GM CONTAMINATION IN CANADA

THE FAILURE TO CONTAIN LIVING MODIFIED ORGANISMS: INCIDENTS AND IMPACTS

CANADIAN BIOTECHNOLOGY ACTION NETWORK

GM Contamination in Canada

The failure to contain living modified organisms: Incidents and impacts

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The Canadian Biotechnology Action Network (CBAN) brings together 16 groups to research, monitor and raise awareness about issues relating to genetic engineering in food and farming. CBAN members include farmer associations, environmental and social justice organizations, and regional coalitions of grassroots groups. CBAN is a project on the shared platform of Tides Canada. **www.cban.ca**

In October 2001, SOD (now SaskOrganics) launched the Organic Agriculture Protection Fund to pay the expenses for the Class Action lawsuit on behalf of all certified organic grain farmers in Saskatchewan against Monsanto and Aventis (Bayer), which was seeking compensation for damages caused by their genetically engineered canola and to get an injunction to prevent Monsanto from introducing GE wheat in Saskatchewan. This was the beginning of many other important actions taken by the Committee and their dedicated and passionate members over the years. **http://saskorganics.org/organic-agriculture-protection-fund/**

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This report is available online at **www.cban.ca/ContaminationReport2019**
For updates, the report summary and to find out more, visit **www.cban.ca/contamination**

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Executive Summary

Once released into our environment, genetically modified organisms (GMOs) can be difficult or impossible to control or recall. Over the almost two and half decades of GM commercialization **in Canada, we have observed the escape of a number of GMOs: GM canola, flax, wheat and pigs.**

Some of these escapes were isolated incidents while others are widespread or ongoing contamination cases. Some escape events occurred with GMOs that were approved by our government (canola and flax) and others with unapproved experimental GM plants and animals (wheat and pigs).

The unwanted escape and spread of GM (also called genetically engineered) traits and GM organisms can have profound economic, social and environmental consequences. So far, farmers have been the first to pay the price of GM contamination. In Canada, these consequences have included the temporary or permanent loss of export markets, lower crop prices in the short or long-term, the loss of access to a particular crop, and the loss of farm-saved seed. The federal GMO review process does not assess the full risk of contamination occurring, nor the potential social and economic harm if contamination does occur.

Widespread GM canola contamination in Canada has meant that most organic farmers have lost the option of growing canola; GM flax contamination changed the flax export market for Canadian farmers; and GM alfalfa commercialization in Canada poses an immediate contamination threat to organic farming systems and other farm operations.

There have also been significant cases of GM contamination in the US and Mexico, which confirm that escape events in Canada are not anomalies. These cases include GM contamination from GM “Starlink” corn, GM “Liberty Link” rice, and GM creeping bentgrass in the US, and the contamination of native corn in Mexico, which is a global centre of diversity of corn.

There are several new and proposed GMOs that pose significant risks of escape, such as GM forest trees, or would result in serious environmental harm if escape occurred, such as GM salmon. Furthermore, some new GMOs, such as gene drive mosquitoes, are specifically designed to be released into the wild, to deliberately cross with wild populations.

Human error, biology, pollinator and wind movement, extreme weather events, and other factors make GM contamination predictable.

The diverse incidents of GM escape and contamination in Canada show that these risks cannot be managed by current government regulation nor through industry-developed best practices. Instead, government needs to regulate segregation and containment measures for some GMOs and recognize that **the only way to prevent contamination from certain GMOs is to stop their release**. Some GMOs are too prone to escape, and others have consequences that are too serious if escape occurs.

This report documents in one place, for the first time, GM escape and contamination incidents that have occurred in Canada. These experiences provide lessons that need to be evaluated and understood before any more GM plants and animals are released.

Introduction

Once released into our environment, genetically engineered (also called genetically modified or GM) organisms are difficult or impossible to control or recall. Each release of a GM organism is an experiment – some are more controlled and controllable than others. Over almost two and half decades of GM commercialization, we have observed multiple escapes of genetically modified organisms (GMOs) and can now document the results of these real-world experiments.

This report details the known cases of GM escapes and contamination in Canada, as well as significant cases in the US and Mexico. These cases highlight the persistent contamination threat posed by GMO releases, and their potential consequences. The report ends with an examination of the contamination risks posed by new and proposed genetically modified organisms – GM trees, fish and insects.

GM contamination is the unwanted escape and spread of genetically modified organisms (GMOs) or genetic material from GMOs to non-GM plants, animals and foods. This dispersal can occur via a number of pathways, including pollen spread and seed escape, and mixing of food and feed.

Most often, escape is predictable. The biology and use patterns of some crops, such as GM alfalfa, make their unwanted spread unavoidable.

GM contamination is living pollution that can self-replicate. Such contamination can have negative environmental, social and economic impacts. So far, farmers have been the first to pay the price of GM contamination.

PATHS OF CONTAMINATION

Contamination of non-GM crops with genetically modified traits can take place in a number of ways, and at a number of links in the food chain. It can be the result of natural processes, or human activity.

CROSS POLLINATION: Pollen from GM plants can spread to non-GM plants, carried by the wind, insects, or other animals. The probability and the distance over which this contamination can take place differs from one species to another, and depends on how the plant is pollinated, how far its pollinators can travel, and other aspects of its biology. GM volunteer and feral plants[a] can also perpetuate cross-pollination.

SEED ESCAPE AND MIXING OF FOOD AND FEED: GM seed can escape and mix with non-GM seed during seed production or through the use of farm equipment, during transportation and storage, and even on clothing and footwear. Seed spilled during transport can lead to feral or volunteer GM plants growing along transport routes. Domestic or wild animals can also spread GM seed. GM and non-GM crops can also mix during storage and milling, and GM and non-GM food and feed can mix during processing.

[a] Volunteers are crop plants that appear in farmers' fields without having been planted. They may grow from seeds that are transported by birds, animals, machinery or the wind, seed dropped during harvest, or dormant seed from a previous crop. Feral crop plants are those that persist in non-cultivated and wild areas, including ditches, roadsides and near fields.

GM CONTAMINATION IN CANADA

"The movement of transgenes beyond their intended destinations is a virtual certainty."

— Michelle Marvier and Rene Van Acker, 2005[1]

There have been a number of cases of GM escape in Canada. These include isolated incidents that did not reach or left no trace in the food system, as well as widespread or ongoing contamination events. Some of these escapes have had serious negative impacts on farmers and the farm economy. One case raised human health concerns. These events offer important warnings about the risk of escape that can accompany the release of genetically modified organisms, and the potential impacts of such incidents.

GM contamination – which the biotechnology industry calls "unintended presence" – can occur with approved GM crops that are being commercially grown (as in the case of GM canola); approved but uncommercialized GM crops (as in the case of GM flax); and experimental, unapproved GMOs (as in the case of GM pigs and GM wheat).

Canadian farmers grow five GM crops: corn, canola, soy, white sugar beet, and a small amount of alfalfa.

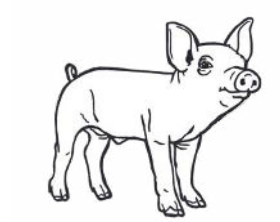
In Canada, contamination has occurred with GM canola, GM flax, and, on two occasions, with GM pigs. There has also been one isolated escape incident with several GM wheat plants.

Each GM organism presents a different profile of contamination risk, in part because each organism has different biological mechanisms that facilitate or hamper the spread and persistence of contamination. However, there are some common causes of escape across all crop types, including the possibility of human error.

CANOLA

FLAX

WHEAT



PIGS

GM CANOLA

"Since its introduction into the environment of Western Canada, GM canola has widely proliferated and has been found growing on land on which it was never intended to be grown."

— Statement of Claim: Larry Hoffman and Dale Beaudoin v. Monsanto Canada Inc. and Aventis CropScience Canada Holding. 2002[2]

Contamination of canola due to pollen and seed escape from GM canola in Canada compromised seed purity to such a degree that, within seven years of introducing GM canola, seed growers no longer guaranteed their conventional canola seed as GM-free. Organic grain farmers in the Prairies stopped growing canola due to high levels of GM contamination and attempted to sue companies for compensation for the loss of this crop. GM canola has been widely adopted in Canada – approximately 97% of canola grown is now GM.

Herbicide-tolerant canola was the first genetically engineered crop approved in Canada, in 1995. **The early adoption of GM canola by farmers in Canada was high, but so was the contamination rate.** Half of the canola planted in Western Canada was GM by 2000 and contamination from GM canola reached such a high point by 2002 that most, if not all, pedigreed seed[b] growers in Saskatchewan could not guarantee their canola seed stocks as GM-free.[3] Furthermore, most, if not all, grain farmers in Saskatchewan could not guarantee that their canola crop was not contaminated, even if planted with seed sold as GM free.[4]

GM canola contamination can take place via canola pollen, which can be carried over long distances by the wind (over 2 kilometres)[5]; mixing of GM and non-GM seed; and via feral and volunteer plants.[6] Contamination from GM canola is hard to prevent because canola seed is small, its pollen travels long distances, and it is widely grown in the Prairies.

[b] Pedigreed seed is genetically pure seed of a known variety, developed with unique characteristics such as disease resistance, or with special qualities, and is carefully inspected to meet quality and characteristic requirements.

GM traits were found in volunteer canola plants as early as 1998 and in the pedigreed canola seed production system by 2003, likely due to seed mixing or contamination of earlier generations of pedigreed seed production.[7] By 2007, GM traits had been documented in escaped and feral roadside populations.[8] By 2010, escaped GM canola was found growing on the edges of fields and roads in Manitoba[9] as well as in Vancouver, from where most canola for export is shipped.[10] These escaped GM populations then further spread GM traits, "confirming concerns that escaped transgenes cannot be retracted once released."[11]

In the case of canola, the seed industry was unable to prevent contamination – even with the pedigreed seed sector's strict varietal purity management control systems and the economic incentive to ensure that these controls work. **If professional seed growers cannot avoid the unintended presence of GM in their seed, it is not reasonable to expect other farmers to succeed in doing so.** A 2003 survey of Canadian farmers' experiences with GM canola found that farmers generally felt that it was not possible to stop herbicide-tolerant traits from spreading in the environment.[12]

After it was approved, GM canola from neighbouring farms began appearing in organic fields where other crops such as wheat, oats or peas were being grown. Affected farmers had to bear the cost of implementing measures to avoid contamination. GM canola also appeared in organic canola fields, but could not be detected before harvest. Buyers in the organic market tested for the presence of GM canola, and seed contamination also quickly became an issue. Ultimately, except in a few isolated areas where other farmers do not grow canola, **certified organic grain farmers in Canada have lost the ability to grow, sell and export canola.**

ORGANIC FARMERS PAY THE COST

Not all farmers pay equally for GM contamination. The responsibility for preventing contamination falls to farmers who grow for non-GM markets, rather than those who plant GM crops. And when GM contamination occurs, organic and other non-GM farmers bear the brunt of its impacts.

Organic farmers, in particular, can pay a heavy price if GM contamination occurs. Because organic farming prohibits the use of GM seed, farmers take a number of costly measures to prevent such contamination. GM contamination can jeopardize the livelihoods of organic farmers.

"If biotech companies are entitled to monopoly rights over their patented genes wherever they occur, according to the Canadian Supreme Court Schmeiser vs. Monsanto decision, then we assert that these companies must also be liable for the losses due to the unwanted presence of these patented genes."

— Organic Agriculture Protection Fund, SaskOrganics[16]

GM canola prompted Monsanto's well-known legal pursuit of Saskatchewan farmer Percy Schmeiser for patent infringement. Schmeiser maintained that the GM canola found on his land fell out of trucks on the road, but Monsanto alleged that Schmeiser knowingly used its patented GM trait without purchasing the seed. In 2004, the Supreme Court ruled that Monsanto could claim patent rights over GM plants, regardless of where they were found or how they got onto a farmer's field.

Canola contamination also spurred the only legal action brought forward by Canadian farmers seeking redress for GM contamination. In 2002, the Organic Agriculture Protection Fund (OAPF) of the farmers' organization now called SaskOrganics, filed for certification of a class action suit seeking compensation from Monsanto and Bayer (formerly Aventis) for GM canola contamination.[13] The claim alleged that when Monsanto and Aventis introduced their GM canola varieties, they knew, or ought to have known, that the genetically engineered canola would spread and contaminate the environment, and that the companies had no regard for the damage these crops would cause to organic agriculture. The OAPF held that the loss of canola as an organic crop robbed organic farmers of a high-paying and expanding market.[14] The class action was not certified in Saskatchewan and the Supreme Court of Canada would not hear the appeal, and so, in 2007, the legal action ended without its merits being heard in the courts.

To avoid the costs of preventing and/or cleaning up contamination, and to avoid any possible related legal action or threat of action, **the only strategies left for most Canadian farmers were to stop growing canola or to buy GM canola seed and pay the royalty** (called a "Technology Use Fee"). Just as GM canola was being widely adopted, most non-GM canola varieties were being deregistered by seed companies, reducing the non-GM options for farmers and securing market dominance for GM canola. For example, in 2000, 80% of the 120 registered varieties of canola were non-GM, but by 2007 only five non-GM canola varieties were registered.[15]

GM FLAX

"Man thought he could master the triffid."

— John Wyndham, The Day of The Triffids, 1951

Almost ten years after farmers stopped GM flax seed from being introduced in Canada, Canadian flax was found contaminated with a genetically engineered flax variety called "Triffid". The GM flax had been developed in Canada but never sold on the market to farmers. As a result of pedigreed flax seed contamination, flax farmers lost important export markets in Europe and Asia, some lost their saved seed, and flax acreage and price dropped.

The genetically engineered flax "Triffid", developed by Alan McHughen at the University of Saskatchewan's Crop Development Centre (CDC), was resistant to residues of sulfonylurea herbicides in soil.[17] It was approved for environmental release and human consumption in Canada and the US, and the variety was registered for sale in 1998. It was being prepared for commercial release in Canada in 2001 but flax farmers were concerned that the GM flax would contaminate exports bound for the European market where it was not yet approved. Represented by the Flax Council of Canada and the Saskatchewan Flax Development Commission, **farmers convinced the university to deregister the GM flax variety in 2001, stopping the seed from being introduced into the market.**

TRIFFID

The GM flax was named "Triffid" after the escaped man-eating plant from the 1951 science-fiction novel "The Day of the Triffids" by John Wyndham. In the story, after most people in the world are blinded by an apparent meteor shower, a bioengineered plant is accidentally released and starts killing people.

"There's no question this will change the industry forever."

— Barry Hall, President, Flax Council of Canada, 2010[27]

At the time it was deregistered, GM flax seed was being prepared to sell to farmers – about 40 seed growers had multiplied a total of around 200,000 bushels of the GM flax seed[19] – but the stocks were acquired by the Flax Council of Canada and destroyed or crushed.[20] **Almost 10 years later, in September 2009, the GM flax was detected in Canadian flax export shipments and reached at least 35 countries that had not approved it.** About 3.5% of farmer and elevator flax samples tested positive for the GM flax at or above 0.01% (one seed in 10,000), as did 10-15% of rail shipments and 7% of vessel holds.[21]

Canada is a world leader in flax production and export, and the economic consequences of the contamination were profound:

- Canada is still struggling to regain its most important flax export market, Europe. At the time of contamination, 60% of Canada's flax exports went to Europe but this number was only 12% in 2017.
- In 2009, the price of flax fell by 32% in Manitoba based on rumour alone, before contamination was confirmed.[22]
- Flax acreage in Canada dropped by 47% after contamination was discovered (from 692,000 planted hectares of flax in 2009, to 370,000 in 2010).[23] Acreage did not recover until 2014.[24]
- Canada's flax market shifted from a high-priced food market to a lower-priced industrial market.[25]
- **The total cost of the contamination incident to the Canadian flax industry is estimated at $29.1-million.**[26]

Flax growers had acted to keep GM flax off the market to prevent this exact situation: "This is an absolute nightmare for flax growers and why we worked so hard to have the GM flax removed. Flax growers forced the GM flax off the market eight years ago to prevent any threat of contamination and protect our export markets. GM flax was never wanted or needed. We knew it would destroy our European markets and now we fear this has happened," said Terry Boehm, past president of the National Farmers Union.[28]

Under the auspices of cleaning up the contamination, grain companies tried but failed to require flax farmers to buy and plant only certified pedigreed seed.[29] A Flax Council of Canada policy to require farmers to buy certified seed was reversed after contamination was discovered throughout the pedigreed seed system.

Ultimately, stocks of five varieties of breeder seed from the university's CDC were found to be contaminated,[30] which means that the contamination occurred in a stringently controlled, small breeding center. These varieties could be a primary source of the contamination problem because roughly 80% of Canada's flax acres were planted to CDC varieties. However, the specific chain of events that resulted in contamination have not been established and may never be identified.[31]

"We still don't know how Triffid got into the system. Yes, it was supposed to have been destroyed. We're still trying to determine what happened."

— Saskatchewan Flax Development Commission, 2019[32]

In 2014, the flax industry set up a "Reconstituted Flax Seed Program" that encouraged farmers to buy certified seed from re-constituted supplies: "Flax producers need to replace their existing planting seed stocks for the 2014 season so that all traces of Triffid can be flushed from the seed supply."[33] The industry reconstituted its breeder seed from selected flax varieties developed at the University of Saskatchewan's Crop Development Centre.

In 2010, the federal government gave up to $3-million to the Flax Council of Canada to support testing. This included subsidies to allow approved labs to provide farmers a 50% discount on tests.[34]

Farmers were asked to test their flax seed before planting, or buy new, certified seed.[35] For many, this meant losing farm-saved, older varieties that may no longer be easily available and which were adapted to specific local conditions and/or particular market demands. Before 2009, about 75% of Canada's flax farmers used farm-saved seed.[36]

Eventually though, farm-saved seed was more reliably free of GM contamination. Terry Boehm, past president of the National Farmers Union, observed that, because pedigreed seed was contaminated, "Ultimately it was farm saved seed that was tested and found free of GM contamination, that allowed flax production to continue in Canada, albeit to a lower priced and smaller market segment."[37]

GM WHEAT

"We may never know how this GM wheat came to be present on an access road."

— The Canadian Food Inspection Agency (CFIA), 2018

There is no GM wheat approved or commercialized anywhere in the world, but in 2018, the Canadian Food Inspection Agency announced that several unapproved GM wheat plants were found on an Alberta roadside. The government could not determine how the GM trait got there 17 years after it was last field tested in Canada. This was an isolated incident and the first escape event with GM wheat in Canada. There had been three previous incidents in the US.

There is no genetically engineered wheat approved for growing or eating anywhere in the world. In 2004, Monsanto withdrew its request for approval of its herbicide-tolerant Roundup Ready® wheat in Canada and the US due to pressure, particularly from the Canadian Wheat Board and farmer organizations who were concerned that GM wheat would close most of Canada's important export markets.[38] Since then, there have been four escape incidents in North America.

In 2018, the federal government disclosed the discovery of GM wheat plants found growing on a roadside in Alberta. The herbicide-tolerant plants were discovered in 2017 when roadside spraying to control weeds failed to kill several wheat plants. The plants contained GM event MON71200, which had been field-tested by Monsanto from 1998-2000 in Alberta, Manitoba and Saskatchewan. The Canadian Food Inspection Agency (CFIA) could not determine the cause of the escape and said, **"We may never know how this GM wheat came to be present on an access road."**[39] The CFIA could neither rule out nor establish a direct link to the previous field tests: "Given the passage of time and large distances involved, there is no evidence that would explain how or if the current GM wheat finding is linked with a previous trial."[40] However, the CFIA did determine that there was no connection (no genetic match) to the previous three contamination incidents in the US with Monsanto's GM herbicide-tolerant wheat.

The CFIA was able to conclude that the contamination did not reach the food or feed system because the wheat plants found in Alberta were not a genetic match for any of the registered wheat seed varieties currently grown in Canada or exported from Canada over the past three years. However, this information adds to the mystery of the source and cause of the GM escape. Subsequent testing done by the CFIA and later by Japan and South Korea, both of whom suspended trade pending the results, confirmed that **the GM wheat did not enter the food or feed system.**

The CFIA concluded that the GM wheat plants were present "only in a highly localized area", and will monitor the site for the next three years. It additionally stated that "any areas identified for improvement will be pursued."[41]

There have been three incidents where GM wheat has escaped in the US – in 2013, 2014, and 2016 – and all occurred with Monsanto's GM glyphosate-tolerant Roundup Ready wheat. The 2013 incident temporarily closed the same two export markets – Japan and South Korea – that suspended Canadian exports in 2018:

- In 2013, a farmer in Oregon found Monsanto's GM wheat in her field.[42] The US Department of Agriculture was "unable to determine exactly how the GM wheat came to grow in the farmer's field."[43] Japan and South Korea suspended imports of US wheat[44] while China, Thailand, European member states, and the Philippines tightened inspections.[45,46,47] Farmers successfully filed two lawsuits against Monsanto, claiming that the company had failed to protect their markets from contamination. **Monsanto paid US farmers $2.75-million to settle the lawsuits.**[48]
- In 2014, Monsanto's GM wheat was found growing on a former trial site at a university research centre in Montana.[49]
- In 2016, a farmer in Washington State discovered 22 of Monsanto's GM glyphosate-tolerant wheat plants in an unplanted field.[50,51] The variety had been tested in field trials in the Pacific Northwest between 1998 and 2000.

Biotechnology companies including Monsanto (now Bayer), and Agriculture and Agri-Food Canada, have continued to field test other GM wheat varieties in Canada over the years. In 2018, there were 12 field tests of GM herbicide-tolerant and/or fungal-resistant wheat in Manitoba and 40 tests of Bayer's herbicide-tolerant wheat with yield increase in Saskatchewan.[52]

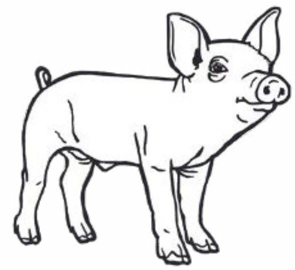
RISKS OF ESCAPE FROM GM FIELD TRIALS

Field trials of GM crop plants and trees pose a contamination risk. In 2018, in the wake of GM wheat escape, the National Farmers Union reiterated their 2001 demand for an end to open-air GMO field tests. The NFU also asked for, but was denied, the location details of all past and current GM wheat trials.[53]

In Canada, the federal government provides a list of field trials per province for past years, but **the exact locations of the trials are kept confidential**. This lack of information means that farmers who are near GMO field test sites are unaware and unable to implement any of their own mitigation measures to protect themselves from GM contamination.

In 2013, the *Ottawa Citizen* reported a containment breach of outdoor GM wheat research at Agriculture Canada's Ottawa Experimental Farm by a flock of Canada geese. The geese landed on the test plot in the summer of 2012 and ate the experimental GM fusarium-resistant wheat growing there.[54] They then flew out of the site, possibly spreading viable undigested GM wheat seed through their droppings.[55]

The Canadian Food Inspection Agency regulates field trials and refers to these tests as "confined environmental release."



GM PIGS

"Things you don't expect to happen can happen."

— Alan Wildeman, Vice President of Research, University of Guelph, 2002

There have been two separate contamination incidents with experimental, unapproved genetically engineered pigs in Canada, one from a university and the other from a private company. In both cases, the unapproved GM pigs entered the food system. These incidents reiterate the predictable problem of human error as a cause of contamination.

In 2004, three experimental genetically engineered pigs from the now-defunct Quebec company TGN Biotech were accidentally turned into chicken feed instead of being incinerated. The government seized 800 tonnes of feed but 1% of the contaminated material had already been fed to chicken and swine in Ontario and Quebec.[56] The pigs were being genetically engineered to produce pharmaceutical compounds in their semen.[57]

In 2002, eleven GM piglets in experiments at the University of Guelph in Ontario were accidentally sent to a meat rendering plant and turned into animal feed instead of being destroyed as biological waste. This GM "Enviropig" was engineered to excrete less phosphorus in its faeces, with the use of genetic material from a mouse and *E coli*.[58] The GM pigs had not been approved as safe for animal feed or human consumption but contaminated 675 tonnes of poultry feed that was then sold to egg, turkey and broiler chicken producers. The Canadian Food Inspection Agency ordered a recall of the feed. In a statement to *The Globe and Mail*, Alan Wildeman, Vice President of Research at the university said, **"Things you don't expect to happen can happen."**[59]

GM CONTAMINATION IN NORTH AMERICA

GM contamination incidents in the US and Mexico show that the cases of escape observed in Canada are not anomalies. Additionally, in at least one case ("Starlink" corn), GM contamination in the US entered Canada's food system.

GM "STARLINK" CORN

In 2000, a GM variety of corn that had been denied approval for human consumption in the US due to safety concerns was found in the North American food system. The corn was approved in the US for use as animal feed and was being grown solely for that purpose. The incident led to large-scale recalls of corn products from grocery store shelves in both Canada and the US, with huge costs to food manufacturers as well as to the US government.

"Ships literally turned around and were told to dump their corn into the sea."

— Former Aventis CropScience Chief Operating Officer John Wichtrich[60]

GM "Starlink" corn, owned by Aventis (now Bayer), was engineered with a gene from the bacteria *Bacillus thuringiensis* (Bt) to make it resistant to insects. However, the Bt Cry protein in Starlink was different from those used to produce other GM Bt corn already on the market. The US Environmental Protection Agency refused approval for the use of Starlink for human consumption because of concerns that the new protein may act as an allergen, but it **approved production for animal feed and industrial purposes.** This GM corn was not approved in Canada or any other country.

As part of the company's 1998 license to grow it in the US, Aventis was responsible for ensuring that farmers kept this GM corn segregated from other corn that could be sold for direct human consumption. However, in 2000, half of Iowa's cornfields showed at least a trace of contamination from Starlink, despite the fact that it had only been planted on 1% of fields in the state.[61] Contamination spread from the US to Canada, Egypt, South Korea, Japan, Guatemala and Bolivia.

The contamination was discovered when Greenpeace commissioned tests of corn products. The results triggered **the first-ever recall of GM foods.**[62] The voluntary recall started with taco shells and led eleven companies, including Kraft, Safeway, Mission Foods, Western Family and Kellogs, to remove more than over ten million food items from US stores.[63] The US Department of Agriculture ordered a recall of the 350,000 acres of Starlink corn planted in 2000[64] and awarded farmers between $172-million and $776-million in payments and loans through programs that compensate producers if the price of a commodity falls below a set rate.[65]

Aventis spent $110-million to buy back contaminated corn and paid another $110-million to farmers in a class-action lawsuit.[66] Analysts estimated that in 2000/2001 alone, the incident cost farmers between $26-million and $288-million in lost revenue,[67] and caused a 6.8% drop in the price of corn that lasted a year.[68] **The total cost to Aventis from crop recalls and compensating growers, grain buyers and food companies was estimated at at least $1-billion.**[69]

Starlink was not approved for any use in Canada but, following its discovery in the US, the CFIA tested over 135 food, feed and seed products. The tests resulted in four voluntary recalls of imported US food products, one disposal of a whole grain shipment, one feed recall, and one seed recall.[70] The cost of the Canadian government response was estimated at $900,000.[71] The CFIA initially recommended that companies test food supplies but a year later, the agency added a requirement that whole grain corn from the US had to be accompanied by a certificate guaranteeing that it was Starlink-free.[72]

Contamination from StarLink was still being detected in seed stocks in 2003.[73] In 2005, food aid sent by the UN World Food Programme to Guatemala, Nicaragua, Honduras, and El Salvador was found to be widely contaminated with Starlink, with 80% of 50 samples testing positive.[74] A few samples collected in 2009 and 2019 in Saudi Arabia tested at over 1% contamination.[75]

Starlink contamination prompted the federal government to implement a policy whereby no GM crop is approved for environmental release and/or animal feed in Canada if it is not also approved as safe for human consumption.

GM "LIBERTY LINK" RICE

In 2006 and 2007, Bayer's GM "LibertyLink" rice was found in US export shipments and contamination was later estimated to have reached 30% of US rice supplies. Several countries closed their doors to US rice after the incident and the total cost to the rice industry worldwide was estimated at over $1-billion. The US government was unable to report exactly how the contamination happened.

In 2006, Bayer's "LibertyLink" LL601 GM rice variety was detected in US export shipments, reaching 30 countries including Canada.[76] It was not approved in any country and was one of two uncommercialized GM rice varieties that would be found contaminating exports, both tolerant to Bayer's brand-name glufosinate-based herbicide called "Liberty." The GM rice had been field-tested five years earlier.

Contamination was widespread: it was estimated to have reached 30% of US rice supplies, and to have reached rice seed stocks.[77] Several countries, including many of the US's top markets, closed their doors to US rice and others imposed strict testing protocols.[78] **The total cost to the global rice industry was estimated at over $1-billion.** Approximately 11,000 US farmers sued Bayer for market losses and cleanup costs and, in 2011, the company agreed to pay farmers $750-million.[79]

Neither of the GM varieties were ever commercially grown. Aventis (later bought by Bayer) had conducted field trials from 1998 to 2001, five years before contamination was found. The US Department of Agriculture reported that **field trials were the source of contamination** but they were unable to determine the cause.[80]

In an attempt to protect itself, Bayer sought, and was granted, human safety approval in the US for the GM rice variety LL601 *after* the contamination was discovered.[81]

GM ALFALFA

Alfalfa is the first perennial GM crop approved for growing in Canada. Alfalfa is an economically important crop with a high risk of gene flow. In 2013, GM alfalfa seed was registered despite the contamination risk, and sold in Eastern Canada. Since then, GM alfalfa contamination has been found in the US and US government scientists have reported the wide dispersal of feral GM alfalfa.

The Canadian Food Inspection Agency (CFIA) and Health Canada approved GM glyphosate tolerant Roundup Ready alfalfa in 2005 but it was not until April 2013 that the CFIA registered the first variety. A small amount of GM alfalfa seed was first sold in 2016, for pasture and hay for farm animals, and over 9000 acres were grown in Ontario and Quebec in 2017.[82] **The company Forage Genetics International agreed not to sell GM alfalfa in Western Canada yet, due to opposition from alfalfa seed growers and other farmers.**[83] The company has since added a GM low-lignin trait to the herbicide-tolerant GM alfalfa.

The US government first allowed GM alfalfa cultivation in 2005, but in 2007 a court imposed a moratorium on new seed sales while environmental impacts were further studied. Sales resumed in 2010, and in 2013 about 810,000 acres were planted with GM alfalfa, approximately a third of newly seeded acres that year.[84] In 2017, 2.9 million acres of GM alfalfa was grown in the US.[85]

GM contamination has also been found in US alfalfa exports:

- In 2014, China began testing its imports of US alfalfa after it found GM traits in hay shipments from three companies.[86] Those companies were blacklisted from exporting to China. Several other hay shipments from the US were rejected when GM traits were found.[87] US alfalfa exports to China declined sharply: Between August and October 2014, shipments of alfalfa to China declined by 22% by weight from the year before.[88]
- In 2013, a farmer in Washington State reported that his alfalfa shipments were rejected when the export buyer tested and found GM alfalfa. The US Department of Agriculture concluded that the contamination incident was a "commercial issue" i.e. that it did not require government action because the GM crop was approved for commercial growing.[89]

No GM alfalfa contamination incidents have been confirmed in Canada, but in 2016 an Alberta farmer anonymously reported to the media that the foundation seed he had ordered from a US supplier four years earlier was contaminated with GM Roundup Ready alfalfa seed.[90] At the time, the farmer had called Forage Genetics International (FGI), the company that holds the rights to the GM traits, to inspect his farm. The company did not make the results of their investigation public, but four years later when asked for comment by the

The only way to prevent contamination from GM alfalfa is to stop growing it and terminate existing stands.

media, FGI said that the contaminated seed would have come from the US due to a lack of quality control by seed companies: "If someone buys seed from the U.S., they can end up with Roundup alfalfa… Companies can be lousy companies, and not have formal, rigid quality controls and test their seed."[91] **US alfalfa seed imports may be another potential source of contamination in Canada.**

In 2016, US government scientists published a study confirming that GM alfalfa has dispersed widely in the environment in the US. The scientists studied alfalfa-seed producing areas in 2010-2011 and found 20.5% of feral alfalfa populations had the GM trait.[92] The scientists believe that most of the GM alfalfa came from spilled GM seed and stated, "feral transgenic plants could spread transgenes to neighboring feral plants, and potentially to neighboring non-GE fields."[93] The scientists also found evidence that the GM trait may have been spread by bees because the GM feral alfalfa stands were within foraging distances for honeybees, leafcutter bees and alkali bees.[94] The amount of GM alfalfa being planted in the US has significantly increased since 2011 when data for this study was collected.

If the cultivation of GM alfalfa in Canada expands, the flow of genes and traits from GM to non-GM alfalfa will be unavoidable. Canadian farmers who grow non-GM alfalfa, use non-GM alfalfa products, or sell their alfalfa products to markets that do not accept GM crops will be negatively affected by this contamination. Many farmers will be severely affected because of the important role alfalfa plays in many different production systems

Alfalfa is the first genetically engineered perennial crop in Canada. Its biology and the ways that alfalfa is used make it particularly susceptible to contamination through seed escape, cross-pollination, and through the proliferation of volunteer and feral alfalfa. Alfalfa seed is very small and the likelihood that seed may spill during planting, transport and harvest is very high. Seed may get left behind in farm equipment or be inadvertently spread by animals. Additionally, "hard seed" in alfalfa can stay dormant and germinate months or years later.

Alfalfa also relies on insects for pollination. It may be pollinated by leafcutter bees, honeybees, or a number of native pollinators. Variability in farm management practices and weather increase the chances that stands of GM alfalfa will not be cut before alfalfa flowers bloom, further increasing the risk of contamination via pollen flow. Furthermore, alfalfa survives well as feral populations in unmanaged habitats such as ditches and pastures, exacerbating the risk of contamination from GM to non-GM fields.

Alfalfa is a very important crop in diverse farming systems. It is used as a high quality feed for livestock, as well as to build soil fertility for growing other crops. Canada is among the top five exporters of alfalfa products, used for animal feed in other countries. Contamination from GM alfalfa will come at a high cost for organic farmers, conventional farmers who do not wish to use or grow GM alfalfa, and alfalfa product exporters.

See www.cban.ca/alfalfa for detailed reports and updates on GM alfalfa in Canada

GM CREEPING BENTGRASS

GM creeping bentgrass was field tested by Scotts Company in 1999 in the US. In 2003, windstorms scattered pollen and seed from the GM grass, and in 2010, it was found growing in large mats in Oregon. This GM grass has produced a seed bank in the soil that is almost impossible to control.

In the 1990s, Scotts Company and Monsanto genetically engineered a glyphosate-tolerant Roundup Ready creeping bentgrass, mainly for use on golf courses. Bentgrass is a perennial grass adapted to a range of habitats and found in feral populations in all US states, thriving in ditches and canals. It produces extremely small seeds that can travel long distances in wind or water, or via birds (up to 21 kilometers) and also reproduces vegetatively via horizontal creeping runners that spread aggressively.[95]

Scotts field-tested GM bentgrass in 21 states, starting in 1999. In 2003, farmers sowed 80 acres in Idaho and 420 acres in Oregon for seed production before **two windstorms swept through eastern Oregon and scattered pollen and seed as far as 13 miles away.**[96]

In 2007, the US government fined Scotts $500,000 (the largest amount allowable) for failing to control its field tests, including by not following equipment-cleaning protocols and implementing all required buffer zones.[97]

In 2010, the GM grass was found growing in large mats throughout the irrigation system across Malheur County in Oregon. The plant has produced a seed bank in the soil that's nearly impossible to eliminate.[98]

In 2015, the US Department of Agriculture (USDA) and Scotts signed a 10-year agreement whereby the company committed to not sell the GM grass and to implement a management plan for these "unauthorized releases into the environment".[99] However, the USDA and Scotts have been unable to eliminate the contamination. GM creeping bentgrass was declared a noxious weed in Malheur County in 2016.[100]

The USDA approved ("deregulated") the grass for commercial release in early 2017 which means that the GM grass contamination is no longer illegal in the US and that the government is no longer responsible for controlling the GM contamination. This new legal status of GM bentgrass also means that the company is no longer required to pay for contamination clean up.[101]

GM CORN IN MEXICO

In 2001, native corn varieties in a remote region of Mexico were found to be contaminated with GM corn. Mexico had established a moratorium on growing GM corn in 1998, but GM corn was imported as food from the US. Mexico is the global centre of origin for corn, and this GM contamination poses a serious threat to biodiversity and food security.

There have been many contamination incidents around the world but arguably the most significant case thus far is the contamination of native corn varieties in Mexico. Mexico is the global centre of origin for corn and has a high diversity of corn varieties that are adapted to a wide range of conditions. This diversity is the genetic pool that corn breeders rely on and is foundational to Indigenous cultures in Mexico. **GM corn contamination in its centre of origin is a serious threat to Mexican and global biodiversity and food security.**

Mexico legislated a moratorium on growing GM corn in 1998, but it was still making its way across the border from the US, much of it distributed to villages through domestic food aid programs.[102] In 2001, researchers Ignacio Chapela and David Quist from the University of California Berkeley reported finding significant levels of transgenic DNA in native corn varieties in the remote mountains of

Oaxaca, Mexico.[103] The initial discovery was made as the researchers were responding to concerns from indigenous communities about potential contamination: The scientists expected to use local native corn as a control in their demonstrations of how local people could test for GM contamination but, instead, they discovered that the native corn was contaminated.[104]

That same year, the Mexican government corroborated this evidence when it found contamination in 15 of 22 communities sampled.[105] However, the results as reported by Dr. Ignacio Chapela and PhD student David Quist were subject to much scepticism and public critique. After many letters questioning the validity of their research, in 2002 the journal *Nature* stated that it should not have published their peer-reviewed article, although they did not retract it. The same journal also rejected the paper from the Mexican government reporting contamination.

In 2003, another study tested 2000 plants from 138 communities and found contamination in 24% of the samples, and a second round of testing of 1500 plants found contamination levels ranging from 1.5% to 33%.[106]

Chapela and Quist also found that the transgenic DNA discovered was unstable, suggesting that **GM contamination could have unexpected impacts on native plants.** The transgenic DNA was moving around within the genome and was found in several unintended places in the native corn.[107] In 2003, indigenous community representative Gabriela Linares Sosa testified about contaminated corn found in two of eleven villages in the Sierra Juárez mountain range of Oaxaca: "Although in both communities the source of contamination could not be established, the plants that tested positive for up to three different GM-genes differed starkly from the norm: they were more than six feet tall and featured up to seven seedless cobs."[108]

RISKS FROM NEW GM CROPS AND ANIMALS

There are several new and proposed GMOs that either pose significant risks of escape and/or serious environmental or other risks if escape were to occur. Furthermore, some proposed GMOs are specifically designed to be released into the wild to deliberately cross with wild populations.

GM FRUIT TREES: Apple and Papaya

A GM non-browning apple is the first genetically engineered tree approved for growing in Canada. There are commercial GM apple orchards in Washington State (600 acres in 2017, with a company goal of over 2000 acres by 2020[109]) but none yet in Canada. In 2000, protests from BC apple growers stopped the GM apple from being field tested in Canada.[110]

Even though apple blossoms are pollinated by bees, the company that developed the GM Arctic® apples, Okanagan Specialty Fruits (OSF), claims that the risk of contamination is low because bees stay close to their hives when there is enough food (such as when an orchard is in bloom) and that "dense orchard plantings and buffer rows make it very difficult for bees to maneuver far, so the risk of bees carrying pollen far enough to be an issue is almost nonexistent."[111] **However, there are approximately 450 native bee species in British Columbia**[112] and the many small orchards clustered in apple-growing areas, like the Okanagan Valley of BC, support a great variety of these species. The U.S. Apple Association has said that, "in the growing practices common in the Pacific Northwest, there is reasonable concern about genetic flow."[113] Okanagan apple growers say that commercial hives are often transported from orchard to orchard around the valley.[114] OSF has said that, "grower stewardship standards will further reduce this already low risk by defining buffer distances between Arctic and other apple orchards."[115] However, setting up such buffer zones has so far been the burden of organic farmers and other growers who want to protect their crops from GM contamination, rather than the responsibility of farmers who are planting GM crops. Setting aside land for non-productive buffer zones would be a disincentive for orchardists to plant GM trees. Furthermore, experience in Canada with insect refuge requirements for GM Bt corn shows that GM growers often fail to implement such controls.[116] Currently, OSF is managing the GM apple orchards itself rather than selling the trees to other growers, and the company's own stewardship practices are unknown.[117]

There are also many ways that GM apple seeds could spread in our environment: by humans discarding apple cores, cores in compost piles, seeds scattered by animals, and deliberate plantings. For example, the Ambrosia apple variety (which is naturally slow-browning) began as an apple tree found growing in a compost heap in British Columbia.

The first GM fruit tree in the world was the virus-resistant "Rainbow" papaya. **Five years after its commercial release in Hawaii, high levels of GM contamination were found in Hawaiian papaya seeds**.[118] Feral GM papaya trees were also found on roadsides and in backyards. The causes of this contamination are speculated to include pollen flow, negligence in early field-testing, and the ongoing practice of saving and trading seed from (unlabelled GM) papayas.[119]

GM FOREST AND PLANTATION TREES: Pine, Poplar, Spruce, Eucalyptus, American chestnut

A number of biotechnology companies have plans for plantations of genetically engineered trees in North and South America. So far, however, the only large-scale planting of genetically engineered trees was approximately 490 hectares of insect-resistant black poplar in China in 2001.[121] Arborgen's GM cold-tolerant eucalyptus, for energy and/or paper production, is awaiting approval in the US and may be the first GM tree planted for non-food purposes in the Americas. The Brazilian government approved FuturaGene's high-yielding GM eucalyptus tree in 2015, but it has not yet been commercially planted. Researchers are now genetically engineering a blight-resistant American chestnut tree for deliberate release into US and Canadian forests, to replace wild trees that are almost extinct due to chestnut blight.

Genetically engineered trees have enormous potential for gene flow because trees are large, long-living organisms that produce abundant pollen and/or seed that are designed to travel long distances, carried by wind, water and animals. For example, researchers have found that 50% of pollen from the loblolly pine can still germinate after drifting 41 kilometres from the source and up to an altitude of 610 metres.[122] Commercial cultivation and outdoor tests of chestnuts, poplars, and pines and other conifers could pose a high risk of gene flow to native forests, including into Canada from the US.

Once contamination from GM trees begins, it cannot be stopped and will continue to spread.

The Canadian Biotechnology Action Network, with groups across the world, has reached the conclusion that **"The only reliable method for preventing the escape of genetic material such as transgenes from genetically engineered trees is to not release such trees into the open environment."**[123]

Scientists at the Canadian Forestry Service have warned that, "gene flow from genetically modified trees will occur unless they are strictly made unable to reproduce."[124] Because of their high contamination

"GE trees have the potential to wreak ecological havoc throughout the world's native forests. GE trees could also impact wildlife as well as rural and indigenous communities that depend on intact forests for their food, shelter, water, livelihood and cultural practices...GE trees should not be released into the environment in commercial plantations, and any outdoor test plots or existing plantations should be removed." — David Suzuki, 2012[120] risk, proposals to release GM trees are often accompanied by suggestions that they should also be engineered to be sterile. (See box *The risks of Terminator Technology,* page 25).

Despite this acknowledged risk, the Canadian government has allowed field tests of GM trees since 1997, and has invested in GM tree research through the Canadian Forest Service of Natural Resources Canada. Government scientists have conducted field trials of GM poplar and spruce trees, with controls that included pulling up roots post-trial and monitoring for regrowth.[125] The only current field test – of over 2000 GM poplar trees managed at Queen's University and begun via public funds from Genome Canada – includes a physical root barrier around the site.[126]

In the case of GM trees, the chance of contamination is high, as are the stakes. GM contamination of native forests will have unpredictable and complex impacts on forest ecosystems and biodiversity. Forests are home to some of the richest biodiversity in the world, provide a range of other ecological services, and are critical in stabilizing local and global climate.

GM FISH: Atlantic Salmon

The world's first commercialized GM food animal is a GM salmon that is in limited production at a land-based pilot plant in Panama. The company AquaBounty is preparing commercial-scale factories to produce it in North America – in Indiana, US, and at Rollo Bay, Prince Edward Island.[127] For many years, the GM fish eggs have been produced in PEI and shipped to Panama for research and, more recently, commercial grow-out. The "AquAdvantage" salmon is genetically engineered with a growth hormone gene from Chinook salmon and genetic material from ocean pout, and is designed to reach market size in half the time of other farmed Atlantic salmon.

Because the risk of farmed fish escaping from ocean net pens is already a serious, recurring issue, AquaBounty says it will only produce the GM fish in land-based facilities. In fact, the company argues that their fast-growing GM salmon will help make the move to on-land aquaculture more economical. All the fish are designed to be sterile females (via a technology called triploidy) but the company can only guarantee that 95-99% of the salmon are infertile.[128]

The chance of an escape is small but the stakes are high. Any risk of GM Atlantic salmon escaping threatens wild Atlantic salmon populations, which are either endangered or at risk across North America. GM Atlantic salmon can survive and breed in the wild, and are capable of breeding with brown trout, for example.[129] Research from the Department of Fisheries and Oceans with experimental GM Coho salmon found that GM salmon are more aggressive in times of scarcity and could outcompete wild salmon for food.[130] **The true environmental impacts will only be known when escape occurs.**

The initial 2013 Canadian decision to allow GM salmon production was challenged in court by Ecology Action Centre (Nova Scotia) and Living Oceans Society (British Columbia).[131] Specifically, the groups argued that the environmental risks posed by GM fish escape should have been assessed, rather than just the strength of the company's containment plans.

GM INSECTS: Gene Drive Mosquitoes

The new genetic engineering technologies of gene editing (CRISPR) are being used to create "gene drives" that will engineer the genetics of entire wild populations of plants, insects or animals. **Gene drives force a specific trait to spread through generations of a species, bypassing the process of natural selection, and can be used to eradicate entire populations.**

Gene drives research is being used in experiments to alter the genes of weed and insect pests for agriculture.[132] Another proposed use is to genetically engineer mosquitoes to prevent their reproduction, to reduce populations that carry diseases such as malaria. The research group *Target Malaria* aims to use gene drive mosquitoes to reduce the population of *Anopheles gambiae* mosquitoes, which can transmit the parasite that causes malaria. The project is run by researchers at Imperial College in the UK and funded by the Bill and Melinda Gates Foundation and the Open Philanthropy Project (a group of Silicon Valley donors).

Gene drive mosquitoes have a high potential to become invasive, and their gene drive systems could spread to other species, with unintended consequences. The role of mosquitoes in the ecosystem is not well understood and the implications of removing certain populations may lead to unpredicted ecological impacts (including the possibility that another disease-carrying species may take their place).[133]

In November 2018, the United Nations Convention on Biological Diversity laid out strict conditions for any environmental release of gene drive organisms, including requiring risk assessments and "free, prior and informed consent" from all potentially affected indigenous peoples and local communities. Over 200 organizations and leaders representing farmers and food workers from around the world are calling for a global moratorium on all gene drives.[134]

Once released, gene drive organisms cannot be recalled and any changes to wild populations would likely be irreversible. **Gene drive organisms can – and will – spread beyond target geographic regions and political boundaries.** These GMOs could therefore have far-reaching and unpredictable consequences for society and the environment.

Additionally, gene drive mosquitos are an unproven solution for malaria.[135] Projects such as *Target Malaria* ignore the root causes of malaria: Measures such as improving sanitation, eradicating mosquito breeding sites, and draining swamps are effective, affordable, and provide other social and public health benefits.[136]

Mosquitoes have previously also been genetically engineered by the company Oxitec.[c] The GM mosquitos were released in Brazil, Panama and Cayman Islands in an attempt to combat Zika virus disease and dengue fever, but there was no evidence of a fall in the number of female biting mosquitoes or reduction of infection.[137,138]

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[c] Oxitec was later bought by the US-based synthetic biology company Intrexon, which also now owns the GM "Arctic apple" company Okanagan Speciality Fruits and is a majority owner of the GM fish company AquaBounty.

THE RISKS of TERMINATOR TECHNOLOGY

Terminator Technology, or Genetic Use Restriction Technologies (GURTs), describes a range of technologies to genetically engineer plants to produce sterile seeds at harvest. There is a global moratorium at the UN Convention on Biological Diversity on field-testing or commercializing such technologies, however they continue to be discussed as a tool to stop GM escape.

Proposals to use Terminator Technology often accompany the development of GMOs where contamination is either recognized as inevitable, as with the release of GM trees, and/or where a GMO is acknowledged as particularly dangerous, as with crops engineered to produce pharmaceuticals or industrial chemicals. Theoretically, such biological containment technologies would offer a built-in safety feature for GM plants. In reality, like all containment strategies, they can fail.

Rather than solving the problem of GM contamination, attempting biological containment would enhance the problem:

- The technologies are likely to fail. GURTs are complex systems involving multiple inserted genes that work together in a sequence. Scientists warn that the technology will not be 100% effective and that the likelihood of system failure means it could never be a reliable tool for "biocontainment".[140]
- When biological containment fails, the consequences could be particularly dire because the technologies will have been used to contain particularly dangerous GMOs. **If Terminator Technology is accepted as a containment strategy, it will facilitate the development and introduction of particularly dangerous GMOs.**
- The technology itself poses its own contamination risks whereby a sterility trait could spread, leaving farmers to unwittingly plant seeds that will not germinate, or the system could behave in unanticipated ways once released.

"Given that no single bioconfinement technique is likely to be completely effective, the use of multiple techniques with different strengths and weaknesses will decrease the probability of failure."

— National Research Council (US), 2004[141]

RESPONSES TO GM CONTAMINATION

"We should not have confidence in our ability to keep GM plants on a tight leash. Rather, total containment can never be assured or assumed, and our evaluation of risk should be predicated on the idea that transgenes always have some chance of escaping."

— Michelle Marvier and Rene Van Acker, 2005[144]

PREVENTING CONTAMINATION

Contamination can be prevented. The biology and use of some GMOs can limit their escape. For example, GM soy and GM sugar beet in Canada have successfully been contained due, in part, to their biological characteristics (for example, soybean is self-pollinating and its seeds are large and can be easily cleaned from equipment, and sugar beets are biennial). Furthermore, some escaped GMOs, such as GM pigs, can be tracked and recalled more easily than others. However, **for some genetically modified organisms, preventing contamination requires stopping their release.**

Contamination should be prevented. The US National Research Council advises that, "The evaluation of whether and how to confine a GEO [genetically engineered organism] should be an integral part of its development."[142] However, the Canadian Food Inspection Agency (CFIA) does not evaluate the full contamination risk. This is largely because federal GMO safety evaluation processes exclude non-scientific considerations such as economic impacts. This means that the full contamination potential of a GMO, and the full range and depth of any related impacts, are not assessed by the federal government.

For example, the CFIA recognized the risk of volunteer glyphosate-tolerant alfalfa plants in the summary of its 2005 approval of Roundup Ready alfalfa but concluded, "these can still be managed by growers through the use of alternative herbicides with different modes of action, or cultivation practices which do not involve the use of herbicides."[143] This conclusion does not appear to consider the cost of these options to producers, nor the feasibility of options available to organic farmers. **The potential economic and social impacts of contamination, as well as the full environmental impacts, need to be assessed before a GMO is released.** Such an assessment would necessarily involve consulting farmers.

ACCEPTING CONTAMINATION

Rather than take measures to prevent GM contamination, the biotechnology and seed industry is advocating for policies that accept contamination. The Canadian government has committed, via the 2018 trade agreement with the US and Mexico, to developing a "Low Level Presence" (LLP) policy that will allow some GM contamination in imports to Canada.

Agriculture and Agri-Food Canada had already drafted an LLP "policy model" that would allow a certain percent of contamination in imports to Canada, from GM foods *that have not yet been approved as safe by Health Canada* – if the contamination comes from a country whose regulatory system Health Canada considers trustworthy.[145] **This policy would mean that Canada's safety regulation of GM foods would no longer be applied to all the GM foods that Canadians eat. Low level presence would replace the global norm of zero-tolerance for contamination** from GM events that have not been approved by domestic regulators.

If Canada's trading partners accept LLP, it could remove the most immediate negative economic impacts of GM contamination in global trade. A global LLP policy would go a long way to realizing the industry's goal of harmonizing regulations across the world or simply accepting the regulatory decisions of other countries. As the lobby group for pesticide and GM seed companies, CropLife Canada, proposes: "Canada could consider and recognize the conclusions of risk assessments completed in other countries with reliable regulatory systems."[146]

MONITORING CONTAMINATION

The Canadian government does not track which GMOs are on the market in Canada. The federal government does not collect statistics on where and how many GM acres are planted, with the exception of some Statistics Canada numbers on GM corn and soy plantings in Ontario and Quebec.[147]

The European Union tracks and maintains a public database of all food safety risk incidents, including the entry of unapproved GM foods. This *Rapid Alert for Food and Feed* system made it possible to track the extent to which GM flax from Canada reached other countries.

The *GM Contamination Register* provides a global database of contamination incidents (1997-2015). It was hosted by Greenpeace International and GeneWatch UK from 2005 until it was suspended due to funding constraints in 2015. It compiled all publicly documented incidents of contamination and illegal release of GMOs, backdated to 1997.[148] **From 1997 to September 2014, 396 incidents of GM contamination around the world were recorded.**[149]

Our report documents in one place, for the first time, the GM escape incidents in Canada. Such monitoring and reporting efforts are necessary to provide an awareness of the risks and acknowledge the impacts of GM escape, and to take actions to prevent future harm.

Conclusions

So far, it is farmers who have felt the brunt of the impacts of GM contamination, and have been left to deal with the often costly consequences. In Canada, these consequences have included the temporary or permanent loss of export markets, lower prices in the short or long-term, the loss of access to a particular crop, and the loss of farm-saved seed.

While the risks are not uniform across all organisms, human error, biology, pollinator and wind movement, extreme weather events, and other factors, make GM contamination predictable. The diverse incidents of GM escape and contamination in Canada – with canola, flax, wheat, and pigs – show that these risks cannot be managed by current government regulation nor through industry-developed best practices.

Our experience with GM escape incidents and contamination in Canada supports the conclusion that the co-existence of GM and non-GM crops is not possible. Instead, the many cases of escape described in this report show that the government needs to regulate segregation and containment measures for some GMOs and that **the only way to prevent contamination from certain GMOs is to stop their release.** Some GMOs are too prone to escape and others have impacts that are too serious if escape occurs.

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