THE CLASS OF 1964 POLICY RESEARCH SHOP

PESTICIDES AND NEONICOTINOIDS

PRESENTED TO NEW HAMPSHIRE HOUSE COMMITTEE ON ENVIRONMENT AND AGRICULTURE

Rep. Howard Pearl, Chair

This report was written by undergraduate students at Dartmouth College under the direction of professors in the Nelson A. Rockefeller Center. Policy Research Shop (PRS) students produce non-partisan policy analyses and present their findings in a non-advocacy manner. The PRS is fully endowed by the Dartmouth Class of 1964 through a class gift given to the Center in celebration of its 50th Anniversary. This endowment ensures that the Policy Research Shop will continue to produce high-quality, non-partisan policy research for policymakers in New Hampshire and Vermont. The PRS was previously funded by major grants from the U.S. Department of Education, Fund for the Improvement of Post-Secondary Education (FIPSE) and from the Ford Foundation and by initial seed grants from the Surdna Foundation, the Lintilhac Foundation, and the Ford Motor Company Fund. Since its inception in 2005, PRS students have invested more than 70,000 hours to produce more than 200 policy briefs for policymakers in New Hampshire and Vermont.

PRS POLICY BRIEF 2021-03
MARCH 27, 2021

PREPARED BY:
PARIDHI KAPADIA
EMILY LU
JEREMY RODRIGUEZ

NELSON A. ROCEFELLER CENTER FOR PUBLIC POLICY AND THE SOCIAL SCIENCES
Contact:
Nelson A. Rockefeller Center, 6082 Rockefeller Hall, Dartmouth College, Hanover, NH 03755
http://rockefeller.dartmouth.edu/shop/ • Email: Ronald.G.Shaiko@Dartmouth.edu

TABLE OF CONTENTS

EXECUTIVE SUMMARY

In recent years, research has increasingly suggested that pesticides such as neonicotinoids cause harm to the environment and pollinator populations. The New Hampshire legislature introduced a bill in January 2019 to ban the use and sale of insecticides and treated seeds in the following categories: neonicotinoids (neonics), sulfoximines, butenolides, and phenyl-pyrazoles.[1] The Committee on Environment and Agriculture Committee in the New Hampshire House of Representatives is interested in obtaining additional data about the impacts of neonics to inform potential decisions on neonic regulation. This report first provides an overview of pesticide and neonic usage, including licensing procedures in the state of New Hampshire. We then explore the risks of neonics to pollinator and human health. Despite this potential harm, neonics are widely used insecticides—we therefore also examine the economic benefits of using neonics. Following this review of both risks and benefits, this report evaluates the reasoning and consequences behind neonic regulations in other states to assess the most effective regulatory path for New Hampshire.

1 INTRODUCTION: A BRIEF HISTORY OF PESTICIDE AND NEONICOTINOID USE

Pesticides are natural or synthetic substances used to kill unwanted organisms that cause harm. Insects and plants are the most frequently targeted organisms, but other pests can include mold, mammals, and microorganisms such as bacteria. A common application of pesticides occurs in agricultural enterprises to protect crops and livestock from losses due to insects, weeds, and diseases. Pesticides may also help preserve food and prevent vector-borne diseases.

The Food and Agriculture Organization of the United Nations estimates that between 20 to 40 percent of global crop production is lost to pests each year, with invasive insects costing the global economy about $70 billion annually.[2] This is not a new problem—farm crops have long suffered losses in yields from pests. Up until the mid-twentieth century, pest control consisted mostly of inorganic substances or organic chemicals from natural sources, which were highly toxic. Newer compounds still struggle to isolate their harmful impact to the targeted species.

Pesticides are designed to repel and kill organisms, and they work by interfering with biological mechanisms within pests. Living organisms often share many of these mechanisms, and as a result, pesticides can cause unintentional harm to other organisms. Pesticides may therefore also impact human health, whether through regular exposure in occupational use or residue from food products.

Neonicotinoids, which are widely used neurotoxic insecticides, replaced earlier pesticides such as organophosphate and carbamate compounds within 20 years of their introduction in the 1980s. Neonics were presented as a solution to human toxicity concerns with older chemicals. However, within the past decade neonics have recently gained global attention for potential harm. Some research has shown that neonics may impair pollinators and cause colony collapses. Given the vast usage of neonics throughout the world, it is crucial to examine the effects they can have on environmental and human health along with the potential benefits they bring to the agricultural community.

2 PURPOSE STATEMENT

The state of pesticide regulation and control has long been debated in New Hampshire. While every state is required to follow federal laws outlined by the Environmental Protection Agency (EPA) and United States Department of Agriculture (USDA), state governments vary on additional pesticide restrictions, regulation, and control. In New Hampshire, organizations such as environmental advocacy groups, the New Hampshire Farm Bureau Federation, the New Hampshire Beekeepers Association, specialists, and other representatives of the agricultural industry are stakeholders impacted by state policy on the regulation of pesticides.[3]

A major bill recently debated in the state legislature has centered on the use of neonics. House Bill 646 was presented in January of 2019 and proposed a ban on most uses of pesticides that are toxic to bees. The bill was proposed in response to a massive decline in bee population in previous years. Farmers urged the House to kill the bill and rely on recommendations from the Pesticide Control Board while advocacy groups and activists pressured the House to regulate neonics in order to protect bee populations. The House did not pass the bill into law; however, it will be brought before the legislature again in 2021 to discuss the formation of a study committee.

This research report provides a literature review on the current data and scientific literature surrounding pesticide use and its effects on human health, agriculture, and the broader environment. Neonics, as a class of pesticides, will be examined more thoroughly in the literature review. The report utilized interviews with stakeholders, data aggregation, and analysis of the benefits and harms of pesticides and neonics. We hope this report provides important analysis that may be utilized to inform policymakers on the use of pesticides and neonics.

3 OVERVIEW OF PESTICIDES

This section will examine the current scientific literature for the harmful effects of pesticides broadly on human health and identify vulnerable groups. This will provide information on the benefits and dangers of pesticide use and contextualize our research into neonics.

3.1 PESTICIDES

This section will start with an exploration of the effects of pesticides to human health. We will explore whether or not pesticides are harmful to humans, if farmers and pesticide applicators are at higher risk for health issues caused by pesticides, and the kinds of health issues caused by exposure. Lastly, we will identify potential vulnerable populations to pesticide exposure and its risks.

First, what is a pesticide? The EPA defines a pesticide as:

- "Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest."[4]
- "Any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant."[5]
- "Any nitrogen stabilizer."[6]

3.1.1 PESTICIDE EXPOSURE AND DISEASES

There is a growing body of scientific literature outlining the detrimental effects of pesticides to the human body. The EPA states that "the health effects of pesticides depend on the type of pesticide. Some, such as the organophosphates and carbamates, affect the nervous system. Others may irritate the skin or eyes. Some pesticides may be carcinogens. Others may affect the hormone or endocrine system in the body."[7] While the effects of pesticides do vary, the EPA largely understates the danger and severity of the health issues pesticides may cause. Pesticides may cause acute, or immediate, health effects such as rashes, blisters, blindness, nausea, dizziness, diarrhea, and death.[8] In addition, pesticides may also cause long-term health issues such as cancers, birth defects, reproductive harm, and neurological and developmental toxicity.[9] It is difficult to establish direct causal relationships between pesticides and disease due to the complexity of factors that influence diseases and the large range of applications used for pesticides. Table 3.1.1 below provides a list of detailed health issues related to pesticide use, vulnerable groups, and the number of scientific sources.

TABLE 3.1.1

Overview of Diseases Caused by Pesticides

Below is an overview of diseases caused by pesticides with the number of studies providing evidence for the association and vulnerable groups. Data was taken from a database collecting studies connecting pesticides to disease from the data aggregators of *Beyond Pesticides*.[10]

Disease	Major Pesticide Type Studied	# of Studies	Vulnerable Groups/ Highest risk
Alzheimer's Disease	Organophosphates, organochlorines	4	Individuals 65 and older
Asthma	Herbicides	41	Children; Low-income communities; African Americans
Birth/fetal defects (i.e. spina bifida, cleft lip, Down's syndrome, etc.)	Nitrates, atrazine, DDT, other	19	Infants; Pregnant mothers
Brain Cancer	Insecticides, herbicides (common household pesticides)	30	Children
Breast Cancer	Organochlorines, Herbicides, (other lawn & garden pesticides)	11	Women
Leukemia	Residential and agricultural pesticides	40	Aerial pesticide applicator pilots; Children; In utero

Lymphoma	Carbamates, organophosphates, chlorinated hydrocarbons, triazines and triazoles, phenoxy herbicides, chlorophenols, insecticides, fungicides	79[11]	Farmers & pesticide applicators
Prostate Cancer	Herbicide glyphosate, organochlorines, endocrine disrupting chemicals	23	Farmers; Agricultural Workers
Soft Tissue Sarcoma	Chlorophenoxy herbicides, fungicides, insecticides	7	None listed
Attention Deficit Hyperactivity Disorder	Organophosphates, Polycyclic aromatic hydrocarbons, herbicides	8	Children
Autism	Organochlorines, endocrine disrupting chemicals, pyrethroid pesticides	5	Infants; Children
Parkinson's Disease	Herbicides, insecticides, pyrethroid pesticides	65	Individuals 60 and older
Diabetes	Insecticides, organochlorines, glyphosate herbicide	6	Pesticide applicators

3.1.2 HIGHER RATES OF HEALTH ISSUES AMONG FARMERS

Most scientific findings suggest farmers are at higher risk for health issues caused by pesticide exposure. This section will investigate the occupational risks of agricultural work, pesticide applications, and identify vulnerable groups within the agricultural workforce.

Pesticides are largely used across agricultural spaces to control harmful pests, insects, and organisms that might feed off the crops, and prevent crop yield losses or crop damage. Not surprisingly, farmers and agricultural workers are exposed to high levels of pesticides due to their close proximity. Exposure occurs mainly when preparing and applying pesticides to crops, through spraying equipment, aerosols, soil injections, rope wicks or wipers, tree injections, and spot treatments.[12] Farmers can experience pesticide exposure through direct contact with the pesticides, drift from neighboring farm fields, or contact with pesticide residues in the crop and soil. Dermal (skin) and inhalation routes of entry are the most common ways in which farmers are exposed.[13]

One of the main routes of exposure to pesticide applicators and people living near farms is pesticide drift. Pesticide drift occurs when the applicator is spraying pesticides to the crop and wind carries the spray away. Only approximately 10 percent of the pesticide actually reaches the target crop, leaving 90 percent of it to drift as far as 50 miles from the original site.[14] This produces a major problem for farmers and those living near farms because pesticide drift can reach irrigation water, groundwater, and overexpose homes to the pesticides. In New Hampshire, 39 percent of the population is served by community systems using surface water and 38 percent of the population is served by groundwater alone; thus, pesticide drift poses a significant risk to communities through contaminated drinking water.[15] Ostensibly, pesticide use poses a risk to health issues for the general population and farmers especially, who are working in areas exposed to large amounts of pesticides.

3.1.3 OCCUPATIONAL RISK AND EXPOSURE BASED ON TASKS IN THE FIELD

Farmers and applicators are exposed to pesticides in a variety of ways, and risk differs based on occupational responsibilities. One study measured exposure to organophosphate pesticides based on completed agricultural tasks. This research found that farmworkers who performed fieldwork (i.e., harvesting, pruning, loading, packing, weeding, thinning, irrigating, etc.) had higher amounts of metabolite concentrations of the pesticide in urine samples in comparison to those who mixed, loaded, or applied pesticides.[16] These trends were also reflected in the household of the farmers studied. Children living in the same household as fieldwork farmers also had higher concentrations of metabolite in their urine than children not living with such adult farmworkers.[17] This finding suggests fieldwork farmers carry more pesticides residues into their homes, exposing their families. These results are likely due to laws that require pesticide mixers, loaders, and applicators to wear protective equipment and take more sanitary precautions outside of the workplace. Fieldworkers are not subjected to the same safety training and precautions as pesticide applicators, resulting in high exposure risk in the fields. However, both types of agricultural workers and their families had significant metabolite concentrations in their urine. This study highlights two key findings: farmworkers and their families are at high risk for pesticide exposure regardless of task performed and there is a need for protective equipment to be worn by all farmworkers due to pesticide residues and presence in the fields.

3.1.4 LIMITS OF PROTECTIVE EQUIPMENT

Protective equipment only reduces pesticide exposure—farmers complying with state worker protection standards are still at risk for health issues caused by pesticide exposure. In 1992, the Worker Protection Standard (WPS) became a federally mandated program that aimed to reduce poisonings and injuries among agricultural workers and pesticide handlers. The program requires farmworkers and pesticide handlers to comply with a standard of personal protective equipment and protocols (i.e.., showering immediately after work, washing hands, etc.) that mitigate pesticide exposure. In a study conducted in California, researchers investigated the effectiveness of WPS by monitoring urinary metabolite levels of organophosphorus pesticide exposure in farmworkers. The study found that wearing WPS-recommended clothing and abiding by behavioral precautions such as washing hands with soap were associated with decreases in pesticide metabolite levels, however, farmworkers still had significantly higher levels in comparison to a national reference sample. In addition, the study notes that many farmworkers do not receive WPS-training and other studies suggest low rates of compliance with after-work behaviors recommended for decreasing take-home exposures.

3.1.5 VULNERABLE AGRICULTURAL WORKERS

Vulnerable groups exist in the agricultural sector. Migrant and seasonal farmworkers are at higher risk for health issues caused by pesticide exposure due to their social, economic, and linguistic marginalization that exacerbate occupational hazards, poverty, poor living conditions, and cultural barriers. In the U.S., estimates of the number of migrant and seasonal farmworkers range from 1.4 to 5 million.[18] In New Hampshire, most farmers are self-employed and use unpaid family workers as well as a large number of seasonal and migrant workers.[19] For this reason, it is difficult to understand the complete picture surrounding agricultural employment. However, seasonal and migrant workers are more likely to be paid less and experience occupational injuries and illness; they are also less likely to be covered by health insurance and receive WPS-training.[20] Thus, migrant and seasonal workers constitute a major underserved and vulnerable population that are more susceptible to the dangers of pesticide exposure.

4 OVERVIEW OF NEONICS

Neonicotinoids, or neonics, are a class of insecticides—pesticides that specifically target insects. Neonics were first introduced in the 1980s and have become the most widely used insecticides in the world. This section will examine neonic usage and application methods as well as licensing procedures in the state of New Hampshire. We will also explore potential harms associated with neonic compounds and residue in the environment.

4.1 USAGE

Neonicotinoid literally means "new nicotine-like insecticide." Like nicotine, it affects the central nervous system and acts on nicotinic acetylcholine receptors in the nerve synapse. These neurotoxic insecticides permanently bind to insect nerve cells, which leads to overstimulation and to ultimately kill the insect.

Neonics are applied in over 120 different countries and have 140 different crop uses, including rice, wheat, maize, and cotton. Non-agricultural applications include golf courses, lawns, and gardens. Neonics are particularly effective against sap-feeding insects such as aphids. In New Hampshire, neonics are frequently used in apple orchards.

Since neonics are water-soluble, they dissolve when in contact with water and can be taken up by plant roots. This allows neonics to be applied to the soil, which can reduce the risk of insecticide drift from the intended site of application.[21] Neonics can also be sprayed onto foliage. However, neonics are predominantly used as seed treatments, and all parts of the plant take up the insecticide as the plant grows. The treatment is systemic and appears in vascular tissues of a plant, unlike contact pesticides, which remain on the surface of the treated parts of a plant. Neonics are therefore also present in the pollen and nectar of a plant.

According to a 2015 report from the Center for Food Safety, between 79 and 100 percent of corn seed and 34 to 44 percent of soybean seed is coated with neonics.[22] Treating seeds can protect vulnerable seedlings for up to 10 weeks and also reduces the need for multiple pesticide sprays, which makes coated seeds a widely used option.

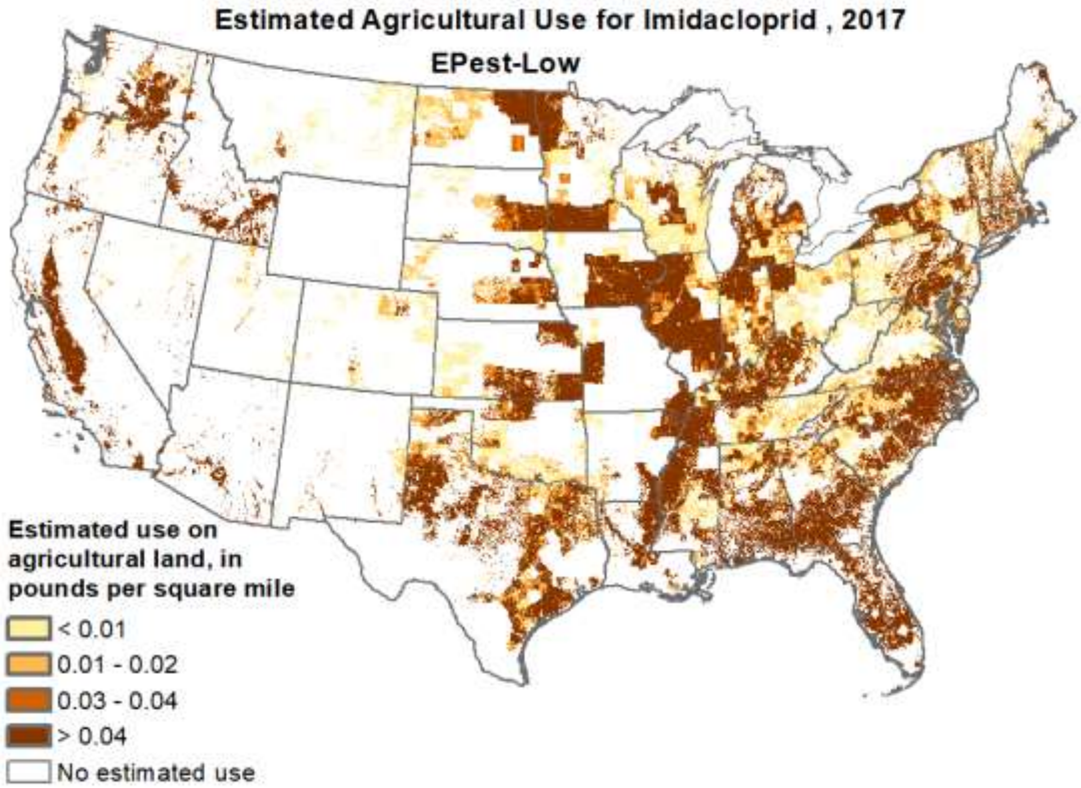

Figure 4.1: Agricultural Usage of Imidacloprid in the United States in 2017

This map, produced by the Pesticide National Synthesis Project of the United States Geological Survey, shows the use of imidacloprid, one type of neonic, in estimated pounds per square mile. In 2017, imidacloprid was used most for orchards and grapes—approximately .06 million pounds—followed by cotton and vegetables and fruits.[23]

4.2 LICENSING PROCEDURES FOR USING NEONICS IN NEW HAMPSHIRE

In New Hampshire, the Division of Pesticide Control within the New Hampshire Department of Agriculture, Markets & Food oversees pesticide licensing and regulation to ensure pesticides are used safely. First established in the 1960s, the Division predates the national Environmental Protection Agency and focuses on human health and protection of the environment in New Hampshire.

To ensure only individuals who have demonstrated competence can apply pesticides, the Division regulates pesticide licensing through exams and applications. The Division issues licenses to both commercial and private applicators as well as pesticide dealers. The core materials of the required exams focus on pesticide safety and environmental concerns, including concepts such as the rate in which pesticides should be applied and how to read pesticide labels. Because core materials focus on the impacts of a broad range of pesticides, these exams do not ask about neonics specifically. Neonics have, however, become a topic covered during recertification education. To be recertified and maintain a pesticide license, every five years an individual must attend educational seminars and obtain 12 credits of classes to stay updated on pesticide knowledge. Recertification and continued education materials help to address recent changes in research about pesticide safety. In addition, in recent years, oral exams required for supervisors of commercial applicators have consistently covered pollinator health and neonicotinoid use.

The Division enforces pesticide regulations and licensing protocols through random field checks, in which inspectors may visit farms and ask questions about products in use. Punishments for violations can range from written reports to fines.

4.3 TYPES OF NEONICS

There are currently seven commercially available neonics: imidacloprid, thiacloprid, clothianidin, thiamethoxam, acetamiprid, nitenpyram, and dinotefuran. Approval of an eighth compound, sulfoxaflor was canceled by the EPA in 2015 due to lack of sufficient data.[24] Imidacloprid, patented by Bayer in 1985, was the first neonic to appear in markets.

TABLE 4.3

Common agricultural manufacturers that include neonic compounds in their products.[25]

Acetamiprid	Imidacloprid	Clothianidin	Dinotefuran	Thiamethoxam
The Scotts Company	ArborSystems Bayer Advanced/BioAdvanced Control Solutions Gro Tec Nufarm Rainbow Treecare Scientific Advancements Voluntary Purchasing Groups	Bayer Advanced/BioAdvanced Valent USA	PBI/Gordon Corporation The Scotts Company Valent USA	Syngenta

4.4 UPTAKE AND RESIDUE

While it is established that neonics are taken up by plants through the roots or leaves and transported to other parts of the plant, the mechanisms behind translocation of pesticides in plants are not well known. The chemical properties of neonics, such as water solubility are highly variable and impact the extent to which these compounds appear throughout the plant.[26]

Residues that appear in products such as fruits or vegetables may pose a risk for human consumption. The concentration of residues depends on plant species and application method, though few studies have examined the specific role of application method. One study in 2004 categorized fruit and vegetable groups and quantified the amount of neonic residue that could be detected. This study found that fruiting vegetables such as tomatoes and cucumbers exhibited the highest proportion of positive samples with 46.7 percent, followed by leafy vegetables and fresh herbs at 10 percent—though information about the application of neonics was not provided.[27]

Even though neonic compounds may appear in any part of the plant, there is still a considerable amount that is not taken up by the target plant. A study from 2003 revealed that only about five percent of the neonic active ingredient is taken up by crop plants, and most of it is distributed throughout the environment.[28] Typical neonic application methods of seed coats and soil drenches lead to soil contamination. The degradation of neonics in soil varies based on factors such as soil type, moisture, and temperature. Calculated half-lives of neonics in soil therefore range significantly—the half-life of imidacloprid can range from 100 to 1,230 days following application. In some conditions, neonics can therefore accumulate in the soil for months or years.

5 RISKS OF NEONIC USE

There are several risks associated with neonic use, including harm to non-target organisms and a variety of impacts on human health.

5.1 HARM TO NON-TARGET ORGANISMS

Within the last decade, new studies have raised concerns that neonics may have a negative impact on non-target organisms — specifically pollinators and surrounding animals. While exposure to neonics does not typically kill bees directly, their navigation and ability to forage for nectar may be impacted due to contaminated nectar and pollen. The chemical structure of neonics seems to play a role in toxicity to bees; nitro-containing neonics (imidacloprid, thiamethoxam, and clothianidin) are generally more toxic than cyano-containing neonics (acetamiprid and thiacloprid).[29]

5.1.1 IMPACT ON POLLINATOR HEALTH

Findings on the impact of neonics on the health of bees are currently conflicting, perhaps because of different methodologies employed by different studies. The majority of laboratory and semi-field studies demonstrate that neonics are associated with increased mortality, altered foraging behavior, impaired feeding and locomotion, damage to learning and memory, and reduced colony growth in bees.[30] One study that has been replicated several times found evidence in a laboratory setting of a connection between low doses of imidacloprid and Colony Collapse Disorder (CCD), a phenomenon in which bees abandon their hives during the winter and die.[31] The breadth of research is centered around the effect of imidacloprid on honey bees, but additional studies have found evidence to suggest low doses of another neonic, clothianidin, is also linked to CCD.[32] However, it should be noted that CCD has been declining since 2008 and can be caused by a number of factors including parasites, pathogens, poor nutrition, pesticide exposure, habitat loss, and lack of genetic diversity.[33] Ostensibly, there are numerous stressors that can lead to CCD and attributing it to neonic exposure alone may not capture the full picture.

That said, a recent report published by Cornell University honeybee researchers demonstrates evident risk of neonic exposure to honeybees. While the aforementioned studies have assessed the hazard risk of neonics on honeybee mortality, reproduction, behavior, and physiology, little is known about the extent of exposure where neonics are used. Using hazard data such as toxicity and exposure data as metrics for risk, a wide-scale meta-analysis revealed that neonicotinoid-treated seeds cause high risk to bees. According to the report, in and near corn and soybean fields receiving neonic seed treatments, 74 percent of exposures are likely to impact honeybee physiology, 58 percent of exposures are likely to impact honeybee behavior, and 37 percent of exposures are likely to impact honeybee reproduction.[34] (See Figure 5.1.1 below for a depiction of this data). Impacted physiology includes effects such as disruption of cellular respiration, impacted honeybee behavior includes interference with worker memory and foraging efficiency, and impacted reproduction includes negative effects on egg laying and survival of new queens. Moreover, high risk of neonicotinoids used on cucurbits (e.g., squash, pumpkin) has been recognized by the EPA and use of imidacloprid, clothianidin, and thiamethoxam on cucurbits between vining and harvest has been prohibited to protect pollinators. Researchers found that these exposures are likely to impact honeybee reproduction in 85 percent of cases and the window of exposure can extend prior to the vining stage because of treatments applied to the soil before or during planting.[35] Furthermore, exposures in ornamental crops (i.e., flowering plants in nurseries) are likely to have an impact on honeybee reproduction in 70 percent of cases, suggesting potential harm by the widespread use of neonics on ornamental plants.[36]

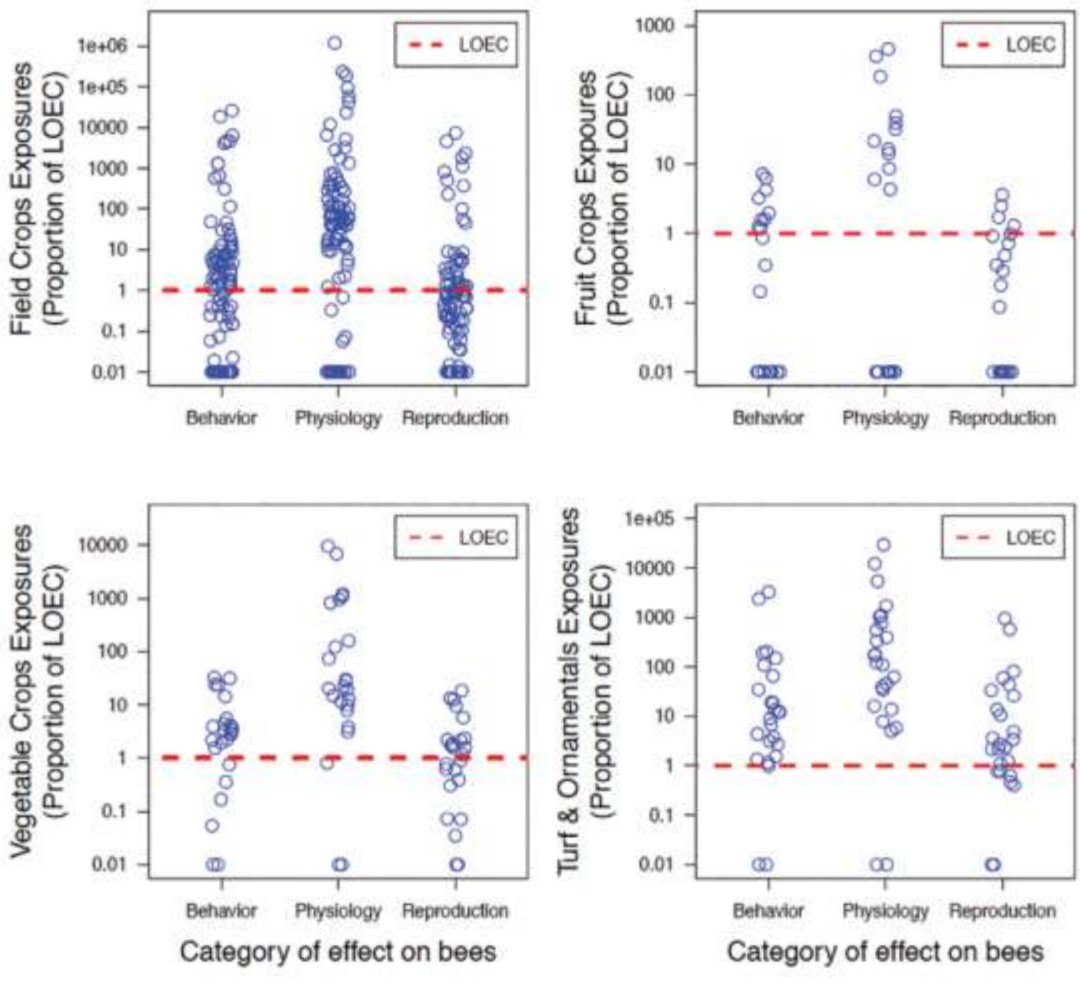

Figure 5.1.1: Quantitative neonicotinoid exposures to bees in field crops, fruit crops, vegetable crops, and turf & ornamentals settings expressed as a proportion of the lowest observed effect concentrations for adverse impacts on honeybee behavior, physiology, and reproduction.[37]

5.1.2 LIMITATIONS OF DATA ON POLLINATOR RISK

These data further elucidate the harmful effects of neonics on pollinator health. Negative impacts on physiology, behavior, and reproduction can be detrimental for the survival of a bee colony. Moreover, while this study expands on the literature concerning exposure risk, there are still few studies that have examined the effects of exposure to neonics across different settings. According to Cornell researchers, risk is a product of exposure and hazard and more research is needed to draw concrete conclusions about risk across various environmental settings. Similarly, many studies only examine the effect of neonics on the honeybee species. Bee size affects susceptibility to toxicity making the median size of the Western honeybee an ideal model to be used by the EPA. However, since exposure is a major contributor to risk, foraging behavior should also be considered for the model pollinator. Western honeybees experience exposure to pesticides at higher rates because of their larger foraging radius. Specifically, they experience exposure to a wide range of pesticides at lower concentrations; whereas bees with smaller radii may experience concentrated levels of exposure to a smaller number of pesticides.[38] Thus, while these studies are useful in understanding the impact of neonics on pollinators, more research should be conducted to be inclusive of various bee species and contexts of exposure.

5.1.3 RISK TO OTHER ORGANISMS

Lastly, while neonics are effective insecticides with generally low toxicity, long-term usage has introduced questions about their environmental impact and other organisms. Neonics are reported to damage genetic information and reduce immune systems of aquatic organisms. Land animals can also be impacted by direct contact or food chain transmission. For example, exposure to neonics has been shown to damage lipids and proteins in earthworms, which may adversely affect soil ecosystems.[39]

5.2 IMPACT ON HUMAN HEALTH

Human exposure to neonics may come through contaminated foods or drinking water. A 2015 study by the United States Geological Survey detected the presence of at least one neonic in over half of the streams tested across 25 states and territories. Agricultural workers face even higher levels of exposure due to occupational uses.[40] A systematic review of available literature on the effects of neonics on human health suggests elevated risk of developmental or neurological damage. Within this review, chronic exposure studies reported adverse health effects such as congenital heart disease and memory loss.[41]

Exposure must be significant for neonics to cause acute toxicological effects.[42] Because neonics have been selected to be specific for nicotinic acetylcholine receptors in insects, they show low affinity for vertebrate nicotinic receptors and are less toxic to vertebrates than older insecticides are.[43] Mammals can also metabolize and eliminate neonics quickly. Neonics additionally do not typically pass the blood-brain barrier, which prevents circulating solutes and potential toxins from crossing into fluid of the central nervous system, where neurons are.[44] This reduces the potential for mammalian toxicity.

6 BENEFITS TO USING NEONICS

It is generally understood that neonics and pesticides provide economic benefits for their users, although the exact scope of those benefits is difficult to ascertain. Anecdotally, it appears that most field crop and fruit and vegetable farmers in New Hampshire use neonics because of their efficacy and relatively low mammalian toxicity. Nevertheless, economic benefits to neonic use vary based on factors including "neonicotinoid type, crop or pest system, application method and timing, and landscape context.[45]"

6.1 MAJOR CROPS IN NEW HAMPSHIRE

In New Hampshire, the industries with the highest market value of the agricultural products sold include greenhouse and nursery products as well as milk and dairy products.[46] For crops, the products with the highest market value are apples, vegetables and sweet corn, as well as maple products.[47] According to the 2017 Census of Agriculture conducted by the United States Department of Agriculture, New Hampshire agriculture consists mainly of hay, corn, and vegetables.[48] The top crops by acreage for New Hampshire are listed below.

Top Crops in Acres [d]

Forage (hay/haylage), all	64,393
Corn for silage or greenchop	11,214
Vegetables harvested, all	3,695
Cultivated Christmas trees	2,892
Apples	1,458

Figure 6.1: Top crops by acreage for New Hampshire in 2017.[49]

6.2 POTENTIAL ECONOMIC BENEFITS OF NEONIC USE

The aforementioned report published by Cornell University's honeybee researchers examined the value of neonics in New York in addition to examining risk to pollinator health. They interpreted data from more than 5,000 paired neonic and control field trials that assessed impact of neonic use or nonuse on pest populations, crop damage, or yield, of which crop yield is most closely connected to income.[50] The researchers found that majority of the trials conducted on fruits and vegetables showed that neonic use "reduces pest populations, limits crop damages, or improves yield compared to untreated control plots," which usually results in direct economic benefits to the farmers.[51]

Although the study found that neonics were economically beneficial for most crops, in 83 to 97 percent of field trials examined, there was no significant increase or decrease in corn yield when neonicotinoid-treated seeds are used compared to pyrethroid chemical alternatives or untreated control seeds (see Figure 6.2 below).[52] This translates to infrequent economic benefits for corn farmers who use neonics, yet nearly all conventional field corn farmers use neonicotinoid-treated seeds.[53] The study also found similar results for soybean crops: "82-89% of field trials [found] no increase (or a decrease) in soybean yield compared to chemical alternatives or untreated controls.[54]" The EPA also released a study in 2014 that revealed that seed treatments provide negligible overall benefits to soybean production, as there is often no difference in soybean yield.[55]

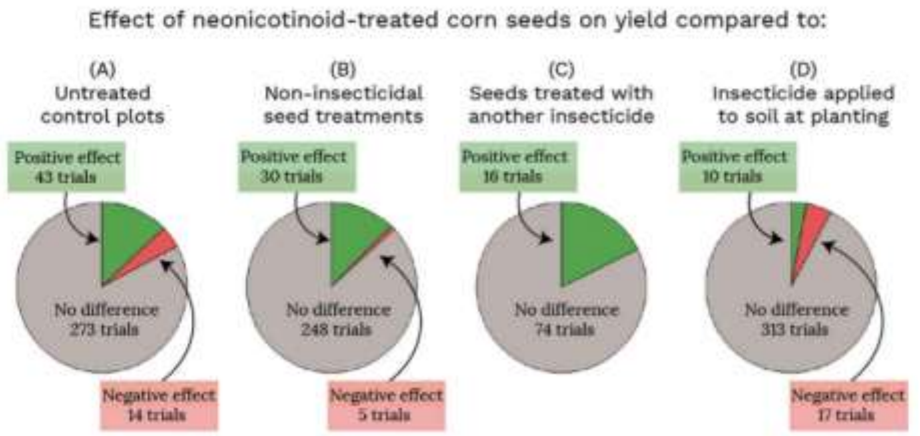

Figure 6.2: Effect of neonicotinoid-treated corn seeds on yield compared to insecticide alternative and control plots.[56]

6.3 LIMITATIONS OF DATA ON ECONOMIC BENEFITS

The data collected by the group of researchers from Cornell did acknowledge a number of limitations in their economic meta-analysis. The analysis could not account for differences between pest pressure and yield response associated with different crops, which did vary between farms in the surveys they examined. The data also did not account for the "insurance value" of using neonics in a preventative manner. This is of importance in considering the relatively low increase in crop yield and expected net income for corn products. While that finding implies low economic benefit associated with neonic use, it does not factor in motivation for farmers to use the insecticides to prevent unpredictable but potentially severe damage from early-season pests.[57]

More data-based research is needed to assess potential economic benefits to farmers, specifically for those crops that comprise the agricultural sector of New Hampshire listed in Section 6.1. An analysis similar to the one conducted by the Cornell University researchers about New York neonic risks and benefits might be beneficial for New Hampshire.

7 PERSPECTIVES ON HB 646

Policy surrounding regulation of neonic use affects a number of groups in New Hampshire, as evidenced by the debate surrounding HB 646 in 2019. This section features information and perspectives from interviews with community stakeholders and experts who spoke about HB 646 and its effects on industry and pollinator health.

7.1 FARM BUREAU STAKEHOLDER PERSPECTIVES

The New Hampshire Farm Bureau Federation is a trade association with over 3,000 members representing each of the county farm bureaus across the state. The organization is dedicated to educating the public about agriculture in addition to advocating for Farm Bureau policies as legislative actions. Members can serve on boards and committees to work on legislation, regulations, and issues regarding agriculture in New Hampshire and are supported by professional staff from the Farm Bureau. The Farm Bureau also provides its members with benefits including insurance programs and networks that facilitate discounts on products and services such as farm equipment and vehicles. In our interview with representatives from the federation, we spoke with Farm Bureau President Denis Ward, Policy Director Robert Johnson, and representatives from the fruit and vegetable grower community and beekeepers from New Hampshire counties.

In regard to pesticide and neonic regulation, the Farm Bureau takes the position that the New Hampshire Division of Pesticide Control should be the chief regulating authority. The Farm Bureau advocates for science-based decision-making that they contend would be best facilitated by and most appropriate for New Hampshire's farmers in the hands of the Division of Pesticide Control. New Hampshire was one of the first states to institute a Division Pesticide Control and the Farm Bureau believes the Control Board is best suited, due to their use and promotion of scientific literature and professional working relationship with farmers, to make decisions regarding pesticide and neonic regulation.

Representatives from the Farm Bureau make the call for increased funding for agricultural research.[58] Currently, 25 percent of the licensing revenue from the Division of Pesticide Control is used to support Integrated Pest Management (IPM) grant funds. The Integrated Pest Management program was created in 1998 to "bring out the broadest possible application of the principles of integrated pest management to agriculture, horticulture, arboriculture, landscape, building maintenance, and any other areas in which economic poisons are employed."[59] Any individual, group, or organization may apply for grant funding; grant requests are evaluated based on the proposed objects and whether the work plan is appropriate and consistent with IPM techniques and ideas. However, representatives from the Farm Bureau would like to see increased support and funding for agricultural research regarding IPM (as well as other agricultural fields of research) to assure accurate long-term scientific and economic risk benefit analyses.[60] The representatives believe that this peer-reviewed science and increased funding would best predicate any regulatory action and reduce any harm to the farmer community caused by blanket prohibitions.

Agricultural workers and farmers are under immense pressure to produce safe, clean, and aesthetically appealing products in sufficient supply while minimizing any damage to people, animals, and the environment. In order to keep up with consumer demands and produce products that are economically viable and safe for humans, the grower community relies on the use of chemicals such as neonics. Representatives from the community are trained and comply with any educational programs mandated by federal and state laws. They contend they stay up to date with the rules and regulations. Members of the Farm Bureau have voiced concern about the potential impact of blanket prohibitions, such as the one HB 646 proposes, on the farmer and agricultural community.

Representatives from the Farm Bureau assert that current regulation and training is sufficient to minimize risk to bees, and they feel a blanket regulation on a whole class of insecticides (neonics) would do more harm than good. These representatives have also argued that they are aware of bee populations in their farms and support pollinator health in any capacity they can. Some farmers from the Farm Bureau have even complied with pollinator health research conducted by the Xerces Society; the research found a high diversity of bee species and successful bee population growth on the farm despite the use of neonics. One farmer has made the case that healthy bee populations around his farm can be attributed to the proper use of insecticides and extra care given for pollinator health. While this is just one case that arose during the interview, it seems to be a consensus from the grower community that they believe they are making the best use of the chemical and giving extra care to bee health.

7.2 POLLINATOR HEALTH EXPERT PERSPECTIVES

An expert in pollinator health explained elements of HB 646 that might have caused confusion among crop protection experts. The language of the bill was not consistent with crop protection definitions of "bee toxic pesticides," namely in the understanding of systemic pesticides. In the bill, bee-toxic insecticides were defined as "systemic" insecticides. In the fields of conservation ecology and environmental protection, "systemic" means long-lasting in the environment. However, those working in crop protection refer to "systemic" insecticides products that enter the crop tissue, such as neonics, which are water soluble. Some materials are systemic but not toxic to bees, and others are non-systemic but highly toxic to bees, and clarification of such language in neonic regulation might prove more effective.

To standardize the definition of "bee-toxic pesticides," the expert suggested a reliance on EPA definitions of bee toxicity. The EPA has a proposed risk assessment in evaluating potential harm to honeybees, which takes a three-phase, tiered approach (problem formulation, analysis, and risk characterization).[61] There is a screening-level risk assessment intended to be sufficiently restrictive that chemicals that pass the screen are considered to represent a relatively low risk of adverse effects to bees. For those chemicals which do not pass the initial screen, "refinements in exposure estimates and/or mitigation measures may sufficiently reduce risk quotients below levels of concern such that further refinements are not needed.[62]" The pollinator health specialist affirmed that EPA standard has a sufficient body of research to back up its standards, and that further legislation aimed at bee toxic pesticides might be well-served to incorporate federal standards.

The pollinator health specialist also elaborated on the issue of residential use of neonics, whereby unlicensed citizens and backyard growers obtain products that contain imidacloprid and use them for non-commercial purposes. There are minimal restrictions on whether unlicensed citizens may obtain such products and use them without knowing they are using neonics, which could be resolved by making neonics a restricted class of insecticides, whereby the only people allowed to use neonics would be licensed to do so. Since mammalian toxicity is relatively low with neonics, this class of pesticides has not been placed in the restricted class. However, doing so would aid this issue of the use of neonics by unlicensed citizens.

8 POLICIES AND GUIDELINES

In light of studies suggesting that bees may be harmed by neonics, environmental groups have called for additional reviews of these insecticides by the EPA. The EPA has scheduled reviews of five types of neonics — imidacloprid, clothianidin, thiamethoxam, dinotefuran, and acetamiprid — with hopes of completion by 2021. The EPA will be conducting reviews of these neonics under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), which was amended by the Food Quality Protection Act of 1996. Under FIFRA, all pesticides distributed or sold in the US must be registered by EPA, and the pesticide must demonstrate that it "will not generally cause unreasonable adverse effects on the environment."[63] FIFRA defines this to mean "any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide" or "a human dietary risk from residues that result from a use of a pesticide in or on any food inconsistent with the standard under section 408 of the Federal Food, Drug, and Cosmetic Act."

In January 2020, the EPA announced a proposed interim decision of allowing neonics to remain in the marketplace but implementing new protective measures for humans and bees. This included the use of personal protective equipment for farmworkers and restrictions on applying neonics to blooming crops.[64]

Certain states and regions have already acted to restrict neonics. In 2016, Connecticut was the first state to curb neonic usage by placing restrictions on who may use neonics and on which types of plants they may be applied. Maryland followed shortly thereafter with new regulations for where neonics can be sold.[65] Also since 2016, Minnesota has required verification of anyone who wants to use neonics; the Minnesota Department of Agriculture requires approval from the state legislature to set up seed treatment programs. Similarly in Canada, the province of Ontario introduced a requirement in 2015 to demonstrate crop damage to get access to neonic-coated seeds.[66] In addition, Vermont restricted neonic use to certified applicators in 2018.

The European Union introduced a landmark ban in 2018 on all outdoor uses of clothianidin, imidacloprid, and thiamethoxam to protect bees. However, countries have issued at least 67 different "emergency authorizations" for the outdoor use of these neonics, lessening the impact of this agreement.[67]

8.1 VERMONT STATE NEONIC REGULATIONS

The Vermont state legislature passed HB 205 restricting neonicotinoid use in the state in May of 2018.[68] The bill classifies neonics as restricted-use pesticides, meaning only state-certified applicators are able to purchase and apply neonics. Consumer use of neonics is therefore banned under the bill, and restricted-use pesticides can only be sold by licensed dealers. [69]

In addition, the act increases the annual registration fee for pesticides by $25 to $200, which will be used to offset inspection costs of pesticides and develop educational services. The increase in fees also helped to establish two new positions at the Agency of Agriculture, Food and Markets who will work in pesticide enforcement and pollinator protection.[70] Other initiatives to support pollinator health in this bill include a requirement for all owners of bees, apiaries, and colonies to register with the Agency. Beekeepers will also be required to submit a pest mitigation plan as part of an annual report.

The debate over the bill was influenced by data from the Bee Informed Partnership that revealed that Vermont beekeepers lost an average of 52 percent of hives from 2017-2018, compared to a national average loss of 30.7 percent. Vermont saw an average of 32.5 percent and 38.2 percent of hives lost in the winters following the neonic restriction bill, with respective national averages of 37.7 percent and 22.2 percent, though there are a variety factors that impact hives lost.[71]

8.2 MINNESOTA STATE NEONIC REGULATIONS

In 2014, Minnesota passed HF 2798, a labeling law aimed at informing consumers which plants have been treated with neonics and which have not. The legislation holds that: "A person may not label or advertise an annual plant, bedding plant, or other plant, plant material, or nursery stock as beneficial to pollinators if the annual plant, bedding plant, plant material, or nursery stock has been treated with and has a detectable level of systemic insecticide that: (1) has a pollinator protection box on the label; or (2) has a pollinator, bee, or honey bee precautionary statement in the environmental hazards section of the insecticide product label." These systemic insecticides include neonics.

This legislation did not address agricultural neonic use, which in Minnesota occurs mostly with field crops such as soybean and corn. New Hampshire's agricultural neonic use is mostly concentrated in field crops and produce, although the recent legislation was motivated by overuse of neonics in landscaping.

In Minnesota, there are over 500 registered neonic products to control pests, and total sale of these products from 2010 to 2013 was 381,300 pounds. Over 99 percent of neonic products sold from 2010 to 2013 in Minnesota were made up of clothianidin, thiamethoxam, and imidacloprid. In comparison to all chemicals, neonicotinoids accounted for 0.05, 0.12, 0.06, and 0.09 percent of all chemical products sold in Minnesota in 2010, 2011, 2012, and 2013, respectively. This data does not include treated seeds, which is a major class of neonic use that evades federal regulation under the FIFRA — meaning a large portion of neonic use goes unregulated.

8.3 MARYLAND STATE NEONIC REGULATIONS

Maryland passed a law in 2018 prohibiting a person from "selling a neonicotinoid pesticide unless the person also sells a restricted use pesticide; prohibiting a person from using a neonicotinoid pesticide unless the person is a certified applicator or a person working under specified circumstances; [and] requiring the Department of Agriculture to incorporate pollinator habitat expansion and enhancement practices into the State's Managed Pollinator Protection Plan." The Act does allow certified applicators, farmers, and veterinarians to use neonics, but language in the bill refers to a six-month neonic study being conducted by the EPA, instructing the Maryland Department of Agriculture to revisit its rules of allowable use of neonicotinoids once that study has been released. However, this study did not yield significant, conclusive results and thus did not impact future legislation from Maryland. This law came into effect at the beginning of 2018 but the impact on state agricultural use of neonics has not been measured to shift agricultural output significantly.

8.4 CONNECTICUT STATE NEONIC REGULATIONS

On March 6, 2016, the Connecticut state legislature passed SB 231, becoming the first state in the United States to restrict the use of neonics. SB 231 or "An Act Concerning Pollinator Health," classifies all neonics under restricted use and bans use by consumers. Under this legislation, neonics are not allowed to be applied to plants that have bloomed unless the plant is in a greenhouse inaccessible to pollinators. Aside from restrictions on the use of neonics, the bill also set up infrastructure supporting education on neonic and pollinator health.

SB 231 established Pollinator Advisory Committee to inform the General Assembly on matters regarding pollinator health and called for a report from the Commissioners of Energy and Environmental Protection and Agriculture analyzing the effects of neonic restrictions on pollinator health, changes in agriculture, and the presence of varroa mites that affect pollinator populations.[72] Also, the bill also called upon the Office of Policy and Management to give priority to development that includes model pollinator habitat and state funds that further conservation efforts in protecting pollinator habitats.[73] According to the bill, a model pollinator habitat must be compiled by the Connecticut Agricultural Experiment Station and be made accessible to the public on the internet. Connecticut's model pollinator habitat is aimed at directing further pollinator restoration efforts and educating the public on how to best protect pollinator health.

This neonic restricting legislation also made efforts to create habitat interventions aimed at improving pollinator health. SB 231 called upon the Department of Transportation to find ways to replace turf grasses installed along state highways to include model pollinator habitats.[74] In addition, the bill gave the Connecticut Siting Council power to make restoration and revegetation orders (inclusive of model pollinator habitats) where there has been significant vegetation loss due to clearing activities. The bill similarly requires the Commissioner of Transportation to plant vegetation that includes pollinator habitats in areas that have been deforested along the state highway.[75] Lastly, SB 231 gives the State Entomologist the means to examine apiaries, enforce quarantine on diseased plants, appoint inspectors, and regulate the transportation of bee colonies and packaging.

8.4.1 CONNECTICUT HONEYBEE DATA

As the first state to enact legislation regarding neonic restrictions, Connecticut serves as a significant case study to examine the inadvertent effects of neonic legislation. This analysis could serve as a potential model for determining whether New Hampshire legislators should enact legislation regarding neonic restrictions. In 2016, Connecticut enacted neonic legislation and restrictions were effective from the passage of SB 231. Pollinator health and bee colony loss measured before and after the passage of this legislation may serve as potential markers for pertinent effects of the restrictions.

National surveys are conducted by a 501(c)(3) nonprofit supported by the United States Department of Agriculture and National Institute of Food and Agriculture called Bee Informed Partnership to collect data on bee colony loss annually. The organization is a national collaboration of research labs and universities in agricultural science to monitor and understand honeybee declines in the U.S. Although the surveys only represent about 10 percent of all U.S. colonies, these surveys function as representation of bee colony loss trends across the nation. While these data represent trends and not causal relationships, it is important to examine any correlations between neonic restrictions and bee colony loss or growth to support future research.

According to the National Loss and Management Survey, conducted by the Bee Informed Partnership, Connecticut lost 44.32 percent of its hives in the 2015-2016 year.[76] In the following growth year, Connecticut lost 61.97 percent of its colonies and the increase in losses continued in 2017-2018.[77] However, the trend significantly decreased in 2018-2019 in which 39.99 percent of colonies were lost.[78] These trends are significant as it appears an increase in colony loss occurred after the enacting of legislation. However, these trends could be a result of other causes such as climate change, disease, predators, and weather. Likewise, it is possible that there was a delay in observing the changes of restricting neonics likely due to time constraints on enforcement and the other infrastructural developments enacted by SB 231.

For further examination, it might be fruitful to analyze the percent loss of colonies based on colony health stressors. The National Agricultural Statistics Service, Agricultural Statistics Board, and the United States Department of Agriculture collect data annually on the number of colonies, maximum, lost, percent lost, added, renovated, and colonies lost with Colony Collapse Disorder Symptoms. While there may be some limitations in methodologies employed by the NASS in measuring exact causes of colony loss as well limited state data available, these data may serve as important contexts for understanding changes in colony loss patterns in Connecticut. As shown in Table 8.4.1 below, the largest stressor causing colony loss in Connecticut from 2015 to 2019 appear to be varroa mites. Pesticides, on the other hand, caused 3.4 percent of colony loss in the 2015-2016 year and experienced a dip in 2017-2018 to 1.9 percent.[79, 80] However, in 2018-2019, pesticide-related losses increased.[81]

Given the passage of legislation restricting neonic usage in 2016, one may expect that the trends in 2018-2019 would show additional decrease in pesticide-related losses. This mismatch raises questions about the effects of neonic restrictions on colony losses and elucidates the need for controlled experiments to be conducted in this field. Although these data do not present a clear causal characterization of the impacts of neonics to assist policymakers in New Hampshire, they do underscore that the effects of neonic restrictions may be more multifaceted and complex than a simple and clear causal relationship. All states would thus benefit from the employment of controlled experiments isolating whether neonic restrictions truly make a difference in protecting bee colonies.

TABLE 8.4.1

Average Percent of Honeybee Colonies Lost to Stressors in Connecticut by Quarter [82]

Year	Varroa mites	Other pests	Diseases	Pesticides	Other	Unknown
2015	15.6%	1.2%	0.7%	0.9%	8.3%	1.3%
2016	13.8%	2.4%	0.5%	0.4%	5.7%	1.7%
2017	30.5%	1.5%	0%	0.3%	5.7%	2%
2018	12.8%	1.3%	0.7%	1%	3.8%	1.9%

8.5 NEW YORK STATE NEONIC REGULATIONS

In March of 2021, the New York Senate introduced the Birds and Bees Protection Act, which aims to eliminate use of neonicotinoids where risk to pollinators or the broader environment outweighed economic or other benefits.[83] The new language reflected the findings from the study by Cornell University, referenced in this report. The language proposes banning neonic-treated seeds for corn, soybean, and wheat crops, banning neonic used for ornamental and turf purposes, but allowing other uses such as to control hemlock woolly adelgid, which are significant foundation species in New York. The bill appears to follow the science-based findings of the Cornell report and potentially target the riskiest uses of neonicotinoids in the state.

9 CONCLUSION

This policy report is aimed at expanding the understanding of pesticide and neonicotinoid effects on human health, critical pollinator species, and the broader environment. The purpose of this research is to present the most recent and applicable data surrounding the issue. There are numerous critical stakeholders who are impacted by regulation or non-regulation of pesticides, and the New Hampshire legislature is poised to enact policy in service of these stakeholders. This report has elucidated the complexity of neonic usage and effects across various settings. There is a need for nuanced legislation that addresses the needs and perspectives of the stakeholders involved while making changes propelled by science-based evidence. In this report, we have outlined the potential harmful effects of neonic use on pollinators, humans, and the environment. We have also shown how neonics can be beneficial agriculturally and economically in certain contexts, though recent studies have found that some of these benefits are negligible for crops such as corn and soybeans. Lastly, we have conducted an analysis of states that have existing legislation on neonics to highlight potential implications of neonic legislation in New Hampshire.

10 REFERENCES

---

[1] An Act Relative to the Labeling Signage, And Restrictions On the Sales and Use of Bee-Toxic Pesticides, 646-FN, New Hampshire House of Representatives, 2019 (2019). http://gencourt.state.nh.us/bill_status/billText.aspx?id=711&txtFormat=html

[2] "New Standards to Curb the Global Spread of Plant Pests and Diseases." Food and Agriculture Organization of the United Nations, April 3, 2019. http://www.fao.org/news/story/en/item/1187738/icode/.

[3] Landrigan, Kevin. "Bee Saviors Stung by Criticism Over Proposed Pesticide Ban." UnionLeader.com, October 8, 2019. https://www.unionleader.com/news/environment/bee-saviors-stung-by-criticism-over-proposed-pesticide-ban/article_019c817a-b950-5a46-8715-4f1ea2f1edf0.html.

[4] What Is a Pesticide?" EPA. Environmental Protection Agency, April 2, 2018. https://www.epa.gov/minimum-risk-pesticides/what-pesticide.

[5] Ibid.

[6] Ibid.

[7] "Human Health Issues Related to Pesticides." EPA. Environmental Protection Agency, March 7, 2017. https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/human-health-issues-related-pesticides.

[8] "Pesticides & Human Health." Californians for Pesticide Reform. Accessed November 3, 2020. https://www.pesticidereform.org/pesticides-human-health/.

[9] Ibid.

[10] Owens, Kagan, Jay Feldman, and John Kepner. "Wide Range of Diseases Linked to Pesticides ." Pesticides and You 30, no. 2 (August 18, 2010): 13–21. https://www.beyondpesticides.org/assets/media/documents/health/pid-database.pdf.

[11] "Do Pesticides Cause Lymphoma? ." Lymphoma Foundation of America, 2001. Lymphoma Foundation of America. https://www.lymphomahelp.org/documents/pesticides.pdf.

[12] Popenoe, Juanita. "Pesticide Application Methods." Citrus Industry . CEU Central , November 1, 2018. https://crec.ifas.ufl.edu/media/crecifasufledu/extension/extension-publications/2018/2018_november_pesticide.pdf.

[13] Damalas, Christos, and Spyridon Koutroubas. "Farmers' Exposure to Pesticides: Toxicity Types and Ways of Prevention." Toxics 4, no. 1 (2016): 1. https://doi.org/10.3390/toxics4010001.

[14] Moses, Marion. "Pesticide-Related Health Problems and Farmworkers." AAOHN Journal 37, no. 3 (1989): 115–30. https://doi.org/10.1177/216507998903700304.

[15] Fortier, Timothy W. "New Hampshire's Water Assets Under Pressure: Public Drinking Water Systems." New Hampshire Municipal Association. Accessed November 3, 2020. https://www.nhmunicipal.org/town-city-article/new-hampshire%E2%80%99s-water-assets-under-pressure-public-drinking-water-systems.

[16] Coronado, Gloria D, Beti Thompson, Larki Strong, William C Griffith, and Ilda Islas. "Agricultural Task and Exposure to Organophosphate Pesticides among Farmworkers." Environmental Health Perspectives 112, no. 2 (2004): 142–47. https://doi.org/10.1289/ehp.6412.

[17] Ibid.

[18] Nielson, Annette. Rep. Agricultural Trends in New Hampshire. Concord, NH: Economic and Labor Market Information Bureau of New Hampshire Employment Security, 2003.

[19] Ibid.

[20] Hansen, Eric, and Martin Donohoe. "Health Issues of Migrant and Seasonal Farmworkers." Journal of Health Care for the Poor and Underserved 14, no. 2 (2003): 153–64. https://doi.org/10.1353/hpu.2010.0790.

[21] Ensley, Steve. "Neonicotinoids." In *Veterinary Toxicology (Third Edition)*, edited by Ramesh Gupta, 521-524. Academic Press, 2018.

[22] "Hidden Costs of Toxic Seed Coatings." Center for Food Safety, June 2015, https://www.centerforfoodsafety.org/files/neonic-factsheet_75083.pdf

[23] "2017 Pesticide Use Maps ." n.d. Accessed March 26, 2021. https://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=2017&map=IMIDACLOPRID&hilo=L&disp=Imidacloprid.

[24] "What is a neonicotinoid?" Texas A&M AgriLife Extension, December 29, 2015. https://citybugs.tamu.edu/factsheets/ipm/what-is-a-neonicotinoid/.

[25] "Neonicotinoids." Pollinator Network @ Cornell, Cornell College of Agricultural and Life Sciences, Accessed November 2, 2020. https://pollinator.cals.cornell.edu/threats-wild-and-managed-bees/pesticides/neonicotinoids/

[26] "Help the Honey Bees." Center for Food Safety, April 2003. https://www.beyondpesticides.org/assets/media/documents/pollinators/documents/pesticide_list_final.pdf
[27] Bonmatin, J.-M., C. Giorio, V. Girolami, D. Goulson, D. P. Kreutzweiser, C. Krupke, M. Liess, et al. "Environmental Fate and Exposure; Neonicotinoids and Fipronil." *Environmental Science and Pollution Research* 22, no. 1 (2014): 35–67. https://doi.org/10.1007/s11356-014-3332-7.
[28] Bonmatin et al. "Environmental Fate and Exposure; Neonicotinoids and Fipronil."

[29] Cresswell, J. E. (2010). A meta-analysis of experiments testing the effects of a neonicotinoid insecticide (imidacloprid) on honey bees. *Ecotoxicology (London)*, *20*(1), 149–157. https://doi.org/10.1007/s10646-010-0566-0
[30] Lu, C., Warchol, K. M., & Callahan, R. A. (n.d.-b). *Sub-lethal exposure to neonicotinoids impaired honey bees winterization before proceeding to colony collapse disorder*. 6.
[31] Woodcock, B. A., Isaac, N. J. B., Bullock, J. M., Roy, D. B., Garthwaite, D. G., Crowe, A., & Pywell, R. F. (2016). Impacts of neonicotinoid use on long-term population changes in wild bees in England. *Nature Communications*, *7*(1), 12459. https://doi.org/10.1038/ncomms12459
[32] Ibid.
[33] vanEngelsdorp, Dennis, Jay D. Evans, Claude Saegerman, Chris Mullin, Eric Haubruge, Bach Kim Nguyen, Maryann Frazier, et al. "Colony Collapse Disorder: A Descriptive Study." Edited by Justin Brown. *PLoS ONE* 4, no. 8 (August 3, 2009): e6481. https://doi.org/10.1371/journal.pone.0006481.
[34] McArt, Scott H., Travis A. Grout, Phoebe A. Koenig, and Julie K. Kapuvari. Rep. Neonicotinoid Insecticides in New York State: Economic Benefits and Risk to Pollinators. University of Cornell, June 23, 2020. https://pollinator.cals.cornell.edu/pollinator-research-cornell/neonicotinoid-report/.
[35] Ibid.
[36]McArt, Scott H., Travis A. Grout, Phoebe A. Koenig, and Julie K. Kapuvari. Rep. Neonicotinoid Insecticides in New York State: Economic Benefits and Risk to Pollinators. University of Cornell, June 23, 2020. https://pollinator.cals.cornell.edu/pollinator-research-cornell/neonicotinoid-report/.
[37] Scott McArt, Travis Grout, Phoebe Koenig, Julie Kapuvari, *Quantitative neonicotinoid exposures to bees in field crops, fruit crops, vegetable crops, and turf & ornamentals settings expressed as a proportion of the lowest observed effect concentrations (LOECs) for adverse impacts on honeybee behavior, physiology, and reproduction* (University of Cornell, 2020), 223, fig. 6.7.
[38] McArt, Scott H., Travis A. Grout, Phoebe A. Koenig, and Julie K. Kapuvari. Rep. Neonicotinoid Insecticides in New York State: Economic Benefits and Risk to Pollinators. University of Cornell, June 23, 2020. https://pollinator.cals.cornell.edu/pollinator-research-cornell/neonicotinoid-report/.
[39] Pisa, L. W., V. Amaral-Rogers, L. P. Belzunces, J. M. Bonmatin, C. A. Downs, D. Goulson, D. P. Kreutzweiser, et al. 2015. "Effects of Neonicotinoids and Fipronil on Non-Target Invertebrates." *Environmental Science and Pollution Research International* 22: 68–102. https://doi.org/10.1007/s11356-014-3471-x.
[40] Hladik, Michelle L., and Dana W. Kolpin. "First National-Scale Reconnaissance of Neonicotinoid Insecticides in Streams across the USA." *Environmental Chemistry* 13, no. 1 (2015): 12. https://doi.org/10.1071/EN15061.
[41] Cimino, Andria M., Abee L. Boyles, Kristina A. Thayer, and Melissa J. Perry. "Effects of Neonicotinoid Pesticide Exposure on Human Health: A Systematic Review." *Environmental Health Perspectives* 125, no. 2 (2017): 155–62. https://doi.org/10.1289/EHP515.
[42] McArt, Scott H., Travis A. Grout, Phoebe A. Koenig, and Julie K. Kapuvari. Rep. *Neonicotinoid Insecticides in New York State: Economic Benefits and Risk to Pollinators*. University of Cornell, June 23, 2020. https://pollinator.cals.cornell.edu/pollinator-research-cornell/neonicotinoid-report/.
[43] Seifert, Josef. "Neonicotinoids." In *Encyclopedia of Toxicology (Third Edition)*, edited by Philip Wexler, 477-481. Elsevier, 2014.
[44]Ensley, Steve. "Neonicotinoids." In *Veterinary Toxicology (Third Edition)*, edited by Ramesh Gupta, 521-524. Academic Press, 2018.
[45] McArt, Scott H., Travis A. Grout, Phoebe A. Koenig, and Julie K. Kapuvari. Rep. Neonicotinoid Insecticides in New York State: Economic Benefits and Risk to Pollinators. University of Cornell, June 23, 2020. https://pollinator.cals.cornell.edu/pollinator-research-cornell/neonicotinoid-report/.
[46] "New Hampshire Department of Agriculture, Markets & Food," NASDA, accessed March 27, 2021, https://www.nasda.org/organizations/new-hampshire-department-of-agriculture-markets-food.
[47] Ibid.
[48] USDA - National Agricultural Statistics Service, "2017 Census of Agriculture - New Hampshire State Profile," accessed March 27, 2021, https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/New_Hampshire/index.php.
[49] Ibid.

[50] McArt, Scott H., Travis A. Grout, Phoebe A. Koenig, and Julie K. Kapuvari. Rep. Neonicotinoid Insecticides in New York State: Economic Benefits and Risk to Pollinators. University of Cornell, June 23, 2020. https://pollinator.cals.cornell.edu/pollinator-research-cornell/neonicotinoid-report/.
[51] Ibid.
[52] Ibid.
[53] Ibid.
[54] Ibid.
[55] Myers, Clayton, Elizabeth Hill. "Benefits of Neonicotinoid Seed Treatments to Soybean Production." United States Environmental Protection Agency, October 15, 2014 https://www.epa.gov/sites/production/files/2014-10/documents/benefits_of_neonicotinoid_seed_treatments_to_soybean_production_2.pdf
[56] Ibid.
[57] Ibid.
[58] "2020 Policy Document." New Hampshire Farm Bureau Federation, August 28, 2020. https://www.nhfarmbureau.org/policydocuments/.
[59] "TITLE XLAGRICULTURE, HORTICULTURE AND ANIMAL HUSBANDRY." TITLE XL AGRICULTURE, HORTICULTURE AND ANIMAL HUSBANDRY. The General Court of New Hampshire, 1998. http://www.gencourt.state.nh.us/rsa/html/XL/430/430-50.htm.
[60] "2020 Policy Document." New Hampshire Farm Bureau Federation, August 28, 2020. https://www.nhfarmbureau.org/policydocuments/.
[61] Office of Pesticide Programs, "Guidance for Assessing Pesticide Risk to Bees" (United States Environmental Protection Agency, June 19, 2014).
[62] Ibid.
[63] "Summary of the Federal Insecticide, Fungicide, and Rodenticide Act." Overviews and Factsheets. US EPA. February 22, 2013. https://www.epa.gov/laws-regulations/summary-federal-insecticide-fungicide-and-rodenticide-act.
[64] "Proposed Interim Registration Review Decision for Neonicotinoids." Overviews and Factsheets. US EPA. January 30, 2020. https://www.epa.gov/pollinator-protection/proposed-interim-registration-review-decision-neonicotinoids.
[65] Lemelin, Annie. "Beelieve It! Maryland and Connecticut Pass Landmark Legislation To Protect Pollinators," Conservation Law Foundation, June 24, 2016. https://www.clf.org/blog/beelieve-maryland-connecticut-pass-landmark-legislation-protect-pollinators/.
[66] Ibid.
[67] Dowler, Crispin and Joe Sandler Clarke. "Loophole Keeps Bee-Killing Pesticides in Widespread Use, Two Years after EU Ban," Unearthed, July 8, 2020. https://unearthed.greenpeace.org/2020/07/08/bees-neonicotinoids-bayer-syngenta-eu-ban-loophole/.
[68] "Bill Status H.205 (Act 35)." n.d. Accessed March 26, 2021. https://legislature.vermont.gov/bill/status/2020/H.205.
[69] Ibid.
[70] Ibid.
[71] "Bee Informed Partnership - National Management Survey Map." n.d. Accessed March 26, 2021. https://bip2.beeinformed.org/loss-map/.
[72] Bill, An Act Concerning Pollinator Health § (2016). https://www.cga.ct.gov/2016/ACT/pa/2016PA-00017-R00SB-00231-PA.htm.
[73] Ibid.
[74] Ibid.
[75] Ibid.
[76] "Bee Informed Partnership - National Management Survey Map." https://bip2.beeinformed.org/loss-map/.
[77] Ibid.
[78] Ibid.
[79] National Agricultural Statistics Service, Honey Bee Colonies § (2016). https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Bee_and_Honey/
[80] National Agricultural Statistics Service, Honey Bee Colonies § (2017). https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Bee_and_Honey/
[81] National Agricultural Statistics Service, Honey Bee Colonies § (2018). https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Bee_and_Honey/
[82] National Agricultural Statistics Service, Honey Bee Colonies. https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Bee_and_Honey/
[83] Daniel Raichel, "Science, Polling Support Renewed NY Bill to Save Bees," NRDC, accessed March 27, 2021, https://www.nrdc.org/experts/daniel-raichel/science-polling-support-renewed-ny-bill-save-bees.