Neonicotinoids and Bees

Assessing the Debate Surrounding the Impacts of Neonicotinoids on Pollinator Populations

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Neonicotinoids are a family of insecticides used to protect against various crop pests. Over the past two decades, concern amongst scientists and policymakers has arisen over the impacts that neonicotinoids may have on pollinator populations. Neonicotinoids target the central nervous system of insects and have been shown to have acute and sub-lethal effects on bees that include but are not limited to: limited reproductive rates, impaired foraging abilities, increased susceptibility to disease, and decreased learning abilities. This paper reviews the literature to assess the risks that neonicotinoids pose to pollinator populations and to better understand the debate surrounding neonicotinoids. Federal, state and local approaches to regulating neonicotinoids are then discussed. This paper concludes that as neonicotinoids pose a distinct risk to pollinator populations, policy actions should be undertaken that reduce the exposure of neonicotinoids to bee populations while limiting financial impacts to farmers.

Section 1.0 Introduction:

Pollinators, including bees, are an essential component of the global sustainable food system (Gallai et al., 2009).[1] It has been estimated that pollinators contribute to the pollination of 90% of the world's flowering plants and while the exact figure is debated, bees contribute to higher yields in 96% of crops that rely at least in part on pollination services provided by some animal species (Desin, 2014; Kearns et al., 1998). In fact, 71 out of the 100 leading crops that provide 90% of the world's food—including almonds and strawberries—are pollinated, at least in part, by managed honey bees (Bee Action, 2014).[2] According to research conducted by Gallai et al. (2009), the total economic value of pollination to the global economy is reported to be about $200 billion. In the U.S., annually, bees provide an estimated $20-30 billion in domestic agricultural revenue and thus play an important role in ensuring the stability of the U.S. agricultural economy (USDA, 2013).

In New York State, agriculture is a vital component of the state's economy. For example, in 2011, approximately $37.6 billion was generated in total agricultural economic output (Office of the New York State Comptroller, 2012).[3] Pollinators are essential for facilitating the growth of the state's apple and strawberry industry and New York State beekeepers travel around the nation with their colonies in order to pollinate annual almond, strawberry, and blueberry crops (Calderone, 2012; Park, Orr, & Danforth, 2009). It is estimated that pollinators contribute approximately $500 million per year in agricultural revenue to New York's economy (Office of the Governor, 2015). Additionally, in New York State and abroad, there has been a growing number of emerging beekeepers who recognize the important ecological role that honey bees and pollinators play (Pam Welch personal communication, 2015).

In addition to their importance to the global agricultural sector, pollinators also strongly influence ecological relationships, ecosystem conservation and stability, genetic variation in the plant community, floral diversity, specialization, and evolution (Kjohl, Nielsen & Stenseth, 2011). For example, certain plant species cannot reproduce on their own and rely on the pollination services provided by bees and other pollinator species for their survival. Indeed, a healthy pollinator population is essential for maintaining a biodiverse ecosystem.

Currently, there is mounting evidence that pollinator populations around the world are declining at an alarming rate and the consequences for the U.S. agricultural economy could be dire. For example, since 2006, sustained declines in pollinator populations have directly and indirectly resulted in financial impacts of $2 billion to the beekeeping industry and have generated concern amongst producers whose crops rely on the pollination services provided by bees (Center for Food Safety, 2014). Due to the irreplaceable nature of the services provided by pollinators, much research has been conducted to determine the exact cause of the rapid decline

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[1] The term "pollinator" is not expressly intended to refer solely to honey bees but rather to the wide range of bird, bat and insect species—including native bee species—that provide pollination services to the global agricultural sector.
[2] For the purpose of this paper, the term "managed honey bees" refers to colonies of European honey bees (*Apis mellifera*).
[3] Total economic output refers to the total value of all goods and services produced in a particular economy.

in global pollinator populations. While many drivers have been attributed to the decline in pollinator populations, there is an increasing body of literature devoted to the discussion of the impacts of neonicotinoids (hereinafter referred to as "neonics") on managed honey bee populations (Raine & Gill, 2015).

Through a review of the literature, this paper analyzes the debate surrounding the effects of neonics on pollinator populations and provides policy recommendations regarding the best management practices to reduce exposure to neonics. Section Two provides a brief background on colony collapse disorder (CCD) and introduces the debate surrounding the impacts of neonics on pollinator populations. Section Three reviews the literature on the impacts of neonics on bee populations. Section Four discusses ongoing efforts to limit the exposure of pollinators to neonics. Finally, Section Five provides policy recommendations intended to help federal, state, and local entities to effectively limit the rate of neonic exposure to managed, native, and wild bee populations.

Section 2.0 Background:

Bees constitute a valuable ecological resource, and monitoring, cataloguing and the protection of bees are necessary (Arbuckle et al., 2001). Currently, there are approximately 25,000 species of bees worldwide, divided into nine families. The New York State Biodiversity Clearinghouse reports that there are 477 different species of bees in the state. This paper focuses on one of the nine families of bees, *Apidae*—including honey bees and bumble bees—as that family is the focus of the majority of the academic discourse on the effects of neonics on bee populations.

Annually since 2006, beekeepers around the nation have lost an average of 30% of their hives during overwintering periods with some beekeepers losing all of their hives and having to exit the industry entirely (Friends of the Earth, 2014).[4] These sustained losses continue to occur across the nation. A 2014-2015 honey bee survey conducted by Steinhauser et al. (2015) showed that total annual loss rates amongst beekeepers was reported at 42.1% nationwide and, in New York, the figure stands at 54.1%.[5] These sustained losses have been mostly attributed to colony collapse disorder (CCD)—a phenomenon in which a majority of adult bees disappear from a colony leaving behind the queen and the hive's young (EPA, 2015). There have been several theories associated with the cause of CCD and declining bee populations, including: parasitic mites, disease, habitat destruction, malnutrition, climate change; and increasing levels of pesticide application (Spivak et al., 2011; Van Der Sluijs et al., 2013). Despite all the theories surrounding CCD, a single causal factor behind the phenomenon has yet to be distinguished. As such, it has been difficult for researchers to fully understand and mitigate the issues associated with CCD. In addition to bee losses attributed to CCD, bee die-offs can also be independently traced to exposure to pesticides, loss of forage habitat, disease, and infectious mites and parasites, among other factors.

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[4] According to Steinhauser et al. (2015), normal overwintering loss rates for honey bee hives are between 5-10% annually.

[5] Annual loss rate refers to the number of colonies that are lost during overwintering and summer periods combined.

In the face of recent declines in pollinator populations, the demand for pollination services are rising (Calderone, 2012). Breeze et al. (2014) found that, in Europe, the recommended number of honey bees to provide pollination to European crops has risen 4.9 times faster than the rate at which honey bee stocks could be restored between 2005 and 2010. Similarly, the U.S. Department of Agriculture (USDA) in a 2013 report indicated a lack of confidence that U.S. honey bee stocks would be capable of meeting a rising demand for pollination services (Keim, 2013). The subsequent decline in supply and increase in demand has led to an overall increase in the cost of acquiring pollination services. For example, between 2000 and 2010, the cost of hive rentals in the Pacific Northwest more than doubled, jumping from $33.65 per colony to $70.85 per colony (Desin, 2014). Should the cost of acquiring pollination services continue to increase, government agencies such as the USDA fear the price of crops dependent on pollination may rise significantly. In New York State, beekeepers face a growing struggle when it comes to maintaining a sustainable apiary (Blumgart, 2014; Clyde Goodrich personal communication, 2015). Consider the plight of bees in western New York. Eight of the 10 largest farms in the northeastern U.S. are located in western New York (Blumgart, 2014). As such, pollination services are in high demand in the Northeast. However, large beekeepers are facing multiple challenges to maintain financially viable apiaries in the region due to the lack of forage habitat, increased levels of pesticides, harsh winters, and heightened losses caused by parasitic mites and infectious diseases (Blumgart, 2014). In 2007, Jim Doan, a beekeeper in western New York, testified in front of the U.S. House of Representatives' Subcommittee on Horticulture and Organic Agriculture providing insight into this matter (Doan, 2007). In 2006, Doan—a third-generation beekeeper—owned approximately 4,300 hives (Boulder County Beekeepers' Association, 2013). That winter, Doan lost approximately 56% of his hives—many of which exhibited CCD-related symptoms. In order to meet current pollination contracts, he spent approximately $130,000 to purchase new hives, split existing hives and was able to restore his bee population to 3,300 colonies. Doan implied that one-time losses of such a large sum of money could be overcome but cautioned that sustained losses of that nature would devastate the beekeeping industry in western New York.

Pests, disease, loss of forage habitat, and climate change have all been implicated as drivers for the recent unsustainable level of bee losses (Frazier et al., 2011). However, a growing body of scientific literature has focused on a possible link between neonics—a family of systemic pesticides used on crops, nursery stock and outdoor plants—and the recent decline in bee populations (Lu, Warchol, & Callahan, 2014; Rundlof et al., 2015).[6] Over the past 20 years, neonics have become the most widely used class of insecticides with a global market share of over 25% (Van Der Sluijs et al., 2013). Neonics are designed to mimic acetylcholine neurotransmitters and are thus highly neurotoxic to insects (Van Der Sluijs, 2013).[7] The effects from neonics in bees include but are not limited to: decreased foraging ability; impaired navigation abilities; decreased reproduction rates (in certain species of bumblebees); impaired memory and learning ability; decreased brood and larval development rates; reduced hive cleanliness; and damage to the central nervous system of insects (Lu, Warchol & Callahan, 2014) Due to the systemic nature of neonics, they can be distributed through the tissues of plants by

[6] The term "systemic" refers to a chemical that is soluble enough in water that it can be absorbed by a plant and moved around in its tissues, thus making the whole plant toxic. Systemic pesticides are generally used to kill crop pests that, otherwise, would be difficult to kill.

[7] Acetylcholine neurotransmitters can be thought of chemical vessels through which signals from the brain pass from receptor to receptor.

phloemic and xylemic transport and thus can be present in a plant's nectar and pollen (Krupke et al., 2012). As such, neonic-treated forage can be available to pollinators year round thus posing an immense risk to global pollinator populations (Van Der Sluijs et al., 2013).

Several laboratory-based experiments have demonstrated that exposure to neonics can contribute to honey bee die-offs, and field studies are beginning to corroborate these findings (Kessler et al., 2015; Rundlof et al., 2015). In response to a report by the European Food Safety Authority, the European Union (EU), in 2013, placed a two-year moratorium on the usage of neonics due to the "high acute risk" that the insecticides posed to bees (Sanchez-Bayo & Goka, 2014). In the U.S., however, there remains much debate with regard to the way in which neonics affect bees in the field and whether or not a moratorium is necessary. Proponents of a moratorium argue that neonics pose an unacceptably high risk to bee populations, while critics contend that the ubiquitous nature of neonics—coupled with a lack of field-based evidence on the hazards of neonics—warrants a much more cautious regulatory approach (Blacquiere et al., 2012; Stewart et al., 2014). The following section discusses the impacts of neonics on bee populations and delves further into the debate regarding the level of risk they pose to pollinators.

Section 3.0 The Impacts of Neonics on Bee Populations

Neonics are used as seed treatments on more than 140 crops, with the nitroguandine family of neonics such as imidacloprid, clothianidin, dinotefuran and thiamethoxam posing the greatest threat to bee populations (Friends of the Earth, 2014). In fact, according to a 2014 report by the advocacy organization "Bee Action," there are approximately 300 insecticide products containing neonic-based insecticides as active ingredients being used on ornamental plants (e.g. African daisies, marigolds, and lavender) in either nursery or home garden settings. Virtually all corn and a large percentage of soybean, sunflower, wheat, and canola seeds planted in the U.S. are pretreated[8] with neonics (Bayer Bee Care, 2015). First introduced in the U.S. in the mid-90s, neonics were intended to protect crops against harmful crop pests, some of which had developed resistance to other insecticides (Blacquiere et al., 2012). Neonics became widely adopted due to their effectiveness on target pests, improved operator safety, and a reportedly favorable environmental profile (Bayer Bee Care, 2015). However, there is an increasing body of literature which questions the benefits of neonics and states that the risks posed by neonics to several vital insect species including pollinators warrant the cessation of all future neonic usage (Jenkins et al., 2014; Lu, Warchol & Callahan, 2014). Currently, the debate surrounding neonics concentrates on three primary questions: (1) To what extent do neonics help or hurt the agricultural environment? (2) What is the level of risk that bees and other pollinators face when exposed to field-relevant dosages of neonics? (3) Do the benefits of neonics as an insecticide outweigh the impacts to pollinator populations? The following section provides insight into this debate.

Jeschke et al. (2010) reviewed the status and global strategy concerning the usage of neonics and found that, due to their relatively low risk for non-target organisms and the environment, high toxicity for target organisms, and multiple means of application, neonics

[8] Seed treatments are products applied to seeds that are considered beneficial or necessary in maintaining or enhancing the yield of a given crop. For example, neonics are typically applied to seeds to ward off harmful crop pests.

greatly benefited the agricultural ecosystem. Neonics are typically used to control dangerous crop pests such as aphids, white flies and a number of beetle pests (APVMA, 2014). Further, the effectiveness of neonics on target species helps horticulturists and farmers limit the ability of pests to develop cross-sectional resistance to other pesticides (APVMA, 2014). It has also been argued that the application of neonics has greatly benefited the agricultural economy in Europe, contributing an estimated $4.28 billion in revenue (Noleppa & Hahm, 2013). Noleppa & Hahm (2013) further asserted that the ban on neonics such as the moratorium instilled by the EU would result in economic losses due to farmers having to implement alternative integrated pest management plans and through having to bear greater yearly crop losses.

Contrary to the findings of Jeschke et al. (2010), a growing body of research indicates that neonics adversely affect the agricultural environment. Goulson (2013) states that the excessive usage of neonics has led to an overall decline in the agricultural ecosystem, and finds that neonics can persist and accumulate in soils, surface water, and groundwater sources due to their long half-life. For example, between 1996 and 2004, the New York State Department of Environmental Conservation (DEC) expressed concerns to pesticide manufacturers that imidacloprid was being found in surface and groundwater sources in western New York (DEC, 2004). The findings of Goulson (2013) are supplemented by Mason et al. (2013) who argue that the immune systems of pollinators, fish and other animals are impacted by neonics as evidenced by declines in their respective populations in parallel with the increased application of neonics.

Laboratory tests on individual honey bees have shown that field-relevant, sub-lethal doses of neonics can alter behavior and can increase their susceptibility to disease and that LD_{50} dosage values[9] for neonics are much lower than older pesticides such as organophosphorous, pyrethroids, and carbamates (Decourtye & Devillers, 2010; USDA, 2012). A 2010 study reviewed the literature to assess the toxicity of neonics to pollinator populations and to determine if enough data existed to establish an unambiguous causal relationship between pollinator decline and elevated levels of exposure to neonics (Decourtye & Devillers, 2010). The study found that neonics, especially imidacloprid, can have distinct behavioral effects on bees including reduced reproductive success, impaired learning abilities, reduced foraging rates, limited mobility and increased susceptibility to disease (Decourtye & Devillers, 2010). Another study conducted an experiment in which 18 honey bee colonies were observed over the course of a season, with 12 colonies being exposed to neonics and six colonies being utilized as a control group in hopes of determining the relationship between neonic treatments and CCD (Lu, Warchol & Callahan, 2014). The study concluded that, during the overwintering period of the season, 50% of the honey bees in neonic-treated colonies had abandoned their hives, and were eventually found dead with symptoms resembling those seen in CCD-related cases (Lu, Warchol & Callahan, 2014). It is theorized that the honey bee die-offs were caused by an inability to regenerate their broods between winter and spring due to impaired cognitive and behavioral functions that were resultant from exposure to sub-lethal dosages of neonics (Lu, Warchol & Callahan, 2014).

Conversely, some researchers question the relevance of laboratory-based experiments on the lethal and sub-lethal hazards associated with neonics (Blacquiere et al., 2012; Nguyen et al., 2009). A 2012 study reviewed 15 years of research on the impacts of neonics on bee populations

[9] LD_{50} Dosage levels refer to the dosage of a particular chemical which is fatal to 50% of the population that is exposed to it.

in order to prepare an ecological risk assessment to further inform the discussion on neonics (Blacquiere et al., 2012). The data reviewed showed a discrepancy between laboratory and field-based studies. Laboratory studies resulted in a multitude of lethal and sub-lethal effects of neonics on honey bee populations, while field-based studies indicated that neonics posed a minimal risk to honey bees, wild bees, and solitary bees at field realistic dosages (Blacquiere et al., 2012). Further, Cutler & Scott-Dupree (2007) conducted a field study in which hives were exposed to flowering canola grown from clothianidin-treated seeds. They concluded that no side-effects on honey bees' foraging behavior resulted from their exposure to the clothianidin-treated seeds. A similar conclusion was drawn for imidacloprid (Schmuck et al., 2001; Nguyen et al., 2009).

Researchers point out that the resultant differences between laboratory and field-based studies concerning the impacts of neonics on bee populations do not preclude the fact that neonics still pose a significant risk to bee populations (Kessler, 2015; Rundlof et al., 2015). A 2011 study, conducted in response to large-scale bee die-offs in Indiana, examined the ways in which foraging bees were exposed to neonics over the course of a growing season (Krupke et al., 2011). The study found that primary exposure routes include crop dust during planting season, neonic-laced puddles, and through pollen and nectar in neonic-treated plants. In particular, the study noted that during the spring growing season, bees were exposed to high amounts of clothianidin and thiamethoxam as they collected pollen from neonic-treated maize crops and stored it in their hives (Krupke et al., 2011). Samson et al. (2014) cautions that bees are also exposed to neonics while foraging for water. Bryden et al. (2013) suggests that exposure to sub-lethal levels of neonics can contribute to heightened levels of stress in a colony, making it more susceptible to pathogens, varroa mite infestations and CCD. More importantly, a study by Kessler et al. (2015) found that bees cannot detect the presence of neonics in their food and, in fact, preferred neonic-laced solutions. It is hypothesized that neonics act like a drug, activating the same receptors in bees' brains that nicotine activates in the brains of humans (Kessler et al., 2015).

In a 2013 podcast with "The Organic View Radio Show," Jim Doan (the beekeeper mentioned in Section 2.0) provided his assessment of the way in which neonics impacted his managed honey bee colonies (Stoyer, 2014). Doan stated he noticed a distinct correlation between the application of neonics to crops on nearby fields and the rapid die-offs of his colonies (Stoyer, 2014). Per his request, scientists from Penn State University sampled Doan's hives and found high levels of neonics in the hives indicating that the sub-lethal effects of neonics were impairing the quality of Doan's hives (Stoyer, 2014). Subsequently, Doan experienced his first major bee die-off in 2012, presumably as a result of crop dust from a nearby corn field treated with clothianidin that had drifted into an orchard where Doan's bees were foraging (Stoyer, 2014). During the interview, Doan hypothesized that the risk to his and other bees was growing due to the increased intensity of corn and soybean production occurring in western New York (Stoyer, 2014). Doan mentioned he had observed nearby farms planting corn seeds at 40,000 seeds per acre as compared to the 25,000 seeds per acre level he had observed in previous years. Indeed Doan's observations are confirmed by Douglas & Tooker (2015) who found that in 2011, 34-44% of soybean acreage and 79-100% of maize hectares in the U.S. were treated with insecticides including neonics, creating a heightened risk of neonic-laced crop dust that could potentially be fatal to bees pollinating nearby fields. Doan suggests that bees in western New

York have multiple ways in which they could be exposed to neonics and that the lack of forage habitat has forced bees to ingest neonic-treated food or risk starvation (Stoyer, 2014).

While the experiences of Doan and other beekeepers around the nation implicated neonics as the culprit behind their significant bee losses, other areas in the world have reported no such effect. In 2014, the Australian Pesticides and Veterinary Medicines Authority (APVMA) put forth a study which reviewed the literature published in the U.S., Australia, and Europe to determine the risk neonics posed to bee populations. The study found that, when used incorrectly, neonics are acutely toxic to bees yet pointed out that despite the widespread usage of neonics in Australia over several years, bee populations have remained stable. The APVMA argued that other families of pesticides, such as organophosphates, posed a higher risk to bees and other pollinators than neonics and stated that the introduction of neonics had yielded a net gain in the nation's agricultural environment. The APVMA study concluded by arguing that the ability of the neonic family of pesticides to kill a wide range of crop pests warrants their use in Australia's agricultural community, pointing to nearly 20 years of consistent neonic treatments on crops without significant declines in bee populations (APVMA, 2014).

Due to the debate surrounding the impacts of neonics and the varying levels of responses pollinators have to this type of insecticide, researchers have raised the additional question: Do neonics result in any agricultural benefits? Stevens & Jenkins (2014) reviewed 19 studies and concluded that neonics have little to no benefits to the agricultural yields of soybeans and corn. The U.S. Environmental Protection Agency (EPA) also conducted a study in 2014 estimating the benefits the application of neonics had on soybeans and their findings concurred with those established by Stevens & Jenkins (2014) . Additionally, Stevens & Jenkins point to a study conducted by Sinnathanby et al. (2013) which concluded that increased pesticide usage was a key driver behind a $79 million annual decline in U.S. agricultural value when compared with 1986 figures—a figure derived from yield reductions in pollinator-dependent crops.

It should be noted that a majority of studies performed to date focus on the effects of neonics on honey bee populations as opposed to bumblebees, wild bees or solitary bees (Rundlof et al., 2015; Samson et al., 2014). This led critics of the EU's moratorium on neonics to suggest that the action lacked an adequate amount of field-based evidence. In response, Rundlof et al. (2015) conducted a study which examined the ways in which neonics influence bees and wild bees in particular. It is important to note that little research had been done to this point on the effects of neonics on wild bee populations. As such, eight pairs of landscapes surrounding 16 geographically separated spring-sown oilseed rape fields were monitored with the purpose of assessing how neonic-treated seed crops can affect bees in an agricultural landscape. The study had four major findings: (1) exposure to neonic-laced seed coatings led to decreases in the density of wild bee populations; (2) the nesting activity of solitary bees was decreased due to the presence of neonic-treated seeds; (3) neonic-laced seed coatings reduced the colony growth and reproductive rates of bumblebees; (4) the seed treatment had no apparent effect on honey bee populations. The findings from Rundlof et al. (2015) show that neonics, at field-relevant dosages, do pose a distinct risk to bee populations and suggest that honey bees may not always be the best proxy for determining the effects of neonics on wild bee populations.

Indeed, the risks associated with neonics to bee populations warrant concern in the policy arena. While the European approach to neonic regulations was to place a moratorium on their usage, the U.S. approach has been much more cautious. However, there are several efforts at multiple levels of government here to regulate neonics. The following section examines the current policy actions related to the regulation of neonics in addition to examining current pollinator protection activities at the federal, state and local levels.

Section 4.0 Federal Actions to Limit the Exposure of Pollinators to Neonics

Generally, in the U.S., the regulation of pesticides is administered by the EPA through the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (EPA, 2015). Given that neonics are closely regulated by FIFRA, it is important to consider the basic requirements and regulatory actions that can be undertaken through the law. In its current form, FIFRA authorizes the EPA to undertake three actions: (1) strengthen the registration process of pesticides by shifting the burden of proof to the chemical manufacturer; (2) enforce compliance against banned and unregistered products; and, (3) promulgate the regulatory framework missing from the original law (EPA, 2015).

FIFRA requires that all new pesticides used in the U.S. must be registered by the Administrator of EPA (EPA, 2015). Each registration of a pesticide essentially specifies the crops and area on which it may be applied, and such usage must be supported by research data (EPA, 2015). To properly register a pesticide, the EPA must make four findings: (1) its composition is such as to warrant the proposed claims for it; (2) its labeling and other material required to be submitted comply with the requirements of the Act; (3) it will perform its intended function without unreasonable effects on the environment; (4) when used in accordance with widespread and commonly recognized practice, it will not generally cause unreasonable adverse effects on the environment (EPA, 2015).[10]

Given the dynamic nature of the pesticide industry, FIFRA contains provisions stipulating that registrations for pesticides be reviewed every 15 years and it requires EPA to reregister all pesticides registered before 1984 (EPA, 2015). Further, EPA can cancel a registration if it is found that the pesticide does not comply with the requirements of FIFRA and can even suspend the pesticide registration, thus ceasing all sale, distribution, and use of the pesticide in question (EPA, 2015). Over the past decade, scientists, beekeepers and environmental advocacy organizations have pressured the EPA to either ban or place a moratorium on neonics through FIFRA (Frazier et al., 2011; Pollinator Health Task Force, 2015). In response to the growing body of research discussing the acute and sub-lethal effects of neonics on pollinator populations, the EPA and other agencies have taken several actions to limit the exposure of honey bees and other pollinators to neonics.

Overview of Federal Actions on Neonics

In 2007, the National Academy of Sciences National Research Council issued a study which detailed the serious problems facing the beekeeping industry (Beyond Pesticides, 2015).

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[10] As defined through FIFRA, an unreasonable adverse effect on the environment is: (1) any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of the pesticide; or (2) a human dietary risk from residues that result from the use of a pesticide in or on any food inconsistent with the standard under Section 408 of the Federal Food, Drug, and Cosmetic Act (EPA, 2015).

Since then, due to the immense ecological value of pollinators, a multitude of actions have been undertaken to protect pollinator populations nationwide (National Pollinator Task Force, 2015; USDA, 2013). In 2011, EPA formed a Pollinator Protection Workgroup which provided information to the EPA on the following topics: (1) initial science-based risk management approaches, including appropriate label restrictions; (2) development of information on state approaches and authorities; (3) transfer of lessons learned by various stakeholders to improve existing management practices; (4) continuing international communication; and (5) other issues that the EPA wished for the work group to research (Beyond Pesticides, 2015). Further, in 2014, President Obama issued a memorandum which directed federal agencies to implement actions that would "reverse pollinator losses and help restore populations to healthy levels" (Beyond Pesticides, 2015). To date, federal actions on neonics include but are not limited to the consideration and implementation of regulatory action on neonics, phasing out the usage of neonics on federally-owned property, and revamped guidance for risk assessors to better understand the risks pesticides pose to bee populations.

Consideration and Implementation of Regulatory Action on Neonics: In response to the 2014 memorandum put forth by the Obama Administration, the EPA has undertaken several actions to limit the exposure of pollinators to neonics (EPA, 2015). Of particular note, given the extensive body of research showing that bees exhibit a wide range of sensitivity to neonics, the EPA is reviewing the data from multiple field-based studies at the colony level and has expedited its review of the impacts of neonics (Pollinator Health Task Force, 2015). It is expected that the EPA will publish further findings on the impacts of neonics by 2017.

To date, the EPA has restricted the use of pesticides that are acutely toxic to bees by improving labeling language and restrictions for pesticides that have negative effects on bee populations, has halted new registrations of pesticides containing neonics, and is conducting a crop-by-crop economic analysis of the benefits of neonic seed treatments. Further, the EPA will propose to prohibit the foliar application of acutely toxic products during bloom for areas with bees on site under contract, unless the application is made in accordance with a government-declared public health response (Pollinator Health Task Force, 2015).

Phasing Out the Usage of Neonics on Federally Owned Property: In 2014, the U.S. Fish and Wildlife Service (USFWS) published a decision stating that, by January 2016, the agency would no longer use neonics in agricultural practices on USFWS-owned property due to the risks neonics posed to ecosystems nationwide (USFWS, 2014). The USFWS further found that "the prophylactic use, such as a seed treatment, of the neonicotinoid pesticides that can distribute systematically in a plant and can potentially affect a broad range of non target species is not consistent with Service policy" (USFWS, 2014). Additionally, the White House Council on Environmental Quality (CEQ) stated that it would require all landscaping practices on agency-owned or leased property to source neonic-free insecticides (Beyond Pesticides, 2015).

Revamping Risk Assessment Guidelines for Pesticides: In 2014, the EPA released a document titled "Guidance for Assessing Pesticide Risks to Bees" which is intended to revamp, discuss and provide guidance to risk assessors for evaluating the potential risk of pesticides to bees, in particular honey bees (EPA, 2014). The document is part of a long-term strategy to advance the science of assessing the threats posed by pesticides to bees, giving responsible parties the means to further improve pollinator protection in EPA's regulatory decisions (EPA, 2015). The creation of this set of guidelines will allow the EPA to utilize emerging research and allow regulators to make more informed regulatory decisions on neonics in a more adaptive manner.

Overview of State and Local Actions on Neonics

New York: Due to concern generated over the environmental impacts of neonics, the DEC currently restricts the usage of imidacloprid—requiring a valid applicator's license for members of the public to apply it (DEC, 2004). Also, in 2005, the DEC banned the sale and usage of clothianidin-treated seeds due to significant risk posed to New York State's groundwater resources (DEC, 2005). Finally, in May 2015, Governor Andrew Cuomo stated that New York State will "establish an interagency taskforce to develop a Pollinator Protection Plan to promote the health and recovery of pollinator populations in New York State" (Office of the Governor, 2015). It is expected that the plan will investigate best management practices for landowners, state agencies, pesticide applicators, and beekeepers and will evaluate the effectiveness of New York's programs, certifications, and incentives related to pollinator health (Office of the Governor, 2015). Finally, the New York State budget includes $500,000 of funding to Cornell University's Integrated Pest Management Program.

Regulatory Actions on Neonics: Over the past decade, there has been a growing trend amongst state and local governments to more closely regulate or ban the usage, sale and application of neonics. For example, in 2014 Seattle passed Resolution Number 31548 banning the usage of neonics on land owned or maintained by the city (Beyond Pesticides, 2015). The ordinance urged the federal government to institute a moratorium on neonics and requested that retailers operating in the City of Seattle ensure that no plants, seeds or products containing neonics are offered for sale (City of Seattle, 2014). With the passing of this resolution, Seattle became the largest U.S. city to ban the use of neonics (Beyond Pesticides, 2015). It should be noted that the municipalities of Shorewood, MN and Skagway, AK have also instituted similar bans on the usage of neonics on municipal properties.

In regard to state-level actions on neonics, California is currently in the process of re-evaluating the effects of neonics on bee populations (California Legislative Information, 2014). Assembly Bill 1789 requires the California Department of Pesticide Regulation to issue a determination on the effects of neonics on bee populations and adopt any control measures necessary to protect pollinator health (California Legislative Information, 2014). According to AB 1789, should any additional control measures be necessary to limit the exposure of bees to neonics, the State of California Department of Pesticide Control would be required to adopt them. Some states have undertaken less aggressive approaches to regulating neonics. Minnesota, for example, has implemented regulations which prohibit garden retailers from labeling plants treated with neonics as "bee friendly" (Fiscal Note, 2014). As of 2014, bills relating to neonics have been proposed in nine states, with Maine, New York, New Jersey, and Vermont considering bans on neonics while restrictions on neonics were considered in Maryland and Alaska (Fiscal Note, 2014).

Section 5.0 Policy Recommendations to Limit Exposure to Neonics

Consider Regulatory Action on Neonics: Given the rate of rapid bee population declines and the growing body of research demonstrating the connection between prolonged exposure to neonics and bee die-offs, federal, state, and local governments should consider adopting more stringent regulatory actions on neonics. However, it is important for government agencies to ensure that the proper policy mechanisms and resources are in place to assist farmers and pesticide applicators in adopting alternative pest management practices to limit potential financial damages from a top-down regulatory action. For instance, current media coverage with regard to the aftermath of the EU's ban on neonics indicates that the agricultural community is struggling to find effective alternatives to limit the spread of crop pests (Randall, 2015). It is reported that crop pest infestations, in large part, have led to a 15% decline in the European harvest of rapeseed—a three-year low (McFerron, 2015). Further, some farmers are resorting to older, more dangerous pesticides to combat crop pest infestations (McFerron, 2015). It should be noted that field-based research quantifying the effects of the EU's ban on neonics is ongoing and it is expected that the EU will revisit the ban on neonics in the near future.

At the same time, it is becoming more difficult for beekeepers to maintain sustainable apiaries. For example, in Otsego County, beekeepers are facing overwintering losses of 50% or more and are finding it difficult to maintain a functional apiary (C. Goodrich personal communication, 2015; P. Welch personal communication, 2015). Therefore, it is recommended that federal, state, and local agencies consider further regulatory action on neonics while instituting a moratorium on all new registrations of pesticides containing neonics, and that they urge retailers to temporarily suspend selling all products containing neonics until an appropriate regulatory action can be determined.

Phase out the Usage of Neonics: Another option for federal, state, and local governments to limit the exposure of bees and other pollinators to neonics would be to determine areas in which neonics can be phased out. For example, as mentioned in Section 4.0, the USFWS chose to phase out the usage of neonics on all USFWS-owned refuges because the application of neonics conflicted with the agency's internal policies. Also, several retailers such as BJ's Wholesale Club began to phase out neonics due to the impact these insecticides have on pollinators (Friends of the Earth, 2014). A mandatory phase-out of neonics would allow farmers, gardeners and retailers time to adopt alternative integrated pest management approaches. However, it is important that such actions be undertaken using an adaptive approach that utilizes collaboration between advocacy organizations, government agencies, businesses and scientists to ensure that the transition away from applying neonics is conducted smoothly.

Develop Pollinator Protection Plans: Pollinator protection plans represent an efficient means to enhance communication at the state level between regulators, applicators, farmers and beekeepers. Due to the fact that bees do not adhere to societal boundaries, it is important that states take a coordinated regional approach to identifying, mitigating and monitoring stressors to their pollinator populations. For instance, as a result of increased bee die-offs and a growing recognition of the ecological and economic benefits that pollinators yield, several states including California, Mississippi, Florida, and North Dakota currently have plans in place that are designed to restore pollinator populations back to healthy levels. Further, pursuant to the National Strategy to Protect Honey Bees and Other Pollinators, the EPA is in the process of developing overarching guidelines for the creation of pollinator protection plans that will assist states in developing strategies that effectively protect pollinators and determine a course of action to mitigate the threats facing them (Pollinator Health Task Force, 2015). As a result, several states are waiting for the EPA to establish those overarching guidelines for the contents of a state-level pollinator protection plan (Pollinator Stewardship, 2015). It is recommended that states without pollinator protection plans in place conduct the necessary outreach, communication, and research that will allow lead agencies to adopt and implement such plans in an expeditious manner.

Conduct Additional Localized, Field-Based Research on Neonics: Currently, several questions remain regarding the drivers behind pollinator decline and the ways in which neonics factor into that discussion. Localized research on stressors affecting bee populations can inform policies at the local, state and, potentially, the national level. Also, additional field-based research needs to be conducted to assess the manner in which neonics interact with other stressors such as varroa mites, the *Nosema apis* parasite, and other fungicides and herbicides. Research should also be conducted by relevant regulatory agencies to assess the way in which neonics affect non-target species such as birds, bats, amphibians, aquatic macroinvertebrates and fish. Additionally, localized research can be conducted to estimate how various regulatory actions on neonics would affect state and local economies, local beekeeping industries, and regional and local governing bodies. Local advocacy organizations should partner with research institutions, state agencies, and farmers to develop long-term and short-term research projects to assess the risks facing pollinator populations at the local scale.

Conclusion

While additional field-based research is needed to fully assess the exact nature of the impacts of neonics on bee populations, the literature clearly demonstrates that neonics pose a distinct risk to pollinator populations nationwide. It should be noted that exposure to neonics alone will not translate to increased food prices or a mass disappearance of bee populations. Rather, the acute and sub-lethal effects of neonics contribute to a growing body of stressors that, combined, pose an unacceptably high risk to pollinator populations. If left unchecked, declines in pollinator populations will result in economic effects that will translate to higher food prices and potentially alter the U.S. agricultural landscape (Sinnathamby et al., 2013). It is important that any risk, especially that posed by neonics, is mitigated fully in a manner that protects pollinator populations while limiting financial damages to farmers, producers and beekeepers alike.

Works Cited

1. Aizen, M.A., Garibaldi L.A., Cunningham S.A. & Klein A.M. (2009). How much does agriculture depend on pollinators? Lessons from long-term trends on crop production. *Annals of Botany*, pages 1-10: mcp076. Retrieved from: http://aob.oxfordjournals.org/content/early/2009/04/01/aob.mcp076.short

2. Arbuckle, T., Schröder, S., Steinhage, V., & Wittmann, D. (2001, October). Biodiversity informatics in action: identification and monitoring of bee species using ABIS. In *Proc. 15th Int. Symp. Informatics for Environmental Protection* (Vol. 1, pp. 425-430). Retrieved from: http://enviroinfo.eu/sites/default/files/pdfs/vol103/0425.pdf

3. Australian Pesticides and Veterinary Medicines Authority. (2014, February). *Overview report: Neonicotinoids and the health of honey bees in Australia*. Retrieved from: http://archive.apvma.gov.au/news_media/docs/neonicotinoids_overview_report_february_2014.pdf

4. Bauer, D.M. & Wing, I.S. (2010). Economic consequences of pollinator declines: A synthesis. *Agriculture and Resource Economics Review*, *39*/3, pages 368-383. Retrieved from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.383.1003&rep=rep1&type=pdf

5. Bee Action & Friends of the Earth. (2014) *Bees in trouble fact sheet.* Retrieved from: http://www.foe.org/system/storage/877/4b/3/4908/Bees_in_Trouble.pdf

6. Beyond Pesticides. (2015). *Pesticide enforcement and compliance: Examining state and federal response to bee decline.* Retrieved from: http://www.beyondpesticides.org/pollinators/documents/Enforcement.pdf

7. Beyond Pesticides. (2014, Spring). No longer a big mystery: Recent scientific research confirms the role of pesticides in pollinator decline. *Pesticides and You*, 34(1), 9-12. Retrieved from: http://www.beyondpesticides.org/pollinators/nolongeraBIGmystery.pdf

8. Blacquiere, T., Smagghe, G., Van Gestel, C.A.M., & Mommaerts, V. (2012) Neonicotinoids in bees: A review on concentrations, side-effects and risk assessment. *Ecotoxicology*, *21*, 973-992. DOI: 10.1007/s10646-012-0863x. Retrieved from: http://link.springer.com/article/10.1007/s10646-012-0863-x

9. Blumgart, J. (2014, December 8). *Sick, poisoned and hungry: The bees of New York State.* [Web log post]. Retrieved from: http://www.truth-out.org/news/item/27627-sick-poisoned-and-hungry-the-bees-of-new-york-state

10. Breeze, T.D., Vaissiere, B.E., Bommarco, R., Petanidou, T., Seraphides, N., Kozak, L., Scheper, J., Biesmeijer, J.C., Kleijn, D., Gyldenkaerne, S., Moretti, M., Holzschuh, A., Steffan-Dewenter, I., Stout, J.C., Partel, M., Zobel & M., Potts, S.G. (2014). Agricultural policies exacerbate honeybee pollination service supply-demand

mismatches across Europe. *PLOS ONE*, 9(1*)*, 1-8. Retrieved from: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0082996#pone-0082996-g002

11. Bryden, J., Gill, R.J., Mitton, R.A.A., Raine, N.E., & Jansen, A.A. (2013). Chronic sublethal stress causes bee colony failure. *Ecology Letters, 16,* 1463-1469. DOI: 10.1111/ele.12188. Retrieved from: http://onlinelibrary.wiley.com/doi/10.1111/ele.12188/full

12. Calderone, N.W. (2012). Insect pollinated crops, insect pollinators and U.S. agriculture: Trend analysis of aggregate data for the period 1992-2009. *PLOS ONE, 7* (5), 1-27. Retrieved from: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0037235

13. Pesticides: neonicotinoids: reevaluation: determination: control measures, Assembly Bill 1789. *California State Assembly.* (2013-2014). Retrieved from: http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB1789

14. City of Seattle. (2014). *Resolution Number 31548*. Retrieved from: http://clerk.seattle.gov/~scripts/nph-brs.exe?s1=&s3=31548&s2=&s4=&Sect4=AND&l=20&Sect5=RESNY&Sect6=HITOFF&d=RESF&p=1&u=%2F~public%2Fresny.htm&r=1&f=G

15. City of Shorewood. (2014). *Resolution No. 14-066: A resolution endorsing "bee-safe" policies and procedures.* Retrieved from: http://www.ci.shorewood.mn.us/pages/envmt/A%20Resolution%20Endorsing%20%E2%80%9CBee-Safe%E2%80%9D%20Policies%20and%20Procedures.pdf

16. Colla, S.R. & Packer, L. (2008). Evidence for decline in eastern North American bumblebees (Hymenoptera: Apidae), with special focus on *Bombus affinis* Cresson. *Biodiversity Conservation, 17,* 1379-1391. DOI: 10.1007/s10531-008-9340-5. Retrieved from: http://alus.ca/wpsite/wp-content/uploads/2013/05/decline-paper-published.pdf

17. Colony Collapse Disorder: Hearings before the Subcommittee on Horticulture and Organic Agriculture, House of Representatives, 110th Cong. (2007). (Testimony of James "Jim" Doan). Retrieved from: http://www.cmbeea.org/sub/Doan_CommercialBeekeeper.pdf

18. Cutler, G. C., & Scott-Dupree, C. D. (2007). Exposure to clothianidin seed-treated canola has no long-term impact on honey bees. *Journal of Economic Entomology, 100*(3), 765-772. Retrieved from: https://dspace.lib.uoguelph.ca/xmlui/bitstream/handle/10214/2621/32546.pdf?sequence=1

19. Decourtye, A. & Devillers, J. (2010). Ecotoxicity of neonicotinoid insecticides to bees. *Insect Nicotinic Acetylcholine Receptors,* 85-95. Springer New York. Retrieved from:

http://www.researchgate.net/profile/Axel_Decourtye/publication/45950073_Ecotoxicity_of_neonicotinoid_insecticides_to_bees/links/0c960529662c985e34000000.pdf

20. Desin, L.P. (2014). *The economic consequences of honey bee colony collapse disorder for California's agriculture industry*. Unpublished senior thesis, Sacramento State University, Sacramento, California. Retrieved from: http://www.csus.edu/envs/Documents/Theses/Spring%202014/814.Honey%20Bee%20Colony%20Collapse%20Disorder.pdf

21. Douglas, M. R., & Tooker, J. F. (2015). Large-scale deployment of seed treatments has driven rapid increase in use of neonicotinoid insecticides and preemptive pest management in U.S. field crops. *Environmental science & technology*, *49*(8), 5088-5097. Retrieved from: http://pubs.acs.org/doi/abs/10.1021/es506141g

22. Douglas, M.R., Rohr, J.R., & Tooker, J.F. (2014). Neonicotinoid insecticide travels through a soil food chain, disrupting biological control of non-target pests and decreasing soya bean yield. *Journal of applied ecology*, DOI: 10.1111/1365-2664.12372, 1-11. Retrieved from: http://biology.usf.edu/ib/data/flyers/ROHR-INSECTICIDE-12-2014.pdf

23. Fiscal Note Blog. (2014, October 28). *Akeelah and the neonicotinoid: A new trend in agriculture legislation*. Retrieved from: http://blog.fiscalnote.com/2014/10/28/akeelah-and-the-neonicotinoid-a-new-trend-in-agriculture-legislation/

24. Frazier, M., Mullin, C., Frazier, J. & Ashcraft, S. (2011). What have pesticides got to do with it? *American Bee Journal*, *148*(6), 521-524. Retrieved from: http://bee-quick.com/reprints/fraizer_abj.pdf

25. Friends of the Earth, Bee Action & Sum of Us. (2014). *Gardeners beware 2014: Bee-toxic pesticides found in "bee-friendly" plants sold at garden centers across the U.S. and Canada*. Retrieved from: http://libcloud.s3.amazonaws.com/93/3a/3/4738/GardenersBewareReport_2014.pdf

26. Gallai, N., Salles, J.M., Settele & J., Vaissiere, B.E. (2009). Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. *Ecological Economics*, *68*(3), 810-821. Retrieved from: http://www.researchgate.net/profile/Jean_Michel_Salles/publication/23647989_Economic_valuation_of_the_vulnerability_of_world_agriculture_confronted_with_pollinator_decline/links/00b4951d48c3a15e7c000000.pdf

27. Goodrich, C. (2015, May 20). Interview by D. Lapin [phone].

28. Goulson, D. (2013). Review: An overview of the environmental risks posed by neonicotinoid insecticides. *Journal of Applied Ecology*, *50*(4), 977-987. Retrieved from: http://www.researchgate.net/profile/Dave_Goulson/publication/264606027_REVIEW_An_overview_of_the_environmental_risks_posed_by_neonicotinoid_insecticides/links/

540cb9e40cf2f2b29a38226a.pdf

29. Jeschke, P., Nauen, R., Schindler, M., & Elbert, A. (2010). Overview of the status and global strategy for neonicotinoids. *Journal of Agricultural and Food Chemistry*, *59*(7), 2897-2908. Retrieved from: http://pubs.acs.org/doi/abs/10.1021/jf101303g

30. Johansen, E., Hooven, L.A., & Sagili, R.R. (2013) *How to reduce bee poisoning from pesticides.* [Corvallis, Or]: Oregon State University Extension Service. Retrieved from: http://wasba.org/how-to-reduce-bee-poisoning-from-pesticides-pnw-591/

31. Kearns, C. A., Inouye, D. W., & Waser, N. M. (1998). Endangered mutualisms: the conservation of plant-pollinator interactions. *Annual review of ecology and systematics*, 83-112. Retrieved from: http://www.jstor.org/stable/221703?seq=1#page_scan_tab_contents

32. Keim, B. (2013, May 8). One-third of U.S. honeybee colonies died last winter, threatening food supply. Retrieved May 29, 2015, from: http://www.wired.com/2013/05/winter-honeybee-losses/

33. Kessler, S.C., Tiedeken, E.J., Simcock, K.L. Derveau, S., Mitchell, J. Softley, S., Stout, J.C., & Wright, G.A. (2015). Bees prefer foods containing neonicotinoid pesticides. *Nature,* 000, 1-14. Retrieved from: http://www.moraybeedinosaurs.co.uk/neonicotinoid/Bees%20prefer%20foods%20containing%20neonicotinoid%20pesticides.pdf

34. Kjohl, M., Nielsen, A., & Stenseth N.C. (2011). *Potential effects of climate change on crop pollination.* Centre for Ecological and Evolutionary Synthesis, Department of Biology, University of Oslo, Norway. Retrieved from: http://www.fao.org/fileadmin/templates/agphome/documents/Biodiversity-pollination/Climate_Pollination_17_web__2_.pdf

35. Krupke, C.H., Hunt, G.J., Eitzer, B.D., Andino, G., & Given, K. (2011). Multiple routes of pesticide exposure for honey bees living near agricultural fields. *PLOS ONE*, 7(1), DOI: e29268. Retrieved from: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0029268#pone-0029268-t006

36. Lu, C.S., Warchol, K. M., & Callahan, R. A. (2014). Sub-lethal exposure to neonicotinoids impaired honey bees winterization before proceeding to colony collapse disorder. *Bulletin of Insectology*, *67*(1), 125-130. Retrieved from: http://pesticidetruths.com/wp-content/uploads/2014/08/Reference-PCP-Bees-2014-03-27-Chensheng-Lu-Lunatic-Report-On-Sub-Lethal-That-Impaired-Honey-Bees-Italy.pdf

37. Mason, R., Tennekes, H., Sánchez-Bayo, F., & Jepsen, P. U. (2013). Immune suppression by neonicotinoid insecticides at the root of global wildlife declines. *Journal of Environmental Immunology and Toxicology*, *1*(1), 3-12. Retrieved from: http://www.boerenlandvogels.nl/sites/default/files/JEIT%20Immune%20Suppression%

20pdf_6.pdf

38. McNeil, M. E. A. (2014) Bees, pesticides and a game-changing presidential initiative. *Bee Culture*, 142(9), 48. Retrieved from: http://connection.ebscohost.com/c/articles/97741235/bees-pesticides-game-changing-presidential-initiative

39. McFerron, W. (2015, January 7). Bugs invade Europe as save-bees cry spurs pesticide ban. Retrieved from: http://www.bloomberg.com/news/articles/2015-01-08/bugs-invade-europe-as-save-bees-cry-spurs-pesticide-ban

40. Municipality of Skagway. (2014). *Ordinance No. 14-15.* Retrieved from: http://www.skagway.org/vertical/sites/%7B7820C4E3-63B9-4E67-95BA-7C70FBA51E8F%7D/uploads/Ord._14-15_Limiting_Herbicide_CLEAN.pdf

41. Neonicotinoids. (n.d.). Retrieved May 29, 2015, from http://beecare.bayer.com/home/what-to-know/pesticides/neonicotinoids

42. New York State Department of Environmental Conservation. (2005). *Withdrawal of application for registration of the new product Poncho 600 (EPA reg. no. 264-789-7501) which contains the new active ingredient clothianidin*. Retrieved from: http://pollinatorstewardship.org/wp-content/uploads/2014/12/new-york-state-clothianidin-letter-2005.pdf

43. New York State Department of Environmental Conservation. (2003). *Status of Imidacloprid in New York State.* Retrieved from: http://pmep.cce.cornell.edu/profiles/insect-mite/fenitrothion-methylpara/imidacloprid/imidac_let_1003.html

44. New York State Office of the Comptroller. (2015, March). *The importance of agriculture to the New York State economy*. Retrieved from: http://www.osc.state.ny.us/reports/importance_agriculture_ny.pdf

45. New York State Office of the Governor. (2015, April 23). *Governor Cuomo announces taskforce to develop pollinator protection plan to protect New York's agricultural economy.* Retrieved from: https://www.governor.ny.gov/news/governor-cuomo-announces-taskforce-develop-pollinator-protection-plan-protect-new-yorks

46. Nguyen, B.K., Saegerman, C., Pirard, C., Mignon, J., Widart, J., Thirionet, B., Verheggen, F.J., Berkvens, D., De Pauw, E., & Haubruge, E. (2009). Does imidacloprid seed-treated maize have an impact on honeybee mortality? *Journal of Economic Entomology*, 102(2), 616-623. Retrieved from: http://orbi.ulg.ac.be/bitstream/2268/20825/1/Nguyenetal2009.pdf

47. Noleppa, S., & Hahn, T. (2013). The value of neonicotinoid seed treatment in the European Union. HFFA Working Paper 01/2013, Humboldt forum for Food and Agriculture. Retrieved from: http://www.ask-force.org/web/Bees/Noleppa-Value-

Neonicotinoid-Seed-Treatment-2013.pdf

48. Park, M. G., Orr, M. C., Danforth, B. N., & Hall, C. (2010). The role of native bees in apple pollination. *NY Fruit Quarterly*, *18*, 21-25. Retrieved from: http://www.nyshs.org/pdf/fq/10spring/the-role-of-native-bees-in-apple-pollination.pdf

49. Pollinator Health Task Force. (2015, May 19). *National strategy to promote the health of honey bees and other pollinators.* Retrieved from: https://www.whitehouse.gov/sites/default/files/microsites/ostp/Pollinator%20Health%20Strategy%202015.pdf

50. Pollinator Stewardship Council, American Honey Producers Association, National Honey Bee Advisory Board, American Beekeeping Federation, Thomas R. Smith, Bret L. Adee, and Jeffery S. Anderson v. United States Environmental Protection Agency, Et Al., and Dow Agrosciences. 20-2 8891598 1-126. United States Court of Appeals Ninth Circuit. 06 Dec. 2013. Retrieved from: http://earthjustice.org/sites/default/files/files/sulfoxaflor-declarations.pdf

51. Raine, N. E., & Gill, R. J. (2015). Ecology: Tasteless pesticides affect bees in the field. *Nature*, 521, 38-40. Retrieved from: http://www.nature.com/nature/journal/v521/n7550/full/nature14391.html

52. Randall, R. (2015, January 27). Pests invade Europe after neonicotinoids ban, with no benefit to bee health. Retrieved from: http://www.geneticliteracyproject.org/2015/01/27/pests-invade-europe-after-neonicotinoids-ban-with-no-benefit-to-bee-health/

53. Rundlof, M., Andersson, G.K.S., Bommarco, R., Fries, I., Hederstrom, V., Herbertsson, L., Jonsson, O., Klatt, B.K., Pedersen, T.R., Yourstone, J., & Smith, H.G. (2015). Seed coating with a neonicotinoid insecticide negatively affects wild bees. *Nature*, 521(7550), 77-80. Retrieved from: http://www.nature.com/nature/journal/v521/n7550/abs/nature14420.html

54. Samson-Robert, O., Labrie, G., Chagnon, M., & Fournier, V. (2014). Neonicotinoid-contaminated puddles of water represent a risk of intoxication for honey bees. *PLOS ONE*, *9*(12), 1-17. DOI: e108443. Retrieved from: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0108443#pone-0108443-t003

55. Sanchez-Bayo, F., & Goka, K. (2014). Pesticide residues and bees—a risk assessment. *PLoS One*, *9*(4), e94482. Retrieved from: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0094482

56. Sinnathamby, S., Assefa, Y., Granger, A. M., Tabor, L. K., & Douglas-Mankin, K. R. (2013). Pollinator decline: U.S. agro-socio-economic impacts and responses. *Journal of Natural and Environmental Sciences*, *4*(1), 1-13. Retrieved from:

http://www.asciencejournal.net/asj/index.php/NES/article/viewPDFInterstitial/430/pdf_111

57. Simon, M. (2014). *Follow the honey: 7 ways pesticide companies are spinning the bee crisis to protect profits*. Retrieved from: http://www.foe.org/news/archives/2014-04-follow-the-honey-7-ways-pesticide-companies-are-spinning-bee-crisis

58. Spivak, M., Mader, E., Vaughan, M., & Euliss Jr., N.H. (2011). The plight of the bees. *Environmental Science and Technology,* 45(1), 34-38. Retrieved from: http://www.xerces.org/wp-content/uploads/2011/02/plightofbees.pdf

59. Steinhauser, N., Rennich, K., Lee, K., Pettis, J., Tarpy, D.R., Rangel, J., Caron, D., Sagili, R., Skinner, J.A., Wilson, M.E., Wilkes, J.T., Delaplane, K.S., Rose, R., van Engelsdorp, D. (2015, May 13). *Colony loss 2014-2015: Preliminary results*. *Bee Informed*. Retrieved from: http://beeinformed.org/results/colony-loss-2014-2015-preliminary-results/

60. Stevens, S. & Jenkins, P. (2014, March). *Heavy costs: Weighing the value of neonicotinoid insecticides in agriculture.* Retrieved from: http://www.centerforfoodsafety.org/files/neonic-efficacy_digital_29226.pdf

61. Stewart, S.D., Lorenz, G.M., Catchot, A.L., Gore, J., Cook, D., Skinner, J., Mueller, T.C., Johnson, D.R., Zawislak, J., & Barber, J. (2014). Potential exposure of pollinators to neonicotinoid insecticides from the use of insecticide seed treatments in the mid-southern United States. *Environmental science and technology*, 48(16), 9762-9769. DOI: 10.1021/es501657w. Retrieved from: http://pubs.acs.org/doi/abs/10.1021/es501657w

62. Stoyer, J. (Producer) (2014, March 26). The end of an American beekeeper: The Jim Doan story. *The organic view radio show*. [Audio podcast]. Retrieved from: http://www.theorganicview.com/environment/the-end-of-an-american-beekeeper-the-jim-doan-story/

63. The Center for Food Safety, Beyond Pesticides, Pesticide Action Network North America. (2014). *Economic value of commercial beekeeping*. Retrieved from: http://www.beyondpesticides.org/pollinators/EconomicValueCommercialBeekeeping.pdf

64. U.S. Department of Agriculture. (2012, October 15-17). *Report on the national stakeholders conference on honey bee health.* Retrieved from: http://www.usda.gov/documents/ReportHoneyBeeHealth.pdf

65. U.S. Department of the Interior, Fish and Wildlife Service. (2014). *Use of agricultural pesticides in wildlife management in the national wildlife refuge system*. Retrieved from: http://www.centerforfoodsafety.org/files/agricultural-practices-in-wildlife-management_21049.pdf

66. U.S. Environmental Protection Agency. (2014, October 14). *Benefits of neonicotinoid seed treatments to soybean production*. Retrieved from: http://www2.epa.gov/sites/production/files/2014-10/documents/benefits_of_neonicotinoid_seed_treatments_to_soybean_production_2.pdf

67. U.S. Environmental Protection Agency. *Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)*. (2012, June 27). Retrieved from: http://www.epa.gov/agriculture/lfra.html#Summary%20of%20the%20Federal%20Insecticide,%20Fungicide,%20and%20Rodenticide%20Act

68. U.S. Environmental Protection Agency Office of Pesticide Programs, Health Canada Pest Management Regulatory Agency, California Department of Pesticide Regulation. (2014, June 19). *Guidance for assessing pesticide risks to bees.* Retrieved from: http://www2.epa.gov/sites/production/files/2014-06/documents/pollinator_risk_assessment_guidance_06_19_14.pdf

69. U.S. Environmental Protection Agency. (2014, last updated 2015, May 21). *Federal pollinator health task force: EPA's role*. Retrieved from: http://www2.epa.gov/pollinator-protection/federal-pollinator-health-task-force-epas-role

70. Welch, P. (2015, May 22). Interview by D. Lapin [phone].

71. White House Council on Environmental Quality. (2014). *Supporting the health of honey bees and other pollinators*. Retrieved from: https://www.whitehouse.gov/sites/default/files/docs/supporting_the_health_of_honey_bees_and_other_pollinators.pdf

72. van der Sluijs, J.P., Simon-Delso, N., Goulson, D., Maxim, L., Bonmatin, J.M., & Belzunces, L.P. (2013). Neonicotinoids, bee disorders and the sustainability of pollinator services. *Environmental Sustainability,* 5, 293-305. Retrieved from: http://www.sciencedirect.com/science/article/pii/S1877343513000493