ABSTRACT

CREATING A NON-GMO GRAIN AND FEED EXCHANGE SYSTEM
FOR OHIO FARMERS

by Jessica E. Doty

The relatively recent rise of genetic modification technology and its increasing use has changed the agricultural, economic, and regulatory landscape of the United States. This technology is considered by many to be controversial. There are similarly many topics to consider when making an informed decision regarding the use of genetically modified organisms in agricultural application. Opponents of this technology are increasingly demanding non-GMO alternatives, which are perceived as safer and higher quality than GMOs, which are viewed by many as unnatural. The Ohio Farmers Union (OFU) wishes to meet this growing consumer demand for non-GMO seed, feed, and grain by creating useful and accessible resources for buyers and sellers of these commodities. Part one of this report is a review of current literature on these issues, to present a view of the significance and relevance of non-GMO production in today’s world. Part Two discusses the creation of an online platform for the sale and exchange of non-GMO grains and a forum for communication between producers to allow for increased knowledge and awareness of current GMO issues. Part Three discusses the future possibility of creating an OFU-branded certification scheme for non-GMO seed, feed, and grain, while keeping in mind the issues and barriers discussed throughout Part One.
CREATING A NON-GMO GRAIN AND FEED EXCHANGE SYSTEM FOR OHIO FARMERS

Practicum

Submitted to the
Faculty of Miami University
In partial fulfillment of
The requirements for the degree of
Master of Environmental Science
by
Jessica E. Doty
Miami University
Oxford, Ohio
2016

Advisor: Alfredo Huerta

Reader: Peggy Shaffer

Reader: Suzanne Zazycki

©2016 Jessica E. Doty
This practicum titled

CREATING A NON-GMO GRAIN AND FEED EXCHANGE SYSTEM
FOR OHIO FARMERS

by
Jessica E. Doty

Has been approved for publication by

College of Arts & Science

And

The Institute for the Environment & Sustainability

_______________________________________
Alfredo Huerta

_______________________________________
Marguerite Shaffer

_______________________________________
Suzanne Zazycki
# Table of Contents

About the Project........................................................................................................1

The Ohio Farmers Union and Non-GMO Platform Project.................................1

## Part One: Examining Non-GMO Issues: Relevant Background Information.......3

- Brief Overview of Agriculture in the United States.........................................3
- GMOs..................................................................................................................4
- Corporate Seed.................................................................................................7
- Non-GMO Crop Production and Challenges..................................................10
- Culture and Non-GMOs................................................................................12
- GMOs and Animal Production.......................................................................14
- Organic Production and Non-GMOs..............................................................18
- Regulation and Politics of GMO...................................................................19
- Economy of non-GMO..................................................................................26
- Labeling non-GMOs.....................................................................................31
- Current Concerns with CRISPR Technology..............................................34
- In Summary....................................................................................................43

## Part Two: The Ohio Farmers Union Online Forum and Seedbank........38

- Background....................................................................................................38
- Learning from Example................................................................................39
- Discussion of Website....................................................................................45

## Part Three: Non-GMO Certification Process Design..............................51

- The Proposed OFU Certification Process....................................................51
- Non-GMO Certification................................................................................52
- Certification Program Alternatives..............................................................55
- OFU Certification Process............................................................................57
- Final Recommendations................................................................................61
- In Summary....................................................................................................62

## References...........................................................................................................64

## Appendix..............................................................................................................75

- Appendix A: GMO Testing Facilities.............................................................75
- Appendix B: Non-GMO Feed and Seed Suppliers........................................75
- Appendix C: Websites and Additional Resources........................................76

## Afterward...............................................................................................................78
List of Tables

Table 1: Non-GMO Legislation Introduced to the 114th Congress
Table 2: KACE Subscription Prices
Table 3: OEFFA Organic Program Fees
List of Figures

Figure 1: Ohio Farmers Union Logo
Figure 2: Denver, Colorado 2015 March against Monsanto
Figure 3: % Levels for GMO Acceptance by Country
Figure 4: Growth in Sales of GMO products Graph
Figure 5: CRISPR Recordings of RNA Memories
Figure 6: Seed Savers Exchange Cost and Expenditures
Figure 7: Seed Savers Exchange Screenshot of Grain Exchange
Figure 8: Seed Savers Exchange Screenshot of Available Corn in Forum
Figure 9: National Agricultural Market Working Model
Figure 10: Screenshot of Commodities Online Trading Floor
Figure 11: Envirologix Quicksan System
Figure 12: Potential Model of Interaction Between an OFU Certification Model and the Online Platform
Acknowledgements

I would like to express gratitude to my committee. I would like to thank my primary advisor Dr. Alfredo Huerta for his effort on behalf of and dedication to this practicum. I would like to thank Suzanne Zazycki for her guidance, and Dr. Marguerite Shaffer for her support. For the committee’s commitment to and support of this practicum project, and I am very thankful.

This project could not have been completed without the assistance of the wonderful people at the Ohio Farmers Union. I am especially grateful for the assistance of Mr. William Miller, who provided his valuable advice and guiding input to this project.

Finally, I would also like to thank Stewart Doty, for his contribution throughout the duration of this project. His willingness to provide input and constructive advice has been invaluable.
About The Project:

The Ohio Farmers Union and Non-GMO Platform Project

As a Practicum

This report was written as a practicum, prepared on behalf of the Ohio Farmers Union (OFU) in partial fulfillment of requirements for a Master of Environmental Science degree from Miami University’s Institute for the Environment and Sustainability. The initial goal of the practicum was to develop a program that will allow the OFU to connect sellers of non-genetically-modified Organism (GMO) seed and grain with buyers. This project reflects the vision of the OFU to create a non-GMO grain exchange, certification, and education system for producers and consumers, and foster the development of thriving rural economies by creating a network for moderately sized and family farms (Ohio Farmers Union 2015).

The OFU

The Ohio Farmers Union is a membership-based organization originally founded in 1934 which advocates on behalf of Ohio’s consumers, farmers, and rural residents, ensuring that agricultural markets do not favor mega-producers over organic producers, and/or local family farmers. The OFU believes that creating networks of moderately-scaled family farms is more economically, socially, and environmentally responsible than mega-producing farms (Ohio Farmers Union 2015a). The mission of the OFU is focused on several goals, including creating legislation and increasing legislative representation for members, grassroots advocacy, education for all age groups and consumers, and development of rural communities by fostering cooperative business practices (Ohio Farmers Union 2015b).
The OFU and Non-GMO

Non-GMO production often starts with smaller, family farms (Goldbas 2014, Roff 2007), and these smaller family farms are exactly who the OFU works to support. A core part of the OFU’s belief is that grassroots movements to support more sustainable agriculture such as non-GMO farming can not only protect the environment but increase a sense of community and culture (Goldbas 2014). Food is an important vehicle for community and culture. Production techniques, processing, and consumption habits are all part of a socially transmitted identity (Uche 2015).

In today’s modern society for the production of non-GMO food to gain more recognition, three social variables should be taken into consideration: cost, accessibility, and knowledge (Uche 2015). The OFU’s goals address all of these variables and this current project aimed at the creation of a non-GMO grain exchange system will be supportive of this effort by developing the foundation for the creation of a network for small farm businesses to easily buy and sell non-GMO grains while increasing consumer knowledge. Finally note that the project is also intended to provide publicity and media, and act as a crucial medium for shaping public perceptions on relevant issues (Uche 2015), which may eventually create an atmosphere which allows for easier non-GMO production and distribution.

The Project

The OFU wishes to create an online tool for buyers and sellers of non-GMO seed, feed, and grain. This tool will establish a platform for buyers and sellers to communicate, share information, and trade their grain. It is also hoped this tool will eventually provide a non-GMO certification program for farmers throughout Ohio. To establish the core program, background research will be conducted on FDA, USDA, and state policies concerning non-GMO grain and non-GMO certification systems. The current market for these grains will need to be analyzed, the necessary contents of the online platform will need to be determined, and it is necessary to thoroughly analyze the required methodology involved in certifying the non-GMO status of the grains involved.

This report outlines the three components of this project, contained in the three sections, or parts of this report:

1) A summary of relevant background information on the regulatory, legal, economic, and social aspects of non-GMO grain, seed, and feed.
2) A plan for an online trading and communication platform for buyers and sellers of non-GMO grain, seed, and feed.
3) A framework for establishing a program for non-GMO certification on this platform, keeping regulatory and other possible obstacles in mind.
Part One:

Examining the Non-GMO Issues- Relevant Background Information

Brief Overview of Agriculture of the United States

The United States has 377 million hectares (931,587,282 acres) of agricultural land (Baylis et al. 2008). Agricultural production varies regionally, with activities including the planting of traditional crops such as corn, soybeans, wheat, and cotton, producing animal products such as meat, dairy, and eggs, or growing fruit, nuts, and other vegetables. Agricultural production may also include forestry, nursery products, machine hire, or other activities (Schnepf 2015).

While there were around 5.7 million farms in the United States in 1900, that number decreased to 2.1 million in 2012, 90% of which are individually or family owned (Beach & Kulcsar 2015). While the numbers of farms have decreased, the average size of farms has increased (Beach & Kulcsar 2015). The growth of agricultural production has remained less than 1% per year (Ball et al. 2013). Often diversification and the revenue from work off-farm (either from the primary producer or their spouse) is required to maintain a family farm operation (Beach & Kulcsar 2015). The average age of the farming population is also increasing, with the average age of the primary producer being around 58 years of age (Beach & Kulcsar 2015).

In the 2000s, demand for bio-fuel and increased bio-ethanol production led to an increase in planting of grain and oilseed crops, and farmers tended to establish many more continuous corn plantings versus their typical, or historical rotations of crops such as soybeans alternating with corn (Ball et al. 2013). While the use of pesticides and fertilizers has increased, yield per acre has not (Ball et al. 2013). Since 2015, national farm income, an indicator of agricultural wellbeing, has dropped by 38%, which may reflect lower commodity prices (Schnepf 2015).

The biodiversity of agricultural plants and crops is greatly decreasing (Campbell 2012). Biodiversity is represented by the number of species present and how their composition varies within an ecosystem (Convention on Biological Diversity n.d.). Genetic diversity is important for phenotypic variation, which helps organisms adapt to survive pathogens, resist invasive species, and climate extremes and adapt to environmental changes (Friedman 2015) while providing a range of ecosystem services including but not limited to nutrient cycling, pest control, disease regulation, erosion, and hydrologic cycling control (Convention on Biological Diversity n.d.). A diversity of open-pollinated crop varieties is vital in helping agro-ecosystems cope with pests and disease and to respond to climate fluctuations. However, over 90% of maize, cabbage, pea, and tomato varieties traditionally grown in the United States have been lost within the last century.
Shifting to hybrid and GMO cultivars creates a less environmentally friendly, homogenous landscape with the genetic erosion of food crop species (Campbell 2012). Indeed, 80% of the Midwestern Corn Belt region exists in a simple rotation of corn and soybean crops (Russelle et al. 2007). This is why diversification of, and introduction of non-GMO varieties into current cropping systems is important. Genetic diversification can create higher grain yield potential and can also reduce loss from pest insects, and plant diseases (Russelle et al. 2007).

Conservation programs have worked towards subsidizing farmers to intensify agriculture while reducing pollution. Subsidies have been given for activities such as installing fencing and manure storage facilities. This allows for greater numbers of livestock within a confined area (Baylis et al. 2008). Funding for agricultural grants is competitive, with bidding a requirement for the largest programs. Funding is allocated to areas where they create the most environmental impact, and the most impact per dollar used (Baylis 2008).

**GMOs**

*What are GMOs?*

Genetically Modified Organisms (GMOs) are organisms whose genetic make-up has been radically changed through biotechnology or genetic engineering by inserting, deleting, or modifying genes, which do not exist and cannot be replicated in nature without such human intervention (Friedman 2015, Gamoning 2015, Goldbas 2014, Sprinkle 2014, Uche 2015). The term genetically modified can be used interchangeably with others such as biotechnology, and genetically engineered (National Research Council & Institute of Medicine 2004). Genetically engineered food or feed products contain ingredients that are derived from the scientific methods which introduce new genetic traits into organisms. These methods are used as a means to increase crop yield, create herbicide tolerance (ht), create tolerance to the soil bacterium *bacillus thuringiensis* (bt), promote virus resistance, or alter nutritional content (Lanza 2016, Carmen et al. 2013). Genetic engineering has allowed for the development of many different methods of altering organisms compared with traditional breeding methods. Genetic engineering allows modification through various methods of direct insertion of DNA into plants or other organisms (National Research Council & Institute of Medicine 2004). Unlike in traditional plant breeding, genetically modified organisms have used scientific techniques and engineering to break down pre-existing genetic and/or physical barriers in nature, therefore allowing genes to be transferred across different species such as bacteria, viruses, plants, and animals (Non-GMO report 2015).

There are three different types of GMO crops. These types are based upon whether the genetic modification was developed in the 1st, 2nd, or 3rd generation, or “wave”, of new biotechnology. Genetically modified organisms from the 1st generation are those which are modified with inputs resulting in useful characteristics to the organism such as drought tolerance. 2nd generation genetically modified organisms have characteristics that make them more pleasing to consumers, such as those which increase food quality or appearance. 3rd generation organisms are made to be more useful for certain processes, such as in the production of novel pharmacology materials or in the production of bioethanol or biodiesel (Bellia & Pilato 2011).
Environmental Risks of GMOs

There are important uses for genetically modified organisms, some of which have the potential to fix various large problems in crop production. Organisms may be modified to prevent diseases such as citrus greening, fungal blight in bananas, rice blast, soybean or stem rust, and other overpowering plant diseases which threaten commercial food production (Caplan 2013). However, there are also key concerns related to the use of these modified crops.

While genetic modification has enabled the creation of crops that may have new characteristics, such as those that are pest or herbicide resistant, or can tolerate drought conditions, there are a number of ethical and health concerns and risks thought to be associated with GMO organisms (Goldbas 2014, Sprinkle 2014, Carman et al. 2013). The risks of GMO organisms are not fully understood by scientists, but could potentially include possible negative effects on the environment, and potential health risks to humans from introduction of novel chemicals into food (Olson 2000). For example, one possible environmental consequence of GMO production is harmful competition between GMO organisms and local plant communities. There is also some evidence to show that GM can create ‘superbugs’ or ‘superweeds’, which not only threaten endangered plant species, but which can require up to five times more herbicide than conventional crops to eradicate. GM can also threaten beneficial pollinators such as monarch butterflies by causing viruses to which they are naturally immune to mutate into new more potent forms. Pollen drift may also contaminate nearby non-GMO farms (Hartley 2000).

Chemicals made to be used with various GMO crops, and the unusual genes contained within the GMO crops themselves may actually travel through food webs, becoming biomagnified (Friedman 2015). Biomagnification is the process in which contaminants accumulate as they move through the food web. Organisms which are on higher trophic levels of the food chain ingest the consumers which initially absorbed the contaminants. Because of the higher efficiency of predators to uptake nutrients, the concentrations of contaminants will increase on upper tiers of the food web (USGS 2015). Exposure to higher amounts of a contaminant due to biomagnification implies that there is much greater risk of possible effects from that contaminant. This biomagnification could increase potential dangers from GMO crops. Because of promoters (part of the DNA that controls gene transcription) included in GMO DNA sequences, it may be possible that such DNA mutations result in unexpected and unpredictable results (Johnson-Green 2002).

Bacillus thuringiensis (Bt) is a bacterium which naturally occurs in the soil. Bioengineering has incorporated Bt genes into crops for the purpose of creating plants that produce their own Bt toxic proteins resulting in greater protection against certain pests that are sensitive to the Bt toxin. When insects ingest this protein, they will die. (Monsanto 2015b). Studies have also found that transgenic toxins, such as those found in Monsanto’s Bt crops, have actually altered soil microbiota. These microbiotas are extremely important for both biogeochemical cycling and plant growth (Friedman 2015).
Possible Risks to Human Health

There are those who are concerned that GMO DNA promoter sequences could pose potential dangers to humans (Johnson-Green 2002). DNA promoter sequences are sections of DNA where RNA polymerase begin to transcribe genes. A promoter indicates what genetic sequence will be transcribed (Nature Education 2014). Activists claim that if these genes travel from the human GI tract and into the bloodstream, they could result in synthesis of dangerous proteins which may lead to such hazards as tumors (Johnson-Green 2002). Exposure to higher amounts of a contaminant due to biomagnification implies that there is much greater risk of possible effects from that contaminant.

While many countries require GMOs to be labeled, such as Korea, Japan, and the European Union (Olson 2000), there is also currently a concerning lack of regulation of GMO organisms in the United States (Goldbas 2014). The system of testing new GMO organisms before they are released to the market, for example, is much less strict in the United States than in many other countries (Carman et al. 2013). This means that potential hazards could actually go unnoticed. Likewise, even when testing is conducted, the system of testing used has been questioned by some. Most often, animals have been used to test the safety of GMO foods for humans. However, some animals may be more suited to simulate human physiology (such as pigs) and some less so (Ekmay et al. 2016).

There are actually few GMO feeding studies that have used animals physiologically compatible with humans, few studies over long-term timescales, and likewise few studies exploring GM foods other than soy, corn and rice (Carman et al. 2013). Additionally, human foods are often heavily processed or enriched before reaching consumers, therefore potential health effects of the final product may be different than the original, raw product or feed crop which the animal test subjects consume (Ekay et al. 2016). Therefore, although a GMO food may have been found to have nutritional equivalence to non-altered or non-GMO varieties (Ekmay et al. 2016), potential hazards to human health are still vague (Carman et al. 2013). Lastly, there have been no properly-conducted human clinical trials to date testing the long-term safety of GMO crops or food ingredients (Monsanto 2015a).

GMOs Today

In the United States, many crops (including those for feed, and those used in the making of food products) are currently GMO. This includes around 90% of the total crop production of corn and sugar beets, and 94% of the soybeans grown each year (Bain & Dandachi 2015, Gasparro 2014, Carman et al. 2013). Globally, there is a 3% annual increase in area dedicated to GMO production (Kamle & Li 2016, Cowan 2015) and since the first GMO crops have begun growing in 1996, the global GM production area has increased 100 times (Arruda et al. 2016, Kamle & Li 2016). Worldwide, 181 million hectares (447,260,737 acres) of farmland have now been sewn with GMO crops (Ledford 2016).
GMO crops are grown in the United States, Brazil, Argentina, Canada, India, China, and Spain in particular (Russo 2015). The U.S. leads GMO crop production overall, with over 173 million acres devoted to GMO crop production which is 73.6 million acres more than the second largest producer, Brazil (Cowan 2014). Some of the most widely available GMO crops include corn, soybeans, alfalfa, papaya, summer squash, sugar beets, cotton and canola (Brat 2015) and the United States is the world’s largest producer of soybean (Arruda et al. 2016). GMO crops grown in the United States haven’t been modified in a way which would increase their yield potential, but their compatibility with herbicides and pesticides have made weed and pest management easier for farmers (Benbrook 2003).

Many U.S states have had GMO labeling ballot initiatives, driven by the non-GMO movement. Large companies such as Nestle, Monsanto, and the Grocery Manufacturers Association have spent more than $100 million dollars trying to defeat these initiatives (Bain & Dandachi 2015). As of 2014, Ohio has no legislation for the regulation of GMO organisms (Bain & Dandachi 2015). Because of the potential risks associated with genetically modified organisms, many producers and consumers are beginning to turn back to non-GMO food products.

Corporate Seed

Saving of GMO Seed is not Allowed

GM seeds are developed by large companies such as Syngenta and Monsanto, who claim intellectual property rights (IPRs), or their exclusive ability to utilize and market or sell what they’ve created, in order to make back the money they spent developing GMO materials. This means farmers who buy these seeds are not legally allowed to save them, and must purchase new seed each growing season from these companies (Anderson 2006). IPRs are rigidly enforced by these companies. Monsanto has even had nearly 100 lawsuits against farmers in the U.S. for infringing upon the IPRs of GMO seed, with the final lawsuit finding in favor of Monsanto with awards totaling more than $15,000,000. Many more farmers have chosen to settle out of court rather than face such a lawsuit (Anderson 2006).

Monsanto has even been known to sue farmers whose seeds have been unintentionally contaminated through genetic drift (Anderson 2006). One well known instance of this is Canadian farmer Percy Schmeiser, of 1998’s Percy Schmeiser vs. Monsanto. Third generation farmer Schmeiser’s canola crop was contaminated by a GM canola crop growing in a neighboring field (Smith 2001). The vast majority of Schmeiser’s neighbors were in fact growing GM crops, according to Monsanto (2015). Although Mr. Schmeiser had worked to develop his own line of canola seeds over a 40-year period, Monsanto sued the then 70-year-old man, under the claim that he had infringed upon the company’s IPR. Mr. Schmeiser was ordered to pay $85,000 dollars to Monsanto for licensing fees and crop sales (Smith 2001). Much to Mr. Schmeiser’s dismay, after replanting his fields with new, non-GMO seed, his crops were still contaminated because of “Round-up Ready” crops which couldn’t be completely removed (Smith 2001).
Monsanto has stated on their website that they tried to settle this matter out of court, but Schmeiser was unwilling, claiming that the GMO canola in his field wasn’t planted by him. This case was decided in three separate decisions in the Canadian Supreme Court, so Schmeiser was in the wrong. They have also said that while Schmeiser is viewed as a folk hero to many, and has spoken at anti-biotechnology events around the world, he is not a hero, and no more than a patent infringer who “knows how to tell a good story” (Monsanto 2015c).

Monsanto’s GMO

There are four major biotechnology seed companies including Dupont/Pioneer, Syngenta, Dow AgroSciences, and Monsanto (Wilson 2014). Monsanto is the world’s largest seed biotechnology corporation based out of St. Louis, Missouri known for producing such products as NutraSweet, recombinant Bovine Growth Hormone (rBGH), Roundup Ready and Bt crops, and Agent Orange, the chemical sprayed as a defoliant in Vietnam during the Vietnam war (Murray 2013, Kneen 2004). The reputation of Monsanto, according to a Harris Poll, was third lowest of all major transnational corporations, and has long been controversial (Bennett & Kaskey 2014). Worldwide, Monsanto’s patented GMO technology is planted on 282 million acres, making up 80% of GM corn and 93% of the GM soybean market (Wilson 2014).

Protests have been held against Monsanto worldwide. There is an annual March against Monsanto, in which people in cities across the world participate (Bennett & Kaskey 2014). Figure 2 shows one such protest. Some protests have been in part a response to the Farmer Assurance Provision, a bill termed by some as the ‘Monsanto Protection Act’ (Murray 2013). This bill creates legal loopholes in existing USDA regulations for companies such as Monsanto which create GMO food products (Murray 2013). Foreign importers have slowed their purchase of U.S. crops due to the controversy over possible effects of GMO on human health and the result of unapproved GMO wheat varieties growing in U.S. fields in Oregon (International Business Times 2013, Murray 2013). Monsanto’s seeds have been calculated to be 5 times higher in price than the open pollinated version of a similar variety, due to the royalties paid by the farmer for this patented technology (Kneen 2004). Farmers are required to sign a Technology Use Agreement, which forbids seed saving (Kneen 2004).

As previously stated, cross-contamination could result in legal battles for Farmers (Murray 2013) and in fact some have labeled Monsanto as a “corporate bully”, pursuing lawsuits against farmers for copyright infringement (Bennett & Kaskey 2014, 57). However, it was a completely different scenario when sued by a farmer in 2013 for negligence in allowing an un-approved strain of wheat to escape. In 2013, workers found the GMO patch of wheat in the field they were responsible for, and after dousing it with herbicides which would not kill it, sent it a lab for testing. Monsanto’s response was a statement saying that finding volunteer plants in an Oregon field was far from enough proof to base a lawsuit upon, when no harvest had yet been affected. (Hegeman 2013).
Self-replication will pass the genetically modified DNA to future generations of crop plants, but due to the promiscuous nature of plant reproduction, cross-pollination may occur, with pollen from GMO crops traveling sometimes miles to contaminate other non-GMO crops, including those being grown on organic farmland. There is no federal regulation specific to managing this issue of cross-contamination, so there many questions concerning the ownership of this patented genetic drift (Wilson 2014). Because of the threat of lawsuit from Monsanto, farmers are often unwilling to report contamination, despite knowing that it has occurred. Farmers that take this corporation to court will almost always inevitably lose their case (Wilson 2014).

Patented GMO Technology and Glyphosate Use

One major problem is herbicide use associated with GMO crops. As discussed earlier in Part One, GMOs make up a huge portion of U.S. crop production. While Monsanto claimed that GMOs would lead to a reduction in the use of herbicides, in fact, over 13 years after GMOs were first introduced, the total use of herbicides increased, perhaps as much as 383 million pounds per year (Smith 2011). Benbrook (2003) explains that there is a 5% herbicide increase (in pounds per acre) when applied to GM soybeans in comparison to similar, conventional varieties. In fact, since GMOs are often bred to be herbicide tolerant to control weeds and pests, farmers typically double the amount of herbicide used per acre (Benbrook 2003).
30% of all herbicides contain glyphosate, a chemical patented by Monsanto for use with their Roundup Ready crops. Forty plant diseases have been shown to increase in severity with the use of this chemical, and more are surfacing as people recognize the connections. These diseases include soybean root rot, citrus variegated chlorosis, fusarium wilt, sudden death syndrome, verticillium wilt in potatoes, root, crown, and stem blight of grain, and many more (Smith 2011). Sudden Death Syndrome in Roundup Ready Soybeans has been shown to increase by 500% with the application of glyphosates (Smith 2011).

Glyphosate may also increase the fungus Fusarium on plant roots, which has been linked to disease outbreak such as medieval European plague, cancer of the esophagus in Africa and China, and blood disorders in Russia. In animals, this fungus also creates diseases and leads to infertility (Smith 2011). Roundup application to GMO crops can lead to decreased defense against soil borne disease, causing the crops in those sprayed areas to die earlier in the season than other crops (Smith 2011). Glyphosate may remain for years in the soil and environment, and also could create a dangerous toxic cocktail of chemicals which may end up in human food or animal feed through its runoff into waterways (Smith 2011). Glyphosate has been linked to hormone disorders, sterility and reproductive issues including low sperm count, miscarriage, birth defects, and cancers (Smith 2011). Recently, a division of the World Health Organization, The International Agency for Research on Cancer, stated that glyphosate is possibly linked to cancer (Weaver 2015).

Non-GMO Crop Production and Challenges

_GMOs vs. Selective Breeding_

It was first understood that plants can be bred for different traits when Gregor Mendel conducted reproduction and pollination experiments on peas starting in the 1850s (Mendel 1986). Mendel attributed his experiment’s success to selecting plants suitable for experimentation in which a few very visible features could be changed to allow for easier study (Mendel 1986). Using methods based on simple genetic crosses, hybrid varieties of plants could be bred and developed through artificial selection to be utilized for different purposes. This can be termed as conventional/traditional breeding (National Research Council & Institute of Medicine 2004).

Conventional plant breeding via simple cross-pollination has been occurring from as early as 10,000 years ago as plants naturally evolve and farmers select the best of their crops to use as seed for the next generation, therefore slowly selecting the strains which are best suited for certain conditions (National Research Council & Institute of Medicine 2004). Farmers could use this selective breeding to improve plant growth and yield, increase pest resistance, or create other desirable traits (Cowan 2015). In this way, non-GMO production of plants with new traits is by no means a new technology, but a very old one. According to Andrew Kimbrell, Center for Food Safety founder and executive director, “(people are) conflating what is a very new and novel technology with traditional types of breeding, which is simply crossing different varieties of, say, corn. It’s kind of like saying an abacus is very much like a computer,” (Stom 2015, np).
While plant breeding methods are rooted in Mendel’s experiments from the 1800s, the first GMO organisms which used recombinant DNA technology were patented in 1980 (Swanson & Mehrbani 2014) and became commercialized in the 1990s (Pechlaner 2012). In 1996, GM crops were first introduced for commercial production, and since that time, the dominant trait of GMO plants being grown has been herbicide resistance followed by resistance to certain pests (McCullum et al. 2003).

What is Considered Non-GMO?

According to the U.S. Food and Drug Administration (FDA), crops may be genetically modified without being genetically engineered. This creates some food labeling discrepancies and confusion for both producers and consumers of Non-GMO products (Strom 2015). Non-GMO is a term for organisms that have not been assisted in their growth and development through any scientific or engineering techniques which alter their gene sequences (Non-GMO Report 2015, National Research Council & Institute of Medicine 2004). Therefore, any varieties of crops, feeds, and products that have been traditionally bred without the interference of biotechnological genetic manipulation can be considered non-GMO.

A wide variety of food products can be considered GMO simply because of their use of common GM crop materials in their ingredients (Cowan 2015). Common iodized table salt, for example, which uses dextrose during processing can be made from GMO corn in the iodizing process (Brat 2015). Many GM crops are designed to appeal to producers of commodities and processed foods, but plants that may end up directly on the table of consumers for direct consumption without processing are more commonly being developed (Cowan 2015).

Why is Non-GMO Important?

According to research conducted by the firm Nielsen Holdings N.V. (New York), non-GMO is becoming one of the fastest growing food segments in the U.S (Bunge 2015). Regardless of any misinterpretations of the definition of non-GMO, non-GMO crops are becoming the premium standard of agricultural products because they are perceived by consumers as healthier and better for the environment (Bunge 2015, Brooks 2010). There is also the consumer ‘right to know’, meaning that consumers have the right to know the origin of products they are using and to know what is in the food they are eating (Hemphill & Banerjee 2014, McGarity 2007).

Contamination and Tolerance Levels

One of the challenges associated with producing non-GMO crops is genetic contamination by GMO crops through the process of cross-pollination. When GMO crops are produced in a vast, monoculture scale, the loss of genetic diversity in the crop plants is significant (Friedman 2015). Producers of non-GMO crops, given the high percentage of modified crops being sown each year, are often surrounded by GMOs. This means that pollen drift from the surrounding GMO fields growing a similar crop can contaminate the non-GMO crop (Neuman 2009).
The Non-GMO Project (which can be found at http://www.nongmoproject.org/) is the most well-known and most strict verification scheme in the U.S., requires that a food product contain a maximum contamination level or tolerance of 0.9% with material derived from GMOs. Tolerance refers to the acceptable level of contaminating GMO genetic material allowed in products. Seed purity warranties typically range from 1-2% (Redick 2014). Non-GMO seed corn should be grown at least 660 feet from modified varieties to significantly reduce (but not eliminate) the risk of contamination, or if grown in closer proximity 12-16 rows of corn should be stripped from field at harvest and separated from the non-GMO corn (Brooks 2010). Non-GMO growers typically assume the risks of economic loss due to contamination by GMOs (Redick 2014). There is no way to record or quantify the pollen drift from U.S. approved GMO crops in a way which would prove that they have contaminated non-GMO crops and to what extent. Therefore, there is no legal means to compensate organic or non-GMO growers for this contamination when it occurs (Redick 2014).

Contamination from GMOs can also occur in storage and processing. During storing and processing, it is necessary for a food processor to be careful to insure proper cleaning of equipment and storage facilities when they are shared between non-GMO and GMO crops (Barker 2015, Neuman 2009). According to Jasen Urena, director of specialty eggs at NestFresh, a facility selling non-GMO verified egg products, cleaning equipment and storage facilities is important to ensuring that grain and seed remains uncontaminated. “If you don’t clean out the mill, or all of the grinders and the silos, and if GMO ingredients contaminated the silos prior to contact with our non-GMO seeds, contamination is sure to occur,” (Gamoning 2015, 2)

Culture and Non-GMOS

American vs. European Attitudes towards Non-GMOS

In general, environmental goals of the EU are broader, and less direct than goals in U.S. environmental policy. The EU provides subsidies for farmers who commit to organic production standards, since this type of production likely leads to the improvement of environmental quality. These subsidies, unlike in U.S. policy, do not need measurable environmental targets to qualify for agri-environmental programs, and much less information is required to qualify (Baylis et al. 2008).

Polls have been conducted by research agencies on behalf of the Pew Initiative on Food and Biotechnology (PIFB) to assess the attitudes of Americans concerning biotech food production. According to the survey, Americans have little knowledge about GM foods and biotechnology (Mellman Group, Inc. & Public Opinion Strategies, Inc. 2005). Despite this lack of knowledge, most Americans would like GMO foods to be regulated. Public support for the production and consumption of genetically modified foods is steady, although not prominently voiced, while public opposition to GMOs is strong, but can be unstable at times. Based on that survey, when information is provided about GM foods, the opinions of Americans tend to be flexible and able to be changed (Mellman Group, Inc. & Public Opinion Strategies, Inc. 2005). Americans are more
likely to support biotechnology they think will benefit them rather than biotech applications that will only help business. (Fink & Rodemeyer 2007).

The different perceptions held by Americans and Europeans have influenced the availability and production of GMOs within those regions. The national identity of Americans is far less linked to food than those in Europe, where food plays an essential role in culture (McCullum et al. 2004). Instead, scientific progress and a sense of freedom are greatly valued by Americans, whereas regulation by government is often seen in a negative light. Americans see GMO foods as part of scientific progress. This scientific progress is seen as positive and beneficial to humans in that it will create new innovations in food production (Wohler 2016). Therefore, GMOs are given a perfect environment with comparatively little regulation, to flourish and develop freely as a major part of the economy (McCullum et al 2003). Europeans may also consider ethical, social, and cultural factors when making decisions about what they consume (McCullum et al 2003), and tend to see less benefit to using GMO crops (Aerni 2016). In European countries where culture and food are strongly linked, GMO food can actually be seen as a threat to cultural identity itself, casting GMO production in a negative light (McCullum et al. 2003). Traditional agricultural products coming from small and medium sized farms may be threatened by the possible contamination of GMO production (Layadi 2012). There is concern that if traditional production is threatened enough by GMO contamination, the social structure and economy of rural areas will be affected to the point where the economy may not be maintained, creating a new rural exodus (Layadi 2012). This strong cultural connection, and other social differences in Europe create a perception which influences the regulatory environment, creating a more restrictive atmosphere for the production of GMO products.

These differences in attitudes could account for more rapid growth of GMO commercialization in the U.S. as compared to Europe since the 1990s. In studies concerning GMOs, Americans are most often addressed in their status as consumers, while Europeans are addressed first as citizens of a society first, and as consumer second (McCullum et al. 2003).

Reasons for Supporting Non-GMO

Attitudes towards GMO products are complicated. Perceived environmental benefits or risks, risk to human health, attitudes towards purchase or labeling, cultural and moral values, level of education toward the risks, and economic and ethical issues are all different aspects that come into play when considering perceptions of GMOs. The acceptability of GMO foods often weighs the perceived benefits of these different aspects against the risks which may outweigh them, or justify GM production (Aleksejeva 2014).

Consumers may have several reasons for wanting their food to be non-GMO. Foods that are organic and non-GMO are generally seen as more pure, healthier, and with less risk than foods that are genetically modified and therefore unnatural. Consumers may have environmental concerns that cause them to purchase non-GMO foods, including the desire to reduce monoculture (McGarity 2007), the agricultural cultivation or production of a single type of organism (Merriam-Webster 2015) and the harmful environmental practices associated with industrial farming and GMO production.
Consumers may also be cautious of GMOs as a new technology (McGarity 2007). There may also be a religious or moral component to GMO foods. Those with strict dietary restrictions such as vegetarians or vegans may have objections to foods possibly containing animal DNA. People may be opposed to the entire concept of GMO foods, as they are seen as unnatural. People who are Jewish would have concerns about the use of swine DNA, and Buddhists may not want any of their food to contain the genetic information of animals (McGarity 2007). Personal experiences or access to media and technology may also have a role in shaping individual views on GMOs, whether they be positive or negative (Aerni 2016).

**Current Issues**

107 Nobel laureates have issued a letter in support of GMOs, challenging the position of Greenpeace and other groups who are openly against GMOs (Staff 2016). Their focus does not address the concern many have about knowing what is in the food they are consuming, but was based upon on Golden Rice, which could potentially make positive impacts in food security, malnutrition, and the reduction Vitamin A deficiency in developing nations (Staff 2016). The Nobel laureates argue that Greenpeace’s position is anti-science (Staff 2016).

**GMOs and Animal Production**

*Importance of Crop Systems in Animal Production*

Agriculture must not only produce food and fiber resources for society, but it must work toward ensuring that environmental services and quality of life are maintained (Russelle et al. 2007). Some livestock production systems have resulted in a decrease of soil organic matter, increased the need for nitrogen fertilizers, and led to concern about long-term sustainability of agricultural systems (Russelle et al 2007). Incorporating livestock into cropping enterprises (or vice versa) has been shown to improve profitability (Russelle et al. 2007). For example, farms with both crops and beef cows (versus crop only farms) in North Dakota showed a nearly $9000 greater net worth (Russelle et al. 2007). Growing grain and feed crops reduces the cost of seeking livestock feed from other sources. Likewise, ruminants can utilize crop residues as a significant source feed biomass. Manure from cows and other livestock can also create significant improvement in soil carbon accumulation. On-premises feed and fertilizer sources can also reduce energy costs to farmers of importing these resources (Russelle et al. 2007). This may improve sustainability of farming systems.
**GMOs and Livestock**

Livestock themselves may be genetically engineered to achieve different traits (Cowan 2015). For example, cows are frequently administered a GM version of a bovine growth hormone (BST, or RBST) to boost their milk production (Cowan 2015, Cook-Mowery et al. 2008). When injected into cows, rBST boosts milk production on average from 10-15% (Toman 2011). The majority of consumers across the country (88%) have expressed concerns about these growth hormones (Consumers Union 2011). While the FDA’s claims that there is no difference between treated and untreated milk (Wheeler 2011, Cook-Mowery et al. 2008), they require a package insert for the hormone explaining that when administered, it increases the chance of 16 harmful conditions for the cow (Toman 2011). This includes conditions such as reduced rates of pregnancy, smaller birth weight and length of calves, various digestive disorders including boat, and hocks and lesions of the knee (Toman 2011). Likewise, while non-rBST cows can produce milk up to 7 years, rBST cows generally only last two lactation cycles. Furthermore, the effects these hormones may have on humans who consume beef and milk are still relatively unknown. Concern for both animal and human health have caused many countries to ban this hormone (Toman 2011).

In September of 2010, the U.S. Sixth Circuit Court of Appeals overturned a law in Ohio that prohibited the labeling of the GMO additive rBST in milk. Ohio was the last state in the U.S. to make it legal to promote milk without genetically engineered additives (Consumers Union 2011, Wheeler 2011). Use of this additive was already banned in other countries including Australia, Canada, The European Union, Japan, and New Zealand (Wheeler 2011). However, despite this new law, milk products claiming to be free from this additive are still required to include a disclaimer stating that there was no difference between rBST treated and untreated cows (Wheeler 2011).

**GMO Feed for Livestock**

Livestock may also ingest GMO crops as feed. In the US, 70-90% of GMO crops are grown to be used as livestock feed (Swiatkiewicz et al. 2014). The majority of soybean meal, an important source of protein for livestock, is genetically modified (Swiatkiewicz et al. 2014). Likewise, 80% of soybeans produced in the US will end up as animal feed (Olson 2000). This feed is not just for large livestock such as cattle. Animals such as chickens also eat feed made from GMO corn and soy materials (Gamoning 2015). Much livestock feed is genetically modified (Olson 2000) and even if it is not intentionally modified, non-GMO corn and soy are ingredients are often at high risk for contamination by other GMO material (Gamoning 2015). Even when processed, GMO DNA fragments of many sizes were found in non-GMO rapeseed meal feed (Flachowsky et al. 2007). Consumers have concerns about the residue from GMOs preserved within the animal as a result of their feed (Flachowsky et al. 2007). Although genetically modified residue is virtually undetectable in meat products, consumers are beginning to demand assurance that the quality of meat products are able to be traced through all stages of production (Olson 2000).
**Possible Risks of GMO Feed**

Although there have been a number of studies which show that Bt Corn (developed for tolerance against specific corn pests) does not significantly change the quality of meat compared to livestock fed diets of non-GMO seed and grain. Feeding livestock GMO feed raises both ethical questions and concerns about possible GM DNA transfer to animals (Swiatkiewicz et al. 2015). For example, a 2013 Study on the effects of GMO corn feed for pigs by the Institute of Health and Environmental Research (IHER) presented some evidence that there were striking differences between pigs fed a diet of Roundup Ready™ GMO corn versus pigs with non-GMO corn diets. These differences, observed during autopsy, showed that GMO-fed pigs had 25% heavier uterine weight, and higher rates of severe stomach inflammation compared with pigs fed non-GMO feed (Carman et al. 2013). These differences were statistically significant, meaning that the results showed a notable difference between the different groups. The difference was shown to be linked to the pigs’ GMO diet. This shows a possible concern for the gastrointestinal and reproductive systems of humans as well, since pigs are physiologically close to humans and consumption of GMO products by humans is now widespread (Carman et al. 2013).

Pigs fed with 2nd generation rapeseed showed several differences compared to pigs fed a GMO-free diet. The GMO rapeseed-fed pigs showed higher glucosinolate content, and showed a negative weight correlation with GMO food intake, meaning they gained less weight eating GMO feed. Likewise, GM potato feed led to altered feeding habits. This may be related to the GM plant containing substances the pigs consider undesirable (Flachowsky et al. 2007).

**Horizontal Gene Transfer**

One of the worries associated with using GMO crops as animal feed is the possibility of Horizontal Gene Transfer (HGT). HGT is the transfer of genetic material from one organism to an organism of the same or different species through non-sexual means. This can potentially occur as a result of one organism consuming the other as food. Horizontal gene transfer through food means that one organism must first ingest the DNA of another, followed by the uptake and expression of that new DNA in the new host body (Eede et al. 2004). This process can assist in the adaptation of bacteria to new environments through changes in their DNA that might not occur by other means. Typically, DNA which does not provide an evolutionary advantage is discarded through natural selection (Eede et al. 2004). The worry for HGT is that traits such as antibiotic resistance or the capability to express novel proteins from GM plants can actually be taken up and expressed by other organisms, or when bacteria naturally occurring in the livestock are transformed as a result of GMO traits in the food chain (Eede et al. 2004).

Encouragingly, storage and processing (grinding, milling, heat or steam treatments which break the grain down) of food and animal feed are shown to degrade DNA, leading to lower likelihood for HGT to occur (Eede et al. 2004). Uptake and expression of foreign DNA through feed consumption is most likely to occur in animals that consume non-processed GMO feeds. Under these conditions where consumption of unprocessed feed occurs, the DNA is far less degraded by the time it reaches the microflora in the intestinal tract of the animal (Eede et al. 2004).
Although genetic material is usually broken down in the gut of animals, which reduces the risk that livestock may actually absorb DNA, this issue may still pose a potential risk, because of the multitudes of bacteria living inside animals which may still be able to absorb some genetic traits from GMOs in feed. This possibility has led to various research and testing procedures to identify possible dangers (Eede et al. 2004).

Research conducted by Światkiewicz et al. (2015) determined there is in fact a possibility that DNA could be transferred from the feed into broiler chickens; however, transgenic DNA was not found in detectable quantities in the chickens (Światkiewicz et al. 2015). Other studies as cited by Światkiewicz et al. (2015) indicate that ingested DNA could linger in the gut, and be absorbed through the intestinal wall to end up in various parts of the animal Exposure levels to GMO genetic material through an animal’s diet is an important parameter for determining the risk of possible HGT through GMO feed to livestock. Although there has been concern that the more GMO feed an animal ingests, the more likelihood there is that genetic material will have survived (Eede et al. 2004), this doesn’t seem to be significant threat, if it would occur at all. A study performed in 2003 by Jennings et al., indicated that DNA from GMOs was not detected in samples of pork loin from swine that were fed multiple levels of GMO concentrations in their diet (Jennings et al. 2003). It can therefore be concluded that GMO DNA likely poses little risk for HGT into animals through feed (Eede et al. 2004).

**Regulation of GMO Feed**

Protective regulations are set by the FDA that consumers will not be exposed to chemicals in food at levels greater than 0.01 times the least toxic concentration, however, because many biotech crops are used in animal feed, the possible toxicity in GMOs can be biomagnified in the food chain, or increase exponentially due to the large amount of feed consumed by livestock (Johnson-Green 2002).

Regular, reliable feed monitoring is important for assuring that livestock intended to be raised for non-GMO or organic meat or dairy remain uncontaminated by GMOs (Schreiner & Latacz-Lohmann 2015). Farmers who wish to switch to non-GMO livestock production can replace GMO feed with other grain legumes, oilseed feeds, or non-GMO soybeans without reducing the quality of milk produced (Schreiner & Latacz-Lohmann 2015).

USDA certified organic livestock and milk production standards require 100% organic feed (Friedman School 2015, Gasparro 2014). Non-GMO honey production requires tracing the path of the bees to assure they do no cross-pollinating or feeding on nectar from non-GMO crops (Gasparro 2014).
Why Feed non-GMO?

Snowville Creamery in Southwest Ohio transitioned their cows to non-GMO forage and feed to meet the demand of their customers. One of their largest dairy suppliers, Hamm Valley Farms in Racine Ohio believes this switch to non-GMO feed has actually improved the condition of their livestock (Taylor 2014). Both meat and milk products produced for niche markets, such as the market for non-GMO food and feed products, can increase product values. Consumers may perceive increased benefits or improvements in animal welfare which may increase their willingness to pay premiums for these products (Russelle et al. 2007).

Organic Production and Non-GMOs

Organic Production

The USDA Organic label is a tightly regulated agricultural program. It regulates food from production to consumption. This includes soil and water quality, pest control, livestock practices, and food additives, verifying that food is free of irradiation, synthetic fertilizers and prohibited pesticides, and raw sewage. Under the United States Department of Agriculture (USDA) National Organic Program, the use of GMOs is prohibited in organic production (Sonnabend 2015, Smith 2014).

While organic foods, feed, crops, and seed are all non-GMO, non-GMO products are not necessarily organic. Non-GMO produce and products may still contain ingredients grown using chemical fertilizers and synthetic chemicals used as herbicides (Smith 2014). Non-GMO products may cost less than similar organic certified products (Smith 2014). Many farmers have already transitioned to Organic production, and there is help available for those who wish to transition. Ohio’s Snowville Creamery points out that dairy farmers who want help transitioning to certified organic status can get monetary assistance from organic milk companies such as Horizon or Organic Valley (Snowville Creamery 2015). Although a lengthy process, there are rewards. Organic milk producers also pay premium prices for organic corn and feed to farmers who establish a relationship with the company. They start with an additional premium over market value from $0.50 the first year, and continuing to subsidize farmers who wish to transition their crops to organic with 0.50 more per year until they reach $2-3 over premium (Snowville Creamery 2015).

Organic and GMO Contamination

Products must be shown to be GMO-free and protected from potential contamination by other GMO products, but at this time testing for GMOs is not a requirement, which means there could possibly be some level of GMO contamination (Smith 2014). Contamination by GMOs can happen in the field, and is not always the responsibility of the producer (Sonnabend 2015). Some production systems are more harmful to the environment than others (Russelle et al. 2007).
Organic production is more environmentally friendly than traditional farming methods and it ensures that food and products have not come into contact with potentially dangerous substances that could affect human health (Smith 2014). To avoid contamination or organic crops by GMO crops, it is recommended that organic and non-GMO growers maintain buffer zones to minimize GMO creep from conventional agricultural fields (Redick 2014). This means that the area which could be devoted to growing non-GMO and organic crops would be lost, since the producer must sacrifice land to this buffer zone (Redick 2014).

**Organic Livestock Production**

Consumers may prefer to buy animal products (including meat, eggs, and dairy) produced from animals raised using only non-GMO feeds (Meijer et al. 2005). Growing numbers of consumers are demanding organic livestock farming methods as a result of their reputation for being both environmentally sustainable and creating higher animal health and welfare standards (Castellini et al. 2003). This reputation is supported by studies. In a study by Castellini et al., assessment of the breast and drumstick meat of organically raised broilers revealed that these animals’ improved welfare conditions resulted in reduced stress prior to slaughter. Additionally, these birds had greater mobility, interest in the observer, and higher quality plumage, indicating better animal welfare. A sensory panel also scored the juiciness and acceptability of the organic broilers higher than the conventional control birds (Castellini et al. 2003). Organic livestock production must meet animal welfare standards, with no growth hormones or antibiotics used in production (Friedman School 2015). At least 80% of feed for organic livestock must be grown in accordance to organic standards (Castellini et al. 2002).

**Regulation and Politics of GMO**

Introduction and Overview

Regulation of GMO and biotech agriculture occurs on national and international scales (Johnson-Green 2002). On these scales, there are many variations and degrees of regulation. As this shows, regulations can range from required, government sponsored non-GMO regulation, to regulation being voluntary or frowned upon by governments. Governments must balance the environmental and health risks while taking into account economic benefits, the concerns of consumers and business, and the scientific evidence. (Johnson-Green 2002). Current GMO policy issues include what potential environmental impacts GMO crops may have, should GMOs be labeled, the liability concerns of GMO crops, health concerns for human consumption, and issues of global trade. There are also concerns of whether federal regulation and oversight of GMOs is adequate, since GMO technology is relatively new and unexplored (Cowan 2015).
Global Regulation

A recent survey (Aleksejeva, 2014) showed that EU decision makers generally examined GM food and feed production on a case-by-case basis. This is a testament to how complicated the issues surrounding GMO production are. While many consider the risk of GM food and feed minimal on the health of animals and humans, there were those that also felt that cultivating GM plants would cause significant environmental risks. This survey also shows that many institutions have not developed an official policy regarding the production and consumption of GMO food and feed.

GMOs have been regulated in Europe on a much greater scale than in the United States. Europe’s GMO labeling regulation (EC 1829 and 1830) have been in effect for 13 years (Kepler 2014). These regulations affect stakeholders on all tiers of production including growers, processors, restaurants, and grocers (Olson 2000). The majority of Europe’s farmers are conventional, non-GMO farmers. EU laws follow the “polluter pays” principal, which places the burdens to prevent contamination on the grower of GMO’s by planting buffer crops (Redick 2014).

The EU and Russia require that food be labeled as containing GMO if it has more than 0.9% GM material, Australia and New Zealand require labeling at 1%, Japan at 5%, and South Korea at 3% (Veyssiere 2007) (see Threshold % levels for GMO Acceptance by Country, figure 3). Austria has had a voluntary GMO-free product label since 1996, with tolerance set at a 0.9% threshold (Layadi 2012). Germany adopted GMO-free labeling for meat, poultry, and dairy from livestock fed non-GMO feed in 2008 (Layadi 2012). France’s Brittany region launched a guidebook called ‘GMO-free Products in Brittany’ in 2007. This guidebook is a comprehensive list of producers selling non-GMO directly to customers, and retailers, butchers, and restaurants who also sell non-GMO products (Layadi 2012).

Federal Regulation for GMOs in the U.S.

In July of 2015, the Obama administration proposed to update the 1986 framework to create a better functioning regulatory system which can adequately assess possible risks from biotechnology products through a memorandum issued by the Obama administration (Cowan 2015). This memorandum recognized that while federal agencies may have their own system and guidance documents since 1992 to regulate GMOs, improvements in technology and science have created more need for federal oversight to increase transparency while continuing to innovate. The updates will include public input, and clarify the duties and areas to regulate each federal agency will have (Cowan 2015). Various examples of legislation created to govern GMOs can be found in Table 1.
According to U.S. Law,

“Whoever invents or discovers and asexually reproduces any distinct and new variety of plant, including cultivated sports, mutants, hybrids, and newly found seedlings, other than a tuber propagated plant or a plant found in an uncultivated state, may obtain a patent therefore, subject to the conditions and requirements of this title. The provisions of this title relating to patents for inventions shall apply to patents for plants, except as otherwise provided,” (35 U.S.C. § 161).

Asexual reproduction means that reproduction can occur by methods such as cuttings, layering, division, and budding, but not by seed. This type of reproduction preserves the plant’s genetic identity and allows them to be patented. There are three classes of plants able to be protected under plant patenting laws. These are sports (a distinctive variety of a plant that is propagated vegetatively), mutants (a genetically new distinctive variety of a plant), and hybrids (new distinct variety resulting from cross-pollination of a combination of different species or varieties) (Swanson & Mehrbani 2014).
In this way, seeds should be free from U.S. patenting laws. However, GMOs have been patented under a different set of laws, corresponding to their utility (Swanson & Mehrbani 2014). The argument has been made that the legal system in the U.S. is set up in a way that protects intellectual property rights, including the ownership of modified organisms by the companies which create them, and therefore, has established a regulatory environment which has helped agricultural biotechnology companies flourish (Pechlaner 2012). According to a variety of scholarly sources, the current position of the U.S. government is that GMO crops are essentially the biological equivalent of non-GMO crops and there is therefore no need to be labeled. This concept is otherwise known as substantive equivalence (Veyssiere 2007, Moon & Balasubramanian 2003, Johnson-Green 2002).

The Food and Drug Administration (FDA), the United States Department of Agriculture (USDA) and the Environmental Protection Agency (EPA) are the federal organizations responsible for regulating biotech companies and holding them accountable to the public by testing the safety of their GM products (Cowan 2015, Center for Food Safety 2015, Hartley 2000, Johnson-Green 2002). The agricultural biotech industry is regulated by those three federal agencies under the 1986 Coordinated Framework for the Regulation of Biotechnology (Cowan 2015, McCullum et al. 2003). These agencies must analyze scientific data and interpret the results to make decisions about GMOs to balance their benefits and risks to the environment and humans, while making correct judgements about policy and the legal framework within which they operate (McCullum et al. 2003).

The USDA’s APHIS program (The Animal and Plant Health Inspection Service) protects agriculture from diseases and pests, and in this way regulates GMOs which may result in pest risks (Yang & Chen 2016). The EPA controls pesticides to assure they are safe to humans, animals and the environment, and in this way regulates GMOs which may have bioengineered pesticide traits (Yang & Chen 2016). The FDA regulates GMOS as organisms which will be consumed, testing if necessary to ensure safety of food and drug products (Yang & Chen 2016).

Efforts to control and regulate GM crops have been labeled both uncoordinated and contradictory by many. Similarly, the voluntary nature of the regulation is often seen as a loophole (Center for Food Safety 2015). Repeated non-compliance issues with regulations have created concerns about the adequacy of existing regulations, and the ability of the USDA’s Animal and Plant Health Inspection Service’s environmental assessments (Cowan 2015).
### Non-GMO Legislation Introduced to the 114th Congress

(Lanza 2016)

<table>
<thead>
<tr>
<th>Legislation Name</th>
<th>Purpose</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The Genetically Engineered Food Right-to-Know Act</strong></td>
<td>• Amend FFDCA, classifying any foods containing 1 or more GMO ingredients misbranded unless these ingredients are disclosed</td>
<td>• Exempt food served in eating establishments, medical food, or produced with GE vaccines, processing aid or enzyme</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• GMOs for human consumption</td>
</tr>
<tr>
<td><strong>The Safe and Accurate Food Labeling Act of 2015</strong></td>
<td>• Establishment of certification programs overseen by the FDA and USDA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Amend Plant Protection Act to create a pre-market certification program for interstate commerce with approval from the Secretary of Health and Human Services (HHS) and the Secretary of Agriculture.</td>
<td>• FDA would continue premarket consultation for products derived from new plant varieties</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Labels must state material differences between non-GMO and GMO foods.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ‘Natural’ labeling terms would be considered misbranded unless clearly defined by FDA.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• State regulation of GMOs would be affected</td>
</tr>
<tr>
<td><strong>S. 2609</strong></td>
<td>• Establish GMO voluntary food labeling standards overseen by USDA</td>
<td>• USDA create regulation to outline process of determining when foods are labeled as GE.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Prohibit assumption food is unsafe based on GE status alone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Provision on state laws.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Allow state labeling requirements if identical to labeling standard</td>
</tr>
<tr>
<td><strong>S. 2621 Biotechnology Food Labeling Uniformity Act</strong></td>
<td>• Amend FFDCA to consider food misbranded unless bearing labeling stating it is GMO.</td>
<td>• Label must say genetically engineered or GE before the name of GMO ingredients, with asterisk denoting modified ingredient</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Symbol by HHS secretary to disclose GE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Processed foods to not apply unless 9/10 of product weight is GMO ingredients</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Require state labeling to conform to standards</td>
</tr>
</tbody>
</table>
The U.S. Department of Agriculture (USDA) and The Animal Plant Health Inspection Service (APHIS)

The USDA currently regulates GMO considered “plant pests” or nuisance crop (Redick 2014). The Animal Plant Health Inspection Service (APHIS) is the agency within the USDA which coordinates inspections of GMO products (Sonnabend 2015). APHIS authorizes tests of genetically engineered plants and animals. If they see that unconfined release of these organisms does not create significant hazards to agriculture and the environment, they are then deregulated. Once deregulated, organisms can be planted without further authorization (Fernandez-Cornejo & Caswell 2006). They test plants and products, regulating plants which should not be introduced to the environment through a permitting process which includes field trials, to ensure that plants will not harm human health, damage other agriculture, or harm the environment. They regulate organisms which may be considered pests under the Plant Protection Act (PPA; 7 U.S.C. §7701 et seq.), animal viruses, toxins for vaccines, and sera under the Virus, Serum, and Toxins Act (21 U.S.C. 151 et seq.), and plant pests considered to be regulated articles under APHIS regulations (7 C.F.R. 340-340.9) (Cowan 2015). Typically, developers of commercial GM plants go through the process to reach APHIS’s non-regulated status, which allows them to grow these crops without federal oversight. By 2013 APHIS had approved over 14,200 GM plant field trials (Cowan 2015). There have been questions about the adequacy of the APHIS regulatory regime, especially following a 2007 incident in California, where the U.S District Court in California’s Northern District found that APHIS had failed to consider the effects GM alfalfa had on the environment, including contamination of non-GMO alfalfa (Cowan 2015).

The USDA’s own Office of Inspector General (OIG) has criticized the biotech regulations of APHIS, concerned that their regulation efforts have not kept pace with their vast number of field testing sites (49,300 as of 2005), and that GM contamination could escape into the environment before they are considered safe. The OIG also claims that APHIS lacks information about the field test site locations, does not properly review containment protocols on applications, that inspection requirements are not definite enough and are not followed by inspectors, and that there need to be more guidelines for GM seed containment (Cowan 2015). Based on materials from a 2011 U.S House Agriculture committee meeting, Congress sees no statutory authority for the USDA to require containment of GMO crops. While there is no legal duty to prevent biotech pollen migration, seed flow, or movement of contaminated plants from conventional agricultural fields to non-GMO or organic fields, according to Redick (2014) this could potentially lead to non-GMO crops becoming contaminated and to loss of National Organic Program certification (Redick 2014). The USDA asserts that organic farmers can protect themselves by “fencing out” GMO crops, while others still argue this is not possible (Redick 2014). The APHIS responded by reorganizing permit applications and evaluation procedures, and developing a new system for preventing environmental releases based on the plant’s durability in the wild, and the potential for the plant to cause harm (Cowan 2015).

APHIS began holding meetings to discuss the presidential memorandum “Modernizing the Regulatory System for Biotechnology Products” in 2016 (USDA APHIS, 2016) (as mentioned in the previous section). This memorandum may change the responsibilities that APHIS has in managing and testing GMO and non-GMO products. This meeting is scheduled to occur in the near future with the collaboration with the FDA and EPA.
In sharp contrast, the US EPA has restricted the planting of genetically modified organisms on the basis of their properties as a pesticide. Substances that prevent, destroy, repel, or mitigate pests are considered pesticides and are regulated by the EPA (Fernandez-Cornejo & Caswell 2006). The EPA, under the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. §§ 136–136y 2012), registers and approves pesticides, including those GMOs that incorporate into their makeup compounds otherwise known as plant incorporated protectants (Cowan 2015). The agency desires to limit any possible “imminent hazards” resulting from situations where plant toxicity is a potential problem. These imminent hazards may result in unreasonable environmental effects, including jeopardizing the survival of native species listed by the Endangered Species Act of 1973 as endangered or threatened. The EPA takes into account that genetic modifications in organisms may be considered a pesticide, and creates regulations for them to ensure that the environment will not be affected in unpredictable ways (7 U.S.C. §§ 136–136y 2012).

The EPA also has a duty to weigh the possible risks on human health of GMOS against the possible benefits (7 U.S.C. §§ 136–136y 2012). The EPA sets tolerances for pesticide levels in food, and conducts field tests to determine if these tolerances are upheld (Cowan 2015). This restriction includes a requirement that a farmer maintain 20-50% of their acreage as conventional corn when GMO corn is planted (Hartley 2000). This strategy attempts to decrease the likelihood that pests will adapt and develop resistance to GMO crop varieties, and avoiding pests no longer be able to be controlled by pesticide use (Fontes et al. 2002).

FDA regulates crops intended for food applications, and tests to ensure that GMOs are safe to eat (Fernandez-Cornejo & Caswell 2006). The FDA believes that because GM food contains material previously unknown in human diets, they should be regulated. However, the FDA has no formal rules in place for testing biotech foods like it does for new pharmaceuticals (Center for Food Safety 2015). The FDA expects instead that the developers and manufacturers of GMO products will be responsible for exploring the safety of their products and consult with the agency as needed (Center for Food Safety 2015, Hemphill & Banerjee 2014).

Under the Federal Food, Drug, and Cosmetic Act (FFDCA; 21 U.S.C. §301 et seq.) and the Public Health Service Act (FFDCA; 42 U.S.C. §201 et seq.) the FDA regulates both human and animal food and drugs which may pose a threat to human health (Cowan 2015). They regulate all domestic and imported food and feed, GMO or not, and uphold all to the same standard. All food additives must seek FDA approval, and those approved may be recognized as safe (Cowan 2015). The FDA does not approve of the term ‘GMO’ because they claim it is overly broad, and most food does not contain whole organisms. They would prefer terms such as ‘not bioengineered’. However, they will not take action against labeling products as non-GMO as long as the claim is not misleading (Center for Food Safety 2015, Strom 2015). The FDA does not require GMO ingredients to be disclosed on labels (Strom 2015).
Non-GMO and the Law

Social movements, which previously worked to transform agricultural production practices through targeting government regulation or creating alternatives to industrial agriculture have emerged as actors which have mobilized their concerns about food and agricultural issues by driving the markets for non-GMO (Bain & Dandachi 2015). Consumption, in this way, becomes political power. Consumer power which can be used to influence retailers to provide labeling of GMO foods also influences them to explore new possibilities, including providing organic and non-GMO options to consumers (Bain & Dandachi 2015).

Economy of non-GMO

Growth of a Non-GMO Market

There is a growing consumer market for non-GMO products (see Figure 4). In 2014, the global food and beverage market was worth $5 trillion. According to market research conducted by Packaged Facts, $550 billion of this $5 trillion consisted of non-GMO sales. In the U.S. alone, over $200 billion in non-GMO products were sold, which is 36% of the total global market (Global Non-GMO Food & Beverage Market Reaches $550 Billion 2015).

In the U.S., 43% of new product launches over a one-year period made GMO-free claims, which is 4% more than the European Union (U.S. Leads Demand for GMO-Free Labeling 2015). 78% of American consumers have an interest in how their food is produced and 74% think food safety should be taken into account by producers (U.S. Leads Demand for GMO-Free Labeling 2015). Approximately 42% of consumers surveyed either strongly agree or somewhat agree they would want to buy non-GMO products (Sprinkle 2014). Sales of labeled, non-GMO-verified food products alone have increased from $0 in 2010 when the non-GMO label was first created, to 3.5 billion dollars in 2014 and it is estimated that total non-GMO product sales will reach 30% of the $264 billion food and beverage sales by 2017 (Smith 2014). With a compound annual growth rate of 15%, sales of non-GMO food and beverages are expected to nearly double on the global market by 2019 (Global Non-GMO Food & Beverage Market Reaches $550 Billion 2015).

Non-GMO product launches in breakfast cereals have led the breakfast cereal market at 13%. This is followed by 7.4% of snack foods being launched as non-GMO, and 4.6% of bakery products (U.S. Leads Demand for GMO-Free Labeling 2015). There is also a focus on the labeling of dairy products, however under 10% of U.S. dairy products are currently labeled as GMO-free (U.S. Leads Demand for GMO-Free Labeling 2015). In both retail and food service, non-GMO product launches are increasing, with an estimated 2,000 products per year (Global Non-GMO Food & Beverage Market Reaches $550 Billion 2015). Currently, 60% of the non-GMO products being sold are organic or natural foods, and this number is expected to increase (Global Non-GMO Food & Beverage Market Reaches $550 Billion 2015).
Consumer Demand for Non-GMO

U.S. consumers eat many products containing ingredients based on processed GMO plants, including oil, sugars, and cornmeal, among others, despite being unaware of the GM content (Fernandez-Cornejo & Caswell 2006). In the American market, consumers have generally been responsible for finding their own information about the products that they purchase and consume. Although the government regulates products to protect consumer health, and also protect consumers from fraud, requiring too much information on labels could both slow technological advancement and be burdensome to the free market. Therefore, labeling is only required within reasonable extents (McGarity 2007).

Non-GMO foods and labeling are generally seen as something consumers do want more information about. Although consumers do not necessarily understand what GMOs are, because of their existing preconceptions about biotech and processed foods, they want to know where their food is coming from, and are beginning to ask whether or not the products they are consuming are genetically modified (Stom 2015). Whether or not GMO foods pose true risks, consumers prefer to have the option to avoid buying these foods, to avoid risk altogether (McGarity 2007).

Consumer concern and the desire for pure and healthier foods, desire to protect the environment from non-GMO seed spread and pesticide use, and the desire to fight against the perception of poor business practices by seed companies, has created a significant demand for non-GMO products (Kepler 2014, Smith 2014). Non-GMO food from smaller farms tends to have a transparency for consumers, which is not currently provided by commercial mega-producers of GMO crops (Bain & Dandachi 2015). However, it should also be noted that private initiatives, rather than government regulation, can help to create public awareness of non-GMO products and create long-term, significant change toward labeling and using non-GMO food products (Bain & Dandachi 2015). Most studies and surveys conducted have indicated that consumers not only have concerns about food containing GM ingredients, but that they would be willing to pay higher prices for foods that are GMO free (Fernandez-Cornejo & Caswell 2006).

Research conducted by Moon & Balasubramanian (2003) has shown that subjective levels of risk perception (such as the risk of chemical use during production of crops, and improved nutritional quality of non-GMO food) of GMO foods can contribute to consumers’ willingness to pay premiums for non-GMO products (Moon & Balasubramanian 2003).
Non-GMO and Producers

Stakeholders in the non-GMO supply chain include producers, grain handlers, food processors and retailers, biotech and non-biotech firms, regulatory agencies, and consumers (Moon & Balasubramanian 2003). Many farmers are beginning to turn away from GMO production. This is probably in part due to the fact that GMO seeds typically cost more than non-GMO seeds (Bunge 2015). They have found that the higher cost of added GMO traits in seeds didn’t necessarily equate to larger yields, meaning that GMO agriculture came at a financial loss (Barker 2015). The lower cost of non-GMO seeds can also offset the cost of pesticides (Bunge 2015).

Non-GMO crop production can yield premium prices at market because of growing consumer demand (Barker 2015, Brooks 2010, Bunge 2015). The preservation of the non-GMO identity of crops and market segregation increases the cost to producers, increasing the marketing cost in 2003 from country to export elevator by $0.22 per bushel of corn, and soybeans by $0.54 (Moon & Balasubramanian 2003). Non-GMO soybeans, for example, typically cost $20 dollars less to purchase initially and earn $2 more per bushel than the GMO version of similar seeds (Barker 2015). Non-GMO corn can also earn 25 extra cents per bushel in the U.S. than their GMO counterpart (Barker 2015). Demand for non-GMO products is also driven by overseas markets,

Figure 4. Green Market (Brat 2015). These graphs show sales increases of non-GMO food products and percent of new products that are certified as non-GMO each year. From 2012, both sales and new products labeled as GMO-free have increased markedly.
such as in Japan and South Korea, and the European Union (Barker 2015). The EU is the US’s largest export market for soy beans, and yet exports have fallen because many countries now demand non-GMO seed and grain, such as the EU, Japan, and Korea. This makes it economically beneficial for farmers in the US to convert production from biotech crops to non-GMO (Olson 2000).

Depending on where in the US a producer is located, different types of non-GMO products may actually be easier to grow and sell. For Example, Bruce Abbe of the Midwest Shippers Association says that if a farmer is located along a river shipping corridor, then there will be more opportunities to market non-GMO corn products than for farmers who are located elsewhere (Brooks 2010).

Farmers in Germany who produce GMO free milk are rewarded by 0.80 Euros (approximately 1 USD) as a premium per kg (0.26 gallons) of milk sold (Schreiner & Latacz-Lohmann 2015). This would equate to $3.85 more per gallon for non-GMO milk. However, regional differences, and differences in values among both producers and consumers have been shown to affect this price (Schreiner & Latacz-Lohmann 2015). The sale of non-GMO milk in the US also draws a premium price of upwards of 25 cents more per gallon over non-GMO milk according to Clover Stornetta Farms, in Petaluma California (Duggan, 2016).

Non-GMO Supply Chains

One economic factor to consider as an important component of the marketing system is the supply chain of non-GMO products, meaning how the product travels from its location of origin throughout its journey to the consumer. To ensure that contamination remains less than threshold levels, it is important to have a visible, traceable supply chain. It is difficult to supply non-GMO products to those demanding them if there is also no mechanism for tracking their origin, and controlling their production and commercialization (Teuscher et al. 2006). Therefore, standards must be developed to safeguard non-GMO products against contamination. It is important that standards are upheld at all levels of the supply chain (Teuscher et al. 2006).

Setting up a supply chain guaranteed to be non-GMO is a lengthy process. When the Swiss organization called Gebana wished to establish a supply chain of non-GMO soybeans (for the Swiss market) they hired the Business Sustainability Development Consulting firm (BSD) in order to outline several goals to help them achieve this goal (Teuscher et al. 2006). The first goal was to create an organic or non-GMO certification system to ensure the product being sold was genuine. Secondly, they thought it was important to create a social and environmental niche for their products. This included meeting with agricultural and food industries to discuss non-GMO product possibilities, creating relationships and developing products with partners and product distributors, and creating a set of criteria to monitor the social criteria of their supply chain (Teuscher et al. 2006).
These relationships are important to ensure that all expectations are met. This will help to guarantee that there is a market for non-GMO products, by ensuring that producers will be able to sell their products, but also that the needs of the buyer are going to be met. Thirdly, establishing a social fund for community development would help to improve social conditions of producers and ensure cooperation among different groups within the community. Monitoring to ensure product quality would also take place within this goal. (Teuscher et al. 2006).

Through this process, Gebana learned many valuable lessons. They found that communication among the different parties involved in this project was extremely important, as it provides the most technical and comprehensive knowledge of both production and non-GMO guidelines, leaving the least possible room for misinterpretation, which can increase costs (Teuscher et al. 2006). Employing third parties to ensure that the supply chain is managed effectively and in a timely manner, from production to marketing can be helpful. Likewise, professionals knowledgeable in the management of information were found to be very helpful for communication and intermediation within supply chains (Teuscher et al. 2006).

**Corporations and the GMO Market**

At around $6 billion dollars a year, the United States’ commercial seed market is the world’s largest (Fernandez-Cornejo & Caswell 2006). In the 1930s, hybrid seeds first became available for commercial production. These hybrid varieties delivered higher crop yields, but farmers were compelled to purchase new seed each year to maintain these yields due to the degenerative nature of the commercially hybridized seed (Fernandez-Cornejo & Caswell 2006). This yearly buying of seeds created further economic incentives for companies to invest in seed development. New varieties of seed developed can be protected by the Plant Variety Protection Office of the USDA and U.S. patent and trademark laws, which give developers of these varieties exclusive legal rights to grow and market (Fernandez-Cornejo & Caswell 2006). Increased technology during the 1980s led to a boom in research and development of large scale biotechnology, once again transforming the seed industry (Fernandez-Cornejo & Caswell 2006). To offset costs from this research, companies merged, partnered, and became larger (Fernandez-Cornejo & Caswell 2006).

Worldwide, there are a few multinational corporations which control the vast majority of the sale and supply of corn and soybeans. These include Monsanto, Dupont (Pioneer), Syngenta, Groupe Limagrain, Land O’Lakes, KWS AG, and Bayer Crop Science (Sarich 2013). By far, Monsanto makes up the lion’s share with their product covering 87% of GM cropland (Sarich 2013). In September, 2016, it was announced that Bayer Crop Science agreed to buy Monsanto for $66 million. If the deal gains regulatory clearance, this merger will give Bayer a distinct advantage over its competitors, and form a company that controls over 25% of the world agribusiness market. Market research analysts see as little as a 50% chance that this deal will in fact gain regulatory clearance (Roumeliotis and Burger 2016).
These large corporations have the financial means and ability to deflect risk, making them primarily responsible for the development of transgenic crops (Johnson-Green 2002). GMO patents have been granted not on the plant patenting law, but as previously stated in an earlier section of this report, U.S. utility patent precedents (Swanson & Mehrbani 2014) which allows these large corporations which are able to afford research and production of transgenic crops to patent and control the vast majority of GMO seed.

Many other large corporations including Ben & Jerry’s, and General Mills, and Whole Foods are beginning to assure their products are free of biotech ingredients by having their products certified non-GMO (Brat 2015). As CEO of W. Atlee Burpee & Company, the largest provider of garden seeds, George Ball, says, “You got to play defense and offense in any game,” (Brat 2015). Certifying products as non-GMO can both increase sales, and act as insurance that sales will not decrease because customers wish to buy from assuredly non-GMO sources.

**Labeling non-GMOS**

61 countries around the world have laws that require that genetically modified foods be labeled (International Business Times 2013). Biotech industry representatives claim that GMOs are completely safe for consumption by humans, however opponents and health advocates state that studies may suggest they contribute to damage of the kidney and liver, as well as reproductive issues, therefore concluding that GMO food should be labeled to allow people to make their own better decisions (International Business Times 2013). Not labeling GMO food as containing GMO ingredients creates an atmosphere of distrust, especially to large corporations such as Monsanto who control the monopoly of GMO seed production (Caplan 2013).

Marketing of non-GMO products as a component of the food industry is becoming one of the fastest growing trends in the U.S. (Gasparro 2014). However, there are potential problems regarding non-GMO products, particularly with regard to quality control and/or regulation (Bain & Dandachi 2015, Roff 2008). Because of the lack of federal GMO regulation of the labeling of non-GMO products, it is possible that even labeled products can contain varying amounts of GMO products or even GMO DNA. (Bain and Dandachi 2015). Third-party certification has emerged as a way to ensure that products are not contaminated by GMOs, and to provide labeling for non-GMO products (Roff 2008). It is important that products claiming to be non-GMO are verified through a standardized labeling initiative. If products claim they are non-GMO, and then are later tested and found to contain GMO ingredients above some standard level of contamination, consumers could lose faith in this component of the food industry (Neuman 2009).
Current Labeling Practices

Mandatory labeling has already been adopted by countries such as Japan, South Korea, Australia, New Zealand, and the European Union (Peters & Lambert 2007). In these countries that require labeling, the strictest labeling contains the phrases ‘does contain’ or does not contain’, and the less strict labeling may use the phrase ‘may contain’ (Peters & Lambert 2007). The European Union strictly regulates GMO products, and not only has adopted standardized risk assessment methodology, but has also implemented GMO labeling (Wohler 2016).

Although European governments have largely accepted the labeling of non-GMO products, until recently the United States government has not required any GMO or non-GMO labeling, even though bills considering labeling have at times moved through congress (McGarity 2007). Federal Food, Drug, and Cosmetic Act (FFDCA) prohibits false or otherwise misleading information on products that will be sold to consumers. Such terms as ‘natural’ are not specifically defined, and therefore misleading to consumers (Lanza 2016). The FDA didn’t differentiate between GMO and non-GMO products if it was considered safe by FFDCA standards and is not significantly different in composition from the traditional, non-GMO form of the crop or animal variety (Lanza 2016). Food was considered to be different enough to warrant a label if the product contained an allergen not typically present in the food, which consumers would not expect the product to contain. In this case, labeling serves to disclose possible health risks. In 2001, the FDA encouraged voluntary labeling of GMO foods by manufacturers if the products follow FFDCA guidelines and the labels are truthful, scientifically valid, and not misleading in any way (Lanza 2016).

Many U.S. states have seen grassroots campaigns to label GMOs, but some failed to gain the necessary support. For example, GMO labeling initiatives have failed in Washington, Oregon, and California (Wohler 2016). Momentum to address GMO labeling is still strong, especially in the West, Midwest, and Northeast, with over 15 states considering possible legislation (Wohler 2016). Connecticut passed a law in 2013 requiring baby food and infant formulas containing GMOs to be labeled (effective 2019). Maine also passed legislation requiring that food products exceeding the 0.9% threshold be labeled, but this legislation contains provisions similar to Connecticut’s stipulations. Vermont implemented mandatory labeling of GMO food in 2014, and was the first state to do so (Hemphill & Banerjee 2014). These mandatory labeling requirements are effected by a new, federal labeling law, S. 764 (Addady 2016).

The U.S. House of Representatives recently passed a bill that would require mandatory labeling of GMO ingredients in food, and Senator Debbie Stabenow (D; MI) (Strom 2015). When this bill, The Safe and Affordable Food Labeling Act (HR 1599) passed through senate, it failed to pass in March until it was agreed that GMO ingredients would be disclosed from digital codes, 1-800 numbers or website URL website if the business is very small, rather than directly on the package (Addady 2016, Brasher 2016). Obama signed this bill, despite 250,000 petitioners (Greenberg 2016). This legislation make’s Vermont’s GMO labeling law, which requires GMO production information directly on the package, and the labeling laws of other states, null and void (Brasher 2016). Stabenow and the USDA both approve of the bill, the USDA claiming that it will increase transparency while not providing inaccurate information about food (Brasher 2016).
Critics of the bill know it as the DARK Act (Deny Americans the Right to Know Act), and claim that allowing this bill to pass shows how much control the agrochemical industry and large corporations have over American politics. They assert this bill is opposite of transparency, since it allows GMO producers to hide information about the product behind the digital codes (Greenberg 2016). Likewise, it is said to be discriminatory, as those without access to technology will be unable to access the information provided by the labels (Addady 2016). Despite this criticism, the bill will create the standard for GMO labeling after the USDA’s Agricultural Marketing Services finishes writing the rules, within two years (Brasher 2016).

Meat and dairy will not be considered GMO as a result of animals consuming GMO feed, and products whose main ingredients are meat will be exempt from labeling, however animals who are genetically modified themselves must be disclosed on the label (Brasher 2016, Shearer 2016). Food companies that wish to label products as non-GMO will be allowed to do so by the USDA if the claim is verified by a third party (Shearer 2016).

The USDA has announced it is in the process of developing the first government sponsored non-GMO label, The USDA “Process Verified” label (Jalonick 2015). This label creates a federal standard for food companies’ products, and verify claims through independent third-parties (Askew 2015, Cowan 2015). The Process Verified Program creates transparent process points, with documentation of management systems and third-party verification to ensure consistency of quality. A process point, defined by the Agricultural Marketing Service can be following a set standard of quality, production or handling practices, quantifiable characteristics of production or product, or other requirements. Asserted claims must be factual, repeatable, quantifiable, and able to be verified (USDA Agricultural Marketing Service 2016). The Process Verified label favors voluntary labeling through the National Genetically Engineerd Food Certification Program (part of the Agricultural Marketing Act of 1946) over federally regulated GMO labeling (Cowan 2015). The label is not free, and companies who wish to use this label must pay for certification (Jalonick 2015). This label is created as part of the USDA’s Agricultural Marketing Service (AMS) at the request of what AMS Agriculture Secretary Tom Vilsack called a “leading global company” (later identified as Toronto’s SunOpta) (Askew 2015, Jalonick 2015). Companies would pay the AMS to test their products and verify the non-GMO claims to assure accuracy before approval (Jalonick 2015).

Non-GMO Labeling Concerns

While consumers want to know where their food comes from and what is contained in their food, providing too much information could create information overload, in which non-relevant information overshadows potentially important information (McGarity 2007). Products may not contain a great deal of space in which to provide important information. Therefore, product size and amount of space available must be balanced with critical food information, such as their Non-GMO status (McGarity 2007). There are also concerns voiced by GMO producers that requiring the labeling of GMOs in products would violate First Amendment rights, as a form of compulsory speech. For commercial speech to be regulated, harm to the consumers must be directly shown, and as yet there has been too little evidence demonstrating that GMOs harm consumers (Yang & Chen 2016).
The Non-GMO Project

Because until recently there has been a lack of federal regulation, most companies choose to use the Non-GMO project, a non-profit, independent certification process, to assure their products are free of GMOs (Jalonick 2015). The non-GMO project is the fastest-growing private non-GMO labeling initiative in the natural food industry (Smith 2014). According to the Non-GMO Project’s Executive director, Megan Westgate, the new federal labeling law will not have a direct impact on the Non-GMO project itself. The law will make verifying products as non-GMO even more critical. The law doesn’t change the project’s verification program or affect producers’ abilities to use the Non-GMO project logo (Westgate 2016).

The Non-GMO Project works to provide services including the testing of products, requiring producers to adhere to standards of traceability and segregation, establishing a tolerance level of 0.9% for acceptable GMO traces (i.e., the same level set by the EU), and ensure products remain non-GMO throughout their production and distribution. (Bain and Dandachi 2015). Testing by The Non-GMO product can be conducted for single ingredients or final products, while producers must work to monitor possible points of contamination during production (Roff 2008). This project has certified over 18,000 products and 1200 brands (Bain & Dandachi 2015).

The project tests ingredients at risk for GMO contamination including alfalfa, canola, corn, cotton, papaya, and soy, beets, squash, and animal products such as meat, eggs, and milk on an ongoing basis (Smith 2014). Through the non-GMO project, products must be certified annually, making the certification process a time-consuming commitment. All new products must be verified individually, and labeling will need to be updated. Seed suppliers must also assure that breeding processes for seeds are also non-GMO (Sparks 2015). For a list of non-GMO seed suppliers, see Appendix B.

Current Concerns with CRISPR Technology

What Is CRISPR?

CRISPR Cas-9, which stands for Clustered Regularly Interspaced Short Palindromic Repeats, is a new technology for creating genetically modified organisms first developed in 2012 by a team of biologists led by Jennifer Doudna and Emmanuelle Charpentier (Ledford 2016, Sontheimer & Marraffini 2016). Within three years of its original conception, this breakthrough has changed the entire field of genetic manipulation (Talbot 2016, Unniyampurath et al. 2016).

CRISPR-Cas9 is different from previous GMO technologies. It allows scientists to alter, disable, or change genes by rewriting DNA itself through an organism’s naturally occurring immunity strategy (Ledford 2016, Sontheimer & Marraffini 2016 Unniyampurath et al. 2016). The genome of almost any organism can be changed using this technique, via normal gene expression (Ledford 2016, Sontheimer & Marraffini 2016).
CRISPER uses the foundation of the immune system and building blocks of DNA to create a blueprint from which a new modified structure can be built by showing the DNA how it should construct itself (see figure 5). Genes are inserted and deleted at a specific, targeted genomic site with the guidance of RNA, using naturally occurring immune system defensive responses (Unniyampurath et al. 2016). DNA stores pieces of information about harmful invaders in a body’s system, eventually resulting in the potential synthesis of molecules that act to fight back against harmful change or invasion of foreign materials. To store this information, invading DNA fragments are incorporated into the host’s DNA as new sequences of DNA known as spacers. These spacers are used to make heritable memories, to instruct immune responses in the future against foreign DNA in that same sequence (Sontheimer & Marraffini 2016).

This technology uses a guide strand of RNA to determine where DNA sequences will be snipped and the genome rewritten (Ledford 2016). When DNA is cut, it can either be allowed to heal itself or it will mend in accordance to a DNA template provided by scientists (Ledford 2016). This means that the genome can be altered into almost any sequence at that location (Ledford 2016). Synthetic biologist at MIT, Ron Weiss, has even altered multiple genes within a single experiment (Ledford 2016). Supporters of CRISPR technology claim that it is safer than previous versions of genetic modification because gene editing has greater precision, which smaller on-point mutations (Kuzma 2016).

---

**Figure 5.** CRISPR Recordings of RNA Memories by K Sutliff/Science (Sontheimer et al. 2016). There are three steps to the CRISPR mechanism. 1, Create immunity response by capturing invading DNA fragments (spacers) into CRISPR loci. 2, Host organism transcribes CRISPR loci, generating CRISPR RNA (crRNA). This RNA contains both information from the CRISPR gene and the foreign DNA. 3, crRNA detects foreign DNA, which is then clipped through biochemical nucleic acid machinery (Unniyampurath et al. 2016).
The Market for CRISPR Technology

The market for CRISPR technology is expected to grow 43% by 2021 (Research and Markets 2016). It is more cost-effective, simplistic, and more efficient than other technology created to develop GMOs, and because of this, it is increasingly utilized for medical and agricultural research, curing human genetic diseases and improving crops (Ledford 2016, Research and Markets 2016). CRISPR-related molecular tools have even been shipped to scientists in over 83 countries (Ledford 2016). Also, private companies are creating and investing in many products intended for commercial distribution (Research and Markets 2016). This technology has raised many millions of dollars since its conception and may be the future of genetically modified crop biotechnology (Ledford 2016).

Labs in China are already creating CRISPR wheat to express fungus resistance and high-yield rice. In the U.K., barley has been altered to increase germination during droughts by changing genes that control the process of seed germination, and this technology is being applied to other crops such as potatoes and tomatoes (Talbot 2016). Large companies such as Dupont Pioneer have already begun investing in CRISPR technologies. An inventor of this technology, Jennifer Doudna hopes that within five years, seeds created using this technology will be available for sale (Talbot 2016).

Why CRISPR is a Concern?

The Coordinated Framework for the Regulation of Biotechnology (CFRB) is the United States’ system of regulating and overseeing GMO products. This system has been in place since 1986. Various federal agencies worked with the Office of Science and Technology Policy (OSTP) to develop this framework. Under this framework as discussed earlier in this report, different categories of organisms, and organisms created through different types of processes are funneled into particular agencies (Kuzma 2016). The EPA and USDA require organisms created using recombinant-DNA technology or genetic modification to face regulatory review before being allowed to enter the market, while the FDA requires that all new plant varieties go through voluntary consultation processes with the agency (Kuzma 2016). The USDA requires detailed descriptions of the genetically modified organism’s molecular biology (Kuzma 2016). The USDA oversees GMO organisms containing DNA from plant pests including viruses and bacteria, which was required for creating GMOs before new gene-editing technology such as CRISPR came into existence (Ledford 2016, Waltz 2016). In the past 5 years, only 30 GMO organisms, some of which made with gene editing techniques, have been declared by the USDA as something that doesn’t fall under their regulations (Waltz 2016).

New crops are being developed using CRISPR gene editing technology, but it is not yet understood how they will be regulated. Because plants created through CRISPR methods do not show traces of foreign DNA, they are less likely to fall under existing U.S. regulations over GMOs. Another gene-editing method, Transcription activator-like effector nucleases (TALENs), has already created corn, potatoes, and soybeans, that don’t fall under regulation (Talbot 2016). Therefore, while the USDA may regulate some of these new crops, many other new crops may not fall within the agency’s regulatory oversight (Ledford 2016).
For example, the USDA has chosen not to regulate a common white button mushroom created using CRISPR technology (Waltz 2016). This organism, created to resist browning by removing genes which produce the enzyme polyphenol oxidase, is the first CRISPR organism to be approved (Waltz 2016). Choosing not to regulate this organism may set a precedent for future gene-edited organisms to go unregulated by the U.S. government. As new CRISPR-Cas9 technology is developed, debates about the safety and use of genetically modifying plants and animals are only intensifying (Kuzma 2016). These debates encompass many concerning issues including whether regulation should focus on the manufacturing processes or the GMO products created through genetic manipulation. Also a concern is whether organisms created with new gene-editing technologies such as CRISPR will fall under the regulatory framework federal agencies use for overseeing GMOs (Kuzma 2016).

Besides this mushroom, several genetically engineered plants have gone to market without any formal regulatory oversight by the USDA or other U.S. federal agencies. The number of plants entering the market without USDA review are increasing. In 2015, 10 un-reviewed plants entered the marketplace versus 6 in 2012 and 1 in 2010 (Kuzma 2016). This is a concern because since CRISPR technology is so new, unintended modifications may still occur within the genome of gene-edited organisms (Ledford 2016).

While it is largely accepted that editing RNA will have off-target effects, this technique is without methodology to eliminate this concern (Unniyampurath et al. 2016). Second generation CRISPR plants have been shown to contain traces of the foreign DNA initially used to create the original, first generation plant (Talbot 2016) and Chinese research in human genome editing from Sun Yat-sen University has shown that while CRISPR potential is great, the new technology doesn’t always function in the way intended (Miller 2016). Research conducted recently shows that there may be off-target effects due to interaction of the Cas-9 protein and the DNA sequences and other biological factors (Rongxue et al. 2016).

As a highly-programmable operation, the design of the gene-editing methodology may be a potential pitfall in the process of using CRISPR technology. The way this technology is implemented (in-vitro, microinjection, chemical transfection, etc.) can lead to off-target effects or unexpected outcomes. Off-target outcomes can create undesired genetic mutations. Important aspects of the system, such as the Cas-9 catalytic mechanism, remain unclear (Rongxue et al. 2016). Because of the possible array of consequences from these unintended changes, many activists support strict regulation of this technology (Ledford 2016).

There are worries that CRISPR will result in the genetic manipulation of the human genome, which raises ethical questions about the nature of eugenics. David Baltimore, a prominent scientist, winner of the Nobel Prize in Medicine, developer of the Whitehead Institute for Biomedical Research, and previous president of both Rockefeller University and California Institute of Technology, calls for scientists to allow time for regulators to develop reasonable policies for the new CRISPR technology, likening this technology to the dystopian novel, Brave New World (Miller 2016). While his argument is primarily from the perspective of human modification, the same concept is important within the potential CRISPR agricultural revolution. While this technology is new, both short and long term consequences may remain unknown.
Part Two:
The Ohio Farmers Union Online Forum and Seedbank

Background

The scarcity of non-GM raw materials and lack of GMO testing procedures may raise the costs of producing non-GM feed crops, in turn increasing the difficulty of raising livestock fed using non-GM feed. Seed exchanges have formed worldwide as a way to fight erosion of agrobiodiversity (Meijer et al. 2005). The second project deliverable of this project was to create an online tool for online feed, grain, and seed exchange on behalf of the Ohio Farmers Union. The project will largely be a private endeavor, funded by the OFU, and is intended for use by producers within the State of Ohio. Providing such a platform to not only make local non-GMO seed, grain, and feed crops available, but to eventually provide the assurance of testing for GMO thresholds, will decrease the burden and cost to farmers to meet consumer demands for non-GMO products (Meijer et al. 2005).

Online platforms represent a cutting-edge innovation system in the evolution of modern agricultural markets and they may become even more commonly used as access to technology increases. They have been developed to exchange a variety of products, and to serve various purposes on vastly different scales of use. The proposed OFU online non-GMO seed grain and feed exchange platform will act to ensure the success of family farms, through collaboration, and the exchange of non-GMO seed, grain, and feed grain and allow for communication and collaboration between farmers with different sets of knowledge, people from different generations, or growers specializing in different varieties. Increasing the interaction and collaboration between farmers, including the development of non-GMO seed and feed exchange systems, can create more successful and mutually beneficial outcomes for the parties involved (Russelle et al. 2007). The different land management strategies of farmers, differences in knowledge, and increased varieties available for planting through these can all help to maintain crop diversity (Campbell 2012). In addition, it will provide a valuable resource for farmers and enthusiasts alike to help preserve important cultural knowledge which may otherwise be lost.

In the following section, first, several examples of organizations with seed or commodity exchange systems already in place are presented. These programs can be utilized as best practice examples, and taken into consideration by the OFU in the creation of their own system. Second, an example of a potential OFU’s non-GMO focused website is outlined. This website will not only house the online exchange platform, but it will serve as a reference to educate producers and the public, and will serve as a instrument to further the OFU non-GMO brand image.
Learning from Example

Using already established seedbanks as sources of reference not only shows what creating the online exchange platform requires, but will demonstrate what has worked for other organizations and locales in the past, therefore acting as a guide for the OFU in this process. Several organizations have established online seed exchange communities. These organizations include the Seed Savers Exchange, Ohio’s own Cleveland Seed Bank, India’s National Agricultural Market, and the Kenya Agricultural Commodity Exchange Limited. Although pre-existing online programs related to non-GMO seeds and agricultural exchange will not be an exact reflection of the program the OFU intends to create, knowing how these platforms function and what they include can be a valuable frame of reference for showing best practices including what formats others have found to work best, what has been found to be most useful for users, and what methods are used by website visitors to make exchanges of products in question.

According to Cleveland Seed Bank (CSB) a nonprofit organization run with the donations from members and other seed saving entities, their goal is to provide people with a reliable source of heirloom seeds, along with the knowledge needed to save them, and a place in which they could be exchanged between users of the platform. This will allow for the creation of a seed supply that was regionally adapted (Cleveland Seed Bank n.d.).

The CSB has created an online exchange system where members can exchange seed and grain. The open source plug-in (a component of computer software which allows for specific functions to occur) for a WordPress site, once downloaded, allows people to join CSB and then post seed offers. This plug-in was so successful, the seed exchange program has been downloaded 500 times in three different languages. The CSB has now over 200 members (Cleveland Seed Bank n.d.). CSB has not only a well-established website, but has created a physical location to exchange seeds at the Cleveland Public Library through their five branch locations (Cleveland Seed Bank n.d.).
Seed Savers Exchange (SSE) has also created an open seedbank to allow for exchanges between users on their website (Seed Savers Exchange 2014). This organization is run as a non-profit 501(3) (c) (Seed Savers Exchange 2015) with their headquarters located in Decorah Iowa. The SSE organization directs the majority of its expenditure toward education and outreach activities. The majority of their revenue comes from the sale of the products listed on their website (See figure 6).

![Support and Revenues Table](image)

To exchange seeds through the SSE site, one must browse listings on the interactive web page (see figures 7 and 8) (Seed Savers Exchange 2013a). When an interested party decides upon a listing, they click a link to send a private message to the person who originally listed the seeds. Contact information is provided when a profile is created, although it can be hidden upon request (Seed Savers Exchange 2013a). Using this example, if seeds are for sale through the new OFU seed exchange, a third-party OFU contact can act as a safeguard to ensure reasonable and fair use of the seed exchange system.
Small Farmers Agribusiness Consortium (SFAC), along with the government of India and its Ministry of Agriculture are currently developing an e-marketing platform for small farmers across India to sell agricultural commodities, called National Agricultural Market (NAM). The development of the NAM began June 2015 and will be in use by mid-2016. Benefits to farmers are expected to take effect within 5-7 years as the program is implemented (Small Farmers Agribusiness Consortium 2013).
The NAM is developed through a government monetary grant by India’s Ministry of Agriculture to create a national market for all agriculture commodities. This will greatly increase the options for farmers, allowing them to accept local or nation-wide offers for their products, and fostering positive competition. It is also expected to stabilize commodity prices, and ensure their availability to consumers. This portal will provide one standard of quality for all goods, coupled with testing to ensure that goods meet the set standards (Small Farmers Agribusiness Consortium 2013). On the NAM e-portal, there is no mention of the program’s total expenditures and budgeting information, however the website mentions that there is a single market fee charged, at the time when the agricultural product is purchased from the farmer (National Agricultural Market 2016).

According to SFAC, online trading through a portal such as NAM will not only allow local farmers to access a much larger market for their goods, but it allows farmers to find better prices, reduce transaction costs and keep prices stable, and provide transparency within supply chains. Instead of farmers buying and selling to each other, goods are purchased wholesale from the farmers to be sold on the market (Small Farmers Agribusiness Consortium 2013). This program is free of fees for participating producers, and the software and plug-ins developed for this system is offered free of cost. The Ministry of agriculture will cover the costs of updating, maintaining, and managing the website online portal using a transaction fee acquired from the sale of products through this program (see figure 13) (Small Farmers Agribusiness Consortium 2013).

The online portal functions in the following manner (figure 9) (Small Farmers Agribusiness Consortium 2013):

1. **Farmers/Traders will list their products on the NAM portal**
2. **Buyers will supply a price quote and farmers will accept or reject price.**
3. **Through a third party facilitator, goods will be tested for quality.**
4. **Through a third party facilitator, buyers will make payment (first entering a clearing bank prior to delivery of goods).**
5. **Through a third party facilitator, farmers/sellers will deliver their goods.**
The Kenya Agricultural Commodity Exchange Limited (KACE) is an online agricultural market. It is a private sector firm and limited liability company (Kenya Agricultural Commodities Exchange 2016). Online agricultural markets can cut down on the long supply/transaction change, cutting out middlemen and reducing costs to both farmers and consumers. It is a for-profit program, charging users small fees to cover costs for maintenance and services (see table 2) (Mukhebi & Kundu 2016).

**Table 2.** KACE Subscription Prices (Kenya Agricultural Commodities Exchange 2016). Retrieved from http://www.kacekenya.co.ke/section.asp?ID=64. The online services provided by case require users to purchase a membership. These memberships vary in price base

<table>
<thead>
<tr>
<th>Category of Individual/Group</th>
<th>Monthly Subscription Fee (in US dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate</td>
<td>$2,500</td>
</tr>
<tr>
<td>SMEs</td>
<td>$500</td>
</tr>
<tr>
<td>Individual</td>
<td>$100</td>
</tr>
<tr>
<td>Student</td>
<td>$50</td>
</tr>
</tbody>
</table>
Initially, KACE utilized physical locations for the trade of agricultural goods, but has since become an online platform (figure 10), with staffed market information points (MIPS) in rural villages. These market information points are for utilizing the internet and mobile phone technology to trade goods. KACE managers coordinate sales of goods, sending price quotes and other information directly to users (Mukhebi & Kundu 2016). Internet platforms also exist for this program, sending price and market information to over 1,000 users via email, displaying information and keeping a database of all markets.

This service also provides storage for agricultural commodities, so farmers can avoid selling at low prices, quality testing services, transportation, and weighing of agricultural products. These services link smallholder farmers to markets across Kenya, improving their ability to bargain for better prices, creating higher prices, and creating additional income for farmers to continue investing in their farms (Mukhebi & Kundu 2016).

Figure 10. Screenshot of Commodities Online Trading Floor. (Kenya Agricultural Commodities Exchange 2016). Retrieved from http://www.kacekenya.co.ke/exchange. Commodities may be searched via the search bar which shows type and variety, and allows the user to choose whether they are buying or selling. Results are then displayed below.
Further Considerations for the OFU

According to the Seed Saver’s Exchange guide for organizing a community seed bank (shown on the Seed Saver’s own website), one aspect of successfully creating a seed bank is creating partnerships with a diversity of people and organizations. These partnerships can provide financial resources or important knowledge, or even work with the seed bank to create publicity (Seed Savers Exchange 2013e).

Although the OFU’s seed bank will largely be a private endeavor, and may not rely on outside financial support, education and outreach may be a possible focus. Likewise, publicity could help the OFU brand their seed bank and reach out to a broader audience. This idea of partnership could also include reaching out to those who may be interested in participating in this exchange program as sellers, to create the initial supply of seed and grain available on the website to jump start the program into success.

Other considerations are suggested by the Seed Savers Exchange to ensure success of a seed bank (Seed Savers Exchange 2013e). The following questions and items should be considered by decision makers as relevant to the OFU’s seed bank project:

1. Will there be a physical location?
2. Will membership/membership fee be required?
3. How will records of transactions of outgoing and incoming seed and the list members/users be kept?
4. How do we create an orientation to show how the seed bank is used (or in the case of an online forum, a page which explains how to use the website)?
5. Will there be a calendar created with relevant information that members/users may need?

Discussion of Website

Website Layout Considerations

The internet is an important tool that people already use to place advertisements for and acquire information about agricultural products and material (Xu et al. 2012). Automating technology can improve the process of acquiring both goods and information needed by farmers. The ability to run fast and accurate searches can help increase convenience and the farmer’s ability to obtain the goods they need (Xu et al. 2012). The OFU website should contain a search bar to easily access any information and seed listings on the site. Likewise, the website should be organized in a logical way as to be found quickly by visitors to the site.

Since the issues associated with non-GMO and certification can often be extremely complicated and convoluted, designing a functioning website to meet the needs of both site visitors and the OFU could pose a challenge. Websites should provide adequate guidance, but be simple enough that visitors to the site can still take action (Sloboda 2011).
Too much information in one place could lead to information overload for the user, therefore it is important to create a visual and informational hierarchy (Amunwa 2012). Including a page with a main site map, displaying all pages of the website can help users quickly search and access information (Stevenson 2010). The information should be organized in a way that it not only easy to understand, but will be easily accessed by users (Sloboda 2011). The most important information should be that which the user sees first (Amunwa 2012). Information should be arranged in a cohesive way that is logical for visitors to the website to comprehend (Amunwa 2012, Sloboda 2011). Text should be succinct, and further information should be available as a PDF to download. Many photos should also be included. (Stevenson 2010).

In short, it is important to create a website which flows well, and is in an order in which visitors will not have to guess where content is located. That is, any website must be user friendly. The most important topics for the website are labeled with numbers in the outline (see below). This information is what the user will be drawn to first. From there, the site visitors can logically assume the other categories included in these primary topics.

Possible Website Contents

Including a forum in which discussions can happen is a valuable asset to a website. The website called DataTHRESH could be used as one example of the usefulness of creating a forum for farmers. It has already launched a free online forum for conversation between farmers (Huting 2014). They have topics listed as threads within a larger forum where both farmers and experts are invited to discuss issues which not only help farmers gain knowledge but also to improve their profitability. Threads, as DataTHRESH’s example shows, could include farmer’s right to data ownership, data driven profitability improvement, management zones, personal stories, and precision agricultural challenges (Huting 2014).

A forum for the OFU’s project could include discussions such the best varieties of non-GMO seed and grain, organic farming methods, profiting through non-GMO production, education, and any other topics of interest. Likewise, such a forum could be a useful tool for the OFU to gain feedback from the users on their website and certification program. Forums should have clear content guidelines (Stevenson 2010). This will make sure that information posted to a forum is relevant and acceptable.

Securing buyers and product contracts for non-GMO grain is important for assuring that non-GMO production is worthwhile (Brooks 2010). An important aspect of preparation for the website must be to establish contacts with individuals/companies who would be the buyers for the certified seed and grains. Providing resources to growers for industrial suppliers of non-GMO seed and grain could also be useful. Success of non-GMO grains could depend on the variety of hybrid being grown (Brooks 2010). Companies like Pioneer produce several varieties of non-GMO corn (Brooks 2010).

Education and tools to support producers transitioning to non-GMO seed and grain would be desirable to include. For example, according to the Pew Initiative on Food and Biotechnology (PIFB) research, less than half of Americans had seen, read, or heard anything about GM foods in 2001, and this number has since changed little (Fink & Rodemeyer 2007). Farmers may also lack
knowledge about methods of switching feeding regimens of their livestock from GMO to non-GMO (Schreiner & Latacz-Lohmann 2015). Education measures should be designed in a manner which would make it easy for laypeople to understand so the material reaches a broader audience. Providing more information can create more trust in the message and organization (Brossard & Shanahan 2007). This educational component may also include designating staff to answer questions and offer advice, as a continuous means of support for producers. Free technical advice is shown to be of value to producers who wish to switch to non-GMO seed and grain (Schreiner & Latacz-Lohmann 2015). Resources listed on the Seed Savers Exchange website include information on how to save seeds, how to hand pollinate, how to organize community seed gardens and seed swaps, raising pollinating insects, and how to bench graft (Seed Savers Exchange 2013b).

Phone numbers, emails, departments, and biographies are all good resources to include as contact info (Stevenson 2010). Producers should know who to contact for further information or assistance. Additionally, resources for the press or anyone seeking information would be extremely helpful. A media kit can help an organization easily manage public relations and communication (Stevenson 2010). Media kits may include such information as FAQs, Organizational Updates, the option to sign up for news alerts, directory of experts, useable images and graphics, and links to news coverage of an organization (Stevenson 2010).

Pages and Informational Hierarchy

The contents of the website are suggested below. Bolded headings are the main components. Specific details of the main components are listed below the bolded headings.

*** denotes information dependent on possible certification program. It is important to note these sections because if the OFU decides not to pursue their own certification scheme, then this information becomes irrelevant.

- **Background Information**
  - About the OFU
  - About GMOs?
    - Why Care about GMOs?
  - About non-GMOs
  - Non-GMO labeling
    - Why Label?
    - OFU and non-GMO Labeling***
  - Benefits of Labeling with OFU

- **Education**
  - Laws and Regulations
  - Economy of Non-GMOs
  - Printable Information/Flyers/Pamphlets
    - What is Non-GMO
    - Switching to Non-GMO Production/Feed
    - OFU Certification Program***

- **Online Forums**
  - Main Grain/Feed/Seed Exchange Platform
- Message Board
  - Online Forum for Miscellaneous Communication

- **OFU Press**
  - Articles on OFU
  - Non-GMO Articles
  - Press Releases

- **Non-GMO Certification***
  - About Certification
    - Benefits of Certification
  - FAQs
    - What Can Be Certified
    - Cost
    - Timeline
    - Process Outline
    - What Forms Required?
  - Detailed Instructions/Information
    - Outline of Certification Plan
    - Rules and Restrictions
    - Who Will Oversee Certification?
    - Cost
    - Time
    - Contacts
      - Approved Labs
      - Partner Organizations
      - Contacts
  - Forms/Information Sheets

- **Resources**
  - Resources at OFU
  - Certifying Labs
  - Seed Supplies
  - List of Buyers
  - List of Sellers
  - Related and/or Partner Organizations
Discussion of Grain, Feed, and Seed Exchange Platform

Although all background information listed in the previous section is valuable to include in the proposed website, the main focus of the website will be the Grain, Feed, and Seed Exchange platform. Examples and screenshots from other organizations, as illustrated in the previous sections, have shown examples of best-practice in creating online platforms for exchanging non-GMO seed, grain, and feed crops. Based upon what these leaders have already done, there are some important aspects that should be considered and possibly applied to the OFU’s project.

- **Fees/Membership Costs**

  Most of the organizations listed charge some sort of fee for users of the online exchange platform. Such fees could in fact be membership costs in the OFU non-GMO program. Fees could be based upon membership type—for example, whether the user is a producer, a commercial buyer, or a hobby gardener. Fees could also be based on a percentage of the commodity sale, volume of the commodity being sold, or a flat fee per transaction. Whether the OFU’s program is for profit or not, fees and membership costs would help pay for the services most useful for producers, and perhaps even allow the program to expand and grow as necessary.

- **Division of the Exchange Platform**

  It is up to the OFU to create a platform which will help users access what they are looking for easily, without sorting through information in which they have no interest. As shown in previous examples (figures 7, 8 and 10) dividing the exchange platform into sections based on crop type creates more convenience for buyers and sellers of grain and seed who are seeking something specific. These categories could further be divided, either in alphabetical order based on crop variety or attribute, date posted to the platform, or by price, among others.

- **Real-time Commodity Prices**

  For the convenience of those using the website, a real-time display of commodity prices, or link which shows current commodity prices could be included. This would be helpful for those making buying and selling decisions, and create a more interactive, useful website.
Other Recommendations

If there is not already an OFU staff member devoted to website maintenance, this responsibility should be assigned to a knowledgeable staff member to ensure that quality and consistency are maintained. An up-to-date website is the most useful for users of the website, and also for possible press contacts who may take information from the website (Stevenson 2010). A devoted staff member may also monitor the forums and respond to emails and questions in a timely manner.

OFU or its designated site manager should develop low-cost strategies to increase visibility and traffic to the website. These strategies could include developing further content, such as producing short videos on relevant topics, an online blog to share important information, or a social media presence. Likewise, audio files can be created for platforms like ITunes. Free podcasts could help to better explain the contents of the website, or discuss interesting topics relevant to the OFU’s non-GMO goals. Garnering more attention could increase the number of website users and in turn, the success of programs.

Once the website is established, it may be a good idea to consider the different types of users who will be utilizing the OFU seed-exchange forum. In choosing a type of user, information on a website can be tailored to different purposes based on this user status, providing a personalized experience in which information provided is more useful. Allowing the choice of customization not only increases ease and efficiency of a website, but it sets an organization apart. (Stevenson 2010). Perhaps one way to tailor the website to meet multiple sets of needs is to develop categories of users (based upon on information from their registration for the website) or different sets of forums based on their needs- such as a commercial grower versus a family farmer, or a hobby gardener. For example, while a commercial grower or family farmer may require grain and feed crops in large quantities to meet their needs, hobby gardeners may be seeking smaller amounts of different types of seeds, or other vegetable crops.
Part Three:  
Non-GMO Certification Process Design

The Proposed OFU Certification Process

Before a product can be labeled non-GMO, it must be verified, through a standardized process, which proves that it contains below the maximum allowable trace amounts of GM material. Creating a certification program will require much attention to detail, and may be a difficult undertaking. In this section, important aspects of certification, such as information on other successful non-GMO certification schemes, and non-GMO testing best practices are presented. Also included is a basic outline for a potential standardized certification scheme to be used if and when the OFU endeavors to create such a program.

Having such standardized process, based upon GMO testing best practices and other successful certification schemes, is a way to create the assurance that products are absolutely considered non-GMO. This will generate trust in the OFU as a reliable certification organization.

The following are all important items in the standardized process:

- All state and national regulation should be considered to ensure the certification process is legal and meets any requirements.
- Consumers should know the seed and grain is safe, through assured testing measures and tracing of supply chains.
- The identity of non-GMO seed should be preserved and contamination in field, in storage, and in transportation should be avoided.
- An OFU-specific non-GMO label will need to be created or the OFU should choose an organization to partner with which will allow the use of an already existent certification label.
Non-GMO Certification

Laws Regulating Certification in Ohio

Section 907.2 of Ohio Code Title 9 contains specific requirements for labeling seed products. It states:

“No person shall use, orally or in writing, alone or with other words, "certified," "registered," "foundation," or any other term that suggests that the seed, tubers for seeding purposes, or plants have been certified unless the seed, tubers for seeding purposes, or plants have been certified by the Ohio seed improvement association. The prohibition established in this division does not apply to use of the word "certified" for the purpose of describing seed, tubers for seeding purposes, or plants that have been certified as organic in accordance with 7 U.S.C. 6501 et seq.” (Ohio Revised Code Title [9] IX AGRICULTURE § 907(02)).

Since organic products are certified through a government program, this could be the reason for excluding organic certified labeling from needing to be approved by the Ohio seed improvement association. Now that S.764, The Safe and Affordable Food Labeling Act, a federal labeling program, has been passed (Addady 2016) there is a question as to whether Non-GMO labeling would be excluded from this regulation as well.

There is also the issue of confirming that a non-GMO label upholds the standard of truth. According to Snowville Creamery, in Southeastern Ohio, after being shuffled through government organizations including the USDA and the FDA, the Ohio Department of Agriculture finally agreed to examine their non-GMO claims. The Ohio Department of Agriculture Dairy division finally approved their non-GMO milk label as truthful and acceptable (Snowville Creamery 2015).

Non-GMO Testing Technology

Seed and grain must be monitored and tested to assure the purity of the product. Several methods could be employed to monitor the status of non-GMO crop production.

Farmers may document their own crop sources and methods to assure that crops are not contaminated, or independent agencies may be brought in to monitor compliance with set regulations (Schreiner & Latacz-Lohmann 2015).

Strip testing and other techniques analyze for the presence of GM proteins or DNA present in a sample determine if there is GMO contamination within an ingredient. According to the Non-GMO project, strip testing is a good screening method which is both fast and available on site. It can be a helpful initial screening method to prevent mixing between GMO and non-GMO grain and seed and can be used by the producer (Non-GMO Project 2016). However, it is important to continue with PCR (polymerase chain reaction) testing.

There is technology being sold to make GMO testing and tracing more convenient to producers. One such testing system is the EnviroLogix Quickscan System. Using test strips, the testing unit, and a software program, producers can conveniently test for the presence of GM material in seed and grain (EnviroLogix 2016). Snowville Creamery in Southeast Ohio uses this system to test for GMOs at a 1.5% tolerance level in samples of feed before each load of corn and
soybean is deposited into grain bins at the Maysville Elevator (Snowville Creamery 2015). It took Snowville two years to transition to recognized non-GMO status (Taylor 2014). Snowville Creamery uses milk from multiple farms to make their products. Feed is also tested at the Maysville Elevator, and farms which grow their own feed crops submit samples to the elevator to be tested (Snowville Creamery 2015).

The Snowville Creamery company has a 100% testing policy for feed ingredients. Results of the Quickscan testing data is included in tables on the Snowville Creamery website for convenient public and consumer access to their records (Snowville Creamery 2015). Snowville spent a total of $7000 dollars for the testing equipment and materials for 100 tests, which averages around $70 a test. Snowville expects to spend $7,000 each year to continue testing. While this price may seem high, it is lower than the priced that they were quoted of $600 dollars per test performed in a laboratory (Taylor 2014). The equipment, (figure 11) demonstrated by an Envirologix representative, was easy to use and calibrate, and posed no significant inconvenience for Snowville employees (Taylor 2014).

PCR testing is one method used to determine the presence of GM genetic material which has been generally accepted by regulatory agencies. There are several methods of PCR including qualitative PCR (simply ascertaining whether or not the product contains GMO) end-point quantitative PCR, and quantitative real-time PCR (which shows how much GM material a product actually contains). PCR testing sets a target DNA structure, and to pass the test, a sample must meet the minimum requirements or threshold for that target (Mamiroli et al 2008).

PCR testing is an industry standard for detecting all commercialized GMOs in agricultural products in almost any concentration. To determine the presence of GM material in grain crops with the Quickscan System a sample must be taken. The grain is ground to a fine consistency and water is added to create a solution to express the proteins contained within. Then, the test comb is placed into the solution for five minutes. Afterwards, the comb is scanned and interpreted by

Figure 11. Envirologix Quickscan System (Envirologix 2016). Retrieved from http://www.envirologix.com/solutions/catalog/306-10050-accessory-quickscan-reader-system/. This system can test samples to determine if they are under the threshold for GM material.
the system. The system shows results as percent of GMO or Below Level of Detection (Taylor 2014).

PCR testing can be cost-effective and provide quality information when single ingredient samples are tested, so it is an ideal test type for seed and grain products (Non-GMO Project 2016). It has high DNA yield identification compared with other methods of testing, and takes as little time as 2 hours for 13 samples (Mamirol et al 2008). PCR tests can be either qualitative, showing yes/no, there is or is not GMOs detected within the 0.01% limit, or quantitative, displaying the actual percentage of GMOs a sample may contain. PCR tests may also be performed by an approved lab (Non-GMO Project 2016). A list of Non-GMO project approved labs can be found on their website, and a link to this page is included in the Appendix A of this report.

Example of a Certified Company

There are several factors which could lead to an easier, more streamlined process for non-GMO verification. First, it is important to consult existing non-GMO certification programs (Roff 2008). An examination of the different website models has already been accomplished in the previous section of this report, but these organizations may be further examined to determine what requirements they have for certifying the products listed on their online portals. Exploring previously successful programs will show the OFU what programs and models work for producers. Because the Non-GMO project is a well-respected labeling effort for non-GMO products, it would be wise to use their already established certification requirements as a guideline for the program the OFU intends to create. The OFU’s certification program would not focus on completed products, however, but rather the building blocks of all food and animal products—seed and grain. Therefore, the certification program should be tailored to these specific needs, and the information gleaned from the Non-GMO project should be focused towards this goal.

NestFresh, a company that produces Non-GMO certified eggs worked with the Non-GMO project to develop standards for their verified egg products (Gamoning 2015). This standard begins with the seeds used to grow crops which will become animal feed. Grain and seed is tested before planting to ensure that it is free from GMO contamination prior to being placed in the ground. Grain is also tested after harvesting to ensure it remains unpolluted by such factors as cross-contamination. Feed is tested again at the feed mill before finally becoming certified as non-GMO (Gamoning 2015).

This example has highlighted the importance of thorough testing procedures and making sure that along every step of the process, from seed storage, to growth, to the final product, contamination is avoided. Traceability of the supply chain from feed to farm is also vital to the certification process, which ensures seed and grain is in fact Non-GMO. Likewise, using small family farmers committed to non-GMO production for storage and growing feed grain ensures that there is more control over how the product is managed, meaning greater success in ensuring threshold levels are not exceeded (Gamoning 2015).
Third-Party Administrators

Taking an example once again from the Non-GMO project, among others, it is recommended that independent third party administrators should be used for testing. This will ensure that products are certified without bias, and technical expertise and standards are upheld during testing (The Non-GMO Project 2016). Technical administrators used by the Non-GMO project include Food Chain ID, NSF International, Where Food Comes From Inc., and SCS Global Services (The Non-GMO Project 2016). These third party administrators can assist with such tasks as evaluating and consulting, development of standards, testing, auditing, and assisting in navigating the legalities of the certification requirements (The Non-GMO Project 2016). Although SGS and several of these administrators currently only offer certification through the Non-GMO project label, their services would still be valuable to the OFU. Links to NSF and SGS, which may be most useful for OFU certification are included in Appendix A.

Timeline Considerations

Once a program is established, it is important to set reasonable timelines for the verification process (Roff 2008) so producers and those going through the certification process are not discouraged by inaccurate timelines. So that the certification program does not get backed up, it is important to create a staggered verification scheme (Roff 2008). This staggered verification will control the flow of products, and therefore keep the verification on schedule. It is also important that ample educational materials are provided not only for those interested in certifying their crops, but to anyone interested in buying them.

Certification Program Alternatives

As discussed in Part One, Organic Production, organic production is prohibited from using GMOs, therefore although not plainly stated on the USDA organic label, grain and produce certified as organic is also non-GMO. While non-GMO certification may be a relatively new process, there are already programs and options in existence for the certification of organic crops and livestock. Employing these programs instead of designing an entirely new system for crop certification may help the OFU avoid pitfalls such as a large expense or a large time commitment required to design and run their own project.

Since 1981, The Ohio Ecological Food and Farm Association (OEFFA) has been a valuable resource for producers. Certification happens through OEFFA as a vehicle to the end goal of
organic certification. In other words, they work with producers to help them achieve the high standards of National Organic Program USDA organic certification within states including Ohio, Michigan, Indiana, West Virginia, Pennsylvania, Virginia, Kentucky, Illinois, Iowa, and Missouri (OEFFA 2016c). Their program itself can also be used as a best practice model for the OFU, given the pursuit of the OFU’s own certification scheme. They have a five-step certification process for reaching organic status (OEFFA 2016c):

1. An application and Organic System Plan, describing the producer’s organic operation.
2. The organic operation receives a preliminary review to determine if it qualifies for certification, and is assigned an inspector if approved.
3. A site inspection which evaluates the operation and how the OSP is being implemented is conducted.
4. The inspectors report is reviewed to determine if the operation complies with the organic standards.
5. If in compliance, a certification certificate is issued by OEFFA.

Fees are charged for each certification application. Fees for the application to become a producer are different from those to become a handler or processor of organic products (Table 3). Fees for required inspections are additional to the application fees (OEFFA 2016b).

One major benefit of organic certification with OEFFA is the National Organic Certification Cost Share Program. This helps reimburse producers and handlers of organic produce with up to 75% or up to $750 dollars per year for each certificate or category (crops, wild crops, livestock, and handler) (OEFFA 2016a). Costs covered include application fees, inspection costs, certification fees, and expenses for postage, travel, or user fees. Late fees, inspections resulting from violating USDA organic standards, materials, and other equipment are not covered (OEFFA 2016a). The application for this program is readily available on the OEFFA website (see link to OEFFA organic certification resources in the Appendix C).

Table 3. OEFFA Fees (OEFFA 2016b). Retrieved from http://certification.oeffa.org/fees.php. The OEFFA charges fees with applications to become organic certified. The fees are based on location and date for growers and producers, and sale volume for handlers and processors.

<table>
<thead>
<tr>
<th>Postmark Date</th>
<th>Fees</th>
<th>Sale Volume</th>
<th>Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In Ohio</td>
<td>Regional (IN, KY, MI, PA, &amp; WV)</td>
<td>Out of region</td>
</tr>
<tr>
<td>03/05</td>
<td>$850</td>
<td>$950</td>
<td>$1000</td>
</tr>
<tr>
<td>05/15</td>
<td>$900</td>
<td>$1000</td>
<td>$1050</td>
</tr>
<tr>
<td>06/15</td>
<td>$1050</td>
<td>$1150</td>
<td>$1200</td>
</tr>
<tr>
<td>07/15</td>
<td>$1150</td>
<td>$1250</td>
<td>$1300</td>
</tr>
<tr>
<td>08/15</td>
<td>$1300</td>
<td>$1400</td>
<td>$1450</td>
</tr>
</tbody>
</table>

The Organic Farmers’ Agency for Responsible Marketing (OFARM 2014b) is a service which through membership in a partner organization, can provide useful marketing services for
sourcing consistently high-quality organic grains (OFARM 2014b). OFARM requires producers to meet strict organic certification standards while maintaining sustainable practices. This maintain the consistency of grain quality. Other services provided are potential long-term contracts favorable for producers, customized supplies, and identity preservation during shipments (OFARM 2014a). OFARM also handles negotiations between buyers and sellers, and monitors credit (OFARM 2014a).

Two partner organizations to join in order to receive OFARM services in Ohio would be the National Farmers’ Organization (NFO) or the Midwest Organic Farmers Co-op (MOFC). While this program does not provide certification services, and producers must already be growing USDA certified organic feed and grain crops, it could be a valuable option to consider for the purposes of convenience for the producers for ensuring a steady revenue stream and maintenance of commodity quality. Producers can join the NFO for $125/year (NFO 2016), and a membership in the MOFC co-op costs $500 (MOFC 2016) to receive these services.

**OFU Certification Process**

Whether or not the OFU decides to implement a certification program, a plan for establishing a certification scheme has been created to begin this process. The steps shown below were designed using the example and modifying the apparent best practices of other certification programs as shown previously in this report. If implemented, this plan should work in coordination with the OFU online grain and feed exchange portal.

**Certification Process Outline**

**Initial Steps Pre-Certification Program Approval**

1. **Establish a Testing Parameter**

   A testing parameter should be established to determine the levels of GMO acceptability in the feed, grain, and seed products. Typical GMO thresholds by country are shown in figure 3. A threshold level should be chosen based on an already existing level used by a region or country such as the EU, or an organization, such as the Non-GMO Project.
2. **Determine Methods**

The responsibility for testing should either be delegated to a trustworthy, approved testing lab (see Appendix A), or the OFU will need to determine both what type of testing is carried out and who will be responsible for testing. Testing types include faith-based measures, testing for GMO content in the field, third-party (lab) testing, or testing at a grain elevator which offers this service.

3. **Create Partnerships**

The success of the non-GMO supply chain depends largely on the buyers and sellers. It is important to create partnerships and establish relationships of trust with farmers, organizations promoting non-GMO, grain elevators, and possible buyers to ensure a certification program will have adequate financial resources to continue and be a worthwhile endeavor for the OFU and certification platform users.

4. **Establish Reasonable Timelines**

To ensure that users of the platform will be aware of the time commitment they make entering into the certification, a time frame for this process should be established. To create a timeline, it is important to provide a reasonable estimate of the entire length of the certification process, which includes any testing by labs, routine testing that may need to occur, and possible on-site field inspections, along with the time that is required to apply and be approved as non-GMO.

5. **Establish Chain of Responsibility**

Before designing a certification process there are certain questions that will need to be asked. Will the farmer sell their own crop, or will the OFU, a grain elevator, another organization be managing the sale? Likewise, who will be responsible for handling any payments, or transportation of the products? These parameters should be clearly defined by the start of a certification program.

6. **Create a Final Plan**

All details of the plan will need to be clearly defined, and able to followed by any producers. It is important to consult with the Ohio Department of Agriculture to guarantee any OFU plan to create non-GMO label will be permitted. The plan should ideally be submitted to the Ohio Department of Agriculture for approval, with any recommendations provided then incorporated into the final draft of the plan.
After Approval

1. Provide Information

The final plan should be provided to producers in a way that every detail is as clear as possible. Producers should be aware of any necessary requirements, regulations, fees, or forms they will be required to fill out. Information about non-GMOs and relevant topics may be useful for both educating consumers and showing the benefits of certifying through the OFU program.

2. Application

Producers will need to apply for certification with an application, either online or in print. An application should include any pertinent information needed by the OFU to start the certification process. This may include but is not limited to the producer’s name, contact information, what crop will be certified, any possible sources of GMO contamination which may affect this crop, and the origin of the producer’s original seed.

3. Review Period

Once an application is received and it follows the guidelines (including any additional guidelines determined by the OFU), a producer should receive initial approval to begin crop certification. After this initial approval, testing should occur. If there are concerns, such as possible contamination from GMOs, recommendations should be provided to producer for addressing these issues. Once the issues are addressed, a final report (which may be as short as an additional form stating everything is in order) will be written. This final report may include reasons for denying certification approval, or additional requirements for follow-up testing if necessary.

4. Certification Approval

If a farmer’s crop adheres to the testing parameter, all issues are addressed, and guidelines are followed, he/she should be approved for certification. His/her non-GMO products should have authorization to use an OFU non-GMO label, assuring its quality and high standard of purity.

Certification Model

The model shown below (figure 12) is now necessarily designed to be an example of the possible OFU certification scheme, but more importantly it shows how the OFU online portal could incorporate the sale of non-GMO certified grain and feed. While this model may not reflect the final product pursued by the OFU, it is a useful visual for understanding the possible flow the product may take, from certification, to its listing on the portal, to the final sale. The green colored arrows represent interaction between buyers, sellers, and possible administrators of the program. Blue represents the flow of grain and feed, from listing to sale. Also listed below is a description of each step of the model:
1. **Certification and Listing Commodities**

   The model begins with the certification of grain or feed through the established program devised by the OFU. If the OFU does not choose to pursue a certification program, grain and feed may be certified by another trusted organization or third party lab. This certified commodity will then be listed on the OFU online exchange portal, in whatever manner determined best.

2. **Using the Portal**

   Buyers will browse the OFU online exchange portal offering. For more information about the possible design of the online platform, see Part Two of this report.

3. **Purchasing**

   When buyers have decided upon a commodity, they will select the option to buy, which will alert the producer who originally listed the seed. Prices for the commodity may either be fixed, or bids for the commodity may be made by the buyer, depending on the scheme the OFU wishes to pursue. This step could be moderated by an administrator at the OFU assigned to oversee the program, for the purpose of assuring proper procedure is appropriately followed, while assuring buyers and sellers security in their transactions.

4. **Accepting Offers**

   At this point, producers who listed grain and seed may accept or reject bids, or be informed of the purchase of their product if a fixed price has been set. Any additional details about the grain or transaction, including method of delivery and transport will be arranged with the buyer through the OFU administrator.

5. **Payment**

   Buyers will make payment to the producer through the OFU portal. This may be either an automated process or once again a step moderated by the recommended administrator.

6. **Delivery**

   Once payment is finalized, the product will be delivered to the buyer, using the arrangements determined in step 4. It may also be beneficial if the OFU administrator handle this process, for the convenience of the buyer, and other reasons previously mentioned.
**Final Recommendations**

It may be beneficial to create database of certified grain, feed grain, and seed traded through the OFU database. This could help to establish a known non-GMO pedigree, and simplify the process of certifying future products and crops. This could act as a way to track the supply chain and help show where the non-GMO grain came from, who developed/protected it, its current certification status, and any important notes about the cultivar and variety. This will allow traceability of the production chain, showing that there is no GMO within the line and possibly reducing contamination of future crops. Ensuring traceability of the supply chain of seed, grain, and feed crops can maintain consumer freedom of choice (Layadi 2012).

Animal products are not always labeled to allow consumers knowledge about the type of feed they consumed (Layadi 2012). A future recommendation for the certification program could include a program for farmers who wish to participate by labeling non-GMO fed meat, dairy, and other animal products. This label could be linked back to the OFU website, providing detailed information about the maintenance of the livestock and perhaps other information including animal welfare, or information (contained in the database as mentioned above) about the feed crops the livestock consumer.
In Summary

Deliverable one of this report consisted of a cohesive literature review on current non-GMO topics. GMOs are not created through traditional means of hybridization using well-known plant breeding methods, but rather use instead invasive processes using novel biotechnological means which edit the genome of organisms for a specific purpose such as drought, pest, or pesticide tolerance. The production of GMO feed and food crops has already dominated U.S. production systems for several agriculturally important crops. Because of patents on GMO technology, farmers are not able to save the seed produced and are forced to pay increased prices every season for new seed. There have been concerns voiced about the safety of new gene-editing technologies which create GMOs that may escape government regulation before going to market. The increased awareness and use of non-GMO crops and seeds could be considered part of a social, environmental, or even economic movement. Although there is a great deal of skepticism and conflicting information about the actual safety and impacts of GMOs, because many consumers are distrustful of GMO products and are willing to pay for what they believe is safe, it can be seen as a wise investment decision to certify products, including produce, grain, animal feed, and livestock as non-GMO. This consumer demand for perceived safe, non-GMO products creates a demand for certification, which assures the purity of food and grain. Because the definition of what is non-GMO is not always consistent between different government agencies, certification programs have largely been independent projects, with one of the best being the Non-GMO project.

Deliverable two of this report provided examples for the creation of the OFU online platform. The OFU platform for feed, grain, and seed exchange will not only provide a platform to increase the availability of non-GMO commodities, but will also provide opportunities for communication and collaboration between farmers. Organizations who have already designed and implemented such programs, which can be used as examples of best practices in the field include Seed Savers Exchange, Cleveland Seed Bank, India’s National Agricultural Market, and the Kenya Agricultural Commodity Exchange Limited. The OFU’s non-GMO website should not only house the exchange platform, but should provide a variety of resources and information, to assist farmers in producing non-GMO seed, feed and grain, and to educate the public, further building the OFU non-GMO brand. Questions that still need to be addressed include what fees or memberships will be required, how will the exchange platform itself be divided, and will additional resources be provided through the website.

Deliverable three of this report was a possible outline of the OFU the certification scheme. A standardized process is needed to certify feed, seed, and grain as non-GMO. The OFU will need to determine whether they wish to employ a program already in existence, or whether it will be feasible to create their own. A variety of topics will need to be considered in this process including testing thresholds, possible sources of GMO contamination, methods of testing for GMO content, state and national legislation, and partnerships between the OFU and those who will use the program or other organizations who could provide valuable assistance. If the OFU pursues the challenge of creating their own non-GMO commodity certification program, there are several steps in this process. The program will first have to be designed and approved by the Ohio Department of Agriculture to ensure that it is legally allowed. The potential program itself is also outlined in this paper. The final step in ensuring the success of this program is that the certification process will work in cooperation with the OFU online exchange portal.
The report provides a consolidated source of information covering many relevant topics, which will allow producers and consumers to develop their own informed opinion on non-GMO food and feed products. The online platform will create the ability of producers and consumers to choose, by not only creating more access to non-GMO feed, grain, and seed commodities, but allowing users to benefit economically through the sale of their listed products. For producers who do choose non-GMO, a certification program will ensure that their products follow all guidelines and regulations, giving consumers peace of mind that the products are held to a high standard of purity and quality. In conclusion, not only do these deliverables fit the mission of the Ohio Farmers Union, but this project, if continued, will give power to producers and consumers to make their own choices.
References:


FFDCA; 21 U.S.C. §301 et seq.

FFDCA; 42 U.S.C. §201 et seq.


Appendix: Additional Resources

Appendix A: GMO Testing Facilities

(*** denotes third-party administrators/consultants)

Biogenetic Services, Inc. http://www.biogeneticsservices.com/

BioProfile Testing Laboratories LLC http://www.bioprofilelabs.com/

CSP Labs http://www.calspl.com/

***Eurofins BioDiagnostics http://www.biodiagnostics.net/

Genetic ID http://www.genetic-id.com/

***IMI http://www.imiglobal.com/non-gmo-project-verification.html

Indiana Crop Improvement Association http://www.indianacrop.org/

Iowa State University Seed Testing Laboratory http://www.seeds.iastate.edu/seedtest/


North Dakota State Seed Department http://www.nd.gov/seed/

***NSF http://www.nsf.org/

Ohio Seed Improvement Association http://ohseed1.org/

Omic USA Inc. http://www.omicusa.com/

Professional Seed Research http://www.psrcorn.com/


Woodson-Tenent Laboratories http://www.wtlabs.com/

Appendix B: Non-GMO Feed and Seed Suppliers

State and Local

Cedar Crest Farm and Feed http://www.cedarcrestfarmandfeed.com/index.htm

Cloverland Ag Service http://cloverlandagservice.com/
HD Feeds http://www.hd-feeds.com/about_us.html
Honeyville Feed and Farm Supply http://honeyvillefeedmill.com/
Kraut Creek Natural Feed Company http://www.krautcreeknaturalfeed.com/
Scratch and Peck Feeds http://www.scratchandpeck.com/
The Seed Conservatory http://www.theseedconservatory.com/

**Regional/National**

Bar Ale Inc. http://www.baraleinc.com/
Coyote Creek Farm http://coyotecreekfarm.org/
Green Mountain Feeds http://www.greenmountainfeeds.com/
Hiland Naturals http://www.hilandnaturals.com/
Kamblach Feeds http://www.kalmbachfeeds.com/
Liberty Feed and Bean Meal http://www.libertyfeedandbeanmeal.com/
Midwest Organic Farmers Cooperative http://www.midwestorganic.com/feed-pricingproducts.html
Texas Natural Feeds http://www.texasnaturalfeeds.com/

**Appendix C: Websites and Additional Resources**

Center for Food Safety CFS http://www.centerforfoodsafety.org/issues/311/ge-foods
The Cleveland Seed Bank- http://www.clevelandseedbank.org/
The Non-GMO Project- http://www.nongmoproject.org/
The Ohio Ecological Field and Farm Association Resources for Organic Certification - http://certification.oeffa.org/certification_resources.php

The Ohio Department of Agriculture http://www.agri.ohio.gov/

The Ohio Farmers Union- http://ohfarmersunion.org/

Ohio Seed Improvement Association http://ohseed1.org/


Afterward:

Reflection on the IES Experience

This report, ‘Creating a non-GMO Grain and Feed Exchange System for Ohio Farmers’ was a long term project, and the final element before the conclusion of the Miami Environmental Science master’s program. It has been a wonderful learning experience. I can breakdown what I’ve taken away from this project into several categories - time management, communication, and vision:

- **Time management:** I found that key to being successful is setting deadlines and scheduling time to work. At each step in the research and writing process I would create a deadline for when I wanted sections or drafts finished by. To meet these deadlines, I would have to effectively manage my time to keep on schedule around other important activities including work and classes. That way, I was certain to make continuous progress that I would be confident in. This work ethic and time management will be valuable in my future employment, to ensure deadlines are met and at a certain level of quality.

- **Communication:** Although one would hope to live in ideal world where all communication happens smoothly and consistently, this is not always the case. It is important to keep in contact in timely manner so the overall schedule of a project is not greatly impacted. It would have been beneficial to me during this experience to have had a written plan of communication agreed upon by committee members and stakeholders beforehand to ensure not only that everyone was kept updated but that feedback could more easily be received. On future projects, this is something I will be certain to set in stone from the beginning.

- **Vision:** Not everyone will see the same object in the same way, just like everyone will have their own ideas about scope and what will be accomplished by a project. In this project there was a great deal of freedom to make it my own, but I found stakeholder feedback an important source to guide the overall focus of the project.

It is my hope that the OFU has been given a product which will prove useful in guiding their future decision making. The first section of my report meets one of the aspects of the OFU’s vision statement, education. In establishing through research the definition of non-GMO, and discussing relevant issues in politics and legislation, culture, business, and science, among others, I am providing information to educate OFU members about this topic and its important current issues. This education will give stakeholders the ability to think about, discuss, and make choices about something that is vital to life - their food. Although I did not deliver a finished website, to
the OFU, the second and third sections of my report will be an initial step toward this final product. The report I submitted illustrates options for creating a seed bank and certification scheme. This information will give the client what they need to make an informed decision whether or not to pursue this program to its finality.

The IES program provides the opportunity to learn many new skills and develop oneself in a way which prepares an individual to face the challenges relevant to their future employment, and real world problem solving. There were several IES courses which gave me a distinct advantage during this project:

- **PSP.** Because my project consisted of creating a report for my client, I had several IES classes and experiences to draw upon which helped me a great deal. I think that the Professional Service Project class (PSP) was the most useful of these experiences. PSP gave me the experience of not only doing a project on behalf of a client, but offered opportunities to learn many new methods of report writing, which taught me more effective ways of organizing my own practicum report, while delivering meaningful content. It also allowed me to learn more communication and ‘people’ skills, which are always helpful in any instance.

- **Environmental Communications** was a class required as part of the program assisted me in being able to appropriately and effectively convey scientific information to a broader audience in a way which would be most engaging.

- **Topics Seminar** was also a great help. In this class we explored overarching federal legislation that governed environmental issues. Although not the same legislation, this helped to influence the lens with which I examined and interpreted federal regulations regarding non-GMO issues.

The IES program has helped me grow as both a person and a professional. It will definitely shape my future actions and ways in which I will seek employment. I see several ways in which this will occur:

- To see that my work has value in real world application is itself is very rewarding and exciting, on top of accomplishing a major IES program requirement by completing this practicum. In the future, I will seek employment where I feel my work will contribute the most, creating positive impacts on the environment and society.

- Writing the report helped to show me the many dimensions a real-world issue, such as non-GMO as shown in this report, can take, and how many differing viewpoints there are on the issue. This will help in the future, not only to determine all the dimensions of a problem which will be necessary to solve it, but in analyzing important stakeholder feedback.
• This practicum has given me the valuable experience of working with an organization. Although I worked from outside the organization, I could begin to see the dynamics of that organization, including their values and communications. This will be important, as it will provide an example so I know what to expect with other organizations in which I could possibly be employed.

In conclusion, the IES experience and this practicum project has been a valuable experience and pivotal point in my life. It has given me many valuable skills and experiences to shape a better future, not only for myself, but for the society in which I exist.