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The Glyphosate Controversy: How Vermont Perspectives Could Inform Future Policy

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The Glyphosate Controversy: How Vermont Perspectives Could Inform Future Policy

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Abstract

Glyphosate is the most widely used herbicide in the world and remains the main active ingredient in Monsanto's product *Roundup*. Not only is glyphosate used for agricultural production, including *Roundup-Ready* crops, it is also used in many other day-to-day applications outside of agriculture, including lawn-care maintenance. Though there are policies set in place by the EPA, different studies conducted by national and international agencies show that this herbicide poses significant health risks to humans and the broader environment. Grounded in the concepts of risk perception, and 90 survey responses from a door-to-door survey, this study investigates the public perceptions on pesticide use in Franklin County, Vermont and makes future policy-recommendations surrounding glyphosate usage in the State of Vermont. The study finds that citizens are rarely involved in chemical regulations; studies on risk perceptions and risk analysis can be resourceful in future policy-making.

Keywords:
glyphosate, Roundup, regulations, environmental health, human/community health

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Introduction

While studying abroad in Vietnam, Morocco, and Bolivia, I got a chance to examine first-hand how environment and community health were deeply intertwined. I examined how competing interests in natural resources fueled by the political economic interests play an underlying, yet fundamental role in environmental conflicts, as well as the health and wellbeing of the communities subjected to these conflicts. In particular, I found that glyphosate was one of the most common chemicals that farmers were using in agricultural production. Food is health. Food is knowledge. Food is power. Food is the core of human existence and success. Food, deprived of its nutritional qualities may impact the health of the population in general and growing kids in particular. However, it is not just the food that we consume that can negatively affect human health, but also what goes into the land, and agricultural practices can impact the quality of the food produced. "Each year the world uses about 3 million tons of pesticides (comprising herbicides, insecticides, and fungicides) formulated from about 1,600 different chemicals" (Horrigan, Lawrence, & Walker, 2002, 446). These chemicals directly affect humans, and it is seldom that something is done about it.

My research into chemical use in agricultural production in Vietnam, Bolivia, and Morocco found that glyphosate was widely used in these regions. I also found that glyphosate, the main active ingredient in the herbicide *Roundup* produced by the agro-giant Monsanto, is not only used in agriculture but also lawn-care, forest management, and industrial development. When I returned from the field courses, I wondered how extensively glyphosate is used in Vermont, a state that is heavily dependent on agriculture. I wondered what people's perception of these field chemicals were. This led me to explore the use of glyphosate in Franklin County, Vermont and the people's perception of the risks of glyphosate in Vermont.

The goal of this study is to explore what Vermont residents know and understand about the use of glyphosate on the land and the possible environmental and human health impacts it may have. Recently, California has passed a law enforcing Monsanto to label *Roundup* as carcinogenic on their containers. Should Vermont be following in their footsteps? Is there

an even better solution? What are the views of glyphosate from the people who are using these chemicals on a day-to-day basis, and what information do they have on these chemicals? What access do they have to scientific information regarding glyphosate use? Through extensive background research from scientific studies and federal records, and survey responses, I will examine the risk perceptions of Vermonters on this contaminant.

Literature Review

History of Pesticide Use in Agriculture

Agricultural technological advancements have come a long way, from the use of just fertilizers to the use of biotechnology and genetic modification to help produce food in a more efficient and profitable way. There are three agricultural revolutions classified throughout history according to the agronomic researcher and author, Robert Zimdahl, in his book *Six chemicals that changed agriculture*. Settled agriculture is defined by Zimdahl as releasing "people from the necessity of producing or finding food. It gave us the time to accomplish many things—indeed, to flourish" (2015, 24). The first era as he calls the 'Blood Sweat, and Tears Era' was when settled agriculture was first created 10,000 to 7,000 years ago and "inadequate food supplies were frequent and agriculture was inefficient, hard work" (Zimdahl, 2015, 24). The 'Mechanical Era' followed, and in the late 1700's and early 1800's invention of labor-saving machines, such as the moldboard plow, were produced to increase efficiency (Zimdahl, 2015). According to Zimdahl, the third era of agriculture was at the start of the 1900's when fertilizers (made up heavily of nitrogen and phosphorus) were abundantly used (2015). Around 1945, following World War II, there was a rapid increase in chemical use in agriculture through fertilizers, pesticides, herbicides, insecticides, fungicides, etc. From this time on, herbicides were widely used to, "kill or inhibit the growth of unwanted plants, that is, weeds" (Zimdahl, 2015, 33), which were increasingly manufactured after the introduction of genetically modified organisms (GMOs) (Mart, 2015). It is important to understand the history of pesticide use in agriculture because the agricultural movement kept enhancing technologically to create better, strong crops to sustain the growing population to allow for economic growth in other sectors. Nowadays it is hard to find food and crops that are not produced with a chemical input. "Pesticides are correctly regarded as dangerous poisons, especially if they are used improperly. If they were not poisonous to something, they would not be useful" (Zimdahl, 2015, 33). The impacts that climate change has on increasingly higher temperatures and more severe weather patterns, including excess rainfall and drought, can be detrimental to the amount of chemical inputs being used in the agriculture industry.

The inconsistency that weather variability has on crops can disturb growth, therefore yield output. To produce consistent yield to assist the growing human population in a time of changing climates will result in the production and usage of more industrial chemicals, altercating land, soil, and seeds, as well as human health (Boxall, 2009). The outcome of adding additional inputs in the ground is to eliminate the fear of climate change severely affecting output. There are hundreds of chemical inputs used in agriculture, many of which have not been adequately evaluated and analyzed in the United States, but glyphosate continues to be at the forefront of these conversations. Glyphosate, the main active ingredient in *Roundup*, an herbicide manufactured by Monsanto, is used alongside seeds that are genetically modified, referred to as *Roundup-Ready Seeds*, to produce the highest yield in the least amount of land surface. Glyphosate is the most widely used herbicide in the world, yet its chemical components are extremely controversial as it is heavily debated as carcinogenic in humans. As it is heavily used, applicators, as well as the surrounding communities and areas, are susceptible to exposure.

Glyphosate – An Overview

Glyphosate is produced by Monsanto, a multinational, multi-billion-dollar company, specializing in agrochemical and agricultural biotechnology. Glyphosate is used worldwide: it can be found in the food, the air, and the water we drink. Its use has been controversial over the years as extensive research shows implications on the environment and human wellbeing (Kruger, 2014). While no concrete conclusions have been reached on the existing research, these uncertainties warrant further investigations of glyphosate and its impact on human and animal health (Krueger 2014). Glyphosate was recently under review by the Environmental Protection Agency (EPA) and the final report on the Carcinogenic Risk Assessment was released in late 2017, concluding that "glyphosate is not likely to be carcinogenic to humans" (EPA, 2018). This assessment reviewed the dietary, residential/non-occupational, aggregate, and occupational exposures of glyphosate in human health (EPA, 2018). Other agencies like the European Food Safety Authority (EFSA), have come to the same conclusions, stating in their 2015 assessment report requested from the European Union (EU) that "glyphosate is "unlikely to pose a carcinogenic hazard to

humans" (EFSA, 2015). However, the International Agency for Research on Cancer (IARC) a subdivision of the World Health Organization (WHO) believes otherwise. Their concluding research from 2015 states that glyphosate is "probably carcinogenic to humans" (IARC, 2015). Different national and international agencies are coming to different conclusions creating confusion surrounding exposure to this herbicide. On top of these reports, there are also speculations that Monsanto is influencing these more 'positive' outcomes as internal documents were analyzed after being released for pending lawsuits against the company. The following sections will analyze glyphosate further and explain its uses in society.

What is Glyphosate?

"Glyphosate is a white and odorless crystalline solid comprised of one basic amino function and three ionizeable acidic sites" (*Glyphosate resistance in crops and weeds*, 2010, 1*)*. Glyphosate is a nonselective systemic herbicide, "which kills plants…including grasses, broad leaf weeds, and even woody plants" (Robbins, 2012, 59). It was estimated that in 2011, "global demand of half a million tonnes per annum and $5.5 billion in sales" (Bai & Ogbourne, 2016). This particular herbicide was synthesized in 1950 by a Swiss chemist, Dr. Henry Martin, but it was not until 1974 until it became commercialized and sold to the public (Bai & Ogbourne, 2016). It rapidly increased in production and use and became the most frequently used herbicide in the world. Monsanto patented glyphosate in *Roundup* in the early 1970's before it was distributed to the public.

What is it used for and who uses it?

Glyphosate is used in both food and non-food field crops as well as non-crop areas. Glyphosate is used in order to control total vegetation and plant growth. It is structured to reduce plant growth by preventing plants from making their necessarily protein for survival (Devos *et al.*, 2008). "The chemical enters the plant, and disrupts the enzyme required for the production of amino acids that are essential to plant growth. The plant dies within a day or two, down to the roots, inhibiting regrowth or further reproduction" (Robbins, 2012, 59). Glyphosate is most commonly used by farmers as its use is highly concentrated in the agricultural system, and even more so in 'conventional' agriculture.

Being sprayed over fields and on crops, this herbicide is used to primarily kill weeds at a low cost, to increase crop production and yield, especially during a time of changing climates. It also has components that allow rapid absorption by plants. Glyphosate is absorbed through the plant, specifically through its leaves and travels through the sap until it reaches the roots and rhizomes (Robin, 2010). Farmers are typically the ones who purchase this herbicide for aerial spraying over their cropland. However, other stakeholders also use this herbicide at various scales, especially the general public who can purchase hand-held sprayers for quick, efficient lawn upkeep. Glyphosate is also used in public spaces, such as parks, golf courses, and highway developments to manage and control weeds (Robin, 2010).

What is it found in?

One of the largest distributors of glyphosate is found in the commercial herbicide spray called *Roundup*. Combined with many other components, this is the largest selling herbicide in the world. *Roundup* can contain a range of 14.5-75% of glyphosate salts, whilst Monsanto withholds information on the remaining additives from the public (Robin, 2010). This can be a concern because *Roundup* is predicted to be more toxic than glyphosate based on the additives in its solution (Robin, 2010).

According to Clair *et al*., Glyphosate combined with AMPA (aminomethyl phophonic acid) "are amongst the first major pollutants of surface waters," which they concluded in their study to be linked to reduced biodiversity in aquatic ecosystems (2012, 487). Glyphosate gets absorbed through environmental and human layers having been found in milk in Europe and therefore humans at the ppm level (Clair *et al.*, 2012). Glyphosate once applied to land can work its way up the food chain from soil, to water, plants, animals, and humans. Glyphosate is not only an ecological concern, but it also facilitates conversations and concerns in the human levels.

Monsanto, Roundup, and Genetic Modification

Advancements in biotechnology and the production of GMOs has resulted in the increased use of chemical inputs, such as *Roundup*. Monsanto, has produced genetically engineered

crops that are resistant to glyphosate to help promote a higher yield. Since glyphosate has strong components to kill weeds, this has also resulted in the killing of other surrounding crops. However, due to the large inputs of *Roundup* in soil, weeds are now becoming more resistant to *Roundup* spraying (Bai & Ogbourne, 2016). This results in the increase of spraying causing farmers to purchase more to use on their land. GMOs "were found in 70 percent of processed foods in the United States by 2003 (especially through high-fructose corn syrup, soy, and cotton and canola oils)" (Mart, 2015, 194). At this point in time, 98% of crops being produced with GMOs were found in only 5 countries: The United States, Argentina, Canada, China, and Brazil. The only crops that were grown with these GMOs were soybeans, corn, cotton, and canola (Mart, 2015). Since then, the list has expanded.

Impacts on Environment

One of the concerns of glyphosate use is its afterlife in soil. According to an article written by Marie-Monique Robin, a French investigative journalist, the company Monsanto states on its website that, "'The active ingredient in *Roundup* is inactivated when it touches the soil, which preserves surrounding plants and permits seeding or replanting one week after application'" (Robin, 2010, 70). Although this information has come from the company who profits from glyphosate use in *Roundup,* there is a debate on whether or not it is specifically the ingredient of glyphosate itself or the other active ingredients in *Roundup* that are harmful. However, glyphosate has been found to be strongly absorbed by the soil, but typically does not seep below 6 inches in the ground (Robin, 2010). Since it has such a strong absorption rate, it acts quickly in plants and can become present in species up the food chain. It is hard for glyphosate compounds to be broken down and will not be readily done so by water or sunlight. Glyphosate is also found in the uptake from plants and can further be found in a plants fruit. Usually if glyphosate is found in an animal through the food chain, it is eliminated from the body through urination and feces (Prevention, Pesticides and Toxic Substances, 2016). From its high presence in soil, glyphosate has found its way through the food chain and can be present in both living and non-living species.

Impacts on Human Health

During the last evaluation in 2000, the U.S. Environmental Protection Agency has "classified glyphosate as a Group E carcinogen, which is defined as having 'evidence of non-carcinogenicity for humans'" (EPA's Office of Pesticide Programs, 2016). Contaminants need to be reviewed every 15 years, hence the EPA has finalized a new assessment of glyphosate under a Registration Review, which was mandated by the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The final report released at the end of 2017 concluded that glyphosate is still not a likely carcinogen to humans. Another epidemiological case-control study conducted by Mink *et al.*, concluded that "currently available epidemiologic literature on glyphosate and cancer found no evidence of a consistent pattern of positive associations that would be indicative of a causal relationship between any site-specific cancer and exposure to glyphosate" (Mink *et al.*, 2012, 451). Although this study concluded that there was no causal relationship, this is an area of study that is continuing to be researched. The International Agency for Research on Cancer (IARC), a subdivision of the World Health Organization, came out with a report in March of 2015 suggesting that glyphosate can cause cancer in laboratory/experimental animals, after a study conducted on mice showed results of active tumors after their exposure to glyphosate (International Agency for Research on Cancer, 2015). IARC has identified glyphosate as a "probable" carcinogen (EPA's Office of Pesticide Programs, 2016). This study sparked debate and ever since this report was released other national and international agencies have been re-evaluating glyphosate. The results still differ and are inconclusive.

However, there are acute injuries associated with the direct handling of glyphosate, such as eye irritation or skin irritation, which is typically reported from farmers who are mixing and/or loading glyphosate in their products (Prevention, Pesticides and Toxic Substances, 2016). These more acute injuries are reported by having direct interaction with glyphosate, but it is more difficult for glyphosate to be reported for chronic illnesses as these are usually diagnosed over a longer term and other point-sources could be contributors as well. The Mink *et al*. study did not find any conclusions of glyphosate

having a causal association with reproductive, respiratory, or other chronic health issues (2011). However, even though there is no conclusive study, some science being conducted is suggesting that even small residue exposure can contribute to liver and kidney damage as well as being suspected of being an endocrine disruptor. Monsanto is also currently facing four hundred lawsuits against them filed by people who believe that exposure to *Roundup* has caused them to develop non-Hodgkin lymphoma (IARC, 2015).

Regulations

"All pesticides sold or distributed in the United States must be registered by the Environmental Protection Agency (EPA), based on scientific studies showing that they can be used without posing unreasonable risks to people or the environment" (Prevention, Pesticides and Toxic Substances, 2016, 1). The EPA documents various fact sheets on the use of chemicals and their toxicity to the environment and humans. Having one for glyphosate, the EPA came to the conclusion that this chemical is categorized as generally "non-toxic" and can be sold as long as the proper labeling requirements are met.

In 1976, the Toxic Substances Control Act (TSCA) was enacted to ensure the safety of chemicals used in everyday instances. More recently, to replace and enhance this act, The Frank R. Lautenberg Chemical Safety for the 21st Century Act was presented to better protect human health from all these toxic chemicals in our products. This new act requires a stronger safety standard by mandating reviews and revisions of already existing chemicals in a timely manner (EPA, 2017). The main goal of this act is to increase public transparency. It was enacted by former President Obama in June of 2016. However, with the new political administration in the United States, it is uncertain whether the EPA will continue to mandate this act moving forward.

The United States does not regulate toxins according to the precautionary principal, meaning that "we should err on the side of caution whenever a situation seems potentially dangerous" (Steingraber, 2012, 284). The United States allows toxic chemicals to be distributed and used until proven to be harmful to humans. Many environmental activists advocate for precautionary measures "even if some cause-and-effect relationships are not

yet fully established scientifically" (Steingraber, 2012, 285). Science is a slow process; therefore, we should take precautions before it is too late for reversal.

Currently, the EPA claims that glyphosate is one of the 'least toxic' herbicides that can be exposed to humans and animals (*Glyphosate resistance in crops and weeds, 2010)*. However, there has been a long history of glyphosate evaluations conducted by the EPA and their committees through the Proposed Guidelines for Carcinogen Risk Assessment. The first peer review was completed in 1985 and concluded that glyphosate classified as a Group C chemical, meaning that it was a "possible" human carcinogen (EPA's Office of Pesticide Programs, 2016). In 1986, the EPA had the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Scientific Advisory Panel do an evaluation. They determined through a study on mice that glyphosate should be classified as a Group D chemical, meaning that it is "not classifiable as to human carcinogenicity" (EPA's Office of Pesticide Programs, 2016). After that, a second peer review was done in 1991 by the EPA's Carcinogenicity Peer Review Committee. They concluded that glyphosate should actually be classified as a Group E chemical, meaning that there is "evidence of non-carcinogenicity for humans" (EPA's Office of Pesticide Programs, 2016). This new classification was based off a study that resulted in a lack of evidence on carcinogenicity in both mice and rats (United States Environmental Protection Agency, 2015). The newest report released in 2018 continues to provide evidence that glyphosate is not likely to be carcinogenic to humans.

Policies in Europe

A report in 2015 published by the Joint Food and Agricultural Organization (FAO)/WHO Meeting on Pesticide Residues, another subdivision of the World Health Organization, concluded the glyphosate was unlikely to pose a carcinogenic risk to humans (EPA's Office of Pesticide Programs, 2016). These international agencies have come to different conclusions resulting in the need for more studies and revisions.

The evaluations completed by the European Food Safety Authority differ from the evaluation that the IARC concluded. One of the main differences between the two evaluations is that the European Food Safety Authority looked at glyphosate as an

individual chemical, where the International Agency for Research on Cancer looked at "both glyphosate – an active substance – and glyphosate-based formulations, grouping all formulations regardless of their composition" (European Food Safety Authority, 2015). This suggests that the IARC report does not solely access glyphosate as an individual chemical.

Although the United States have their own rules and regulations on glyphosate, this is not the case for the whole world. Europe is one of the major forces that differs from the United States. Europe has had a lot of controversy over the past couple of decades about producing GMOs. This is based upon 3 main reasons stated by Mart. Firstly, "the food culture in these countries was more likely to treat foods as part of the essence of identity and national character and less as a science experiment or a means to improve production efficiencies" (Mart, 2015, 195). Secondly, they did not want another episode or outbreak of another food contamination after mad cow disease broke out. Third, they did not want to pose any environmental risk, regardless if it was 'safe' or not (Mart, 2015). With that being said, in 1997, the EU passed legislation that all foods produced with GMO crops needed to be labeled on the package creating more transparency (Mart, 2015) and in 2002 glyphosate was first approved in Europe. However, glyphosate is still widely used in conjunction with genetically modified crops. To evaluate herbicides and pesticides in Europe the European Food Safety Authority (EFSA) have a list of guidelines they follow to ensure its safety prior to its commercial use. Even though glyphosate has been present in Europe for quite some time, in 2015, the European Chemicals Agency (ECHA) re-evaluated all reports and studies on glyphosate and concluded that,

> ECHA's Committee for Risk Assessment (RAC) agrees to maintain the current harmonised classification of glyphosate as a substance causing serious eye damage and being toxic to aquatic life with long-lasting effects. RAC concluded that the available scientific evidence did not meet the criteria to classify glyphosate as a carcinogen, as a mutagen or as toxic for reproduction (European Chemicals Agency, 2017).

Glyphosate in Europe continues to be licensed, however, it will need to be re-evaluated in the next five years as there was insufficient support in favor or against the renewal proposal (European Commission, 2018).

Public Opinion

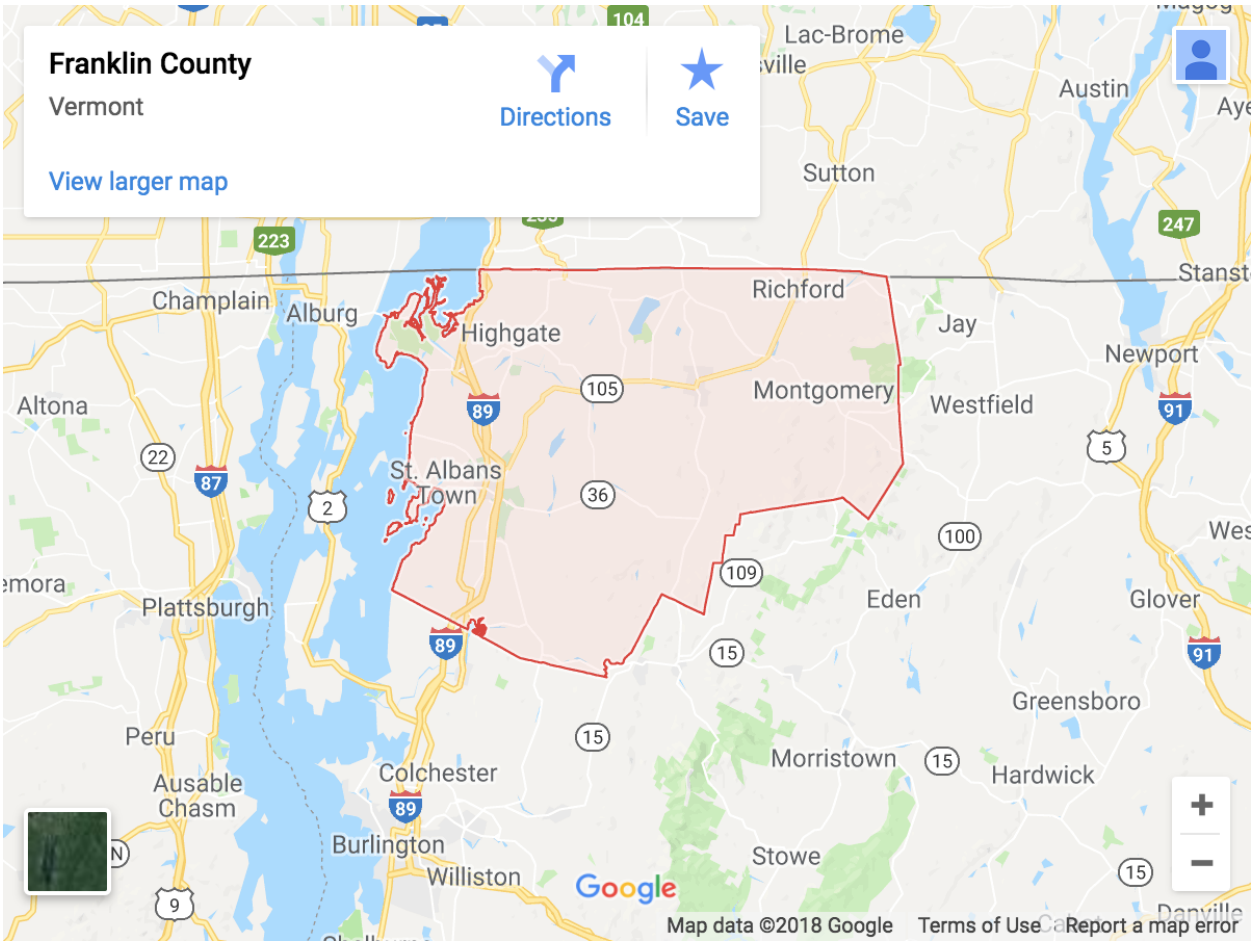
Monsanto and its product *Roundup* is a lot more controversial than glyphosate itself. Originally the general public viewed GMOs to be revolutionary in the agricultural sector as this new technology promoted higher yields (Mart, 2015). Glyphosate and *Roundup* was originally advertised as it "leaves no residue in the soil" and as "100% biodegradable" (Robin, 2010, 70). The perception of purity of lawns was pushed on the general public. Due to these advertisements, many believe that *Roundup* is one of the least toxic inputs in our environment. But, over time it has become a controversy due to the inconclusive consensus on glyphosate by various agencies not only in the United States, but also abroad (i.e. Europe). These controversies have fueled the public concern and their receptivity to glyphosate in the United States partly due to ethical concerns that biotechnology should not be implemented in the agricultural system (Mart, 2015).

Methodology

The goal of this research is to interpret Vermont resident's understanding and knowledge surrounding the use of glyphosate on land and the possible environmental and human health impacts it may have by evaluating the risk perception of the general public. This information will provide supplemental perspectives when determining if any policies surrounding glyphosate usage should be implemented in the State of Vermont based on the concern, or lack of, from Vermont citizens.

A key component of this study is to ask the question: How do people think about, perceive, and respond to risk? "Studies of risk perception examine the judgements people make when they are asked to characterize and evaluate hazardous activities and technologies" (Slovic, 1987, 280). According to Ricci, Sagan, and Whipple in their book *Technological Risk Assessment*, the definition of 'risk' has two components: "The probability and magnitude of consequences" (1984, 2). Risk can either be viewed from a whole population or from an affected individual. They then define 'assessment' as "the systemic evaluation of the technology under examination" (Ricci, Sagan, Whipple, 1984, 2). In this case, glyphosate is a chemical compound that is used in the new age of technology, specially revolving around *Roundup-Ready* seeds, and poses some health risks that are portrayed to the general public in a variety of voices. "Important contribution to our current understanding of risk perception have come from geography, sociology, political science, anthropology, and psychology" (Slovic, 1987, 281). Risk perception is an interdisciplinary theory and can be analyzed across all fields of study. "Many decisions are based on beliefs concerning the likelihood of uncertain events…" and if one does not understand public perception, that could negatively influence future policy making (Tversky & Kahneman, 1974, 1124).

To conduct this research 90 surveys were distributed to stand-alone households in Franklin County, Vermont (see map below). Although surveys typically do not involve much interaction with specific individuals, I was able to create some dialogue with each respondent as I distributed each survey myself and was present the whole duration the survey was filled out. This method was used in order to receive data from a large enough sample size of those who may be exposed to glyphosate.



Franklin County was chosen because there are 736 farms averaging at 253 acres as of 2012 (Census of Agriculture, 2012). 43% of the land in farms is used for cropland, majorly growing hay, corn, and soybeans (Census of Agriculture, 2012). Franklin County has always primarily been agricultural land. As early as the 1700's, European settlement occurred and promoted farming, which resulted in rapid deforestations. Between 1850 and 1990, corn and hay were primary crops grown, but over time, corn has exceeded production over hay due to agricultural advancements and being a primary additive in feed for animals (Hyde, Kamman, & Smeltzer, 1994). Both corn for silage and corn for grain are widely grown in this county. Monsanto produces *Roundup Ready Seeds* in eight row crops, including both corn and soybeans, which are both widely grown in Franklin County (Monsanto, 2018).

Background research primarily sourced from scholarly articles and state and federal public records, gives a very one-sided understanding of glyphosate usage as it pertains to health. The publics opinion is never taken into account. Media representation of the chemical and public perception on the chemical gives a better idea on why people are motivated to use this herbicide. By distributing 90 surveys I was able to evaluate risk perception from Franklin County citizens. The survey was distributed to individual stand-alone households in Franklin County to reach a wide range of responses (the survey can be found in Appendix A). Before travelling to Franklin County, I filled out an IRB to ensure ethical research methods. To make the sample random, I travelled to different towns within Franklin County including St. Albans, Georgia, Fairfield, Swanton, Sheldon, Enosburg, Highgate, Franklin, and Montgomery, to receive information from the entirety of the county as some areas are more developed while others are more farmland. After all the surveys were filled out, I compiled all the data and found some reoccurring themes. All the data was inputted into an Excel sheet and analyzed based on themes including chemical usage on household properties, *Roundup* usage in Franklin County, *Roundup* in relation to Monsanto and GMOs, risk perception on toxicity, and education regarding glyphosate usage. Below we examine the role glyphosate has in Vermont, what Vermonters think about glyphosate usage and whether there is a concern of exposure regardless of being a direct applicator or not. with either being a direct applicator and user.

Results

Vermont and Glyphosate Chemical Usage on Household Properties

According to the State of Vermont in its *Pesticide Usage Report* in 2016, glyphosate is widely used in agricultural production, as well as many other fields including lawn-care maintenance, industrial development sites, golf courses etc. Statewide in 2016, 62,458.12 pounds of glyphosate was used for corn production (three times as much since 2013, where the total was 20,849.76 pounds), 31.94 pounds for golf course maintenance, 1,510.94 pounds for forestry use, 12,127.97 pounds for lawn-care, and 40.88 pounds for highway building (The State of Vermont, 2016).

Glyphosate is used in the form of *Roundup* in many different fields/occupations. Farmers use glyphosate to manage weeds to promote higher yield and overall production. In the past decade, glyphosate usage has increased 10-fold with an increase in growing corn for feed and is highly used in the dairy industry. Glyphosate is also widely used on golf courses, forest management, lawn-care, highway and railroad development, pest control, and around electrical utilities (The State of Vermont, 2016). These are just a few of the main sources that glyphosate is used for. The annual amounts of glyphosate used in Vermont by category can be found in the *Annual Repot of the Commercial Applicator Pesticide Usage Host Group Summary* released by the Vermont Agency of Agriculture (see Appendix B for the entire list of total glyphosate usage in the State of Vermont).

Of the 90 households I surveyed in Franklin County, Vermont, a third of the households (31%) were presently using at least one pesticide, herbicide, insecticide, fungicide, or fertilizer on their property.

There is a plethora of different products, for different uses in lawn care, owned by different companies with different main active ingredients. Nine respondents (10%) claimed to use *Roundup* on their property. However, almost half (45%) have used Roundup either currently or at least once in their lifetime. This in particular points to the recall or reporting bias that is a systematic problem within survey-based research. Since I

personally administered the surveys, I was able to converse further with the participants while they were filling out the questionnaire. I noticed that there were a handful of respondents who checked the box as 'no', they do not use herbicides on their property, but when they got down to the next question regarding *Roundup* usage currently, they checked the box as 'yes'. This is somewhat concerning because this claims that there is a disassociation of *Roundup* as a chemical herbicide. Why did they not initially claim that they use *Roundup* in the first question? I also surveyed people who said they currently do not use *Roundup* on their new property but have extensively on previous properties. However, this does not take away from the number of respondents who have decided to discontinue spraying and spot-treating their land. Forty-one respondents claimed that they used *Roundup* in the past, down to nine respondents who currently use Roundup is a significant decline. This could be because of new information being relayed to the public or the evolution of testing for glyphosate and the possible human and environmental adverse health claims it may have.

Five respondents said that they used an insecticide or herbicide produced by *Bayer* on their property. In September of 2016, Monsanto acquired Bayer by purchasing their shares (Bayer AG Communications, 2016). "The combined business will benefit from Monsanto's leadership in Seeds & Traits and Climate Corporation platform along with Bayer's broad Crop Protection production line across a comprehensive range of indications and crops in all key geographies" (Bayer AG Communications, 2016). Such mergers consolidate the power of the companies that produce a wide range of pest and weed control products such as insecticides and herbicides.

Six respondents wrote that they use a pesticide, herbicide, insecticide, or fertilizer product on their lawn, but could not remember the name of the product. This could be due to the fact that they were surveyed during the winter and have not used the product for a couple of months because of freezing temperatures and snow, therefore it was not on the forefront of their mind. Or, there might be a disconnect between purchasing the product and using it on their property. There could be a disinterest in understanding the product itself, or who owns it, especially if it does the job and is effective on the property.

There are a variety of pesticides, herbicides, insecticides, fungicides, and fertilizers used on properties and they all are catered to different problems associated with lawn care. The majority of respondents said that they used these products to control pests, which included ants, wasps, beetles, spiders, mosquitos, worms, etc., while some used them to preserve their gardens to eliminate certain plants, weeds, and grasses. A small handful of respondents used these products for alternative reasons. However, two respondents claimed that they used these products because they are effective, cheap, and have a low environmental impact because they do not persist in the ground/soil. The frequency of spraying or spot-treatment varied significantly. While some respondents said they use these products only once a year, some respondents used them as frequently as once a week. This could be due to the intended use of each product by the homeowner and how effective they find it to be.

Public Perception of Roundup/Glyphosate Usage in Franklin County

According to the Vermont Agency of Agriculture, glyphosate is used all over the State, not just for agricultural or homeowner lawn care. Some less obvious uses are on golf courses, forest management, developmental areas (including highway clearings, railroad clearings, electrical utility areas, and pipelines), and greenhouses/nurseries (see Appendix B). It is clear why the majority of the participants interviewed knew that glyphosate was used in households and lawns because *Roundup* is a common product sold in many garden and hardware stores and is advertised to the public for personal use (see Figure 1). However, we are typically disconnected from land usage that is not our own. In terms of agricultural use, one can buy organic food products, one does not necessarily know what practices are used on an agricultural farm. It is also atypical to think about how to maintain forestry practices or how to clear an area in a community for developmental purposes.

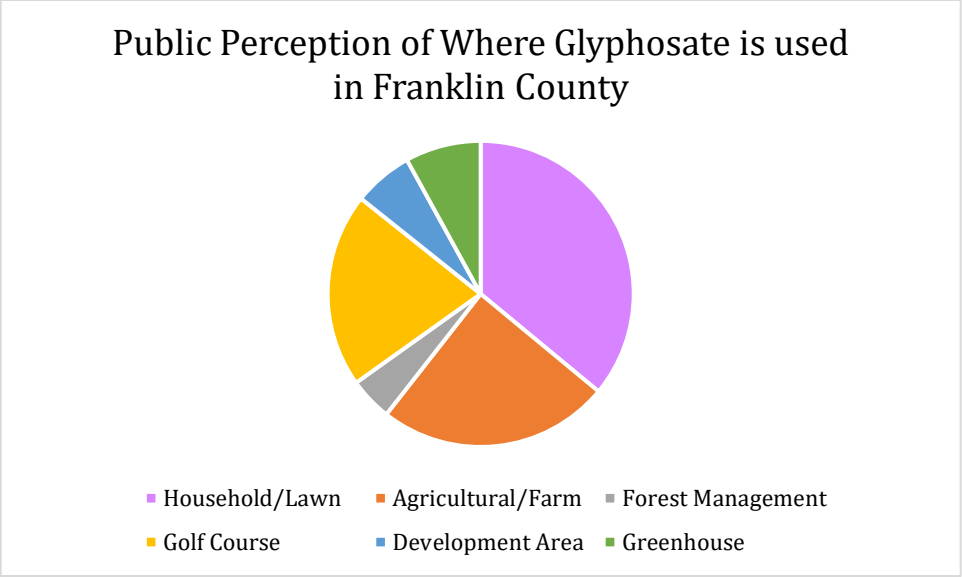


Figure 1: Public perception of where glyphosate is used in Franklin County

A large sum of the general public of Franklin County knew that glyphosate was used for lawn-care (36%), agricultural purposes (25%), and golf course management (21%). However, 15% of the respondents or less knew that glyphosate was used for developmental areas, greenhouses, and forest management. Even though some respondents chose to leave this section blank because they did not feel adequate enough to answer the prompt correctly, there may need to be more education surrounding these uses.

Public perception of Roundup and its association with GMOs

Roundup is commonly associated with Monsanto because they are the manufacturers and producers of this herbicide and have been in the media the past couple of years for toxicity measures, controversial environmental practices, and filing lawsuits with farmers. One of the reasons why I chose to focus on this herbicide is because it is commonly known by the general public, regardless of its use by all individuals.

Count of GMO Association	Column Labels		
Row Labels	**No GMO Association**	**GMO Association**	**Grand Total**
Agriculture / Farm Usage	18 (42%)	25 (58%)	43
No Agriculture / Farm Usage	41 (87%)	6 (13%)	47
Grand Total	**59**	**31**	**90**

Table 1: Glyphosate/Roundup in association with GMOs

Thirty-one people checked that 'yes', they associate glyphosate with GMOs (about 33% of the respondents), and out of those 31 people, 25 checked that 'yes' glyphosate is used in agriculture/farmland (see Table 1). Fiftly-nine people checked that 'no' they do not associate glyphosate with GMOs, and of those, 18 checked that 'yes' glyphosate is used in agriculture/farmland. Some of the respondents may already know (or assume) that *Roundup* is used in agriculture, but they might not know that Monsanto has patented this herbicide because of their genetically modified *Roundup Ready Seeds*. *Roundup* is commonly associated with Monsanto and GMOs because it is typically required when planting *Roundup Ready Seeds*, mainly corn.

Risk Perception of the Toxicity of Chemicals Used

Although glyphosate is widely used in Franklin County, the majority of people (43%) only think they have a slight exposure to the chemical, regardless if they use it personally. This is then followed by 27% people who said they had no exposure whatsoever, followed by 24% people who expressed a moderate exposure. Only one respondent said they were highly exposed to the chemical. Although over 66% of respondents believe they are exposed to glyphosate at some level, there are mixed responses on concerns and where to go next.

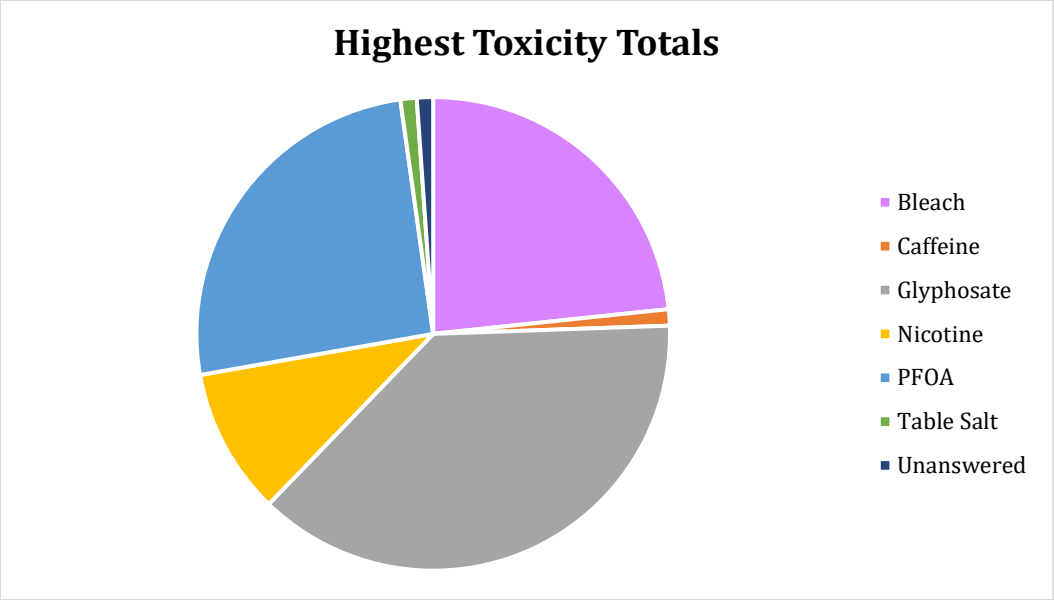


Figure 2: Highest Toxicity Exposure

One of the questions asked in the survey was on risk perception and asked respondents to choose the compound that respondents believe to have the highest toxicity (see Figure 2). The correct answer was nicotine, but this question was created to see if people chose glyphosate regardless of educational background or previous knowledge of the subject. Thirty-four respondents chose glyphosate, while other high responses included perfluorooctanoic acid (PFOA) (another controversial synthetic chemical compound) and bleach. The majority of people assumed that glyphosate had the highest toxicity. This could be because the survey was focused on glyphosate knowledge, usage, and perspectives. However, 17 people who chose glyphosate as the highest toxicity were not confident on their knowledge of pesticides, followed by 14 people who were somewhat confident. Only two people were confident in their knowledge and one was very confident. This data suggests that respondents who do not have a profound knowledge of pesticides or herbicides may assume that it has a high toxicity compared to other everyday compounds.

Public Knowledge and Awareness of Glyphosate/Roundup Usage

The majority of individuals surveyed received their information on pesticides from the Internet (27 respondents), and about 9 respondents got their information from various news outlets, including the television and newspapers. The media plays a big role in how one views chemical inputs on land. The media representation of glyphosate is very controversial and depending on where one receives their information can greatly influence perception, which can influence risk perception. New information about glyphosate and *Roundup* is constantly being updated and released to the public through different medias. For example, the *Burlington Free Press*, a local newspaper, published an article in 2016 titled *VT lake advocate questions use of Roundup*. This article appeals for more research surrounding glyphosate usage in agriculture due to its potential role in algal blooms in Lake Champlain. Lake Champlain's ecosystem health is vital for Vermont's economy and "reining in Roundup could prove to be cost-effective in the long run" (Baird, 2016). Another local newspaper, *VTDigger*, published an article in 2018 claiming that GMOs, specifically corn production in Vermont, has increased pesticide use throughout the State:

> It is tragically ironic that at a time when pesticide use is rising, the Vermont Agency of Agriculture is turning its regulatory resources away from pesticide protection and toward water protection—as if they aren't intricately connected. But it's yet another clear signal that our political and regulatory leaders are standing in the way of the public's increasing call to address the failed dairy model that connects not just pesticide and water issues, but also labor, economic, animal welfare, and climate issues (Colby, 2018).

Glyphosate is being associated with water health issues in the State of Vermont but should be viewed simultaneously with other environmental and social sectors. Vermont's general public has access to controversial news articles such as these, but State and National regulatory reports portray a lack of concern of glyphosate usage.

News from online sources and other media outlets show a wide range of perspectives and it can be difficult to filter through the different information. However, 16 respondents get their information from the actual bottles/containers of the pesticides, herbicides, insecticides, and fertilizers that they purchase. This is also problematic because one will only receive the information that Monsanto wants to portray. Some others received their

knowledge/information of pesticides from word of mouth or hardware stores. Twenty percent of the respondents mentioned that they did not get their information from anywhere at all because they have never researched or thought about it before. This research furthered the knowledge of these participants and further aroused their interest in investigating local pesticide use in the region.

Policy Regulation

Chemicals such as glyphosate once classified under The Federal Insecticide, Fungicide and Rodenticide Act, it needs to be documented and registered for use. Regulation includes the certificates, licenses, and permits for the sale and purchase of glyphosate, which can be found through the Vermont Department of Agriculture (Vermont Agency of Agriculture, 2017). Vermont has specific laws on the standards of applying pesticides in Vermont and all pesticides sold in Vermont need to be registered through the State (Vermont Agency of Agriculture, 2017). They are set in place to protect the environment and public health. If one is registered to apply pesticides one must keep a detailed record on the applications to refer back to if ever questioned about usages (Vermont Agency of Agriculture, 2017).

Forty-nine percent of respondents expressed concern for glyphosate usage in their community and all these respondents want to see more regulation. However, 48% people are not concerned about glyphosate usage, 58% from this not concerned group still want to see more regulation. This ideology does not seem to make sense because concerns usually lead to a certain action, which could include regulations or policy implementations.

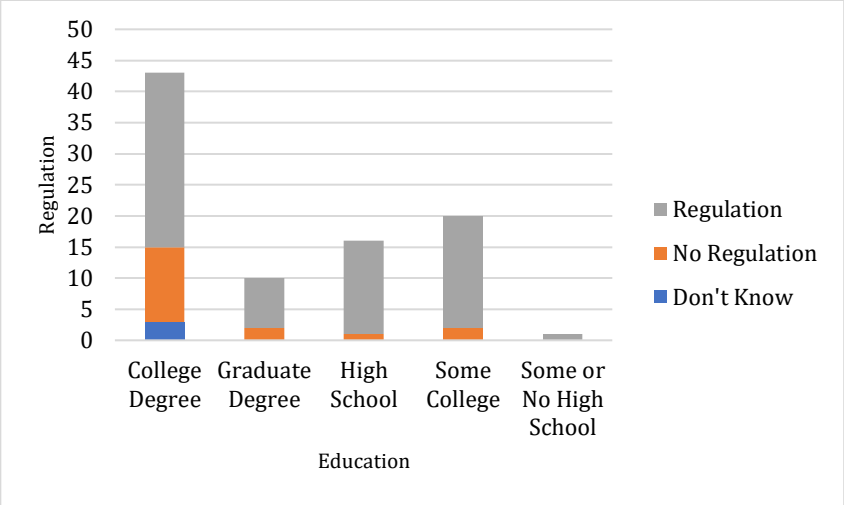


Figure 3: Educational Background in Relation to wanting Regulation

However, there were little to no correlations between educational milestones and wanting more regulation (see Figure 3). Forty-three people claimed that they have a college degree, and of those 43 people, 28 want to see more regulations surrounding glyphosate, whereas 12 do not, and 3 do not have an opinion. In every sphere (besides the one respondent with some or no high school experience) the majority of people want to see regulation in some capacity regardless of educational background. This is a topic that has therefore reached all educational levels.

Discussion

Lawn Care

The social and cultural pressures of lawn care maintenance is a significant factor when analyzing the various use of chemical inputs on land. Spending time on lawn upkeep is a sign of having a higher socio-economic status because one either has the time or the money/resources to manipulate the land to make it look pristine. Manicured lawns can also be a matter of pride and prestige due to the impression it may leave on the surrounding community and one's neighbors (Clark, 1999). "In particular, the highly visible front yard may be constrained not simply by the aesthetic, recreational, or functional utility of the space but also by a desire to fulfill neighborhood norms and to communicate a group membership or social status" (Carrico, Fraser, & Bazuin, 2013, 430-431).

Lawn maintenance in America has been around since European colonialism. According to Paul Robbins in his book *Lawn People*:

> The American lawn, although it forms a coherent aesthetic, has never been the expression of a regional American cultural sensibility. Instead, it has at various times played a number of symbolic roles in the ecological metabolism of a shifting political economy. In its European roots, it was an embodiment of emerging labor and land arrangements tied to expropriation of agrarian property. In its early American development, it was an expression of political ecological transitions of colonial development and imperial ecology. In the nineteenth century, it was a vehicle through which certain kinds of urban subjects might be formed… In its explosive growth in the twentieth century, it formed the quasi-common property for an emerging suburban citizenry (Robbins, 2012, 32). After World War II, suburban land became vast and cheap, making land and property easily assessable. Lawns represent private land that is "not fully enclosed" and "the lawn will reflect on the moral sensibilities of its owner," which represented the rising of the middle-class (Robbins, 2012, 28-29).

The pressures of having a manicured lawn throughout history can result in the high use of chemical inputs, especially in the twentieth century following World War II. Roughly 33% of respondents said that they use a chemical input on their land, mainly to maintain aesthetic, which could be an underlying result of unconscious psychological behavior.

"Lawn care is an extremely visible behavior that is often the target of both scrutiny and praise by one's neighbors" (Carrico, Fraser, & Bazuin, 2013, 431). The aesthetic and maintenance of the lawn may not only be for one's individual liking, but rather to give off an appearance and reputation to the surrounding community. These cultural and social norms are common at certain points in American history and can influence one's decision to use chemical inputs in one's lawn due to psychological behavior.

Therefore, risk perception may be overlooked when it comes to lawn care because the exposure may be looked at as minimal with no immediate repercussions, making chemical usage not as significant as maintaining reputation. The majority of respondents do not use chemicals often (roughly once or twice a year), and usually use them as spot-treatment remedies or for specific problems pertaining to the aesthetic of their lawn, including pest control or weed control. An applicator may not have a concern for the long-term repercussions these chemicals could pose on human health and instead would like their manicured lawn to represent current reputation and community status.

Media Portrayal

The media plays a large role in the assessing of risk perception:

> Whereas technology sophisticated analysts employ risk assessment to evaluate hazards, the majority of citizens rely on intuitive risk judgements, typically called "risk perceptions. For these people, experience with hazards tends to come from the news media, which rather thoroughly document mishaps and threats occurring throughout the world (Slovic, 1987, 280).

Roundup has been around since 1970 and in the earlier days of its existence, Monsanto advertised *Roundup* to be 'biodegradable', 'cheap', and 'effective'. It was considered to be different than alternative herbicides because it did not persist in the soil, therefore, did not pose any ecological risks.

In one British television advertisement in 1990, it portrayed a dog running out into the yard after *Roundup* was sprayed, implying that it is pet-safe. In this study, 49% of

respondents expressed concern with glyphosate usage and of whom, 10% were concerned for their pets' health.

One older man who I spoke with explained that he used to heavily apply *Roundup* in his yard because he remembers the advertisements to justify that glyphosate was safe to use in large quantities because it did not accrue in the soil and was biodegradable so there were no lasting effects. He gets his information on glyphosate from the label of *Roundup* itself. He still uses it when needed and explains that he still believes that it does not persist in the ground because that is the information he has always been exposed to. Eighteen percent of respondents get their information on glyphosate from the bottle of *Roundup* itself. The information that these individuals are receiving is very skewed because they are only gathering information from the company producing the product: Monsanto. Monsanto's main motive is economic gain, so they have self interest in protecting the image of the product as safe.

Glyphosate has repeatedly been under review by multiple federal and international agencies. Over time, these documents and results have been shared with the public and there seems to be some difficulties coming to a consensus that this herbicide is safe and not carcinogenic. This information is being relayed to various media and the public is receiving a very mixed response. Many environmental and safety organizations are claiming that glyphosate can be a lot more harmful than the studies conducted by government agencies are finding. Forty percent of respondents said that they got their information on glyphosate from various media and news outlets including the Internet. If the language of these articles and advertisements are portraying harmful tendencies, then we might see how risk perception can be exacerbated because media can inflict fear.

It seems that there are two extremes that the general public is exposed to and no common ground in the middle. One is claiming no harm, while the other is claiming probable harm. However, there needs to be more thorough results and analysis from government and outside agencies to conduct these studies for safety risk assessments.

Education

Public education may be the next step when deciding to use *Roundup* on one's property or in the surrounding community on a larger scale. The public seems to be either completely unware of the conversation surrounding *Roundup* and the adverse health risks while others have a skewed perception based on the knowledge that they previously known or heard mainly due to media advertisements. "A consequence of the public's concerns and its opposition to risky technologies has been an increase in attempts to inform and educate people about risk" (Slovic, 1987, 285).

The first step to address public education is to address the scientific data and media portrayal to the general public surrounding probable cause. In the United States, herbicides can be used on land until proven to be harmful to society. We do not implement the precautionary principle when deciding whether or not to spray chemicals in the ground. Therefore, the information to use until proven harmful is going to be controversial because it is so widely used, with debated risks to the human health and the environment.

If the public can be provided with unbiased information about glyphosate usage, there can be a better representation of it in the media. However, glyphosate usage is political, and it is hard to obtain the correct information when the public is not given adequate information.

Conclusion

Should public perception or scientific fact drive future policy-implementation? "Many decisions are based on beliefs concerning the likelihood of uncertain events…" and if one does not understand public perception, that could negatively influence future policy making (Tversky & Kahneman, 1974, 1124). The public should be provided more easily accessible information on the scientific data surrounding glyphosate and *Roundup* and the policy debates regarding these chemicals for the public to make an informed decision as well as for aiding policy-implementation in the future. A lot of people tend to get their information from various outlets, resulting in a mixed and extreme viewpoint, which can alter perspectives. Glyphosate is one main active ingredient in one herbicide, yet there are hundreds of different herbicides being manufactured and produced that could be just as harmful to the environment and human health.

Glyphosate is a multi-disciplinary topic that can be viewed from politics, science, health, economics, etc. Glyphosate is so widely used that there needs to be an overarching scientific consensus on the adverse health risks it may pose. This can then be portrayed to the public in a clear way. However, we may need to look at the broader scope: industrial agriculture. Technological advancements in agriculture are continuing to grow and this one case study opens up the door to explore the many different facets of chemical inputs on land and what the health implications may be for the future.

Science and public perception should be viewed simultaneously when implementing new policies. Understanding how science is perceived, utilized, and interpreted in society is vital when addressing controversies like glyphosate. "Risk communication and risk management go hand in hand and any management efforts are destined to fail unless they are structured as a two-way process. Further, expert–public interaction could democratize science and public acceptance of science and policy-making. Each side must respect the insights and intelligence of the other" (Slovic, 1987, 285). Public and community observation in terms of place-based exposure is an important factor when deciding on regulations for the future, especially when the precautionary principle is not implemented in the regulation of herbicides and other chemical toxics in the first place. Conducting

science is slow process and the public should not be asked to wait any longer to re-evaluate certain chemicals when exposure could potentially be dangerous.

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Appendix A

Glyphosate and Environmental Health Survey

This survey is part of a thesis project conducted by an undergraduate student at the University of Vermont. The goal of this survey is to gain a better understanding of the public's knowledge on pesticides, more specially glyphosate, and one's concerns on pesticide exposure related to health. Your participation is completely voluntary and no identifying information will be collected, nor medical information. Please ask any questions about this survey to the individual administering it.

Please take a moment to fill out this survey:

Location: Franklin County

With which gender do you identify? Please Check ONE:

☐ Female ☐ Male ☐ Other: _____

What is your age?

☐ 18-44 Years ☐ 45-65 Years ☐ 65+ Years

What age groups of people live in your household, not including yourself? Please check ALL that apply:

☐ Under 2 Years ☐ Men 18-44 Years ☐ Over 45 Years

☐ 2-18 Years ☐ Female 18-44 Years

What is your primary occupation?

_____

What is your highest level of education completed?

☐ Some of No High School ☐ Some College ☐ Graduate Degree

☐ High School ☐ College Degree

Where do you get your information on pesticides?

_____

Do you use any pesticides, herbicides, or fungicides on your property?

☐ Yes ☐ No

If you chose yes, please indicate which ones:

_____

How often do you use them?

_____

Why do you use them?

_____

Have you ever used glyphosate or *Roundup*?

☐ Yes ☐ No

If you chose yes, is it effective?

☐ Yes ☐ No

Does it have any other impacts in your community?

_____

Do you associate glyphosate with genetically modified organisms?

☐ Yes ☐ No

Where is glyphosate used in your community? Please check ALL that apply:

☐ Households/Lawn Care ☐ Agriculture/Farms ☐ Forest Management

☐ Golf Course Maintenance ☐ Development Areas ☐ Greenhouses

Do you believe you are exposed to glyphosate?

☐ No Exposure ☐ Moderate Exposure ☐ Extreme Exposure

☐ Slight Exposure ☐ High Exposure

How confident are you in your knowledge of pesticides?

☐ Not Confident ☐ Somewhat Confident ☐ Confident ☐ Very Confident

Are you concerned about glyphosate usage?

☐ Yes ☐ No

If you chose yes, please define your concerns:

_____

Is glyphosate regulated in Vermont?

☐ No Regulation ☐ Moderate Regulation

☐ Some Regulation ☐ High Regulation

Which compound do you think ranks as the highest toxicity? Please choose ONE:

☐ Bleach ☐ Caffeine ☐ Nicotine

☐ Table Salt ☐ Glyphosate ☐ PFOA

Would you like to see more regulation or policy-implementation regarding glyphosate usage?

☐ Yes ☐ No

Are you familiar with the new law in California requiring all *Roundup* containers to be labeled as carcinogenic?

☐ Yes ☐ No

Additional Comments:

Appendix B
(The State of Vermont, 2018)

Commercial Applicator Pesticide Usage Host Group Summary
Pounds of Active Ingredient Statewide
Reporting Year: 2016

B - Birds/bats	
3-Chloro-p-toluidine hydrochloride	1.67
TOTAL B - Birds/bats	1.67
C - Corn	
2,4-D	5,361.84
2,4-Dichlorophenoxyacetic Acid	114.00
2,4-DP	4.08
Acetochlor	718.85
Atrazine	44,985.52
Azoxystrobin	2.52
Bacillus thuringiensis var. kurstaki	2.70
Chlorothalonil	30.00
Chlorpyrifos	319.18
Clomazone	2.50
Clopyralid	122.62
Dicamba	4,762.56
Dichlobenil	4.00
Diflufenzopyr-sodium	61.56
Dimethenamid	1,141.02
Ethalfuralin	8.00
Flumetsulam	45.86
Glyphosate	62,458.12
Halosulfuron	13,009.69
Imidacloprid	4.60
Kaolin	166.25
Lambdacyhalothrin	54.97
Mesotrione	2,260.54
Metolachlor	41,949.02
Nicosulfuron	0.83
Pendimethalin	3,072.26
Primisulfuron methyl	21.75
Prosulfuron	13.11
Rimsulfuron	421.55
Sethoxydim	81.00
Simazine	12,613.51
Thifensulfuron methyl	88.64
Topramezone	0.61
Triclopyr	728.34
TOTAL C - Corn	194,631.58
D - Cooling towers	
2,2-Dibromo-3-nitropropionamide	31,937.50
2-Bromo-2-nitropropane-1,3-dol	1,847.79
2-Methyl-4-isothiazolin-3-one	1,381.34
5-Chloro-2-methyl-4-isothiazolin-3-one	3,788.08
ALKYL DIMETHYLBENZYL AMMONIUM CHLORIDE	38,865.54
Bromine	229.90
Busan 77	138.07
Chlorine	96.50
Dazomet	184,624.00

DBNPA	49.53
Glutaraldehyde	78.20
HYDROGEN PEROXIDE	29.16
Lambdacyhalothrin	0.33
Methylene bisthiocyanate	15,314.61
QUARTERNARY AMMONIUM COMPOUNDS	7,440.48
Sodium Bromide	172.50
Sodium hypochlorite	127,689.91
Trichloro-s-triazinetrione	1,858.46
TOTAL D - Cooling towers	415,541.90
E - Golf Course	
2,4-D	481.62
2,4-Dichlorophenoxyacetic Acid	5.50
Aluminum tris	387.20
Azoxystrobin	31.11
Bensulide	2.40
Bifenthrin	54.06
Boscald	777.35
Carfentrazone-ethyl	12.11
Chlorantraniliprole	8.63
Chloroneb	38.96
Chlorothalonil	6,218.53
Chlorpyrifos	2.52
Clopyralid	22.02
Cyfluthrin	0.71
Dicamba	89.83
Dichloro-8-quinolinecarboxylic acid	4.35
Diquat	0.09
Dithiopyr	6,901.83
Ethephon	219.36
Extract of Neem Oil	54.80
fipronil	2.41
Fludioxonil	43.73
Fluoxastrobin	0.48
Flurprimidol	81.07
Flutoanil	8.40
Glyphosate	31.94
Imidacloprid	2,361.44
Indoxacarb	10.88
Iprodione	1,508.25
Isoxaben	11.25
Lambdacyhalothrin	0.31
Mancozeb	1,108.72
MCPA	136.95
MCPP	151.71
Mecoprop	28.37
Mefenoxam	24.00
Mefluidide	9.18
Mesotrione	1.32
Metalaxyl	9.43
Metconazole	5.67
Mineral Oil	2,776.44
Myclobutanil	0.05
Paclobutrazol	43.66
PCNB	46.92

Pendimethalin	6.60
Prodiamine	19.31
Propamocarb hydrochloride	12.00
Propiconazole	333.36
Pymetrozine	0.18
Pyraclostrobin	25.88
Quinclorac	89.00
Sethoxydim	2.81
Siduron	6.30
Spinosad	5.50
Sulfentrazone	2.52
Thiamethoxam	6.75
Thiophanate	767.74
Triadimefon	250.73
Trichlorfon	21.00
Triclopyr	27.23
Trifloxystrobin	6.91
Trinexapac-ethyl	130.94
Vinclozolin	192.85
TOTAL E - Golf Course	25,623.13
F - Forestry	
2,4-D	0.47
Aminopyralid	1.18
Diquat	0.04
Glyphosate	1,510.94
Metsulfuron methyl	0.47
Pendimethalin	0.56
Sulfometuron methyl	2.58
Triclopyr	132.90
TOTAL F - Forestry	1,649.14
G - Lawncare	
2,4-D	3,958.41
2,4-Dichlorophenoxyacetic Acid	794.97
Bacillus popilliae	0.09
Bifenthrin	17.60
Boric acid	0.18
Carbaryl	8.00
Carfentrazone-ethyl	2.52
Chlorantraniliprole	76.52
Chloroneb	0.98
Chlorothalonil	3,672.66
Clothianidin	1.85
Dicamba	384.44
Diquat	23.34
Dithiopyr	233.57
Diuron	34.22
Fenoxaprop-ethyl	5.13
Glyphosate	12,127.97
Halosulfuron	14.88
Imazapic	0.13
Imazapyr	4.28
Imidacloprid	775.80
Mancozeb	1.41
MCPA	290.26

MCPP	1,763.11
Mecoprop	28.66
Mesotrione	2.37
Methanearsonic acid	0.00
Mineral Oil	318.47
MSMA	12.00
Myclobutanil	113.66
Pelargonic Acid	0.08
Permethrin	0.06
Prodiamine	17.03
Prometon	1.60
Propionic acid	56.46
Quinclorac	766.23
Siduron	5.99
Simazine	11.12
Sulfentrazone	1.16
Thiophanate	0.49
Triadimefon	2.10
Trichlorfon	59.87
Triclopyr	184.33
TOTAL G - Lawncare	25,774.01
H - Highway	
Aminopyralid	0.02
Glyphosate	40.88
Metsulfuron methyl	0.02
Sulfometuron methyl	0.09
Triclopyr	77.87
TOTAL H - Highway	118.88
M - Mosquitos	
Bacillus thuringiensis var. israelensis	20.09
Bifenthrin	0.50
Permethrin	0.89
TOTAL M - Mosquitos	21.49
O - Ornamental, shade trees	
2,4-D	0.75
Abamectin	1.03
Acephate	17.53
Bifenazate	2.03
Bifenthrin	849.23
Bromoxynil	4,001.12
Captan	0.02
Carbaryl	15.19
Carbendazim	0.01
Carfentrazone-ethyl	0.18
Chlorothalonil	8,487.11
Debacarb	0.03
Dichlobenil	8.00
Diquat	22.30
Dithiopyr	1.43
Glyphosate	873.31
Imidacloprid	11,478.73
Indoxacarb	2.09
Isoxaben	1.48
Malathion	0.00

Mancozeb	6.00
Mefenoxam	0.20
Metalaxyl	0.29
Methoxychlor	0.02
Myclobutanil	7.49
Paraquat	4.00
Permethrin	1,378.58
Phosmet	14.00
Phosphoric Acid	12,073.85
Piperonyl butoxide	1,573.20
Potassium salts of fatty acids	0.31
Prodiamine	0.05
Propiconazole	477.69
Pyrethrum	157.32
Pyriproxyfen	2.41
Spinosad	0.02
Spiromesifen	42.18
Sulfur	541.80
Superior oil	58,344.62
Tebuconazole	0.02
Thiabendazole	438.24
Thiophanate	3.38
Triadimefon	0.30
Triclopyr	1.04
Trifluralin	5.93
Zinc phosphide	0.70
TOTAL O - Ornamental, shade trees	100,835.22
P - Plant propagation, greenhouse, nurseries,Christmas trees	
Abamectin	0.00
Ancymidol	0.00
Bacillus thuringiensis var. kurstaki	0.00
Bifenthrin	0.01
Carboxin	9.10
Chlorfenapyr	0.20
Chlorothalonil	22.50
Diquat	0.02
Etridiazole	0.09
Glyphosate	11.69
Malathion	2.00
Myclobutanil	0.05
Oryzalin	14.80
Paraffinic Oil	6.74
Permethrin	0.03
Potassium salts of fatty acids	0.21
Pymetrozine	0.04
Pyridalyl	0.00
Pyriproxyfen	0.01
Spinosad	0.03
Thiamethoxam	0.10
Thiophanate	0.16
Triadimefon	0.01
Triclopyr	2.52
TOTAL P - Plant propagation, greenhouse, nurseries,Christmas trees	70.28

Q - Aquatic	
2,4-D	2.52
Bromacil	2.52
Diquat	25.36
Fluridone	53.76
Glyphosate	11.15
TFM	146.80
Triclopyr	3,853.68
TOTAL Q - Aquatic	4,095.79
R - Railroad	
Glyphosate	3,113.65
TOTAL R - Railroad	3,113.65
S - General pest control, structural, food processing	
2,4-D	0.00
2-Phenethyl Propionate	0.65
3-phenoxybenzyl-(1RS,3RS,1SR,3SR)-2,2-dimethyl-3-(2-methylprop-1enyl)cyclopropanecarboxylate	0.16
Abamectin	0.01
Benzene acetate	1.10
Bifenthrin	353.24
Borax	1,043.70
Boric acid	1.03
Brodifacoum	0.21
Bromadiolone	0.33
Bromethalin	0.00
Chlorfenapyr	95.50
Chlorophacinone	0.01
Cyfluthrin	152.80
Cypermethrin	26.01
Deltamethrin	162.08
Diatomaceous earth	53.10
Dicamba	0.00
Dichloro-8-quinolinecarboxylic acid	0.19
Difethialone	0.24
Dinotefuran	0.02
Diphacinone	0.00
Diquat	0.08
Esfenvalerate	0.59
fipronil	169.62
Fluvalinate	0.01
Glyphosate	203.00
Hydramethylnon	3.65
Hydroprene	1.15
Imazapic	0.03
Imidacloprid	175.39
Indoxacarb	0.29
Lambdacyhalothrin	69.12
MCPA	0.00
Methanearsonic acid	0.01
Methomyl	0.00
Methoprene	42.44
MGK-264	1.39
Naphthalene	4.20
Orthoboric Acid	10.33

Permethrin	3.17
Phenothrin	3.49
Piperonyl butoxide	61.31
Pyrethrins	0.36
Pyrethrum	17.29
Pyriproxyfen	0.85
QUARTERNARY AMMONIUM COMPOUNDS	0.16
RAK *1	0.00
Rotenone	0.04
Sulfur	16.82
Thiamethoxam	0.00
Zinc phosphide	0.02
TOTAL S - General pest control, structural, food processing	2,675.20
T - Tree Fruits	
Captan	30.79
Carbaryl	18.01
Chlorpyrifos	7.51
Dichlobenil	3.13
Esfenvalerate	0.10
Fenpropathrin	0.60
Glyphosate	0.94
Indoxacarb	0.68
KRESOXIM-METHYL	1.25
Lambdacyhalothrin	0.55
Malathion	0.01
Methoxychlor	0.29
Permethrin	302.72
Phosmet	12.57
Trifloxystrobin	5.89
Zinc - elemental	30.10
Zinc phosphide	0.50
TOTAL T - Tree Fruits	415.62
U - Electrical Utility, substations, pipelines	
2,4-D	6.80
Aminopyralid	10.36
Dichlobenil	6.85
Fosamine ammonium	89.24
Glyphosate	18,313.83
Methyl isothiocyanate	6,052.40
Metsulfuron methyl	21.52
Sulfometuron methyl	50.39
Triclopyr	1,004.88
TOTAL U - Electrical Utility, substations, pipelines	25,556.26
V - Small fruits & vegetables	
Azoxystrobin	5.51
Clomazone	33.44
Ethalfuralin	107.01
Imidacloprid	0.41
Lambdacyhalothrin	26.00
Metam-sodium	2,130.00
TOTAL V - Small fruits & vegetables	2,302.37
W - Wood treatment	
Bifenthrin	2.02

Borax	5.76
Copper quinolinolate	16.83
Sodium Tetraborate Decahydrate	2,450.39
Tebuconazole	10.77
TOTAL W - Wood treatment	2,485.76
X - Field & forage	
fipronil	0.00
TOTAL X - Field & forage	0.00
TOTAL Statewide	804,911.96
GRAND TOTAL	804,911.96