EXHIBIT C

UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF VERMONT

GROCERY MANUFACTURERS ASSOCIATION, SNACK FOOD ASSOCIATION, INTERNATIONAL DAIRY FOODS ASSOCIATION, and NATIONAL ASSOCIATION OF MANUFACTURERS,

Plaintiffs,

v.

WILLIAM H. SORRELL, in his official capacity as the Attorney General of Vermont, PETER E. SHUMLIN, in his official capacity as Governor of Vermont; TRACY DOLAN, in her official capacity as Commissioner of the Vermont Department of Health; and JAMES B. REARDON, in his official capacity as Commissioner of the Vermont Department of Finance and Management,

Defendants.

Case No. 5:14-cv-117

DECLARATION OF DR. CHARLES M. BENBROOK

Introduction and Major Conclusions

1. I, Charles M. Benbrook, make this declaration pursuant to Federal Rule of Evidence 702. My *curriculum vitae* is attached as Exhibit 1 to this declaration.

2. In the course of preparing this report, I read Vermont's Act 120 governing the labeling of GE foods, the "Frequently Asked Questions" regarding Act 120, and the implementing rules for the Act. I also read documents developed as part of this litigation, including Plaintiffs' Motion for a Preliminary Injunction, Plaintiffs' Opposition to Motion to Dismiss, and the Declaration of Dr. Alan McHughen that Plaintiffs submitted in support of their Motion for a Preliminary Injunction. I also have read, and taken into account in forming my

opinions, documents provided to, and reviewed by, the Vermont Legislature during its deliberations on the legislation that became Act 120.

3. The principal conclusions of my report are as follows:

   i. **GE plants are not the same as natural plants.** Genetically engineered crops, and the foods manufactured from them, are different from traditional crops and the foods manufactured from traditional crops. Genetically engineered crops are therefore not "natural" within the common understanding of that term.

   ii. **GE plants have led to herbicide-resistant weeds and insecticide-resistant insects.** The recurrent and widespread planting of genetically engineered, herbicide-tolerant crop varieties has led to the emergence and spread of herbicide-resistant weeds. Glyphosate-resistant weeds are now present on around 100 million acres – about two-thirds of the annual acreage planted to a GE crop variety. More frequent applications of a greater number of herbicides, often at higher doses, are required to contain the spread of resistant weeds. As a result, reliance on 2,4-D, dicamba, and paraquat – three of the most hazardous herbicides still allowed for widespread use in the United States – has risen sharply in recent years. In addition, the use of crops genetically engineered to produce insecticidal toxins has led to the emergence and spread of insecticide-resistant insects.

   iii. **GE crops have led to increased pesticide use.** Genetically engineered, herbicide-tolerant corn, soybeans, and cotton have dramatically increased reliance on herbicides, as well as the volumes that farmers are spraying on their fields, with potential consequences for health and the environment. Over the last five years, GE corn has led to substantial increases in the total volume of insecticides and *Bt* toxins required to bring a crop to harvest.

   iv. **GE plants result in the contamination of non-GE crops.** It is impossible to contain the flow of genes from fields planted to most GE crop varieties to nearby, sexually compatible crops and/or weedy relatives. Sometimes pollen carrying genes from a GE crop move onto organic farms, or a farm producing for a market offering a premium for non-GE crops. As a result, the planting decisions made by one farmer can prove costly for neighboring organic and non-GE farmers, and ultimately raise doubts as to sustainability of certain forms of agriculture. The presence of even low levels of unapproved GE proteins in U.S.-grown food and animal-feed exports has cost U.S. agribusiness billions of dollars, and reduced farm income by billions more. It has also intensified concern in foreign countries over the quality and safety of food produced in the U.S., and the scientific rigor and completeness of U.S. regulatory programs.

   v. **GE plants present environmental risks.** Widespread planting of genetically engineered herbicide-tolerant crops, and the accompanying, recurrent use of broad-spectrum herbicides, have also reduced biodiversity in and around farm fields. As a result, there has been a dramatic decrease in the habitat supporting populations of pollinators and many beneficial insect species, including Monarch butterflies. And repeated applications of herbicides to herbicide-tolerant genetically engineered crops have altered the composition of soil microbial communities. Herbicides have also been detected in rain and groundwater, and in human urine and blood.

vi. **Existing studies do not demonstrate the safety of GE foods.** Very few, if any, studies by independent scientists have been published assessing the potential human health effects of the GE corn, soybean, and canola traits and varieties that are currently the most widely planted in the United States. Because of gaps in the science supporting the assessment of human health risks stemming from today's very heavy reliance on GE crop technology, and in particular on GE crops expressing multiple, stacked traits, I conclude that today's GE foods cannot be judged safe. Indeed, in my opinion, today's GE crop technology is among the least well studied agricultural technologies ever adopted from the perspective of human health risks.

Expert Background and Qualifications

4. I am currently a research professor at Washington State University's Center for Sustaining Agriculture and Natural Resources. I received a B.A. in Economics from Harvard University in 1971, and a Ph.D. in Agricultural Economics from the University of Wisconsin in 1980. I have worked on the impact of agricultural technology on pesticide use, pesticide efficacy, risks, public health, and costs for more than 30 years, as well as the impacts of regulatory policies, requirements, actions, and laws on pest management systems, pesticide use and risks, and food quality and safety.

5. I was the Staff Director for the House subcommittee with jurisdiction over the Federal Insecticide, Fungicide, and Rodenticide Act ("FIFRA") from 1981 to 1983. During this period, the first hearings were held leading to the passage of the Organic Food Production Act, legislation that became part of the 1990 Farm Bill. One of the critical issues at that time was the difference between "organic" and "natural" foods. Indeed, this core question has remained a recurrent issue over the last 25 years as the detailed rules governing the labeling of organic foods have been codified.

6. From 2006-2012 I served as Chief Scientist at The Organic Center, where I was responsible for tracking developments in the scientific literature, government agencies, food industry, and non-profit organizations impacting consumer understanding of, and confidence in, the official, U.S. Department of Agriculture ("USDA") "certified organic" seal.

7. I currently serve on the USDA's AC-21 Agricultural Biotechnology Advisory Committee. That committee issued a report in 2013 on "coexistence" between farmers planting fields to organic, conventional non-GE, and GE crops. I have actively participated in efforts to deal with the impacts of gene flow and contamination from GE crops to nearby, non-GE and organic crops.

8. I have served for several years on the technical standards committee of the Non-GMO Project. The Non-GMO Project manages a labeling program that verifies the absence of GE content in food products within the specific technical parameters set forth by the organization. Food products that meet the Non-GMO Project's technical parameters are authorized to bear the "Non-GMO Project" label. As part of its central mission, and in order to determine appropriate technical parameters, the Non-GMO Project examines issues concerning plant breeding, pesticide usage, animal drug (e.g., antibiotics and hormones) usage, food ingredient manufacturing processes, and use of GE ingredients by food manufacturers.

9. Since 1990, I have been President of Benbrook Consulting Services, a small consulting firm conducting projects on agricultural technology, food safety and quality, and pesticide use and regulation. For a variety of clients since the mid-1990s, I have reviewed petitions and other documents submitted by biotechnology companies seeking government approval (i.e., "deregulation") of a new GE trait or crop.

10. I have studied over many years the content and impacts of Food and Drug Administration ("FDA") assessments of the safety of GE crops, and Environmental Protection Agency ("EPA") pesticide program decisions and policies relevant to insect-protected GE crops and herbicide-tolerant GE crops.

11. I have written extensively on the impacts of the commercialization of GE crops on pesticide use (encompassing both the use of insecticides and herbicides), the efficacy of pest control systems, the emergence and spread of resistant pests, and the human health and environmental impacts of pesticides. As discussed in greater detail below, in 2012 I published a peer-reviewed paper on the impact of GE crops on pesticide use in the U.S.[1]

12. In 2007, I published a peer-reviewed paper in a book entitled *Biodiversity & the Law: Intellectual Property, Biotechnology & Traditional Knowledge.*[2] My chapter was entitled "Principles Governing the Long-Run Risks, Benefits and Costs of Agricultural Biotechnology." In that chapter I discuss, in detail, the principles that should be applied to any technology in evaluating its possible or actual impacts. The characteristics of today's GE crops were appraised relative to a set of "first principles" for safe and sustainable agriculture, both in the U.S. and in developing countries.

13. I have followed the scientific literature on the characterization, efficacy, costs, human safety, environmental impacts, and nutritional equivalence of GE crops. I was invited along with 20 other scientists to make a presentation on September 15, 2014, before the opening

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[1] Benbrook, C. 2012. Impact of genetically engineered crops on pesticide use in the U.S. - the first sixteen years. *Environmental Sciences Europe* 24:24. Available at: http://www.enveurope.com/content/24/1/24.

[2] Benbrook, C. 2007. Principles Governing the Long-Run Risks, Benefits, and Costs of Agricultural Biotechnology. *Biodiversity and the Law: Intellectual Property, Biotechnology, and Traditional Knowledge* 149-167. Charles McManis, ed., Earthscan, 2007.

meeting of a newly formed National Academy of Sciences Committee charged with assessment of the risks, benefits, and costs of GE crop technology.

14. I serve as an expert witness in two other cases involving the labeling of foods derived from GE corn, soybeans, and canola. One focuses on Wesson oils extracted from GE corn, soybeans, and canola that were labeled "all natural," and the second case involves certain Kashi products that bear an "all natural" label on their packaging. Exhibit 2 lists my past litigation experience and includes cases in which I have prepared an expert report, testified at trial, or been deposed.

GE Plants Differ From Those Found In Nature

15. Genetic engineering is a laboratory-based process that typically entails moving genetic material from one organism, such as a bacterium, into the genome (i.e., the set of genetic material) of another organism, such as a plant. Several genetic engineering techniques exist, and more will almost certainly be developed in the future. Regardless of the specific methods used to create a given GE event within a genetically engineered plant, however, the process relied upon is inherently artificial and unnatural, and the transferred material could not be moved into the plant's genome via normal reproductive and/or plant breeding processes.

16. Several of the essential genetic elements within so-called transgenes (i.e., the foreign genetic material that is moved from one set of organisms into a plant genome) are synthetic constructs, pieced together through a carefully sequenced series of genetic-engineering modifications that entail both eliminating some DNA that would undermine performance in the transformed plant, and adding elements to regulate expression of foreign DNA in the target plant. The combination of genetic transformations required to move foreign DNA into a plant genome,

and then gain its expression – and the right amount of expression at the correct time – could not occur as a result of natural processes.

17. For example, the genes and genetic elements listed below, which are some of the major traits used in GE crops, would not be found in commercial crops without genetic engineering:

- <u>YieldGard, MON810 Corn</u>: Corn containing the *Bt* trait Cry1Ab (an insect toxin) was introduced in 1997 and remains one of the top three traits incorporated into corn hybrids. It was created to control *Lepidoptera* (moth) pests, mainly the European corn borer, and, secondarily, the corn earworm. The engineered gene of primary interest is the Cry1Ab gene from the soil bacterium *Bacillus thuringiensis* (*Bt*). This gene would not be found in corn or other plants through processes other than genetic engineering. The GE corn also contains "promoter" elements (gene sequences that regulate when a gene is expressed, or turned on) derived from the virus CaMV (Cauliflower Mosaic Virus). That viral promoter is rarely found in plant genomes in the wild, other than at CaMV sites of infection in susceptible plants, and has been further manipulated before insertion into the YieldGard GE corn.

- <u>NK603, EPSPS ("Roundup Ready") Corn</u>: NK603 corn contains the CP4-EPSPS gene, which confers resistance to the herbicide glyphosate. That gene was taken from the bacterium *Agrobacterium tumafaciens*. In addition, the CP4-EPSPS gene has had a "transit peptide" (CTP2) from the weed *Arabidopsis thaliana* attached to it. It would be extremely unlikely that the bacterial EPSPS gene would end up in corn, or that any of the other genetic elements required to express and regulate the EPSPS gene would also be present in the same corn.

- <u>Roundup Ready Soybeans</u>: Glyphosate tolerant soybeans contain the same basic genetic elements as NK603 corn (discussed above), except that instead of the *Arabidopsis* transit peptide, the CP4-EPSPS gene contains a transit peptide (CTP4) from petunia (*Petunia hybrida*). As with NK603 corn, none of these genes or genetic elements would be found in soybeans without genetic engineering.

- <u>MON863 RootGard Corn</u>: The Cry3Bb1 gene in the MON863 corn event produces in the cells of corn plants a *Bt* endotoxin that controls the larvae of corn rootworm beetles and certain other soil-dwelling insects. The MON863 Cry3Bb1 gene is an altered version of the gene found in a strain of the bacterium *Bacillus thuringiensis*. The Cry3Bb1 bacterial gene, either in its full, unaltered form or in the truncated (activated) form introduced into GE events, would not be found in plants without the genetic engineering process. The GE RootGard Corn also contains genetic regulatory elements (i.e., elements that control the expression of the targeted gene) taken from the CaMV virus, wheat, and rice.

- Kanamycin Resistance Gene (npt11): RootGard corn also contains an antibiotic resistance gene that serves as a selectable marker. This gene is derived from a soil bacterium and codes for resistance to the antibiotic kanamycin (npt11). This gene does not have a purposeful, agronomic function, but is used to isolate the small percentage of transformed callous cells that contain and express the desired genes, after the transgene is introduced into the plant tissue. As with the other examples set forth above, finding any one of these genetic elements in corn, or any other plant, would be exceedingly unlikely, and finding them all together could only occur through genetic engineering.

- Roundup Ready Canola, RT73: The 247gox syn gene is a synthetic version of an oxidoreductase gene that metabolizes glyphosate and makes it harmless to a transformed crop. It is from a bacterium, *Orchobacter anthropi*, and so this gene would not be found in plants in nature. In addition, its sequence was altered in the lab, and so again would not be found in nature. This gene is turned on by a promoter from the 35S figwort mosaic virus, which is not typically found in plants (except at sites of infection in susceptible plants), and contains genetic elements from other organisms as well.

18. Accordingly, I conclude that the plants that are the end product of genetic engineering have been rendered artificial through a synthetic process of genetic manipulation. Hence, any foods, or food ingredients, derived from them cannot accurately be called or characterized as natural.

19. Indeed, the biotechnology industry has issued formal statements and definitions discussing the nature of food produced from GE crops, and those definitions make clear that GE foods are not the same as those found in nature.

20. For example, Monsanto, the market leader in the biotechnology industry, offers this definition of GMO: "Genetically Modified Organisms (GMO) – Plants or animals that have had their genetic makeup altered to exhibit traits ***that are not naturally theirs***. In general, genes are taken (copied) from one organism that shows a desired trait and transferred into the genetic code of another organism."[3] The crux of this definition is that a GMO has had its "genetic

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[3] Monsanto, *Glossary*, http://www.monsanto.com/newsviews/pages/glossary.aspx (emphasis added).

makeup" changed in a way that makes possible the expression of a novel trait that is not natural, or, in Monsanto's own words, "not naturally theirs." The World Health Organization's definition is similar: "Genetically modified organisms (GMOs) can be defined as organisms . . . in which the genetic material (DNA) has been altered in a way ***that does not occur naturally***."[4]

21. Significantly, the biotechnology companies that have created and sought patent protection for these (and other) GE traits and/or GE crops assert in their own patent applications that the traits and GE crops are unique and non-natural because of the insertion and expression of foreign DNA.

22. For example, Monsanto holds U.S. Patent No. 6,063,597, which covers YieldGard rootworm corn expressing the Cry 3Bb *Bt* endotoxin. The abstract of that patent states: "Disclosed are Coleopteran-toxic *B. thuringiensis* delta-endotoxins, nucleic acid sequences, and transgenic plants expressing these genes. Methods of making and using these genes and proteins are disclosed as well as methods for the recombinant expression, and transformation of suitable host cells." The abstract further states that it discloses "novel methods for constructing synthetic Cry3* proteins, ***synthetically-modified nucleic acid sequences*** encoding such proteins, and compositions arising therefrom." U.S. Patent No. 6,063,597, col. 7 (emphasis added). Not only are the genes expressing the Cry3Bb endotoxin extracted from bacteria, but they are also altered into a synthetic form to enhance their performance in the target plants. The multiple alterations of the natural Cry3Bb gene through this patented process are described in great detail in the patent, and the alterations include "at least one amino acid substitution, one amino acid addition,

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[4] World Health Organization, *Frequently Asked Questions on Genetically Modified Foods*, http://www.who.int/foodsafety/areas_work/food-technology/faq-genetically-modified-food/en/ (emphasis added).

or one amino acid deletion in the primary sequence of the native or unmodified Cry3Bb polypeptide." U.S. Patent No. 6,063,597, col. 793.

23. Indeed, GE plants are not "natural" under the common understanding of that term. For example, Merriam-Webster's dictionary defines "natural" as "existing in nature and not made or caused by people."[5] The Oxford Dictionaries likewise defines "natural" as "existing in or caused by nature; not made or caused by humankind."[6] It is undisputed that GE plants are "made or caused by people" – as discussed above, biotechnology developers themselves state as much.

GE Plants Have Led To The Emergence And Spread Of Pesticide-Resistant Weeds And Insects

24. Herbicide-tolerant crop technology is designed to enhance the farmer's ability to spray specific herbicides to kill weeds without killing the crop (e.g., corn). The vast majority of GE, herbicide-tolerant crop acreage has been planted to glyphosate-tolerant, "Roundup Ready" varieties.

25. Herbicide-tolerant corn, soybeans, and cotton were first planted commercially in 1996. Two years later, in 1998, 42.6 million acres of these three herbicide-tolerant crops were planted, corresponding to nearly 25% of the total acres planted to these three crops. Planting of genetically engineered herbicide-tolerant corn, soybeans, and cotton rose dramatically to 132.4 million acres in 2008. That represents 77% of the total acreage planted to these three crops. By 2013, fully 84% of the 185 million acres planted to corn, soybeans, and cotton were planted to genetically engineered herbicide-tolerant varieties. The data through 2011 come from the published, supplemental tables that accompanied a journal article I published in September 2012

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[5] Merriam-Webster, *Natural*, http://www.merriam-webster.com/dictionary/natural.

[6] Oxford Dictionaries, *Natural*, http://www.oxforddictionaries.com/us/definition/american_english/natural.

in *Environmental Sciences Europe*.[7] The data through 2011, and more recent years, come from annual USDA statistical series on the planting of GE crops and pesticide use levels (all sources fully referenced in the supplemental tables).

26. Over-reliance by farmers on herbicide-tolerant technology, and in particular on Roundup Ready corn, soybeans, and cotton, has imposed heavy selection pressure on weed populations. While weeds that were vulnerable to glyphosate would die when exposed to glyphosate, those that had developed resistance to glyphosate would survive and go to seed – and thus increase in number over time. Heavy and repeated applications of glyphosate have imposed very strong and continuous selection pressure on weed populations, favoring or "selecting" weed variants that are less susceptible to glyphosate. If such selection pressure continues for several years, the survival of less susceptible weed variants can eventually lead to the emergence and spread of fully resistant weeds. There are now about a dozen economically significant weeds in the U.S. that are resistant to glyphosate, and more than two-dozen worldwide.

27. The spread of glyphosate-resistant weeds has been remarkably rapid. When GE crop technology was introduced in 1996, there were essentially no glyphosate-resistant weeds in the Unites States. Stratus Agri-Marketing has conducted a series of surveys on the acreage infested with glyphosate-resistant weeds in the United States. On January 25, 2013, they reported that 61.2 million acres in 2012 were infested with one or more resistant weeds – about a 50% increase over the area infested in 2010 (40.7 million acres). Glyphosate-resistant weeds

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[7] Benbrook, C. 2012. Impacts of genetically engineered crops on pesticide use in the U.S. – the first sixteen years. *Environmental Sciences Europe* 24:24. Available at: http://www.enveurope.com/content/24/1/24. Supplemental tables available at: http://www.enveurope.com/content/24/1/24/additional.

have spread at a faster rate each year since 2010. And the percent of fields infested with two or more resistant weeds has increased from 12% in 2010 to 27% in 2012.[8]

28. Based on the Stratus results and academic research and commentary, I project that in 2014 there were between 110 million and 128 million acres infested with one or more glyphosate-resistant weeds, based upon a minimum projected increase of 80% from 2012 to 2014 and a maximum increase of 120%. During crop year 2014, the percentage with two or more resistant weeds was likely around 40%, with as much as 15% infested with three or more.

29. The rapid and dramatic spread of glyphosate-resistant weeds is triggering unprecedented changes in weed management systems, in part because there are no new "silver bullet" herbicides that farmers can switch to. In fact, there have been no new herbicides registered in 20 years that work through a novel mode of action (and hence would control resistant weeds).[9] And there is also no herbicide-based relief in sight. According to Michael Owen, Iowa State University weed management specialist, "it is very unlikely that new herbicides with new modes of action will be available within ten to 15 years."[10]

30. The increase in herbicide-resistant weeds has significant costs. Each glyphosate-resistant weed in a field increases the cost of herbicides by about $25.00 per acre, and requires farmers to spray one to three additional herbicides than they otherwise would.

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[8] Kent Fraser, *Glyphosate Resistant Weeds – Intensifying*, Stratus AG Research (Jan. 25, 2013), http://stratusresearch.com/blog/glyphosate-resistant-weeds-intensifying/.

[9] Gerwick. Thirty years of herbicide discovery: surveying the past and contemplating the future. *Agrow* (Silver Jubilee Edition) 2010, VII-IX.

[10] Owen, M. D. K. 2011. Weed resistance development and management in herbicide-tolerant crops: experiences from the USA. *J. Consumer Protection and Food Safety*, Supp. 1, 85-89.

31. Plants have also been genetically engineered to produce proteins that are toxic to insects. In 2014, about 75% of total national corn acres were planted to a GE hybrid expressing one to three *Bt* genes for corn rootworm control.

32. Multiple papers in peer-reviewed publications have shown that the planting of *Bt* corn has led to the emergence and spread of corn insects resistant to various *Bt* toxins (just as the use of genetically engineered Roundup Ready crops has led to the spread of herbicide-resistant weeds).

33. The first major paper documenting insect resistance to a common *Bt* endotoxin in GE corn (Cry3Bb1) was written by a team led by Aaron Gassmann of Iowa State University. The team documented resistance to Cry3Bb1 endotoxins in corn rootworms from fields planted for three consecutive years to GE corn expressing this form of *Bt*. According to the team, "[t]his is the first report of field-evolved resistance to a *Bt* toxin by the western corn rootworm and by any species of Coleoptera. Insufficient planting of refuges and non-recessive inheritance of resistance may have contributed to resistance."[11] Subsequent studies have also documented resistance in insects targeted by the *Bt* endotoxins expressed in GE *Bt* corn and cotton cultivars. For example, a 2013 paper by Gassmann's team reported resistance in corn rootworm populations to multiple *Bt* endotoxins in "stacked" varieties of *Bt* corn expressing two to six *Bt* genes.[12]

34. The initial approvals of genetically engineered *Bt*-corn varieties required farmers to plant sections in each field to a non-*Bt* corn cultivar. Such areas in cornfields serve as

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[11] Gassmann, et al. 2011. Field Evolved Resistance to *Bt* Maize in Western Corn Rootworm. *PlosOne,* Vol. 6(7): e22629.

[12] Gassmann, et al. 2013. Field-evolved resistance by western corn rootworm to multiple Bacillus thuringiensis toxins in transgenic maize. *Proc. Nat. Acad. Sciences*, 111: 5141-5146.

"refuges" where insects susceptible to *Bt* endotoxins will presumably survive, and then hopefully breed with any resistant insects that survive in the portions of fields planted to *Bt* corn (thus preventing the evolution of Bt-resistant insects). Over approximately the first decade of *Bt* corn use, a mandatory 25% refuge was required on all fields in which *Bt* corn was planted.

35. Unfortunately, compliance with *Bt*-corn refuge requirements was spotty. In 2010, for example, more than 41% of corn farmers did not comply with mandatory *Bt* corn resistance management provisions.[13]

36. In order to slow the spread of insects resistant to key *Bt* endotoxins produced by *Bt* corn hybrids, both the seed industry and academic insect pest management specialists are now recommending that farmers apply soil insecticides when they plant GE-*Bt* corn varieties, especially in areas where there already is evidence pointing to the presence of resistant or tolerant insect populations. For example, Dr. Michael Gray, the leading corn insect pest management specialist at the University of Illinois, has surveyed Illinois farmers in recent years regarding their intentions to apply soil insecticides in fields planted to *Bt* corn. In 2013, growers in multiple regions of Illinois reported they would apply soil insecticides on 39% to 56% of *Bt*-corn acres planted.[14] In 2014, it is likely that about 40% of total corn acres were also treated with a soil insecticide targeting the corn rootworm.

37. In the decade before the introduction of *Bt* corn for rootworm control, in contrast, between 18% and 23% of corn acres were sprayed with a soil insecticide. Accordingly, corn

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[13] Jack Kaskey,*Gene-Modified Corn Violations Triple Among U.S. Farmers*, Bloomberg Businessweek (Feb. 9, 2012), http://www.businessweek.com/news/2012-02-09/gene-modified-corn-violations-triple-among-u-s-farmers.html.

[14] Gray, M. 2013. Soil Insecticide Use on *Bt* Corn Expected to Increase this Spring Across Much of Illinois. *The Bulletin*. Univ. Illinois, March 28, 2013.

soil insecticide use has ***risen*** well above the pre-GE era levels – despite the fact that over two-thirds of national corn acres were planted to GE *Bt* corn hybrids in to control the corn rootworm.

The Impacts of GE Crops on Pesticide Use and Risks

38. I have carried out several studies on the impact of genetically engineered crops on pesticide use in the U.S. In 2012, I published a paper setting forth data sources, methodology, and reporting results for the first 16 years of commercial use of GE crops (1996-2011).[15]

39. Through 2011, the three major GE crops planted by U.S. farmers had increased total pesticide use (i.e., herbicide use plus insecticide use) by 404 million pounds above the level it would likely have been in the absence of GE-crop technology. Herbicide use rose by 527 million pounds. *Bt* corn and cotton reduced conventional insecticide applications by 123 million pounds in the sixteen-year period (1996-2011) – though, as discussed below, that reduction has been more than offset by an increase in insecticidal Bt toxins produced by GE plants.

40. The annual rate of increase in the average pounds of herbicide active ingredient applied per acre planted to herbicide-tolerant corn, soybeans, and cotton is accelerating as farmers are compelled to manage one to three-or-more species of resistant weeds in most GE corn, soybean, and cotton fields. For example, in 2000, GE crops increased herbicide use by only 2.2 million pounds in the three major GE crops. The annual increase rose to 27 million pounds in 2005, 72 million in 2008, and 90 million in 2011.

41. I have recently updated my analysis of the impacts of GE crops on pesticide use, and will publish a paper in a peer-reviewed journal on such impacts through the first 20 years (1996-2015) in early 2015. The results of the updated analysis show that use of glyphosate has

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[15] Benbrook, C. 2012. Impact of genetically engineered crops on pesticide use in the U.S. - the first sixteen years. *Environmental Sciences Europe* 24:24. Available at: http://www.enveurope.com/content/24/1/24.

increased over 20-fold since the pre-GE crop era (before 1996). In 2014, around 240 million pounds of glyphosate were applied on U.S. agricultural land – almost two-thirds of a pound, on average, across every acre of cropland in the U.S. The rate of increase in total herbicide use on an annual basis has continued to rise, and now exceeds the level in 2011 by a wide margin.

42. Even worse is the escalation in the number of different herbicides that farmers must spray on acres infested with glyphosate-resistant weeds, the added costs for farmers, and the associated environmental and public health risks. Many of the additional herbicides that farmers are turning to are applied at low rates (0.1 to 0.5 pounds of active ingredient per acre) to very low-rates (0.01 to 0.1 pound of active ingredient per acre). Thus, applications of these more biologically active herbicides do not increase overall herbicide pounds applied significantly. But they can markedly increase costs and unintended environmental and public health impacts.

43. In addition, the biotechnology and seed industry is seeking approval of new herbicide-tolerant varieties engineered to withstand applications of older, higher-risk herbicides including 2,4-D and dicamba. The USDA recently approved (deregulated) combined glyphosate and 2,4-D herbicide-tolerant corn, and commercial plantings will begin in 2015. As a result, there will be substantial increases in the use of 2,4-D on corn.

44. In my 2012 *Environmental Sciences Europe* paper, I reported the results of projections of the increase in 2,4-D use on corn in the wake of USDA approval of 2,4-D HT corn. Based on plausible assumptions regarding the percent of acres treated (55%; the label allows 100%), application rates (0.84 pound; the label allows 1.0 pound), and number of applications (2.3; the label allows three), I projected a 60-fold increase in 2,4-D applications to corn, relative to the level of spraying in 2010. About 104 million pounds of 2,4-D would be sprayed on corn annually once this technology is adopted to the degree projected in the above

analysis. An increase in herbicide use of this magnitude would add about 1.2 pounds per acre of additional herbicide across all corn acres, and would constitute almost a 50% increase over current corn herbicide use.

45. 2,4-D, moreover, is prone to movement away from the fields it is sprayed on, via both spray drift and post-application volatilization. As a result, 2,4-D causes more instances of damage to non-target plants, trees, and vines than any other pesticide, according to a review of spray drift incidents in 2002, 2003, and 2004 compiled by the American Association of Pesticide Control Officials.[16]

46. Human exposures to 2,4-D increase the risk of birth defects, reproductive problems, and certain cancers, as discussed and documented at length in comments dated June 30, 2014, that I submitted to the docket on the pending approval of "Enlist" herbicides that contain both 2,4-D and glyphosate.[17]

47. As noted above, my analysis also showed a 123 million pound reduction in corn and cotton insecticide use between 1996 and 2011. That reduction in insecticide use is the result of planting GE crop varieties that express one or more *Bt* toxins (thus reducing the need to spray insecticides). But the reduction in the use of conventional insecticides was brought about by a dramatic increase in insecticidal *Bt* toxins expressed directly by the genetically engineered corn plants themselves. Thus, while GE *Bt* corn was introduced to reduce the volume of insecticides

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[16] AAPCO, *2005 Pesticide Drift Enforcement Survey Report*, http://www.aapco.org/documents/surveys/DriftEnforce05Rpt.html.

[17] Letter from Charles Benbrook to Administrator, Environmental Protection Agency, regarding Docket ID No. EPA-HQ-OPP-2014-0195 (June 30, 2014), available at: http://csanr.wsu.edu/wp-content/uploads/2014/06/EPA_24D_Comment.FINAL_.pdf. See also, *EWG, Scientists and Doctors Sign Letter Urging EPA to Reject Potent Herbicide Mix*, Environmental Working Group (June 30, 2014), available at: http://www.ewg.org/testimony-official-correspondence/ewg-scientists-and-doctors-sign-letter-urging-epa-reject-potent.

needed to produce a crop, it actually has increased the overall volume of insecticides needed to protect the crop from insect feeding damage.

48. Technology developers submit *Bt* expression level data (i.e., the amount of toxins produced by the GE plants) in whole corn and cotton plants to regulatory agencies. These data are summarized in Supplemental Tables 20-25 to the *Environmental Sciences Europe* paper. One widely planted *Bt* corn trait – MON 810, which expresses the Cry1Ab endotoxin – produces 0.183 pounds of Cry endotoxins per acre, based on the planting of 32,000 seeds per acre. The most common combination of two *Bt* toxins expressed in Dow AgroSciences-Pioneer corn hybrids produces 2.5 pounds of *Bt* endotoxins per acre. And SmartStax corn hybrids express six different *Bt* endotoxins that collectively produce a remarkable 3.7 pounds of endotoxins per acre. That corresponds to 19-times the average conventional insecticide rate of application in 2010.

49. In other words, while *Bt* plants reduce conventional insecticide use, they produce their own insecticides – the *Bt* endotoxins – and the volume of these toxins more than offsets the reduction in conventional insecticides. Prior to the emergence of *Bt* resistant insects (i.e., 1996-2010), corn aces planted to *Bt* hybrids expressing *Bt* endotoxins for control of both the European corn borer and corn rootworm *reduced* conventional insecticide use by about 0.21 pound per acre, but they also *produced* about 2 pounds of *Bt* endotoxins per acre. Ironically, in the last few years, a significant share of GE *Bt* corn acres have been sprayed with soil insecticides for rootworm control to help slow the spread of insects resistant to *Bt* endotoxins, further driving upward the ***total volume of insecticides*** compared to where it stood in 1996, at the beginning of the GE era.

50. *Bt* cotton plants produce far more *Bt* per acre than the natural *Bt* bacteria in the soil. Roughly 0.25 grams per hectare of *Bt* endotoxin is produced in the soil by natural *Bt*

bacteria (Blackwood and Buyer, 2004), compared to 400-1,000 grams per hectare in the case of *Bt* cotton, and 2,800-4,200 grams in the case of modern *Bt* corn varieties. Accordingly, *Bt* cotton produces up to 4,000-times more *Bt* than soil microorganisms per acre or on a given field, while *Bt* corn produces up to 16,800-times more.[18] The longer-term ecological consequences of such a profound change in the quantity of a ubiquitous soil bacterium are largely unknown.

Gene Flow From GE Crops To Non-GE Crops

51. One of the environmental and economic problems associated with GE crop technology arises as a result of "gene flow" from fields planted to GE crop varieties onto nearby fields growing non-GE crops. Gene flow refers to the transfer of genes from one population to another. In this context, it refers to the transfer of the genetically engineered transgene from GE crops to populations of non-GE crops (for example, by cross-pollination between GE and non-GE crops). For those consumers and markets not wanting food containing genetically engineered DNA, such gene flow contaminates non-GE crops with unwanted foreign genes.

52. Such gene flow between genetically engineered and non-GE crops is unavoidable, especially in the case of open-pollinated crops. And it has significant consequences for farmers, who may lose access to markets that pay a premium for organic or other non-GE crops. Such market impacts can hit an individual organic or non-GE producer, companies shipping grain, or food companies exporting products to GE-sensitive markets abroad.

53. There have been several past episodes of substantial costs being imposed on one group of farmers by the development and/or commercial release of a new GE variety. For example, genetically engineered StarLink corn and LibertyLink rice were found to have contaminated non-GE crops. Such an "adventitious presence" can trigger loss of foreign

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[18] Blackwood, C.B. and J.S. Buyer. 2004. Soil Microbial Communities Associated with Bt and Non-Bt Corn in Three soils. *J. Environ. Quality* 33:832-836.

markets and subsequent reductions in crop prices and farm income. And indeed, in both the StarLink and LibertyLink contamination cases, conventional grain producers suffered adverse marketing impacts as a result of the detection abroad of contamination in U.S. exports with a GE trait not approved, or wanted, in the importing country.

54. Currently there are two major ongoing episodes of market disruption triggered by the presence of unimproved and/or unwanted, and unlabeled GE traits in U.S. agricultural exports. The most significant involves Syngenta's Agrisure Viptera corn varieties, which are genetically engineered both to make the conversion of corn into ethanol more efficient and to control corn insects. China, however, has not approved for importation the trait that makes corn easier to convert to ethanol, even when found in trace amounts as a result of gene-flow contamination or incidental commingling during handling and transport. A lawsuit against the manufacturer has alleged nearly 3 billion dollars of damages to corn farmers, handlers, shippers, and exporters.

55. The second episode of market disruption involves the recent widespread planting of genetically engineered Roundup Ready alfalfa in the Pacific Northwest, where high-value shipments of top-quality alfalfa hay are being blocked to certain markets that have not approved and/or do not want to import hay with even a trace of genetically engineered "Roundup Ready" alfalfa. The Capital Press reported that China is importing 700,000 metric tons of high-value alfalfa, exports that are now in jeopardy because the Chinese detected traces of the unapproved (in China) Roundup Ready gene in supposedly non-GE alfalfa.[19] As a result, shipper-exporters are facing markedly higher testing and marketing costs. Investigations are ongoing to discover the source of the Roundup Ready gene in the alfalfa hay exports, but considerable evidence

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[19] Dan Wheat, *GMO test slows hay exports to China*, Capital Press (Sept. 25, 2014), http://www.capitalpress.com/20140925/gmo-test-slows-hay-exports-to-china.

points to a low-level of contamination of non-GE alfalfa seed. Alfalfa pollen can travel long distances, sometimes with the help of bees and other native pollinators. Hence, there is considerable risk of GE-gene contamination moving from a GE-alfalfa seed field to a nearby non-GE alfalfa seed field.

56. At the request of the Secretary of Agriculture Tom Vilsack, I participated in a "Alfalfa Coexistence Working Group" convened by USDA late in 2010 to advise the Secretary on options to address the gene flow and coexistence challenges that would arise in the event of approval (de-regulation) of RR alfalfa. Our working group recommended a range of measures to reduce the odds that low-level presence of the RR gene in alfalfa hay would curtail the supply (and thus increase the cost) of alfalfa hay for organic livestock producers, or disrupt exports of alfalfa seed and hay to GE-sensitive markets. There was widespread working group support for a maximum threshold for adventitious presence (i.e., contamination) of the Roundup Ready gene in non-GE and organic alfalfa seed of less than 0.1%. That is approximately the level that is detectable by current Chinese alfalfa hay test methods, and hence serves as a *de facto* threshold for imported hay or seed in that country.

57. A January 28, 2011, story ran in the *New York Times* reporting the approval of unrestricted planting of GE Roundup Ready alfalfa.[20] The story states that pressure from the biotechnology industry and farm groups during a Congressional hearing led Secretary Vilsack to drop a number of measures designed to help prevent gene flow, and reduce the chances of commercially significant RR-gene contamination in non-GE and organic alfalfa seed and hay.

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[20] Andrew Pollack, *U.S. Approves Genetically Altered Alfalfa*, N.Y. Times, Jan. 27, 2011, at B1, http://www.nytimes.com/2011/01/28/business/28alfalfa.html?_r=0.

The restrictions that were dropped included several that had been recommended by the Alfalfa Coexistence Working Group.

58. A modest amount of GE Roundup Ready alfalfa seed was planted in 2011, but demand and supply grew rapidly, and accounted for a reported 60% of new plantings in the western U.S. in 2013. That suggests that a majority of alfalfa seed production now contains the Roundup Ready gene, increasing the risk of Roundup Ready gene flow to non-GE and organic alfalfa. The absence of the added, preventive measures recommended by the Alfalfa Coexistence Working Group no doubt accelerated the movement of the Roundup Ready genes into other, non-GE alfalfa breeding lines. The full range of consequences, both near-term and longer-run, from the contamination of the non-GE alfalfa seed supply and germplasm stocks are not known, but could be considerable.

59. As a result of unwanted GE-gene flow into non-GE and organic canola (rapeseed) breeding lines, many organic farmers have lost access to premium markets and can no longer include canola in their crop rotations. The possible loss of alfalfa as a rotational crop option could place many contemporary organic farms in jeopardy, since canola and alfalfa are high-dollar crops that deliver sizable environmental and agronomic benefits.

The Impact of GE Crops On The Environment

60. The impacts of GE crop technology on natural resources and the environment fall into several general categories:

61. (i) Alterations in soil microbial communities and pest pressure: Heavy and repeated applications of glyphosate herbicides have altered the composition of soil microbial communities. Glyphosate is toxic to certain beneficial soil microorganisms that play a role in making nutrients bioavailable to corn and/or soybean plants. As a result, it has triggered

negative shifts in the composition of soil microbial communities. For example, a team led by Andy King in Arkansas documented adverse impacts of glyphosate on the efficiency of nitrogen fixation by soybean plants.[21] Capturing nitrogen from the air via the action of microorganisms that colonize the surface of soybean roots is one of the major agronomic and environmental benefits of legumes, including soybeans.

62. Recent research has also documented adverse impacts of repeated glyphosate applications on the ability of plant roots to take up certain minor, but essential, micronutrients in soil, especially manganese. This vital micronutrient plays an important role in the plant's response to certain pathogens and environmental stresses, and impaired uptake of manganese in Roundup Ready soybean fields has been implicated as a risk factor for several soybean diseases.[22]

63. (ii) <u>Impacts associated with heightened use of pesticides and/or toxins associated with GE crops</u>: As discussed above, around 240 million pounds of glyphosate active ingredient are now sprayed annually on the 300-plus million acres of U.S. cropland – nearly two-thirds of a pound for every acre. No other pesticide in history has been sprayed as intensively as glyphosate. Reliance on glyphosate exceeds by more than a factor of two the degree of reliance on any past herbicide, in terms of pounds applied annually across American agriculture.

64. Glyphosate is now present in the soil, air, rainfall, and drinking water in many regions around the world. Concentrations were found in 60% to 100% of rain and air samples tested in Iowa and Mississippi by the U.S. Geological Survey.[23] Nearly every stream, river, and

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[21] King, A.C., L.C. Purcell, and E.D. Vories. 2001. Plant growth and nitrogenase activity of glyphosate-tolerant soybean in response to glyphosate applications. *Agron. J.* 93:179–186.

[22] Johal, G.S. and D.M. Huber, 2009. Glyphosate effects on diseases in plants. *European J. of Agronomy* 31:144-152.

[23] Chang, F-C, M.F. Simcik, and P.D. Capel. 2011. Occurrence and Fate of the Herbicide

reservoir in heavily farmers regions contains runoff of glyphosate and its degradation products. The frequency of detections in groundwater is rising worldwide, wherever glyphosate-based herbicide-tolerant technology now dominates weed management systems.

65. Recent human biomonitoring studies, moreover, suggest that glyphosate residues are present in the blood and urine of a substantial share of the human population in developed countries.[24] The public health consequences of now-ubiquitous exposure to glyphosate in the air, drinking water, and food is under intensive investigation by toxicologists and risk assessment scientists around the world, but are not yet fully understood. Concern is greatest over evidence pointing to the ability of glyphosate to bind with certain metals often found in drinking water from wells in certain regions with hard water. Glyphosate is a strong chelating agent, and as a result, binds tightly to metal molecules. The bound complexes of glyphosate and certain metals can apparently lodge in the human kidney and cause chronic kidney disease if exposures last for several years.[25]

66. (iii) Reductions in biodiversity and habitat supporting populations for beneficial organisms and wildlife species: The biggest impact of GE crop technology on ecosystem resiliency and biodiversity has been triggered by the widespread and repeated uses of glyphosate. Glyphosate is a broad-spectrum herbicide that kills almost all growing plants, vines, and trees (except of course for resistant plants). There is also some movement of glyphosate from sprayed

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Glyphosate and Its Degradate Aminomethylyphosphonic Acid in the Atmosphere. *Envir. Toxicology Chem*. 30:548-555.

[24] Brandii, D. and S. Reinacher. 2012. Herbicides Found in Human Urine. *Ithaka Journal* 1:270-272; Friends of the Earth Europe. 2013. Human contamination by glyphosate. Available at: http:foeeurope.org.

[25] Jayasumana, C., et al. 2014. Glyphosate, Hard Water and Nephrotoxic Metals: Are They the Culprits Behind the Epidemic of Chronic Kidney Disease on Unknown Etiology in Sri Lanka? *Int. J. Res. Public Health* 11:2125-2147.

fields into field border areas, extending the herbicide's impact on plant diversity and biomass to field borders. In many areas, field border areas are not very wide, and hence glyphosate spray drift can cover all or most of the land between fields planted to GE Roundup Ready crops.

67. Research has shown that heavy dominance of glyphosate-based weed management systems in North America has reduced milkweed biomass throughout most of the Midwest. Milkweed is the major food source of nutrition for Monarch butterflies as they migrate through the Midwest. One study estimated that the loss of milkweed habitat in and around farm fields has caused an 81% decline in Monarch populations in the Midwest. Other studies suggest linkages between the health of introduced honeybees and native pollinators as a result of the overall pesticide and *Bt* toxin load associated with GE-*Bt* corn and cotton.[26]

Existing Studies Do Not Demonstrate The Safety Of GE Foods

68. In an effort to reassure individuals concerned about the human health impacts of GE foods, many people and organizations have asserted that GE crops and food are the most thoroughly tested agricultural technology in history. See McHughen Decl. ¶ 71. That claim is both misleading and factually wrong.

69. The claim is misleading because the vast majority of studies published on GE crops, animal feeds, and food address issues ***other than*** human food safety. The vast majority of studies on GE foods focus on one of two issues: whether the nutritional composition of GE food is "substantially equivalent" to that of non-GE varieties, and whether GE foods and ingredients deliver the same nutritional value when used in food manufacturing or as animal feed (an area of

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[26] Pleasants, J.M. and K.S. Oberhauser. 2012. Milkweed loss in agricultural fields because of herbicide use: effect on the monarch butterfly population. *Insect Conservation and Diversity*, 6(2): 135-144.

interest to livestock farmers). Few published studies, however, directly address the safety of GE foods.

70. J.L. Domingo, a Spanish toxicologist, carried out the first systematic review of the nature of the published studies on GE crops and food. Two of his published papers are included in the documents reviewed by the Vermont legislature. The first study, published in 2007, reported the results of a literature search of the Medline database (a repository for scientific journal articles) for studies on GE plants from 1980 - 2007.[27] The second study updated and refined the analysis in 2011.[28] Together, the studies show that, from 1980-2011, only 75 studies address the human health risks associated with GE foods. According to the authors, after eliminating studies addressing nutrient composition, feed efficiency in livestock systems, and other studies not focused on human health risk assessment, the published studies reporting original data on health effects "remain very limited."

71. The claim that GE crop technology is the most heavily studied food technology is also factually wrong. For example, a search of the PubMed database (the successor to Medline as the repository for scientific publications worldwide) on November 8, 2014, on "health effects artificial sweeteners" yields 4,846 citations, while a search on "health effects genetically engineered food" yields 276. "Health effects genetically engineered crops" yields 53 citations. Limiting the search to "human health effects of genetically engineered food" reduces the number of citations to 44, while "human health effects artificial sweeteners" identifies 3,057 citations. And the human health database on dozens of widely used pesticides includes hundreds to thousands of studies per pesticide. For example, a PubMed search on November 7, 2014 yielded

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[27] Domingo, J.J. 2007. Toxicity Studies of Genetically Modified Plants: A Review of the Published Literature. *Critical Reviews in Food Science and Nutrition* 47:721-733.

[28] Domingo, J.L., and J.G. Bordonaba, 2011. A literature review on the safety assessment of genetically modified plants," *Environment International* 37:734-742.

667 references on "DDT cancer" alone, and 11,650 scientific citations on "DDT." The insecticide "chlorpyrifos" yields 3,402 citations, while "chlorpyrifos neurotoxicity" identifies 206 citations. It is therefore inaccurate to state that GE foods are the most heavily studied food technology.

72. Moreover, most of the studies on the most widely planted GE crops in the United States – GE corn and soybeans – focus on GE corn and soybean traits that are no longer on the market. One or more of the GE traits in ***almost all*** of today's market-leading GE corn and soybean varieties have not been analyzed or addressed in ***any*** human-health relevant studies published in peer-reviewed journals.

73. Moreover, most GE corn varieties on the market today contain "stacked" traits – i.e., they contain more than one transgene, producing multiple traits (for example, glyphosate resistance and expression of one or more *Bt* toxins). Single-trait corn varieties account for just a few percent of total GE corn acreage, and in recent years, the average acre planted to GE corn contains more than three traits (glyphosate tolerance and at least two *Bt* toxins). Yet nearly all published studies focus on the risks of individual GE traits. I am not aware of a single study carried out by technology developers, independent scientists, or the government that tests whether there might be new and unique human health risks associated with stacked-trait GE corn cultivars.

74. The FDA considers any stacked-trait cultivar that is composed of traits previously approved on an ***individual*** basis to be acceptable. Thus, the FDA assumes that there will be no adverse consequences in a stacked-trait cultivar from the presence of multiple transgenes and their linked regulatory and terminator sequences, and possibly several marker genes. Yet it is known that the regulatory sequences introduced into a GE corn variety can sometimes influence

the expression of other genes that were not the target of the technology developer. This “cross-talk” between genetic elements introduced via the GE process and other gene sequences within the crop’s natural genome can alter gene expression patterns, or trigger the production of novel proteins, some of which may prove to be human allergens.

I declare under penalty of perjury of the laws of the United States that the foregoing is true and correct to the best of my knowledge, information, and belief.

Charles Benbrook

Charles M. Benbrook November 14, 2014