Bees: a Consideration of the Economic Value of Insect Pollination in Ontario

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ABSTRACT

The province of Ontario has enacted The Pollinator Health Action Plan*, a collection of policy measures aimed at preserving the health of pollinator-species populations, measures that include the 80% reduction of neonicotinoid-based pesticide use in the province by 2017. Ontario corn and soybean producers are vocal critics of the plan who argue that this mandated reduction of neonicotinoids could cost the province's GDP $440 million annually and could cost corn and soybean farmers upward of $630 million annually. This argument and its figures, however, appear quite self-serving: corn and soybean production do not depend on pollination to thrive, but the whole of the horticulture sector does. In this paper, we calculate and analyze the Economic Value of Insect Pollination in the province of Ontario and, considering different scenarios, we scrutinize the claims of the Action Plan's detractors. in purely monetary terms, the incredible dominance of corn and soybean production in Ontario's agriculture sector eclipses all others, yet there are other factors that must be considered, taking into account the threat that the loss of pollinator species poses to horticulture production in the province. In such a scenario where bees and pollination services would be threatened, it is necessary to evoke what is called the Precautionary Principle and guarantee that the environmental will be protected regardless what monetary values represent.*[1]

INTRODUCTION

Humankind depends on pollinators to produce food, to support natural-resource economies and to guarantee biodiversity. As pollinators, bees guarantee the production of food for humans, and they are responsible for the very existence of some plants and for the growth of fruits and vegetables that are extensively consumed by humans. According to Elke Genersch (2010), pollination by honeybees is responsible for 35% of global food production, and Klein et al. (2007) consider honeybees to be the most valuable pollinators of crop monocultures in the world. The role that honeybees play in the maintenance of the food supply is crucial and should not be

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[1]**A note on the limitations of scope in this paper:** The primary aim of this paper is to highlight the combination of factors—economic, scientific, environmental, ethical—that must be considered when establishing sound policy. It is not possible within these pages to embark on any sort of full-scale economic impact assessment involving different scenarios or degrees of bee-loss effects to Ontario's GDP. For example, we do not take into consideration that regions that are net importers of horticulture products would be more affected by a loss of pollinators, such as is suggested by Gallai et al (815). Also, simple farming adaptations, such as the changing of crops being produced, have not been considered in the analysis provided in this paper because that would require detailed and separate research for each horticulture crop in each region of the province of Ontario. Throughout this paper, where these and other limitations appear most evident, we attempt to address them with additional footnotes.

underestimated. In the province of Ontario, honeybees and bumblebees are responsible for pollinating $897 million of the $6.7 billion worth of agricultural crops annually (*Pollinator Health* 2014). Furthermore, each year Ontario beekeepers transport honeybee colonies outside of the province to pollinate about $71 million worth of blueberry and cranberry crops in eastern Canada (*ibid.*).

It is therefore alarming to note that bees have been disappearing at a high and unusual rate. On a yearly basis, beekeepers across North America and Europe have been reporting increasing numbers both of bee deaths, that is to say individual insects reported to be dying while out foraging for nectar and pollen to feed their hives, and of colony collapse, which occurs when great numbers of bees within the hive—including queens—die off suddenly (Health Canada 2014; Bonmatin et al. 2015). One possible cause for these losses pointed out by scientists is neonicotinoids, a class of pesticides that have been in commercial production since the 1980s and that are used in field crop production. As a result, the European Union in 2013 voted to restrict neonicotinoid use in all EU member-states, and several European countries have implemented further and more stringent restrictions within their own jurisdictions. Similarly, the province of Ontario has enacted *The Pollinator Health Action Plan*, a collection of policy measures partially aimed at reducing and potentially reversing reported annual bee losses. One of the Plan's policies calls for an 80% reduction in neonicotinoid use in Ontario by 2017.

The goal of this research essay is to consider possible outcomes of *The Pollinator Health Action Plan*, with a focus on the Plan's aim to reduce neonicotinoid pesticides in an effort to stabilize bee populations in decline. It is tempting to advocate only for the protection of the bees and the environment as a whole, and such measures have been rightly applauded. However, there is nonetheless a level of human intervention in nature that is desired to produce goods for our consumption. The use of the neonicotinoid pesticides is one such human intervention, since it is an effective insecticide to control pests that are already proven to cause significant economic damage, such as aphids, leafhoppers and whiteflies (Blacquière et al. 2012).

The Conference Board of Canada-commissioned report, *Seeds for Success: The Value of Seed Treatments for Ontario Growers*, paid for by the The Grain Farmers of Ontario and CropLife, special interest groups with a vested interest in maintaining current neonicotinoid use-levels, claims that if *the Pollinator Health Action Plan* enters into force, the province's Gross Domestic Product (GDP) could be reduced by more than $440 million—or 0.063 % of the provincial GDP—per year (in 2013 values) due to potential losses to corn and soybean production (Grant, Knowles and Gill 2014). While this $440-million figure is certainly debatable, there is nevertheless an economic tradeoff that must be considered between the use of neonicotinoids and the survival of bees and their role as pollinators. The authors of *Seeds for Success,* however, do not take into consideration any potential benefits or environmental impacts that this new policy can bring. In fact, potential benefits of the Plan are ignored. In this essay, we analyze some of those ignored benefits, considering the economic value of bee pollination to horticulture[2] in Ontario. Beyond this, I thoroughly vet the claims made by Grant, Knowles and Gill in *Seeds for Success*. By quantifying potential benefits and by closely scrutinizing their report, we offer an alternative assessment of *The Pollinator Health Action Plan*.

[2] Horticulture includes the farming of fruits, vegetables, and flowers.

BACKGROUND

The Task Force on Systemic Pesticides Worldwide Integrated Assessment

Since the late 1990s, incidents of bee losses across the globe have been reported in more and more alarming numbers. The Task Force on Systemic Pesticides (TFSP) is an independent group of scientists from different nations working on the Worldwide Integrated Assessment of the Impact of the Systemic Pesticides on Biodiversity and Ecosystems. The TFSP is composed of experts in chemistry, physics, biology, entomology, agronomy, zoology, risk assessment and (eco) toxicology, as to provide a very interdisciplinary viewpoint. The goal of the assessment is to provide a scientific review, an evaluation of the impact of systemic pesticides on biodiversity and to provide advice that will guide those policy makers and governmental staff who make decisions about the permissions of pesticides and the society in general. Results of the Assessment show that large-scale systemic pesticide use is negatively impacting non-target species, endangering the well-functioning of ecosystems. These results were published as a collection of articles in the January 2015 special issue of *Environmental Science and Pollution Research.* Below are summaries of findings from selected articles from the special issue.

"Global Collapse of the entomofauna: exploring the role of systemic insecticides"
Maarten Bijleveld van Lexmond et al. [1-4]

Lexmond et al. argue that since the bees are dying at higher than usual rates, governments should employ The Precautionary Principle. This principle states: "When human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or diminish that harm” (Lexmond et al. 2015, 2). This principle has been adopted by the E.U. Comission’s Directive 91/414 and defined by the UNESCO in 2005.

Neonicotinoids, the most widely-used pesticides in the world, act as neurotoxins in arthropods. Specifically in bees, they cause impaired learning and navigation, susceptibility to disease since their immune system is affected, reduced fecundity and increase in mortality. The study ponders that the decrease in the number of bees has also other explanations. One of them is the synergistically action of the different pesticides. Bees are exposed to a variety of insecticides and their combined action creates reaction on bees that are not fully understood yet.

Lexmond et al. contest the prophylactic use of neonicotinoids, specially because it is not benefiting the yield. They argue that, in Europe, the use of pesticide considered broad-spectrum pesticides[3] in a prophylactic way is not recommended by the Integrated Pest Management (IPM) and therefore, it is against the EU directives, which make compulsory the IPM recommendations. For Lexmond et al. the reason for that is because farmers are usually advised by agrochemical companies.

“Systemic insecticides (neonicotinoids and fipronil): trends, uses, mode of action and metabolites”
N. Simon-Delso et al. [5-34]

The success of neonicotinoids is due to the fact that they spread over all the tissues of plants, making them more effective than similar pesticides. Studies made by Maienfisch et al. 2001, Kuhar et al. 2002, Nault et al. 2004, Koch et al. 2005 and Jeschke et al. 2013 show that neonicotinoids reduce the chance of crop damage from pests and that they can increase crop yield. Despite the efficiency and contribution to pest avoidance, there is a crescent feeling of

[3] Broad-spectrum pesticide is a pesticide that is toxic for other species and not only the target one. (Society of American Foresters – The Dictionary of Forestry).

resistance and avoidance in society with respect to neonicotinoids. The scientific community shows that neonicotinoids are being used indiscriminately. For example, in the American and Canadian corn production sectors, 100% of seeds are treated with neonicotinoids. One reason for this is the difficulty of finding non-treated seeds on the market; according to Simon-Delso et al. this due to crop insurers, who have requirements to cover eventual drops in yield.

Some researchers also argue that the pests that neonicotinoids combat are only sporadic. They argue that it is important to have remedies against them, but that there is no need for the prophylactic use of neonicotinoids, since this only increases the cost and there is almost no benefit in return, or at least not always. They argue that simple farming techniques such as crop rotation can considerably reduce the chance of these sporadic pests. Therefore it is worth questioning if the seeds treated with neonicotinoids are not almost exclusively increasing the costs on the corn and soybean production, as well as on the environment, through the increase in bee and other animal deaths, with too small benefit.

“**Effects of neonicotinoids and fipronil on non-target invertebrates**”
L. W. Pisa et al. [68-102]

Pisa et al. show that the honeybee is crucial to crops that serve as human food, and that all over the world, the mortality of bees increased drastically and to worrisome levels. The authors present some negative impacts that sublethal doses of neonicotinoids can have on bees. Research shows that the dust created during the sowing of seeds during planting seasons is the manner of contamination with the most risk of mortality to bees. Because of that, some techniques to improve the seed coating and the drilling machines have been developed.

These improvements, while helpful, are not enough to protect bees against contamination. Among the negative impacts of contamination are problems with locomotion, metabolism, activity and ontogenetic development. In honeybees, for example, neonicotinoids can cause the paralysation of flight muscles, and bees can be affected by neonicotinoids even during the larval stage; bees can have their neural development amended, causing "impairment of olfactory associative behaviour" during adult life (Pisa et al. 2015, 72). Memory and orientation problems have also been found in honeybees exposed to neonicotinoids . These effects are very dangerous for the bees because their ability to learn how to live in society is essential for the good operation of a hive. This lack of orientation can culminate in the loss of forager bees and that can lead to a colony's collapse. Furthermore, exposure to neonicotinoids and other environmental factors can aggravate the negative effects that neonicotinoids cause in bee populations. For example, some pathogens act synergistically with neonicotinoids and together they increase the mortality rate that is already normally expected with the pathogen in question. Pisa et al. argue that because of the current level of pollution, rate of use of insecticides, including neonicotinoids and the overwhelming set of evidence that the environmental negative impacts are too high, government and regulatory agencies should put into force Precautionary Principles and tighten the restrictions on neonicotinoids.

"Risks of large-scale use of systemic insecticides to ecosystem functioning and services"
Madeleine Chagnon et al. [119-134]

Research has been and continues to be conducted into how neonicotinoids affect different ecosystem functionings. Some of the risks that neonicotinoids can present are risks to soil quality and to soil-dwelling organisms such as the microbes and earthworms that are responsible for soil decomposition; risks to freshwater ecosystems due to the fact that many of the insect species negatively affected by neonicotinoids are at the base of the aquatic food chain, their being a primary food source for many fish and amphibians; risks to cultured fisheries, through both direct water contamination and because aquaculture still relies, to a large degree, on the same aquatic food chains as wild aquatic ecosystems. Further to these examples are the risks to pollination.

Pollination is crucial for some fruits, vegetables, nuts, cotton, seed crops and wild plants. The absence of pollination would cause yield losses and would also negatively impact genetic diversity. Even if some crops do not present large increases in yield when pollinated, others, like apples, blueberries and carrots, are completely dependent on pollination. Indeed, many foods that are part of the human diet are dependent on pollination[4], and it has been shown that pollination efficiency increases by five times in the presence of honeybees.

There are 124 major crops produced for human consumption and 87 of them are dependent on pollination. Pollination provides not just quality but also variety of food for humans. In Europe, 84% of the crops depend on pollination and in its absence, there would be a drop of 7% in yield in the European Union. Also, of 1,330 tropical crops studied, 70% of them present a better yield after animal pollination. Pollination dependence is increasing worldwide. From 1961 to 2006, for instance, there was an increase of 16.7% in pollinator-dependent crops in the developing world and an increase of 9.4% in the developed world. This is a trend and is expected to keep moving in this direction, especially in the production of oil palm, sunflower and canola.

[4] When pollination is mentioned here, it is taking into consideration all kind of pollination: wind, insect and other types.

In respect to human food we have that, from 15 to 30% of the human food come from crops that depend on bee pollination. This number alone might look small, but it is necessary to remember that the micronutrients that humans can get from fruits, vegetables and nuts are crucial for humans to have a healthy life and do not suffer from undernourishment or from nutrient or mineral deficiencies. In the developing world, one out of every three people suffer from undernourishment, be it calories or micronutrients.

Neonicotinoids pose a particular problem : Will we be able to provide food for all the world's people? There is pressure to meet the food needs of an increasing world population. Neonicotinoids are used to improve the production of some crops such as corn and soybean. And while a good deal of research does not show that neonicotinoids increase crop yield, it is true that corn and soybean are grain staples of many populations and could, theoretically, meet the caloric needs of the world. However food security is much more than calories. Food security involves and requires not just adequate calories, but quality and diversity of foods in order to promote good health and quality of life. Studies show that when people do not have access to all the nutrients that they need, they might present intellectual or physical disabilities. These beneficial nutrients are usually found in fruits and vegetables, i.e. pollinator-dependent crops. Beyond health, food and agriculture are also intrinsically linked with cultural identity. Some example are vanilla, olives, sunflowers and cotton. If people lose the access to their traditional food and other crops, there will be a social or cultural loss as well, and localized economies can be negatively affected and even marginalized. Furthermore, other economic losses caused by the negative effects—i.e. bee losses—of neonicotinoids would be seen with crops such as cucumbers or apples, which cannot meet market standards if not properly pollinated.

NEONICOTINOIDS IN ONTARIO

Neonicotinoid-based Pesticides and Crop Production in Ontario

Neonicotinoid pesticides are the most widely used pesticide in the world, representing 40% of the world market, and in 2011 neonicotinoids sales surpassed US$2.63 billion, according to the International Union for Conservation of Nature (IUCN). The province of Ontario contains almost 7 million acres of crops, of which 2.4 million are corn and 2.5 million are soybeans (*Pollinator Health* 2014). Almost 100% of corn farms and about 60%[5] of soybean farms use seeds treated with neonicotinoids.

Neonicotinoids and Pollinator Health in Ontario

When neonicotinoids were first approved for use in Ontario, they seemed to be the best option compared to other pesticides because they acted more directly on target pest species and apparently had lesser effects on non-target species. At that time, there was no sign that neonicotinoids would be harmful to bees. It is now widely agreed that neonicotinoids are highly toxic to bee populations. According to Health Canada (2014), since July 2012 a great fall in the number of bees has been recorded and an increase in bees' overwintering mortality rate was verified from the normal average 10 to 15% to a current average of 15 to 29% (data in relation to the whole country). Bee losses are occurring at unexpectedly high rates, and bee specialists and government agree that these losses are due to pests, pesticide exposure, loss of habitat and climate change. Furthermore, evidence is continually mounting showing neonicotinoids as a major factor in these losses. In July 2014, the International Union for Conservation of Nature

[5] Ontario's *Pollinator Health Action Plan* sets this number at 60% while Grant, Knowles and Gill state this number as 65%.

(IUCN) released the results of an analysis of 800 peer-reviewed reports on the topic. One of the lead authors of the study, Dr Jean-Marc Bonmatin, claims: “Far from protecting food production, the use of neonics is threatening the very infrastructure which enables it, imperilling the pollinators, habitat engineers and natural pest controllers at the heart of a functioning ecosystem” (IUCN 2014).

Neonicotinoids have been shown to affect bee health in a number of ways. Among them we have neonicotinoid-treated seeds, soil application and foliar sprays of neonicotinoids (Health Canada 2014). Health Canada, in its document called *Update on Neonicotinoid Pesticides and Bee Health* (2014), states that the only kind of contamination from neonicotinoids that causes bees to die is if the bees enter in contact with the dust from the planting of the neonicotinoids-treated seeds. Farmers use seeds that contain neonicotinoids pesticides and when the plants grow, the pesticide is spread throughout the tissues of the plant (*Pollinator Health* 2014). When the bees pollinate plants they end up being exposed to the neonicotinoids through the nectar and pollen, exposure that then causes problem in the bees’ neurological systems. More specifically, research by the IUCN found that neonicotinoids can negatively affect the individual navigation, learning, food collection, resistance to disease and fecundity of bees. However, the biggest problem of the neonicotinoids-treated seeds is the dust that is produced during the planting period. When bees enter in contact with this dust, they often simply die. In 2012, 70% of the dead bees in Ontario contained residues of neonicotinoids present in their body and in the year of 2013 this level increased to 75% (Health Canada 2014; *Pollinator Health* 2014). Health Canada showed that in the years of 2012 and 2013, 70% of the dead bees had some residues of neonicotinoid in their bodies. However, research continues to determine if the other two types of neonicotinoid-use really affect bees.

Health Canada's Pest Management Regulatory Agency (PMRA) proved that the exposure to contamination from neonicotinoid-treated seed dust is one of the causes of losses in bees and that such contamination-related losses usually happen during planting periods for corn and soybeans. However, the PMRA is not yet convinced that, after the planting season, the increase in the mortality rate of bees is due to neonicotinoids. Because of this uncertainty, the PMRA is conducting research to evaluate this. The research is also investigating whether or not neonicotinoid-treated seeds, when used in extensive culture—i.e. canola—can harm bees. This research is being done because until now the PMRA has found that such harm happens only when there is an intensive culture – i.e. Ontario corn production (Health Canada 2014).

During the 2012 and 2013 planting seasons, a huge number of bee losses occurred in Ontario. Therefore, before the 2014 season the PMRA, OMAFRA, the Canadian Seed Trade Association, CropLife Canada and pesticide registrants made an effort to prevent bees becoming contaminated by neonicotinoid dust from corn and soybean seeds. This effort generated good results and there was a decrease of around 70% to bee losses during the planting period. Although following this there were continued reports of queen losses, the underdevelopment of colonies, a low number of foragers, dwindling colonies and a loss of population. All these unexpected findings suggest that bees are affected not only by the dust from neonicotinoid-treated corn and soybean seeds. Therefore the PMRA is doing the research mentioned to fill the gaps in this knowledge, and the expectations are that the report will be finished in 2015.

Ontario's *Pollinator Health Action Plan*

There is an undeniable link between crops that use seeds treated with neonicotinoids and bee deaths. In Ontario, the provincial government has responded with new policies, contained within the *Pollinator Health Action Plan*. Currently, almost 100% of the corn farms and about 60% of the soybean farms in Ontario use neonicotinoid treated seeds (*Pollinator Health* 2014). The objective of the Plan is to decrease the number of acres planted with seeds treated with neonicotinoids by 80% by 2017, and to reduce the honey bee winter mortality rate to 15% by 2020. The winter mortality rate for honey bees currently stands at 58%. By doing this, the government expects to improve the health of pollinators and connected ecosystems, guarantee food supply, and strengthen the economy in Ontario. (*Pollinator Health* 2014).

Ontario's efforts follow in the footsteps the European Union (EU), United Kingdom and United States, all of which are also making moves to deal with the situation of neonicotinoid-related bee deaths. The EU banned the use of this pesticide for two years to assess exactly what are the impacts on bee populations. The United Kingdom has released a plan called the National Pollinator Strategy that decreased the amount of neonicotinoids used in crop production, as well as strictly regulating how farmers may use this pesticide.

The government of Ontario, too, plans to heighten regulations for the use of neonicotinoids. First of all, the government wants to place seeds treated with neonicotinoids under the *Pesticides Act*. By making this regulatory change, the sales of these seeds would be regulated and restricted.

Conference Board of Canada Report:
Seeds for Success: The Value of Seed Treatments for Ontario Growers

Grant, Knowles and Gill (2014) argue that, with a severe restriction to the use of neonicotinoid pesticides, such as those restrictions proposed in Ontario's *Pollinator Health Action Plan*, Ontario corn and soybean revenues will fall by $630 million and that the province's GDP could fall by $440 million, when considering supply chain effects. They also predict that corn and soybean production in Ontario will decrease by more than 1.9 million tonnes and by more than 750,000 tonnes, respectively. These numbers were calculated based on the production of corn and soybeans in Ontario, using a farm-level microeconomic model, with the results then expanded into a macroeconomic model to represent production province-wide. The authors estimated revenue, costs and profitability across five revenue classes, based on national data collected from Statistics Canada between 2008 and 2012. Based on these models, four scenarios were created from which conclusions have been drawn. The scenarios were crafted assuming that 99% of corn seeds and 65% of soybean seeds planted in Ontario are currently treated with neonicotinoids:

Scenario 1: **(The best-case scenario)** There is no yield loss. An alternative pesticide is already in use in soybean production, which means that there will be no extra costs. Corn producers have to pay more for a new pesticide for those crops.

Scenario 2: No Yield Loss/Higher Pesticide Costs. There is no yield loss. Farmers have extra costs because they must use an alternative pesticide for both soybean and corn crops.

Scenario 3: Medium Yield Loss/Higher Pesticide Costs: Farmers have extra costs because they have to use an alternative pesticide for both soybean and corn crops. The alternative pesticide is not as efficient as neonicotinoid pesticides and there is a loss of 5% in yields.

Scenario 4: (The worst-case scenario) Farmers have extra costs because they have to use an alternative pesticide for both soybean and corn crops. The alternative pesticide is not as efficient as neonicotinoid pesticides and there is a loss of 10% in yields.

In respect to yield loss, the authors claim that there will be a decrease of 5% to 10% to corn and soybean yields, explaining that the expected decrease is very significant since the operating and profit margins vary only between 10 to 15%. They argue that the efficacy of neonicotinoids is very uncertain and that the choice of the value of the yield loss was made based on what they believe to be the most appropriate based on the literature. However, the authors provide no further information of this literature nor how they determined what were the more appropriate values.

After having divided the farms into these four types and having made their assumptions, Grant, Knowles and Gill calculated that the average impact of a severe reduction in the use of seeds treated with neonicotinoids are $700 for a small farm under the best-case scenario and $90,000 for a large farm under the worst-case scenario. Aggregating these results, the net income effects vary from $90 million to $325 million dollars (depending on the assumptions). The authors also expect that the available capital in the corn and soybean crops will be reduced by the same amount.

The table below shows in detail how each type of farm (divided according to revenue) would have its net income reduced by neonicotinoid-use restrictions:

Table 9

Ontario Corn and Soybean Farms: Average Reduction in Net Market Income by Revenue Class

(2012 C$)

	Revenue class				
	Micro	Small	Medium	Large	Very large
1. Best case	700	1,654	3,639	7,807	23,435
2. No yield loss/higher pesticide costs	1,000	2,362	5,197	11,149	33,466
3. 5 per cent yield loss/higher pesticide costs	1,680	4,145	9,215	19,864	60,500
4. Worst case	2,360	5,928	13,232	28,578	87,535

Source: The Conference Board of Canada.

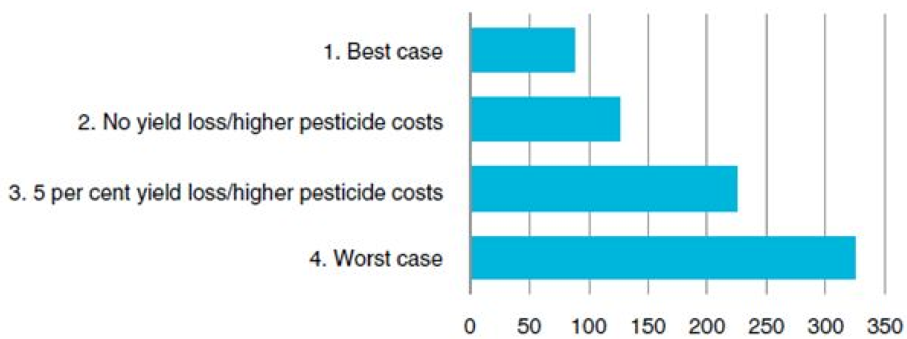
(Grant, Knowles and Gill 2014, 41)

The graph below shows the aggregate result of the reduction in the net income under each of the four scenarios.

Chart 3

Reduction in Net Market Income for Ontario Corn and Soybean Industry Under Different Scenarios

(2012 $ millions)



(Grant, Knowles and Gill 2014, 42)

The next table shows in details the impact of the neonicotinoid restriction in the Ontario's GDP:

Table 10

Impact on Ontario Corn and Soybean Sector

(2012 C$)

	Base case	Model with exits/ acreage reduction	Variance
Revenue	2,424,120,233	1,791,865,384	-632,254,849
Profit (adjusted for CCA)	226,212,945	124,104,753	-102,108,192
Wages	281,708,792	213,699,015	-68,009,777
Capital depreciation	319,848,673	242,631,214	-77,217,458
Corn production (t)	7,360,713	5,440,905	-1,919,808
Soy production (t)	2,895,570	2,140,353	-755,218
Contribution to GDP	827,770,410	580,434,982	-247,335,427

Note: Wages were estimated from the Statistics Canada input table for Ontario's crop and animal production industry. It was assumed that wages for the corn and soybean sector were proportionate to that sector's share of the total gross output of the crop and animal production industry. Results were generated from an unweighted average of all four modelled scenarios.
Source: The Conference Board of Canada.

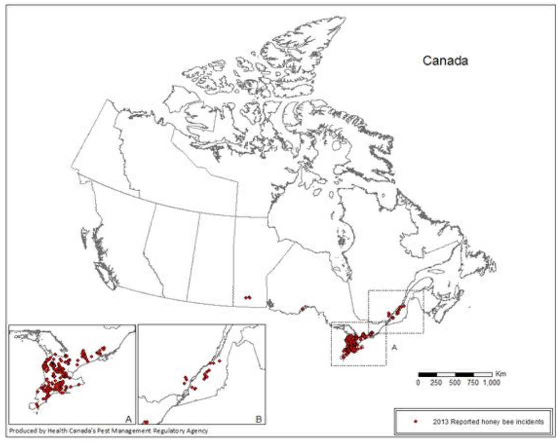
(Grant, Knowles and Gill 2014, 46).

The table above cannot be truly analysed because there is not enough clear information about how Grant, Knowles and Gill calculated the numbers when there is a severe restriction in neonicotinoids[6]. All estimations made by the authors were based on a scenario in which only the province of Ontario would apply a restriction to the use of neonicotinoids. That would limit the ability of Ontario farmers to recuperate the losses that this new policy would inflict because the farmers in Ontario would not be able to increase the price of corn and soybeans since they are price takers in the market of these two goods –both are competitive markets- and Ontario farmers would be operating with higher costs (Grant, Knowles and Gill 2014).

The assumption that only Ontario would implement a policy to restrict the use of neonicotinoids is valid because no other province is signalling a move in that direction, and the report called *Update on Neonicotinoid Pesticides and Bee Health* (Health Canada 2014), shows that the loss

[6] We have contacted the Conference Board of Canada in an attempt to get this information. At this time, we have not yet been successful in obtaining it.

of bees is happening almost exclusively in Ontario. This map shows the Location of Reported Honeybee Incidents Across Canada, 2013



(Health Canada 2014, 9).

The table below shows the "Number of Incidents, by Beeyards and Beekeepers, Reported to Health Canada's PMRA (2012-2014) (as of 17 October 2014)" (Health Canada 2014, 14).

Province	**Beeyards reporting incidents in 2012** [1]	**Beekeepers reporting incidents in 2012**	**Beeyards reporting incidents in 2013** [2]	**Beekeepers reporting incidents in 2013**	**Beeyards reporting incidents in 2014** [3]	**Beekeepers reporting incidents in 2014**
Ontario	240	40	395	76	322	52
Quebec	17	2	15	11	13	8
Alberta	2	2	---	---	---	---
Saskatchewan	16	6	---	---	---	---
Manitoba	1	1	10	4	6	3
Nova Scotia	2	2	---	---	2	2
Total of all provinces [4]	278	53	420	91	343	65

[1] Investigation of the 2012 incidents indicated mortalities were related to corn and soybean planting in 239 beeyards (33 beekeepers). Reasons why some incidents reports were considered not related to corn planting included pests and diseases, and spray incidents in other crops. Incidents related to corn/soybean occurred in Ontario and Quebec.
[2] Investigation of the 2013 incidents indicated mortalities were related to corn and soybean planting in the majority of the beeyards reported; final causality assessment pending. Reasons why some reports were considered not related to corn planting included pests and diseases, spray incidents in other crops and, insufficient information to assess the potential causality. Incidents related to corn/soybean occurred in Ontario, Quebec and Manitoba.
[3] Investigation of the 2014 incidents, and the number that may be related to corn and soybean planting, is in progress. These numbers are as of October 2014.
[4] The following are the available numbers of beekeepers and honeybee colonies in Canada for 2012 and 2013 as reported by Statistics Canada. Beekeepers: 2012: 8,312; 2013: 8,483. Colonies: 2012: 690,037; 2013: 672,094. [Source: Statistics Canada. http://www5.statcan.gc.ca/cansim/pick-choisir?lang=eng&p2=33&id=0010007

This table shows that the bee incidents in Canada were overwhelmingly higher in Ontario than in the other provinces, which reaffirms the point made by Grant, Knowles and Gill that only Ontario will apply a restrictive policy for the use of neonicotinoids.

Although it is a valid argument that Ontario is the only Canadian province that will make changes in respect to the use of neonicotinoids, this is not true for jurisdictions outside Canada. As mentioned above, the European Union, the United Kingdom and the United States are already acting to restrict the use of neonicotinoids. If such restrictions keep advancing in America, the costs to produce corn and soybean would rise and Ontario's producers would be able to increase the price of corn and soybeans. The rise in costs might cause a decrease in the supply of these two commodities and if the demand for them is inelastic, farmers' total revenue could even rise.

METHODOLOGY:

In the previous section, the scientific literature presented soundly argues that there exists a clear relationship between bee population decline and neonicotinoid-based pesticide use. The government of Ontario is responding with a policy aimed at protecting against continued bee losses and against losses to pollinator species in general. The *Pollinator Health Action Plan*, which is currently undergoing public consultations, will come into full force in 2017, requiring an 80% reduction in the use neonicotinoid-based pesticides in the province's agricultural sector. Yet, opponents of the plan, as presented by Grant, Knowles and Gill, argue that such drastic of a reduction will result in rather extreme financial losses for both grain farmers in Ontario and for the province as a whole, in terms of profit losses for farmers totalling $630 million and reductions of nearly $440 million to Ontario's GDP.

These sharply contrasting arguments are difficult to reconcile. One is based on scientific and ecological concerns while the other's preoccupations are financial and commercial. Each position, when considered exclusively or in isolation, could be seen as justifiable. However, in the following sections of this essay, we introduce arguments to challenge Grant, Knowles and Gill's opposition to *The Plan*. This challenge requires valuing the importance of pollinator health through the same monetary lens through which Grant, Knowles and Gill oppose restrictions to neonicotinoid use.

Monetizing the Value of Pollinators

To analyze this economic value of bee pollination, we have adapted the following formula, developed by Gallai et al. (2012), as to be applicable to horticulture in Ontario:

$$\mathrm{IPEV} = \sum_{i=1}^{I} \sum_{x=1}^{X} (P_{ix} \times Q_{ix} \times D_i)$$

i = The different types of crop
x = Each provincial district
P_{ix} = Price of crop i produced in region x
Q_{ix} = Quantity produced of crop i in region x
D_i = Dependence ratio of crop i on insect pollinators
IPEV = Total economic value of insect pollination

This formula shows "a bioeconomic approach[7] to [calculating] the economic value of the impact of pollinator loss" (Gallai et al. 2009, 812). Calculations performed using the formula will ultimately provide a monetary value that can then be analysed in relation to the dollar figures introduced by Grant, Knowles and Gill. With these two values we will be able to do a first

[7] A bioeconomic approach is thusly named because the formulae for the calculations utilize, as one of the factors, the dependence of crops on insect pollination, which represents the "bio" (biological) part and it provides the result in monetary value, which in turn, represents the "economic" (p.811, Gallai et al.).

comparison between costs—as presented by Grant, Knowles and Gill—and benefits—as presented in this paper—of the new environmental policy that has been in discussion in Ontario.

Application of the formula

In our application of this formula, we perform a number of separate calculations using different values that we have divided into two major sections. In each of these sections we conduct a Sensitivity Analysis, so as to provide a range of output scenarios. The reason for the Sensitivity Analysis is to account for uncertainties due to volatility of variables P and Q across years.

In Section I, we take into consideration the prices and quantities of horticultural crops in the province of Ontario as a whole. In this section, we set x equal to 1, since the focus is horticultural production in Ontario, province-wide; we set i equal to 20, which represents the twenty Ontario horticulture crops for which we have pollination-dependency ratios. We use the calculations performed in Section I to determine Insect Pollination Economic Value (IPEV):

$$\mathrm{IPEV} = \sum_{i=1}^{I} \sum_{x=1}^{X} (P_{ix} \times Q_{ix} \times D_i)$$

In Section II, we divide the province of Ontario regionally into five major districts plus a sixth "other districts" to show the IPEVs for each of these districts, individually. In this section, we set x equal to 6, since the focus is now the six separate districts within the province; we set i equal to 5, which represents the five horticulture crops for which we have both pollination-dependency ratios and district-level data. We use the calculations performed in Section II to determine which may be the most affected regions of the province should bees continue to decline:

$$\mathrm{IPEV} = \sum_{i=1}^{I} (P_{ix} \times Q_{ix} \times D_i)$$

Data Collection

All data relating to price (P) and quantity (Q) of horticultural crops in Ontario come from the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). For Section I, we collected data relating to the marketed production and the average prices paid for various horticultural crops grown in Ontario between the years 1995 and 2013. This timeframe was selected based on the fact that neonicotinoid-based pesticide use in Ontario began in 1995 (*Pollinator Health* 2014) (for Section I, see Appendix 1a). However, district-specific data used in Section II is available only from 2002 to 2013 (See Appendix 1b). The pollination dependence ratios (D) used both in Section I and in Section II are provided by Morse and Calderone (2000) (for Section II, see Appendix 2).

CALCULATIONS AND ANALYSIS[8]

Section I

In their Conference Board of Canada report *Seeds for Success*, Grant, Knowles and Gill argue that, with the implementation of Ontario's *Pollinator Health Action Plan,* the province will see a GDP loss of $440 million, and grain farmers would see a revenue loss of $630 million. These are significant numbers. In 2013, total revenues for corn and soybean production topped $3.7 billion. Grant, Knowles and Gill's $630-million figure, then, could represent a 17% revenue reduction for corn and soybean farmers; The $440-million, in turn, would represent a 0.063% reduction in the province's $695 billion GDP (Ontario Ministry of Finance 2015). These numbers are Grant,

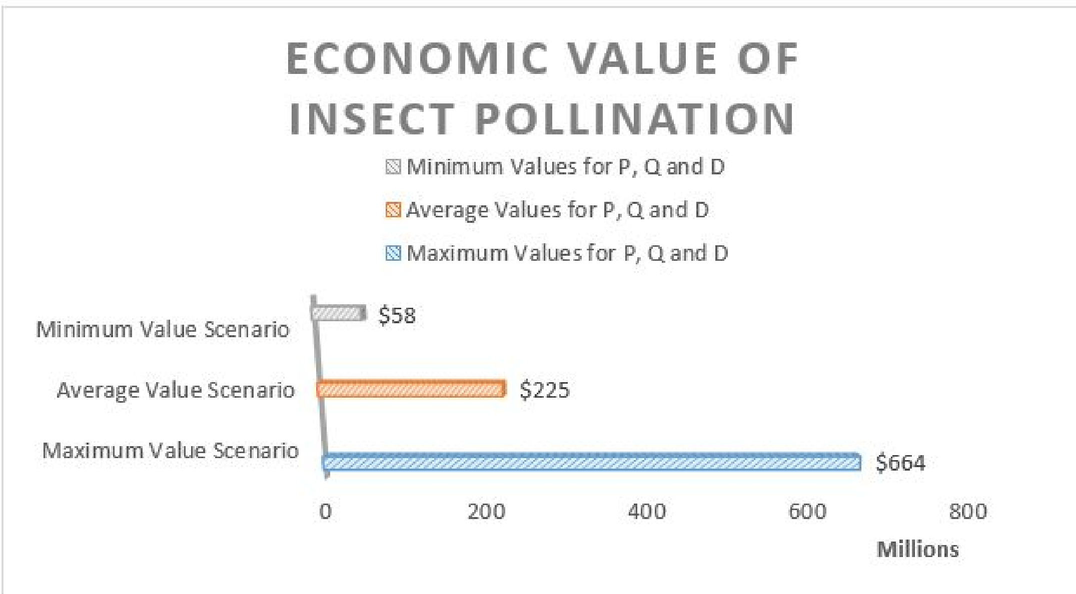
[8] These figures and calculations do not take into account price-level changes (inflation) from 1995 to 2013.

Knowles and Gill's predicted negative effects that would be generated from costs associated with reducing the use of neonicotinoid-treated corn and soybean seeds during planting season.

However, another predicted effect of reducing the use of neonicotinoid-treated corn and soybean seeds is the preservation and increased health of pollinator insects such as honeybees. Corn and soybean production, itself, is not in any way dependent on pollinator insects in order to thrive. But Ontario's entire horticulture industry is highly dependent. Some crops, including apples, blueberries, carrots, asparagus, broccoli, cauliflower, celery and honey, are 100% dependent on pollinator insects, and horticultural production, among the twenty crops considered in this research (see Appendix 1a), has an average 84% dependency rate. In 2013, total revenues for these twenty crops totaled $427 million. Compared to the corn and soybean industries, these revenues are valued at just 11.5% of what corn and soybean farmers generated in revenue in the same year. In fact, the total 2013 revenues of these horticultural crops are still considerably less than the $630 million that Grant, Knowles and Gill predict that the corn and soybean producers would lose.

By the numbers alone, considering the economic importance of corn and soybean production in Ontario, implementation of the province's *Pollinator Health Action Plan* would appear to sabotage the province's own GDP. But what Grant, Knowles and Gill ignore in their *Seeds for Success* report is the other side of this coin, that is to say all of that which the whole of Ontario's horticulture sector would lose if the *Pollinator Health Action Plan* were *not* implemented.

The table below presents a calculated range of IPEV[9]. The values range from $58 to $664 million, to account for the volatility[10] of variables. The $225-million figure represents the average economic value of insect pollination for the province of Ontario. This figure also has the potential to demonstrate the average of production loss should neonicotinoid seed treatments continue. Such a situation could possibly lead to the "ultimate disappearance of pollinators" (Gallai et al. 2009, 811). The Minimum Value and Maximum Value results are presented to provide a range of economic value that pollination services could have to Ontario.



Minimum Value Scenario: Manufactured scenario using lowest P value and lowest Q value from data between years 1995 and 2013 to suggest a best case scenario (in terms of potential losses).
Average Value Scenario: Manufactured scenario using P and Q values averaged from all data between years 1995 and 2013.
Maximum Value Scenario: Manufactured scenario using highest P value and highest Q value from data between years 1995 and 2013 to suggest a worst case scenario (in terms of potential losses).

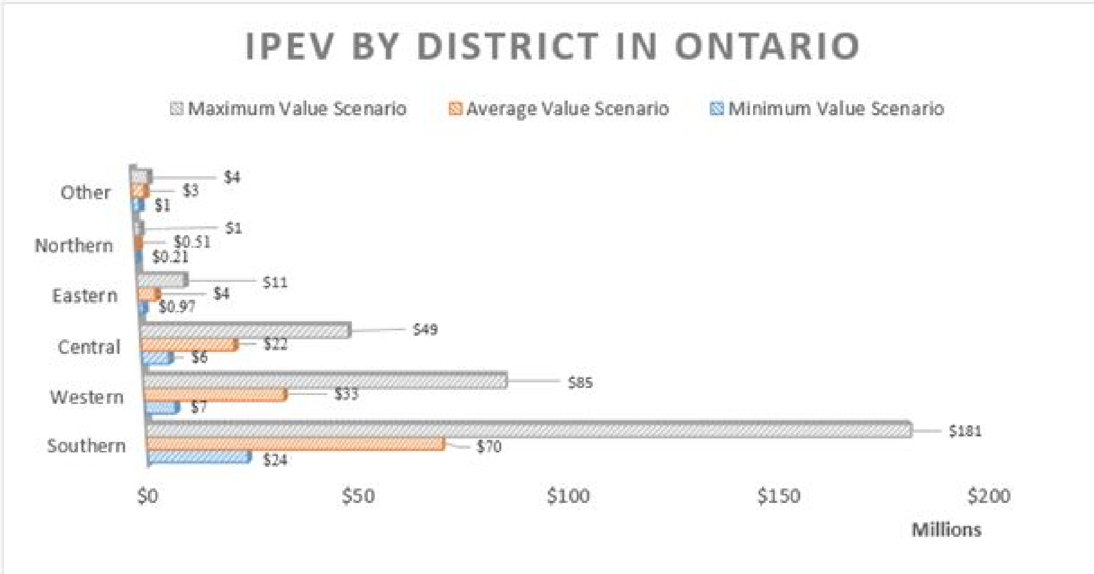
[9] Similar to Gallai et al., the IPEV used in this essay is calculated without taking into consideration adaptations that horticultural producers could make to adapt to pollinator decline. Gallai et al. note: "It must be clearly stated that this economic valuation is not a scenario assessment, since all economic agents can change their behavior in order to adapt to a pollinator decline. These changes will have some costs, namely opportunity costs. But one can assume that producers will make efficient trade-offs between the costs of changing crop species, or varieties, or production technologies – namely pollination techniques – and the losses resulting from keeping less profitable practices" (Gallai et al. 2009, 817). Gallai et al. go further to claim that while such IPEV results demonstrate the economic importance of insect pollinators, they "cannot be considered as a scenario since [they do] not take into account the strategic response of the market (Gallai et al. 2009, 820). Possible adaptations to the loss of pollinators go beyond the scope of this essay and should be analysed in future and more specific research.

[10] The agricultural sector is sensitive to a large number of unpredictable natural and market forces including weather conditions, as well as extreme weather events such as drought or flooding, that can affect yield, which in turn can affect price, availability, demand and even food security.

If we speculate that bee populations would risk complete collapse should *the Plan* not come into force, production losses to these farmers could even surpass the $630-million loss figure presented by Grant, Knowles and Gill if we were to consider the Maximum Value Scenario above. A more plausible speculative prediction might be the Average Value Scenario presented above. That $225 million potential production loss would equal more than 52% of all horticulture revenues in the province (looking at 2013 revenues). When compared to the 17% losses to corn and soybean revenues supposed by Grant, Knowles and Gill, the damage it would inflict on horticulture in the province is much more severe, if not irreparable. Furthermore, what must be stressed about all of the figures presented in this table is that, even the best case scenario—which is monetarily valued at just $58 million—could still mean the collapse of the entire horticulture sector, from both an ecological and an economic perspective.

Section II

Horticulture production is spread across much of Ontario, as is all agricultural production, with highest concentrations in the Southern and Western regions. Indeed, more than 75% of all revenues generated from horticulture come from these two regions (See Appendix 1b). Similarly, these same regions demonstrate the highest IPEVs, as shown in the chart below, and would therefore suffer proportionally most greatly from the losses discussed in Section I, above.



Minimum Value Scenario: Manufactured scenario using lowest P value and lowest Q value from data between years 1995 and 2013 to suggest a best case scenario (in terms of potential losses).
Average Value Scenario: Manufactured scenario using P and Q values averaged from all data between years 1995 and 2013.
Maximum Value Scenario: Manufactured scenario using highest P value and highest Q value from data between years 1995 and 2013 to suggest a worst case scenario (in terms of potential losses).

In calculating the values in this table, we used the same sensitivity analysis as that used in Section I. Therefore the ranges showing potential consequences, this time by district, remain large between the Minimum, Average and Maximum Value calculations.

If the Government of Ontario does not implement the *Pollinator Health Action Plan*, there will likely be a severe decrease in the number of pollinators. If we look at the Southern region in the table above, the Average Value Scenario IPEV for the Southern district is $70 million. This value is equal to 48% of the average combined revenue of the production of apples, grapes, peaches, strawberries and carrots in the Southern district between the years 2002 and 2013 (See Appendix 1b). The average provincial revenues for the same crops during the period is $216, 728, 143.58 with the Southern district representing 67%. This shows how important the Southern district is in respect to horticultural production in Ontario, and the IPEV values show the potential monetary loss that the loss of pollinators represents to this district.

However, the losses go much beyond this monetary value. For example, a diminished population of pollinators could decimate the horticulture industry. And should that occur, the risk is then presented that corn and soybean production would extend to those areas previously occupied by horticultural crops. And with that come the environmental dangers of monoculture farming practices. Ketcheson (1980) writes that “[t]he most serious long-range effect of intensive cultivation and monoculture on soil quality appears to be deterioration in organic matter levels and in soil physical properties. The result may be lower productivity, accelerated erosion losses, and impeded drainage” (409). These dangers would further extend to any pollinator populations that still remained: Cane and Tepedino (2001) claim that monocultures cannot sustain pollinator populations because they provide neither pollen nor nectar to bees, nor the natural habitat that those and other pollinators require.

It is certainly true that the losses that Grant, Knowles and Gill suppose in their *Seeds for Success* report are significant. But if action is not taken to protect pollinator health in Ontario, the absolute value of loss will be much bigger. It is unethical to put the welfare of bees completely aside and allow the decimation of their population just because, financially, it is more beneficial to the province to keep the corn and soybean production as it is. Destroying or damaging bee populations, we are interfering with an entire ecosystem. That means that in injuring bees, we would be injuring other species that depend on bees, and this would trigger a cascade effect that is almost impossible to measure. “The impact of pollination on the ecosystem as a whole is probably of great significance, but has been little investigated. The pollination of plant species that aid soil conservation and control erosion and those that provide valuable resources for wildlife can, of course, be of considerable economic importance both now and for the future" (Free 1993, 10).

Expanded Analysis

Grant, Knowles and Gill also argue in *Seeds for Success* that the profitability of agricultural production is already small and if a policy that drastically reduces the use of neonicotinoids is implemented, that profitability would be reduced even further. However, while the profitability of corn and soybean farmers might decline should the policy enter into force, if the policy is not enacted, the horticultural sector could suffer much greater losses.

In their calculations, Grant, Knowles and Gill do not consider the fact that farmers can adapt for changes. For example, they can start using more the IPM measures such as crop rotation and tillage that are simple farm techniques that help to avoid pests and therefore, can substitute the prophylactic use of neonicotinoids. According to Bradshaw (2004), when the situation changes drastically, farmers become more opened to adopt new measurements. Therefore, with the new Ontario policy about the use of neonicotinoids, farmers will look for alternatives to the neonicotinoid seed treatment and adapt to that. Thus, this is another reason that shows that the report *Seeds for Success*, overestimates the costs of a policy that reduces the use of neonicotinoids.

Therefore, the government of Ontario should take into consideration the Precautionary Principle that the European Union took when they abolished completely the use of neonicotinoids until more studies are developed and they are convicted that the bees are not in danger. Even the value of pollination, that has been largely studied, is still very hard to calculate. "The pollinating potential of a single honeybee colony becomes evident when it is realized that its bees make up to 4 million trips per year and that during each trip an average of about 100 flowers are visited" (Free 1993, 8).

The effects of the loss of horticulture crops could go much further than just the negative impacts suffered by those in the horticulture industry. A decrease in the production of horticulture would imply a lesser variety of food for the population. The population would have more restricted access to certain micronutrients that are only present in fruits and vegetables. Such a situation could cause a diminishment in consumer satisfaction due the lack of variety, and the lack of micronutrients could increase malnutrition, leading to increased health problems (Chagnon et al. 2015), which is bad for individuals and for the government, which would need to support increasing healthcare expenditures.

CONCLUSION

Further Arguments

One of the main arguments that Grant, Knowles and Gill advance in their Conference Board of Canada report *Seeds for Success* is the outdated claim that the principal competitor for Canada's grain producers, The United States, is not placing any restriction upon the use of neonicotinoids[11] and that this will impact negatively Canadian producers because they will have a higher cost of production than the Americans. The authors argue that Ontario has the largest production of corn and soybean in Canada, but compared to production in the U.S. Canadian production is small,

[11] See *infra* 33-34 for examples of actions being taken by U.S. policy-makers toward neonicotinoid use.

and since the corn and soybean markets are competitive, Ontario farmers will not be able to pass this extra cost to consumers.

Although it is true that Ontario will probably be the only province that will have a restrictive policy for the use of neonicotinoids, thinking only about the Canadian market and forgetting about the international trade that can be done, Ontario is the largest producer of corn and soybean in Canada. According to Statistics Canada in its report called Corn: Canada's third most valuable crop (Hamel and Dorff 2015), Ontario produces 61.7% while Quebec, the second largest producer accounts only for 30.2% of the production. For soybeans, according to the Canadian Soybean Council, Ontario is the largest producer with Quebec, again, in second place. Therefore, it is possible to say that, if we take into consideration only the production in Canada, Ontario farmers would have the power to change the price of these two goods.

In every kind of competition, competitors have to deal with the natural conditions that are presented to them and model their productions in consideration of those features. It has never been the case that all the countries that produce a specific good have exactly the same conditions and laws to produce it. Besides that, even though the United States has neither banned nor restricted the use of neonicotinoids pesticides, the country is taking its first steps on the way to imposing some restrictions. For example, the city of Seattle, WA., through the Resolution 31548, has already banned the use of neonicotinoid pesticides on city land aimed at protecting the bees and other pollinators (City of Seattle 2014).

It is true that United States Environmental Protection Agency (EPA) has refused to provide an official conclusion regarding the review of the neonicotinoids before 2018 (PAN – online). However, the President of the United States has created, through a Presidential Memorandum, a

Task Force to protect bees and other pollinators. The Task Force should provide a better understanding of the loss of bees and other pollinators and consider ways to prevent and to recover the losses already seen (Presidential Memorandum – online). Furthermore, The U.S. Fish and Wildlife Service has decided to phase out the "toxic bee-killing pesticides in national wildlife refuges in Hawaii, Idaho, Oregon and Washington by January 2016" (Center for Biological Diversity).

Every day more experts on the topic of bees and neonicotinoids are pressuring the American Government to ban or severely restrict the use of neonicotinoids. More than one hundred experts from the United States and abroad wrote to the White House Task Force to Protect Pollinators asking that the Task Force establish a moratorium on the use of the neonicotinoids and should provide more investments into research for alternatives to neonicotinoids.

Pressures from the European Union, which has banned the use of neonicotinoids for two years, pressures from scholars around the world, and the declaration of the Environmental Protection Agency (EPA) of the U.S. which says that the use of neonicotinoids in soybean production does not seem to really improve the crop yield (Myers and Hill 2014), together with the changes that have already been made in the way of either banning or restricting the use of the neonicotinoids, signal that the United States is gradually aligning itself to the global trend that is concerned with environmental issues and sustainability. Therefore, if the United States follow this trend, Canada would not be disadvantaged in the market of corn and soybeans in the way argued by Grant, Knowles and Gill.

Final Thoughts and Further Study

This research essay is but one step in what could be a larger project to analyze and evaluate the *Pollinator Health Action Plan* as it becomes finalized and comes into force. The calculations provided in this paper using the bioeconomic model developed by Gallai et al. present a value for the economic value of insect pollination in Ontario. Providing these numbers serves to demonstrate the undeniable importance of the services provided by bees and other pollinators. Depending on the context—for example, when using the Maximum Value Scenario—the potential loss caused by pollinator decline could surpass the potential loss of $440 million presented by Grant, Knowles and Gill, and could lead to other effects, compromising the province's ecology and potentially burdening the public health system. While research into these other effects goes beyond the scope this paper, they are worthwhile areas for continued study in this area.

The decision to concentrate, here, on Grant, Knowles and Gill's Conference Board of Canada report *Seeds for Success* is due to the report's single-issue concern and the fact that it is a dissenting voice that deserves both attention and scrutiny. The report fairly notes that Ontario's new policies regarding bee health are still under evaluation, and the report is consistent in its objective to advance grain farmers' business interests: that neonicotinoids are used to prevent against pests, thus improving production since grain producers face a lower risk to their crops; and that restricting neonicotinoid use would have financial implications for these farmers in the form of reduced profits. Seeing that corn and soybeans constitute the largest cash crops in Ontario, there is legitimate concern: Grant, Knowles and Gill argue that if the use of neonicotinoids is reduced, there would be a loss of $440 million to Ontario's GDP. That represents 0.06% of the province's GDP, which was about $696 Billion in 2013 (Ontario Ministry of Finance 2015).

However, in order to advance its argument, the report must sidestep the science that shows overwhelmingly that neonicotinoids must be regulated (IUCN 2014; TFSP 2015). Instead, the report sets up a straw man when it argues that since Health Canada currently allows neonicotinoid use, "it is unclear whether the implementation of [Ontario's] regulations result in an improvement of the decision-making processes or simply [adds] regulatory redundancy and costs" (Grant, Knowles and Gill 2014, 13). This deflection, alone, could be argument for scrutiny of the report, but it is the absence of consideration for the broader environmental and economic costs of continued neonicotinoid use that lead us to question the report. Our analysis, here, of Ontario's horticulture production represents one major factor ignored by the Conference Board study, namely the economic value of insect pollination in Ontario's agriculture sector. If bee declines worsen and horticultural production completely stops in Ontario, the monetary loss would be about $297 million. It is true that, in just comparing these speculated revenue-loss values[12], the option of keeping the neonicotinoids could even sound more plausible. However, in enacting environmental policy, there is much more to consider.

Moreover, all comparisons done in this paper have been done assuming that neonicotinoid seed treatment does, indeed, provide an essential service for the corn and soybean production. However, the scientific community argues that neonicotinoids are actually being used in more of a prophylactic way. Myers and Hill (2014) conducted a peer-reviewed study with the U.S. Environmental Protection Agency (EPA) and discovered that the neonicotinoid seed treatment

[12] That is to say, this $297 million figure vs. Grant, Knowles and Gill's $630 million revenue-loss calculation.

does not provide any yield benefit. Also, because the seeds treated with neonicotinoids are used only in prophylactic way and produce no extra yield, they simply increase the costs of soybean production. Myers and Hill also argue that the use of the neonicotinoid seed treatment is not efficient in avoiding pests because the two main pests that attack the soybeans, aphids and bean leaf beetles, are not yet active in the plants when the treated seeds are sowed, and the pesticide treating the seeds is only effective at killing pests that are already active in the plant. Myers and Hill claim that a foliar spray pesticide would be much better than the neonicotinoid seed treatment. They argue that there are at least nine alternative foliar pesticides with lower per-acre costs than the average per-acre cost neonicotinoid seed treatment. These foliar pesticides, too, are already used by soybean farmers, meaning that there would be no extra costs to acquire necessary materials or knowledge for application of these alternatives.

Therefore, it is our opinion that the government of Ontario needs to move ahead with the *Pollinator Health Plan* and follow through with supports, that have already been drafted into the plan, that would help corn and soybean farmers in adapting their farming processes and techniques. We believe that the government of Ontario also needs to encourage more research in the area of alternatives to neonicotinoid pesticides and seed treatments, including the costs to producers of these alternatives, to have a better understanding of the subject and to improve the policy.

"Far from protecting food production the use of neonics is threatening the very infrastructure which enables it, imperilling the pollinators, habitat engineers and natural pest controllers at the heart of a functioning ecosystem." (IUCN 2014)

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APPENDIX 1a

Quantity yields (in tonnes) of different crops in Ontario

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Apple	276,812	225,313	245,582	228,965	331,350	262,881	241,105	129,289	175,564	186,197	193,412	174,287	224,521	169,301	177,983	135,700	163,769	28,641	181,213
Apricot	254	268	295	204	186	222	204	125	200	86	204	186	181	148	158	104	58	7	88
Blueberry	1,072	1,330	1,306	1,496	1,780	1,266	1,270	1,260	870	1,360	1,120	2,320	2,290	1,840	1,976	2,280	1,914	x	1,950
Grape	50,265	51,390	48,347	47,158	61,090	52,662	54,885	55,063	39,484	59,305	29,101	67,861	59,554	63,561	49,427	56,026	66,575	67,912	82,905
Nectarine	1,309	508	953	2,597	2,703	2,654	2,812	3,651	4,335	3,629	2,313	2,722	2,268	1,724	x	x	2,154	1,433	2,363
Peach	39,358	34,806	23,795	24,585	23,995	24,131	25,492	23,196	25,041	24,338	17,933	23,356	27,318	21,778	19,321	17,704	18,988	15,185	18,189
Pear	7,933	10,231	6,004	7,691	9,099	8,859	6,192	6,183	7,368	7,500	5,389	8,851	6,377	4,082	3,517	2,928	3,143	1,134	3,221
Plum and Prunes	3,842	2,663	2,513	2,860	2,976	1,980	2,497	1,851	2,381	1,860	1,678	2,268	1,134	1,315	1,661	1,970	1,388	934	2,087
Sweet cherry	1,290	1,417	1,383	1,881	2,100	1,463	1,683	763	1,741	1,536	1,323	1,608	1,225	980	799	572	699	135	566
Sourcherry	6,307	4,298	5,359	4,359	7,775	5,688	3,901	3,402	4,658	3,828	7,384	2,927	7,150	5,584	6,364	5,736	2,028	1,120	5,504
Strawberry	15,440	8,398	9,535	9,154	10,229	8,208	8,485	7,938	7,394	6,622	6,078	6,396	7,121	6,260	6,211	5,857	4,731	5,178	4,652
Asparagus	963	804	890	765	741	777	790	833	890	991	977	1,255	1,255	1,295	1,427	1,212	1,105	1,089	1,247
Broccoli	8,181	5,617	6,593	7,886	9,385	7,285	8,310	6,929	6,632	8,301	7,507	8,421	x	7,257	x	13,170	10,935	11,011	12,621
Carrot	112,205	120,801	115,158	152,203	129,809	113,126	141,104	135,575	152,811	147,481	160,826	175,631	122,628	119,043	166,388	228,490	218,917	224,202	153,612
Cauliflower	18,702	15,352	14,016	18,718	22,548	19,276	25,445	16,366	16,338	16,629	12,855	10,909	10,705	11,898	10,906	11,807	9,730	9,524	9,469
Celery	18,810	11,428	14,742	11,852	14,243	13,739	18,323	19,368	17,100	15,059	12,156	13,517	16,783	12,973	12,425	13,608	10,109	12,505	13,666
Cucumber	33,945	30,282	30,155	35,253	44,609	46,829	39,268	48,580	53,234	49,705	31,770	18,815	22,303	19,447	41,271	33,138	33,565	32,835	32,496
Pumpkin	22,101	23,954	19,187	15,252	23,149	20,002	27,920	26,853	28,458	33,076	40,188	41,749	42,664	37,081	41,253	37,445	48,853	54,543	38,998
Honey	3,790	3,458	3,318	4,776	3,740	3,338	3,219	4,824	3,903	3,456	4,055	3,759	2,708	2,081	2,600	3,999	4,093	4,281	2,886

X : data has been suppressed due to confidentiality restrictions (according to OMAFRA)

APPENDIX 1a

Price of different crops in Ontario

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Apple	296.90	352.90	391.30	372.60	306.40	369.90	404.10	490.60	465.80	414.80	339.00	400.30	410.90	445.80	463.10	478.20	535.10	1,032.40	658.50
Apricot	2,066.80	1,924.40	2,119.80	1,861.70	1,882.00	1,642.20	1,984.20	2,236.60	1,954.10	2,262.60	1,763.70	1,451.80	1,433.00	1,284.90	1,539.40	1,917.10	2,807.40	3,086.50	2,943.30
Blueberry	3,156.80	3,066.60	3,620.90	3,411.60	2,631.90	3,439.30	3,758.30	3,936.80	4,231.90	3,922.90	4,054.90	4,447.30	4,495.90	4,696.80	5,112.10	4,186.80	5,063.50	..	5,155.40
Grape	606.00	628.40	786.90	906.00	811.30	852.20	926.50	950.70	753.40	897.70	928.80	1,094.60	1,319.50	1,307.30	1,188.80	1,290.70	1,225.00	1,347.30	1,255.30
Nectarine	1,367.90	1,230.30	1,364.80	1,430.60	1,146.70	1,567.70	1,617.90	1,454.20	1,301.20	1,446.80	1,534.60	1,433.00	1,411.00	1,682.50	..	..	1,782.10	2,392.30	1,922.80
Peach	867.40	615.40	1,081.30	1,059.20	1,064.00	1,023.60	1,093.30	1,165.90	1,184.90	1,133.10	1,279.60	1,209.60	1,207.10	1,397.40	1,220.00	1,108.00	1,433.30	2,048.80	1,566.10
Pear	637.80	621.70	752.90	992.10	785.80	692.00	826.10	928.00	770.90	886.70	868.90	815.10	927.30	1,175.80	1,240.20	1,226.10	1,322.80	1,477.10	1,275.90
Plum and Prunes	1,227.20	1,068.50	1,219.70	1,176.60	1,181.30	1,464.40	1,741.80	1,013.20	1,385.80	1,505.60	1,787.50	1,719.60	1,719.60	1,748.50	2,290.70	1,770.00	2,578.50	3,793.90	2,408.30
Sweet cherry	1,945.00	1,739.00	2,186.50	1,494.20	2,188.00	2,071.30	2,130.30	2,824.60	1,877.20	2,419.50	2,404.20	2,391.90	2,913.40	3,184.50	3,192.40	3,310.40	3,225.30	5,400.00	3,576.00
Sourcherry	191.80	493.30	638.20	583.80	796.80	866.70	884.40	1,559.40	1,149.30	1,016.10	689.10	521.60	573.70	605.50	501.40	437.80	538.80	4,076.30	1,805.40
Strawberry	1,838.00	1,675.90	1,911.00	1,974.10	1,935.80	2,383.60	2,348.90	2,390.40	2,424.40	2,419.80	2,569.90	2,932.90	2,871.60	3,102.40	3,633.00	3,552.00	3,940.80	3,789.30	3,995.80
Asparagus	2,835.80	2,987.80	3,474.20	2,945.00	3,167.10	3,014.50	3,023.70	2,988.50	2,916.40	2,890.10	2,866.30	2,762.90	2,755.80	2,762.40	2,980.80	3,324.00	3,306.60	3,569.00	3,483.00
Broccoli	784.20	617.70	814.50	709.50	685.10	800.30	930.20	916.40	1,019.40	1,156.50	965.80	1,181.50	..	1,212.50	..	934.30	1,193.10	1,282.50	1,486.00
Carrot	141.30	126.30	132.70	141.10	154.20	138.90	142.50	183.40	130.90	145.40	167.00	161.80	172.10	157.60	218.60	187.50	165.90	153.80	208.90
Cauliflower	501.80	442.60	485.20	485.60	407.10	470.50	488.70	550.40	517.90	480.30	468.90	632.50	560.50	560.60	669.60	651.60	697.80	632.00	620.50
Celery	280.70	220.50	203.50	317.20	272.80	338.40	328.00	289.10	270.80	285.50	283.80	336.60	286.00	337.20	389.10	334.40	315.70	405.40	326.40
Cucumber	340.10	286.10	314.30	326.20	303.90	303.30	337.20	327.10	341.30	369.20	335.50	388.40	435.10	478.50	531.10	475.70	406.50	434.60	497.80
Pumpkin	341.20	229.80	262.70	284.60	346.70	365.20	331.80	390.90	406.20	387.80	277.90	284.70	289.60	388.10	429.80	466.50	415.30	427.10	484.90
Honey	2,540	2,480	2,390	1,950	2,150	2,800	2,870	4,340	4,490	4,050	3,530	3,160	3,460	4,420	5,440	5,100	5,510	5,560	7,050

.. : figures not available (according to OMAFRA)

APPENDIX 1b

Quantity yields (in tonnes) of different crops in Ontario, by district

Apple	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Southern District	59,535	83,655	90,655	93,497	89,361	112,658	96,569	85,591	68,381	80,400	16,213	77,042
Western District	43,001	57,728	61,820	64,083	52,254	67,507	57,625	56,731	40,075	51,311	10,345	46,354
Central District	22,537	27,632	27,321	28,968	25,720	34,877	28,980	28,246	21,537	25,385	5,154	22,075
Eastern District					6,497	8,797	7,930	6,956	5,356	6,158	1,289	5,207
Northern District					455	682	538	459	351	514	113	536
Other districts	4,216	6,549	6,400	6,864								
Grape	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Southern District	54,091	38,701	58,023	28,460	63,944	55,944	59,738	46,427	52,763	62,865	64,301	78,330
Western District					722	657	672	520	665	580	604	715
Central District	825	654	1,065	537	3,057	2,829	3,027	2,376	2,483	2,683	2,670	3,268
Eastern District										439	492	582
Northern District										8	8	10
Other districts	153	132	217	102	139	123	123	103	116			
Peach	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Southern District	23,118	26,068	24,227	19,097	25,662	27,032	21,497	18,026	17,474	18,909	16,933	18,250
Western District					275	277	274	226	223	66	56	59
Central District												
Eastern District												
Northern District												
Other districts	78	108	111	107	9	9	7	8	9	13	11	13
Strawberry	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Southern District	3,018	2,829	2,541	2,369	2,942	2,731	2,397	2,400	2,240	1,970	2,131	1,891
Western District	1,591	1,607	1,413	1,288	1,578	1,525	1,309	1,269	1,207	838	934	855
Central District	1,761	1,547	1,394	1,238	1,512	1,495	1,343	1,327	1,261	874	946	845
Eastern District	1,128	1,064	956	890	1,083	1,027	900	907	845	757	841	762
Northern District	440	347	318	293	371	343	310	308	303	291	327	298
Other districts												
Carrot	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Southern District	32,226	51,398	39,932	48,288	60,741	50,946	43,851	63,994	89,471	111,913	112,802	77,661
Western District	28,858	46,500	36,668	45,068	48,991	40,561	35,135	51,448	70,391	34,921	35,936	24,400
Central District	29,613	47,027	36,241	45,760	45,918	37,832	31,978	46,719	64,373	70,461	72,257	50,387
Eastern District	350	527	401	509	810	704	582	826	1,217	1,298	1,344	933
Northern District	260	396	311	399	302	238	213	308	440	323	336	230
Other districts												

APPENDIX 1b

Price of different crops in Ontario, by district

Apple	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Southern District	491.49	465.04	414.35	337.21	398.92	409.94	379.09	462.84	476.06	539.98	1,040.29	511.33
Western District	484.88	462.84	409.94	339.42	398.92	409.94	376.88	456.23	478.27	528.96	1,016.04	506.92
Central District	491.49	469.45	414.35	341.62	405.54	412.15	390.11	473.86	480.47	528.96	1,079.96	526.76
Eastern District					406.97	421.52	394.52	475.29	491.49	542.18	1,075.55	511.33
Northern District					409.94	423.17	405.76	484.88	484.88	566.65	1,057.92	513.53
Other districts	526.76	483.34	466.48	346.8								
Grape	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Southern District	949.92	751.56	897.03	927.88	1,093.18	1,317.99	1,304.77	1,187.96	1,289.34	1,223.22	1,342.24	1,254.08
Western District					1,143.88	1,335.62	1,344.44	1,212.20	1,311.38	1,216.61	1,366.48	1,256.28
Central District	976.37	859.56	916.86	969.76	1,106.41	1,337.83	1,340.03	1,192.36	1,306.97	1,245.26	1,399.54	1,278.32
Eastern District										1,313.58	1,395.13	1,232.04
Northern District										1,225.42	1,388.52	1,254.08
Other districts	969.76	707.48	916.86	927.88	1,095.39	1,320.20	1,317.99	1,187.96	1,284.93			
Peach	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Southern District	1,165.48	1,163.71	1,132.86	1,221.02	1,196.77	1,207.79	1,397.34	1,291.54	1,108.61	1,432.60	1,586.88	1,478.88
Western District					1,342.24	1,110.82	1,370.89	1,212.20	1,035.88	1,503.13	1,549.41	1,650.80
Central District												
Eastern District												
Northern District												
Other districts	1,203.38	943.31	1,128.45	1,165.92	1,198.98	1,207.79	1,387.34	1,291.54	1,099.80	1,432.60	1,596.88	1,615.53
Strawberry	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Southern District	2,389.14	2,426.60	2,424.40	2,569.86	2,937.93	2,887.24	3,107.64	3,632.19	3,541.83	3,967.20	3,812.92	3,967.20
Western District	2,303.18	2,415.58	2,415.58	2,415.58	2,964.38	2,821.12	3,101.03	3,658.64	3,570.48	4,011.28	3,857.00	3,967.20
Central District	2,389.14	2,426.60	2,424.40	2,578.68	2,997.44	2,909.28	3,107.64	3,647.62	3,559.46	3,890.06	3,735.78	4,055.36
Eastern District	2,490.52	2,431.01	2,402.36	2,534.60	2,909.28	2,843.16	3,077.45	3,583.70	3,535.22	3,865.82	3,724.76	3,993.65
Northern District	2,450.85	2,402.36	2,419.99	2,585.29	2,949.17	2,871.81	3,101.03	3,594.72	3,550.64	3,892.26	3,746.80	4,077.40
Other districts												
Carrot	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Southern District	171.91	123.42	149.87	173.32	152.08	174.12	160.89	227.01	191.75	165.3	154.28	207.18
Western District	171.91	130.04	149.87	169.71	152.08	174.12	163.1	215.99	182.93	167.5	156.48	215.99
Central District	171.91	138.85	152.08	167.5	152.08	174.12	160.89	213.79	185.14	165.3	154.28	207.18
Eastern District	187.34	132.24	149.87	176.32	167.5	165.3	165.3	257.87	209.38	196.16	178.52	238.03
Northern District	185.14	132.24	145.46	187.34	163.1	185.14	165.3	249.05	209.38	198.36	178.52	238.03
Other districts												

APPENDIX 2

Dependency Ratios in Regard to Insect Pollination for Selected Horticultural Crops

Crops	Dependency Ratio (D)
Apple	1
Apricot	0.7
Blueberry	1
Grape	0.1
Nectarine	0.6
Peach	0.6
Pear	0.7
Plum and Prunes	0.7
Sweet cherry	0.9
Sourcherry[1]	0.9
Strawberry	0.2
Asparagus	1
Broccoli	1
Carrot	1
Cauliflower	1
Celery	1
Cucumber	0.9
Pumpkin	0.9
Honey[2]	1

[1] For sour cherry we use the same dependency value provided for sweet cherry.

[2] Honey is our own addition to this list. We assume a dependency value of 1 because of the nature of honey production.