MAPPING GENETICALLY ENGINEERED SEED LITIGATION IN THE UNITED STATES

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To farmers in the U.S. and around the world, this thesis is dedicated to you.

Abstract

The phenomenon of U.S. farmers being sued by Monsanto for patent violations involving genetically engineered (GE) seed contamination had, until now, not been presented spatially. This research sought to map the locations of farmers who have been sued either for saving and replanting genetically engineered seed, planting genetically engineered seed without having bought or signed technology agreements for it, or unknowingly or unwillingly had genetically engineered seeds grow on their land.

Since 1996 when genetically engineered seeds entered the market, Monsanto, the company responsible for the technology behind GE seeds, as well as other biotech corporations, have required that any customers purchasing their gene-altered seeds sign 'technology use agreements'. These agreements give the companies power over farmers and subject them to serious potential litigations.

From the late nineties, when GE seeds entered the market, until 2005, for which the most recent data is available, over 120 farmers have been sued in the United States due to patent infringement violations involving GE seeds.

This research utilized ArcGIS to map the distribution of genetically engineered seed litigation in the United States, as well as to show the distributions of the three main GE crops: corn, cotton and soy. The locations of these crops are illustrated with the most recent United States Department of Agriculture crop layers as well as by graduated colors and symbols in relation to their contribution to the national total in addition to the state percentage of those crops that are GE.

1. Introduction

This research investigates the distribution of seed litigation brought against U.S. farmers by the Monsanto Corporation. Monsanto was the first company to genetically modify, or engineer, a plant cell (Hill 2000). The U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) defines genetic engineering as 'the genetic modification of organisms by recombinant DNA techniques (7CFR340: 340.1).

Genetic engineering (GE) of plants is one of the methods of biotechnology, the merging of biology and technology, a field that began in the 1970s. The emergent field of GE has had steady growth since its inception. Since, 1987, nearly 11,600 applications have been turned into APHIS for field-testing of GE varieties, with over 92% of those requests receiving approval (Fernandez et al 2006). In 1996, GE seed crops became available for public sale. Figure 1 shows the countries where genetically engineered or genetically modified organism (GMO) crops were being grown and which crops were being grown internationally as of 2001. It also shows the percentages of the four main GE crops being grown worldwide. These numbers have since increased. Figure 2 shows the trends in planted acreage of GE crops in the United States and Table 1 provides the raw data for Figure 2.

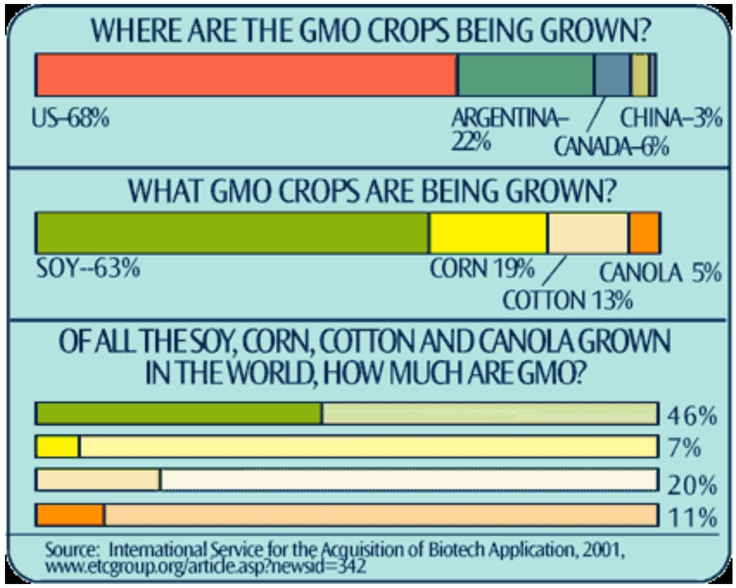


Figure 1 Where are GMO Crops Being Grown? Chart from the International Service for the Acquisition of Biotech Applications (ISABA), 2001

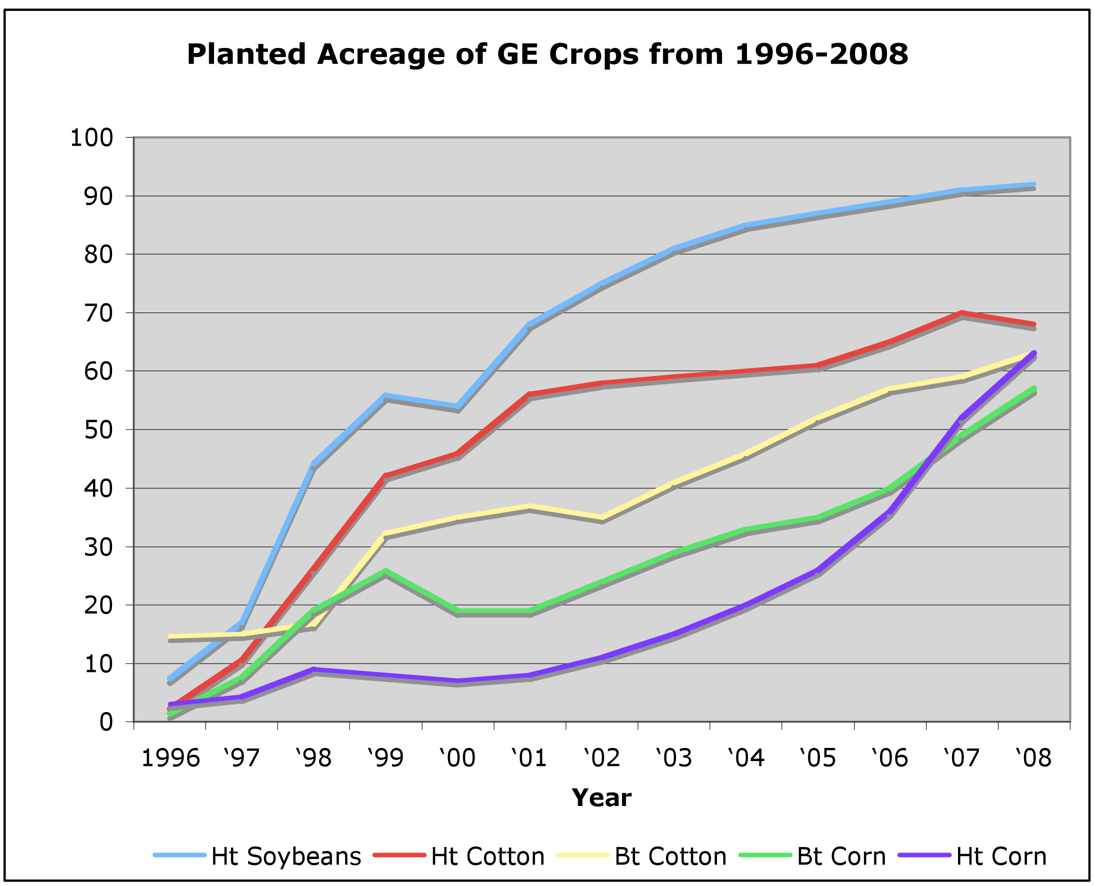


Figure 2 Planted Acreage of Genetically Engineered Crops from 1996- 2008. Graph made with data from USDA's National Agricultural Statistics Service.

	1996	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08
Ht Soybeans	*7.4*	*17*	*44.2*	*55.8*	*54*	*68*	*75*	*81*	*85*	*87*	*89*	*91*	*92*
Ht Cotton	*2.2*	*10.5*	*26.2*	*42.1*	*46*	*56*	*58*	*59*	*60*	*61*	*65*	*70*	*68*
Bt Cotton	*14.6*	*15*	*16.8*	*32.3*	*35*	*37*	*35*	*41*	*46*	*52*	*57*	*59*	*63*
Bt Corn	*1.4*	*7.6*	*19.1*	*25.9*	*19*	*19*	*24*	*29*	*33*	*35*	*40*	*49*	*57*
Ht Corn	*3*	*4.3*	*9*	*8*	*7*	*8*	*11*	*15*	*20*	*26*	*36*	*52*	*63*

Table 1 Planted Acreage of GE Crops from 1996- 2008
Data for each crop category include varieties with both HT and Bt (stacked) traits, USDA NASS

The company involved most in the genetic engineering of plants, and behind the technology itself is Monsanto. Since the 1980s, the biotechnology corporation has bought out seed companies all over the world, and has now positioned itself as the leader in the global seed industry. Through buying out other seed companies, leading the experimentation in plant genetic engineering, and patenting these life forms, Monsanto has gained incredible power. This power has been further reinforced through the use of technology use agreements, which Monsanto requires be signed anytime their patented seeds are sold (CFS 2005).

When this agreement is signed, it allows Monsanto legal access in many areas. First, it gives Monsanto the right to view any farmer records and receipts that the company deems relevant, and allows the company to inspect farms at random up to three years after the seed purchase date to take samples to ensure against patent infringement. These are only a few of the rules and restrictions placed on farmers deciding to grow GE seeds.

Farmers saving and replanting GE seeds are subject to litigation by this company, but they are not the only ones. Farmers growing organic and traditional crops in the vicinity of GE farms are at risk as well, and can be sued for patent infringement even if genetic contamination has occurred accidentally, due to pollination by wind, birds, insects or any other natural vehicle carrying the pollen from the GE field into the non-GE field. Monsanto has sued more than 120 farmers in the U.S. in the last 10 years.

The purpose of this research is to map the occurrences of such litigation relative to the locations where corn, cotton and soy are being grown, which represent the 3 main GE crops. The main research questions are:

- In what regions of the U.S. are genetically engineered crops grown?
- Which regions are most at risk for transgenic contamination and potential litigation?
- What is the spatial distribution of lawsuits filed by Monsanto against U.S. farmers for patent violations?
- Is there a spatial relationship between litigations brought against farmers in areas where corn, cotton and soy are being grown?

Because of the tremendously high percentages of corn, cotton and soy grown in the United States that are genetically engineered, included on the following pages are maps and charts released by the USDA to show the areas where these crops are grown and the trends in their growth from the late 1980s until the present day. Figures 3, 5 and 7 show the production units by county for corn, cotton and soy in the U.S. Figures 4, 6 and 8 show the trends in corn, cotton and soy acreage from 1988- 2009. Understanding the spatial distributions of these crops will help understand the distribution of GE litigations.

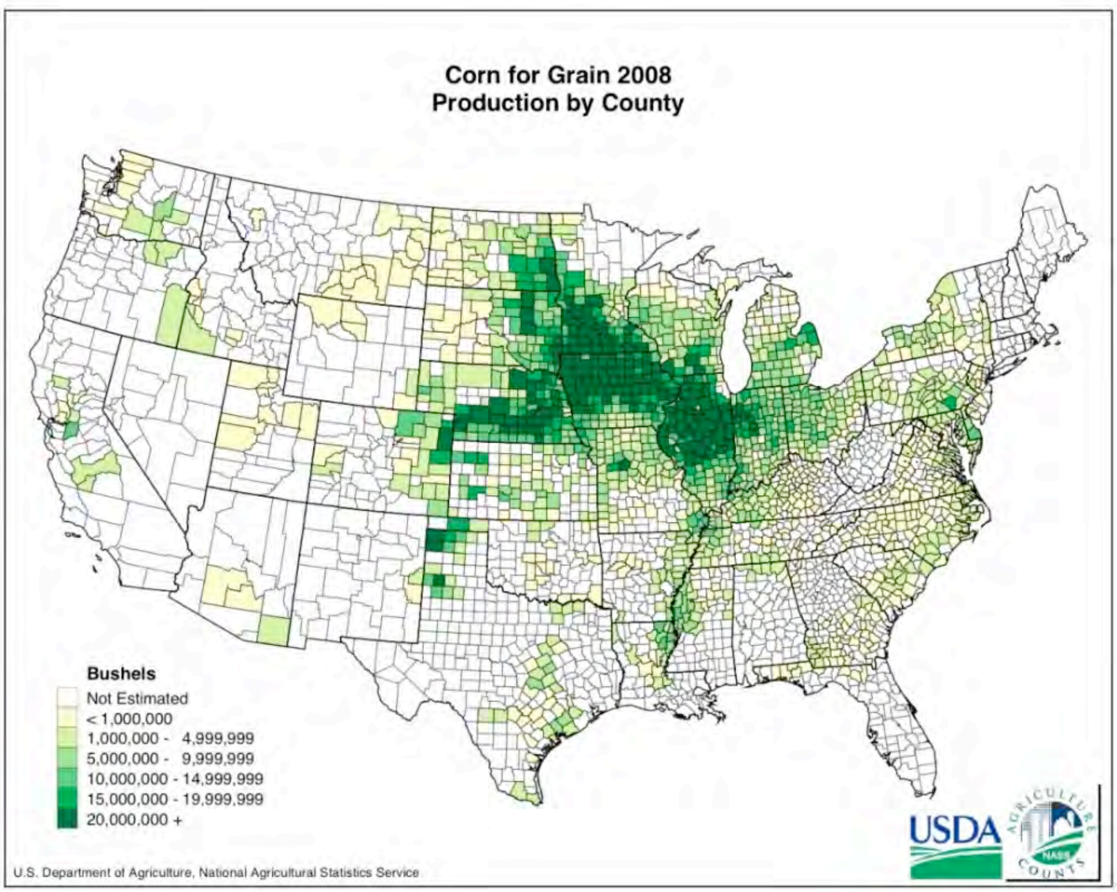


Figure 3 Corn Production by County in Bushels 2008

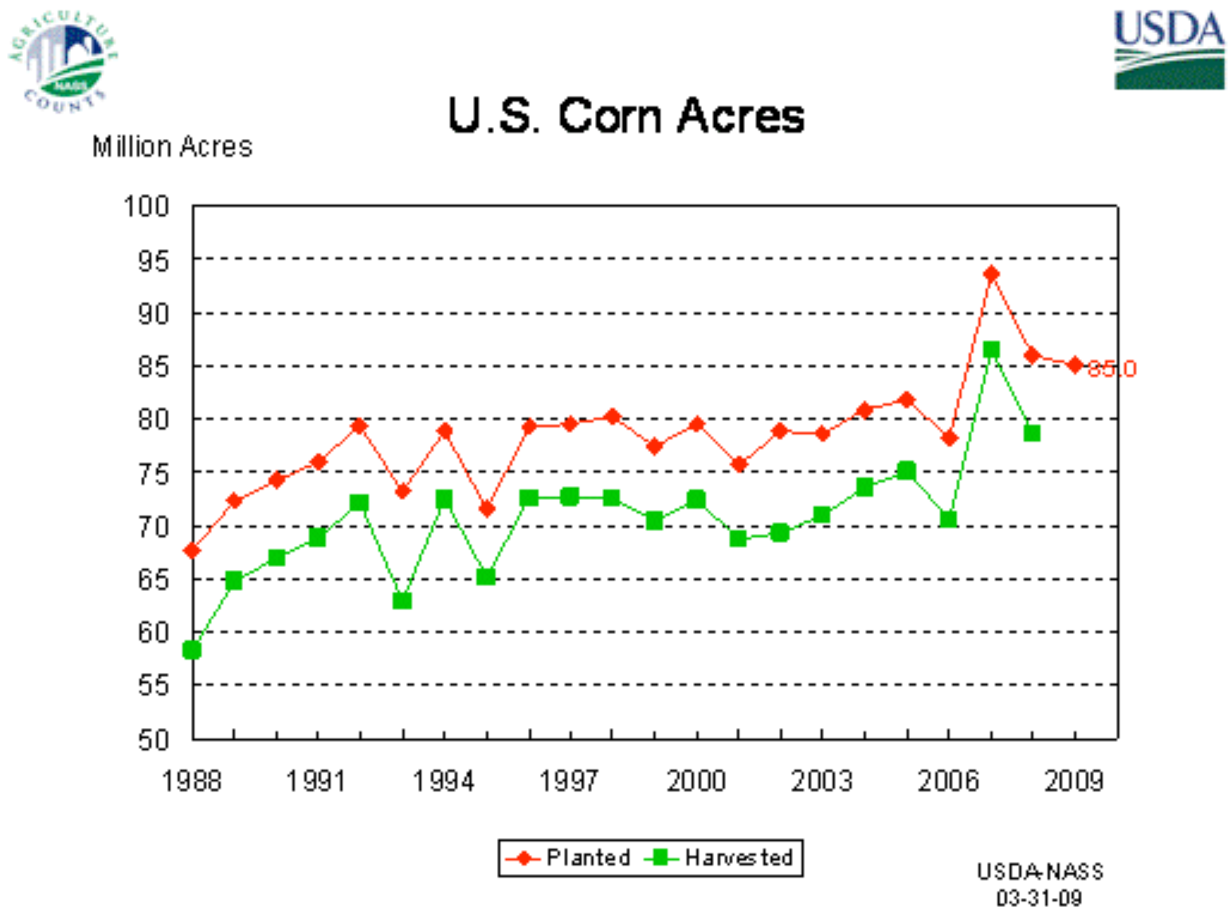


Figure 4 Corn in millions of acres grown from 1988-2009

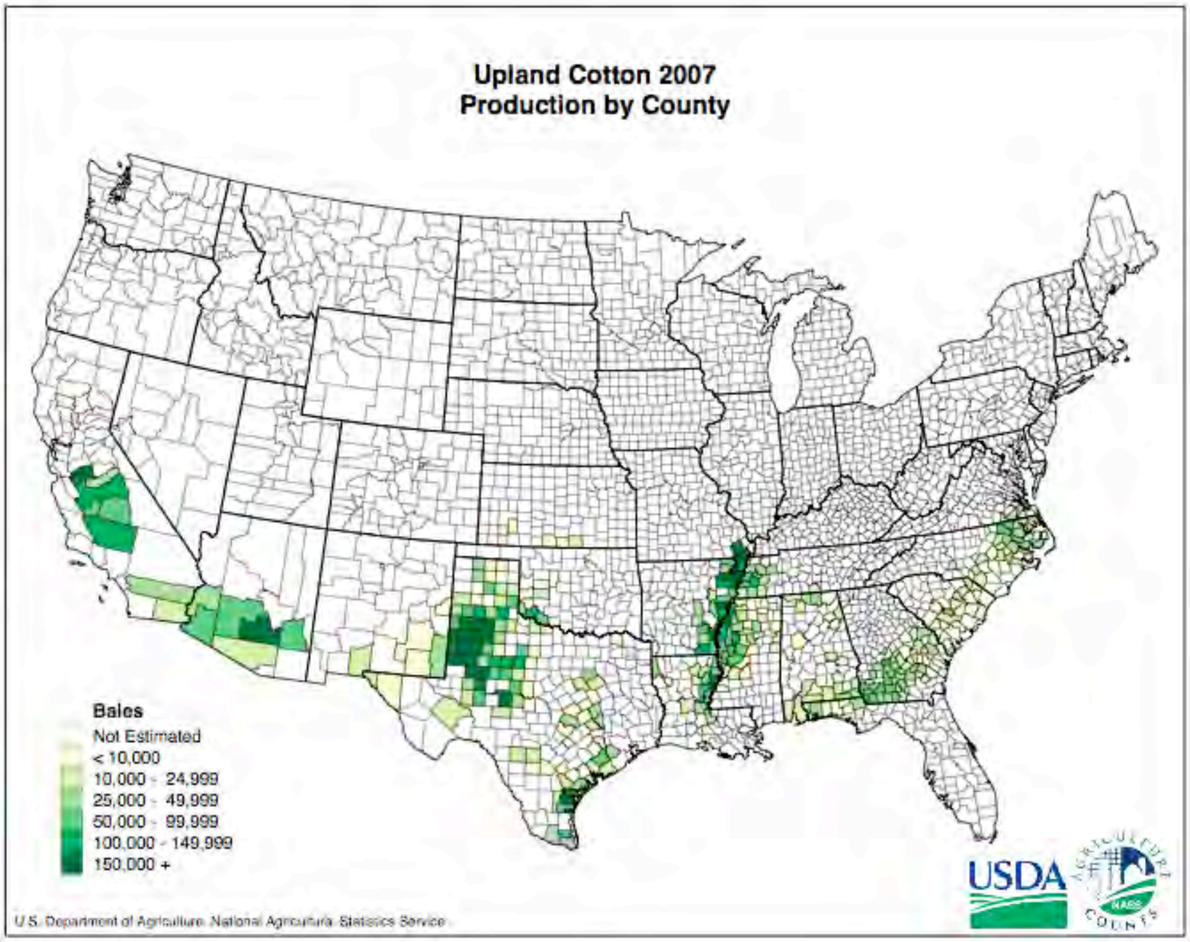


Figure 5 Upland Cotton Production by County in Bales 2007

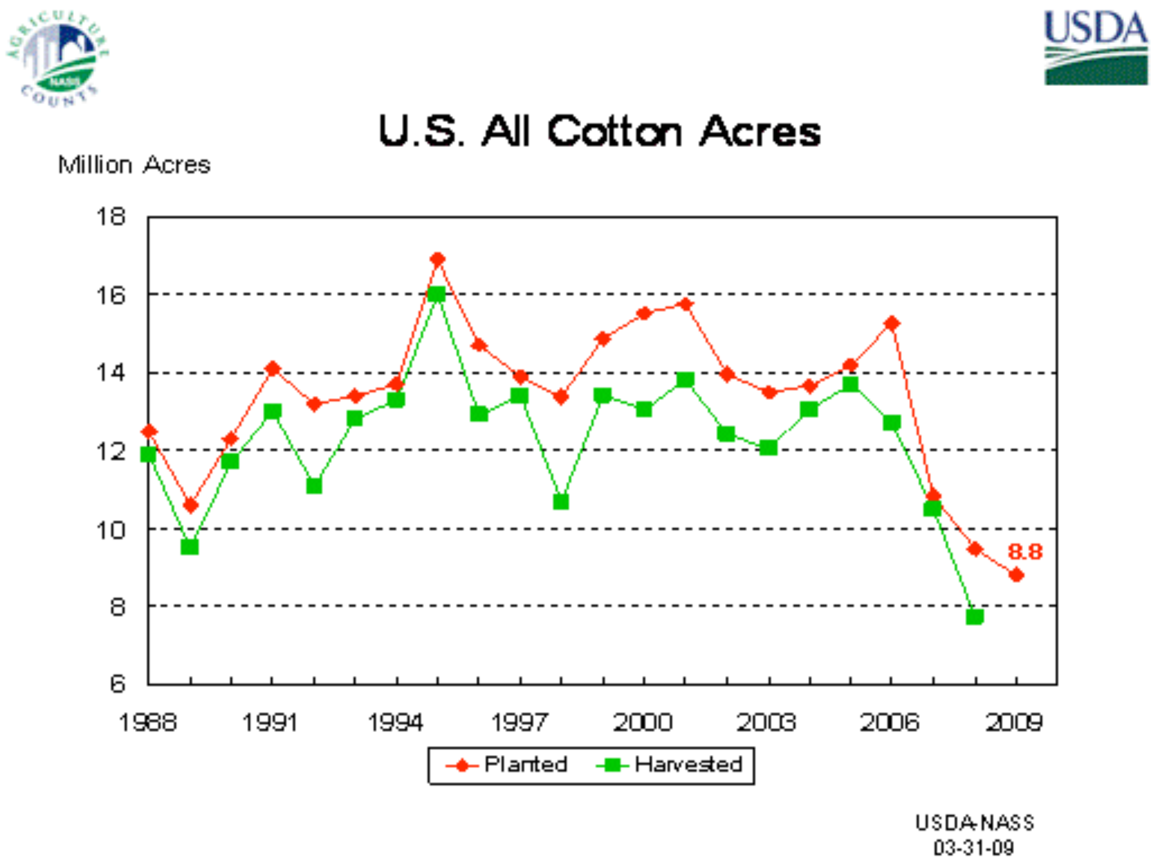


Figure 6 Cotton Grown in Millions of Acres from 1988-2009

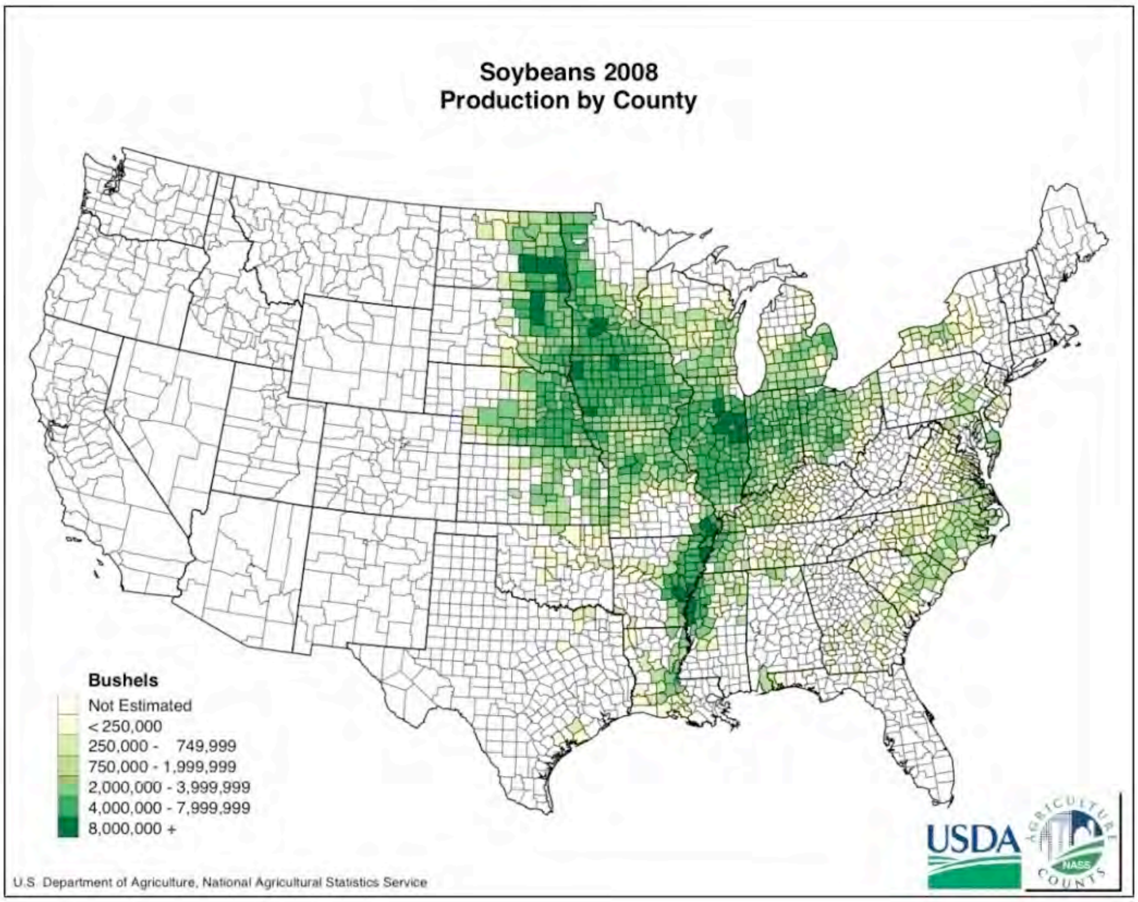


Figure 7 Soybean Production by County in Bushels 2008

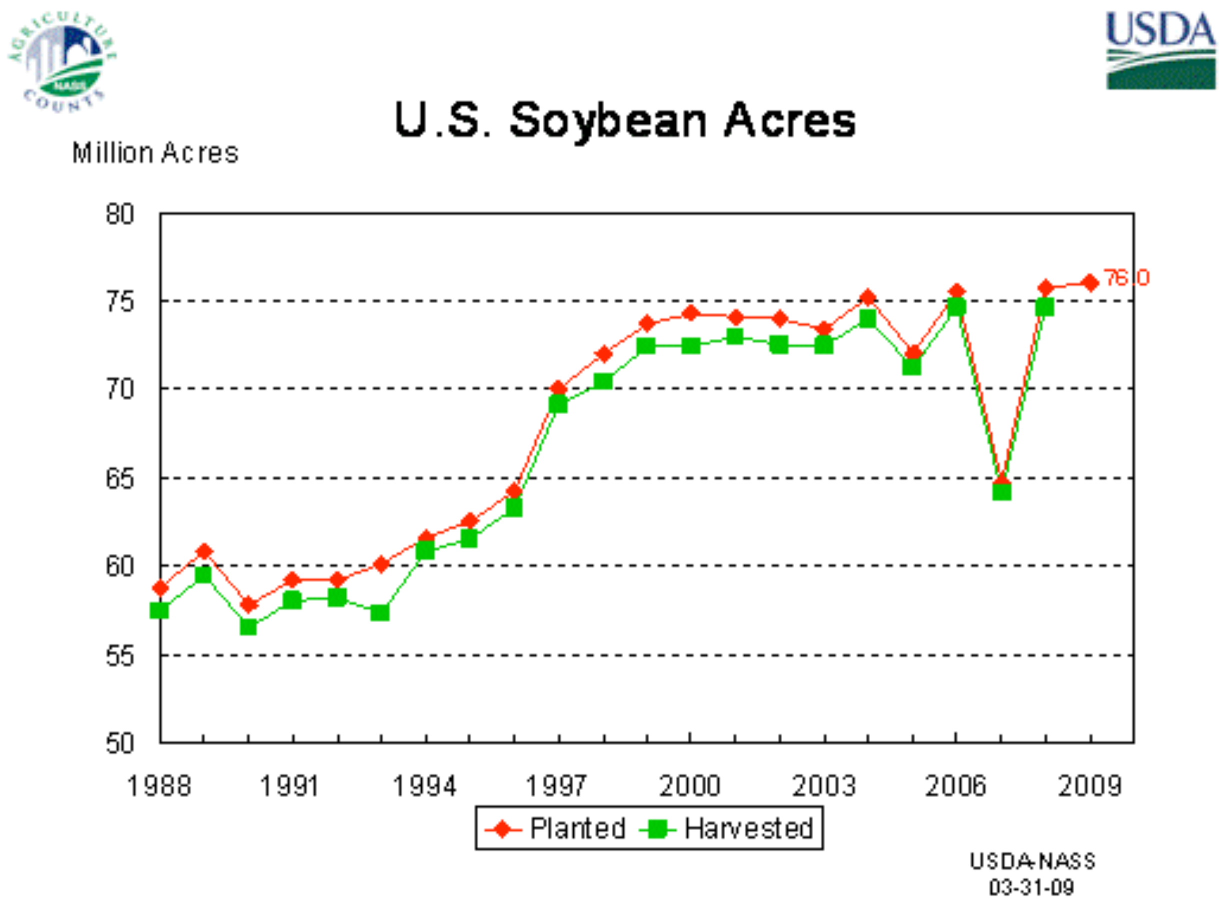


Figure 8 Soybeans Grown in Millions of Acres from 1988-2009

2. Literature Review

2.1 A Short Summary of Plant Breeding Leading up to the 20th Century

Human advancement and the rise of civilizations has largely been the result of human success in agriculture. No society could grow without its people being fed, just as no army could ever go into battle with hungry soldiers. Agriculture is the backbone of civilization, for it is what nourishes and sustains humanity.

A great deal of this success in agriculture is due to the human involvement in plant breeding. Throughout known history, crops have been manipulated through human selection. Humans have sought out certain plants over others, due to taste, texture, smell, beauty, color, sugar content, size of fruit, size of flower, size of seed, height, etc. When someone found one plant they preferred over another, a seed was collected and planted at a later date. If two notable specimens were selected, they were grown near to one another, and when those two plants pollinated and created a new set of seeds, hybrids were born. Humans have grown open-pollinated and hybridized seeds for as long as agriculture has existed, for both seed types arise in nature. Open-pollination creates plants that resemble their self-pollinating parents. Open-pollinated plants have evolved through random mutations, through the sharing of pollen by wind or insects, or through deliberate human intervention for the purposes of influencing certain traits. Open- pollinated plants have one parent line. Hybrids on the other hand, have a two parent line. Two varieties of the same type of plant are deliberately crossed, resulting in seeds that tend to perform a certain way for one generation, but are unstable in the following generations (Texas A&M 2002). To uphold the traits of the parents, a fresh crop of hybrid seeds are needed to maintain the variety. In this way, open-pollinated seeds are more stable than hybrids.

It has only been in the last three decades, that humans have begun to genetically modify, or engineer plant seeds by inserting foreign DNA into their genes. This method of selection is entirely different than anything that has previously before been practiced. The genetic concept of vertical transfer, what two parents pass onto their offspring, has been applied to genetic engineering, which is actually a horizontal transfer, moving DNA from one organism across to, or into, another.

2.2 Genetic engineering of plants

The Merriam-Webster Dictionary defines genetic engineering as:

> *"The group of applied techniques of genetics and biotechnology used to cut up and join together genetic material and especially DNA from one or more species of organism and to introduce the result into an organism in order to change one or more of its characteristics."*
>
> (Merriam-Webster 2009)

Deoxyribonucleic acid (DNA) is found in the cells of nearly all living things. Humans, plants and animals contain DNA in their cell nuclei. Composed of 2 spiraling strands of nucleotides, DNA contains and stores all of the genetic information inherited from its parents into a chemical sequence. Figure 9 illustrates the DNA spiral containing the genetic information for making proteins. There are 4 basic types of nucleotides, each distinguished by a specific base (Hill 2000). Two chemical bases attached to opposing strands of DNA make up a base pair, and the particular sequence of base pairs along a strand of DNA provide the exact instructions for an organism to be created. Each functional unit of DNA is known as a gene (Hill 2000). The entire sequence of base pairs of a DNA molecule is referred to as a genome. Humans have approximately 3 billion genomes, while certain simple bacteria have only 600,000 base pairs. Although there are nearly 6 billion bases (3 billion base pairs) in the human genome, only 2% of that DNA data are genes, meaning less than 2% of genomes code for proteins (USDE 2008).

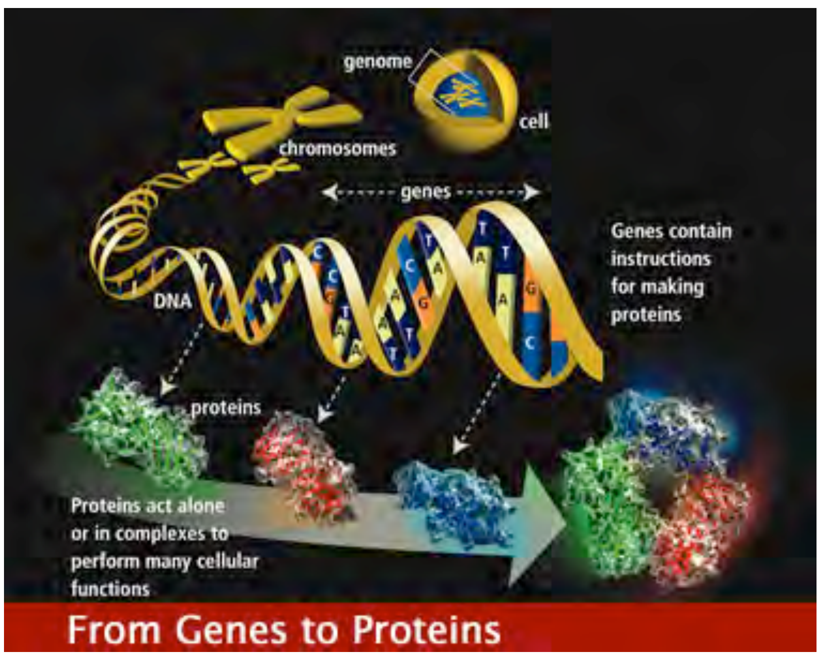


Figure 9 The makeup of a spiral of DNA and how genes code to make proteins. U.S. Dept. of Energy 2008 Human Genome Project Information

The genetic engineering of plants involves inserting genetic sequences, often from a different species, into DNA. Thus, a genetically engineered or genetically modified organism is one which has received a gene insertion. There are two common method of genetic insertion, ballistic and biological. The biological method, involves the microbe *Agrobacterium tumefaciens*, while the ballistic method, employs microprojectile bombardment using a gene gun (Institute of Medicine 2004).

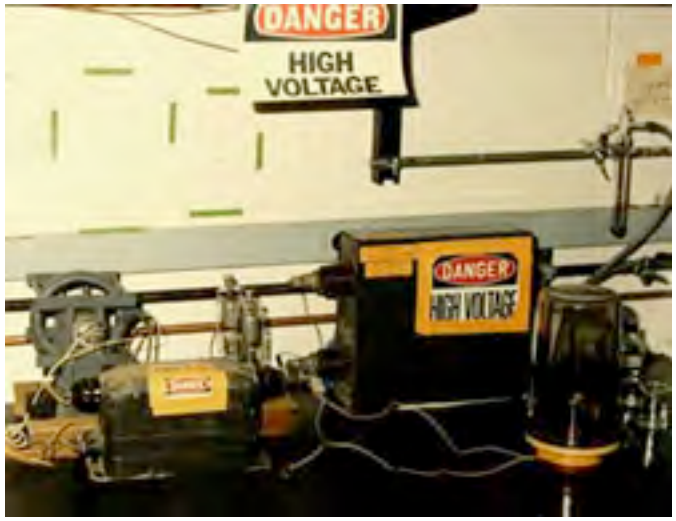


Figure 10 Monsanto Gene Gun on Display at the Smithsonian
UCSD 2009

Using the 'gene gun', DNA attached to microscopic particles of gold and tungsten are shot onto plant cells at high velocities. This technique causes transformation within the living organism and is most commonly used for such crops as rice, corn and certain other grains. Figure 10 above shows Monsanto's Gene-Gun on display at the Smithsonian Institution.

Agrobacterium tumefaciens is a soil microbe that causes crown gall disease in plants. This microbe is unique in that when it infests a plant, it transfers a part of its own DNA into the host's cells. The inserted genes then replicate on their own, all the while following the genetic instructions to create a crown gall instead of host plant tissue. *Agrobacterium* has been modified so that it no longer contains the disease promoting genes, but is still able to infect and replicate using newly inserted genetic material. Scientists have created several *Agrobacterium* species using this method, with each inserted genetic piece coding a marker for a desired trait or attribute. Many GE foods on the market today, are a result of *Agrobacterium* technology (Institute of Medicine 2004).

2.3 Incentive for farmers to use GE crops

Since the end of WWII, pesticide use has been on the increase in the United States, after farmers discovered that its use increased yields far beyond what they were previously. In 1997, one third of the world market for pesticide was in the U.S. alone, with two thirds of that being used in agricultural applications (UCSD 2009).

GE crops are marketed to farmers for specific benefits, each providing some special incentive to the farmer. Whether it be increased yields, or decreased use of pesticides and herbicides, which in turn requires less time, farmers take the risk to grow GE crops because they think they will provide something conventional crops cannot.

Figure 9 shows U.S. farmers reasons for growing GE crops. The data used to make the chart was taken from a survey conducted from 2001- 2003. Figure 10 lists GE crops on the market with their altered value and the corporation that makes them.

In the 1940s Monsanto began producing and selling DDT, a chemical used to control mosquitoes, gypsy moths and beetles. It was effective on insects, but at a very serious cost. Not only did it cause widespread insect resistance, it was also found to increase preterm births in humans and eggshell thinning in bird populations, resulting in the decimation of songbird, falcon and eagle populations where the chemical was used (UCSD 2009). In 1972, Congress banned its use and the EPA now lists DDT as a probable human carcinogen, although the chemical is still used on crops in foreign countries that are imported into the U.S.

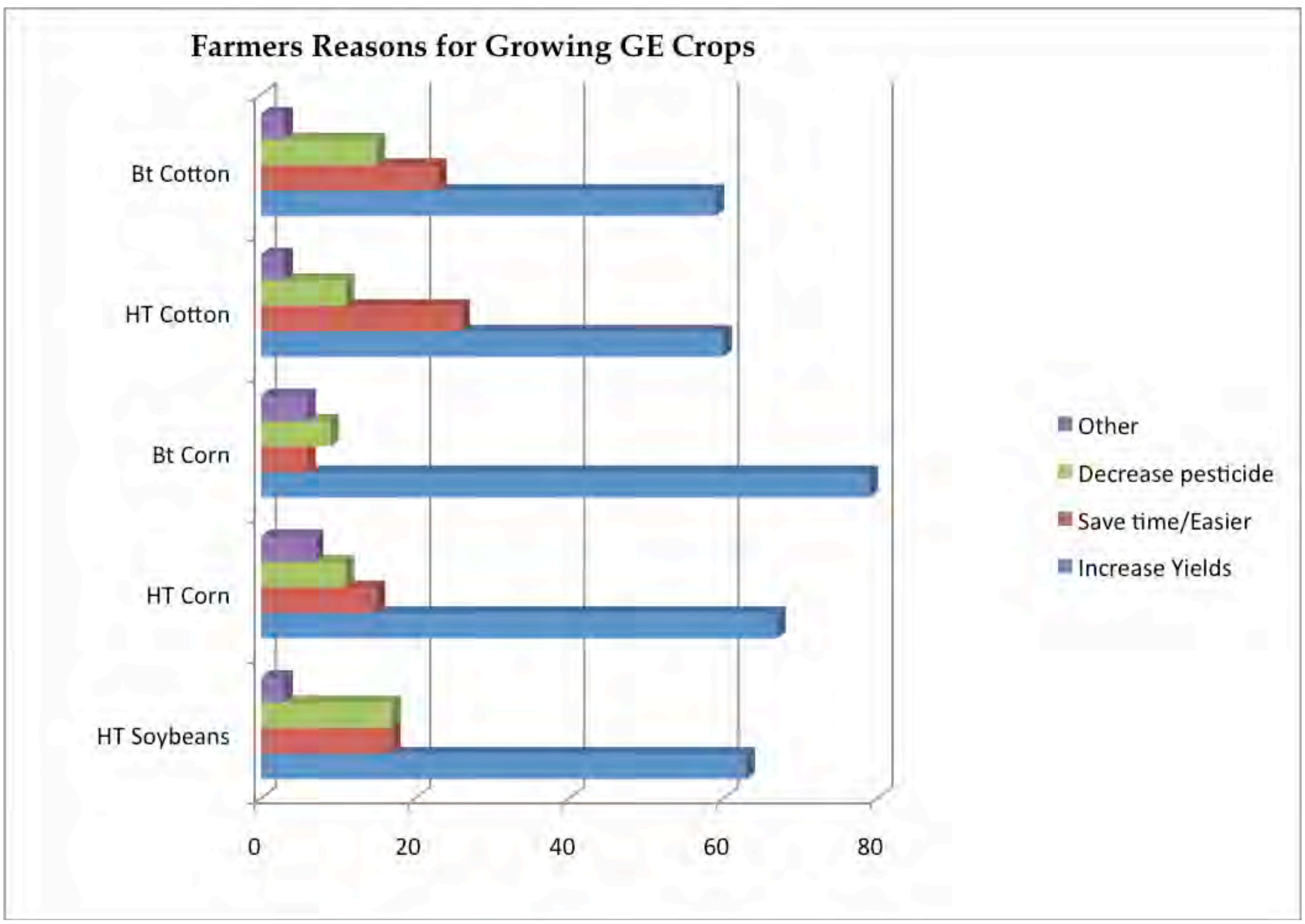


Figure 11 Farmers Reasons for Growing GE crops, USDA ERS.
Data from 2001- 2003 Agricultural Resource Management Survey

GENETICALLY ENGINEERED FOODS ON THE MARKET

PRODUCT	INSECTICIDAL	HERBICIDE TOLERANT	HYBRIDIZATION	DISEASE RESISTANT	ALTERED VALUE	ALTERED OIL	CORPORATION
Canola		●					Bayer
Canola		●					Monsanto
Canola						●	Monsanto
Canola		●	●				Bayer
Chicory			●				Bejo Zaden
Corn		●	●				Bayer
Corn		●					Bayer
Corn	●	●					Bayer
Corn	●						Dow/Mycogen
Corn	●	●					Dow/Mycogen/DuPont/Pioneer
Corn			●				DuPont/Pioneer
Corn	●						Monsanto/DeKalb
Corn		●					Monsanto/DeKalb
Corn	●						Monsanto
Corn	●	●					Monsanto
Corn		●					Monsanto
Corn	●						Syngenta
Corn	●						Syngenta
Corn (pop)	●						Syngenta
Corn (sweet)	●						Syngenta
Cotton	●	●					Monsanto/Bayer
Cotton		●					Monsanto/Bayer
Cotton	●						Monsanto
Cotton		●					Monsanto
Flax		●					Univ Saskatchewan
Papaya				●			Cornell Univ/Univ Hawaii
Potato	●						Monsanto
Potato	●						Monsanto
Potato	●						Monsanto
Soybean		●					Bayer
Soybean						●	DuPont
Soybean		●					Monsanto
Squash				●			Seminis Vegetable Seed
Squash				●			Seminis Vegetable Seed
Sugarbeet		●					Bayer
Sugarbeet		●					Monsanto/Syngenta
Tomato					●		Agritope
Tomato					●		DNA Plant Technology
Tomato					●		Monsanto/Calgene
Tomato					●		Monsanto
Tomato					●		Zeneca/PetoSeed

Union of Concerned Scientists; "Guides: Genetically Engineered Foods Allowed on the Market", http://www.ucsusa.org

Figure 12 Genetically Engineered Foods on the Market with Corporation responsible and traits altered. From the Union of Concerned Scientists

2.4 Plant Patents

For most of U.S. history, it has been illegal to place patents on living organisms. To be identified as living organism, the organism must have structure or shape, make and break down complicated molecules, be able to transform energy, and be able to reproduce (Hill 2000).

In 1970, the Plant Variety Protection Act was passed. This act gave plant breeders exclusive rights and control on sexually reproducing or tuber propagated plants for 25 years, preventing others from selling, reproducing or using the variety to create a new hybrid, although gardeners could still propagate the varieties in home gardens and save seeds. This Act gave plant breeders some power over their developed varieties, but was far from a utility patent. That would come in the next decade. In 1980, an engineer working for General Electric who had created a bacterium for the purpose of cleaning up oil spills, requested a patent on said bacterium on the basis that he had created something that before did not exist. The patent examiner reviewing the request initially rejected it on the principle that living things were not patentable. The Board of Patent Appeals and Inferences concurred with the initial decision, but the U.S. Court of Customs and Patent Appeals later overturned it. A Patent Commissioner in dissent of the new outcome appealed the case to the Supreme Court where the decision was made in the engineers favor in June of 1980. This case opened the doors for utility patents to be placed on all living organisms.

Worldwide, other countries are allowing patents to be placed on plants as well. Figure 11 shows countries of origin for biotechnology patents from 1990-1995.

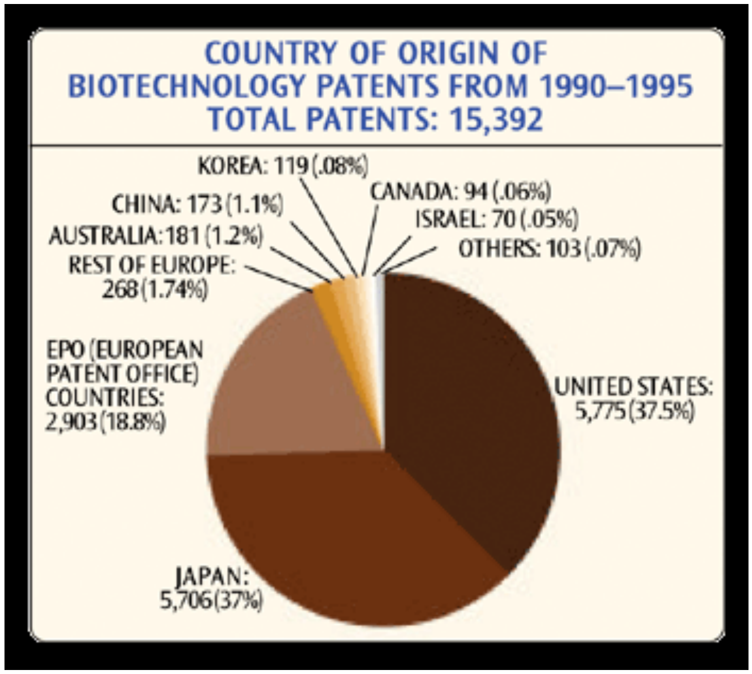


Figure 13 Countries of Origin of Biotechnology Patents from 1990-1995
From the International Service for the Acquisition of Biotech
Applications 2001

The USDA's Animal Plant Health and Inspection Service reports that since 1987, approximately 11,600 applications for field-testing of genetically engineered plants have been submitted by plant breeders, with more than 92% (10, 700) of those applications receiving approval (Fernandez et al 2006). In 1996, genetically engineered (GE) seeds became available commercially, and it was not long before they took hold on the seed crop market. The USDA's National Agricultural Statistics Service (NASS) lists that in 2006, 61% of corn, 83% of cotton and 89% of soybeans grown in the U.S. were GE varieties. Those numbers continued to grow and in 2008, 80% of corn, 92% of soybeans and 86% of cotton grown in the U.S. is now genetically engineered. It is estimated that more than 70% of processed foods now found in U.S. grocery stores contain GE ingredients (USDA Fact Sheet 2009).

2.5 Monsanto

Founded in St. Louis in 1901, the agricultural biotechnology company that is today Monsanto began as a chemical company importing saccharin at the turn of the century. Later, the company began making other chemical substances, including plastics, resins, rubber goods, fuel, artificial caffeine, industrial fluids, fertilizers, herbicides and pesticides. After receiving negative attention for its history and involvement in the 1960s and 1970s production and applications of dioxins and polychlorinated biphenyls (PCB's), Monsanto began to shift its focus away from chemicals and instead towards agricultural applications.

Monsanto was behind the technology that created plant genetic engineering and is now home to the largest biotechnology research center in the world. The facility contains 100 plant growth chamber rooms as well as 250 laboratories able to remote controlled from scientists' homes (Weiss 1999). Monsanto currently holds 674 plant patents, supplying the technology for 90% of the world's GE crops. It is also the largest marketer of GE seeds worldwide, having bought out most U.S. and international seed companies between the years 1996 and 1998 (CFS 2005). Monsanto currently employs over 17,000 people in over 100 countries (Amann 2009).

In 2005 alone, Monsanto spent over $430 million dollars (85% of their development budget) on genomics, biotechnology and seeds. Discussing GE technology, Karen Marshall, spokeswoman for Monsanto said in 1999: “This is part of the agricultural revolution, and any revolution is painful. But the technology is good technology.”

2.6 Genetic Contamination and Litigation

Farmers buying patented seeds from Monsanto must first sign a technology use agreement (see Appendix 1.1, 1.2). This document strips farmers of many rights, giving the corporation the privilege to enter the farmers property at random for up to three years after the date of purchase, legal access to all of the farmers records and property documents to see what nearby farmers are growing and where potential contaminations may take place. If contamination if found to have taken place, farmers might receive a letter similar to the one Mr. Moritz, a Canadian canola farmer received in 2002 (see Appendix 1.3).

Monsanto employs other techniques as well to ensure farmers are not getting their technology for free. In rural farming areas Monsanto runs ads on the radio with the names of local farmers that have been caught growing their seeds without a license. They also provide an 800 number for farmers to call in and report their neighbors or others in the area that might be growing their GE crops illegally (Weiss 1999).

Aside from the damages to farmers resulting from GE litigations, the most serious issue facing farmers is genetic contamination from GE crops. Contamination can take places in many ways. It can occur through the movements of the wind, birds and other pollinators, or through more man-made forms. The sharing of crop equipment like combines, the large operated machines that harvest and clean grain, grain elevators, the facilities that store the grain before being shipped, and grain trucks, which are used to transport the grain, are all potential locations for contamination to take place (Lilliston 2001). Since it is extremely difficult, costly, and time consuming to clean equipment between each use, contamination is unavoidable.

The issue has become so serious that even the American Seed Trade Association (ASTA) has taken action. ASTA is one of the oldest trade organizations in the U.S., having been founded in 1883 and consisting of 850 companies that produce and distribute seeds and plants. In 2001, the Association implemented a one percent tolerance level for 'adventitious biotech presence in maize, cotton, soybeans and canola', the four most genetically engineered crops (ASTA 2009)'. Their website states that this 'threshold would help the seed industry continue to maintain the highest level of genetic seed purity in this age of the gene revolution (ASTA 2009)'.

> *Since seed is produced in and subject to open environments, no commercial seed is 100 percent genetically pure, whether traditional or biotech. With the existence of genetically enhanced crops, it is currently impossible to guarantee that traditional seed will not contain a minute level of adventitious biotech material. Moreover, seed is destroyed in the testing process for genetic purity, therefore, only a small percentage of a seed lot can be tested. Hence, zero tolerance of adventitious biotech material, which may only be verified by testing 100 percent of a seed lot, is not possible.*
> Mark Condon
> American Seed Trade Association, Vice-President of International Marketing (ASTA 2000)

A consequence of this contamination is that some farmers may lose organic certification due to GE presence in their crops. A 2001 article in the Wall Street Journal revealed that an independent study conducted by the Journal testing twenty products labeled as “GMO free’ found sixteen of those products to be GE contaminated, with five of those products containing significant amounts of contamination (Lilliston 2001). It may be surprising that although the USDA requires that certified organic food be produced and handled without the use of genetic engineering, it does not have standards in place for adventitious, or unintended, GE presence in organic foods. In Europe, any food made with more than one percent GE ingredients must be labeled. The threshold in Japan is five percent for labeling. Despite these standards, most food companies in these countries will not accept any grains with more than 0.1 percent contamination (Lilliston 2001).

2.7 Research and Regulation of GE Crops in the United States

Not only has Monsanto made it very difficult for the general public to use or learn more about their products, it has also limited the scope of scientific input as well. The technology agreements that farmers and other buyers of GE seeds must sign forbid the seeds being grown for research purposes. If scientists cannot conduct studies on the nature and qualities of GE seeds, the claims of Monsanto and other GE companies cannot be upheld on scientific basis. In 2002, a plant ecologist from Ohio State University was declined access to conduct a follow-up study after her initial study with genetically engineered sunflowers revealed that the crossing of GE sunflowers with wild varieties caused the wild ones to produce more seed and spread as weeds (Dalton 2002). Now, seven years later, the situation remains the same. A New York Times article published in February illustrates the frustration of 26 corn- insect scientists that jointly submitted a statement to the Environmental Protection Agency petitioning that the agency review its standards for the studies of GE crops. They argue that there are far too many limitations preventing the scientific community from performing the necessary studies needed to ensure the safety of GE crops. In their statement the scientists wrote, "no truly independent research can be legally conducted on many critical questions (Pollack A 2009)."

The regulation of GE crops in the U.S. is a complex one. Simply put, three regulatory agencies oversee these crops: the Environmental Protection Agency (EPA), the USDA's Animal and Plant Health Inspection Service (APHIS), and the Food and Drug Administration (FDA). The EPA assures that the plants are safe for the environment, APHIS determines if GE crops are safe to grow, and the FDA verifies if the plants are safe to eat (Grossman 2002). When a crop completes the regulatory process deeming it safe to the public, it is deemed deregulated. Meaning the product can be moved freely without the use of permits or notifications. If the crop is not or has not been deemed safe, it is referred to as a regulated crop (USDA 2006).

The USDA may be becoming more cognizant of the fact that many Americans are wary of GE crops, as they extended the comment period on a proposed rule to revise regulations ‘regarding the importation, interstate movement, and environmental release of certain GE organisms (APHIS Code of Federal Regulations, Volume 7, Section 340)’ after they received more than 15,000 comments during a 45 day period for input that began on October 9, 2008 (USDA APHIS 2009).

The Biotechnology News and Information Section of the APHIS website states that the purpose in revising the biotechnology regulations is to help:

> …meet current needs in evaluating and addressing the plant or noxious weed risks associated with the importation, interstate movement, and field release of certain GE organisms. The proposed changes will also improve regulatory processes so they are more transparent to stakeholders and the public, make more efficient use of agency resources, and eliminate unnecessary regulatory burdens.
> USDA APHIS 2009

Some U.S. states are even taking precautions to protect their citizens. In May of 2001, the Maine legislature passed the first bill of its kind requiring GE seed dealers to provide explicit instructions on how to grow and harvest GE crops to minimize the probability of genetic contamination (Lilliston 2001).

2.8 International Response

Worldwide, biotech crops are showing upward trends. The International Service for the Acquisition of Agri-biotech Applications (ISAAA) states that 81 million hectares of GE crops were grown in 17 countries by 8.25 million farmers in 2004. This is a 13.3 million hectare increase from 2003 when 67.7 million hectares were grown by 7 million farmers.

Despite this increase in acreage devoted to GE crops, many countries are taking precautionary measures and restricting the growing of such crops in their countries. As recently as March of this year, the governments of the European Union allowed Austria and Hungary to uphold national bans on GE crops from Monsanto in their countries (Kanter 2009).

This spring, a request by Monsanto to grow 40,000 test hectares of their Mon810 Corn was whittled down to 3,600 hectares after public offices were flooded with complaints from citizens (Amann 2009). Just last month though, Germany rejected the project altogether. Agricultural Minister Ilse Aigner said the GE corn "posed a threat to the environment (Spiegel 2009)."

2.9 Biodiversity

Biodiversity is the biological diversity of the millions of plants, animals, bacterium and other organisms living on the earth. The uniqueness of each living creature is like a tile in the endless kaleidoscope of the interconnected planet ecosystem. The specific attributes of an area cause plants and animals to respond and adapt and in order to survive. Over time, plants in areas that have grown drier, develop thorns to repel predators and store a safe supply of water to guard against an otherwise guaranteed demise. Just as biodiversity represents the distinctiveness and inimitability of every organism, it is also the very thing holding the complex web together. Biodiversity provides countless ecosystem services, including regulating pests and disease, controlling erosion, fertilizing the soil and recycling nutrients from one form into another.

Since the beginning of the industrial revolution, there has been an increasing trend signifying a global loss in biodiversity. The Food and Agriculture Organization of the United Nations calculates that since the beginning of the 20th century, approximately 75% of the genetic diversity in agricultural crops has been lost. In China alone, the number of wheat varieties dropped to approximately 1,000 in the 1970s, down considerably from the 10,000 varieties that were in existence in the 1940s (FAO 1997).

> *Genetic diversity is nature's way of assuring that species will endure over time, weathering all types of environmental changes. This diversity has been compromised in modern agriculture because a few large corporations control agriculture and sell relatively few varieties of seeds, resulting in crops that are genetically uniform…With the introduction of new genetically engineered crops, the old seeds of the land races die out, cancelling nature's insurance policy. No crops could be engineered that would have the resilience of the old seeds, for genetically engineered genes do not have the inherent survival capability of genes that have evolved over three billion years.*
>
> Barbara Kingsolver, 2002

GE crops threaten biodiversity not only because of the monoculture they promote by growing hundreds and thousands of acres of the same crop, but also, through their potential for degrading the natural genetic makeup of other living organisms through genetic contamination with wild and traditional plant varieties. If invasive species are one of the main threats to biodiversity, then the question must be asked, what is the risk of releasing plants containing invasive genes in their DNA? The risk clearly becomes genetic contamination, and a type of pollution that reaches to the very foundations of creation.

2.10 Insect and Weed Resistance to GE Crops

In the past, farmers used crop rotation to control insects. By seasonally rotating the crops grown, insects would die of starvation when their host plant was removed (Gould 1991).

History and many scientific studies have proven that insects build resistance to pesticides, herbicides and insecticides. In the 1980s after DDT began to be used on crop fields, insects quickly adapted, building a resistance that was followed with greater chemical applications. Since then, hundreds of studies have documented insect adaptation to insecticides (Gould 1991).

Of the many critical issues that GE crops bring to focus, their effect on plant and soil ecology cannot be overlooked. Many farmers and scientists worry that inserting Bacillus thurengensis (Bt) into plants will speed up insect resistance to the bacterium. Bt is a naturally occurring spore forming bacterium that produces crystal proteins (UCSD 2009). It has been used for years as a natural alternative to pest control by organic farmers. Over 150 insects are known to be susceptible to Bt. Seeds that have been inserted with the Bt gene are able then to produce the toxin, expressing the BT gene throughout the entire plant. It is this fact that many people are concerned about. If a plant is expressing a toxic gene from its roots to its flowering bud, then the plant will also be expressing those genes into the soil while growing, into the air during pollination and back into the earth when the plant completes its lifecycle and decomposes. If the plant is expressing this toxin in every stage of its life, other organisms in its vicinity are adapting to tolerate the higher Bt environment.

Herbicide tolerant cops are created to survive the application of certain herbicides that would otherwise destroy the crop and weeds together. The most common herbicide used in HT crops is glyphosate, known to eliminate grasses and weeds. It has already been proven through various studies that resistance to glyphosate has developed in over 156 weed species (Stoltenberg et al 2003).

The pressing question is, if weeds and insects continue to adapt to increased amounts of insecticides and pesticides, where will the threshold be found, and at what cost to our environment?

2.11 Policy Recommendations

The U.S. government will need to make changes to current patent laws or change the liability to farmers due to the uncontrollable nature of self-replicating patented life forms. The policy recommendations listed here would help protect farmers and are inspired by Center for Food Safety's 2005 document, Monsanto vs. U.S. Farmers (CFS 2005).

- Prohibit sexually-reproducing plants from being patented.
- Change patent laws so farmers inadvertently/unknowingly possessing GE seed are not liable for patent- infringement.
- Change legislation so that Monsanto and not farmers are liable for genetic contamination due to uncontrollable natural forces.
- Force Monsanto to change its 'Forum Selection Clause' to allow farmers to represent themselves in their area courts and not be required to travel to and find a lawyer in St.Louis , the exclusive jurisdiction and venue for all legal disputes with Monsanto.
- Ban the growing of genetically engineered crops on local, state and national levels until more research has been conducted.

3. Methodology

Data was collected from the National Agricultural Statistics Service (NASS), the United States Department of Agriculture (USDA), and the USDA's Economic Research Service (ERS), the Center for Food Safety (CFS), the worldwide web, and other relevant articles in journals, newspapers, reports and research papers.

The litigation data that inspired the maps was obtained from the CFS document Monsanto vs. U.S. Farmers (CFS 2005). Zip codes for farm locations were found through Westlaw, Google and with assistance from the Center for Food Safety.

Using ArcGIS to combine a framework (layer) for geocoding the farm zip codes, a map was created showing the locations of GE litigations across the U.S. with an inset on the St. Louis area as well as a close up of Texas. The national raster crop data showing the areas where corn, cotton and soy are being grown were found on the USDA National Agricultural Statistics Service Data Crop Layer website (http://www.nass.usda.gov/research/Cropland/SARS1a.htm).

4. Data Analysis

The data used to make the maps was gathered from the Center for Food Safety, the United States Department of Agriculture (USDA), the USDA's National Agricultural Statistics Service (NASS) and Economic Research Services (ERS).

ArcGIS was used to create the maps. The crop layers from the USDA are raster, while the raw data from NASS and ERS is vector. Farmer zip codes were geocoded with zip code polygon and point layers.

Using the attribute values of corn, cotton and soy percentages as well as the number of litigations by state, graduated color maps were created of the three main GE crops (Figures 14, 15, 16). Another graduated color map was made of litigations by state (Figure 20) and two maps were maps implementing the crop layers for the

U.S. and for Texas (Figures 17,18). Lastly, using zip code polygon areas and the zip codes of farmers that were sued, a map was created to show the zip code areas with one or more litigations against farmers (Figure 19).

5. Results

- *In what regions of the U.S. are genetically engineered crops grown?*

Iowa and Illinois produce more corn than any other U.S. states. Combined, the two states account for nearly 38% of U.S. corn, though they are not the states with the highest percentages of GE corn. The states containing the highest percentages of GE corn are in order South Dakota, Nebraska, Minnesota and Kansas. Together, these four states make up 27.7% of U.S. corn production. The main GE corn producing areas are South Dakota, Nebraska, Minnesota, Kansas, Iowa and Illinois (see Figure 14).

Texas produces more cotton than any other state in the U.S. alone, totaling 28.6%. 63% of this cotton is GE. Compared with Arkansas, Georgia and Louisiana which together produce 30.9 % of U.S. cotton, and each range between 95-96% GE, the main regions for GE cotton production are Arkansas, Georgia, Louisiana and Texas (see Figure 15).

Iowa and Illinois, which together produce over 30% of U.S. soy, are the main locations of genetically engineered soy in the U.S. Approximately 91% of soy in Iowa is GE, while 81% is in Illinois (see Figure 16).

- *Which regions are most at risk for transgenic contamination and potential litigation?*

Areas surrounded by GE crops or near GE crops are in danger of contamination. These risk areas would be found in the states growing the highest percentages of GE crops. Figures 14,15 and 16 show the GE percentages for corn, cotton and soy by state and the raw data for state contributions to the national total.

- *What is the spatial distribution of lawsuits filed by Monsanto against U.S. farmers for patent violations?*

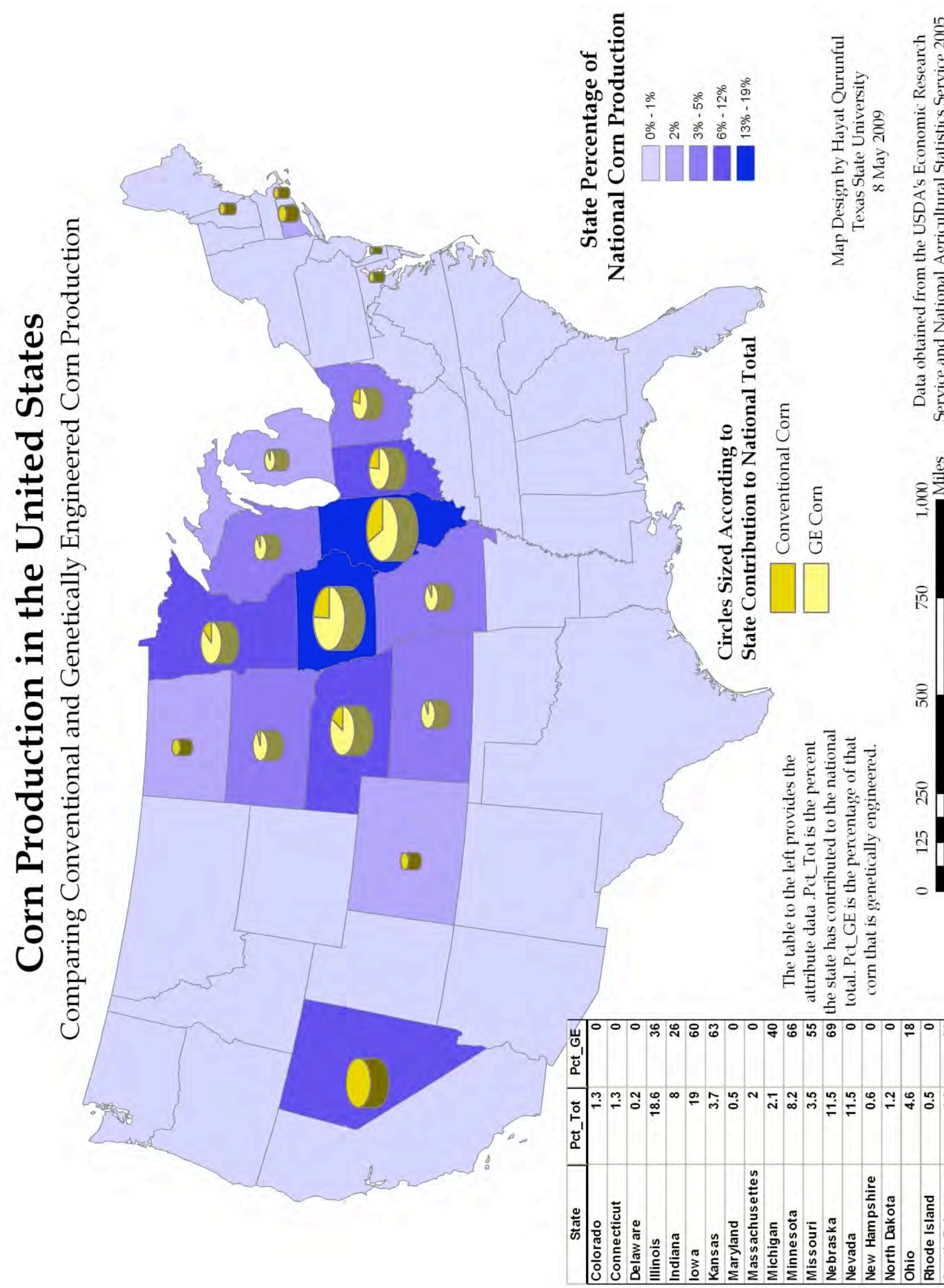
The densest area of litigations against U.S. farmers is in the vicinity of St. Louis, Missouri, the location of Monsanto's headquarters. Due to the proximity of Monsanto's offices and their potential for close oversight, the strongest concentration of litigations was found in Missouri, with 15 lawsuits alone in that state (see Figure 17, 20).

Not surprisingly, three of the four states with the next highest concentrations of litigations border Missouri. Those states are Arkansas, Mississippi and Illinois which each had between 8 – 10 litigations as well as North Carolina, which had 8 litigations.

- *Is there a spatial relationship between litigations brought against farmers in areas where corn, cotton and soy are being grown?*

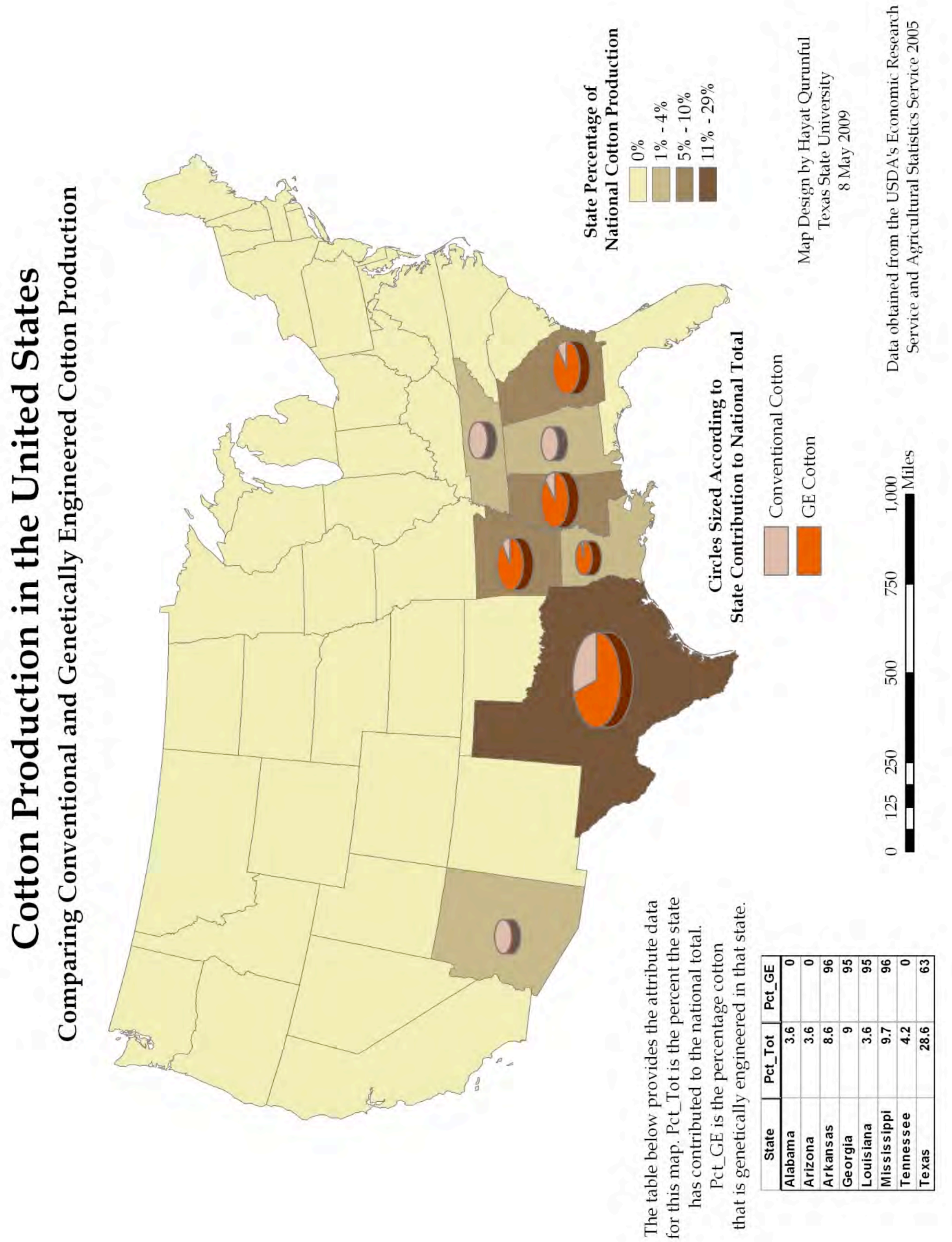
Yes, there is a spatial relationship between litigations brought against farmers in areas where corn, cotton and soy are being grown due to the high percentages of each crop that are GE. It is predominantly in these areas that litigations have taken place. It is difficult to determine the exact spatial relationship between the locations of litigations and GE crops, because the USDA does not make public any data concerning the locations of such crops on state, county or city level.

It should be noted that it was quite difficult to find certain pieces of data for this research. Due to the controversial nature of plant genetic engineering, the USDA provides very little in the way of information on the locations of GE test crops or GE deregulated crops by state. Because of this and the fact that the U.S. does not have labeling standards for GE thresholds in processed foods, most Americans are unaware of plant genetic engineering and the reality that hundreds of farmers have been investigated and sued because of plant patents.



State	Pct_Tot	Pct_GE
Colorado	1.3	0
Connecticut	1.3	0
Delaware	0.2	0
Illinois	18.6	36
Indiana	8	26
Iowa	19	60
Kansas	3.7	63
Maryland	0.5	0
Massachusettes	2	0
Michigan	2.1	40
Minnesota	8.2	66
Missouri	3.5	55
Nebraska	11.5	69
Nevada	11.5	0
New Hampshire	0.6	0
North Dakota	1.2	0
Ohio	4.6	18
Rhode Island	0.5	0
South Dakota	4.3	83
Wisconsin	3	46

Figure 14 Corn Production in the United States



State	Pct_Tot	Pct_GE
Alabama	3.6	0
Arizona	3.6	0
Arkansas	8.6	96
Georgia	9	95
Louisiana	3.6	95
Mississippi	9.7	96
Tennessee	4.2	0
Texas	28.6	63

Figure 15 Cotton Production in the U.S.

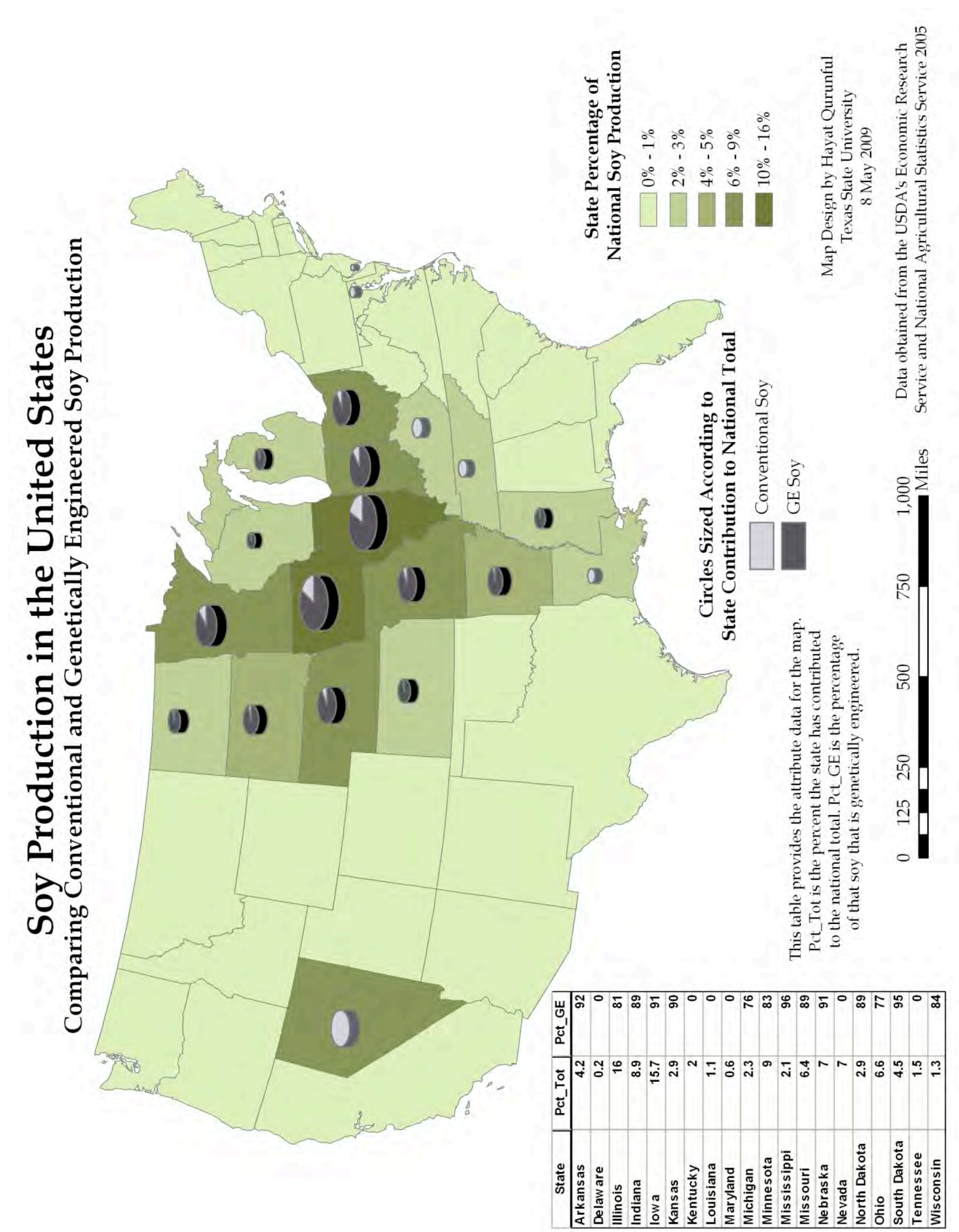


Figure 16 Soy Production in the U.S.

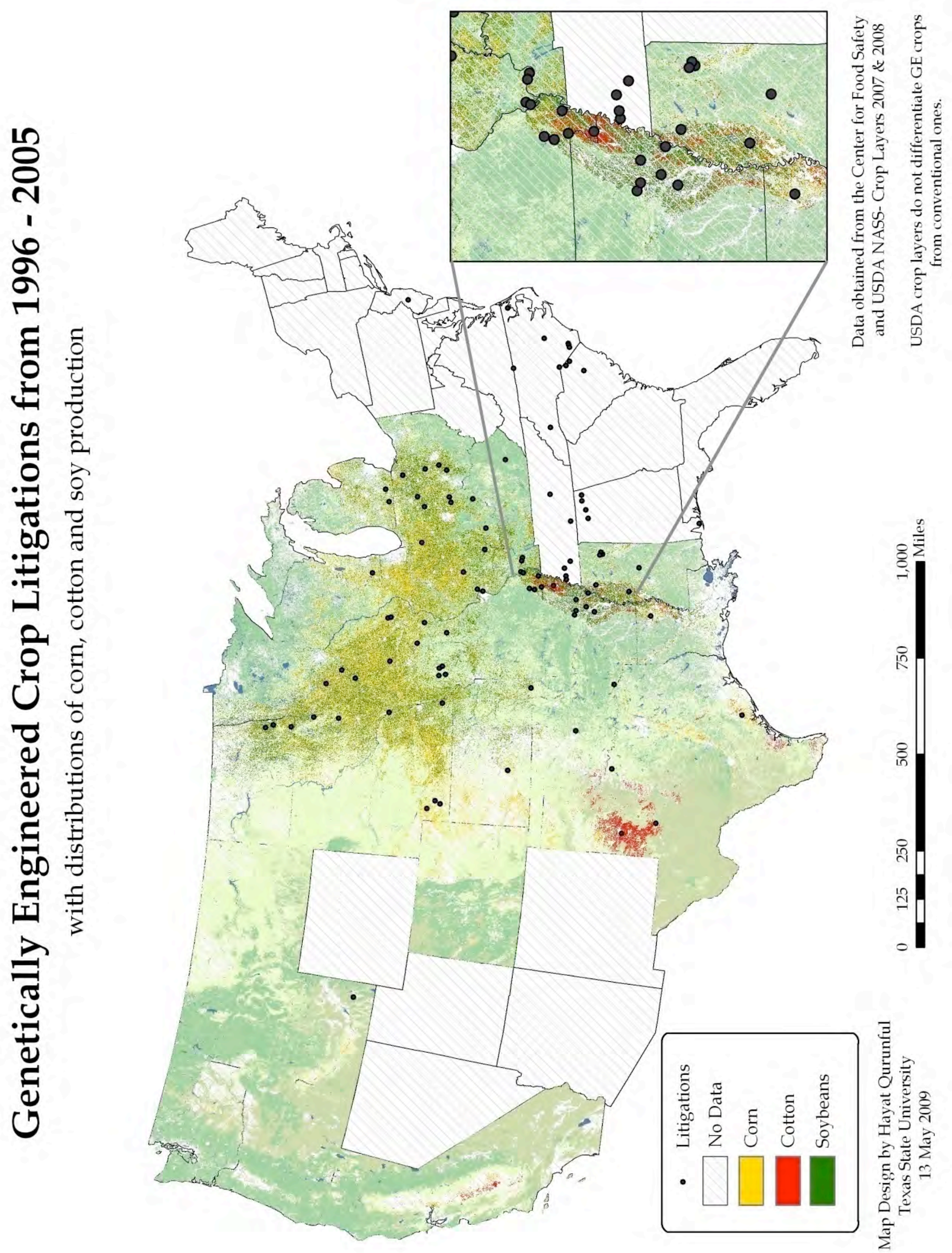


Figure 17 GE Crop Litigations Against U.S. Farmers 1996- 2005

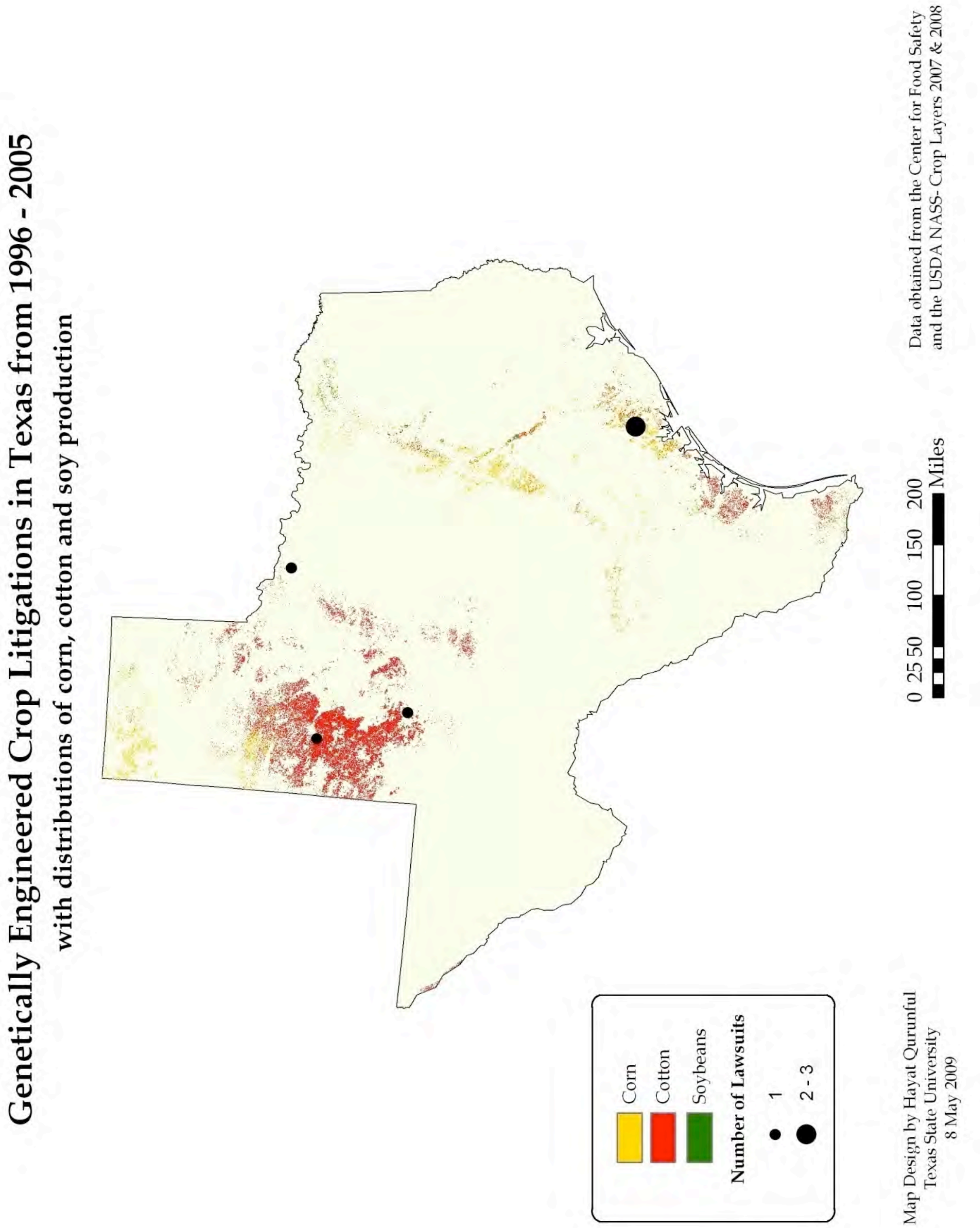


Figure 18 GE Crop Litigations Against Farmers in Texas

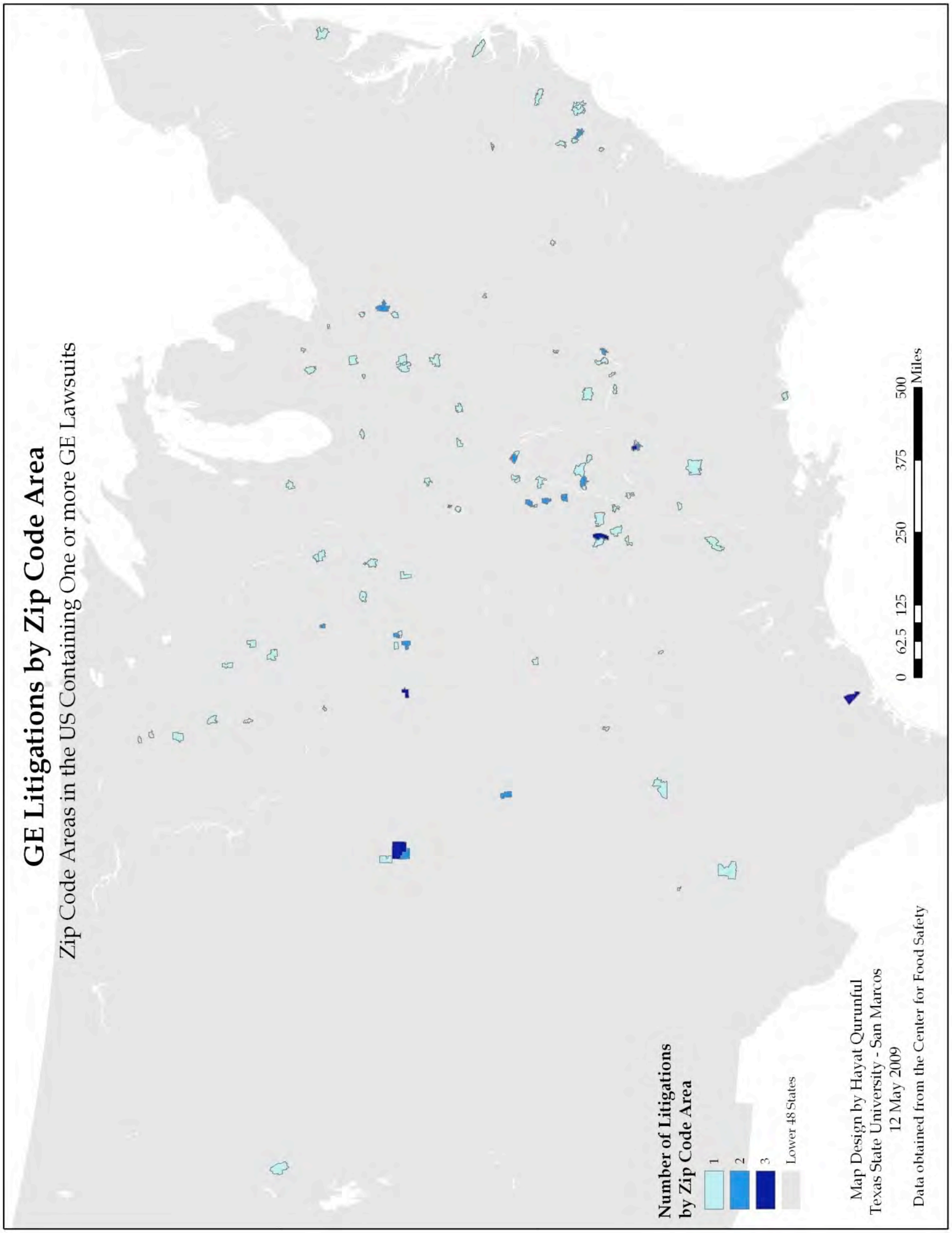


Figure 19 GE Litigations by Zip Code Areas

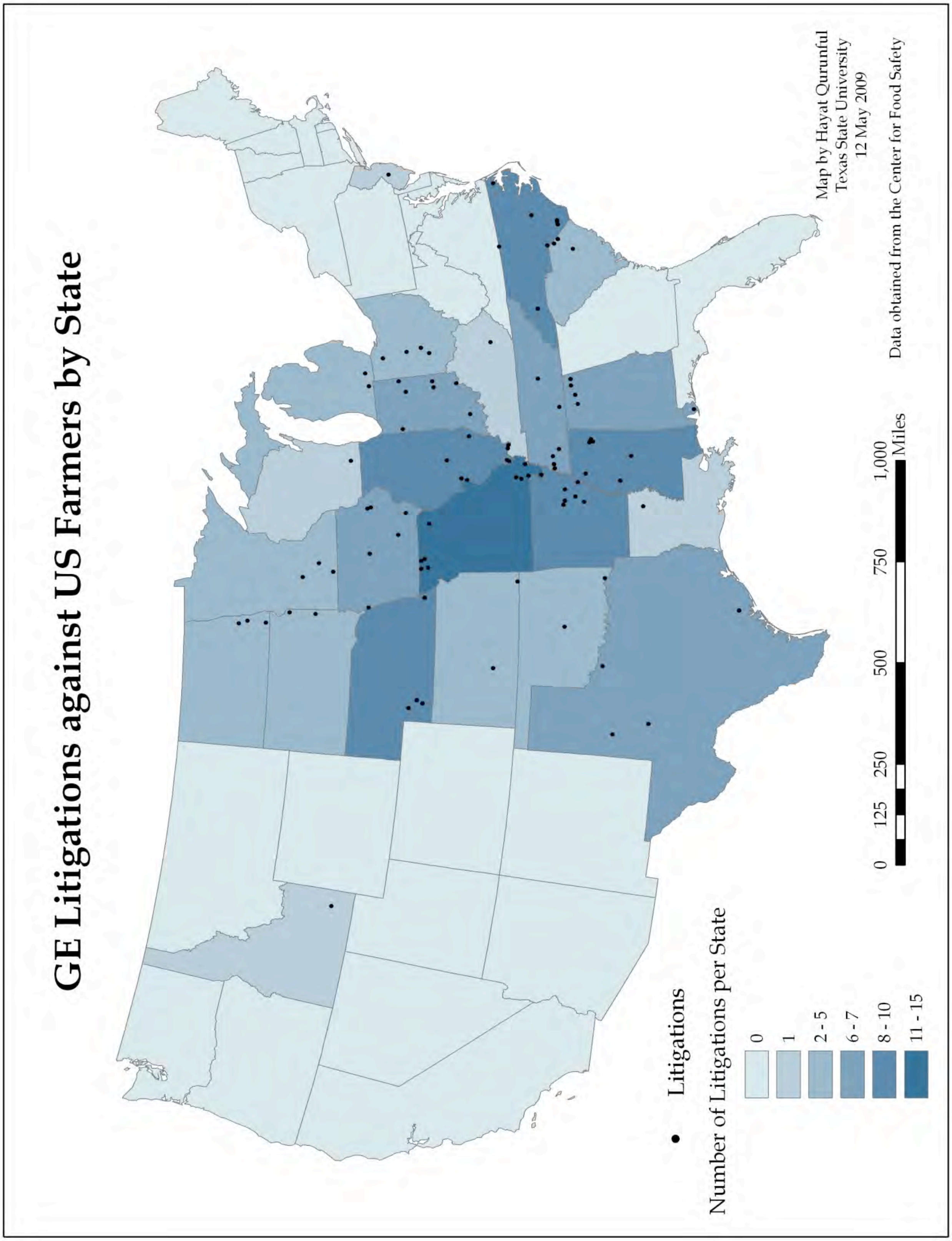


Figure 20 GE Litigations against U.S. Farmers by State

6. Conclusion

Plant genetic engineering will only grow more relevant as the many legal, genetic, geographic and biological concerns surrounding the issue come to focus. It is important that people of all backgrounds familiarize themselves with these matters, especially farmers and those involved in agriculture. From this research several trends have been observed, some that could be mapped and others that could not.

During the data collection process, it became evident that approximately half of the farmers involved in lawsuits with Monsanto were required to travel to St. Louis to present their case, bringing a lawyer with them or finding one there. Also, the data and the maps included in this thesis illustrate the direct correlation between GE crop litigations from 1996 to 2005 with the location of Monsanto's headquarters in St. Louis, Missouri. That state contains more GE lawsuits than any other state, verification of this link.

Information released by Monsanto and on the website of the Center for Food Safety, titled *November 2007 Monsanto vs. U.S. Farmers Report Update* was very interesting and would have been fascinating to map, except for the way the data was presented. The Center for Food Safety has this document on their website as a resource in part because Monsanto took the information it provides off of their website in 2007. This document contains information on the investigations and litigations against U.S. farmers in selected U.S. states listing the numbers of counties involved, as well as average and maximum settlement amounts, and minimum and maximum numbers of cases and funds collected by Monsanto. This data is fascinating and could be analyzed spatially if it were not so vague. The large ranges of minimum and maximum values make it very difficult to present an accurate representation of the activity taking place. As a result, a map was not made for that data. This is an example of the difficulty in finding data on GE crops. It is of great significance however, that the Center for Food Safety provides the information they do for people to learn more about plant genetic engineering and Monsanto's involvement.

In the future, it is my hope that more data concerning the location of genetically engineered crops be made available. Additional methods of analyzing the spatial distribution of GE seed litigation include a wind map of the U.S., showing potential wind patterns and possible areas of contamination given the airflow. The issue of cross contamination of GE crops with traditional ones will continue to increase, as the myriad forms of pollination make the avenues for contagion high. Policy makers and citizens alike will have to take action to change the current course if farmers are to be protected from liability due to transgenic contamination.

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8. Appendix – Monsanto Legal Documents

1.1 Monsanto Product Service Form. Monsanto Canada. www.percyschmeiser.com accessed 9 May 2009

09/30/2005 16:47 306-244-2966 ROBINSON INVESTIGAT PAGE 02

MONSANTO imagine

PRODUCT SERVICE FORM 2005_300001

Please fax completed forms to 1-866-849-3516 (Western Canada), 1-519-823-9733 (Eastern Canada)

STEP 1
Retailer Name: ______ Town: ______ Province: ______

STEP 2 Date of Initial Contact: 26/09/05 (example – 1st field visit) TAP# ______

Grower's Name Percy Schmeiser Address ______

Grower Phone: (306) 369-2520 Town: Bruno Province: Sk Postal Code: ______

STEP 3 Planting Date: dd / mm / yyyy

Product Purchased: ______ Volume Used: ______ (L/Kg) Rate: ______ /Acre Crop: ______

Explanation of Problem / Recommendation: Removal of canola plants by hand raging.

STEP 4 Product to Release: (Note: Use Only ONE Product Per Product Service Form)
Please include Seed Treatment with Seed Selection

- [ ] DK Corn Hybrid + Treatment ______
- [ ] DK/FLS Soybean Variety + Treatment ______
- [ ] DK Canola Variety + Treatment ______
- [ ] Advanta Sunflower Variety + Treatment ______
- [ ] Advanta Canola Variety + Treatment ______
- [ ] HiStick (Case)

Release Type: (Note: Use Only ONE Release Type Per Product Service Form)

- [ ] Re-Seed
- [ ] Product Quality
- [ ] Product Inquiry
- [ ] Risk Share
- [x] Unexpected Volunteers

STEP 5 FINAL RELEASE AND SETTLEMENT OF CLAIM

IN CONSIDERATION OF the delivery of ______ Amount of ______ Product by Retailer, acting as agent for, Monsanto Canada Inc.(Monsanto), to the Grower, the receipt and sufficiency of which is hereby acknowledged, THE GROWER does hereby for himself and/or the corporation, his heirs, executors, partners, joint venturers, administrators, successors, affiliates, subsidiaries and assigns, release and forever discharge Monsanto Canada Inc., its affiliates, successors and assigns, and its officers, directors, employees, servants and agents (past, present and future) (hereinafter referred to as the "Releasees") from any and all actions, causes of action, suits, claims, demands and damages of whatever nature or kind for, upon or by reason of any damage or loss to person and/or property which has been or may be sustained in consequence of the purchase, use and/or application of Product described in Step 3 above.
AND FOR THE SAID CONSIDERATION the undersigned further agrees not to make any claim or take any proceedings against any other person, firm, corporation or other legal entity who might claim contribution or indemnity from the Releasees or any of them, under the provisions of any statute or otherwise.
IT IS UNDERSTOOD AND AGREED that the said delivery of product is not deemed to be an admission of liability on the part of any of the Releasees.
IT IS FURTHER UNDERSTOOD AND AGREED that the terms of this Final Release & Settlement of Claim shall be treated as confidential and shall not be disclosed to others without the written consent of Monsanto Canada Inc.
AND it is hereby declared that the terms of this settlement are fully understood; that the amount stated herein is the sole consideration for this release and that the said product is accepted voluntarily for the purpose of making a full and final compromise, adjustment and settlement of all claims for losses and damages resulting or to result from any of the matters referred to in this release.

WITNESS our hand this 30th day of September, 2005

Witness Signature ______ Grower Signature X ______

MONSANTO REP SIGNATURE ______

I ______ (first and last name) on behalf of ______ (company name & location) do hereby solemnly swear that the aforementioned customer has in fact received his product or a credit representing the retail value of the product as set forth hereinabove and am therefore claiming reimbursement for said product.

Date: dd / mm / yyyy Retail Signature ______ Retailer Invoice # ______

This document becomes null and void if not completed (including all signatures) and processed by Monsanto prior to Dec. 31, 2006

White copy to Monsanto Pink copy to Retailer Gold copy to Farmer

When all required signatures have been obtained, please fax to Monsanto at 1-866-849-3516 Western Canada or 1-519-823-9733 Eastern Canada

See attached page 1 & 4 for better reading of step 5

Text from Step 5 (darkened area) of Monsanto Product Service Form:

IN CONSIDERATION OF: the delivery of _______________ amount of _____________ Product by Retailer acting as agent for Monsanto Canada Inc. (Monsanto), to the grower, the receipt and sufficiency of which is hereby acknowledged, THE GROWER does hereby for himself and/or the corporation, his heirs, executors, partners, joint ventures, administrators, successors, affiliates, subsidiaries, and assigns, release and forever discharge Monsanto Canada Inc., its affiliates, successors, and assigns and its others, directors, employees, servants and agents (Past, present and future) (hereinafter referred to as the, "Releasees",) from any and all actions, causes of action, suits, claims, demands and damages of whatever nature or kind for, upon or by reason of any damage, or loss to person an/or property which has been or may be sustained in consequence of the purchase, use and/or application of Product described in Step 3 above.

AND FOR THE SAID CONSIDERATION the undersigned further agrees not to make any claim or take any proceedings against any other person, firm, corporation, or other legal entity, who might claim contribution or indemnity from the Releasees, or any of them under the provisions of any statute or otherwise.

IT IS UNDERSTOOD AND AGREED that the said delivery of product is not deemed to be an admission of liability on the part of any of the Releasees.

IT IS FURTHER UNDEERSTOOD and agreed that the terms of this Final Release & Settlement of Claim shall be treated as confidential and shall not be disclosed to others without the written consent of Monsanto Canada, Inc.

AND it is hereby declared that the terms of this settlement are fairly understood, that the amounts stated herein is the sole consideration for this release and that, the said product is accepted voluntarily for the purpose of making a full and final compromise, adjustment and settlement of all claims for losses and damages resulting, or to result from any of the matters referred to in this release.

1.2 Monsanto Technology Use Agreement WWW Document:
http://percyschmeiser.com/TUA.htm Accessed 3 May 2009

Seed the Technology,
Harvest the Rewards.

Roundup Ready® CANOLA

TECHNOLOGY USE AGREEMENT
TERMS AND CONDITIONS

1. **The Grower shall use any purchased Roundup Ready® canola seed for planting one and only one crop for resale for consumption. The Grower agrees not to save seed produced from Roundup Ready canola seed for the purpose of replanting nor to sell, give, transfer or otherwise convey any such seed for the purpose of replanting. The Grower also agrees not to harvest any volunteer Roundup Ready canola seed crops.**

2. The Grower shall purchase and use only Roundup® branded herbicide labelled for use on all Roundup Ready canola seed purchased. The Grower shall purchase both the Roundup branded herbicide and the Technology Use Agreement as a package from his retailer of choice. The Seed Purchase Fee shall be non refundable after the date of reconciliation of actual acres planted as set forth in the Monsanto Roundup Ready canola service policy.

3. Monsanto warrants the tolerance of plants from Roundup Ready canola seed to Roundup herbicide when used at specified label rates and as per label instruction.

4. The Grower grants Monsanto the right to inspect, take samples and test all of the Grower's owned and/or leased fields planted with canola, or any other land farmed by the Grower, and to monitor the Grower's canola fields and storage bins for the following three years for compliance with the terms of this Agreement. All such inspections shall be performed at a reasonable time, and if possible, in the presence of the Grower. The Grower also agrees to supply upon request the locations of all fields planted with canola in the following three years. Grower has or shall obtain all permissions required for Monsanto to exercise this right to inspect, take samples and test.

5. If the Grower violates any of the Terms and Conditions of this Agreement, the Grower shall forfeit any right to obtain any Agreement in the future and this Agreement may, at Monsanto's option, be terminated immediately. In the event of any use of Roundup Ready canola seed which is not specifically authorized in this Agreement, the Grower agrees that Monsanto will incur a substantial risk of losing control of Roundup Ready canola seed and that it may not be possible to accurately determine the amount of Monsanto's damages. The Grower therefore agrees:
   a) to pay Monsanto $15.00 per acre for every acre planted with Roundup Ready canola seed not covered by this Agreement; and
   b) to deliver to Monsanto or its designated agent, at the Grower's expense, all seed containing the Roundup Ready gene that results from the unauthorized use of Roundup Ready canola; or at Monsanto's option, the Grower shall destroy all crop containing the Roundup Ready gene resulting from the unauthorized use of Roundup Ready canola; and
   c) if the Grower sells, gives, transfers or otherwise conveys any seed containing the Roundup Ready gene contrary to the Terms and Conditions of this Agreement, the Grower shall pay to Monsanto a sum equal to $15.00 for each acre capable of being planted using the seed that was sold, given, transferred or otherwise conveyed, or a sum equal to the amount received by the Grower for the seed that was sold, given, transferred or otherwise conveyed, whichever is greater; and
   d) to pay Monsanto all costs incurred by it as a result of the Grower breaking any of the terms and conditions of this Agreement, including all legal fees and disbursements incurred by Monsanto on a solicitor and client basis.

6. The Terms and Conditions of this Agreement are personal to the Grower and shall be binding and have full force and effect on the heirs, personal representatives, successors and permitted assigns of the Grower, but the Grower's rights hereunder shall not otherwise be transferable or assignable without the express written consent of Monsanto.

7. All Terms, Conditions and provisions of this Agreement are severable, and any Term, Condition or provision or application thereof which may be prohibited or unenforceable by law shall be ineffective to the extent of such prohibition or unenforceability without affecting the remainder of this Agreement or any other application of such Term, Condition or provision. The use of the title "Technology Use Agreement" is for convenience of reference only and shall not affect or be utilized in the construction or interpretation of this Agreement.

Only Roundup Transorb and Roundup Original herbicides are registered for use on Roundup Ready canola.
Please read and follow label directions for all Roundup branded herbicides prior to use Roundup, Roundup Ready, Roundup Original and Roundup Transorb are trademarks of Monsanto Company Monsanto Canada Inc., licensee © Monsanto Canada, Inc.

1.3 Letter to farmer notifying of impending litigation or "options for settlement".
www.percyschmeiser.com WWW Doc. accessed 9 May 2009

MONSANTO
Food · Health · Hope

MONSANTO CANADA INC.
AGRICULTURAL SECTOR
206 - 111 RESEARCH DRIVE
SASKATOON, SASKATCHEWAN S7N 3R2
PHONE (306) 975 1394
FAX (306) 975 1147

January 23, 2002

Carlyle Moritz
519 Railway Ave. S.
Bruno, SK S0K 0S0

Dear Carlyle Moritz:

<u>**Re: Roundup Ready® Canola**</u>

You may recall that in 2001 Monsanto, with the assistance of Robinson Investigations Ltd., conducted an investigation to determine whether or not you had improperly planted Roundup Ready® canola.

As a result of this investigation, Monsanto has concluded that Roundup Ready® canola was improperly planted on 140 acres on the following land locations:

NW 16 38 26 W2

More than 30,000 customers have fulfilled the Roundup Ready® canola licensing requirements, which include signing a Grower Agreement and Technology Use Agreement and paying a technology licensing fee of $15.00 per acre. When producers plant Roundup Ready® canola without complying with these requirements, they are not only (in our opinion) infringing the patent that exists on this technology, but are also gaining an unfair advantage over those farmers who are willingly paying for this technology because of the value it provides.

Please contact either myself at (306) 657-4655 or Rob Chomyn at (306) 657-4653 within 30 days, so that we may discuss this matter and your options for settlement.

Yours truly,

Aaron Mitchell
Intellectual Property Protection Manager

AM/la