occur after about 5 years, so the SHAPA would impose a similar time constraint for the industry to get on board with these regulations. After which point, non-compliant groups would be fined case-by-case. Without strict enforcement to ensure accountability, the SHAPA system would never be fully implemented.

**Growing Demand for Antibiotic-free Meats**

If the Congress passes the SHAPA act and funds the implementation of the SHAPA’s proposal, it would increase the quality and “purity” of the meat in commerce. Currently, the European Union does not import much meat from the US since it does not pass their standards on antibiotic-use, but the proposed industry changes would open markets for export to the European Union. Moreover, it would satisfy the growing consumer demand for antibiotic-free meat and international effort to reduce antibiotic overuse. Many industry leaders—McDonald’s, Tyson, Perdue, Wal-Mart, Costco—have already realized and begun voluntarily transitioning to antibiotic-free meat systems to supply the consumer demand.

Competition amongst companies is effective to the environmental agenda when the market favors more sustainable practices or healthier products. McKinsey & Company projects that “going green” will influence consumer demand trends over the next decade, proving that businesses will need to supply the market with more environmentally conscious products if they are to keep up (Chatterjee 2010). Thus, if meat producers want to succeed in the future, they must meet this consumer demand and
change their production practices and produce a safer and healthier product. The SHAPA would be one step in assuring safe, sustainable and healthy meat for future generations.

Fast food powerhouse McDonald’s recognized the value of developing a reputation for serving healthier and more wholesome foods. As of March 4th, 2015, they announced a two-year plan to phase out chicken meat raised with antibiotics. Working with their big name suppliers such as Tyson, the fast food industry has initiated a big movement towards antibiotic-free meat in the meat industry. Eric Schlosser, author of *Fast Food Nation*, discovered that McDonald’s is the number one purchaser of beef, pork and potatoes, in the US, and second largest purchaser of chicken. Therefore, its transition towards antibiotic-free meats starting with antibiotic-free chicken will have a major impact on the meat industry. Furthermore, by the end of 2015, McDonald’s plans to stop supplying milk from cows treated with artificial growth hormones, such as rBST, thus further reducing the meat industries dependence on the pharmaceutical industry. (McDonald’s 2015).

Long before Tyson and McDonald’s decided to support antibiotic-free chicken, Perdue—one of the largest poultry producers in the world—voluntarily changed their industry practices. Since the 1990s, Perdue has phased out the use of antibiotics in their production practices, to the point where less than 5% of its chickens receive human antibiotics. Perdue actively works to ensure food safety and quality within governmental standards and beyond. Pew Charitable Trusts supports Perdue’s reduced antibiotic-use and Perdue proves on US soil that pharmaceutical use in chicken production is not required to maintain high yields. Perdue feed mills experiment with “adding oregano, yucca and other herbs and essential oils to its feeds to improve the biomes of its
chickens.” Alternative production methods such as these come with an initial cost and risks, but the growing demand for antibiotic-free meats ensure profitability. Perdue has been spearheading the chicken industry to be more sustainable and with the implementation of the SHAPA, more meat producers would join Perdue (Strom 2014).

**Waste and Animal By-Product Management**

Beyond Denmark’s monitoring systems, the SHAPA would follow the lifecycle of food animal production from birth to animal waste—a problem that does not have enough attention and regulation. Antimicrobial resistance can increase in the bacterial environment in waste lagoons, which are highly prone to failure and risk releasing large amounts of harmful bacteria into water bodies. Manure management is often the most expensive cost on farms, and manure storage facilities are not strictly regulated. Poorly managed manure systems impact the surrounding environment through leaching, runoff into surface water, odor, and contribution of GHGs.

Under the Clean Water Act, large animal operations are required to get permits under NPDES to discharge to water ways, prevent environmental pollution; however, due to lack of sufficient inspections, proper enforcement and surveillance, and major loopholes in the NPDES, it has not done enough to completely protect the environment from waste pollution (Gurian-Sherman 2008). Furthermore, manure that can contain antibiotic resistant bacteria is often applied to nearby fields as fertilizer but without effective regulation, this spreads the contaminants, metals, and excess nutrients to more land (NRDC 2013). This activity falls outside the authority under CWA buts needs regulation, which would fall to the SHAPA.
Animal by-products—parts from livestock production that are not a part of the dressed carcass or intended for human consumption—are a significant waste product from food animal production that contribute to environmental pollution. The USDA Economic Research Service found in a 2011 study that animal by-products accounted for approximately 23-35% of the volume of US pork and beef/veal exports. This includes inedible parts such as, “hide or skin, hair, horns, teeth, fats, bone, ligaments and cartilage, feet, glands, blood, and lungs;” and edible parts such as, “livers, hearts, tongues, tails, kidneys, brains, sweetbreads, tripe, melt, chitterlings and natural casings, fries, rinds, head meat, lips, fats and other trimmings, blood, and certain bones (Marti et al. 2011).” Maximizing animal by-product usage minimizes waste production. The SHAPA would regulate this to ensure environmental protection, since the entire lifecycle of the animal must be accounted for if the livestock industry is to become completely sustainable.

**In Summary**

“Banning subtherapeutic use of antibiotics in Denmark led to marked reductions of antibiotic resistance among fecal enterococci in the animal populations (Aarestrup et al. 2001), demonstrating that it is indeed possible to stop the occurrence of antibiotic resistance among a national population of food animals through regulations restricting antibiotic use (Pruden 2013).”

To reiterate, this is not a call to end antibiotic use for the entire livestock industry. In fact, the SHAPA would initially regulate the large CAFOs and corporations. Small to medium animal farms are often not dependent on prophylactic use of antibiotics and as such, would not need the mandatory compliance required of large industrial production. The industry needs to focus on eliminating non-essential antibiotic uses, including but not
limited to growth promotion, prophylactic measures, and feed efficiency. Prophylactic uses of antibiotics must be stopped and instead, their use should be determined by veterinarian prescriptions rather than be available directly to farmers. Antibiotics are not designed to prevent disease; rather, they are meant to treat specific bacterial infections. Although there have been voluntary movements to eliminate “growth promotion” from labels, there is no such movement to erase “preventative” from them. My proposal attempts to change fundamental practices via a regulatory system designed to improve the quality of our meat supplies. The SHAPA would also increase transparency in the livestock industry, so that antibiotic-use is target-specific rather than preventative. The AR and the ALR would provide the means by which animal health and antimicrobial-use can be tracked to ensure treatment effectiveness.
Chapter 6 – Conclusion

Routinely administering daily doses of antibiotics to animals that are not sick defeats the primary purpose of antibiotics. It creates an environment that allows for the emergence of stronger strains that can outstand the lethal effects of antibiotics. By developing the Safe and Healthy Animal Production Agency (SHAPA) to 1) regulate the Antibiotic Registration, 2) regulate the Animal Location Registration, 3) manage the livestock industry for the entire lifecycle of the animal, 4) establish a labeling system to relay antibiotic-use to the public, and 5) increase overall transparency in the livestock industry; the US can achieve a more sustainable livestock industry and provide safer and healthier meat to the people. Public health will be protected from these efforts and the development of antibiotic resistance can effectively be reduced.
II. Appendix

Figure 2 (page 23): Estimated Maize Production for Animal Feed (Gurian-Sherman 2008)

Source: LEAD. The fraction of total production dedicated to feed was estimated at national level (FAO, 2016b) and the ratios applied to the crop production map (You et al., 2006).
Figure 3 (page 23): Estimated Soybean Production for Animal Feed (Gurian-Sherman 2008)
Figure 4 (Page 26): Number of All Cattle and Beef Cow Operations, US, 1992-2012

http://www.sdstate.edu/vs/extension/beef-procedures-antibiotics.cfm
Figure 5 (Page 34): USDA Timeline of Class and Antimicrobial First Marketed for Use
Figure 6 (Page 35): How Antibiotic Resistance Happens and Spreads (CDC 2013, 14)
Figure 7 (Page 36): Developing Resistance—Timeline of Key Antibiotic Resistance Events (CDC 2013, 28)
Figure 8 (Page 40): CDC Levels of Concern for Antibiotic Resistance (CDC 2013, 7)

**Urgent Threats**
- *Clostridium difficile*
- Carbapenem-resistant Enterobacteriaceae (CRE)
- Drug-resistant *Neisseria gonorrhoeae*

**Serious Threats**
- Multidrug-resistant *Acinetobacter*
- Drug-resistant *Campylobacter*
- Fluconazole-resistant *Candida* (a fungus)
- Extended spectrum β-lactamase producing Enterobacteriaceae (ESBLs)
- Vancomycin-resistant *Enterococcus* (VRE)
- Multidrug-resistant *Pseudomonas aeruginosa*
- Drug-resistant Non-typhoidal *Salmonella*
- Drug-resistant *Salmonella Typhi*
- Drug-resistant *Shigella*
- Methicillin-resistant *Staphylococcus aureus* (MRSA)
- Drug-resistant *Streptococcus pneumoniae*
- Drug-resistant tuberculosis

**Concerning Threats**
- Vancomycin-resistant *Staphylococcus aureus* (VRSA)
- Erythromycin-resistant Group A *Streptococcus*
- Clindamycin-resistant Group B *Streptococcus*
Figure 9 (Page 40): CDC Drug Classes

<table>
<thead>
<tr>
<th>Drug Class</th>
<th>Important Characteristics</th>
<th>Resistance and Other Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>β-lactams</td>
<td>A large class of broad-spectrum drugs that are the main treatment for gram-negative infections. The subclasses are listed below and are presented in an order from narrow-spectrum (penicillins) to broad-spectrum (carbapenem) β-lactam drugs.</td>
<td>Gram-negative bacteria have developed several pathways to β-lactam resistance. Perhaps the most concerning are β-lactamases, enzymes that destroy the β-lactam antibiotics. Some β-lactamases destroy narrow spectrum drugs (e.g., only active against penicillins) while newer β-lactamases (e.g., carbapenemases found in carbapenem-resistant Enterobacteriaceae or CRE) are active against all β-lactam antibiotics.</td>
</tr>
<tr>
<td>β-lactam subclass:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Penicillin, aminopenicillins, and early generation cephalosporins</td>
<td>Among the first antibiotics developed for treatment of bacterial infections. In the absence of resistance, these drugs are active against a broad range of bacterial pathogens.</td>
<td>Resistance among gram-negative bacteria is widespread. These drugs are rarely recommended as treatment for serious gram-negative infections.</td>
</tr>
<tr>
<td>β-lactamase inhibitor combinations</td>
<td>These drugs are still active against gram-negative bacteria that have β-lactamases with limited activity for destroying β-lactam antibiotics.</td>
<td>These drugs are important for treatment of serious gram-negative infections but resistance is increasing. Bacteria that are resistant to extended-spectrum cephalosporins and carbapenems are usually resistant to these drugs as well. New β-lactamase inhibitor combination drugs in development have the potential to overcome some, but not all, of resistance from the most potent β-lactamases such as those found in CRE.</td>
</tr>
<tr>
<td>Extended-spectrum Cephalosporins</td>
<td>These drugs have been a cornerstone for treatment of serious gram-negative infections for the past 20 years.</td>
<td>Resistant gram-negative infections first emerged in healthcare settings but now are also spreading in the community. When resistance occurs, a carbapenem is the only remaining β-lactam agent.</td>
</tr>
</tbody>
</table>
Figure 10 (Page 40): CDC Drug Classes continued

<table>
<thead>
<tr>
<th>Drug Class</th>
<th>Important Characteristics</th>
<th>Resistance and Other Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbapenems</td>
<td>A broad-spectrum β-lactam antibiotic that is considered the last resort for treatment of serious gram-negative infections.</td>
<td>CRE infections are spreading in healthcare facilities throughout the United States and the world. It is reasonable to expect that this resistance will expand to bacteria that circulate in the community, as witnessed by extended-spectrum β-lactamase producing bacteria. Carbapenem resistance can also be found among other gram-negative bacteria including <em>Pseudomonas</em> and <em>Acinetobacter</em> spp. Once bacteria become resistant to carbapenems, they are usually resistant to all β-lactams.</td>
</tr>
<tr>
<td>Fluoroquinolones</td>
<td>These are broad-spectrum antibiotics that are often given orally, making them convenient to use in both inpatients and outpatients.</td>
<td>Resistant bacteria develop quickly with increased use in a patient population. Increased use is also associated with an increase in infections caused by fluoroquinolone-resistant, hyper-virulent strains of <em>Clostridium difficile</em>.</td>
</tr>
<tr>
<td>Aminoglycosides</td>
<td>These drugs are often used in combination with β-lactam drugs for the treatment of serious gram-negative infections.</td>
<td>Despite growing resistance problems, these drugs continue to be an important therapeutic option. However, clinicians rarely use these drugs alone because of concerns with resistance and side effects.</td>
</tr>
<tr>
<td>Tetracyclines &amp; Glycyclines</td>
<td>Tetracyclines are not a first-line treatment option for serious gram negative infections; however, with increasing resistance to other drug classes, tetracyclines are considered as a treatment option. Glycyclines (i.e., tigecycline) are often considered for treatment of multidrug-resistant gram-negative infections.</td>
<td>Tigecycline is a drug that does not distribute evenly in the body, so it is often used in combination with other drugs depending upon the site of infection. Resistance to tigecycline has emerged but it is still relatively uncommon.</td>
</tr>
<tr>
<td>Polymyxins</td>
<td>These drugs are an older class that fell out of favor because of toxicity concerns. Now they are often used as a &quot;last resort&quot; agent for treatment of multidrug-resistant gram-negative infections.</td>
<td>Because these are generic drugs, there are limited contemporary data on proper dosing. In addition, resistance is emerging, but there are limited data guiding the accurate detection of resistance in hospital labs. As a result, use of these drugs present significant challenges for clinicians. In the absence of a drug sponsor, FDA and NIH are funding studies to fill these critical information gaps.</td>
</tr>
</tbody>
</table>
Figure 11 (Page 41): USDA Human/Animal Exposure to Development of Resistance

The Collective Antimicrobial Resistance Ecosystem
Figure 12 (Page 50): Medically Important Antimicrobial Drug Sales and Distribution for Food-Producing Animals from 2009-2013

**ANTIMICROBIAL DRUGS APPROVED FOR USE IN FOOD-PRODUCING ANIMALS**

**ACTIVELY MARKETED 2009-2013**

**DOMESTIC SALES AND DISTRIBUTION DATA**

**REPORTED BY MEDICAL IMPORTANCE AND DRUG CLASS**

<table>
<thead>
<tr>
<th>Drug Class</th>
<th>2009 Annual Totals (kg)</th>
<th>2010 Annual Totals (kg)</th>
<th>2011 Annual Totals (kg)</th>
<th>2012 Annual Totals (kg)</th>
<th>2013 Annual Totals (kg)</th>
<th>% Change 2009 - 2013</th>
<th>% Change 2012 - 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Medically Important</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macrolides 1</td>
<td>562.062</td>
<td>553.229</td>
<td>582.836</td>
<td>616.274</td>
<td>563.251</td>
<td>&lt;1%</td>
<td>-9%</td>
</tr>
<tr>
<td>Penicillins 2</td>
<td>691.644</td>
<td>884.419</td>
<td>885.304</td>
<td>965.196</td>
<td>828.721</td>
<td>20%</td>
<td>-14%</td>
</tr>
<tr>
<td>Tetracyclines 3</td>
<td>5,260.995</td>
<td>5,002.281</td>
<td>5,052.855</td>
<td>5,954.361</td>
<td>6,514.779</td>
<td>24%</td>
<td>9%</td>
</tr>
<tr>
<td><em>Total</em></td>
<td>7,685.564</td>
<td>8,229.369</td>
<td>8,255.697</td>
<td>8,893.291</td>
<td>9,196.083</td>
<td>20%</td>
<td>3%</td>
</tr>
<tr>
<td><em>Not Currently Medically Important</em> 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macrolides 1</td>
<td>329.391</td>
<td>281.221</td>
<td>316.991</td>
<td>344.428</td>
<td>370.551</td>
<td>12%</td>
<td>8%</td>
</tr>
<tr>
<td><em>Total</em></td>
<td>4,906.893</td>
<td>5,057.788</td>
<td>5,313.510</td>
<td>5,725.327</td>
<td>5,591.752</td>
<td>14%</td>
<td>2%</td>
</tr>
<tr>
<td><em>Grand Total</em></td>
<td>12,582.457</td>
<td>13,287.079</td>
<td>13,569.687</td>
<td>14,618.428</td>
<td>14,788.855</td>
<td>17%</td>
<td>1%</td>
</tr>
</tbody>
</table>

---

1. Includes antimicrobial drug applications which are approved and labeled for use in both food-producing animals (e.g., cattle and swine) and non-food-producing animals (e.g., dogs and cats).
2. kg = kilogram of active ingredient. Antimicrobials which were reported in International Units (IU) (e.g., Penicillins) were converted to kg.
3. Antimicrobial class includes drugs of different molecular weights, with some drugs reported in different sol forms.
4. Guidance for Industry #153 notes that all antimicrobial drugs and their associated classes listed in Appendix A of FDA’s Guidance for Industry #153 are considered “medically important” in human medical therapy.
5. Not Currently Medically Important is defined as any antimicrobial class not currently listed in Appendix A of FDA’s Guidance for Industry #152.
6. NIR = Not Independently Reported. Antimicrobial classes for which there were fewer than three distinct sponsors actively marketing products domestically are not independently reported. These classes include the following: Amphotericins, Diminished Penicillins, Floroquinolones, Polyoxymycins (excluding 2012 and 2013), and Steroids.

(FDA 2015)
Figure 13 (Page 51): Medically Important Antimicrobial Drug Sales by Route of Administration 2009-2013

### Antimicrobial Drugs Approved for Use in Food-Producing Animals

**Activey Marketed 2009-2013**

**Domestic Sales and Distribution Data**

**Reported by Medical Importance and Route of Administration**

| Route | Medically Important | 2009 Annual Totals (kg)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2010 Annual Totals (kg)</td>
</tr>
<tr>
<td>Feed</td>
<td></td>
<td>5,683,684</td>
</tr>
<tr>
<td>Injection</td>
<td></td>
<td>388,518</td>
</tr>
<tr>
<td>Intramuscular</td>
<td></td>
<td>23,409</td>
</tr>
<tr>
<td>Oral or Topical</td>
<td></td>
<td>120,506</td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td>1,467,048</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td>7,686,564</td>
</tr>
</tbody>
</table>

| Route | Not Currently Medically Important | 2009 Annual Totals (kg)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2010 Annual Totals (kg)</td>
</tr>
<tr>
<td>All Routes</td>
<td></td>
<td>4,500,893</td>
</tr>
</tbody>
</table>

| Route | Grand Total | 2009 Annual Totals (kg)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>12,587,457</td>
</tr>
</tbody>
</table>

---

1. Includes antimicrobial drug applications which are approved and labeled for use in both food-producing (e.g., cattle and swine) and non-food-producing animals (e.g., dogs and cats).
2. kg = kilograms of active ingredient. Antimicrobials which were reported in International Units (IU) (e.g., Penicillin) were converted to kg. Antimicrobial class includes drugs of different molecular weights, with some drugs reported in different salt forms.
3. Guidance for Industry #123 states that all antimicrobial drugs and their associated classes listed in Appendix A of FDA’s Guidance for Industry #152 are considered “medically important” in human medical therapy.
4. Not Currently Medically Important refers to any antimicrobial class not currently listed in Appendix A of FDA’s Guidance for Industry #152.
5. Orally administered, excluding administration by means of feed and water.
6. Water includes when the drug is administered either through drinking water, as a drench, or through the immersion of fish.
7. This category includes the following: Feed, Water, and Intramuscular. In order to protect confidential business information, the routes of administration for the Not Currently Medically Important antimicrobial drugs are not separately presented.
Figure 14 (Page 52): Graph of Medically Important Antimicrobial Drugs and Routes of Administration 2009-2013

ANTIMICROBIAL DRUGS APPROVED FOR USE IN FOOD-PRODUCING ANIMALS¹
ACTIVELY MARKETED 2009-2013
DOMESTIC SALES AND DISTRIBUTION DATA
REPORTED BY MEDICAL IMPORTANCE AND ROUTE OF ADMINISTRATION

<table>
<thead>
<tr>
<th></th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injection²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intramuscular</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral or Topical³</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water⁴</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Routes²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Medical Importance and Route of Administration

¹ Includes antimicrobial drug applications which are approved and labeled for use in both food-producing animals (e.g., cattle and swine) and nonfood-producing animals (e.g., dogs and cats).
² kg = kilogram of active ingredient. Antimicrobials which were reported in International Units (IU) (e.g., Penicillins) were converted to kg. Antimicrobial class includes drugs of different molecular weights, with some drugs reported in different salt forms.
³ Guidelines for Industry #213 states that all antimicrobial drugs and their associated classes listed in Appendix A of FDA’s Guidance for Industry #153 are considered “medically important” in human medical therapy.
⁴ Not Currently Medically Important refers to any antimicrobial class not currently listed in Appendix A of FDA’s Guidance for Industry #152.
⁵ Orally administered, excluding administration by means of feed and water.
⁶ Water includes when the drug is administered either through drinking water, as a drench, or through the immersion of fish.
⁷ This category includes the following: Feed, Water, and Intramuscular. In order to protect confidential business information, the routes of administration for the Not Currently Medically Important antimicrobial drugs are not separately presented.
⁸ No Topical sales and distribution in 2012 and 2013.
Figure 15 (Page 55): Table of PCAST National Action Plan Targets to Combat Antibiotic-Resistant Bacteria (PCAST 2015)

<table>
<thead>
<tr>
<th>TABLE 1: National Targets to Combat Antibiotic-Resistant Bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>By 2020, the United States will:</td>
</tr>
<tr>
<td>For CDC Recognized Urgent Threats:</td>
</tr>
<tr>
<td>Reduce by 50% the incidence of overall <em>Clostridium difficile</em> infection compared to estimates from 2011.</td>
</tr>
<tr>
<td>Reduce by 60% carbapenem-resistant Enterobacteriaceae infections acquired during hospitalization compared to estimates.</td>
</tr>
<tr>
<td>Maintain the prevalence of ceftriaxone-resistant <em>Neisseria gonorrhoeae</em> below 2% compared to estimates from 2013.</td>
</tr>
<tr>
<td>For CDC Recognized Serious Threats:</td>
</tr>
<tr>
<td>Reduce by 35% multidrug-resistant <em>Pseudomonas</em> spp. infections acquired during hospitalization compared to estimates from 2011.</td>
</tr>
<tr>
<td>Reduce by at least 50% overall methicillin-resistant <em>Staphylococcus aureus</em> (MRSA) bloodstream infections by 2020 as compared to 2011.*</td>
</tr>
<tr>
<td>Reduce by 25% multidrug-resistant non-typhoidal <em>Salmonella</em> infections compared to estimates from 2010-2012.</td>
</tr>
<tr>
<td>Reduce by 15% the number of multidrug-resistant TB infections.</td>
</tr>
<tr>
<td>Reduce by at least 25% the rate of antibiotic-resistant invasive pneumococcal disease among &lt;5 year-olds compared to estimates from 2008.</td>
</tr>
<tr>
<td>Reduce by at least 25% the rate of antibiotic-resistant invasive pneumococcal disease among &gt;65 year-olds compared to estimates from 2008.</td>
</tr>
</tbody>
</table>

*This target is consistent with the reduction goal for MRSA bloodstream infections (BSI) in the National Action Plan to Prevent Healthcare-Associated Infections (HAI): Road Map to Elimination, which calls for a 75% decline in MRSA BSI from the 2007-2008 baseline by 2020. Additional information is available at [http://www.health.gov/hai/prevent_hai.asp#thal plan](http://www.health.gov/hai/prevent_hai.asp#thal plan).

1 The TB activities identified in the NAP are included as they represent critical near-term public health activities that will support progress to reduce the burden of drug-resistant TB in the U.S. Additional domestic and global activities to address drug-resistant TB will be provided in a companion action plan specific to TB and will be submitted to the President no later than September, 2015. The companion action plan will build on recommendations of the Federal TB Task Force ([https://www.cdc.gov/mmwr/pdf/rr/rr5803.pdf](https://www.cdc.gov/mmwr/pdf/rr/rr5803.pdf)) as well the work of the interagency USG TB working group.
Figure 16 (Page 67): Netherlands Antibiotic-use per Food Animal Species 2009-2013

Figure 16. Development of antibiotic use per species in the period 2009-2012 in % of AAVY in 2009 (LEI, 2012).
Figure 17 (Page 68): Netherlands Sales of Veterinary Antimicrobials for Therapeutic Purposes in Ton of Active Substance from 1999-2012

Figure 4. Sales of veterinary antimicrobials for therapeutic purposes in the Netherlands in tons of active substance (source: FIDIN).
Figure 18 (Page 69): Antibiotic Usage Compared to the World, Pew Charitable Trusts

Source: Technical University of Denmark
Figure 19 (Page 73): McDonald’s Press Release 2015

**McDonald’s USA Announces New Antibiotics Policy and Menu Sourcing Initiatives**

**Actions Are Part of Company’s Global Commitment to Address Customers’ Changing Expectations and Preferences**

OAK BROOK, IL—(Marketwire - Mar 4, 2015) - McDonald’s USA (NYSE: MCD) today announced new menu sourcing initiatives including only sourcing chicken raised without antibiotics that are important to human medicine.

In addition, McDonald’s U.S. restaurants will also offer customers milk jugs of low-fat white milk and fat-free chocolate milk from cows that are not treated with rbST, an artificial growth hormone.

"Our customers want food that they feel good about eating — all the way from the farm to the restaurant — and these moves take a step toward better delivering on those expectations," said McDonald’s U.S President Mike Andres.

McDonald’s has been working closely with farmers for years to reduce the use of antibiotics in its poultry supply. This new policy supports the company’s new [Global Vision for Antimicrobial Stewardship in Food Animals](#) introduced this week, which builds on the company’s 2003 global antibiotics policy and includes supplier guidance on the thoughtful use of antibiotics in all food animals.

All of the chicken served at McDonald’s approximately 14,000 U.S. restaurants comes from U.S. farms which are working closely with McDonald’s to implement the new antibiotics policy to the supply chain within the next two years.

"McDonald’s believes that any animals that become ill deserve appropriate veterinary care and our suppliers will continue to treat poultry with prescribed antibiotics, and then they will no longer be included in our food supply," said Marion Gross, senior vice president of McDonald’s North America Supply Chain.

While McDonald’s will only source chicken raised without antibiotics important to human medicine, the farmers who supply chicken for its menu will continue to responsibly use ionophores, a type of antibiotic not used for humans that helps keep chickens healthy.

"If fewer chickens get sick, then fewer chickens need to be treated with antibiotics that are important in human medicine. We believe this is an essential balance," Gross added.

In another move, McDonald’s U.S. restaurants later this year will offer milk jugs of low-fat white milk and fat-free chocolate milk from cows that are not treated with rbST, an artificial growth hormone. The milk jugs are popular choices in Happy Meals.

"While no significant difference has been shown between milk derived from rbST-treated and non-rbST-treated cows, we understand this is something that is important to our customers," Gross said.

All of these actions are the latest steps in McDonald’s USA’s journey to evolve its menu to better meet the changing preferences and expectations of today’s customers. In addition to the menu sourcing changes, McDonald’s USA this week was announced as a founding member of the newly formed U.S. Roundtable on Sustainable Beef. This engagement is a critical step in support of the company’s global commitment and effort to source verified sustainable beef.

"We will continue to look at our food and menu to deliver the kind of great tasting and quality choices that our customers trust and enjoy," Andres added.
Figure 20 (Page 26): Locations of Cattle CAFOs in 2007 in the US

(http://www.factoryfarmmap.org/#animal:all;location:US;year:2007)
Figure 21 (Page 26): Locations of Dairy CAFOs in 2007 in the US

(http://www.factoryfarmmap.org/#animal:all;location:US;year:2007)
Figure 22 (Page 28): Locations of Broiler Chicken CAFOs in 2007 in the US

(http://www.factoryfarmmap.org/#animal:all;location:US;year:2007)
Figure 23 (Page 28): Locations of Egg-laying CAFOs in 2007 in the US

(http://www.factoryfarmmap.org/#animal:all;location:US;year:2007)
Figure 24 (Page 30): Locations of Swine CAFOs in 2007 in the US

(http://www.factoryfarmmap.org/#animal:all;location:US;year:2007)
Figure 25 (Page 22): Locations of all Animal CAFOs in 2007 in the US

(http://www.factoryfarmmap.org/#animal:all;location:US;year:2007)
III. Bibliography


http://www.uspoultry.org/economic_data/.

http://www.who.int/iris/handle/10665/68357.


http://www.youtube.com/watch?v= zIfitUaTBI.