The Ecological Effects of Genetically Modified Organisms and Pesticide use on Land in Northern New York

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EXECUTIVE SUMMARY

The main purpose of this report is to address the potential hazards behind the use of pesticides and genetically modified organisms (GMO) in the agricultural sector of New York State and more locally, St. Lawrence County. Agriculture is an important part of New York States economy. New York State dedicates more than 22% of its total land mass to agriculture. In St. Lawrence County, roughly 72% of the total land mass is either forested or utilized for agricultural purposes. This illustrates the importance and dependency on natural resources in Northern New York. The milk and dairy industry is one of New York’s biggest agricultural sectors. New York States milk and dairy industry is ranked 4th in the nation and locally, St. Lawrence County ranks 2nd in milk and dairy production is the state of New York. As a means to support livestock, dairy farmers depend on conventional farming practices. The majority of the dairy farms in St. Lawrence County utilize genetically modified organisms (GMOs) such as corn, soybeans and haylage to feed livestock. Corn, soybeans and haylage are affective due to their high protein content which helps the animals grow faster, at a low cost. They assure high agricultural yield and efficient use of the land, and relatively inexpensive (Cressey et al. 2009). The topic of pesticides and GMOs presents a controversial issue across the United States, as well as right here in the North Country.

Pesticides are a threat to the biodiversity of many organisms (Geiger et al. 2010). The presence of GMO’s also poses a threat to the biodiversity of the surrounding wild life. Through drift movement, which is the movement of pesticides or GMO pollen from intended site to a non-target site, pesticides and GMOs pose a threat to surrounding plant and animal species. In
this study we combined extensive literature analysis, GIS mapping, survey, and personal interviews. All obtained information is presented in aggregate form. Using GIS mapping software, a map was created illustrating the potential hazard pesticide drift in St. Lawrence County by pointing farm lands within 25 meters of a flowing water system.

The major findings of this study includes the perception of organic and conventional farmers on the use of pesticides and GMOs, the severity of the issues behind the use of pesticide and GMOs, as well as the course of action to minimize or eliminate the potential hazards associated with pesticide and GMO use, within the North Country.

Based on our findings, pesticide and GMO use in agriculture is a critical component of Northern New York’s economy. Thus Northern New York has a huge dependency on these biotechnologies. Thus we propose solutions developed to minimize the potential risk associated with the use of pesticide and GMOs. This report concludes with the best and most feasible solutions towards minimizing the impact of drift movement, followed by an implementation plan.
PROBLEM DEFINITION

Introduction

Agriculture is an important part of New York State’s economy and predominantly the rural North Country. New York State relies on its landscape for the advancement of agriculture, employment, food, raw materials, and a biodiverse ecosystem (Aldrich et al. 2001). New York State is 30.2 million acres, of the 30 million acres, roughly 8 million acres of land is dedicated to agriculture. In other terms 28% of the land in New York State is dedicated strictly to agriculture. According to the 2014 census, New York State has a population of 19.75 million people, 36,300 of which are farmers, and 850 of which are certified organic farmers.

St. Lawrence country (SLC) is 1,805,358.66 acres according to the 2012 census published by the U.S Department of Agriculture (USDA, 2012). Of the 1.8 million acres of land in SLC, 356,906 acres or 48.2% is dedicated to cropland, 12.9% is used for pastures, 29.6% is used for woodlands, and 9.3 % is dedicated to other uses. SLC has 1,303 farms which is a 3% decrease from 2012 which was 1330 farms. The average farm size ranges between 261 to 274 acres (map provided in appendix B).

While much farming in New York State is done on smaller scales, compared to farms across America, it still has an enormous impact on its economy. Agricultural production in New York State includes, but is not limited to:

- Hay, apples, corn, soybeans, cabbage, potatoes, beans, sweet corn, onions, wheat, squash, pumpkins, peaches, cucumbers, oats, strawberries, blueberries, pears,
cherries, cauliflower, barley, tomatoes, haylage, and maple syrup (Project Survey, 2015), (USDA, 2014)

There is a distinction between what is produced by organic farmers and conventional farmers in New York State. Organic production in St. Lawrence County includes carrots, pears, herbs, apples, strawberries, raspberries, plums, grapes, peaches, tomatoes, asparagus, and green salad, pie cherries (Project Survey, 2015). In comparison, organic farms also take up much smaller portions of farm land in Northern New York. The majority of the land is SLC is utilized by conventional farmers, who uses modern means of production (including monocultures, pesticides, large machinery, fertilizers and GMOs). The most highly produced crops on conventional farmland in the SLC are corn, soybeans, and haylage.

Conventional Farming in New York State

Conventional farming in SLC produces primarily corn, soybeans and haylage. As of 2012, 106,264 acres in SLC were dedicated strictly for growing hay utilized in the production of haylage, grass silage and greenchop in order to feed livestock. Approximately 25,871 acres were used to grow corn for silage, 13,744 acres were used to grow corn for grain, 3,754 acres were used to grow soybeans, and 910 acres were dedicated to growing oats (USDA, 2009). The high production of conventional corn and soy beans is primarily for the dairy industry, which is an important component of the SLC economy. Many of the dairy farms in St. Lawrence country grow their own corn, soy beans, grains and silage as well as maintain their own pasture lands in order to support their life stock not for distribution. (Wolfe et al. 2009).
The North Country which comprises Clinton, Essex, Franklin, Hamilton, Jefferson, Lewis and St. Lawrence counties, is ranked the second largest milk and dairy producer in New York State (DiNapoli, 2012). The milk and dairy industry is extremely important as it generates more than one third of New York State’s agricultural revenue, however the dairy industry sees influxes in production which depends on the prices of milk. Since 2006 New York State has seen a decline in dairy farms from 381 to 262 farms (DiNapoli, 2010).

**Pesticide Use in Northern New York**

Each year, an estimate of over 3 billion Kg of pesticides are applied with a cost reaching over $40 billion, across America. In the United States alone, about 500 million kg of over 600 types of pesticides are applied annually, costing over $10 billion (Pimentel, 2005). America has witnessed a 10 fold increase in the use of pesticides between 1945 and 2000 (Pimentel, 2005). This is explained as a result of the change in agricultural practices. Pesticides are poisons used to kill unwanted organisms (Silver and Reiley, 2011). Pesticides is the umbrella term used to describe a wide range of compounds ranging from insecticides, fungicides, rodenticides, molluscicides, nematicides, and plant regulators (Aktar et al., 2009). During the application of pesticides, there is always a risk of drift movement. Not all forms of pesticide drift is harmful, as the degree of risk depends on the type of pesticides that is applied, the amount that is applied, the location, and the means in which it is applied.

Annually, New York State Department of Environmental Conservation and Cornell University publishes a report illustrating pesticide sales and application data reported from regulated communities in New York State. Below is list comparing the total amount of
pesticides used in 2000 versus 2009. Additionally, the list illustrates the top three pesticides sold to private applicators for agricultural use in pounds and in weight between 2000 and 2009. Pesticide numbers displayed in pounds refers to solid mass which is applied through direct placement, while pesticides use illustrated in volume refers to liquid which are applied by spraying. The following data illustrates pesticide use of agricultural purposes:


• 881,817.54 Gallons
• 5,634,912.36 Pounds

The top three largest most sold pesticides to private applicators by weight in New York State in 2000 (Final 2000 PRL Annual Report, 2015)

• Lorsban Insecticide (EPA Registration No. 62719-34)
• Force 3G Insecticide (EPA Registration No. 10182-373)
• Dithane DF Agricultural Fungicide (EPA Registration No. 707-180)


• Prowl 3.3 RC Herbicides (EPA Registration No. 241-337)
• Roundup Ultra Herbicide (EPA Registration No. 524-475)
• Bicep Lite II Herbicide (EPA Registration No. 100-766)

The total amount of pesticide sold to private applicators for agricultural use in New York in 2009 (Final 2009 PRL Annual Report 2009)

• 761,450
• 3,594,419

The three most sold pesticide product sold to private applicators by weight in New York State in 2009 (Final 2009 PRL Annual Report, 2015)

• Penncozeb 75 DF Fungicide (EPA Registration No. 70506-185)
• Captan 80 WDG Herbicide (EPA Registration No: 66222-58-51036)
The three most sold pesticide product sold to private applicators by weight in New York State in 2009 (Final 2009 PRL Annual Report, 2015)

- Drexel Captan 80 WDG Fungicide (EPA Registration No: 66222-58-19713)
- Lumax Selective Herbicide (EPA Registration No. 100-1152)
- Rascal Plus/ Agrisolutions Cornerstone Plus Herbicide (EPA Registration No: 1381-192)
- Glyphosate Herbicide (EPA Registration No: 34704-890)

The list above is comprised of herbicides, insecticides, and fungicides. Herbicides control most annual grasses and broadleaf weeds as they germinate. Insecticides control the insect pest population on in agricultural field. Fungicides inhibit the growth and development of fungus and fungal spores. Each product is labeled to be hazardous to aquatic ecosystems and to aquatic organisms (Monsanto, 2010). New York State Department of Environmental Conservation goes to great lengths to accumulate this data; however, there is concern about the quality of the data collected from regulated communities. Based on the data provided, there has been a drastic decline in the amount of pesticides used by private applicators between 2000 and 2009 both in pounds and in gallons, due to increased regulation.

It is important to take into consideration that this is data only exemplifies collected data. There are many factors that could explain this trend. The reader must take into consideration the possibilities of false reports and lack of reports. Another possibility for this decline could be due to the decline in the number of dairy farms that occurred between 2006 and 2010 as result of the reducing milk prices (Interview Contact, 2015).

**GMO’s**

The vast majority of the dairy industry in the North Country utilizes conventional farming practices. This has promoted the use of genetically modified organisms. GMO is a term
used to describe the genetic alteration of an organism as a means of attaining a desired trait (Swanson, 2013). Dairy farms depend on the production of genetically modified corn and soybeans due to their high protein content which helps livestock mature faster, than if they were raised on grass. Genetically modified organisms, increase crop yields and promotes efficient land use, furthermore, as a result of government subsidies, GMOs are much cheaper (Smith, 2013). Genetically modified corn and soybeans are considered low input crops which means that once planted and sprayed with herbicides, very little maintenance is required until harvest. This is an attractive, and economically necessary, quality to North Country farmers.

The first genetically modified plant was tobacco, genetically modified tobacco was first engineered in 1983 to be herbicide resistant, and later insect resistant and thus the trend began. In 1995 the Food Drug Administration (FDA) approved genetically modified corn, soy, along with other crops which are planted for commercialization (FDA, 2009). Since then, the number of genetically modified crops has gradually increased (Swanson, 2013). Although GMOs have revolutionized food production, the presence of GMOs has aroused concerns across the farming industry (Donohoe and Kondratowicz, 2007).

**What is Drift Movement?**

Pesticide drift which is also referred to as drift movement or drift spray is defined as the physical movement of mist, particles, or vapor gas through space from a target site to a non-target site (Center et al. 2014). Contamination of unintended sites can take multiple. Routes include drift, volatilization, leaching, and runoff. Drift is the movement of pesticides away from the target site by wind or air. Volatilization refers to the evaporation of pesticides from the soil,
foliage or surface water. Leaching is the movement of pesticides through the soil, and Runoff occurs through rainfall and watering which washes chemicals off of soil and plants and into drains and waterways (Silver and Riley, 2001).

Drift movement can occur during, immediately after, as well as hours, days or even months after application. Post application drift occurs after application. While pesticide drift has been regulated to reduce impacts to the greater ecosystem, it has been noted that drift often occurs as a result of illegal application or uneducated application (Fishel and Ferrel, 2010). There are many factors that affects magnitude; air temperature, humidity, and wind. The air temperature and humidity affects the rate of evaporation and topography, which affects the rate at which drift travels. Some other factors include, type of chemicals used, means of application, additive substances in the pesticide, nozzle type, nozzle size, drop size, weather, and height at which the pesticide is applied.

Genetically modified organisms also have the potential to drift from the target site into non target site. For example, corn pollen is one of the largest particles found in the air. It is easily dispersed by wind and gravity (Thomison, ND). Pollen can travel up to 15 miles per hour within minutes; however most are deposited within a close proximity of their origin. Pollen drift is much more difficult to measure for the rate of contamination is affected by biotic and abiotic factors. Pollen can remain suspended in the air as well as drift in all direction simultaneously (Botalian, 2000).
Impacts of Pesticide Drift

Pesticides affect both large and small animals. According to the New York State Department of Environmental Conservation, during the industrial revolution, the peregrine falcon and osprey population numbers dramatically declined as a result of DDT use which is a colorless, odorless and tasteless pesticide. DDT induced eggshell thinning which reduced reproductive output of mating pairs, breeding numbers dropped from 1000 in 1940 to as low as 150 by 1969. Once the effects of the DDT chemical were noticed, DDT was eradicated and deemed illegal for use. Since the eradication of DDT, population numbers of the peregrine falcon and the osprey have increased. Since the ban of DDT, population bounced back to a total of 230 by 1995 within the North Country (Piche, 2011). This exemplifies the effects that pesticides can have on our local ecosystem, as large raptors are an integral part of biodiversity in Northern New York.

Different species play different roles in providing vital ecological services in natural and agricultural systems, contributing to the success of each system. Ecological services include but are not limited to predation, parasitism, pollination, nutrient cycling and pest control. Pesticide use effects more than just the target species. Natural predators and beneficial parasites fall victim to pesticides as collateral damage which can result in pests having the potential to reach outbreak levels (Pimentel, 2005). Furthermore, parasitic insects have complex life cycles which involve searching and attacking host species. Preying on host species provide the ecological service of pest control which is altered and hindered through the use of pesticides.
It is clear that the global decline of bees caused of the phenomena colony collapse syndrome has been felt in St. Lawrence County. The decline in the honey has prompted a rise in the number of bee keepers (Lawton 2014). As more and more people are realizing the importance of wild pollinators in food production, more people are committing to back yard gardening thus proving habitat for bees. Although little evidence has been provided to what may be the cause of the colony collapse syndrome, some suggest that it is due to the changing agricultural practices which depends heavily on pesticides (Lawton, 2014).

The pesticide known as neonicotinoids or neonic poses a serious threat to bee populations as well as other important pollinators here in northern New York (Brooker, 2014). Neonicotinoids disrupts insect’s mobility, navigation, feeding, foraging, memory, learning, and hive activity (Gillibrand, 2012). Honey bees are a vital to sustaining the health of the agricultural industry in northern New York and its economy. Declining numbers in bees and pollinator species may result in the decline of commercial crops such as almonds, blueberries and apples all of which are very important to the economy of New York State (Gillibrand, 2012).

Another widely used chemical in the North Country is the herbicide glyphosate. According to the New York State Department of Agriculture, glyphosate causes diseases, biological and physiological disorders in crops. Glyphosate makes plants more susceptible to disease and biological and physiological disorders in crops. According to a report by the U.S. Department of Agriculture, there are claims that glyphosate is contributing to an increase in more than 40 plant diseases (Camberato et al., 2010). Furthermore, non-judicious use of glyphosate can result in micronutrient deficiency which can lead to more plant disease (Camberato et al., 2010). It has also been proven that glyphosate is no longer effective in killing weeds however its
use is increasing gradually. It is not breaking down as promised, and it has the potential to cause birth defects, tumors and reproductive disorders in animals as well as sharp decline in beneficial insects (Camberato et al. 2010).

**Impacts of GMO Drift**

The presence of GMOs in Northern New York poses considerable environmental concern. Although little data is available that provides specific example to the ecological impact of GMO, the presence of GMO in northern New York is a threat to the biodiversity. Little evidence was found concerning the severity of GMO drift in northern New York (Project Survey, 2015). Gene recombination or gene flow is a big concern for local farmers. This is the hybridization of GMO with wild plants resulting creation of herbicide resistant plant or super-weeds. GMO are capable of successfully mating with wild plants (Sanvido et al. 2006). It has been demonstrated that this can occur through the gene movement from crop to seeds as a result of pollen drift. Through hybridization, GMO leaves next generation plants sterile and unable to reproduce thus cutting off all further reproduction (Sanvido et al. 2006).

The genetically modified Bt corn also known as sweet corn which is one of the most produced vegetables in New York State has come under investigation. Bt corn is a result a cross between sweet corn and the naturally occur soul bacteria, *Bacillus thuringiensis* (Bt). Bt produces a crystalline protein that is very toxic to many insect species and pollinator species (Sear et al. 2001 and Sanvido et al 2006). Bt is effective against insect larva, but not very effective against adults insects. This poses a threat to species population numbers because Bt-crop has the potential to eliminate an entire insect generation (Sear et al., 2001).
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METHODS

Our methods included database literature research, survey, interviews, and GIS spatial analysis. We conducted a survey of 50 farmers comprised of organic farmers and non-organic farmers. The survey instrument is provided in Appendix A and our methods were approved by the St. Lawrence University Institutional Review Board (#123-456).

We obtained the contact information for each individual farmers from Garden shares main website and through the use of GIS mapping software at St. Lawrence University GIS lab. Of the 50 farmers, we made sure that 27 were certified organic farmers that has met the U.S Department of Agriculture (USDA) standards and verified by the Northeast organic farming association of New York (NOFA-NY).

We conducted a database literature analysis of work pertaining to the impact of pesticide drift in northern New York. Little work has been done assessing the ecological impact of pesticide drift in Northern New York, and so we directed our search to recorded ecological impact of Pesticide drift in North America. Our research included a look into the amount of pesticide sold, and used by private and commercial applicators.

To illustrate the potentiation risk of drift movement, our participants, we utilized GIS mapping software to illustrate the distance local non organic farms are to organic farms. Furthermore, we used GIS to illustrate the distance each individual farm was within 100 meters of flowing body of water. Using data collected from the St. Lawrence University GIS lab, we identified lands associated with agriculture, dairy, field crops, orchard crops, apples, pears, peaches and cherries suing the geospatial coding provided. A total of 1886 parcels of land were
identified to contain some aspect of the mentioned characteristics. Of this 1886 we randomly selected 100 parcels. Through location selection, we determined that a total of 46 farm lands from the 100 were located within 25 meters of a water system (The map is provided in Appendix A).
IDENTIFICATION OF STAKEHOLDERS

The controversial issue of pesticide and GMO use is influenced by many stakeholders. Stakeholder is defined as an individual or a group that could influence or could be influenced by others in the process of achieving a goal (Huang, 2004). Regarding GMO and Pesticide use in the St. Lawrence County we have identified six stakeholders: nature and the land itself, conventional farmers, organic farmers, community stakeholders, businesses that sell pesticides and GMOs, and Government bodies. A study performed by Huang found that the more influence exerted by community stakeholders as the driving forces of environmental protection, can push managers to reconsider strategies for lessening pollution (Huang, 2004). Direct stakeholders, according to a study completed in 2006 by Crane et al., acknowledge that a trade-off exists between the potential economic benefits of pesticides and the disadvantages of poisoning events (Crane et al., 2006).

Nature and the Land

Pesticides

Pesticides are developed to target pests that deteriorate the productivity of farm crops. However pesticides not only affect their intended targets but also eliminate beneficial pests and microorganisms in the surrounding ecosystem. Uses include agricultural pest control as well as to battle invasive species (Survey 2015). In addition to the massive collateral damage to the ecosystem, pesticides are also capable of altering the genetic material of organisms through mutations (Briggs, 1992).
GMOs

Genetically modified organisms were developed to increase vegetable productivity. GMOs are present in St. Lawrence County majorly through corn and soybean production. GMOs pose a threat to farmers in the North Country through cross contamination of genetically modified seeds and organic seeds. While St. Lawrence County has yet to identify a case of cross contamination the threat is present and viable as many organic and conventional farms are adjacent to each other.

Conventional Farmers

Conventional farmers utilize pesticides and GMO on mass scale. The use of pesticides and GMO is appealing across the United States as it is the most economically feasible farming technique and produces massive quantities of food and this plays an important in the success of farmer’s livelihood in SLC. Not only do modern farming techniques contribute to the success of North Country farming but it is also crucial to consumers who buy these vegetables at lower prices than organic produce, a key element in the economics of buying food (Survey, 2015). Additionally modern farming techniques which utilize GMO seeds and pesticides are successful in producing enough food to feed America’s growing population as well as livestock that feed off of GMO seeds (Survey, 2015). It is important to note that a larger percentage of conventional farm land in SLC is primarily for feeding livestock. Conventional farmers are held to certain standards while using pesticides. Applicators are expected to undergo educational training about means of application as well as the associated ecological impact. While conventional farmers
recognize that pesticides and GMOs have adverse ecological effects, through the correct application these effects can easily be avoided.

**Certified Organic Farmers**

To become a certified organic farmer you need to become certified by the United States Department of Agriculture. Certified organic farmers take pride in the sustainable practices of their work and are only allowed to utilize certain certified chemicals and fertilizers on their fields (Survey, 2015). Certified organic farmers are stakeholders regarding pesticide and GMO use because their crops and livelihood can be directly affected through drift and cross contamination. If and when organic fields become contaminated with pesticide or GMO drift the organic farmers are held directly responsible for that contamination, and are expected to have taken preventative measures to avoid such contamination. While organic farmers reject conventional growing techniques (the use of pesticides and GMOs) they acknowledge that “agriculture without the use of pesticides would require a truly radical transformation to ecology, economy and society” (Survey, 2015). According to survey results, organic farmers do not place their distrust for pesticide and GMO use directly on conventional farmers, but rather point out the flaws in how America’s food system has become a capitalistic entity (Survey, 2015). Organic farmers are passionate about growing food, and present interest in educating the community and public in general about organic practices, five out of seven completed surveys came from organic farmers (Survey, 2015).
Community Stakeholders

The debate on pesticides has often disregarded the stake that community landholder poses. While farmers, sellers, and government agencies account for the prominent stakeholders regarding pesticides and GMOs they are not the only ones being effected by their use, local community members eat vegetables grown by both organic and conversational farmers. Private land is also at risk of contamination.

St. Lawrence County community efforts to maintain nature as an integral part of the community is vast. The North Country landscape and ecosystem in large part define its people, as seen through different cultural practices and art (Survey, 2015)(TAUNY, 2015). Efforts advocating for sustainable agriculture, outdoor education and local culture are present, through organizations such as Nature up North, Adirondack Raptors, TAUNY, Cornell Cooperative Extension, along with many other local organizations. North Country communities value their land, which may be why organic farming does have such a presence in the St. Lawrence County. Pesticides and GMOs pose a threat to these communities which gives them a stake it the usage of such chemicals and biotechnologies. It wasn’t until more recently that environmental groups were considered stakeholders in pesticide and GMO us, however because the twenty first century is a green one environmental issues have become a part of public affairs, and enterprises should cooperate with stakeholders (Huang, 2004).

Businesses that Sell Pesticides and GMO’s

Research shows that customers buying pesticides and GMOs want to choose products which are not harmful to the environment (Huang, 2004). Therefore businesses selling pesticides
and GMOs are influenced by their consumers and community stakeholders. Tractor supply, a major seller of agricultural materials, located in Potsdam, NY sells pesticides, herbicides, and insecticides in small quantities (one to three gallon containers). These chemicals are not federally restricted and anyone can purchase them for use. While tractor supply hasn’t received any local pressure from community members to reduce sales of chemicals employees suggested that these would be issues dealt with at a corporate level (Interview, 2015).

**Government Bodies**

Government bodies are considered regulatory stakeholders which work to mitigate GMO and Pesticide use via legislation and by influencing environmental management (Huang, 2004). Regulatory stakeholders regarding GMO and pesticide use include the Department of Conservation (DEC), the Environmental Protection Agency (EPA),

**Pesticides**

The United States Environmental Protection Agency has conducted extensive studies regarding the effects of pesticide drift (EPA, 2014). These studies are important because they work to compile economic, social and environmental fact and opinion that are the determining factors influencing legislation on pesticide and GMO use. The EPA plays a critical role in evaluating over 1,050 active ingredients registered as pesticides, which are used in thousands of pesticide products available in the marketplace (EPA, 2014). The EPA sets regulations regarding pesticide use.

The New York State Department of Environmental Conservation works at a state scale to regulate the use of pesticides. The DEC has jurisdiction in the use, sale, distribution and
transportation of pesticides, as well as regulate the registration, commercial use, purchase and custom application of pesticides. Therefore farmers in St. Lawrence county register their use of pesticides through the DEC as well as complete training courses which allow for the use of pesticides (DEC).

GMOs

The EPA works in congruence with the United States Department of Agriculture and the Food and Drug Administration to regulate the use of biotechnology in America’s Agriculture at the federal level (EPA). The goal of these agencies is to ensure the safety of biotechnology research and products. Specifically the USDA oversees the regulation of GMOs as they relate to agricultural practices. The FDA evaluates food safety from the standpoint of human consumption. and the EPA regulates the environmental risks as a result of GMOS. With changing technology and impacts of technology each agency must also adjust their authority (Genetically Modified Organisms).

Local government agencies have yet to take a position regarding GMO use in the North Country. However with increased awareness of biotechnology and the continued controversy around genetically modified seeds, grassroots organisms are fighting for legislation regarding eliminating GMO use in New York. Activist’s websites such as GMO Free NY work to connect the public with their local legislators, fighting for labeling of GMO products in New York and hope for New York to be GMO free. Depending on the success of these activists GMO regulation has the potential to spread to New York State regulatory sectors such as the DEC.
GOVERNMENTAL ISSUES

Pesticide and GMO use in the North Country is regulated at the federal and state levels of government. Both federal and state government bodies work to regulate pesticide and GMO use as well as deal with legislation and legal matters that originate from drift controversies, such as cross contamination. The Federal Government began regulating biotechnology (GMOs) in 1986 for the regulatory oversight of organisms derived through genetic engineering (USDA, 2015).

Pesticides

The EPA plays a critical role in evaluating over 1,050 active ingredients registered as pesticides, which are used in thousands of pesticide products available in the marketplace (EPA, 2014). Four steps of human risk assessment are used to evaluate the health impacts of pesticide use, these four steps include Hazard Identification, Dose-Response Assessment, Exposure Assessment and Risk Characterization (EPA, 2014). Other risk assessment strategies are used to determine ecological impacts of pesticides. While these studies are extensive they are also completed over a large geographic space. However in reality these decisions that are made by the federal government cause different effects on a local scale.

The New York State Department of Environmental Conservation regulates the use of pesticides in the North Country. The Environmental Conservation Law, 33-0301[2][m], 33-0303[3][d], [e], which was last updated on the DEC webpage in 2009, lists the regulations put on pesticide use (DEC, 2015). The DEC mandates educational training to receive a certification, which requires recertification every six years, to use and apply pesticides to fields for agriculture (DEC, 2015). A common occurrence through our research reiterated the importance regarding
the responsible use of pesticides to produce food. The conventional farmers that responded to our survey reported that they needed to get a New York State certification for pesticide use (Project Survey, 2015). Through the responsible use of pesticides conventional users and government stakeholders believe that the trade-offs of pesticide use is not significant enough to stop the use of pesticides. According to the DEC web page agribusinesses using pesticides are highly regulated and knowledgeable on the use of pesticides which minimizes the negative effects of drift, justifying the use of pesticides to produce food excess amounts of food (DEC, 2015).

**GMOs**

The EPA works to regulate the use of biotechnology and its place in our food system. GMO products have unique genetic coding and therefore present unique regulatory challenges. The EPA regulates GMO biotechnology, which produces seeds that are biological pesticides, therefor its regulatory jurisdiction falls under those of pesticides marked and used in the United States. The EPA regulates GMOs under two laws: Federal Insecticide, Fungicide and Rodenticide act (FIFRA) and Federal Food, Drug, and Cosmetics Act (FFDCA). FIFRA act provides the legal requirements for the EPA’s registration process for all pesticides. This includes regulation of the new substance and DNA in the plan when it is pesticidal in nature. FFDCA act or Food Quality Protection Act (FQPA) requires the EPA to set tolerances, or exemptions from tolerances, for the allowable residues of pesticides that are applied to food and animal feed (EPA, 2014). The EPAs five principles of biotechnology regulatory program is based on five important principles that guide the decision making process: using sounds science,
ensuring transparency of the decision-making process, maintaining consistency and fairness, collaborating with regulatory partners, and building public trust (EPA, 2014).

Another agency that works at the federal level to regulate use of GMO seeds is the USDA. The Animal and Plant Health Inspection Service (APHIS) works through the USDA to protect agriculture from pests and disease. APHIS works to oversee products of modern biotechnology that could pose a risk to this. They regulate organisms and products that are suspected to be plant pests or pose a risk to plant pest via genetic engineering (USDA, 2013).

Finally the FDA works to regulate the safety of genetically engineered food to humans. Using a science-based approach the FDA produces a safety assessment, which works to identify distinguishing attributes of new genetic traits. This assessment works to determine whether any new genetic material could be toxic or allergenic when eaten, as well as a comparison of the nutrient level of a genetically altered plant versus traditionally bred plants (FDA, 2015). All of the information gathered via safety assessment, as well as relevant data, is information that is made publicly available in published literature (FDA, 2015). The FDA is clear in their assessment of GMO products that they neither support nor oppose them based on their perceived risks. Rather their goal is to ensure that all foods are safe and in compliance with the FD&C Act and other regulations through the USDA and EPA (FDA, 2015).

Maintaining Organic Status

Regardless of how much legislation is written to control the use of pesticide and GMO drift there are cases of contamination from conventional farms to organic ones across the United States (Lilliston, 2007), (McEvoy, 2012). GMO and pesticide drift are modern issues and
considered a ‘high-tech’ problem (Heald and Smith, 2006). When contamination occurs more often than not small-scale organic farmers are held accountable. The concern is that GMO genes contaminate naturally bred plants and therefore organic seeds then contain genetically modified genetic information. Organic farmer’s crops are then left legally liable as they are considered labeled as ‘falsely organic’ due to cross contamination. It wasn't until April of 2011 that the National Organic Program, a sector of the USDA, issued NOP Policy Memo 11-13 which addressed GMOs in organic production and handling. The policy works to clarify the questions concerning GMOs and organic production of goods (McEvoy, 2012). Such clarifications include organic farmer’s responsibilities to take extensive measures of preventative practices to avoid drift (ie. buffer zones) in order to maintain organic status. The policy also works to ensure preventative measures are being followed to protect organic farmers from legal battles, even if their crops exhibit traces of GMOs (McEvoy, 2012). Organic farmers are upset that they are paying a price for farming responsibly (Project Survey, 2015). But why are the organic farmers required to provide a buffer against the GMO drift and not the farmers who are producing the genetically engineered crops?
Parameterizing Solutions

The development of an adequate solution to the issues of interest requires an analysis of the solution from alternative lenses. To develop an adequate solution to eliminate the current ecological effects of pesticides drift and prevent the further potential risk, we begin to evaluate alternative scenarios from the lens of conventional farmers and organic farmers. The needed changes that need attention include:

- The spread of pesticides from target sites to non-target sites which includes organic farmland. This has affected the biodiversity of many plant and animals species
- The gene flow of genetically modified organisms into wild habitat. Gene flow into the wild habitats compromises surrounding plant biodiversity especially due to the fact that offerings of hybrids are sterile and unable to reproduce
- Drift movement of GMOs into organic farmland. Farmers are concerned about the potential law suits that are present due to the drift movement, as well as selling contaminated vegetable labeled as ‘organic’

Based on extensive literature analysis, many solutions have been proposed as a means of minimizing and mitigating the effects of pesticide and GMO drift. Based on our survey results increased communication between regulators, applicators and organic farmers is highly desired. There is also concern regarding the public’s right to know about toxic chemicals being used where they live (North Country Public Radio, 2014). Increased communication is a highly
desired course of action because if everyone is made aware on the location where pesticides are being applied, as well as the type of pesticides that are applied, risks can be better mitigated. Huang, 2004 defines environmental management as the production of environmentally friendly products and minimizing negative impacts through clean production of pesticides (production processes improvement, industrial waste reduction, energy saving, and resource recovery). This is relevant to the issues of pesticide drift and GMO drift because stakeholders, including conventional farmers and producers are using and selling products that pose a threat to the biodiversity of important surrounding plant and animal species. These stakeholders are held accountable for their products by consumers and environmental action organizations, who have the power to influence the production, sale, and use of pesticides and GMOs (Huang, 2004).

**Identification of Potential Solutions**

Through researching cases of pesticide contamination across the United States, we have found numerous recommendations of pesticide application meant to reduce the impact of drift movement. According to Landers, 2000, to minimize the chances of drift movement, management plans should be implemented before and after application. In the case that one thinks drift may occur, users must take into consideration drift management strategies to reduce affects which include following scenarios (Landers 2000):

- Stop the use of pesticide
- Assure that operators are fully knowledgeable on how to correctly apply the desired chemicals
- Well thought out planning of application, utilizing the correct equipment for the correct target, adjusting as necessary throughout the season with growing crops
- Plant windbreakers
Obtain an informed consent of residents in the affected area before making the application
- Increasing distances between farms
- Inform the community the exact location in which pesticides are sprayed
- Alternative farming: promote small scale organic farming and backyard gardens
- Explore long term planning of buffer systems separating organic farms from conventional farms

There are also management strategies that can be utilized during application which includes (Landers, 2000):

- Users should only spray when weather conditions are ideal and not when conditions are favorable for atmospheric drift
- Keep spray pressure as low as possible, keeping the speed of pressure constant throughout application
- Avoid application near sensitive crops or water sources
- Consider sprayers that direct the chemical to the target, for example, towers and tunnels

Farmers should take into consideration other forms of pest mitigation such as the use of mechanical control. The following methods have proven effective regarding pest control (Linker et al., 2009):

- Biological control using insects natural enemies
- Insect parasitic nematodes
- Using pheromones for mass trapping
- Biological control using insect pathogens
- Insect parasitic fungi

Identification and Evaluation of Feasible Solutions

Based on the results of our survey North Country farmers recognize the use of pesticides as a necessity to maintaining high crop yield on conventional farms, which is necessary to feed North Country residents as well as American residents outside of New York State. According to one of our conventional farmer respondents, without the use of pesticides, agricultural yield
would drastically drop. This is a shared view between organic and conservational farmers (Project Survey, 2015). This is important to take into consideration due to the fact that agriculture is the economic spine of the Northern New York. Listed below are proposed plans that have the potential to minimize the impact of pesticide drift without requiring the complete eradication of pesticides. The list includes solutions we have devised as feasible which would benefit the most stakeholders while not placing economic stress on farmers in the North Country:

1. Inform the community the exact location where pesticides are being sprayed as well as which pesticides are being used, for which pests. This is beneficial for people buying land as well as people farming on the land. Furthermore this is can also be effective means of maintaining protected areas.
2. Promote alternative farming; minimizing the use of pesticides and utilizing biological and organic means of pest control
3. Explore the implementation of buffer systems because any organic farm that is close to conventional farming is at risk of contamination
4. Increase local research regarding pesticide drift including local drift risk assessment

Increasing communication and education

Farmer’s feedback showed that increased communication among neighbors was the most highly recommended means of mitigating the impacts of pesticide drift. Many farms in Northern New York are all within close proximity of one another (Appendix C). Distance from one another ranges from inches up to 100 feet from one another (Project Survey, 2015). Local farmers in Northern New York have begun working with local officials to assure that farmers applying pesticides communicate with their neighbor as to the exact sites of application, chemicals applied, as well as volume (North Country Public Radio, 2014). As communication between farmers and their neighbors increases so will the need for education regarding
pesticides. Not only farmers using pesticides should be made aware of the effects of pesticides but also their neighbors and community members, so they know what to expect or look for if contamination does occur. It also provides them the opportunity to create buffer zones which work to control pesticide drift. Through increased communication and education all parties effected by pesticide use will be best prepared in the case of pesticide drift.

Alternative farming, crop rotation, organic pest control

We categorize alternative farming, crop rotation and natural pest control in one category because they are three methods often used together as a means of sustainable farming. We use the term alternative framing due to the fact local farmers felt it would not be feasible to eliminate the use of pesticide completely. This is due to the fact that without the use of pesticides, agricultural yield would drop drastically, and either there would not be enough food to feed everyone, or the cost of food would rise and people would not be able to afford to buy sustainable produce. Alternative farming could work to decentralize conventional farming practices, by community members working in their own backyard gardens to produce sustainable food.

Another way alternative farming methods could be used is as way to integrate environmentally friendly farming methods with conventional farming. Crop rotation as well as organic pest control are two sustainable practices that could potentially be used to minimize the negative effects of pesticide use on conventional farms.

Crop rotation works to control weeds and diseases as well as limiting insect and other pest infestations that manifest in soil over time (Linker et al. 2009). The changing of crops in
sequence can be used to control or even decrease pest populations. This is a method commonly
used by organic farmers, and today is even moderately used by conventional farmers (Davis et
al., 2012). However conventional farmers in the Northeast generally rely on a two year rotation.
Iowa State researchers determine that through extending the period of crop rotation conventional
farmers are able to maintain increased yields, while using sustainable farming techniques,
therefore reducing dependence on pesticides and fertilizers (Davis et al., 2012). Crop rotation can
also be used to improve soil structure and reduce soil degradation through erosion.

Alternative pest management on conventional farms could include mechanical as well as
biological methods of pest control including; using parasitic nematodes, using pheromones for
mass trapping, using insect pathogens and insect parasitic Fungi (Linker et al., 2009). The EPA
works through the IPM program (Integrated Pest Management) to help develop environmentally
friendly solutions to control pests, with the goal of reducing the use of pesticides (EPA, 2012).
However the solutions proposed to conventional farmers, by the IPM, utilize pest management
that is mainly derived from synthetic materials. However, organic farmers utilize integrated pest
management from natural sources (EPA, 2012). We suggest North Country conventional
farmers work with integrated pest management through natural biological pest control. The
North Country already has a large congregation of small-scale organic farmers as well as
organizations that work with sustainable agriculture, such as the Cornell Cooperative Extension.
Organic farmers and CCE employees/volunteers could work with conventional farmers to help
integrate natural pest management as well as crop rotation practices into conventional
agriculture.
Implementing buffer zones

The implementation of buffer zones has proven effective in reducing soil erosion, protecting plants from wind related damage as well as improving air quality and intercepting air borne particulate matter (Carluer et al., 2011). Different kinds of buffer zones can be implemented to further reduce pesticide drift. For example, vegetation filter strips, humid woods, and constructed wetlands, as well as increasing the distance between neighboring farms (Carluer et al., 2011).

Increasing drift risk assessment by increasing research

Lastly increasing the frequency of drift risk assessment will help us to better grasp what kind of drift and contamination is occurring here in the North Country. Assessment aids in detecting early impacts of pesticide drift prior to bio accumulation, to both humans and biodiversity. Under the code of regulation Title 7: Agriculture, subtitle B, chapter 1, subchapter M, part 205: National Organic Program, subpart G, subsection 205.670: only certified agents may conduct periodic residue testing of agricultural product sold, and labeled. Agents are required to test a minimum of five percent of all operations they certify as organic (ECFR, 2012) Furthermore, only certified agents may legally test for residue in certified organic produce. However, according to the USDA certifying agents this regulation was not being fully implement as of 2012 (USDA National Organic Program, 2012). Increasing the frequency of testing as well as increasing the minimum numbers required for testing, would lead to greater knowledge of the ecological and agricultural effects of drift here in the North Country.
Identification of Best Solution

The best possible solution includes our proposed feasible solutions acting together. We decided that by combining the promotion of increased communication, alternative farming, implementing more extensive buffer zones, and increasing research in the North Country, the issues associated with pesticides and GMOs in Northern New York can be minimized for the present and future. The responsibility of risk assessment should be extended as far as possible, including organic and conventional farmers, community members, as well as government officials. If applicators assess effects of pesticides that they apply, they will be better prepared to adapt safe means of application faster. If organic farmers are able to perform risk assessment on their properties as well as determine if drift residue is effecting their crops then this information can be used to prompt change. Communicating this information to public officials would help local change occur faster as well as prompt change in state or even federal legislation. It is important in the biodiverse and ecologically sound North Country that we work to prevent further accumulation and contamination within our ecosystem.
Ease of implementation regarding the effective implementation of already existing and new solutions can be tedious. It is important to implement solutions that have a high impact as well as a high ease of implementation, as we feel this will be the fastest way to implement change. Especially regarding pesticide and GMO use, because of its connections to the economic success of farms in the North Country. Under federal and state branches of government certain solutions we suggest for implementation are already regulated, such as buffer systems, risk assessment, and residue testing, which were discussed earlier. However we suggest these existing programs are more highly regulated and enforced. We are also interested in implementing alternative means to this already established system, such as increasing research, increasing education and communication to all stakeholders involved, further developing buffers, and alternative farming methods, which can be difficult.

In this case study, there are mainly two factors to take into consideration; factors including ecosystem health and farmers need for pesticides and GMO. These are conflicting interests that require balance for success of implementation. The use of pesticides and GMOs can be hazardous to the surrounding ecosystem however GMOs and pesticides are also a vital part of the North Country’s farming system and crucial to its success (Survey Participant). Challenges to overcome including talking to conventional farmers. For example, two of our surveys were returned empty and one had a note attached that said, “This smells like skunk”. It is inferred that conventional farmers do not want to discuss conventional practices because they are controversial and often conventional farmers are held in contempt for modern farming practices. Such challenges can be overcome by adopting an adaptive management approach to mitigate the
responsibilities of pesticide and GMO use, so that not just one party is held responsible (Figure 3). In both the private and public sectors, stakeholders will be able to adapt to unforeseen outcomes.

Figure 3: Concept map illustrating the means of adaptive management (Groom et al. 2006).

We feel that adaptive management is crucial to pesticide and GMO management because its practices are convoluted and involves many stakeholders. Adopting adaptive management can assist in finding better ways to meet goals, identifying knowledge gaps, gaining valuable information and feedback about effective policies and fostering a culture that places emphasis on delegating responsibilities (Groom et al. 2006). By adopting adaptive management, stakeholders
will be able to overcome challenges associated with pesticide management making new implementations feasible.
IMPLEMENTATION PLAN

In order to implement the best possible solution that would minimize and prevent the potential ecological effects of pesticide drift, it is critical to first raise public awareness around the issues concerning pesticide and GMO drift in the North Country. In order to bring the issues of pesticide and GMO drift to the public’s eye, we would promote open and non-judgmental conversation on public radios, at town meeting, in public offices, between organic and conventional farmers as well as in schools. Based on our survey results, open dialogue between pesticides user and non-users proved to be important in terms of letting neighboring farms know where pesticides were being applied as well as quantities being applied. Additionally, it would be effective to promote agricultural science is schools, as agriculture is a crucial part of North Country culture, children should be educated on its local food system.

Bringing discussion to the table in public settings would prove a valuable base for increasing research on pesticide and GMO use. Increased education and increased research are related in the sense that they promote and challenge one another. In order to educate, first we need to know what we are looking at. A way to increase research regarding pesticide and GMO drift in the North Country would be via citizen science. Local organizations such as the Cornell Cooperative Extension could work with citizen science to teach locals how to detect and gain data regarding pesticide and GMO drift. Increased scientific based research by the DEC is also important to growing the knowledge base of drift in the North Country. Data collected from these efforts could be used to change policy management in regards to quantity of residue allowed, allowed sites of application and even the type of pesticides used.
This increased database would be beneficial towards increasing public knowledge which would prompt communication between stakeholders involved with pesticide and GMO drift. As research on the effects of drift increases it would also prompt further research. For example, the study of land topography would be beneficial in determining the need as well as the magnitude of buffers or wind breakers, whether natural or artificial, between farms. Once strong lines of communication, research, and buffers have been established, implementing alternative farming, crop rotation and organic means of pest control would be effective in mitigating the negative effects of drift movement on the environment. Therefore attempting to decrease dependency on pesticides and continue sustainable practices of agriculture, even through modern day farming techniques. The four proposed goals would be most effective if implemented as illustrated above, using a cascade effect. Building off one plan to another utilizes the full benefits behind the adaptive management approach.
CONCLUSIONS

This case study shows that pesticide and GMO use in Northern New York is already regulated at the federal and state level, and instances of drift have been reduced through legislation and regulation (O'Neil, 2015). Through the results of literature analysis, survey results and interviews, it was determined that St. Lawrence county has yet to show heavy impacts of pesticide and GMO drift. However it is clear that pesticides and GMO’s pose a serious threat to the biodiversity of the local ecosystem. In any instance of pesticide application, there is always a risk of drift movement form the target site to a non-target site, which increases if pesticides are being used without the proper application knowledge. In any instance of GMO use there is also risk of gene drift through cross pollination.

Our case study is significant to assure that these potential threats do not become prominent in the North Country ecosystem. The North Country is a landscape that economically depends on agriculture. Through our research it is evident that the St. Lawrence County farmers do in fact utilize pesticides and GMO’s, and depend on these technologies for food production. This dependency on biotechnologies confirms the significance of our study and the need for further research regarding the effects of pesticide and GMO drift. This can be accomplished through our proposed implementation of the best possible solutions to pesticide and GMO drift.
ACKNOWLEDGEMENTS

This work was supported by St. Lawrence University. We thank Dr. Erika Barthelmess for her useful comments and direction, helping us through different stages of completing this case study. This project has been an accumulation of effort and knowledge through published literature as well as communication with community members. We could not have completed our study without the help of the St. Lawrence Biology Department, St. Lawrence library resources, or the greater Canton, NY Community members. We appreciate the time our respondents put into our survey, as well as the information gained from personal and phone interviews, helping us gain critical data and knowledge for our localized North Country study.
LITERATURE CITED


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Accessed 5th May 2015
APPENDICES

Appendix A: Contacts and Informants

*In person interview:*

Brian Bennett  
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*Phone interviews:*

Ronald DeBeer  
Works for St. Lawrence County  
Pesticide Applicator  
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Kitty O'Neil, PhD.  
Regional Field Crops & Soils Specialist, NNY  
Cornell University Cooperative Extension  
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Mobile 315 854 1218

Tractor Supply  
7473 US HWY 11  
Potsdam NY, 13676  
(315) 265-3101
Appendix B: Copy of Survey Instruments

SURVEY

Hello, thank you for taking the time to read and complete this survey. Student researchers are conducting a study analyzing the use of pesticide and genetically modified organism (GMO) as well as Pesticides and GMO drift in the Northern New York. By filling out this survey you are helping us understand critical issues and views behind the use pesticides and GMO. We understand that this information is strongly affiliated with your livelihood and intend to follow all means necessary towards keeping surveys anonymous. We have included a postage-paid return envelope and would appreciate IF YOU COULD SEND THE COMPLETED SURVEY WITHIN TWO WEEKS OF RECEIVING THIS MAIL. Upon receiving the returned survey, you will also be entered in a raffle drawing for a chance to win a 50$ Visa gift card. If you are interested in being entered in the drawing, please fill out the slip included in this envelope. Thank you so much for your time.

The following questions are looking into the impact of pesticide drift and the impact of the presence of Genetically Modified Organisms (GMO) in organic farmland.

1. What type of farm do you run?
   ○ Organic
   ○ Certified Organic
   ○ Conventional
   ○ Other (Please Explain):

2. What types of products/goods does your farm produce?

3. How large is your farm?
   Total acres:

   50
Number of acres certified organic:

Number of acres conventional:

Number of acres other:

4. Do your fields neighbor any other fields? If so how many, and what type of farming is done on those fields? (ie. organic, conventional, livestock grazing)

5. If you answered yes to question 5. What is the average distance between you and the neighboring fields?

6. Have you detected the presence of unwanted pesticides, GMO crops, invasive species, or other things growing on your land? Please explain
7. To what degree have you been impacted by the effects of pesticide and GMO drift?
   - Low
   - Medium
   - High

8. Have you noticed any ecological side effects of GMO or pesticide use?

9. If you have dealt with GMO or pesticide drift, how was it dealt with?

10. If you answered yes to Question 8. As a farmer what would be your recommendation towards mitigating the effects of pesticide and GMO drift between conventional and organic farms?
11. Who do you think should be held responsible for mitigating the effects of pesticide and GMO cross contamination?

- Local Government
- Pesticide and GMO users
- Organic Farmers
- Other (please explain)

12. Have you ever been approached by a New York State official regarding the monitoring of pesticide use and/or GMO’s? Please explain

13. As an individual what is your overall perception on the use of pesticides?
Appendix C: Map Illustrating the Potential Risk of Drift on Local Water Systems

FarmLand Within 25 Meters of Moving Water in St. Lawrence Country

By: Arnold Olali and Olympia Gioulekas
Data Collected From St. Lawrence University GIS Lab
4/29/2015

Legend

<table>
<thead>
<tr>
<th>SLC River System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prop Data 49/100</td>
</tr>
<tr>
<td>A_SLC_Real_prop_data</td>
</tr>
</tbody>
</table>

0 3 6 9 12 Miles
Appendix D: Visual GIS Representation of Agricultural Land use in St. Lawrence County

Agricultural Land in SLU
Data Collected from St. Lawrence University GIS Lab
By: Arnold Olali and Olympia Giouleka
4/28/2015

Legend
- Green: Pasture
- Pink: Cultivated Crops

338960.8764984 Acres