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The Unsustainable Dynamics of the Production and Consumption of Animal Protein: A Future Vision for a Diverse Plant-based Diet Using a System Dynamics Approach

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Author's declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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Animal protein production and consumption causes severe environmental issues and has been linked to numerous human health problems. Over the past decades, moral concerns about the production of animal proteins have become an increasingly important issue for society. This thesis uses system dynamics modeling as a tool to characterize the collective dynamics of the current protein system by mapping the stocks, flows and feedback loops. Also, a positive future vision was created that minimizes the negative environmental and health impacts of the current system and facilitates a more efficient protein production scheme to serve as the transformational goal. Intervention points were determined where change could occur to transform the system to the positive future vision. The model revealed that the consumer is the most effective point of transformation for change towards sustainable protein production and consumption. Subsequently, an action plan for change was designed based on the intervention points, using New York City as a case study. The shift towards a plant-based diet can help to significantly reduce the unsustainable aspects of the current system by lowering the demand for animal products. Since the only impediment to this transformation is consumer's choice, change can rapidly arise.

Keywords: animals, meat, systems dynamics, protein, consumption, New York City, environment, agriculture, diet, plants

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List of Abbreviations

AFO	animal feeding operation
AMI	American Meat Institute
CAFO	Concentrated Animal Feeding Operation
CEO	Chief Executive Officer
CIA	Central Intelligence Agency
CO_2	carbon dioxide
Corp	corporation
CVD	cardiovascular disease
DOT	Department of Transportation
E.coli	*Escherichia coli*
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization of the United Nations
FAR	floor to area ratio
FDA	Food and Drug Administration
FMIA	Federal Meat Inspection Act
FSIS	Food Safety and Inspection Service
Ft	feet
GHG	greenhouse gas
ha	hectare
IOM	Institute of Medicine of the US National Academy
kg	kilogram
mg	milligram
NCD	non-communicable disease
NY	New York (State)
NYC	New York City
RDA	recommended daily allowance
RR	relative risk
US	United States of America
USDA	United States Department of Agriculture
WHO	World Health Organization

1. BACKGROUND

Worldwide, approximately 4 billion people in 2003 had have a diet predominantly based on plants, whereas an estimated 2 billion people lived mostly on a meat-based diet (Pimentel and Pimentel 2003b). However, at least 65% of the proteins consumed globally are provided by a plant-based diet (Millward 1999). This is largely due to the fact that the highly populated developing world supplies its protein intake mainly from plants.

In North America, a part of the developed world, plant proteins account for only 32% of total proteins consumed (Young and Pellett 1994). According to the Food and Agriculture Organization of the United Nations (FAO), the United States (US) is one of the largest animal protein producers in the world, with a production of approximately 42.5 million tonnes of meat in 2011 (Food and Agriculture Organization of the United Nations 2011). Total consumption of conventional meats as a part of western diets including red meat (beef, veal, lamb, pork) and poultry (broiler, turkey) per person reached 118 kg in 2010. This equaled a consumption of around 79 kg/capita/year boneless meat in the US (U.S. Department of Agriculture 2012b, 2012e). In 2011, the US alone slaughtered at least 9 billion (precisely 9,102,825,500) land animals, which accounts for 14% of all animals slaughtered worldwide (65 billion) for human consumption (Food and Agriculture Organization of the United Nations 2011).

An important factor affecting the consumption of animal proteins are the US food standards and guidelines. Both the earliest US food standards created in the late 18^{th} century and the first US food guidelines in 1916 were published by the United States Department of Agriculture (USDA) and were greatly influenced by leading chemists such as Wilbur Atwater (Campbell *et al.* 2006; Gifford 2002). They suggested a daily protein intake of 125 g; however, not all scientists shared the same points of views at that time (Kiple and Coneè

2000). Noticeably, the first food guide pyramid published by USDA in 1992 reflected the US dietary suggestions from 1916 (Gifford 2002). Then, in 2005 the USDA published an updated version of its food guide. Both food pyramids were heavily criticized for not sufficiently taking into consideration scientific evidence about healthy food choices and misleading the public (Chiuve and Willett 2007; Gifford 2002). More recently, in 2011 the nutrition guide "MyPlate" was introduced and replaced the food pyramid (U.S. Department of Agriculture 2013b). However, the newest nutrition guide still continues to promote the consumption of large amounts of animal proteins to the same degree as it has in the past.

Dating back to the 1800s, it has been argued that the promotion of animal protein led to the societal belief that animal protein was of better quality than plant-based protein. Therefore, those that could afford it, mostly the rich, consumed it as often as possible (Campbell *et al.* 2006). Meanwhile, since plant based proteins were perceived to have minor value, its consumption was associated with an impoverished diet. Gender was also a major factor that controlled the consumption of meat in the past and to some extent continues to have an influence in the present. Men were seen as strong, sole supporters of the family and hence, deserved a diet consisting of energy-rich nutrition (Kiple and Coneè 2000). These social class differences then led to elitism and arrogance, which influenced the field of nutrition (Campbell *et al.* 2006). Generally speaking, in more uncivilized societies, "meat eating has been correlated with passion, aggression, strength and manliness" (Gregory 2004).

1.1 Dietary needs of protein

Proteins, vitamins, water, fat and minerals are the vital nutrients for human survival (Young and Pellett 1994). Nutrients as a whole can be broken down into two sub-groups based on the necessary quantities: macronutrients and micronutrients. Minerals and vitamins are micronutrients, whereas macronutrients consist of fats, carbohydrates, and proteins (Campbell *et al.* 2006).

The word protein has its origin in the Greek word *prōteios* and means "of prime importance" (Campbell *et al.* 2006). By definition, proteins are "nitrogenous organic compounds, which have large molecules composed of one or more long chains of amino acids and are an essential part of all living organisms…" (New Oxford American Dictionary 2010a). Amino acids, the building blocks of protein, are made up of carbon, hydrogen, oxygen, and nitrogen (Gillespie and Flanders 2009).

The lifetime of proteins in the body is limited, thus they have to be replaced constantly in equilibrium with the rate of depletion (Campbell *et al.* 2006). In order to make new proteins available to the body, foods that contain proteins must be consumed. Through digestion, the body breaks down the proteins into amino acids. These amino acids are then used to synthesize protein replacements (Campbell *et al.* 2006). To generate new tissue in adults, it has been estimated that 8 or 9 amino acids must be acquired from foods, otherwise the body cannot produce the necessary proteins to facilitate tissue growth (Campbell *et al.* 2006; Young and Pellett 1994). Therefore, these amino acids are commonly referred to as the essential ones (Campbell *et al.* 2006).

The process of protein production within the body will decrease or cease if just one of the essential amino acids is not available. The efficiency of tissue synthesis is directly proportional to the appropriate type and quantity of the supplied amino acids (Campbell *et al.* 2006). Proteins are generally categorized into two groups based on efficiency: high quality and low quality. High-quality proteins are more efficiently used by the human body and are derived from animal-based foods, whilst low-quality proteins have a lower efficiency and are plant-derived. The main difference being that high-quality proteins contain the "best amino acid matches", whereas low-quality proteins individually may not have one or more of the essential amino acids, but as a group they contain them all (Campbell *et al.* 2006). For instance, fewer quantities of the essential amino acid lysine is known to be available in plant-based proteins (Walker *et al.* 2005; Young and Pellett 1994). However, lower availability of some amino acids in plant foods does not signify that animal protein is a better protein for human health (Campbell *et al.* 2006). This merely suggests that to ensure dietary adequacy, a diet based on plant proteins must be diverse.

1.2 Environmental impacts

There is no doubt that animal protein production leads to significant environmental problems (Baroni *et al.* 2006; D'Silva and Webster 2010; Foster *et al.* 2006; Goodland and Anhang 2009; Hansen 2004; Ilea 2008; Marcotullio *et al.* 2008; Nachman *et al.* 2005; Pimentel and Pimentel 2003b; Steinfeld *et al.* 2007). This has become even more apparent when all of the stages of the production process are considered (Foster *et al.* 2006). Overall, the process of animal protein production is mainly associated with severe land degradation, high greenhouse gas (GHG) emissions, biodiversity loss, water use, and water pollution (Steinfeld *et al.* 2007).

1.2.1 Land degradation

Animal pastureland and agricultural land used for feed production represent approximately 70% of global agricultural land, and approximately 30% of the earth surface (Steinfeld *et al.* 2007). As a result of intensive agricultural and grazing activities, soil degradation has become a major problem. In the US, practices associated with livestock contributes to 55% of occurring erosion (Steinfeld *et al.* 2007) and soil loss is approximately 13 times than the sustainable rate (Pimentel and Kounang 1998). In addition to soil erosion, agricultural lands with intensive practices such as livestock feed production become less productive over time (Pimentel and Pimentel 2003a).

1.2.2 Greenhouse gas emissions

There are three main causes of high GHG emissions related to animal protein production. First, the energy input to generate animal protein should be considered. For instance, the ratio of energy input to protein output for beef cattle is 40:1 (kcal). This means that 40 kcal of fossil fuel are needed to produce 1 kcal of beef protein (Pimentel and Pimentel 2003b). In other words, to produce 1 kg of beef in the most efficient industrial scheme possible, an equivalent of 6.2 gallons of gasoline is burned or 8 kg CO_2 is released into the environment (Fiala 2008). This is largely due to the inefficient transformation of plant protein into animal protein, which requires the production of vast quantities of feedstock associated with great energy consumption (Foster *et al.* 2006; Westhoek 2011). To produce 1 kcal of plant protein from corn, 2.2 kcal of fossil energy is necessary (Pimentel and Pimentel 2003b). Second, the animals themselves emit methane through "enteric fermentation by ruminants" (Steinfeld *et al.* 2007). In 2002, beef and dairy cattle released approximately 5.5 tonnes of methane in the US. These emissions accounted for 71% of all agricultural methane emissions in the US and contributed to 19% of the countries total methane emissions (Steinfeld *et al.* 2007). Third, great areas are altered to allow feedstock production as well as animal grazing, which is a major threat to biodiversity (Steinfeld *et al.* 2007).

The differences between conventional and organic meat production concerning GHG emissions depend on the animal type. Organically produced poultry meat produces more GHG emissions compared to conventionally produced poultry. As for beef, organic production requires less energy. However, due to direct methane emissions from animals and nitrous oxide emissions from soil processes, . organic animal protein production does not represent a solution to reduce GHG emissions within the livestock sector (Foster *et al.* 2006).

The FAO calculated that livestock contributes to 18% of global GHG emissions (in CO_2 equivalent), exceeding GHG emissions produced by the transportation sector (Steinfeld et al.

2007). Currently, there is confusion about the total GHG emissions caused by animal protein production. By taking into consideration all indirect and direct sources such as respiration from livestock, a recent study estimated that animal protein production could contribute up to 51% of global GHG emissions (Goodland and Anhang 2009). As for the US, there is no precise data on the GHG emissions caused solely by livestock.

1.2.3 Water use

Large quantities of water are required to produce food (Pimentel and Pimentel 2003b). The US agricultural sector uses more freshwater than any other sector in the US. However, animal protein production is particularly inefficient (Pimentel and Pimentel 2003b). Generally, the production of 1 kg of animal protein needs 100 times more fresh water than the production of 1 kg grain. To produce 1 kg of beef, over 15,000 liters of freshwater are needed; this equates to over 15,000 m^3 of water per ton of beef (Hoekstra and Chapagain 2007). Chicken (3,900 m^3/ton) and pig (4,900 m^3/ton) production requires less water, but still much more than corn (900 m^3/ton), wheat (1,300 m^3/ton) or husked rice (3,000 m^3/ton) (Hoekstra and Chapagain 2007). Such large volumes of water used to produce animal proteins are caused by the direct consumption of water by animals and the animal feed production. Irrigation activities as a part of the animal feedstock production are the main cause of these water inefficiencies (Pimentel and Pimentel 2003b; Walker *et al.* 2005).

1.2.4 Water pollution

The production of animal feedstock, as well as food crops, causes soil erosion and leachate and runoff, which contain pesticides and fertilizers (Hoffman *et al.* 2007; Runge September 2002). Nevertheless, animal feedstock production in the US uses more land compared to food crop production and thus has a larger impact on water quality. In the US, the Minnesota River flowing through farm land is one of the most polluted rivers (Runge September 2002). As a result of large quantities of pesticides and fertilizers used on farmlands, runoff contaminated with nutrient-rich fertilizers and pesticides pollutes local water bodies. As a result of such nutrient loading, eutrophication, the overload of nutrients in rivers and oceans, results. In the US, this is largely due to the practices associated with animal feedstock production. The overload of nutrients causes unsustainable algal growth and consequently creates anoxic dead zones (Eshel and Martin 2009; Steinfeld *et al.* 2007). These indirect effects of animal protein production have a much greater environmental impact compared to direct water contamination caused by slaughterhouses (Hansen 2004).

1.3 Confined animal feeding operations

A major environmental concern has emerged from concentrated animal feeding operations (CAFO). CAFOs are animal feeding operations (AFO) that comply with stipulated conditions by the Environmental Protection Agency (EPA). AFOs are facilities in which animals are kept for "production purposes" for at least 45 day in a year where grass and vegetation does not exist (Gillespie and Flanders 2009; U.S. Environmental Protection Agency 2012). CAFOs aim to produce animal protein as efficiently as possible by raising masses of animals

Table 1. Regulatory definitions of large, medium and small CAFOs by size and animal sector. Source: Federal Code of Regulations 2008 (with amendments).

Animal Sector	Large CAFO	Medium CAFO	Small CAFO
Mature dairy cattle	700	200-699	less than 200
Veal calves	1,000	300-999	less than 300
Cattle or cow	1,000	300-999	less than 300
Pig (weighing over 25 kg)	2,500	750-2,499	less than 750
Pig (weighing less than 25 kg)	10,000	3,000-9,999	less than 3,000
Laying hens or broilers (liquid manure handling systems)	30,000	9,000-29,999	less than 9,000
Chickens other than laying hens (other than a liquid manure handling; systems)	125,000	37,500-124,999	less than 37,500
Laying hens (other than a liquid manure handling systems)	82,000	25,000-81,999	less than 25,000

in a confined area (Fiala 2008). The numbers of CAFOs in the US rose drastically to efficiently satisfy the high demand for animal protein. Table 1 provides an overview of the regulatory definition of large, medium and small CAFOs by size and animal sector. The environmental impacts caused by CAFOs are well documented (Subak 1999). Enormous quantities of solid waste such as urine, manure, and carcasses are produced from these operations (Walker *et al.* 2005). In 1997, industrial animal protein production accounted for approximately 1.4 billion tonnes of waste. As Walker *et al.* (2005) stated, "this is equivilent to about five tonnes of animal waste for each person in the USA". Solid waste quantities caused by CAFOs greatly exceed the demand for natural fertilizer and storage of such volumes of solid waste is difficult. Leakages that led to groundwater contamination of phosphorus and nitrogen have been reported. This has resulted in the new development of using animal waste to generate electricity through gasification or microbial digestion. However application of animal waste as fertilizer is still the most common method (Van Kessel pers.comm).

1.4 Human health

Debate exists over whether animal proteins or plant proteins are better for human health (Biesalski 2005; Campbell et al. 2006). Plant proteins can provide all essential amino acids, and they are not of inferior quality for human health (Campbell et al. 2006; Millward 1999; Young and Pellett 1994). Some researchers associated with the meat industry argue that only the animal based-diet can provide the necessary micronutrients such as iron, vitamin A or B-12 (Biesalski 2005). The recommended daily allowance (RDA)[1] of protein from a mixed diet for adults is 56 g per day and the average adult American consumes approximately 112 g

[1] Developed by the Institute of Medicine of the US National Academy (IOM)

per day and nearly 73g of this is animal protein. This is approximately two times the recommended amount (Pimentel and Pimentel 2003b).

1.4.1 Associated diseases

As stated by the World Health Organization (WHO) the change to an high (saturated) fat, energy dense diet largely comprising of animal proteins combined with decreased physical activity has been known to increase non-communicable diseases (NCDs)[2] such as diabetes mellitus, obesity, strokes, heart disease and certain types of cancer (Amine *et al.* 2002). A large study with over 14,000 women concluded that the relative risk of breast cancer increases with increasing consumption of meat (Toniolo *et al.* 1994). Osteoporotic fractures in elderly women have also been suggested to be linked with increased consumption of animal protein (Frassetto *et al.* 2000). Another study conducted over an average of 8.8 years, with a few over than 37,300 participants (women ≥ 45 years) found a strong correlation between higher red meat consumption and the development of type 2 diabetes in middle-aged American women (Song *et al.* 2004). In 2006, one of the largest studies on nutrition concluded that the consumption of animal protein correlates with the appearance of chronic diseases such as heart diseases, cancers, diabetes, stroke, arthritis, cataracts, Alzheimer's disease, and more (Campbell *et al*. 2006). Additionally, the notion that milk has positive health effects is also in dispute. The consumption of milk has shown to have no clear benefits to bone mass or reduction of fracture risk in women (Feskanich *et al.* 2003; Feskanich *et al.* 1997).

[2] Chronic diseases

1.4.2 *Drug exposure*

Other matters of concern are drug residues in meat, which may pose a negative effect on human health. This is particularly concerning when the antibiotics that are given to animals, are also given to humans (Phillips *et al.* 2004; Steinfeld *et al.* 2007). Increased antibiotics resistance during treatment has been thought to be the consequence of increased exposure to antibiotics in foods (Mellon *et al.* 2001). The magnitude of this problem should not be underestimated, taking into consideration that more than 70% of all produced antibiotics in the US are used on livestock for non-therapeutic purposes (Mellon *et al.* 2001). In addition, there are health concerns about the use of other substances. Livestock feed can consist of animal waste, animal by-products as well as an array of growth promoters such as phosphorus, antibiotics, nitrogen, arsenic and hormones (Lefferts *et al.* 2006; Nachman *et al.* 2005; Pollan 2006). Theses substances have not been shown to have questionable benefit to human health and therefore should be further researched.

1.5 Research Questions

The environmental impacts and health concerns related to animal protein production and consumption have been extensively researched (Baroni *et al.* 2006; Campbell *et al.* 2006; D'Silva and Webster 2010; Foster *et al.* 2006; Goodland and Anhang 2009; Millward 1999; Pimentel and Pimentel 2003b; Steinfeld *et al.* 2007; Young and Pellett 1994). However, little has been written about the dynamics and actors associated with animal protein systems. Consequently, little research has been carried out to understand specific animal protein production and consumption systems. This thesis aims to close these research gaps.

The consumption of efficiently produced proteins could help to significantly reduce major environmental as well as social problems around the world. The main research questions, which will be addressed within this thesis, are as follows:

1. What are the dynamics (stocks, flows and feedback loops) of the present system and what are their consequences?
2. What are the critical feedback loops that maintain the current protein system in its present state?
3. How would dynamics of a future protein system be different?
4. How can the current protein system be changed to a more sustainable future system?
5. Who are the key groups of actors which will resist change and why? How would they resist change?

2. AIMS AND OBJECTIVES

The purpose of this thesis was to outline the current animal protein production system in the US, to characterize a future protein system and to provide suggestions as to how New York City can be a part of the transformation towards a more efficient and sustainable protein system. Three major aims were addressed to achieve the purpose of this thesis.

The first aim was to characterize the collective dynamics of the current protein system to obtain in-depth knowledge about the pattern of behavior within the system. This aim was achieved by:

- Collecting data about the flows (money, information, additives, protein) through the system;
- Defining actors and their roles within the system;
- Modeling the current system using system dynamics – stocks, flows and feedbacks within the protein system.

The second aim was to characterize the collective dynamics of a future sustainable protein system. This aim was achieved by:

- Creating a desirable future vision focusing of sustainable protein production and consumption;
- Creating a new model of the current system that agrees with the future vision.

The third aim was to design an action plan for New York City, which would carry out the transformation of the current protein system to the future system. This aim was achieved by:

- Identifying the key groups of actors that will resist change and their motivations;
- Identifying the points of intervention in the current system to initiate a successful transformation;
- Proposing actions to be carried out in New York City to transform the current protein system.

3. METHODOLOGY AND APPROACH

3.1 General justification

System dynamics is a tool to determine how a system functions and to outline main linkages between the reciprocal interconnected parts, which are often overlooked. Such interconnections not only defines the system, but creates the "pattern of behavior" that the system produces over time (Meadows 2008). To reveal the relationships that govern the system, a system needs to be more broadly understood (Richmond 1987). Relationships are not visible objects, making them difficult to detect for human beings. In addition, to see such invisible relationships, it is important that the observer is not too much a part of the system; otherwise, it would be impossible to perceive the system from a systems perspective point of view (Richmond 1987). Systems thinking pioneer, Jay Forrester (2009), acknowledges the existence of feedback-loops controls everything that changes through time. A result from any action to solve any problem always produces future problems and actions, and as Forrester (2009) stated, "There is no beginning and no end". Feedback loops are setting the framework in which all change occurs and stocks and flows are the basis of all systems (Forrester 1968b, 2009). Physical or non-physical, stocks are the visible parts of a system one can measure at any given time. Stocks change over time through the action of a flow, or the movements of stocks throughout the system. Therefore, stocks represent the net change of flows within the system (Meadows 2008).

Real world systems with multiple stocks are complex and thus predicting the behavior of the system is difficult. To compensate for the inability of the human mind to predict future scenarios, computer simulations can be used (Forrester 2009). A system dynamic approach enables one to develop a holistic understanding of a system and decisions can be better informed thereby resulting in a potentially more positive outcome. However, the decision making process of most individuals is based on "event-oriented thinking", a linear non-feedback thinking that has one believes that a problem can be quickly "fixed" (Morecroft 2010). Unfortunately, this approach cannot be applied to most complex systems. This thesis will use the application of system dynamics modeling to the transformation of social systems as proposed by Dr. John B. Corliss (2013).

The information gathered for the model building should be derived from all available sources. As Forrester stated, the richest data pool are the information stored in people's head – the mental database (2009). The available knowledge in the mental database is significantly richer than written information. The least amount of information is stored in numerical databases (Fig. 1). Thus, the mental database represents the most important data source for modeling activities within the field of system dynamics (Forrester 2009). These data are known to be mainly of qualitative nature (Forrester 1968a). Qualitative methods can be used to collect the information needed to build a model.

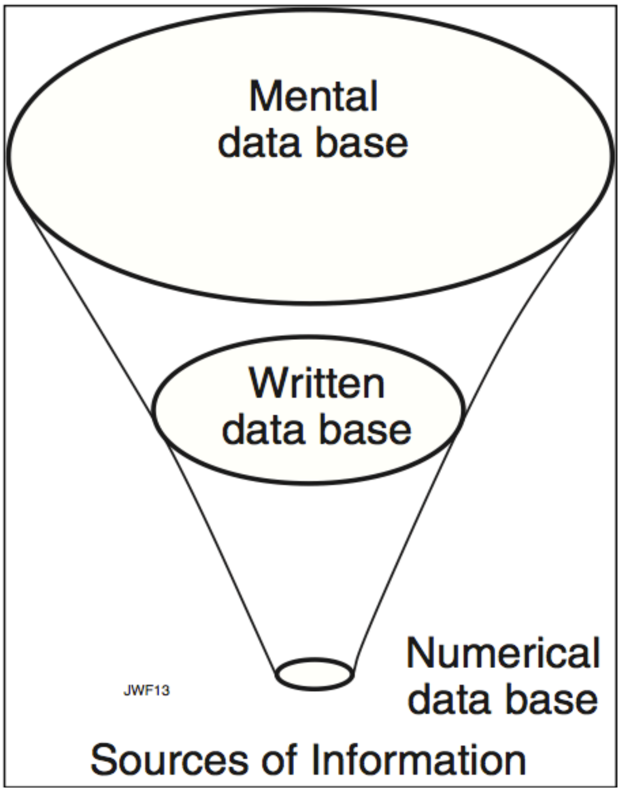

Fig. 1. Source of information for modeling process using System Dynamics. Source: Forrester 2009.

Overall, system dynamics is a powerful approach to understanding and modeling systems, therefore it is a very suitable methodology for understanding and answering questions about the animal protein consumption system in the US and in NYC. System dynamics can also help to determine the path to a future vision of sustainable protein consumption and reveal possible resistance in the system.

3.1.1 New York City as case study

If a change in diet towards sustainability were to happen, it would happen more easily and quickly in a non-traditional atmosphere that allows for an open discussion of what is necessary and what is sustainable. New York City, a melting pot of cultures with a very diverse population, fits this description as a potential trendsetter and, as part of the modern "western" lifestyle, is significantly influenced by the current protein production system in the US.

Dating back to 1916, NYC was the pioneer in city planning and zoning in the US. As a result, other cities followed the New York City model for designing and regulating buildings, while NYC continued to make amendments to major shifts in population and land use (NYC Department of City Planning 2013). Today, Mayor Bloomberg has made extensive efforts to support the greening of NYC and climate leaderships. Therefore, NYC was used as a case study to explore the possibilities to initiate a transformation towards a more sustainable protein system.

4. METHODS AND JUSTIFICATION

To characterize the collective dynamics of the current animal protein system, primary and secondary information was gathered about the group of people involved in the current system such as major animal protein production corporations, governmental institutions and other stockholders who play an important role in the current system. This information was then used to create a model of the current system and to describe the repeated patterns of behavior. Qualitative methods such as document reviews and personal correspondence were used to acquire the necessary data. These methods are well established and have found application within the field of system dynamics (Bowen 2009; Luna-Reyes and Andersen 2003; Sterman 2000). Additionally, further information about production, sales, distribution and consumption was gathered. Production data were collected from existing electronic databases, provided by FAO, USDA, major animal protein producers and sales data were acquired through document reviews. Depending on availability, data were obtained for the United States, New York (NY) State and/or New York City.

Using this information gathered, a model was created using the modeling program STELLA[3]. This model along with the observed patterns of behavior of the system allowed the critical aspects of the system to be identified. It encompassed the dynamic relationships within the protein consumption system using the characterization information and data previously stated. The stocks, flow and feedback loops were then constructed into the current model to represent the current system. By doing so, the dynamic relationships that keep the current system in its present state and the feedbacks that respond to resist change were displayed. As the model was being built, examples of feedback loops connected to the flows became gradually more apparent over time.

[3] Systems Thinking Software STELLA Edition 10. ISEE Systems Inc., Lebanon, New Hampshire, USA.

Secondly, the collective dynamics of a future sustainable system were characterized. The basis for the future system was a collective and desirable future vision of sustainable protein production and consumption for NYC. The transformation toward the future system was outlined based on the intervention points identified in the STELLA model of the current system.

Thirdly, the action plan, which describes how to carry out the transformation of the current protein system for NYC, was created. The method to do so was to first identify the points of intervention to change the system. Then, the key groups of actors were defined to provide feasible strategies for projects to reduce the expected resistance. Finally, the action plan was designed. The feedback loops (transfer of information from corporations, governmental institutions, lobbying groups, etc.) that keep the current system in its present state is anticipated to resist change. The action plan may be initiated in future projects and redesigned based on the finding of this thesis by taking into consideration specific actions designed to mitigate resistance.

5. Animal Protein production processes

5.1 Animal protein production

5.1.1 Feed

Grains planted for feedstock production such as corn, oats, barley and sorghum represent the largest portion of field crops in the US (Gillespie and Flanders 2009; Hoffman *et al.* 2007; Pollan 2006). Corn, the most important animal feed grain, is mainly cultivated in Iowa, Illinois, Nebraska, Minnesota and Indiana (Runge September 2002) collectively known as the Corn Belt region (Gillespie and Flanders 2009; Pollan 2006; Runge September 2002). The first step in the feed production chain is the supply of seeds. Since farmers do not save seeds from previous crops as they once did, seed companies are responsible for providing seeds annually (Fernandez-Cornejo 2004).

Fig. 2. Loading of corn from grain elevator in grain cars. Source: JP Laffont/Sygma/Corbis, n.d.

Usually, corn is planted in late April or early May after the soil preparation (Runge September 2002). During the growth period, pesticides and fertilizers are commonly applied to corn plants (Fernandez-Cornejo 2004; Pollan 2006; Runge September 2002). Besides water and carbon dioxide, nitrogen and phosphorus are the important nutrients needed for sufficient growth, among other nutrients and trace metals (Runge September 2002). After approximately 5 months of growth, plants are ready for harvest in September and October. Following the harvest, corn is trucked to local grain elevator, loaded into grain cars (Fig. 2) and shipped to further processors for domestic use or prepared for export (Runge September 2002).

Once commercial feedstock producers receive the raw material, it is then further processed to primary and secondary feed (Lefferts *et al.* 2006). Primary feed mainly consists of grains, mill by-products and animal proteins (Feedstuffs 2013; Gillespie and Flanders 2009). According to Feedstuffs (2013), feedstock producers in the US produced over 115 million tonnes of primary feed in 2011.

Ingredients added to animal feed are very diverse, ranging from (slaughter) animal by-products such as blood, organs, animal waste (mix of manure and urine), bone meal, animal fats, minerals, vitamins, to chemical substances such as antibiotics, hormones and arsenic. In addition, paper, sawdust and other non-food residues can be added to animal feed (Lefferts *et al.* 2006). Animal waste represents only a small portion of the supplements added to animal feed. Yet of that small portion, applied poultry litter is the most common type of animal waste added to animal feed (Van Kessel pers.comm.).

5.1.2 Cattle

In 2010, the average US citizen consumed 25.7 kg of boneless beef meat, making beef the second most popular type of meat in the US (U.S. Department of Agriculture 2012b). The majority of beef consumed in the US is produced domestically after chicken (Gillespie and Flanders 2009). There are two main beef production systems commonly referred to as: (1) cow-calf production and (2) feedlots (Van Kessel pers.comm.).

Cow-calf production

The production of calves is the main goal of cow-calf production systems (Gillespie and Flanders 2009; Taylor and Field 1998). Calves, beef animals less than 1 year old (Gillespie and Flanders 2009), are commonly weaned between the age of 6 to 9 months and 180 to 320 kg (McBride and Mathews 2011). Weaned calves are either kept on the cow-calf producer's pastureland, grazing until they weigh enough to be sold to feedlots or directly sold to backgrounders or cattle feeders (Gillespie and Flanders 2009; McBride and Mathews 2011; Taylor and Field 1998). Backgrounding refers to the process of feeding calves for the feedlot and usually lasts until the beef animals are between 12 and 16 months old (Gillespie and Flanders 2009). The process of backgrounding is necessary if weaned calves have not gained enough weight to be sent directly to the feedlot (Taylor and Field 1998). Another purpose of the backgrounding phase is to adjust young cattle to grains such as corn (Pollan 2006). Steers and heifers are then usually sold to feedlots for fattening until they reach slaughter weight (McBride and Mathews 2011). A heifer is an immature female that has not given birth to a calf or has not matured, while a cow is a mature female (and has usually calved). Steers are male animals that have been castrated before sexually mature (Gillespie and Flanders 2009).

Cow-calf facilities are typically the source of their own breeding stock (Van Kessel pers.comm.). In the past, pure breeders used to produce animals with superior traits by improving the genetic variability in a commercial herd (Gillespie and Flanders 2009). These farmers are rare today. Instead, there is great variety among cow-calf producers that specialized in various disciplines (Van Kessel pers.comm.). Nowadays, specialized cow-calf producers provide other cow-calf producers with semen and embryos, replacement bulls and occasionally cows and heifers (Van Kessel pers.comm.). Since pure-breeders are no longer a single entity, specialized cow-calf producers are the "backbone" and "genetic engineers" of today's beef industry.

The majority of cow-calf production systems are located in western, southwestern, and north-western central parts of the United States (Gillespie and Flanders 2009). Cow-calf operators that maintain smaller herds more commonly reside in north-central and southern regions of the US (Taylor and Field 1998), whereas larger units more often are located in the Great plains and the West (Taylor and Field 1998). The feedstock fed to the animals in cow-calf operation varies depending on the location (Gillespie and Flanders 2009). Livestock is kept on pasturelands to ensure lower costs yet most farmers cannot leave their livestock outside year-round due to harsh weather conditions, thus stored feed must be fed (Gillespie and Flanders 2009). Throughout the entire rearing process, cows and calves are fed common feedstocks such as pasture, silage, straw, hay and crop residues (Gillespie and Flanders 2009). Other feedstock such as cornstarch, corn silage, hay or crop residues are usually fed during the winter season and in the backgrounding phase. Silage is feed which has been preserved through fermentation in silos (Gillespie and Flanders 2009).

Feedlots

Before being slaughtered for meat consumption, beef animals spend their final period of life in feedlots. At this stage, cattle are fattened as quickly as possible for slaughtering (Gillespie and Flanders 2009). Animals that are fat enough to be placed in feedlots are called feeder-cattle (Gillespie and Flanders 2009). These beef animals usually spend between four to six months in feedlots and are then slaughtered between 12 to 22 months of age and at a weight of 410 to 635 kg (Tyson Foods 2012). Most large feedlots are in north-central and southern states, such as: Texas, Kansas, Nebraska, Arizona, California, Oklahoma, Missouri, Iowa, South Dakota, Wisconsin and Colorado (Feedstuffs 2013; Gillespie and Flanders 2009; Taylor and Field 1998).

Two distinguished AFOs are frequently differentiated: commercial cattle feedlots and farmer feedlots (Gillespie and Flanders 2009; Taylor and Field 1998). Commercial feedlots have an animal capacity of over 1,000 head (Gillespie and Flanders 2009; Taylor and Field 1998). The biggest commercial feedlots in the US have more than 100,000 beef animals (Fig. 3) (Taylor and Field 1998). These facilities are nearby cow-calf operations to ensure short distances for the transport of calves.

Fig. 3. Large feedlot in Texas, US. Source: Richard Hamilton Smith/Corbis, n.d.

The feed available in feedlots comprises mainly of grains and additional supplements such as proteins and minerals (Gillespie and Flanders 2009). Modern beef animals have specific amino acid requirements, which cannot be met by grains. In order to meet these requirements, crystallized amino acids synthesized by microbial fermentation are given to the animals (Van Kessel pers.comm.). These rich feeds foster the fattening process of cattle (Gillespie and Flanders 2009). Corn silage is commonly fed to the animals, which has proved to be most suitable to fatten beef animals in a short period of time. To produce 45 kg of beef about one ton of corn silage is required (Gillespie and Flanders 2009). Beef animals usually gain about 0.45 to 0.90 kg per day during fattening time in the feedlots (Gillespie and Flanders 2009).

However, cattle are ruminant animals that consume natural grasses. Corn is not meant for their digestive system and can be harmful (Pollan 2006). An estimated 35-100 mg of antibiotics are given per head daily to promote the fattening process by 3 to 5% and to keep their digestive system functioning by suppressing severe organ damage (Gillespie and Flanders 2009; Pollan 2006). Without antibiotics, cattle could not be fed the rations of corn they are fed today (Pollan 2006). Hormones or hormone mimics are less commonly included in the feedstock. Instead, hormone implants are inserted into the animal's ear (Van Kessel pers.comm.). The use of such implants is regulated by US Food and Drug Administration (FDA) (Gillespie and Flanders 2009). Milo, barely, oats, soybeans and wheat are also used for feeding purposes in feedlots. The use of other grains beside corn is determined by the current market prices (Gillespie and Flanders 2009).

Dairy cows

Dairy cows play an important role for the meat industry. Approximately 30% of the dairy cows are culled from their herd due to diseases, low milk production and other unwanted features each year. Generally, culling refers to the removal of animals from a herd or flock (Gillespie and Flanders 2009). In 2011, around 20% of annual US beef supply originated from beef and dairy cows that were removed from the herds due to a lack of performance (U.S. Department of Agriculture 2011c).

To produce milk constantly, dairy cows are continuously impregnated (artificially inseminated). Just about every second calf is female, thus is considered for milk production (Gillespie and Flanders 2009). Male calves are of no interest for the dairy industry. The cow's calf is taken away from the mother within days after birth, to ensure milk supply for human consumption (Gillespie and Flanders 2009). Male calves are then separated and slaughtered between 3 and 8 months of age and frequently sold as veal meat after a live in veal crates (Gillespie and Flanders 2009). Dairy production facilities obtain replacement animals with superior traits from specialized dairy producers and through their own production. Such desirable replacement animals are produced similarly to the beef industry (Van Kessel pers.comm.).

5.1.3 Pigs

In 2012, the average consumption of pork, the least consumed meat, was 20 kg of boneless meat per person (U.S. Department of Agriculture 2012b). Most pig production facilities are located in the Midwest and Southeast. The 10 leading pig production states are Iowa, North Carolina, Minnesota, Illinois, Indiana, Nebraska, Missouri, Oklahoma, Ohio and Kansas (Feedstuffs 2013). These areas are most suitable for pig production due to the availability of vast quantities of grains such as corn. Corn is the main feedstock given to pigs for fattening (Gillespie and Flanders 2009; Key and McBride 2007; Pond 2003). Additives given to pigs are comprised of vitamins, antibiotics, arsenic, hormones and beta-adrenergic agonists. These substances are given to promote the growth of the animals. Arsenics, however, are infrequently used compared to the other additives (Van Kessel pers.comm.).

Production process

Pig production can be divided into seven different phases: Breeding, gestation, farrowing, nursing (Breeding Unit), growing, finishing and isolation of replacement breeding stocks (Weaning to finishing facility) (Pond 2003). In the past few decades, pig farms have undergone major changes. Today, most modern production facilities are weaning to finishing operations where pigs are kept on a single site or building from weaning until they are ready for slaughter (Pond 2003). Pigs that arrive to weaning to finishing facilities are called weaned pigs (Van Kessel pers.comm.). For breeding, gestation and farrowing, there may be other sites used and can be carried out by another owner (Gillespie and Flanders 2009). Overall, there is considerable variability in the design of production facilities, location and ownership among the pig production scheme (Van Kessel pers.comm.).

Fig. 4. Sows in gestation crates. Source: Wave/Corbis, n.d.

Space within breeding units is very limited, ranging from 1.1 m^2 to 5.6 m^2 depending on the maturity level of the animal. During the gestation phase (Fig. 4), sows are usually placed in gestation crates (Gillespie and Flanders 2009). Despite being criticized by the public, gestation crates are still common practice in most states, and continue to provide sows with limited space (Gillespie and Flanders 2009). Before giving birth, sows are moved into farrowing units, consisting of crates or pens. Crates are less labor intensive and therefore most common.

Inside these crates, sows have reduced abilities to move in such a small crate with the average dimensions of 1.4 by 1.5 by 2-2.4 meters long. Within the first few days after birth, the sow and her piglets are moved to the nursery unit (Fig. 5). About 3.7 m^2 are allocated per sow and her piglets during the nursery phase (Gillespie and Flanders 2009). Young pigs face various unpleasant procedures during the nursery phase including tail

Fig. 5. A sow nurses her piglets. Source: Jim Richardson/Corbis, n.d.

docking, castration and teeth clipping (Gillespie and Flanders 2009). Due to the stress and lack of simulating activities inside confined production units, pigs bite on the tails of others (Schrøder-Petersen and Simonsen 2001). Therefore, their tails are cut off with cutting pliers to avoid infections (Gillespie and Flanders 2009). The animals are not numbed for any of such procedures. Once the pigs reach between 18 and 28 kg, they are moved to the finishing unit. They remain there until they reach the slaughter weight of 122 kg, between 7 and 8 months (Tyson Foods 2012). However, the slaughter age varies dependent on the desired product.

5.1.4 Broiler

The consumption of poultry meat, which consists predominately of broiler and turkey, has steadily increased over the last few decades. The term broiler refers to chickens that are bred for meat production (Tyson Foods 2012). Today, poultry accounts for the largest portion of consumed meat with a average consumption of 32 kg of boneless poultry meat per person (U.S. Department of Agriculture 2012e).

Most broilers are reared in Georgia, Arkansas, Alabama, Mississippi, North Carolina, Texas, Kentucky, Maryland, Virginia and South Carolina (Feedstuffs 2013). Broiler feedstock comprises mainly of grains such as corn (50-80%), as well as grain by-products and different fats and oils (vegetable, animal). Additives such as antibiotics or arsenic are mainly used to promote growth (Gillespie and Flanders 2009). However, in addition arsenic is used as an anti-coccidiostats to suppress certain diseases (Van Kessel pers.comm.). Hormones are not used in the poultry industry. Maryland has banned arsenic due to environmental concerns associated with the application of poultry litter to agricultural lands as fertilizer, which has polluted nearby water bodies such as the Chesapeake Bay (Van Kessel pers.comm.).

Fig. 6. Hens in battery cages for egg production. Source: Charlie Neibergall/AP/Corbis, n.d.

Fig. 7. Typical confined broiler house. Source: Scott Sinklier/AgStock Images/Corbis, n.d.

Production process

Foundation breeders represent the first stage in the poultry production process supplying commercial hatcheries with eggs under contracts (Gillespie and Flanders 2009). Then, large poultry companies purchase de-beaked or beaked chicks from hatcheries for meat production (Gillespie and Flanders 2009). Hatcheries also supply commercial egg producers with genetically optimized laying hens (Gillespie and Flanders 2009). Next, one-day-old chicks are transported to commercial chicken producers. Male chicks are of no value for the egg industry, thus segregated from female chicks after birth, killed and ground up for further processing (Phelps and Bryan 2003). Broiler producers have no interest in these chicks since they are not genetically engineered to gain weight as fast birds for meat production. Therefore, approximately 226 million male chicks are killed annually in US hatcheries (Phelps and Bryan 2003).

Large facilities keep their hens in battery or wire cages (Fig. 6). Most hens raised for egg production remain in cages until they are culled after 12-15 month (Gillespie and Flanders 2009). Depending on the facility, broilers are brooded in cages and later transferred into confined houses (Fig. 7). Confined houses have to provide broilers with 0.09 m^2 of space until they are ready for slaughter between 35 and 50 days (Van Kessel pers.comm.).

5.2 Meat Processing

5.2.1 Packing

As outlined, the production stages of cattle, pig and broiler differ significantly (Gillespie and Flanders 2009; Loftus and Meghen 2011). The main difference being that the beef industry is highly fragmented compared to the pig and broiler industries (Gillespie and Flanders 2009; Loftus and Meghen 2011). However, the processing and distribution of these animals is carried out similarly (Loftus and Meghen 2011; U.S. Environmental Protection Agency 1995). Generally, once the animals reach slaughter weight, they are transported to meat packing facilities (U.S. Environmental Protection Agency 1995). The design of the processing plants for cattle, pigs and broiler differ. All transportation routes are minimized, yet animals are lost due to death and injury from transportation (Greger 2007; Smithfield Foods 2012). Meat packing comprises mostly of the slaughtering process and the carcass preparation for further shipping and processing (U.S. Environmental Protection Agency 1995). Large meat packers slaughter on behalf of other stakeholders and for their own production (U.S. Environmental Protection Agency 1995). Slaughtering methods recognized by the Humane Slaughter Act are captive bolt (mechanical), gunshot (mechanical), stunning or slaughtering with an electric current (electrical) and the use of carbon dioxide (chemical) (Code of Federal Regulations 1979).

5.2.2 Processing, transport and distribution

Wholesale cuts are shipped from the meat packing plant to processing plants, wholesale meat markets, retailers or foodservices operators (Tyson Foods 2012; U.S. Environmental Protection Agency 1995). Wholesale cuts are shipped in boxes and thus called boxed

Fig. 8. Processing line in meat packing plant. Source: Michael Reynolds/epa/Corbis, n.d.

beef/boxed pork consistent of primal and sub primal cuts (Tyson Foods 2012). Wholesale meat markets further process these wholesale cuts into retail cuts, which are sold to retailers. The retailers then process the retail cuts into meat counter cuts for the end consumer (Tyson Foods 2012). Large meat packers and other food processors process meat further (Fig. 8), add value to it and supply these products directly to retailers and foodservice operators such as large catering firms, (chain) restaurant or school and university cafeterias. (Loftus and Meghen 2011; Tyson Foods 2012). There are many different levels of value added products. Case-ready products are refrigerated, prepackaged and pre-cut and do not need to be prepared by the retailer for sale. These products represent the first level of value added items (Tyson Foods 2012). While further value added products (second level of value added items) undergo additional preparation labels such as fully cooked, marinated or portioned meat, which then is refrigerated or frozen (Tyson Foods 2012).

In addition, large food service distributors also receive wholesale cuts directly from the meat packer. The food service distribution industry stocks animal protein products in gigantic warehouses (Sysco Corporation 2012). They are an intermediary between producer and food service operators for providing chain restaurants, cafeterias and hospitals with retail cuts or added-value products (Seaboard Corporation 2011; Sysco Corporation 2012). Since these corporations also ship non-foods and process foods other than animal proteins, these companies will not be extensively outlined within this thesis (Sysco Corporation 2012).

5.2.3 Waste and by-products

Large quantities of different animal by-products accumulate during the processing of animals in slaughterhouses, processing plans, foodservice operators and retailer markets (Meeker 2006; U.S. Environmental Protection Agency 1995). Humans can not directly consume between one half to one third of an animal that was reared for meat production (Meeker 2006). The rendering industry utilizes these by-products to produce other edible and non-edible product (U.S. Environmental Protection Agency 1995). In addition, the leather industry is an important processor of animal skins, a major by-product of meat processing. The leather industry is beyond the scope of this work and will not be discussed further.

Integrated rendering facilities (business sector of the meat packer) process most animal by-products. Independent rendering plants are less common (Meeker 2006). Most of the byproducts are converted into animal feed (Meeker 2006; U.S. Environmental Protection Agency 1995). However there are products produced for human use such as: soap, gelatin, chewing gum and soup ingredients. In addition, renderers supply the pet food industry as well as biofuel producers (Meeker 2006).

5.3 Animal Protein Production for New York City

Specific data on meat consumption for NYC are not available. However, an estimate can be made assuming that the per capita consumption of meat in NYC equals that of an average American. Given that the national per capita average of meat consumption excluding non-conventional meats (i.e. horse, duck, rabbit, buffalo, etc.) is approximately 118 kg expressed in carcass weight (U.S. Department of Agriculture 2012b, 2012e) and 8.2 million people reside in NYC, it can be estimated that more than 965,550 tonnes of meat are consumed annually in NYC. This equals 2.3% of the total national consumption of meat (42.5 million tonnes). Since this estimate does not account for tourists, visiting businesspersons, illegal residents or non-conventional meats, it is an underestimate of the actual value.

According to data provided by the US Department of Transportation (DOT), most of the meat and seafood shipped to the NY metropolitan area comes from the Northeast, specifically from New York, Pennsylvania and New Jersey (U.S. Department of Transportation 2012) (Marcotullio pers.comm.). Based on the DOT database, more than 50% of all meat and seafood transported into the NYC metropolitan area has originated from NY State (U.S. Department of Transportation 2012). However, this information is not very helpful since the origin of the meat and seafood does not represent where it has been produced according to the DOT database definitions (Barron *et al.* 2010). This is because trucks are often labeled as originating from locations that serve as in intermediate point for distribution such as warehouses rather than their origins of production.

In the northeastern region, particularly in the state of NY, there are few CAFOs for meat production (Food & Water Watch 2007). Subsequently, it is most likely that animal products are transported to warehouses in NY and leave the warehouse labeled as originating of NY (U.S. Department of Transportation 2012). This makes it very difficult to understand the route of meat from its place of production to the city where it is to be consumed. The current DOT dataset for meat transport does not accurately depict the origins, therefore making it impossible to track the animal protein products back to the location of production. Therefore, the production of animal proteins in this thesis is representative of the US system and not New York City. This is not a disadvantage for this project considering that the animal protein production for the US is on a large scale and is responsible for the supply of meats and animal products to all states including New York and New York City.

6. MONEY FLOWS AND MAJOR STAKEHOLDERS

This section will only outline the money flow within the current system towards and from main stakeholders. In addition, the focus was mainly placed on the beef production industry.

There are various stakeholders that supply animal protein products to consumers. Most commonly, consumers can either purchase animal protein products from retail markets (i.e. supermarkets, butcher shops) or service operators (i.e. restaurants, cafeterias and catering firms). Animal protein products can also be purchased at farmers' markets or directly from farmers. There are various farmers' markets in NYC, which offer customers local animal protein products. However, the vast majority of animal protein products in NYC are available through the main chain retail markets and food service operators.

6.1 Hunts Point Meat Market

An important source of animal proteins for chain retailers, as well as restaurants, butcher shops and hotels in NYC has been Hunts Point Meat Market in the Bronx, the most northern of the five boroughs. The Hunts point cooperative market is the largest wholesome retailer in the world (Fig. 9). At Hunts Point among others, meat is processed and distributed. Approximately 1.3 billion kg of meat are sold annually. The total annual revenue of all merchants at the wholesale market is approximately $3.2 billion (Reingold, pers.comm.). The large 50-acre cooperative meat market has 52 merchants and employs around 2,400 people (Reingold pers.comm.).

Fig. 9. Arial view of Hunt Point Meat Market. Source: Reingold. n.d.

6.2 Food processors and foodservice distributors

This section will briefly discuss general food processors and foodservice distributors because these companies do not solely focus on animal protein products (Kraft Foods 2012; Sysco Corporation 2012). Food service operators will not be discussed since they do not create meals that contain animal products.

Main meat packers such as Tyson Foods, JBS USA, Smithfield Foods and Cargill Meat Solutions are key actors in the food processing industry. These companies are not just engaged in the process of slaughtering animals; they are also involved in processing meat further and adding value to it (Cargill 2012; Smithfield Foods 2012; Tyson Foods 2012). However, there are other major actors beside meat packers, which supply consumer with animal proteins. For instance the fourth largest US food processor Kraft Foods Inc. markets animal proteins through its brands Oscar Mayer and Oscar Mayer Lunchables (Fusaro 2012). Gelatin products are sold through the Kraft brand Jell-O (Kraft Foods 2012). Kraft Foods is just one example of a food processor that further processes animal proteins. Noticeably, animal protein products are responsible for a large portion of the company's profits (Kraft

Foods 2012). There are also food processors, which exclusively focus on the processing of meat such as Hormel Foods Corp, the sixteenth largest US food processor (Fusaro 2012).

The three largest foodservice distributors in the US are Sysco, U.S. Foodservice and Performance Food Group (foodservice.com 2013). These companies have established various brands, which exclusively focus on marketing meat products to foodservice operators. Customers are commonly supplied with fresh and frozen meat products as well as prepared entrees (Sysco Corporation 2012). In general, meat products are an important part of their businesses. For instance, fresh and frozen meat sales accounted for up to 19% of all Sysco sales in 2012 (Sysco Corporation 2012). In a sense, large foodservice distributors are also food processors. Meanwhile, their business focuses on the distribution of different food and non-food commodities to foodservice operators (Sysco Corporation 2012).

6.3 Meat packers and processors

In 2012, over 80,000 people worked as slaughterers and meat packers in US meat packing facilities and earned on average $24,190 a year (U.S. Bureau of Labor Statistics 2012). Immigrants represent a large share of the employees occupied in meat packing facilities, one of the most dangerous workplaces in the US (Compa 2004).

6.3.1 Beef

The beef industry plays an important role for the US livestock industry. Beef marketing is responsible for more than 38% of the income generated within the livestock and poultry industry and accounts for 18% of all US farm income (Gillespie and Flanders 2009). According to USDA, the “retail equivalent value” of the US beef industry was approximately $79 billion in 2011 (U.S. Department of Agriculture 2011a). In the same year, beef and veal imports accounted for approximately 8% of beef supply, which is approximately 910 million kg (U.S. Department of Agriculture 2013a) and circa 11% (1.3 billion kg) of the beef

Table 2. Top US beef slaughter companies in 2011. Source: Feedstuffs 2013.

Company	Daily slaughter capacity
1. Cargill Meat Solutions	30,000
2. Tyson Foods	28,900
3. JBS USA	28,850
4. National Beef Packing Co. LLC	14,000
5. American Foods Group LLC	7,200

produced was shipped abroad (U.S. Department of Agriculture 2011a).

Few companies dominate the meat packing/processing industry. The three largest meat packers for beef processing are Cargill Meat Solutions, Tyson Foods and JBS USA (Table 2).

Table 3 shows the main beef brands of the three largest beef packers that market their products under numerous brands and through different distribution channels. These companies have many processing facilities capable of slaughtering around 30,000 head of cattle daily (Table 2). For instance, Cargill Meat Solutions operates eight beef processing facilities in the US and two in Canada (Cargill Meat Solutions 2013a).

that Cargill Meat Solutions is able to process daily (Grandin 2001). The three biggest packers have the capacity to slaughter about 615,000 cattle weekly. To put it in terms of humans, the

Table 3. Main beef brands of the three largest beef packers. Data source: Cargill Inc 2013d; JBS USA 2013a; Tyson Foods Inc 2013.

Cargill Meat Solutions	JBS USA	Tyson Foods
Angus Pride	Swift	Tyson
Excel	G.F. Swift 1855 Brand Premium Beef	IBP
Meadowland Farm ground beef	Aspen Ridge Natural Beef	
Preferred Angus beef	Swift Black Angus	
Ranchers Registry Angus beef	Cedar River Farms	
Rumba	5 Star Beef	
Sterling Silver	Chef's Exclusive	
Circle T Beef	Showcase Premium Ground Beef	
Tender Ridge Angus beef		
Valley Tradition beef		

Table 4. Top US pork slaughter companies in 2011. Source: Feedstuffs 2013.

Company	Daily slaughter capacity
1. Smithfield Foods	114,400
2. Tyson Foods	76,625
3. Swift	47,000
4. Excel Corp.	39,400
5. Hormel Foods Corp.	37,400

If all plants run on full capacity approximately 700 large livestock trailers[4] are needed to deliver the 30,000 cattle number of cattle slaughtered weekly would be nearly equivalent to the number of people living in Boston with 625,000 inhabitants (U.S. Department of Commerce 2011).

6.3.2 Pork

The US is one of the largest pork producers with 110,957,000 pigs slaughtered in 2011 (Food and Agriculture Organization of the United Nations 2011). The majority of pork produced in the US supplies the domestic market. However in 2012, approximately 365 million kg of pork were imported and 2.4 billion kg were exported (U.S. Department of Agriculture 2012a).

US meat packers are able to process many more pigs than cattle. The world's largest pork producer and processor Smithfield Foods can process approximately 114,400 pigs daily (Table 4). Tyson Foods, the second largest pork processor, has a daily slaughter capacity of 76,625 head, followed by Swift (JBS USA) with 47,000 and Excel Corp (Cargill Meat Solutions) with 39,400 (Table 4). Tyson Foods, Cargill Meat Solutions (Excel Corp.) as well as JBS USA (Swift) are not only key actors in the beef packing industry, but also heavily engaged in the pork processing industry.

[4] 44 ft. possum belly trailer (four compartments, 10 ft. front compartment; two middle double decks, 25 ft. each; 9 ft. rear compartment, total of 69 ft. of floor space (Temple 2001)

Table 5. Top U.S. broiler production in mid 2011 on a ready to cook weight basis. Source: Feedstuffs 2013 (with amendment).

Company	Average weekly production, million kg	Market share %
1. Tyson Foods	73	22
2. Pilgrim's Pride	57	17.2
3. Perdue Farms/Coleman Natural	26	7.9
4. Sanderson Farms	23	6.9
5. Koch Foods	16	4.8

6.3.3 Poultry

Tyson Foods is the leading broiler producer and processor in the US (Table 5) with an average weekly production of 41.4 million broilers (73 million kg) (Tyson Foods 2012). Pilgrim's Pride, a brand of JBS USA is the second largest producer of broiler. JBA USA markets its chicken products through seven brands including Pilgrim's, Pierce, Wing Ding, Wing Zings, Speed Grill, Country Pride, and To-Ricos (JBS USA 2013b).

6.4 Renderer

The rendering industry has been referred to as the "invisible industry" (Burnham 1978). With annual revenues of over $5 billion, this industry is an important stakeholder within the animal protein production business (Cook 2012). Approximately 300 rendering facilities are processing approximately 25 billion kg of different animal slaughter and processing by-products per annum in the US (Meeker 2006). These by-products are transformed into animal feed as well as fats and proteins (Render 2011). Main customers for the rendering industry are the animal feed, pet food, biofuel, and food and non-food industries (Meeker 2006). Generally, renderers purchase the raw material from stakeholders involved in the slaughtering of animals or the processing of meat (Meeker 2006; U.S. Environmental Protection Agency 1995).

There are several large rendering corporations that dominate the rendering industry. Since Cargill Meat Solutions operates numerous animal-processing facilities, it also operates integrated rendering plants. This is common practice among all major meat packers. Other important stakeholders operating external rendering facilities are companies such as Valley Proteins Inc. and Darling International Inc. with a total revenue of $1.79 billion (Darling International 2011). Such examples emphasize the importance of the "invisible" rendering industry within the animal protein production business.

6.4.1 Vertical integration

Vertical integration is the combination of two or more stages of production marketing or processing (Gillespie and Flanders 2009). This management practice is common in the poultry industry (Glatz and Bolla 2004). Poultry processors own breeding facilities, broilers, feed mills and/or processing plants (Glatz and Bolla 2004). Poultry farmers only provide housing and labor for broiler producers under contract (Van Kessel pers.comm.). Vertical integration offers large poultry processors nearly full control over the entire broiler production cycle (Walker *et al.* 2005). A similar trend can be observed in the pork industry. Large pork production companies gain more influence over the entire pork production chain by owning the pigs, operating breeding units, providing feedstock, slaughtering and processing the animals (Gillespie and Flanders 2009). The beef industry has not been vertical integrated (Tyson Foods 2012). Due to the complexity and fragmentation of the beef production chain, vertical integration is not commonly perceived as an opportunity to increase the efficiency of beef production. Contracts are a common means to ensure efficient coordination of the production chain (Gillespie and Flanders 2009).

6.4.2 *Acquisition of slaughter animals*

Cattle

Meat packers purchase cattle for slaughtering, commonly referred to as slaughter cattle, mainly through direct negotiation with cattle dealers and feedlot operators (Gillespie and Flanders 2009; Tyson Foods 2012). Meat packers receive 70% of their slaughter cattle through direct selling (Gillespie and Flanders 2009). However, slaughter cattle are also purchased through terminal markets, auctions and through order buyers, which make purchases on behalf of meat packers (Gillespie and Flanders 2009). Payment for slaughter cattle can be based on live weight, carcass weight or grade (Tyson Foods 2012). Grade refers to the quality of the meat, which is subsequently paid for after slaughter.

Pigs and Broilers

Since vertical integration is becoming more common in the pig and broiler industry, large processors such as Smithfield Foods, Cargill and Tyson produce or own the animals that will later be processed in their processing facilities. However, independent pork producers that supply pigs under contract or by negotiation do exist (Gillespie and Flanders 2009; Smithfield Foods 2012). This is less common for chicken production. Contract poultry farms produce most of the chickens for big companies. Tyson, the largest poultry producer, receives broilers from 4,300 poultry farms, which are slaughtered in one of 60 chicken processing facilities (Tyson Foods 2012).

6.4.3 *Feedlot operator*

Small feedlots with less than 1000 head of cattle provide 15% of the total cattle for the US beef industry (Gillespie and Flanders 2009). Most of the beef consumed in the US is being produced from animals fattened in feedlots with a capacity of over 1,000 head. One third of the total beef supply originates from feedlots with a capacity of over 32,000 head (Gillespie and Flanders 2009; Tyson Foods 2012).

Commercial feedlot operators have to purchase most of their feedstock (Gillespie and Flanders 2009; Taylor and Field 1998). Whereas, farm feedlot operators are smaller with an animal capacity of less than 1000 head (Gillespie and Flanders 2009) and are often able to provide most of the needed feedstock themselves (Van Kessel pers.comm.). Some farm feedlots have their cattle partly on pasturelands; however, confined animal farming operations (CAFO) are much more common (Gillespie and Flanders 2009). Feedlot operators face higher costs then cow-calf producers, mostly due to higher feed, labor and transportation costs (Taylor and Field 1998). Large areas of at least five acres per 500 animals of land are required in order to operate feedlots (Gillespie and Flanders 2009). In addition, feedlot operators and cow-calf producer have more expenses due to the treatment of sick animals. Veterinarian services and animal health products must be foreseen (Feedstuffs 2012; Gillespie and Flanders 2009). Animal health production supplier such as Pfizer, Merck and Bayer generate millions of dollars through marketing animal health products to livestock farmers (Feedstuffs 2012).

The top three-feedlot operators in 2011 were JBS Five Rivers Cattle Feeding LLC, Cactus Feeders Inc. and Cargill Cattle Feeders LLC (Table 6). JBS Five Rivers Cattle Feeding LLC is a wholly owned subsidiary of JBS USA with feedlots in Colorado, Kansas, Oklahoma, Texas, Arizona, and Idaho ranging from one-time feeding capacities of 52,000 to 120,000 head (JBS Five Rivers 2013). One time feeding capacity is a physical measurement and refers to the number of animals that can be feed at on point in time (Gates *et al.* 2007). JBS Five Rivers Cattle Feeding LLC is the largest US feedlot operator with a total one-time feeding capacity of 940,000 head (Table 6).

Cactus Feeders Inc. is the second largest feedlot operator (Table 6). The company operates ten feedlots in Kansas and Texas and is the largest privately owned feedlot operator with revenues exceeding $750 million (Cactus Feeders 2013). Cargill Cattle Feeders LLC is a part

Table 6. Top U.S. beef feedlot operator in 2011. Source: Feedstuffs 2013.

Company	One-time capacity (head)
1. JBS Five Rivers Cattle Feeding	940,000
2. Cactus Feeders Inc.	560,000
3. Cargill Cattle Feeders LLC	355,000
4. Friona Industries LP	290,000
5. J.R. Simplot Co.	230,000

of Cargill Inc. and operates feedlots in Kansas, Texas and Colorado ranging from one-time feeding capacities of 52,000 to 104,000 head (Cargill Meat Solutions 2013b). The fifth largest feedlot operator, J.R. Simplot operates one of the largest feedlots in the world in Grand View, Idaho with a one-time feeding capacity of 150,000 head over an area of 750 acres (J. R. Simplot Company 2013).

To run their feedlots, JBS Five Rivers Cattle Feeding LLC employs 650 people, Cactus Feeders Inc. 500 people and Cargill Cattle Feeders LLC approximately 240 people (Cactus Feeders 2013; Cargill Meat Solutions 2013b; JBS Five Rivers 2013).

6.4.4 *Acquisition of feeder cattle*

The most common way to purchase animals for final fattening is through auction markets and direct negotiation with the cow-calf operator/backgrounder (Gillespie and Flanders 2009). At auction markets, cattle are sold publicly to the highest bidder. The seller has to pay a fee to the auctioneer, which is based on the price that the animal has been sold for. Such auctions are particularly important for small cow-calf producer (Gillespie and Flanders 2009). Large cow-calf producer/backgrounder tend to sell their cattle under contracts to feedlot operators through cattle dealers (Gillespie and Flanders 2009; Tyson Foods 2012). However, they also sell their cattle to cattle dealers that then re-sell the cattle to feedlot operator. Another common method is to sell the cattle to order buyers, who are cattle market experts that buy cattle on behalf of feedlot operators. However, other means of purchasing cattle for feedlots do exist such as via terminal markets that are operated by a stockyard company. Cow-calf operators can offer their cattle through an external marketing agent who will try to sell the cattle for a maximum price. Cow-calf producer/backgrounder have to pay a commission fee to the external agent as well as to the terminal market operator. Hence, selling cattle through terminal markets involves many fees and brokers. Electronic marketing is another possibility to market cattle but not as commonly practiced (Gillespie and Flanders 2009).

6.5 Cow-calf operator

There are approximately 765,000 US farms that maintain a herd of animals for beef production (McBride and Mathews 2011; U.S. Department of Agriculture 2013c). Most cow-calf operators (78%) maintain small herds with less than 50 head, which equals about 30% of the national total of beef animals. About 12% of cow-calf herds comprises of 50-99 head, representing 19% of the total beef animals. Nearly 40% of all beef animals come from herds of 100-499 head, maintained by just 9% of cow-calf operators (Gillespie and Flanders 2009; U.S. Department of Agriculture 2009). Herds with over 500 head are least common and contribute to the total beef animal supply with merely 8% (Gillespie and Flanders 2009; U.S. Department of Agriculture 2009). Surveys have shown that approximately 36% of all beef cow-calf operators have employments outside of the farm. One of the greatest expenditures cow-calf producer faces are the investment costs for private pastureland (Gillespie and Flanders 2009).

6.6 Pig producer

There has been an ongoing trend to rear pigs in large confined facilities capable of holding more than 5,000 pigs (Gillespie and Flanders 2009). The largest pig production operations have 10,000 pigs, depending on sizes and weights (Code of Federal Regulations 2008). Facilities with more than 1,000 pigs account for more than 90% of all pigs being produced in

Table 7. Top U.S. pork producing companies in 2011. Source: Feedstuffs 2013.

Company	Thousand sows
1. Smithfield Foods	838
2. Triumph Foods	377
3. Seaboard Farms	214
4. The Maschhoffs	192
5. Prestage Farms	165

the U.S (Gillespie and Flanders 2009). On average, very large farms produce 1.8 million pigs annually (Pond 2003). Meanwhile, most operations have less than 100 pigs, which accounts for less than 1% of all pigs produced in the US (Gillespie and Flanders 2009; U.S. Department of Agriculture 2009).

Smithfield Foods is the largest pig producer followed by Triumph Foods and Seaboard Farms (Table 7). These companies are vertically integrated pig producers, controlling almost all

production and processing activities. For instance, Seaboard Farms produces 76% of the pigs processed in their processing plants. Approximately 24% of the processed pigs are produced under contracts from independent pig producers (Seaboard Corporation 2011).

6.7 Broiler producer

The US poultry industry is gigantic. The "retail equivalent value" of US broiler industry, accounting for 80% of the poultry meat production, was approximately $45 billion in 2010 (U.S. Department of Agriculture 2011b). Large poultry facilities have been built to satisfy consumers' demand for poultry. Large poultry production sites can have 40 chicken houses, each with a capacity to provide space for 30,000 to 45,000 chickens (Glatz and Bolla 2004).

6.8 Structure and financial strength of key players in the meat industry

This section will summarize the structure and financial strengths of the key players within the meat industry, disregarding the dairy and egg industry. Just a few companies control the

Table 8. Total revenue of major meat packer/processors production in 2012. Data source: Bloomberg Businessweek 2013; Cargill Inc 2012b; Smithfield Foods Inc 2012; Tyson Foods Inc 2012b.

Company	2012 Total Revenue (billions $)	2012 Net Income (million $)
Tyson Foods	33.3	583
Beef	13.7	
Chicken	11.7	
Pork	4.6	
Prepared Food	3.3	
Smithfield Foods	13.1	361
Pork	11.1	
Hog Production	3.1	
International	1.5	
JBA USA	---[a]	---[a]
Cargill Meat Solutions	---[b]	---[b]

[a] Not available, total revenue of JBS S.A. 37.7 billion, net income: 358.4 million (Bloomberg Businessweek 2013)

[b] Not available, total revenue of Cargill Inc. in 2012 was 133.9 billion, with net income of 1.17 billion from continuing operations (Cargill Inc. 2012a)

meat market in the US. These companies have nearly fully control over all steps within the meat production process. Major meat packers gradually control even the fragmented beef production scheme. Smithfield Inc., the world's largest pork processor, generated $13.1 billion in revenue and a net profit of $361 million in 2012 (Table 8). The most profitable segment for the company was the pork processing, followed by the pork production segment.

Smithfield's business is primarily pork processing and production (Smithfield Foods 2012). Of the four main meat producers, Smithfield is the only company only focused on pork products.

Tyson Foods Inc. had a total revenue of $33.3 billion and a net profit of $583 million in 2012 (Table 8). Mergers have helped the company to gradually become bigger. In 2001, Tyson Foods Inc. bought back IBP Inc., an important supplier of premium beef and pork products (Barboza and Sorkin 2001).

Cargill Inc. is the largest privately owned business in the US and the parent company of Cargill Meat Solutions. Cargill Meat Solutions act as the umbrella organization for Cargill's beef, pork and turkey businesses. In total Cargill operates 62 different businesses worldwide, of which only 10 are dedicated to the animal protein production, processing and distribution (Cargill 2013b). Data concerning total revenue and net income are not released by Cargill Meat Solutions. However, total revenue of the parent company Cargill Inc. was 133.9 billion, with net incomes of 1.17 billion from continuing operations in 2012 (Cargill Meat Solutions 2012).

Similarly to Cargill Inc., Seaboard Corporation is a multi-faceted company. Seaboard Corporation engaged in commodity trading and milling, marine cargo shipping as well as in pork production and processing through its subsidiary Seaboard Foods. The pork segment generated a net profit of approximately $259 million in 2011 and significantly contributed to the total profit of $407 million in 2011 (Seaboard Corporation 2011).

JBS USA Holdings Inc. is a wholly owned subsidiary of JBS S.A., the largest processor of pork and beef in the world. The company bought Swift in 2007 and absorbed the Smithfield Beef Group Inc. in 2008, which made JBS one of the biggest stakeholder in the US meat market (Goldstein and Pearso 2007). Information about profit or revenue is not released by JBS USA. However, the parent company, JBS S.A. generated $37.7 billion and net income of $358.4 million in 2012 (Bloomberg Businessweek 2013).

All four major meat processors are key players in the US food processing industry. Tyson Foods Inc. is the second largest food processor in the US after PepsiCo Inc., followed by JBA USA, Smithfield Foods Inc. and Cargill Inc., ranked as the 6th, 10th, and 16th largest food processor, respectively (foodservice.com 2013).

The main purchasers for various meat products are large foodservice distributors, foodservice operators and retailers (Tyson Foods 2010, 2012). The density of food service operators and thus the accessibility to chain restaurants such as McDonald's (491), Burger King (245), Kentucky Fried Chicken (158) or Wendy's (140) is high in NYC (New York City Department of Health and Mental Hygiene 2013). Hence, such foods are easily available for the people in NYC.

6.11 Commercial Feed Companies

There are approximately 3,000 primary feed plants in the US and an estimated 5,500 feedstock plants that add different supplements to the feedstock (Lefferts *et al.* 2006). Additionally, several thousand suppliers provide ingredients added to animal feed. An extensive network of 17,500 feedstock dealers market the feedstock to livestock operators, wholesalers, brokers and feed stores (Lefferts *et al.* 2006). The largest commercial feed companies based on annual production capacity in million tonnes are Land O'Lakes-Purina LLC ($11M), Cargill Animal Nutrition ($10M), ADM Alliance Nutrition ($3.2M), J.D. Heiskell & Co. ($2.4M), Kent Feeds ($2.0M), Westway Feed Products ($1.7M), Southern States Co-op ($1.7M), Viterra ($1.7M), Ridley Inc. ($1.6M), Quality Liquid Feeds ($0.8M) and Pennfield Corp. ($0.7M) (Feedstuffs 2012). These companies have an average annual production capacity ranging from 0.7 to 11 million tonnes of feedstock (Feedstuffs 2012).

Animal feed manufacturers acquire necessary ingredients commonly from brokers (Lefferts *et al.* 2006) or in some cases, directly from farmers (Van Kessel pers.comm.). The broker usually purchases grains from grain elevators that had purchased the grains from farmers.

However, grain elevators and brokers can also be one and the same company (Van Kessel pers.comm.). Grain elevators store and distribute grains from a certain region and distribute commodities. By-products from industrial food processing companies are another important source for animal feed manufacturer (Elferink *et al.* 2008). For example, soybean or rapeseed meal, accumulated as a byproduct of (vegetable) oil production, is commonly added to animal feedstock and purchased by brokers or directly by animal feed manufacturers (Van Kessel pers.comm.).

6.12 (Feed) Grain farmers and subsidies

This section will briefly discuss feed grain sector and grain subsidizes. The total US supply of main feed grain (corn, sorghum, barley, and oats) in 2011/12 was 359 million tonnes and a total disappearance of 331 million tonnes (U.S. Department of Agriculture 2013d). Recent data show that corn is the most important feed grain, accounting for 95% of all produced feed grains in the US (U.S. Department of Agriculture 2013e).

Corn plants occupy approximately 85% of all fields utilized for feed grain production in the US (Hoffman *et al.* 2007). Corn prices experienced a dramatic increase due to high demand for ethanol, beginning in 2005/06. In 2005/06 one bushel of corn cost $2, whereas the price increased to $6.22 in 2011/12 (U.S. Department of Agriculture 2013f). By definition a bushel is “a measure of capacity equal to 64 US pints (equivalent to 35.2 liters), used for dry goods” (New Oxford American Dictionary 2010b).

Generally speaking, 88% of all farms in the US are small family farms, defined as having annual sales of less than $250,000. Most family farms are not profitable and farmers rely financially on off-farm occupations. Large-scale farms, defined as having annual revenues exceeding $250,000 are profitable and responsible for 84% of the value of US agriculture products (Hoppe and Banker 2010). In 2011, there were a total of 2,170,000 farms in the US with an average farm size of 421 acres (U.S. Department of Agriculture 2013c).

Table 9. Top 10 Seed companies in the world in 2007. Source: ETC Group 2008.

Company	2007 seed sales (US$ millions)	Market share, % of global proprietary seed market
1.Monsanto (US)	$4,964	23%
2. DuPont (US)	$3,300	15%
3. Syngenta (Switzerland)	$2,018	9%
4. Groupe Limagrain (France)	$1,226	6%
5. Land O' Lakes (US)	$917	4%
6. KWS AG (Germany)	$702	3%
7. Bayer Crop Science (Germany)	$524	2%
8. Sakata (Japan)	$396	<2%
9. DLF-Trifolium (Denmark)	$391	<2%
10.Takii (Japan)	$347	<2%
Total	**$14,785**	**67%**

Governmental support has a long history in the US agriculture sector (Hoffman *et al.* 2007). The most important legislation for the US agriculture sector is the Farm Bill, which was introduced in 1973 and must be passed every five years (Food & Water Watch 2012; Pollan 2006). The Food Conservation and Energy Act of 2008, serves as the current Farm Bill.

Among others, various types of governmental support for feed grain producer have been defined within this bill and previous farm bills. The current scheme, in which subsidizes are allocated to corn farmers, has led to the exhaustive production of as much corn as farmers can possibly produce and the US government spending nearly $5 billion on corn subsidies per annum (Pollan 2006). Corn subsidizes cost the US government and thus the American taxpayer $73.8 billion between 1995 and 2009 (Lessig 2011). In addition, the current governmental subsidy policies push small farmers out of business and benefit large farms and agribusinesses (Lessig 2011).

6.13 Seed, Agrochemical and fertilizer corporations

Famers who produce grains for human and animal consumption acquire seeds, fertilizer and pesticides. Approximately 82% of commercial seeds are proprietary seeds, which are

Table 10. Top 10 Agrochemical producers in 2007. Source: ETC Group 2008.

Company	Agrochemical Sales 2007 (US$ millions)	Market Share %
1. Bayer (Germany)	$7,458	19%
2. Syngenta (Switzerland)	$7,285	19%
3. BASF (Germany)	$4,297	11%
4. Dow AgroSciences (USA)	$3,779	10%
5. Monsanto (USA)	$3,599	9%
6. DuPont (USA)	$2,369	6%
7. Makhteshim Agan (Israel)	$1,895	5%
8. Nufarm (Australia)	$1,470	4%
9. Sumitomo Chemical (Japan)	$1,209	3%
10. Arysta Lifescience (Japan)	$1,035	3%
Total	**$34,396**	**89%**

intellectual property of seed companies (ETC Group 2008). The main three seed companies (Monsanto, DuPont, Syngenta) account for nearly 50% of the proprietary seeds market value. These seed producers control 65% of the global corn market (ETC Group 2008). Table 9 shows the world's ten largest seed companies based on sales and proprietary market share (ETC Group 2008).

In addition, large seed companies are also main agrochemical producers. These companies sometimes also supply corn producers with pesticides such as herbicides, fungicides and insecticides to be used on cornfields. In 2010, herbicides were applied to 98%, fungicide to 8% and insecticides to 12% of US corn acres (U.S. Department of Agriculture 2011d). Table 10 shows the ten largest agrochemical producers based on sales and market share in 2007.

Approximately 50% of the fertilizer used in the US agriculture sector is applied on cornfields. Fertilizer manufacturing and land application are responsible for approximately 30% of the energy used in the entire US agriculture sector (ETC Group 2008). The most important fertilizers applied on cornfield are nitrogen, phosphate, potash and sulfur. In 2010, nitrogen was applied on 97% of corn acres. 5 billion kg of nitrogen have been used on corn acres on an average annual rate of 64 kg per acre (U.S. Department of Agriculture 2011d). The largest fertilizer companies based on net income are PotashCorp (Canada), Yara (Norway) and Mosaic (USA). Cargill Inc. holds 55% of Mosaic stake (ETC Group 2008).

7. SYSTEM DYNAMICS

7.1 The Current System: Model Description

This section will briefly outline the main parts of the current animal protein system to give a broad overview of the flows throughout the production process (Fig. 10). For detailed descriptions of the animal protein production practices, refer to sections 5 through 7.

Within the current system model, there are stocks, flows, converters and connectors. Stocks represent the accumulation of material such as animal protein or money at a certain time and place (e.g. volume of animal proteins or money at the Meat Packing Facility) (Fig.10). Activities that change the size of stocks are flows. For instance, the transport of broilers changes the magnitude of the stock animal protein at the place of a Broiler Unit. Converters commonly modify flow activities. For example, by adding additives such as antibiotics and arsenic to the flow of broiler feed, the operations at the Broiler Unit are consequently modified. Connectors transfer inputs or outputs (e.g. inputs from a converter to a flow).

The dashed line symbols on the diagram are called “ghosts”. Ghosts are dashed stocks or converters connected to flows or converters elsewhere in the model and are used to avoid a confusing maze of connectors. In this model, ghosts were used to show the environmental impacts caused by livestock production e.g. methane emissions or groundwater pollution caused by excretion.

7.1.1 Animal protein flow

Firstly, *Fertilizer* is applied to the soil in order to enrich the *Soil Nutrient* content. Manure is one source of fertilizer and can be obtained from an array of different sources such as *Foundation Breeding Facility*, *Broiler Unit*, *Battery Unit*, *Feedlots* and more. In addition, manure can also be used for energy production utilized through the processes of *Gasification* or *Microbial Digestion*.

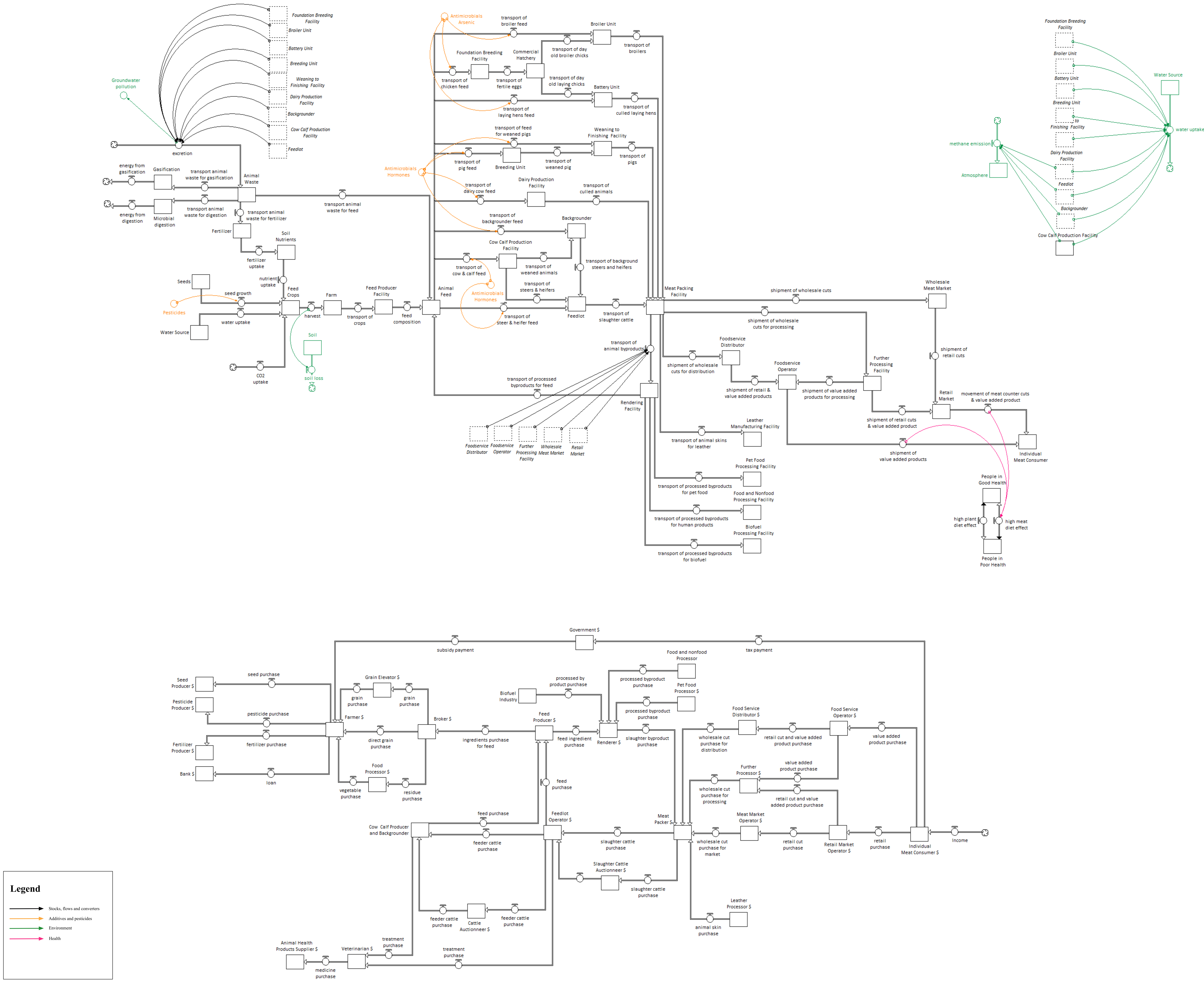

Fig. 10. The current unsustainable animal protein production and consumption system.

Seeds are planted before, after or during the application of fertilizer. *Water*, light, energy and carbon are necessary for proper plant growth. Generally, *Pesticides* are applied to protect the growing plants. Then, *Feed Crops* are harvested by *Farmers* and turned into *Animal Feed*. Harvesting is often accompanied by *soil erosion*. *Animal Waste* and processed animal (slaughter) *by-products*, which accumulate during the processing of livestock, are added to the animal feed. Afterwards *Animal Feed* is distributed to various animal protein production facilities such as the *Broiler Unit, Battery Unit, Weaning to Finishing Facility, Dairy Production Facility, Backgrounder, Cow Calf Production Facility* and *Feedlots*. Depending on the animal species, *animal feed* is enriched with various substances such as *Antibiotics*, *Arsenic* or *Hormones (mimics)*.

Once the animals reach slaughter weight, they are transported to *Meat Packing Facilities* where they are slaughtered and processed. Animal *by-products*, which accumulate during slaughter and processing activities, are further processed from *Rendering Facilities* into different products. Those processed byproduct are sent to *Pet Food Processing Facilities*, *Food and Non-food Processors* and *Biofuel Producers* for further processing. Animal skins, another by-product of the slaughtering process, are further processes by the *Leather Industry*. After slaughter, different kinds of carcass cuts are distributed to *Wholesale Meat Markets*, *Processing Facilities*, *Food Service Operators* and *Food Service Distributors*. These stakeholders add value to the animal proteins and ensure a steady supply of animal proteins to the *Individual Meat Consumer*. Consumers that follow a high meat diet will more likely experience *Poor Health* condition rather than *Good Health*.

7.1.2 Money flow

Individual Meat Consumers and non-meat customers pay taxes to the *Government*, which will be partly used to pay subsidies to farmers and other stakeholders. Meat consumers purchase animal protein products from *Retailers* and/or *Food Service Operators*. These stakeholders purchase different types of carcass cuts from various animal protein suppliers such as *Food Service Operator*, *Processors*, *Retail Market Operator*, and *Meat Market Operator*. Large *Meat Packers* eventually supply these stakeholders. Commonly, meat packers purchase the animals from *Feedlot Operator,* which obtained the livestock from *Cow Calf Producers*. In order to maintain a herd's health, *Veterinarians* are consulted regularly and the medicines applied to the animals are purchased from *Animal Health Product Suppliers*. Slaughter by-products that have accumulated during the slaughter process are sold to *Renderers* which process and sell the material further. The feed is commonly purchased from *Feed Producers*, which received the ingredients from *Brokers*, *Food Processors* and *Farmers*. In addition, farmers have to purchase seed, pesticide, fertilizer and paying the interest rate of loans.

7.2 Actors and Roles

The STELLA model of the current unsustainable protein system illustrates the complexity of the entire animal protein system (Fig. 10). Animal protein production and consumption involves a great variety of different stakeholders in a fragmented industry as described in sections 5 through 7. The most influential stakeholders that control the system are (1) individual meat consumers, (2) meat packing companies, (3) legislative bodies (e.g. Congress), (4) cattle farmers & companies, (5) feed crop farmers, (6) feed production companies and (7) rendering companies shown as blue converters (Fig. 11). However, the consumer ultimately controls the flow of meat in the meat supply chain downstream from the

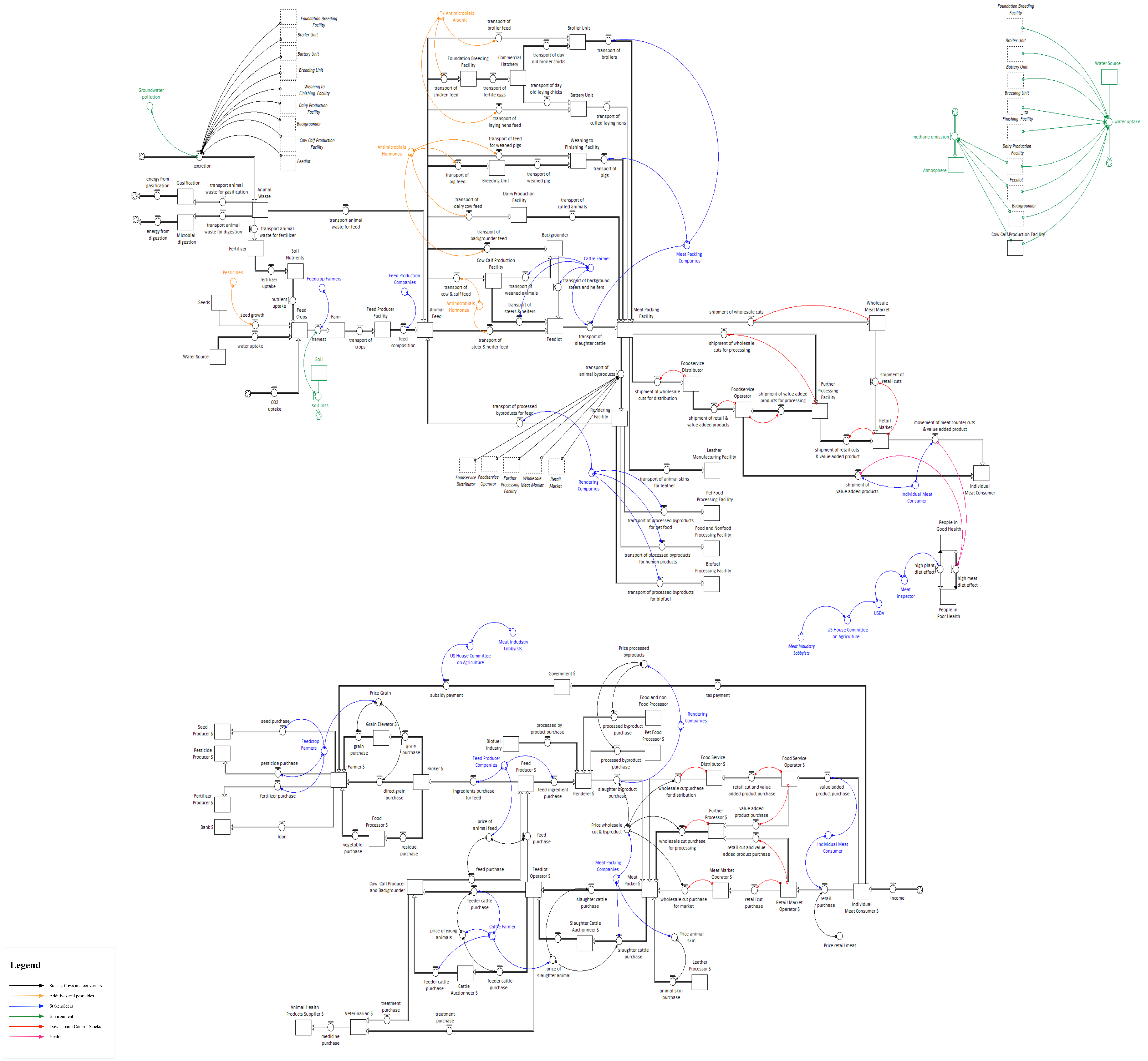

Fig. 11. Most influential stakeholders within the current unsustainable animal protein production and consumption system.

meat packing facility. The downstream flows are dependent on the stocks they flow into, which depend on the consumers demand for animal proteins (Corliss pers. comm.).

Actors are participants in an action or process and their roles are the function assumed or part played by a person or thing in a particular situation (Corliss, 2012). Organizations are commonly referred to as actors, but this should be avoided. To think of an organization as an agent in an environmental system obscures the underlying reality that individual people's decisions determine the actions of these organizations (Corliss pers. comm.). An organization is a "social entity that has a collective goal and is linked to an external environment" (Pianaung and Rudito 2012). Individual actors make up an organization, and it is their collective goals that lead them to act as one cohesive body. Thus, it is more useful to see a system as a function of actors' influences controlled by their roles and individual consciousness. These distinctions become crucial when creating fundamental transformations of an environmental system. Ultimately, a fundamental transformation of a social system requires a fundamental transformation of the consciousness of individuals (Corliss pers. comm.). Actions must be design with this in mind.

Actors take on certain roles linked to common patterns of behavior. Commonly, the roles of individuals are determined by the role they play in organizations or social systems (Corliss 2013). Names and titles are commonly used to describe the role of an actor within an organization. For instance, chief executive officer (CEO) or general manager is a title given to individuals, which make executive decisions or manage a company.

The actions taken by individuals are constrained by their role, the expectations that are linked to this particular role and the definition of the role. Such constraints can lead to the loss of individual consciousness and consequently to immoral decisions (Corliss 2013). For example, most actors with the title CEO have the goal to make a business succeed, which is often interpreted as to increase profits. Since the CEO has to fulfill his role and the expectations of shareholders, her or his role “provides cover for immoral decision” (Corliss 2013) such as laying off thousands of employees to increase the profitability of the company. This can be seen as a result to the commonly taught management theories at business schools that propose that there is no moral responsibility (Ghoshal 2005).

7.2.1 Individual meat consumers

Meat consumers are the most influential individuals within the animal protein production and consumption system. They purchase animal proteins from retail markets and/or foodservice operators, and therefore determine the flow of animal proteins from meat packing facilities through other supply chain stakeholders to retail markets and foodservice operators. Not only do consumers control the animal protein flow, they also control the associated cash flows within the entire animal protein production and consumption system.

7.2.2 Meat packing companies

Meat packing companies control the flow of broilers, pigs and slaughter cattle (Fig. 11). The actors responsible for the decisions made by meat packing companies have the roles of CEOs and board members. They control the money outflows to other parties and can influence the money inflows from other parties by setting the price for the product they sell. The actors controlling the downstream stocks and flows such as food service distributors, further processors and meat market operators have much more control over the flow of animal proteins towards the consumer. Yet ultimately, the flow is still dependent on the consumer’s demand.

7.2.3 Legislative bodies

The United States Congress is the legislative branch of the federal government. Congress consists of individuals such as representatives and senators that are expected to make decision for the people. The actors in charge of the Farm Bill are part of the US House

Committee on Agriculture, a standing committee of the US House of Representatives (House Committee on Agriculture 2013). Actors within this committee determine the subsidy payments to different stakeholders engaged in the production of animal proteins. In addition, lobbyists commonly influence representatives and senators, and therefore also have control over the subsidy payment flows. Lobbyists influence or even control much of the legislation that affects the industries they represent (Lessig 2011).

7.2.4 Cattle farmers

Actors with the role of cattle farmers as well as feedlot buyer control the flow of cattle. These individuals have much more control of the system than for instance pig or broiler farmers, which work under contracts for large meat packing companies and do not own the animals they raise. However, compared to most pig and broiler farmers, cattle farmers own their livestock. This is why cattle farmers also influence the price of young animals. Additionally, actors responsible for core decisions within large feedlot companies have the role of CEO or board member. They have some control over the price of slaughter cattle and therefore also influence the cash inflow based on current market prices.

7.2.5 Feed crop farmers

Actors with the role of a feed crop farmer control the harvest and the crop they are cultivating. In addition, they control the cash outflow to seed, pesticides and fertilizer companies. They also influence cash inflow through grain prices based on current market prices.

7.2.6 Feed production companies

CEOs and board members commonly manage large feed companies. These individuals make executive decisions that control the feed production processes and the cash outflow for ingredient and by-product purchases. In addition, they influence the cash inflow through the price of animal feed compared to the current market price.

7.2.7 Rendering companies

Actors leading large rendering companies have the same roles as other companies involved in the system. Thus, CEOs and board members are common roles that decision makers have. They make important decisions regarding processed by-products transports to various stakeholders within the system. In addition, they control the cash outflow for slaughter by-products and influence the cash inflow by setting prices for processed by-products based on the current market price.

8. PROTEIN CONSUMPTION IN 2040 – A FUTURE VISION

As Donella H. Meadows emphasized, a vision should be the most important step in the policy process and is a powerful tool to achieve ambitious goals (Meadows 1996). Without a vision, real change will not occur. A vision must be responsible, which means physically possible and shared with other people. However, this does not mean that a vision cannot be ambitious. A vision provides hope, strength and courage on the journey of achieving such a vision. In Meadow words, “a vision is not rational but a rational mind can and must inform a vision” (Meadows 1996). All is feasible as long as it is in compliance with the laws of the universe. Individuals who find themselves in an apparently hopeless position might not share this notion, but history has shown that major issues such as slavery, racism and sexism could be (at least partially) abolished. The following vision describes the protein flow and consumption in 2040 in NYC and comprises of the following goals:

- Half of the inhabitants of NYC follow a plant-based diet in 2025
- Abolishment of the owning and exploitation of all animals in 2040

In 2040, North America as well as many parts of the western world underwent one of the most important changes in human history by standing strong against of opposition of big interest groups including the meat industry. The consumption of animal protein has become a rare exception, de-normalized and is not the rule anymore. The idea that most humans once consumed animal flesh seems as disturbing as the thought of consuming human flesh.

Nearly forgotten are the times when North America supplied only 32% of its protein consumption from plants.

Nearly forgotten are the times when 2,000 land animals worldwide were slaughtered every second, merely for human consumption and exploitation.

Nearly forgotten are the times when animal exploitation was seen as “normal” by society at large.

Nearly forgotten are the times when supermarkets and restaurants offered processed and animal-based foods.

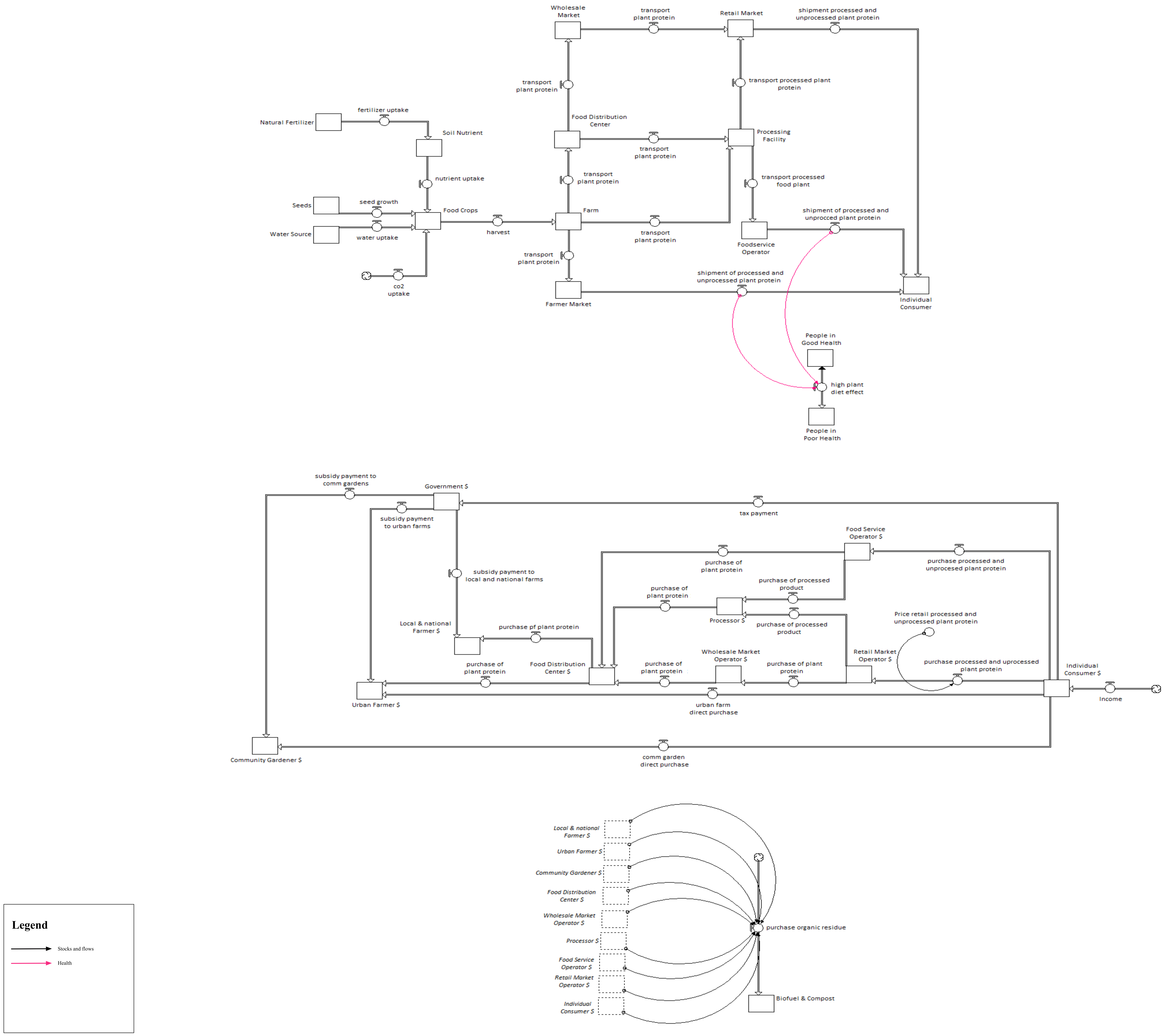

Fig. 12. Sustainable future protein production and consumption system.

2040 is a world where animal derived products do not exist and animals are not perceived as exploitable resources. It is an age when we as humans treat animals with the same respect that we give one another. It seems foreign to emerging generations that society in the past millennia perceived animals as inferior merely on the basis of appearing differently, thinking differently and communicating differently, essentially, because they are different from humans. In 2040, killing of animals for human consumption, pleasure, habit or amusement is unimaginable and prohibited by law. Thus, unnecessary infliction of pain is prohibited and animals cannot be owned. Society has acknowledged that animals are sentient beings to the same degree as humans, both of whom do not wish to experience pain and death.

People's perceptions have changed since the revolution. The movement was initiated by the awareness of animal exploitation and gave rise to its abolishment in 2040. What originally was a lifestyle triggered by the minority, became the "norm" for billions of humans in the western world and lead into a new era of non-violence and enlightenment. Now, society as a whole is more conscious, and aware of the relationships between humankind, animals and nature and how they are intertwined. The change from an animal protein diet to a plant-based diet with great health and environmental benefits allowed humans to realize that they had been blindly following a disadvantaged lifestyle exemplified by the majority of society, in which many generations had been born and trapped into.

People started to question, not only their own beliefs, habits and actions, but also the beliefs, habits and actions of those around them. This began to challenge the status quo and helped people conclude that avoiding animal proteins and consuming plants made them stronger, healthier and happier individuals. Meanwhile, the change to a plant-based diet had a very profound impact on society– people realized that less is better (more often than not). Gradually, individuals started to apply the experience they gained by questioning their diet to other parts of their lives.

The abolishment of animal exploitation can be directly linked to the post -industrial economy of 2040 – an economy driven by the spirit of innovation, promoting a resource neutral co-existence of humankind and nature, rather than driven by growth based on the exploitation of finite resources. Looking forward, drastically minimizing world hunger is the optimistic and realistic reality. This is finally possible now since the vast majority of people in the western world are primary consumers and the essential goal of abolishing starvation is shared by all.

Since the movement towards normalizing plant-based diets spread from throughout NYC to other major cities in North America along with most of Europe, South America, Africa and Asia cities have begun to follow. The City has always been known for its importance as a trendsetter. Nearly 50% of the cities' inhabitants were already following a plant-based diet in 2025. The unique composition of NYC lifestyles and diversity within the population made it possible to de-normalize animal protein consumption and to spread its benefits throughout the planet.

Nowadays, New York City's education system is recognized as a role model for others states and countries in part due to teaching students about the origin, processing, and chemistry of plant-based foods. Also, the City known for reconstructing spaces for lush gardens devoted for plant-based food production allowing the natural world to come back into the city. A part of this reconstruction is rooftop gardens, another common means to produce plant proteins. Large sections of Central Park were converted into fruit and vegetable gardens and are maintained by local citizens. People have much more time in the post-industrial economy, so people are much happier to be able to devote a portion of their day to gardening and farming. Individuals in the city are proud of all of the local food they produce from rooftops, homes and community farms and gardens, thereby making local vegetables easily accessible. Today, much of NYC food supply is locally produced through highly productive sustainable nearly self-sufficient intensive agricultural ecosystems and without animal exploitation.

Over are the times when less than 0.7%[5] of the US population was responsible for the nations food production. In addition organic residues are commonly utilized as compost or for the production of biofuel.

Worldwide, the numbers of animals that have been removed from their natural habitat have dropped to less than 2 billion. Most animals are taken care of at animal farms, which serve as an educational activity for schools trips and the public. On such farms, people have the opportunity to interact with animals and are able to experience their sentient nature. However, most families have a unique relationship to animals since most families help to monetarily support an animal on an animal farm. 2040 is a time of unbound creativity focused on non-violence towards all sentient beings where humans live in tune with the natural environment.

[5] Current percentage distribution of labor force in the US agricultural sector (farming, fishing, and forestry) (Central Intelligence Agency 2013)

9. TRANSFORMATION

9.1 Intervention points and justification

The transformation of the current unsustainable protein system towards the desired future vision (Fig. 12) will need great effort. To create change, the actors and their common patterns of behavior that define the current system need to be transformed. These are the intervention points where change needs to take place in order to break down current feedback loops that stabilize the current system. It is important to intervene at as many points as possible within the system to facilitate change. However, the current system is resistant to change, constrained by the profit motives and driven by major corporations that strengthen their role through lobbying; therefore, effective change can only be achieved at certain intervention points.

Since the Farm Bill is the most important legislation for the US agriculture sector, many different interest groups lobby to persuade the government to act in their interest. More than 1,000 different interest groups lobbied on the 2008 Farm Bill (Food & Water Watch 2012). Overall, these interest groups spend an estimated $173.5 million on lobbying Representatives and Senators to influence the Farm Bill. This is not a surprise since the Farm Bill allocated spending of $307 billion between 2008-2012/13 (Food & Water Watch 2012). Main beneficiaries such as meat packing companies, animal health product supplier, seed supplier, agrochemical and fertilizer companies, biotechnology producers, retailers, food processor and farmers spend millions to keep the current agricultural policy system in its present state (Food & Water Watch 2012; Lessig 2011). According to Food & Water Watch (2012), stakeholders directly engaged in the production of animal protein spent approximately $28 million on lobbying for the 2008 Farm Bill. A new Farm Bill will be introduced in late 2013 continuing to give subsidies to a broad range of stakeholders in the agroindustry as well as dairy farmers through newly introduced dairy policies (House Committee on Agriculture 2013).

Hence, regulatory actions taken by the government to reduce the consumption of animal proteins will not likely occur or be successful. Also, large corporations have progressively gained more power over the political system since the system is highly influenced through companies' campaign contributions (Lessig 2011). These companies will not allow serious laws to be passed to reduce animal protein consumption. The political system will mobilize through promotional politics to oppose any sort of legislative change. The New York State legislature members, who pass laws that govern New York, face similar difficulties as members of Congress. Therefore, change towards a more sustainable protein production and consumption system is unlikely to be catalyzed politically at the federal or state level.

Meanwhile, regardless of the political level, animal welfare regulations have shown to be ineffective. They have increased animal protein consumption rather than decreased by making people feel complacent about exploiting animals as well as enhancing the effectiveness of meat production (Francione and Garner 2010). For instance, the Humane Slaughter Act made the slaughter process more efficient and therefore more economically attractive for animal protein producers.

However, if regulatory action not promoting animal welfare such as a ban of feed crop subsidies were to take place, the current animal protein production system would change by allowing for real market prices to influence the system thereby influencing consumption via the price of production. As a result, feed crop prices would rise however this would not affect food crops. Small farmers would benefit from such regulatory action, since the profit they receive is very limited due to the current agricultural subsidy scheme (Pollan 2006).However, this is not the most effective point of transformation as long as the political system is trapped in a corrupt campaign finance system that has led to “legal corruption” in US politics (Lessig 2011).

The STELLA model (Fig. 11) indicates that to change the current unsustainable protein system the consumer plays the most important role of setting the demand. It is justifiable to focus on the consumer as the primary participant in the process of shifting the unsustainable current system towards the goals formulated in the future vision, since the above mentioned regulatory actions will most likely not be successful or are too difficult to implement. Effective change toward sustainable plant-based protein production and consumption can be significantly accelerated by the power of the consumers’ choice.

Effective change can occur rapidly based solely on the consumer’s decision to avoid purchasing animal protein products. The consumer is the most effective point of transformation because lobbyists and promotional politics cannot directly influence a consumer’s choice. Other potential intervention points such as individuals within meat packing companies, animal feed companies, rendering companies, cattle farmers and companies or feed crop farmers are the least feasible intervention points. However, since the majority of cattle farmers do not raise cattle as their primary occupation, those individuals might be tempted to stop breeding cattle if incentives were in place. Also feed crop farmers, could grow food crops for human consumption if the subsidy scheme would promote food crops instead of feed crops. Overall, the consumer can change the current system drastically by purchasing plant-based proteins and avoiding products derived from animals. This will inevitably lead to a reduction of animal protein production and shift the system towards the proposed future vision by increasing sustainable - and decreasing unsustainable flows of proteins.

9.2 The Consumers' Appeals

Beside the fact that the current animal protein production scheme is very expensive for taxpayers (subsidy payment), numerous health and environmental issues shown in the STELLA model (Fig. 11) can urge individuals to change their pattern of behavior. However, people also might shift the tendency to change the current system towards the proposed future vision for moral reasons. The appeals to consumers based on morality, human health and environment are explored as potential motives to reduce the consumption of animals and their products.

9.2.1 Morality

An increasing number of individuals believe that animals raised for human consumption enjoy no rights, are treated as property and are perceived as inferior beings. Many messages about animal rights express that the human race inflicts pain and death on billions of animals for no good reason. According to Francione (2000), the justification for the killing of animals based on pleasure, amusement, habit or religion is shamefully flawed. Churchland (2011) makes the argument that morality is not a matter of opinion and that there is a right and a wrong. Most individuals would agree that the infliction of unnecessary pain (i.e. cruelty) on animals is also wrong (Francione 2000; Steinbock 1978). Today, the consumption of animal proteins can be seen as unnecessary since it is not essential for human survival. By ruling out pleasure, amusement, habit or religion as justifications for the killing of animals as well as acknowledging that it's unnecessary for human survival, the practices of using and consuming animals and their products can be concluded as unjustifiable.

Many pet owners regard their pets as important individuals in their lives, meanwhile, at the same time, support the suffering of animals by purchasing and consuming animal products. Animal rights pioneer Professor Gary Francione at the University of Rutgers Law School called this phenomenon "moral schizophrenia" (Francione 2000). Since animals have physical features such as nerve systems, thereby defining them as sentient, they also have an interest to continue their lives, are able to experience suffering and death as humans do and therefore deserve the right not to be treated as exploitable property (Francione 2000; Francione and Garner 2010).

Animals are often seen as inferior based on the notion that animals appear, think and communicate differently than humans. Yet, considering the definition of necessity and what is justifiable (Francione 2000), these distinctions do not justify the pain and suffering humans inflict on animals. To facilitate the suffering and death of animals, the practice of "othering", making humans and other groups (e.g. humans or non-humans) different, is used (DeMello 2012). By doing so, this support the perception of class differences and inferiority based on certain characteristics, thereby excluding "others" from the natural rights given to humans (DeMello 2012). Examples in the past of "othering" consist of slavery, racism and sexism, which were widely accepted and, through civil rights movements, are no longer perceived as acceptable. Coined by Sanders and Arluke (1996), "boundary work" is the act of creating boundaries between types of beings (Arluke and Sanders 1996). Drawing a parallel to the German Nazi regime, Nazis made boundaries between the Aryan race and Jews and Gypsies. This was done by animalizing the Jews, therefore seeing them as inferior, as animals were and still are perceived by the masses (DeMello 2012).

The human behavior concerning the consumption of animal products is inconsistent with other practices (e.g. ownership of pets), however is understandable. The consumption of animal protein is a part of the mainstream behaviors in western society and being a part of such a system makes objectively questioning the "norm" difficult. Since it has nearly always been common practice to accept the infliction of suffering on animals for millennia, the perception that animals are inferior beings found its way into human language (Kappeler

1995). Terminologies such as stupid cow, chauvinist pig, filthy pig, chicken, fat cow, etc. are all examples of discriminatory expressions used for the purpose of "othering".

It can also be difficult to question a system when one has limited knowledge about it (Richmond 1987). Many people have little understanding of how animals are reared and processed for food as well as the inhumane and unsanitary conditions that are created when producing animal products (Eisnitz 2006). Retail markets make sure that animal products are displayed in a way that hides the life that had once lived. Also, public confusion about animal exploitation has increased due to animal welfare organizations which have made people believe that animal products can be produced humanly which according to Francione (1996) is never the case.

9.2.2 Health

The consumption of animal protein products causes many negative effects on human health and is a motive for consumers to avoid consuming meat and animal products. Cardiovascular diseases (CVDs), the leading cause of death in the US followed by cancer, have been strongly linked to the consumption of animal products, especially red meat. In 2010, 24% of all deaths were caused by CVDs and 23% were caused by cancer (U.S. Department of Health and Human Services 2010). These figures are also representative of New York City (New York State Department of Health 2010). Current research suggest that dietary L-carnitine in red meat promotes CVDs (Koeth *et al.* 2013).

On the contrary, the consumption of a diverse plant-based diet comprised of fruits, vegetables, whole grains, legumes and nuts has shown to lower the mortality risk from CVD's significantly (DeRose *et al.* 2000; Hu 2003; Key *et al.* 1999; Norouzy *et al.* 2011). Individuals consuming a diverse plant-based diet have a lower total serum cholesterol concentration than individuals consuming a non-vegetarian diet (Key *et al.* 1999). High serum cholesterol concentrations in individuals are believed to be one of the main causes of heart diseases (Key *et al.* 1999).

Another incentive to eat a diverse plant-based diet is that individuals following such a diet are likely to live longer (Key *et al.* 1999). A diverse plant-based diet is know to be low in fat and energy density, which helps to prevent problems such as weight gain and obesity (Hill and Peters 1998) and reduce the risk of cancer. Various studies concluded that the risk of cancer of the oral cavity and pharynx can be drastically reduced by simply consuming legumes such as lentils or beans (Aune *et al.* 2009). Also, fresh and dried mushrooms have shown to decrease the risk of breast cancer (Zhang *et al.* 2009).

It is important to stress that a healthy plant-based diet must be diverse and comprised largely of fruits, vegetables, legumes, whole grains, nuts, etc. This is essential to avoid vitamin B-12 deficiency, which is common among elderly due to malabsorption and can lead to neurologic problems and anemia (Allen 2009; Bor *et al.* 2010). Vitamin B-12 is synthesis by both microorganisms in the soil and the intestines of animals and is needed in the human body for cell production and neurologic purposes (Bor *et al.* 2010; Campbell *et al.* 2006). Individuals who eat a monotonic processed plant-based diet can develop vitamin B-12 deficiency over time (Bor *et al.* 2010).

Also, nutrient-poor soil does not provide enough vitamin B-12 to be absorbed by plants (Campbell *et al.* 2006). Hence, plants growing in nutrient poor soils often lack vitamin B-12. Beside plant-based foods that are grown in nutrient rich soils, fortified foods (such as cereals) and supplements can be an important source of vitamin B-12 (Allen 2009; Campbell *et al.* 2006). Overall a diverse nutrient-rich plant-based diet has many great health benefits and has proven to significantly lower the risk of deadly and chronic diseases (Campbell et al. 2006; Hu 2003).

Despite food safety regulations, contaminated meat is another frequently occurring problem. Just recently, the well-respected consumer magazine "Consumer Reports" analyzed ground meat from turkey and found out that more than 90% of all tested samples were contaminated. Among the most common germs were fecal bacteria such as *Enterococcus* and *Escherichia coli* (E.coli) as well as *Salmonella* and *Staphylococcus aureus* (Consumer Reports 2013a). In addition, other meat types have also been reported to threaten human health due to bacteria contamination. For instance, the dangerous pathogen *E.coli* O157:H7 has caused severe illnesses and death (Consumer Reports 2013b). For years, *E.coli* O157:H7 has been the only bacterium regulated by the Food Safety and Inspection Service (FSIS) under the Federal Meat Inspection Act (FMIA) in trimmed beef (U.S. Department of Agriculture 2012c). However in 2012, the FSIS decided to test trimmed beef for six additional strains of *E.coli* (U.S. Department of Agriculture 2012d).

The problem still remains that, even though is that trimmed beef is tested for dangerous *Escherichia* bacteria in the slaughter facility, "intact" meat cuts such as steaks are not (U.S Department of Agriculture 2013). Meaning if a raw intact beef cut harbors dangerous pathogens and either a retail market or the consumer produces their own ground beef, dangerous pathogens can be consumed. The danger of food born disease in meat occurs as soon as pathogens are relocated from the surface of meat cuts into the interior (U.S Department of Agriculture 2013). This can happen when machines are used to tenderize meat by penetrating needles or small blades through the meat cuts (Consumer Reports 2013b). Also, steaks that are made of pieces of beef by applying transglutaminase enzymes (TG enzyme) as a binder (know as "meat glue") are at risk for *E. coli* contamination (Code of Federal Regulations 2011). By law, products that were created using "meat glue" need to be labeled. In practice however, this is difficult to enforce if foodservice operators used transglutaminase enzymes to create steaks and serve it to their customers.

Another health problem associated with consumption animal products are the threats they pose to medical treatment. Due to the vast application of drugs during animal production many pathogens on meat are resistant to common antibiotics used in modern medicine (Consumer Reports 2013a; Mellon *et al.* 2001; Phillips *et al.* 2004; Steinfeld *et al.* 2007).

9.2.3 Environment

The environmental impacts caused by livestock production are great. The water and atmospheric pollution as well as severe land degradation and biodiversity loss are only some problems caused by livestock production. It is important to reflect on the idea that the natural environment is not something "out there" (Shellenberger and Nordhaus 2005), nor is it something that competes with human desires. The natural environment is directly linked with the well-being of human society. What serves human society will inevitably serve the environment and vice versa. The production of livestock not only causes horrendous suffering and pain for animals, it also harms the environment and hence causes a wide range of problems for human beings. Particularly individuals residing nearby animal production facility experience severe environmental problems that are often linked to serious health concerns (Muehling 1970; Robbin 2001).

The leakage of pathogens from animal production facilities into the groundwater threatens public health (Robbin 2001) as well as "manure lagoons". The storage of animal feces and urine in "manure lagoons" as well as the distribution of manure has been reported to have harmful effects on the communities nearby. Manure spraying and manure lagoons emit a wide variety of different gases such as ammonia, hydrogen sulfide, carbon dioxide and methane (Muehling 1970; Robbin 2001). Hydrogen sulfide is especially threatening for humans since it is associated with adverse health effects such as comas, seizures and death (Frey *et al.* 2000). To give an example, in 1998, the emitted hydrogen sulfide from manure pits caused the death of 19 people (Robbin 2001).

9.3 Resistance

The proposed transformation of the current unsustainable animal protein consumption system will have great impact on various stakeholders. Not only will meat consumers have to change their patterns of behavior, but the meat packers and processors as main profiteers of the current system will have to do so as well. This will most likely result in an aggressive opposition to a change toward a sustainable plant-based protein consumption system. However, this is not surprising and to be expected since the proposed transformation will lead to the collapse of their very own business model.

One of the main tools for stakeholders opposing the proposed vision will be lobbying Fortunately, since the future vision focuses on the consumer, lobbyists will only be able to influence the consumer's decisions in a limited way. Some tactics may involve counter marketing campaigns to encourage the consumption of meat and animal products through encouragement or fear-based messages initiated by the different trade organization representing and lobbying for the stakeholders involved in the animal protein industry such as: the American Meat Institute (AMI), American Feed Industry Association, Livestock Marketing Association, National Cattlemen's Beef Association, National Chicken Council, National Grain and Feed Association, National Meat Association, National Renderers Association and the National Turkey Federation since they are powerful and well connected in the political arena. The American Meat Institute describes its mission as follows: "…AMI keeps its fingers on the pulse of legislation, regulation and media activity that impacts the meat and poultry industry…" (American Meat Institute 2013b).

Over the past 50 years, key actors that represent the meat industry were able to establish strong bonds with important decision makers within the USDA. These actors have shown to be very influential. For instance, in the past, the introduction of stricter food safety regulations were stopped by the meat industry (Johnson 2002). Thus, key actors in the animal protein industry will try to continue to remain influential within the USDA, which is also responsible for shaping and publishing dietary guidelines such as “MyPlate” and “MyPyramid” (U.S. Department of Agriculture 2013b). These very influential food guidelines are not just used to inform individual consumers about healthy food choices, but also to regulate the nutrition content served at public schools. Yet still, these dietary guidelines, due to such corporate influence, promote the consumption of animal proteins against scientific evidence that suggests animal proteins are unhealthy. Some level of meat consumption may not pose significant risks to health, however the environmental costs far outweigh the potential benefits of animal proteins that can easily be supplemented by a healthy plant- diet.

Interestingly, many actors, which currently work for the meat lobby, have previously worked for the USDA. For instance, powerful actors such as J. Patrick Boyle (President and CEO of AMI), James Hodges (Executive Vice President) as well as Mark Dopp (Senior Vice President) along with others in the American Meat Institute have all previously worked for the USDA (American Meat Institute 2013a). These individuals are well connected and aim to protect the interests of their clients. In addition, former members of Congress as well as congressional and executive staffers are commonly hired by lobbyist associations to lobby on the industry’s behalf (Food & Water Watch 2012).

In the 2008 Farm Bill, different trade associations involved in the animal protein production industry (National Milk Producers Federation, Dairy Foods Association.; Livestock Marketing Association.; National Cattlemen’s Beef Association.; National Meat Association) hired former House Agriculture Committee Chairman and Ranking Member Larry Combest (R-Texas) and Charlie Stenholm (D-Texas) to lobby for their interests (Food & Water Watch 2012). Larry Combest received $1.45 million and Charlie Stenholm $1.25 million for lobbying on this bill. These individuals were also in charge of the earlier 2002 Farm Bill.

Another former Members of Congress, Sen. John Breaux (D-LA) received $37,000 for his lobbying activates (Food & Water Watch 2012).

It can be assumed that the actors working for the meat industry will use their influence in the political arena to work against the proposed vision. Lobbyists are and will be a major part of movement to sustain the current consumption scheme. There is no doubt that during the transformation, these beneficiaries of the current system will try to encourage or scare consumers to purchase various animal protein products through an advertisement campaign. The argument that animal derived products are healthy and the avoidance of consuming animal protein is dangerous will be used to intimidate consumers. Stakeholders such as the rendering industry or large cattle farmers that rely on the exploitation of animals will also aggressively oppose change. However, farmers will not necessarily resist if incentives are put in place to encourage the cultivation of crops for human consumption.

Overall, since the consumer will initiate the transformation by reducing the demand for meat and animal products, the new system will become more resistant to returning to the old unsustainable pattern of behavior compared to other possible paths towards transformation (e.g. animal welfare regulations). Lobbyists and the industry may try to influence the demand when sales drop but they will not be able to completely stop the transformation from occurring since the decision lies with the consumer and their free will.

As the moral, health and environmental benefits from avoiding animal protein products become well known, more skeptical consumers will become convinced that a plant-based diet is desirable. At this point in the transformation, the consumers' drive for a state of well being for both the environment and human health will facilitate the stabilization of the new system by shedding positive light on plant-based diets and all of the associated benefits.

10. ACTION PLAN

As described previously, the most effective change towards the proposed future vision should come from the most influential actor: the consumer. For this to happen, the consumer's pattern of behavior must be altered. Just between 3 and 5% of students, teachers, professors, politicians, workers, journalists, managers, etc. need to be convinced to start a broad movement (Welzer 2013). According to the 2012 National Harris Poll, approximately 1%, 3 million, Americans do not eat meat, fish, seafood, poultry, or eggs (Vegetarian Resource Group 2012).

Most individuals usually associate a certain pattern of behavior with their role. However, there is much diversity within the pattern of behavior that an individual follows. The role of the individual consumer is essentially to meet personal needs by consuming, as an individual or for a family, but the choices of how to do this are diverse (Corliss 2013). The diversity can be referred to more generally as the individual's script (Corliss 2013). An individual's script is commonly shaped by experiences, motivations and values. It is the personal way in which an individual makes decision within its own psychological e.g. make up whether to buy animal proteins or not (Corliss 2013). Hence, within this reality created by the individual, is the "form for action" (Peterson 1999), In other words, the choice of actions is based on one's perceptions. Luckily, personal scripts can be influenced and changed. Actors, being individuals, are subject to these psychological principles therefore when change occurs their scripts inevitably evolve over time.

The system will change as soon as individuals change their personal scripts. In general, this applies to all actors within the current animal protein system, but as described, the focus should be placed on changing the scripts of consumers. To accomplish the proposed transformation of the current system the following described actions need to be carried out.

10.1 Education

To achieve the proposed sustainable future vision for NYC and beyond, it is crucial to teach individuals about the moral, health and environmental problems caused by the consumption of animal proteins and to emphasize the benefits of a plant-based diet.

10.1.1 Teaching institutions

Young individuals are the future generations of consumers and decision makers that need to be introduced to nutrition education based on scientific evidence as well as topics such as food production and food preparation with a clear focus on plant-based diets. It is most important that future generations are healthy and aware of the linkages between them and the environment to achieve the proposed future vision. Food is currently not integrated as an mandatory topic in public school curriculums in NYC (Stringer 2010). Hence, food and gardening should be an important part in the curriculums of schools. This extra curriculum could be integrated into current classes such as biology, chemistry, environmental sciences, health education, etc. Although not mandatory, institutions such as the Edward A. Reynolds West Side High School are at the forefront of teaching students about cooking and gardening in cooperation with external organizations such as HealthCorps, a national peer mentor program (Cohen et al. 2012). HealthCorps provides funding for a full time Coordinator who teaches students about important issues such as fitness and health (Foster pers.comm.). Such examples show, that basic nutrition education can already be included into NYC school curriculums.

A tool towards a healthy, environmentally and morally aware student body could be the daily school lunch served in public schools. The NYC Department of Public Health designs lunch menus and ensure that approximately 850,000 meals are served daily to students in public schools throughout the City (NYC Department of Education 2012). Animal proteins are served every single school day; hence, change towards a plant-based diet would have a positive impact on young individuals. This could be implemented by the NYC Department of Public Health since it is in charge of all school menus throughout the City. However, schools themselves also have the power to alter student lunch menus, as long as the nutritious values are in compliance with those given from the USDA. For instance, Public School 244 in NYC announced recently that it is the first public school in the US to serve only vegetarian meals to their students at no additional cost (Brady 2013; Chumley 2013). This decision made by the principal of PS 244 to go all-vegetarian can be replicated at other schools in NYC by making small steps from one day of the week designated to serving vegetarian meals working up to all five days serving vegan meals. This requires working closely with the students to test meals and gather feedback as well as the City's education department food program to ensure that the meals met USDA standards (Brady 2013). As a result of the positive outcome from PS 244 decision to go vegetarian, New York City's Department of Education hopes that now other schools will consider doing the same.

10.1.2 Personal action plan

The creation of this thesis is part of my own personal action plan to inform citizens of NYC and the general public about the unsustainable animal protein production and consumption system. The proposed future vision provides an alternative path of how sustainable protein consumption can change the world for the better. This thesis will be made easily accessible on a homepage and available to download. Downloaders will be asked to share this paper with a least five friends or colleagues. Then, feedback will be collected to serve as a forum for action. Slideshows, illustrations, videos will also be created from the information gathered in this thesis. The STELLA models in particular will be transformed into different forms of art to inform the broader public in NYC and elsewhere. Social media will also be used.

Influential individuals such as educational program managers from non-profit organisations such as HealthCorps will be invited to use this thesis for educational purposes. This thesis hopes to contribute to the spread of non-violence by providing a vision and feasible actions that help make the change from a horrendous food system based on unsustainable animal exploitation towards a food system that is sustainable, healthy and morally justifiable.

10.2 Urban Agriculture Policies for NYC

Although it's unlikely that regulatory actions will be taken to reduce animal protein consumption on a national or city level, policies could be introduced by the City Council to facilitate the transformation to a plant-based diet by promoting urban agriculture. This idea to promote the urban agriculture movement has already been proposed by the Manhattan Borough President Scott M. Stringer (2010). Current institutional farms and gardens (in total 362) as well as community farms and gardens (in total 397) are important for educating both students and the general public and strengthening local communities. Such facilities as well as commercial farms (in total 3) (Fig.13) have the potential to contribute to the local food supply in NYC but are currently not supported through policies in NYC (Cohen *et al.* 2012; Stringer 2010). By bringing urban agriculture to the Mayor's agenda, policies could be implemented to facilitate it's growth such as allocating community gardens and city parks for growing food and creating incentives to encourage small-scale urban farming communities to develop rooftop gardens.

Fig. 13. Commercial rooftop farm in NYC. Source: Seth Wenig/AP/Corbis, 2012.

It has been estimated that approximately 5,000 acres of vacant public land could be used for food production in NYC. By applying high yield production technologies approximately 170,000 individuals could be supplied with plant-based foods (Plunz *et al.* 2012). In addition approximately another 5,000 acres of rooftops in NYC are suitable for rooftop farming (Plunz *et al.* 2012). Backyard space could also be utilized to produce plant proteins. Approximately 52,000 acres of backyard space are available with the potential to provide vegetables for 700,000 people (Stringer 2010). Since conventional agriculture is very inefficient in terms of yield production per hectare and only efficient in terms of production in terms of labor (Eisenstein 2011), high yield (labor) intensive urban agricultural could play and important role for the local food production in NYC. Farmers markets could serve as distribution hubs for vegetables and fruits harvested from urban agricultural sites.

To make use of the given potentials in NYC, it is important that the City Council passes laws to facilitate urban agriculture in NYC. Future policy should address issues such as (Cohen *et al.* 2012; Plunz *et al.* 2012; Stringer 2010):

- Preservation of public community parks so that they are not sold to investors when a new Mayor with different interests is elected.
- Creation of urban agricultural programs to promote the cultivating of fruits and vegetables by providing financial support to supply interested groups (e.g. after-school clubs and community projects) with the necessary tools to maintain the gardens.
- Encouraging the use of rooftops for food production by eliminating current bureaucratic restrictions such as floor to area ratio (FAR) restrictions under NYC zoning laws. Currently, FAR is the limiting factor for whether or not buildings are able to develop their roofs for greenhouses (Plunz *et al.* 2012). By eliminating such regulations applied to greenhouses, more buildings would be able to have rooftop gardens.

Overall, urban agriculture could and should serve as a tool to facilitate the movement towards a sustainable plant-based food system in NYC.

10.3 Rootstrikers Project

As a more long term plan of action to achieve the full transformation for the future vision of 2040 as well as to make social progress, corporate influence within Congress must be stopped (Lessig 2011). Currently, corporate influence controls the Congress through lobbyists and will not allow for the current unsustainable protein production and consumption system to be completed transformed. The political systems do not work to protect the population from unhealthy and environmentally damaging eating habits (Lessig 2011), instead they work to increase profits. Congress is greatly influenced by lobbying groups (e.g. AMI) and their campaign contributions, this relationships weakens the US democracy. The amendment of the current campaign contribution scheme as proposed by Prof. Lawrence Lessig would be a big step towards removing these misaligned interests and would make the complete transformation of the protein system possible. In summary, Lessig suggests voluntary "small dollar funded elections" (Lessig 2011). Candidates for Congress would be given the opportunity to fund their campaigns through small campaign contributions up to $100 granted by individuals. By doing so, the corrupt element of corporate campaign funding that corrupts politics could be removed (Lessig 2011). For example, if such a reform were to take place, the corn subsidy policies, working in favor of large animal protein producers, could be more easily removed and thus help restore the production costs of animal proteins to their natural state. As a result, plant and animal proteins would compete on fairer grounds by removing the governmental aid that helps produce animal proteins cheaper.

11. CONCLUSION

The transformation of the current unsustainable protein system into a functional future system is possible and necessary. Change towards a diverse plant-based diet would solve many urgent issues, such as alarming environmental problems as well as serious health concerns society as a whole faces today. Most importantly, the infliction of pain and death on billions of animals would gradually come to an end as a result of eradicating the consumption of animal derived products.

Various hurdles have to be overcome to achieve this proposed future vision. Corporations have gained increasingly more power over the political system through lobbying driven by profit motives. These beneficiaries of the status quo will strongly oppose change towards a sustainable plant-based protein production and consumption system. However, considering that most beneficiaries are capitalists, they will eventually move their capital investment elsewhere if demand for animal protein products cease to exist.

The STELLA model of the current system maps its dynamics in totality, and as a result clearly shows that consumers, not regulators, are a crucial intervention point where change should occur. Fortunately, the beneficiaries of the current system have less control over the consumers than they do over any other influential actor (i.e. regulators) throughout the system. Therefore, the consumers are a highly qualified actor to lead the way to achieve the future vision.

Awareness of the moral, environmental and health issues associated with animal products should be a goal made to inform consumers, thereby altering their scripts. By creating awareness and transferring knowledge to the consumer, human decisions and actions can be influenced (McEachern and Warnaby 2008). On the other hand, ignorance to important issues can hinders the consumers' ability to exercise their rights. According to Ishak and Zabil (2012), awareness is much more to drive consumers to act compared to knowledge. Knowledgeable consumers about the details of a system do not necessarily act rationally. Rather, it is more beneficial for them to understand how their decisions affect the system so that they can act accordingly. Therefore, by increasing the awareness of consumers' impact on moral, environmental and health issues resulting from the current protein system, the scripts of aware individuals will be altered (and likely of those around them through communication) and thus result in more rational decisions on the consumption of meat and animal products.

Only a small fraction of a population interested in a cause is needed to start a movement, as has been proven time and time again in the past. This small change can grow and catapult cities such as NYC to create a new domain of non-violence towards non-humans. Such a movement would be based on rational expectations such as good health, environmental stability and moral awareness.

People are already beginning to understand that change towards a plant-based diet is necessary. Schools in NYC are starting to explore the benefits of nutrition education and healthy foods, and urban agriculture is becoming increasingly more attractive for its benefits to health, environment and lifestyle. However, it is important to carry out more research on how to create mass awareness of consumers' power over the current protein system so that individuals are effectively informed with appropriate information about their behaviors even when it opposes their current scripts.

It is important that change toward a plant-based diet will happen soon. By doing so, the human species could experience entering a new level of "spiritual" development where their collective patterns of behavior are a result of their own individual conscious choices, shaping the world around them. This new beginning would also help pave the path towards non-violence for generations to come.

References

Allen, L. H. 2009. How common is vitamin B-12 deficiency? *The American Journal of Clinical Nutrition* 89 (2): 693S-696S.

American Meat Institute. 2013a. AMI Staff. American Meat Institute. URL: http://www.meatami.com/ht/d/sp/i/237/pid/237. [cited 15 May 2013].

________. 2013b. FAQs: What is the American Meat Institute (AMI)? American Meat Institute. URL: http://www.meatami.com/ht/d/Faqs/pid/233. [cited 15 May 2013].

Amine, E., Baba, N., Belhadj, M., Deurenbery-Yap, M., Djazayery, A., Forrester, T., Galuska, D., Herman, S., James, W. and Mbuyamba, J. 2002. *Diet, Nutrition and the Prevention of Chronic Diseases*. Geneva: W. H. Organization.

Arluke, A. and Sanders, R. C. 1996. *regarding animals*. Philadelphia: Temple University Press.

Aune, D., Stefani, E., Ronco, A., Boffetta, P., Deneo-Pellegrini, H., Acosta, G. and Mendilaharsu, M. 2009. Legume intake and the risk of cancer: a multisite case–control study in Uruguay. *Cancer Causes & Control* 20 (9): 1605-1615.

Barboza, D. and Sorkin, R. A. 2001. Tyson to Acquire IBP in $3.2 Billion Deal. *New York Times* (New York City), 2 Jan.

Baroni, L., Cenci, L., Tettamanti, M. and Berati, M. 2006. Evaluating the environmental impact of various dietary patterns combined with different food production systems. *European Journal of Clinical Nutrition* 61 (2): 279-286.

Barron, M., Goldblatt, B., Ho, C., Hudson, R., Kaplan, D., Keberle, E., Naumoff, C., Perlmutter, C., Suttile, Z., Thorsteinson, C., Tsien, D., Wild, L. and Wilson, M. 2010. *Understanding New York City's Food Supply*. New York: Columbia University.

Biesalski, H. K. 2005. Meat as a component of a healthy diet - are there any risks or benefits if meat is avoided in the diet? *Meat Science* 70 (3): 509-24.

Bloomberg Businessweek. 2013. Financial Statements For Jbs Sa (JBSAF). Bloomberg L.P. URL: http://investing.businessweek.com/research/stocks/financials/financials.asp?ticker=JBSAF&dataset=incomeStatement&period=A&currency=US Dollar. [cited 19 April 2013].

Bor, M. V., von Castel-Roberts, K. M., Kauwell, G. P., Stabler, S. P., Allen, R. H., Maneval, D. R., Bailey, L. B. and Nexo, E. 2010. Daily intake of 4 to 7 µg dietary vitamin B-12 is associated with steady concentrations of vitamin B-12–related biomarkers in a healthy young population. *The American Journal of Clinical Nutrition* 91 (3): 571-577.

Bowen, G. A. 2009. Document Analysis as a Qualitative Research Method. *Qualitative Research Journal* 9 (2): 27-40.

Brady, B. 2013. New York school goes all-vegetarian. Cable News Network. URL: http://edition.cnn.com/2013/05/02/health/new-york-vegetarian-school. [cited June 15 2013].

Burnham, F. 1978. *Rendering: The Invisible Industry*. Fallbrook, CA: Aero Publishers.

Cactus Feeders. 2013. History of Cactus Feeders. Cactus Feeders, Inc. URL: http://www.cactusfeeders.com/history.html. [cited 2 January 2013].

Campbell, T. C., Campbell II, T. M. and Lym, H. 2006. *The China Study*. Dallas, TX: Benbella Books.

Cargill. 2012. *Annual Report*. Minneapolis, MN: Cargill Inc.

________. 2013a. Brands. Cargill Inc. URL: http://www.cargillmeatsolutions.com/brands/tk_cms_brands.htm. [cited 7 April 2013].

________. 2013b. Five major business segments. Cargill Inc. URL: http://www.cargill.com/company/businesses/index.jsp. [cited 1 February 2013].

Cargill Meat Solutions. 2012. At a glance: Financial highlights. Cargill Inc. URL: http://www.cargill.com/company/glance/index.jsp. [cited 19 April 2013].

________. 2013a. North American Beef Facilities. Cargill Inc. URL: http://www.cargillmeatsolutions.com/about_us/tk_cms_about_loc_beef.htm. [cited 5 February 2013].

________. 2013b. Locations - Facilities across North America maximize flexibility. Cargill Inc. URL: http://www.cargill.com/company/businesses/cargill-beef/locations/index.jsp. [cited 1 January 2013].

Central Intelligence Agency. 2013. *The World Factbook 2013-14*. Washington, D.C.: Directorate of Intelligence.

Chiuve, S. E. and Willett, W. C. 2007. The 2005 Food Guide Pyramid: an opportunity lost? *Nature Clinical Practice Cardiovascular Medicine* 4 (11): 610-620.

Chumley, C. K. 2013. Where's the beef? Bloomberg launches vegetarian-only school lunch. *The Washington Times* (Washington, D.C.), 1 May

Churchland, P. S. 2011. *braintrust: What Neuroscience Tells Us about Morality*. Princeton: Princeton University Press.

Human Slaughter of Livestock 9 C.F.R. 313.1 - 90. 1979. *Office of the Federal Register*

EPA Administered permit program: The national pollutant discharge elimination system

40 C.F.R. Part 122, App. B. 2008. *Office of the Federal Register*.

Chapter III: Food Safety And Inspection Service, Department Of Agriculture: Subchapter A: Agency Organization And Terminology; Mandatory Meat And Poultry Products Inspection And Voluntary Inspection 9 C.F.R. Part 317.8. 2011. *Office of the Federal Register*.

Cohen, N., Reynolds, K. and Sanghvi, R. 2012. *Five Borough Farm:Seeding the Future of Urban Agriculture in New York City*. New York: Design Trust for Public Space.

Compa, L. 2004. *Blood, Sweat, and Fear: Workers' Rights in U.S. Meat and Poultry Plants*. New York: Human Rights Watch.

Consumer Reports. 2013a. *Talking turkey.* New York: Consumers Union.

________. 2013b. *Buying beef? Read this first.* New York: Consumers Union.

Cook, T. 2012. Overview of North American Rendering Industry, NRA and WRO. National Renderers Association. URL: http://www.nationalrenderers.org/events/ipe-seminar-2012-presentations/. [cited 11 April 2013].

Corliss, J. B. 2013. The Systems Dynamics of the Transformation to Sustainability. URL: http://www.collectivedynamics.org. [cited 14 December 2012].

D'Silva, J. and Webster, J. 2010. *The Meat Crisis: Developing More Sustainable Production and Consumption*. London: Earthscan.

Darling International. 2011. *Annual Report*. Irving, TX: Darling International Inc.

DeMello, M. 2012. *Animals and Society: An Introduction to Human-Animal Studies*. New York: Columbia University Press.

DeRose, D. J., Charles-Marcel, Z. L., Jamison, J. M., Muscat, J. E., Braman, M. A., McLane, G. D. and Keith Mullen, J. 2000. Vegan Diet-Based Lifestyle Program Rapidly Lowers Homocysteine Levels. *Preventive Medicine* 30 (3): 225-233.

Eisenstein, C. 2011. *Sacred Economics: Money, gift, and society in the age of transition*. Berkeley: Evolver Editions.

Eisnitz, G. A. 2006. *Slaughterhouse: The Shocking Story of Greed, Neglect, and Inhumane Treatment Inside the U.S. Meat Industry*. New York: Prometheus Books.

Elferink, E. V., Nonhebel, S. and Moll, H. C. 2008. Feeding livestock food residue and the consequences for the environmental impact of meat. *Journal of Cleaner Production* 16 (12): 1227-1233.

Eshel, G. and Martin, P. A. 2009. Geophysics and nutritional science: toward a novel, unified paradigm. *The American Journal of Clinical Nutrition* 89 (5): 1710S-1716S.

ETC Group. 2008. *Who Owns Nature?: Corporate Power and the Final Frontier in the Commodification of Life*. Ottawa: ETC Group.

Feedstuffs. 2012. *Feedstuffs Reference Issue & Buyers Guide*. Minnetonka, MN: Miller Publishing Company.

________. 2013. *Feedstuffs Reference Issue & Buyers Guide*. Minnetonka, MN: Miller Publishing Company.

Fernandez-Cornejo, J. 2004. *The Seed Industry in U.S. Agriculture: An Exploration of Data and Information on Crop Seed Markets, Regulation, Industry Structure, and Research and Development*. Washington, D.C.: United States Department of Agriculture: Economic Research Service.

Feskanich, D., Willett, W. C. and Colditz, G. A. 2003. Calcium, vitamin D, milk consumption, and hip fractures: a prospective study among postmenopausal women. *The American Journal of Clinical Nutrition* 77 (2): 504-511.

Feskanich, D., Willett, W. C., Stampfer, M. J. and Colditz, G. A. 1997. Milk, Dietary Calcium, and Bone Fractures in Women: A 12-year Prospective Study. *American Journal of Public Health* 87 (6): 992-997.

Fiala, N. 2008. Meeting the demand: An estimation of potential future greenhouse gas emissions from meat production. *Ecological Economics* 67 (3): 412-419.

Food & Water Watch. 2007. Factory Farm Map. Food & Water Watch. URL: http://www.factoryfarmmap.org. [cited 1 May 2013].

________. 2012. *Cultivating Influence: The 2008 Farm Bill Lobbying Frenzy*. Washington, D.C.: Food & Water Watch.

Food and Agriculture Organization of the United Nations. 2011. FAOSTAT: FAO Statisitcal Database. Statistics Division. URL: http://faostat.fao.org/site/569/DesktopDefault.aspx?PageID=569 - ancor. [cited 2 April 2013].

foodservice.com. 2013. Top 50 Foodservice Distributors foodservice.com. URL: http://www.foodservice.com/foodshow/restaurant-distributors.cfm. [cited 1 April 2013].

Forrester, J. W. 1968a. Industrial Dynamics - A Response to Ansoff and Slevin. *Management Science* 14 (9): 601-618.

________. 1968b. Industrial Dynamics-After the first Decade. *Management Science (pre-1986)* 14 (7): 398-398.

________. 2009. Some Basic Concepts in System Dynamics. Sloan School of Management. Massachusetts Institute of Technology. Cambridge, MA.

Foster, C., Green, K., Bleda, M., Dewick, P., Evans, B., A., F. and Mylan, J. 2006. *Environmental Impacts of Food Production and Consumption: A report to the Department for Environment, Food and Rural Affairs.* London: Manchester Business School.

Francione, G. L. 1996. *Rain without Thunder: The ideology of the Animal Rights Movement*. Philadelphia: Temple University Press.

________. 2000. *Introduction to Animal Rights: Your Child or the Dog?* Philadelphia: Temple University Press.

Francione, G. L. and Garner, R. 2010. *The Animal Rights Debate: Abolition or Regulation?* New York: Columbia University Press.

Frassetto, L. A., Todd, K. M., Morris, R. C. and Sebastian, A. 2000. Worldwide Incidence of Hip Fracture in Elderly Women Relation to Consumption of Animal and Vegetable Foods. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences* 55 (10): M585-M592.

Frey, M., Hopper, R. and Fredregill, A. 2000. *Spills and Kills: Manure Pollution and America's Livestock Feedlots*. Washington, D.C.: Clean Water Network.

Fusaro, D. 2012. *Food Processing: Top 100.* Itasca, IL: Larry Bagan.

Gates, J., Ballard, K., Becker, M., Perry, B., Vandenberg, M., Voss, K. and Schmitt, W. A. 2007. *Industry Perspective: Feedlot*. Spokane, WA: Northwest Farm Credit Services.

Ghoshal, S. 2005. Bad Management Theories Are Destroying Good Management Practices. *Academy of Management Learning & Education* 4 (1): 75-91.

Gifford, K. D. 2002. Dietary Fats, Eating Guides, and Public Policy: History, Critique, and Recommendations. *The American Journal of Medicine* 113 (9, Supplement 2): 89-106.

Gillespie, J. R. and Flanders, F. B. 2009. *Modern Livestock and Poultry Production*. 8th Edition. Clifton Park, NY: Cengage Learning.

Glatz, P. and Bolla, G. 2004. Production Systems Poultry. In *Encyclopedia of Meat Sciences,* ed. J. Editor-in-Chief: Werner Klinth, 1085-1092. Oxford: Elsevier.

Goldstein, D. J. and Pearso, M. 2007. JBS Owner J&F to Buy Swift, Create Largest Meat Maker. Bloomberg L.P. URL: http://www.bloomberg.com/apps/news?pid=newsarchive&sid=a1PzFx13ZBL4. [cited 6 April 2013].

Goodland, R. and Anhang, J. 2009. *Livestock and Climate Change. What if the key actors in climate change were pigs, chickens and cows?* Washington, D.C.: Worldwatch Institute.

Grandin, T. 2001. *Livestock Trucking Guide - Livestock Management Practices that Reduce Injuries to Livestock During Transport*. Kentucky, KY: National Institute For Animal Agriculture.

Greger, M. 2007. The Long Haul: Risks Associated with Livestock Transport. *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science* 5 (4): 301-312.

Gregory, N. G. 2004. Human Nutrition: Vegetarianism. In *Encyclopedia of Meat Sciences,* ed. J. Editor-in-Chief:¬†¬† Werner Klinth, 633-640. Oxford: Elsevier.

Hansen, P. I. E. 2004. Environmental Impact of Meat Production: Abattoirs and Processing Plants. In *Encyclopedia of Meat Sciences,* ed. J. Editor-in-Chief:¬†¬† Werner Klinth, 430-440. Oxford: Elsevier.

Hill, J. O. and Peters, J. C. 1998. Environmental Contributions to the Obesity Epidemic. *Science* 280 (5368): 1371-1374.

Hoekstra, A. Y. and Chapagain, A. K. 2007. Water footprints of nations: Water use by people as a function of their consumption pattern. *Water Resources Management* 21 (1): 35-48.

Hoffman, L., Baker, A., Foreman, L. and Young, C. E. 2007. *Feed Grains Backgrounder*. Washington, D.C.: US Department of Agriculture Economic Research Service.

Hoppe, R. A. and Banker, D. E. 2010. *Structure and Finances of US Farms: Family Farm Report, 2010 Edition*. Washington, D.C.: U.S. Department of Agriculture Economic Research Service.

House Committee on Agriculture. 2013. Issues: Farm Bill. House Committee on Agriculture. URL: http://agriculture.house.gov/farmbill. [cited 1 May 2013].

Hu, F. B. 2003. Plant-based foods and prevention of cardiovascular disease: an overview. *The American Journal of Clinical Nutrition* 78 (3): 544S-551S.

Ilea, R. C. 2008. Intensive Livestock Farming: Global Trends, Increased Environmental Concerns, and Ethical Solutions. *Journal of Agricultural and Environmental Ethics* 22 (2): 153-167.

Ishak, S. and Zabil, N. F. M. 2012. Impact of Consumer Awareness and Knowledge to Consumer Effective Behavior. *Asian Social Science* 8 (13): p108.

J. R. Simplot Company. 2013. Simplot Livestock Company. J. R. Simplot Company. URL: http://www.simplot.com/pdf/Simplot_Feedlot_Web_PDF.pdf. [cited 1 March 2013].

JBS Five Rivers. 2013. Locations. JBS Five Rivers Cattle Feeding LLC. URL: https://http://www.fiveriverscattle.com/locations/. [cited 2 January 2013].

JBS USA. 2013a. Beef brands - World's leading. JBS USA Holdings Inc. URL: http://www.jbssa.com/Brands/Beef/default.aspx. [cited 7 April 2013].

________. 2013b. Chicken brands - Quality. Taste. JBS USA Holdings Inc. URL: http://www.jbssa.com/Brands/Chicken/default.aspx. [cited 5 January 2013].

Johnson, S. 2002. The Politics of Meat: A look at the meat industry's influence on Capitol Hill. Frontline. URL: http://www.pbs.org/wgbh/pages/frontline/shows/meat/politics/. [cited 10 May 2013].

Kappeler, S. 1995. Speciesism, racism, nationalism... or the power of scientific subjectivity. In *Animals & Women: Feminist Theoretical Explorations,* ed. C. J. Adams and J. Donovan, 320-352. Durham: Duke University Press.

Key, N. and McBride, W. 2007. *The Changing Economics of U.S. Hog Production*. Washington, D.C.: US Department of Agriculture Economic Research Service.

Key, T. J., Fraser, G. E., Thorogood, M., Appleby, P. N., Beral, V., Reeves, G., Burr, M. L., J., C. C., Frentzel, B. R., Kuzma, J. W., Mann, J. and McPherson, K. 1999. Mortality in vegetarians and nonvegetarians: detailed findings from a collaborative analysis of 5 prospective studies. *The American Journal of Clinical Nutrition* 70 (3): 516s-524s.

Kiple, D. F. and Coneè, O. K. 2000. Proteins. In *The Cambridge World History of Food,* ed. D. F. Kiple and O. K. Coneè, Cambridge: Cambridge University Press, Grande-Bretagne.

Koeth, R. A., Wang, Z., Levison, B. S., Buffa, J. A., Org, E., Sheehy, B. T., Britt, E. B., Fu, X., Wu, Y. and Li, L. 2013. Intestinal microbiota metabolism of l-carnitine, a nutrient in red meat, promotes atherosclerosis. *Nature Medicine*

Kraft Foods. 2012. *Annual Report*. Northfield, Il: Kraft Foods Inc.

Lefferts, L., Kucharski, M., McKenzie, S. and Walker, P. 2006. *Feed for Food Producing Animals: A Resource on Ingredients, the Industry, and Regulation*. Baltimore, MD: Johns Hopkins Center for a Livable Future.

Lessig, L. 2011. *Republic, Lost: How Money Corrupts Congress-and a Plan to Stop It*. New York: Twelve Hachette Book Group.

Loftus, R. T. and Meghen, C. N. 2011. Tracing Meat Products through the Production and Distribution Chain Farm to Consumer. In *Microbial Forensics,* ed. B. Budowle, S. E. Schutzer, R. G. Breeze, P. S. Keim and S. A. Morse, 59-73. Burlington, MA: Academic Press.

Luna-Reyes, L. F. and Andersen, D. L. 2003. Collecting and analyzing qualitative data for system dynamics: methods and models. *System Dynamics Review* 19 (4): 271-296.

Marcotullio, P. J., Gadda, T. and Gasparatos, A. 2008. The Environmental Impact of Meat Consumption in New York and Tokyo. In 2008 International Forum of Global Environmental Change and Land Use Change in Peri-Urban Areas:Dialogue and Experience of Asian Cities, ed. Taiwan: IHDP Urbanization and Global Environmental Change.

McBride, W. and Mathews, K. 2011. *The Diverse Structure and Organization of U.S. Beef Cow-Calf Farms*. Washington, D.C.: US Department of Agriculture Economic Research Service.

McEachern, M. G. and Warnaby, G. 2008. Exploring the relationship between consumer knowledge and purchase behaviour of value-based labels. *International Journal of Consumer Studies* 32 (5): 414-426.

Meadows, D. H. 1996. Envisioning a Sustainable World. In Third Biennial Meeting of the International Society for Ecological Economics, ed. 117-26. San Jose,Costa Rica: Getting Down to Earth: Practical Applications of Ecological Economics, Island Press,.

Meadows, D. H. 2008. *Thinking in Systems: A Primer*. White River Junction, VT: Chelsea Green Publishing.

Meeker, D. L. 2006. *Essential Rendering*. Alexandria, VA: National Renderers Association.

Mellon, M., Benbrook, C. and Benbrook, K. L. 2001. *Hogging it: Estimates of antimicrobial abuse in livestock*. Cambridge, MA: Union of Concerned Scientists.

Millward, D. J. 1999. The nutritional value of plant-based diets in relation to human amino acid and protein requirements. *Proceedings of the Nutrition Society* 58 (02): 249-260.

Morecroft, J. 2010. System Dynamics. In *Systems approaches to managing change: a practical guide,* ed. M. Reynolds and S. Holwell, London: Springer.

Muehling, A. J. 1970. Gases and odors from stored swine wastes. *Journal of Animal Science* 30 (4): 526-531.

Nachman, K. E., Graham, J. P., Price, L. B. and Silbergeld, E. K. 2005. Arsenic: A Roadblock to Potential Animal Waste Management Solutions. *Environmental Health Perspectives* 113 (9): 1123.

New Oxford American Dictionary. 2010a. *"Protein". Oxford Dictionary*. New York: Oxford University Press.

________. 2010b. *"Bushel". Oxford Dictionary*. New York: Oxford University Press.

New York City Department of Health and Mental Hygiene. 2013. Restaurant Inspection Information. The New York City Department of Health and Mental Hygiene. URL: http://a816-restaurantinspection.nyc.gov/RestaurantInspection/SearchBrowse.do. [cited 13 March 2013].

New York State Department of Health. 2010. Leading Causes of Death, New York City, 2001-2010. Bureau of Biometrics and Health Statistics. URL: http://www.health.ny.gov/statistics/leadingcauses/leadingcauses_death/nyc_by_year.htm. [cited 10 May 2013].

Norouzy, A., Razavi, A. R., Sanders, T., Emery, P. and Leeds, A. 2011. Vegan diet improves cardiovascular risk factors compared to ominore diet. *Clinical Nutrition Supplements* 6 (1): 18.

NYC Department of City Planning. 2013. History - 1961 Zoning Resolution. URL: http://www.nyc.gov/html/dcp/html/zone/zonehis.shtml. [cited 15 June 2013].

NYC Department of Education. 2012. NYC School Food Services. Office of School Support Services. URL: http://www.opt-osfns.org/schoolfood/public1/page_view.aspx?id=254&g=6&v=. [cited 18 May 2013].

Peterson, J. B. 1999. *Maps of Meaning: The Architecture of Belief*. New York: Routledge.

Phelps, P. and Bryan, S. 2003. Automated identification of male layer chicks prior to hatch. *World's Poultry Science Journal* 59 (1): 33-38.

Phillips, I., Casewell, M., Cox, T., De Groot, B., Friis, C., Jones, R., Nightingale, C., Preston, R. and Waddell, J. 2004. Does the use of antibiotics in food animals pose a risk to human health? A critical review of published data. *Journal of Antimicrobial Chemotherapy* 53 (1): 28-52.

Pianaung, A. A. and Rudito, B. 2012. Human Motivation in Not-for-profit Organization; case Study Kebun Seni Taman Sari. *Journal of Business and Management* 1 (4):

Pimentel, D. and Kounang, N. 1998. Ecology of Soil Erosion in Ecosystems. *Ecosystems* 1 416–426.

Pimentel, D. and Pimentel, M. 2003a. World Population, Food, Natural Resources, and Survival. *World Futures* 59 (3-4): 145-167.

________. 2003b. Sustainability of meat-based and plant-based diets and the environment. *The American Journal of Clinical Nutrition* 78 (3): 660S-663S.

Plunz, R., Conard, M., Katz, R., Dahlgren, E. and Culligan, P. 2012. *The Potential for Urban Agriculture in New York City: Growing Capacity, Food Security, & Green Infrastructure*. New York: Columbia University.

Pollan, M. 2006. *The Omnivore's Dilemma: A Natural History of Four Meals*. New York: Penguin Group.

Pond, W. G. 2003. *Pig Production: Biological Principles and Applications*. Clifton Park, NY: Delmar Learning

Render. 2011. *Market Report 2010.* Camino, CA: Sierra Publishing.

Richmond, B. 1987. *Systems Thinking: Four Key Questions*. High Performance Systems Inc.

Robbin, M. 2001. *Cesspools of shame: how factory farm lagoons and sprayfields threaten environmental and public health*. Washington, D.C.: Natural Resources Defense Council and the Clean Water Network.

Runge, C. F. September 2002. *King Corn: The History, Trade, and Environmental Consequences of Corn (Maize) Production in the United States*. Washington, D.C.: World Wildlife Fund Inc.

Schrøder-Petersen, D. L. and Simonsen, H. B. 2001. Tail Biting in Pigs. *The Veterinary Journal* 162 (3): 196-210.

Seaboard Corporation. 2011. *Annual Report*. Kansas City: Seaboard Corporation.

Shellenberger, M. and Nordhaus, T. 2005. The Death of Environmentalism. *Social Policy* 35 (3): 19-30.

Smithfield Foods. 2012. *Integrated report*. Smithfield, VA: Smithfield Foods Inc.

Song, Y., Manson, J. E., Buring, J. E. and Liu, S. 2004. A Prospective Study of Red Meat Consumption and Type 2 Diabetes in Middle-Aged and Elderly Women: The Women's Health Study. *Diabetes Care* 27 (9): 2108-2115.

Steinbock, B. 1978. Speciesism and the Idea of Equality. *Philosophy* 53 (204): 247-256.

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. and De Haan, C. 2007. *livestock's long shadow:environmental issues and options*. Rom: Food And Agriculture Organization of the United Nations.

Sterman, J. D. 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Boston: Irwin/McGraw-Hill.

Stringer, M. S. 2010. *Food NYC: A blueprint for Sustainable Food System*. New York: Manhattan Borough President.

Subak, S. 1999. Global environmental costs of beef production. *Ecological Economics* 30 (1): 79-91.

Sysco Corporation. 2012. *Annual report*. Houston, TX: Sysco Corporation.

Taylor, R. E. and Field, T. G. 1998. *Scientific Farm Animal Production: An Introduction to Animal Science*. New Jersey: Prentice Hall.

Toniolo, P., Riboli, E., Shore, R. E. and Pasternack, B. S. 1994. Consumption of Meat, Animal Products, Protein, and Fat and Risk of Breast Cancer: A Prospective Cohort Study in New York. *Epidemiology* 5 (4): 391-397.

Tyson Foods. 2010. Press Releases: McDonald's ® USA Names Tyson Foods, Inc. 2010 Supplier of the Year. URL: http://www.tysonfoods.com/Media-Room/News-Releases/2010/10/McDonald-s---USA-Names-Tyson-Foods--Inc--2010-Supplier-of-the-Year.aspx. [cited 1 May 2013].

________. 2012. *Fiscal 2012 Fact Book*. Springdale, AR: Tyson Foods Inc.

________. 2013. Our Brands. Tyson Foods Inc. URL: http://www.tysonfoodservice.com/Our-Brands.aspx. [cited 7 April 2013].

U.S Department of Agriculture. 2013. *FSIS E. coli Testing of Boxed Beef:Audit Report 24601-0003-31*. Washington, D.C.: Office of Inspector General.

U.S. Bureau of Labor Statistics. 2012. Occupational Employment Statistics. U.S. Bureau of Labor Statistics. URL: http://www.bls.gov/oes/current/oes513023.htm. [cited 20 February 2013].

U.S. Department of Agriculture. 2009. *Census of Agriculture 2007: Summary and State Data*. Washington, D.C.: Statistics Service.

_________. 2011a. Statistics & Information: U.S. commercial slaughter. Economic Research Service. URL: http://www.ers.usda.gov/topics/animal-products/cattle-beef/statistics-information.aspx. [cited 11 March 2013].

_________. 2011b. U.S. Broiler Industry: Background Statistics and Information. Economic Research Service. URL: http://webarchives.cdlib.org/sw1vh5dg3r/http://ers.usda.gov/News/broilercoverage.htm. [cited 11 January 2013].

_________. 2011c. Statistics & Information. Economic Research Service. URL: http://www.ers.usda.gov/topics/animal-products/cattle-beef/statistics-information.aspx - .UVnMur_dOQM. [cited 1 April 2013].

_________. 2011d. *Agricultural Chemical Use Program - 2010 Corn, Upland Cotton, and Fall Potatoes*. Washington, D.C.: Statistics Service.

_________. 2012a. Data Set: Food Availability - Pork: Annual and cumulative year-to-date U.S. trade. Economic Research Service. URL: http://www.ers.usda.gov/data-products/livestock-meat-international-trade-data.aspx - .UVpf-b_dOQM. [cited 2 April 2013].

_________. 2012b. Data Set: Food Availability - Red meat (beef, veal, pork, lamb, and mutton). Economic Research Service. URL: http://www.ers.usda.gov/data-products/food-availability-(per-capita)-data-system.aspx - 26675. [cited 12 March 2013].

_________. 2012c. Fact Sheet: Meat Preparation - Ground Beef and Food Safety. Food Safety and Inspection Service. URL: http://www.fsis.usda.gov/Fact_Sheets/Ground_Beef_and_Food_Safety/index.asp - 2. [cited 12 May 2013].

_________. 2012d. News Release: USDA Targeting Six Additional Strains of E.coli in Raw Beef Trim Starting Monday. Food Safety and Inspection Service. URL: http://www.usda.gov/wps/portal/usda/usdahome?contentidonly=true&contentid=2012/05/0171.xml. [cited 12 May 2013].

_________. 2012e. Data Set: Food Availability - Poultry (chicken and turkey). Economic Research Service. URL: http://www.ers.usda.gov/data-products/food-availability-(per-capita)-data-system.aspx - 26675. [cited 11 March 2013].

_________. 2013a. Data Set: Annual and Cumulative Year-to-Date U.S. Livestock and Meat Trade by Country - Beef and veal: Annual and cumulative year-to-date U.S. trade. Economic Research Service. URL: http://www.ers.usda.gov/data-products/livestock-meat-international-trade-data.aspx - .UWAqfL_dOQM. [cited 1 April 2013].

_________. 2013b. Historical Dietary Guidance. National Agriculture Library. URL: http://fnic.nal.usda.gov/dietary-guidance/dietary-guidelines/historical-dietary-guidance. [cited 14 May 2013].

________. 2013c. *Farms, Land in Farms,and Livestock Operations - 2012 Summary*. Washington, D.C.: National Agricultural Statistics Service.

________. 2013d. Data Set: U.S. Supply and Disappearance - Table 3: Feed grains (corn, sorghum, barley, and oats): Supply and disappearance. Economic Research Service. URL: http://www.ers.usda.gov/data-products/feed-grains-database/feed-grains-yearbook-tables.aspx - .UV89er_dOQN. [cited 1 April 2013].

________. 2013e. *World Agricultural Supply and Demand Estimates*. Washington, D.C.: Economic Research Service.

________. 2013f. Data Set: Domestic and International Prices - Table 9: Corn and sorghum: Average prices received by farmers, United States. Economic Research Service. URL: http://www.ers.usda.gov/data-products/feed-grains-database/feed-grains-yearbook-tables.aspx - .UV9rTr_dOQO. [cited 1 April 2013].

U.S. Department of Commerce. 2011. State and County QuickFacts. Boston. US Census Bureau. URL: http://quickfacts.census.gov/qfd/states/25/2507000.html. [cited 3 May 2013].

U.S. Department of Health and Human Services. 2010. QuickStats: Number of Deaths from 10 Leading Causes — National Vital Statistics System, United States, 2010. Centers for Disease Control and Prevention. URL: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6208a8.htm. [cited 10 May 2013].

U.S. Department of Transportation. 2012. Freight Management and Operations. Federal Highway Administration. URL: http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm. [cited 12 March 2013].

U.S. Environmental Protection Agency. 1995. *Compilation of Air Pollutant Emission Factors: Stationary Point and Area Sources*. Durham, NC: Office Of Air Quality Planning And Standards.

________. 2012. Regulatory Definitions of Large CAFOs, Medium CAFOs, and Small CAFOs. Wastewater & Infrastructure Management Branch Water, Wetlands & Pesticides Division. URL: http://www.epa.gov/region7/water/cafo/. [cited 17 April 2013].

Vegetarian Resource Group. 2012. How Often Do Americans Eat Vegetarian Meals? And How Many Adults in the U.S. Are Vegetarian? The Vegetarian Resource Group asks in a 2012 National Harris Poll. URL: http://www.vrg.org/blog/2012/05/18/how-often-do-americans-eat-vegetarian-meals-and-how-many-adults-in-the-u-s-are-vegetarian/. [cited June 15 2013].

Walker, P., Rhubart-Berg, P., McKenzie, S., Kelling, K. and Lawrence, R. S. 2005. Public health implications of meat production and consumption. *Public Health Nutrition* 8 (4): 348-356.

Welzer, H. 2013. *Selbst Denken: Eine Anleitung zum Widerstand [Think yourself: A guide for opposition]*. Frankfurt: S. Fischer.

Westhoek, H. 2011. *The protein puzzle : the consumption and production of meat, dairy and fish in the European Union*. The Hague: PBL Netherlands Environmental Assessment Agency.

Young, V. R. and Pellett, P. L. 1994. Plant proteins in relation to human protein and amino acid nutrition. *The American Journal of Clinical Nutrition* 59 (5): 1203S-1212S.

Zhang, M., Huang, J., Xie, X. and Holman, C. D. A. J. 2009. Dietary intakes of mushrooms and green tea combine to reduce the risk of breast cancer in Chinese women. *International Journal of Cancer* 124 (6): 1404-1408.

Personal Communications

Corliss, Jack. Visiting Professor of the Department of Environmental Sciences and Policy, Central European University. Telephone conversation. New York City, 5 and 10 May 2013

Foster, Ian. Educational Program Manager, Edward A. Reynolds West Side High School NYC. Email communication, 2 May 2013

Marcotullio, Peter. Associate Professor of the Department of Geography, Hunter College of The City University of New York. Personal communication. New York City, 8 February 2013

Reingold, Bruce. General Manager of Hunts Point Coop Market. Email communication, 27 March 2013

Van Kessel, Andrew. Professor and Head of the Department of Animal and Poultry Science, College of Agriculture and Bioresources, University of Saskatchewan. Informal phone interview. Canada, 12 April 2013