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Bee Health: The Role of Pesticides

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Summary

Over the past few decades there has been heightened concern about the plight of honey bees as well as other bee species. Given the importance of honey bees and other bee species to food production, many have expressed concern about whether a "pollinator crisis" has been occurring in recent decades. Although honey bee colony losses due to bee pests, parasites, pathogens, and disease are not uncommon, there is the perception that bee health has been declining more rapidly than in prior years, both in the United States and globally. This situation gained increased attention in 2006 as some commercial beekeepers began reporting sharp declines in their honey bee colonies. Because of the severity and unusual circumstances of these colony declines, scientists named this phenomenon colony collapse disorder (CCD). Since then, honey bee colonies have continued to dwindle each year, for reasons not solely attributable to CCD. The U.S. Department of Agriculture (USDA) reports that CCD may not be the only or even the major cause of bee colony losses in recent years. In the United States, USDA estimates of overwinter colony losses from all causes have averaged nearly 30% annually since 2006.

The precise reasons for honey bee losses are not yet known. USDA and most scientists working on the subject seem to agree that no research conclusively points to one single cause for the large number of honey bee deaths. This general conclusion was reconfirmed in a 2013 joint report by USDA and the U.S. Environmental Protection Agency (EPA). Reasons cited for bee declines include a wide range of possible factors thought to be negatively affecting pollinator species. However, one issue widely noted is the role that pesticides—in particular, neonicotinoid pesticides—might play in overall bee health. Pesticides are the focus of this report. Pesticides are among many identified factors known to affect bee health, including pests and diseases, diet and nutrition, genetics, habitat loss and other environmental stressors, and beekeeping management issues, as well as the possibility that bees are being negatively affected by cumulative, multiple exposures and/or the interactive effects of several of these factors.

The focus of this report on bee exposure to pesticides is not intended to imply that pesticides are any more important in influencing the health and wellness of bees than other identified factors influencing bee health. Pesticides are one of many influences on bee health. The current state of knowledge on pesticides and bee health is summarized in the USDA-EPA report:

> it is not clear, based on current research, whether pesticide exposure is a major factor associated with U.S. honey bee health declines in general, or specifically affects production of honey or delivery of pollination services. It is clear, however, that in some instances honey bee colonies can be severely harmed by exposure to high doses of insecticides when these compounds are used on crops, or via drift onto flowers in areas adjacent to crops that are attractive to bees.

Some experts emphasize research supporting the hypothesis that "total pesticide load" is an important influence on honey bee health, probably in combination with mite infestation, poor nutrition, viruses, and perhaps other stressors.

The past two farm bills (P.L. 110-246, P.L. 113-79) provided for increased funding for bee research, among other types of support to protect pollinators. Other bills in the 113th Congress addressed pesticide issues more directly. H.R. 2692 would have suspended registrations of neonicotinoids and banned new registrations of any pesticide in some cases. Another bill, H.R. 5447, would have amended U.S. pesticide laws to expedite the review and approval of products to control "parasitic pests" in managed commercial bee colonies, and would have required USDA and EPA to evaluate threats to pollinators and the availability of pesticides to manage bee pests.

Contents

Figures

Tables

Appendixes

Contacts

There is increasing concern both in the United States and globally about whether a "pollinator crisis" has been occurring in recent decades. Reports worldwide indicate that populations of managed honey bees, wild bees, and native bees have been declining, with colony losses in some cases described as severe or unusual.[1] Other reports indicate that many insect pollinator species may be becoming rarer, which some say may be a sign of an overall global biodiversity decline.[2]

Many reasons are cited for bee population declines, including bee pests and diseases, diet and nutrition, genetics, habitat loss, agricultural pesticides, and beekeeping management. Because pesticides have been the focus of concerns in Europe and in the United States, this CRS report briefly describes recent scientific research and analysis regarding the potential role of pesticides among the factors affecting the health and well-being of bees. The report concludes with a summary of recent regulatory activity regarding neonicotinoids, a type of pesticide, and also provides the statutory authority and regulatory activities related to pesticide use at the U.S. Environmental Protection Agency (EPA), the federal agency charged with assessing risks and regulating U.S. sale and use of pesticides.

The focus of this report on bee exposure to pesticides is not intended to imply that pesticides are any more or less important in influencing the health and wellness of bees than any of the other identified factors influencing bee health.

Background and Introduction

In the United States, honey bee colony losses due to bee pests, parasites, pathogens, and disease are not uncommon. However, in late 2006, concerns about honey bees gained heightened attention when commercial beekeepers along the East Coast began reporting sharp declines in their bee colonies. Because of the severity and unusual circumstances of these colony declines, scientists named this phenomenon colony collapse disorder (CCD). This issue was legislatively active in the 110th Congress and resulted in increased funding for honey bee research, among other types of farm program support to protect pollinators, as part of the 2008 farm bill (Food, Conservation, and Energy Act of 2008, P.L. 110-246). The 2014 farm bill (P.L. 113-79) reauthorized and expanded upon many of these provisions.[3]

The U.S. Department of Agriculture (USDA) reports that U.S. beekeepers continue to lose colonies each year. Since 2006, USDA estimates that overwinter[4] bee colony losses have averaged nearly 30% annually.[5] However, USDA reports that in 2012/2013, "there were more colonies that dwindled away" rather than suffering from CCD, which is characterized by a sudden loss in bee colony populations and the absence of dead bees.[6] USDA also claims that "beekeepers

[1] More information on the difference between managed honey bees and native bees is available in CRS Report R43191, *Bee Health: Background and Issues for Congress.*

[2] United Nations Environment Programme (UNEP), *Global Honey Bee Colony Disorders and Other Threats to Insect Pollinators*, UNEP Emerging Issues, 2010.

[3] For more information, see CRS Report R43191, *Bee Health: Background and Issues for Congress.*

[4] Bee colony losses are common during the winter months, especially in colder climates. Hives should be strong and healthy before going into winter in order to minimize losses.

[5] D. vanEngelsdorp, et al., "Colony Loss 2013-2014," May 15, 2014, http://beeinformed.org/.

[6] K. Kaplan, "Fact Sheet: Survey of Bee Losses During Winter of 2012/2013," http://www.ars.usda.gov/is/br/beelosses/ (continued...)

did not report CCD as a major cause of colony loss" for overwinter losses reported in its 2012-2013 and 2011-2012 surveys. These data are tracked for managed honey bees only.

Comparable data and information is not collected available for native or wild bee species. Such data collection is complicated by sheer number and solitary nature of native and wild bee species.

Managed Honey Bees and Wild Bee Species

Honey Bees

Honey bees (*Apis mellifera*; Family: Apidae) are the most well-known bee species. However, honey bees are only one of the world's estimated 17,000 described bee species, and one of the estimated total of 20,000 to 30,000 bee species worldwide. Honey bees are not native to North America, but were introduced by European settlers in the 1600s. Honey bees are considered to be "social" bees in that they have a single egg-laying queen and sterile worker bees that tend to work together in a highly structured social order, consisting of cooperation and division of labor within a colony, as well as the presence of two generations in a single nest at the same time. Social behavior allows bees to be domesticated and managed.

Some types of native bees may also be managed, such as bumble bees, orchard bees, and alfalfa leaf-cutting bees. Some of these bees (such as bumble bees and some types of stingless bees) exhibit some of the social behaviors commonly associated with honey bees. Some bumble bee species are managed in controlled environments to pollinate greenhouse tomatoes.

Wild Bee Species

An estimated 4,000 species of bees are native to North America. With few exceptions, most of these are wild and not managed. The five most common families of native bees in North America are Andrenidae, Apidae, Colletidae, Halictidae, and Megachilidae. Andrenid bees are all ground nesters, and mostly comprise a large family of dark, nondescript bees, although some are colorful. Bees in the large Apidae family include not only honey bees, but also bumble bees (such as *Bombus* spp.), carpenter bees, squash or gourd bees, and others. Most types of wild bees are "solitary" bees and do not have long-lived colonies. About 70% of native bee species are solitary ground nesting bees, and about 30% are solitary wood nesting bees. About 45 species of native bees in the United States are social bumble bees. Compared to most native species, bumble bees (*Bombus*) are better studied and, as noted by USDA, among the most effective crop pollinators.

For more information, see: CRS Report R43191, *Bee Health: Background and Issues for Congress*.

To date, the precise reasons for honey bee colony losses are still unknown. USDA and most scientists working on the subject seem to agree that none of the research conclusively points to one single cause for the large-scale number of honey bee deaths. This general conclusion was reconfirmed in a May 2013 report by USDA and the U.S. Environmental Protection Agency (EPA), *National Stakeholders Conference on Honey Bee Health* (commonly referred to as the "USDA-EPA joint report").[7] A 2007 study by the National Research Council (NRC) of the National Academy of Sciences, *Status of Pollinators in North America* (referred to here as the 2007 NRC study), also provides a detailed scientific context for bee health. A series of other

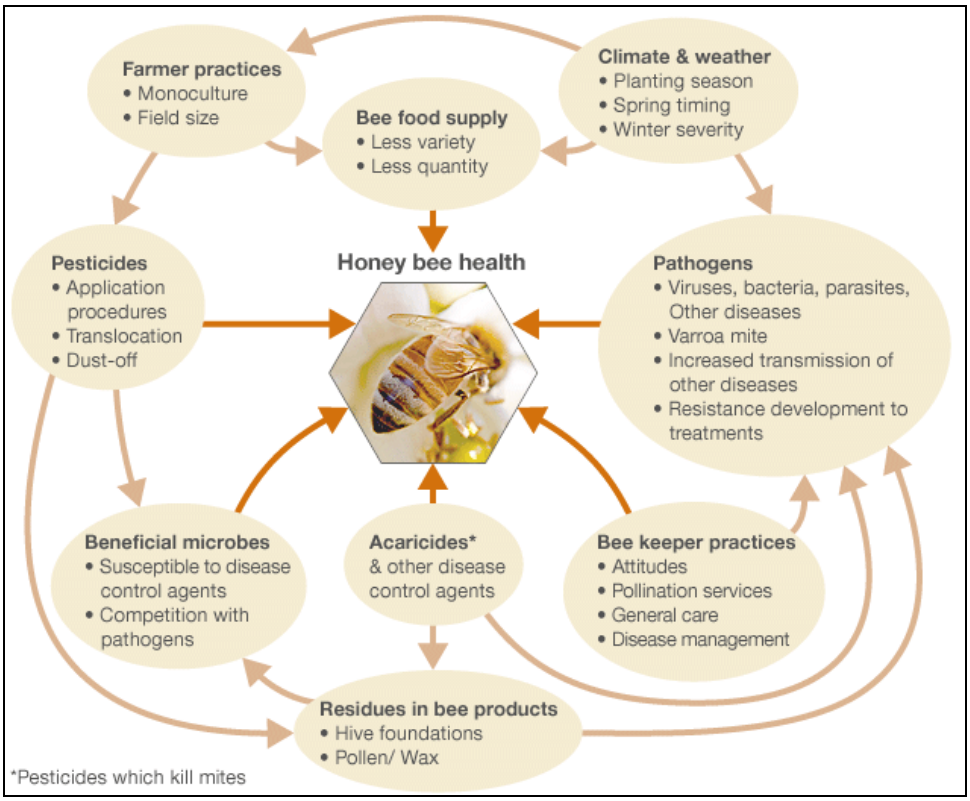
(...continued)

index.htm. Whether losses may be attributable to CCD may be based, in part, on reported colony losses "with no dead bees present, which is indicative of CCD." See USDA, *CCD Progress Report*, June 2012, p. 9.

[7] USDA, *Report on the National Stakeholders Conference on Honey Bee Health*, National Honey Bee Health Stakeholder Conference Steering Committee, May 2013, http://www.usda.gov/documents/ReportHoneyBeeHealth.pdf. This document, widely referred to as the USDA-EPA joint report, provides proceedings of an October 2012 workshop convened by USDA and EPA (edited by the National Honey Bee Health Stakeholder Conference Steering Committee).

reports documenting the findings of USDA's ongoing research also describes the many factors affecting honey bees.[8] See **Figure 1**.

Figure 1. Stress Factors in Honey Bee Populations



Source: OPERA Bee Health in Europe, 2013, http://www.operaresearch.eu/.

Reasons cited for bee population declines include a wide range of possible factors. Potential identified causes include bee pests and diseases, diet and nutrition, genetics, habitat loss and other environmental stressors, agricultural pesticides, and beekeeping management issues, as well as the possibility that bees are being harmed by cumulative, multiple exposures and/or the interactive effects of each of these factors.

One issue widely reported in the media is the potential role that pesticides—in particular, neonicotinoid pesticides—might play in overall bee health. As one of the potential causes of honey bee colony declines, this report addresses what role, if any, pesticides play in influencing the health and wellness of bees. Regarding honey bee health, the current state of knowledge of pesticides was summarized in a 2013 report by USDA and EPA:[9]

[8] See, for example, USDA's annual CCD Research Progress Reports, available at http://www.ars.usda.gov/News/docs.htm?docid=15572.

[9] USDA-EPA joint report, p. 16. Attributed to conferees Reed Johnson (Ohio State University) and James Frazier (Pennsylvania State University). The report references consensus by the Pesticide Risk Assessment for Pollinators in a 2011 Executive Summary, published by the Society of Environmental Toxicology and Chemistry (SETAC).

> There is broad consensus among all stakeholders that pesticide use should not affect honey bees in such a way that (1) honey production is reduced or (2) pollination services provided by bees are threatened.... However, it is not clear, based on current research, whether pesticide exposure is a major factor associated with U.S. honey bee health declines in general, or specifically affects production of honey or delivery of pollination services. It is clear, however, that in some instances honey bee colonies can be severely harmed by exposure to high doses of insecticides when these compounds are used on crops, or via drift onto flowers in areas adjacent to crops that are attractive to bees.

This report examines in greater detail the role of pesticides, providing a summary of selected scientific literature. The relative importance of pesticides in U.S. or global bee health is a subject of numerous research projects, some of which are discussed in this report.

Some groups have expressed concern about the assessment of most experts that the causes of pollinator health concerns are multifaceted and may involve the interaction of multiple factors, since this may deflect attention from the potential role of exposure to pesticides. On the other hand, some groups appear unwilling to acknowledge that pesticide exposure may play an important role in pollinator health concerns, especially if this acknowledgment leads to restrictions or reductions in the use of certain pesticides or related crop pest controls.

This report provides information regarding the potential role of pesticides in the health of bee colonies, and also the importance of pesticides relative to other influences on bee health. The report provides general information about the nature of pesticides, pesticide uses, and pesticide regulation in the United States, as well as more specific information about the registration status of a class of pesticides known as neonicotinoids, which have been implicated in some studies concerning honey bee colony declines. This report also describes a range of options to address pesticide exposure by bees, including implementing crop- and/or product-specific best management practices (BMPs) regarding pesticide use and applications. Some U.S. cities as well as some other countries, including Canada and those in Europe, have opted to institute restrictions on the use of certain pesticides. Congress has introduced similar legislation, but has also considered alternative policy options to address this issue.

U.S. Pesticide Laws and Regulation

Pesticide Laws and Statutory Framework

Pesticides are broadly defined in U.S. law as chemicals and other products used to kill, repel, or control pests.[10] Familiar examples include pesticides used to kill insects (insecticides) and weeds (herbicides) that can reduce the yield, and sometimes harm the quality, of agricultural crops, ornamental plants, forests, and pastures, or wooden structures (e.g., through termite damage). But the broad legal definition of "pesticide" also applies to products with less familiar "pesticidal uses." For example, substances are pesticides when used to control mites, mold, mildew, and other nuisance growths in hives or on equipment. The term also applies to disinfectants and sterilizing agents, animal repellents, rat poison, and many other substances. An estimated 18,000 pesticide products are currently in use in the United States.[11] Pesticides vary greatly in toxicity,

[10] FIFRA § 2(u). 7 U.S.C. 136-136y. See also CRS Report RL31921, *Pesticide Law: A Summary of the Statutes.*

[11] S. Kaiser, EPA, personal communication with CRS staff, December 16, 2011.

persistence in the environment, and ability to bioaccumulate up the food chain, as well as in the range of plants and animals that are likely to be affected in the event of exposure. Some are nearly nontoxic to some species but exquisitely toxic to other species.

All pesticides are regulated by EPA under the authority of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA),[12] and approximately 5,800 pesticide products used in food production also are regulated under the Federal Food, Drug, and Cosmetic Act (FFDCA).[13] FIFRA requires EPA to regulate the sale and use of pesticides in the United States through product registration and labeling so as to prevent unreasonable adverse effects on people and the environment, taking into account the costs and benefits of various pesticide uses. FIFRA prohibits the sale of any pesticide in the United States unless it is registered (licensed) and labeled to indicate approved uses and restrictions. It is a violation of the law to use a pesticide in a manner that is inconsistent with the label instructions. EPA registers each pesticide product for each approved use. For example, a product may be registered for use on bee hives to control mites or as a seed treatment for corn.[14] In addition, FIFRA requires EPA to reregister pesticides first registered prior to 1984 and to review all registered pesticides periodically on a 15-year cycle, based on new data that meet current regulatory and scientific standards.

For the 600 or more active ingredients in pesticide products that are registered for use in food production, Section 408 of the FFDCA authorizes EPA to establish maximum allowable residue levels (also known as "tolerances") to ensure that human exposure to the pesticide ingredients in food and animal feed will be "safe." A "safe" tolerance is defined in the law as a level at which there is "a reasonable certainty of no harm" from the exposure, even when considering total cumulative and aggregate pesticide exposure of children. Under the FFDCA, foods (or animal feeds) with a residue of a pesticide ingredient for which there is no tolerance established, or with a residue level exceeding an established tolerance limit, are declared "unsafe" and "adulterated"; such foods cannot be sold in interstate commerce or imported to the United States. Pesticides may not be registered under FIFRA for use on food crops unless tolerances (or exemptions) have been established under the FFDCA.[15]

Pesticide Registration Process

When pesticide manufacturers apply to register an active ingredient for a pesticide, a commercial pesticide product, or a new use of a pesticide registered under FIFRA Section 3, EPA requires them to submit scientific data on toxicity and behavior in the environment. In evaluating a pesticide registration application, EPA assesses a range of potential human health and environmental effects associated with use of the product. EPA's process of registering a pesticide comprises a scientific, legal, and administrative procedure involving the ingredients of the pesticide; the particular site or crop where it is to be used; the amount, frequency, and timing of its use; and storage and disposal practices.[16] EPA may require data from any combination of more

[12] 7 U.S.C. §136 et seq.

[13] 21 U.S.C. §§ 301, et seq.

[14] The Federal Seed Act (7 U.S.C. § 1561) defines a treated seed as any seed "given an application of a substance or subjected to a process designated to reduce, control, or repel disease organisms or other pests, which attack seeds or seedlings growing therefrom."

[15] For more information, see CRS Report RL31921, *Pesticide Law: A Summary of the Statutes*; and CRS Report 96-759, *Pesticide Legislation: Food Quality Protection Act of 1996 (P.L. 104-170).*

[16] EPA, "About Pesticide Registration," http://www2.epa.gov/pesticide-registration/about-pesticide-registration. Other (continued...)

than 100 different tests, depending on the potential toxicity of active and inert ingredients and degree of exposure.

To register a pesticide for use on food, EPA also requires applicants to determine the amount of residue that could remain on crops, as well as on (or in) food products (such as corn syrup), assuming that the pesticide product is applied according to the manufacturers' recommended rates and methods. Based on the data submitted, EPA determines whether and under what conditions a proposed pesticide use would present an unreasonable risk to human health or the environment, and, for a food or residential use, whether its use would be safe. Some features of pesticides that might affect registration decisions include the specificity of the pesticide for the targeted pest, its toxicity to people who apply it, its tendency to persist in the environment over time, and its ability to bioaccumulate in animals higher in the food chain.

EPA specifically takes into account unintended harm to bees and available information for other nontargeted insects in its registration decisions. EPA requires studies to determine acute (short-term) toxicity of a pesticide on individual bees when they come into body contact with pesticide residue. EPA also collects reports on bee-kill incidents. If a pesticide appears to be very toxic to bees, EPA may require long-term studies of its effects.

If the risk is determined to be unreasonable or unsafe, EPA attempts to mitigate the risk by adjusting requirements on the label (for example, requiring a buffer zone around lakes and streams or requiring personal protective equipment for pesticide handlers). If the risk remains unreasonable or unsafe, EPA will refuse to register the pesticide. If the risk is determined to be reasonable and safe, registration is granted, and the agency specifies the approved uses and conditions of use, including safe methods of pesticide storage and disposal, which the registrant must explain on the product label. EPA can and often does require specific application methods to be printed on the product label to minimize environmental damage. For example, the label sometimes requires that application of certain pesticides occur only when bees are not foraging, when there is little wind, or in a granular form or as a seed coating rather than aerially, in order to minimize spray drift off property. Pesticide registrations are reviewed at least once every 15 years to consider new scientific information and may be reviewed at any time in response to reports of adverse effects and possible unreasonable risks from use of particular pesticides.

Neonicotinoid Pesticides

Neonicotinoids are a relatively new major class of insecticides and among the fastest-growing class of insecticides in modern crop protection. Developed in the 1980s, some products such as imidacloprid were first introduced in the early to mid-1990s, but not widely marketed until the mid-2000s. Neonicotinoids are systemic pesticides that, regardless of application method (spray, drip irrigation, granular spreading, or seed coating), once taken into the plant, migrate into all parts, including flowers, pollen, and nectar.[17] Neonicotinoids are related to nicotine and were developed as an alternative to highly toxic (to humans) organophosphate insecticides such as methyl parathion.[18] Active ingredients of some of the most commonly applied neonicotinoids

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information is available at CRS Report RL32218, *Pesticide Registration and Tolerance Fees: An Overview*.

[17] UNEP, *Global Honey Bee Colony Disorders and Other Threats to Insect Pollinators*, 2010.

[18] S. P. Bradbury, Office of Pesticide Programs, letter to Peter T. Jenkins, Center for Food Safety and International Center for Technology Assessment, July 17, 2012.

include imidacloprid, clothianidin, and thiamethoxam. Others include acetamiprid, dinotefuran, nitenpyram, and thiacloprid. (See text box below.)

Neonicotinoid Insecticides

In the United States, neonicotinoid pesticides are available for use in about 140 crops and garden/horticultural products, and provide potent and systemic action for crop protection, particularly from pests in soil and sap-sucking pests. They are used for seed treatment on most corn, soybeans, canola, sunflower, cereal grains, sugar beets, and potatoes. They are also used as foliar sprays on field and many fruit and vegetable crops (such as apples, cherries, peaches, oranges, berries, leafy greens, tomatoes, and potatoes) and are applied to cereal grains, rice, nuts, and wine grapes. They may also be injected into tree roots or stems and sprayed on tree bark to protect against pests. A single application can provide protection for several months or years and may remain with the plant as it grows. Since these types of pesticides can persist in soil or plants for long periods of time, this raises the potential that bee exposure will persist, even at low levels.

Neonicotinoids reportedly accounted for almost 25% of the global pesticide market, and imidacloprid was the largest selling insecticide in the world in 2009, with sales exceeding $1 billion. More recent information suggests that the total global market for neonicotinoid pesticides exceeded $2.6 billion in 2011.

Neonicotinoid Active Ingredients:

- Acetamiprid
- Clothianidin
- Dinotefuran
- Imidacloprid
- Nitenpyram
- Thiocloprid
- Thiamethoxam

Major Trade Names: Admire®, Acceleron®, Axcess®, Attendant®, Belay®, Cruiser®, Gaucho®, Nitro Shield®, Poncho®, and Trimax Pro®.

Selected Home and Garden Products: ALOFT®, ARENA®, Criterion™, DIY Tree Care Products, Ferti-lome®, Flagship™, Green Light®, Safari®, Hi-Yield®, Knockout Ready-to-Use products, Mallet®, Marathon®, Maxide®, Meridian®, Merit®, Monterey Once A Year products, Ortho®, Safari products, Surrender®, Transtect™, Xytect™, and Zylam®, and also several Bayer Advanced and Bayer Environmental Science products (including "12-Month"; "2-in-1"; "All-in-One"; "Complete Brand"; "Dual Action"; "Hunter"; "Lesco Bandit"; "Season-Long"; termite; and Bayer's fruit, citrus, and vegetable products).

Major Manufacturers: Bayer Advanced, Syngenta Crop Protection, LLC, and The Scotts Company, as well as ArborSystems, Arysta LifeScience, Control Solutions, Inc., Gro Tec, Inc., Gulfstream Home and Garden, Lawn and Garden Products, Inc., Nufarm Americas Inc., OHP, Inc., Rainbow Treecare Scientific Advancements, Valent U.S.A. Corporation, and Voluntary Purchasing Groups, Inc.

Sources: P. Jeschke1 and R. Nauen, "Neonicotinoids—from Zero to Hero in Insecticide Chemistry," *Pest Management Science*, Vol. 64, Issue 11 (November 2008), pp. 1084–1098; M. Tomizawa and J. E. Casida, "Neonicotinoid Insecticide Toxicology: Mechanisms of Selective Action," *Annual Review of Pharmacology and Toxicology*, Vol. 45 (September 2004), pp. 247-268; P. Jeschke, R. Nauen, M. Schindler, et al., "Overview of the Status and Global Strategy for Neonicotinoids," *Journal of Agricultural and Food Chemistry*, v. 59 (2011), pp. 2897-2908; and B. Essler, "Are These Nicotine-Like Insecticides Killing Bees," *Modern Farmer*, November 12, 2014. Also Center for Food Safety (http://www.centerforfoodsafety.org/files/pesticide_list_final_59620.pdf), April 2013.

Neonicotinoids are generally considered to be reduced-risk compared to some other types of pesticides, and have low toxicity to mammals, birds, and fish compared to some other types of pesticides. However, as their use has increased, so have concerns about their potential harm to birds, earthworms, aquatic insects, and insect pollinators, including bees.[19] They comprise a class of active ingredients that have come under considerable scrutiny with respect to their potential effects on bee health. The attention is partly due to an incident of misuse (that is, use not in accord with the pesticide label) of one neonicotinoid, imidacloprid, in Germany[20] that resulted in a large bee kill, as well as widespread beekeeper concerns about use of another neonicotinoid, clothianidin, and its impact on bees in France.[21]

Neonicotinoids are insect neurotoxins that vary in strength of their effect on honey bees.[22] The scientific evidence to date indicates that although neonicotinoids are highly toxic to bees exposed to relatively high levels, individual pesticides in this class are not the only cause of declining bee health, and pyrethroid exposures may be more significant.[23] Although neonicotinoids have been a focus of scientific, public, and political interest, they have not been proven to be the primary cause of declines in bee health. Some experts, however, emphasize that research studies support the hypothesis that "total pesticide load" is an important influence on honey bee health, probably in combination with mite infestation, poor nutrition, viruses, and perhaps other stressors.[24]

Possible Role of Pesticides in Bee Health

Bees can be exposed to numerous different types of pesticides applied to field crops and other types of plants in areas where they forage or maintain their hive.[25] In addition, beekeepers may also use pesticides registered for the control of bacteria, fungi, mites, and other bee pests. These pesticides are applied within and in the vicinity of hives.[26] Besides the active ingredients, pesticide products include other ingredients, such as "inerts" or adjuvants that are intended to

[19] See, for example, D. Goulson, "An Overview of the Environmental Risks Posed by Neonicotinoid Insecticides," *Journal of Applied Ecology*, vol. 50, issue 4 (2013), pp. 977–987; E. Stokstad, "Pesticides Under Fire for Risks to Pollinators," *Science*, v. 340, no. 6133 (May 10, 2013), pp. 674-676; and D. Gibbons, C. Morrisey, P. Mineau, "A Review of the Direct and indirect Effects of Neonicotinoids and Fipronil on Vertebrate Wildlife," *Environ. Sci. Pollut. Res*., June 2014.

[20] D. vanEngelsdorp and M. D. Meixner, "A Historical Review of Managed Honey Bee Populations in Europe and the United States and Factors That May Affect Them," *Journal of Invertebrate Pathology*, v. 103 (2010), Supp. 1, pp. S80-S95.

[21] L. Maxim and J. P. van der Sluis, "Expert Explanations of Honeybee Losses in Areas of Extensive Agriculture in France: Gaucho® Compared with Other Supposed Causal Factors," *Environmental Research Letters*, v. 5 (2010).

[22] D. Laurino, M. Porporato, A. Patetta, et al., "Toxicity of Neonicotinoid Insecticides to Honey Bees: Laboratory Tests," *Bulletin of Insectology*, v. 64, n. 1 (2011), pp. 107-113.

[23] Pyrethroids are synthetic pesticides modeled on the naturally occurring pyrethrins that are formed by chrysanthemums. Most pyrethroids are more toxic and persistent than pyrethrins. Fenvalerate (an insecticide), bifenthrin (a miticide and an insecticide), cypermethrin (an insecticide), and fluvalinate (a miticide) are pyrethroids.

[24] J. L. Frazier, presentation to Senate staff on pesticides and bee health, April 17, 2013.

[25] Pesticides broadly refer to chemicals used to prevent, destroy, or repel pests, such as insecticides, herbicides, fungicides, rodenticides, and miticides, among others. Pesticides also are used to kill organisms that can cause diseases.

[26] Some common pesticides applied deliberately to hives include formic acid (an organic acid), thymol (an essential oil), coumaphos (an organophosphate), and fluvalinate (a pyrethroid).

improve delivery of the active ingredient to the target pest.[27] Others are used to increase the toxicity of a pesticide, for example, by inhibiting breakdown of a pesticide by insets.[28]

Studies have shown that bees are exposed to pesticides in many ways throughout the foraging period: from planter exhaust material produced during the planting of treated seed; from the soil of both planted and unplanted fields; in flowers growing near these fields; as well as applications in or near bee hives.[29] Bees also sometimes are exposed to pesticides accidentally, either when pesticides are misused or misapplied or when they are used according to label directions to control pests in areas frequented by bees—for example, alongside roads or rights of way for the control of weeds, trees, or other pests; on or near commercial farm crops; or on or near fields, lawns, and gardens to control fleas, ticks, weeds, grubs, mosquitos, or other adult insects.

Figure 2 illustrates some significant paths of bee exposure to pesticides applied as a spray or as a soil or seed treatment (systemic). If bees happen to fly through a newly treated field or dust clouds from planting of seeds coated with pesticide or are orally exposed to pesticide in food or water, and if exposure is high enough, bees may be sickened or die from pesticide exposure. With respect to the role of pesticides in honey bee health, "[t]he most pressing research questions lie in determining the true pesticide exposure that bees receive and the effect, if any, that pervasive exposure to multiple pesticides have [sic] on the health and productivity of whole honey bee colonies."[30]

Pesticides are reported to have adverse local impacts on honey bees and some native bees. Widespread use of herbicides reduces habitat available to bees;[31] many pesticides are known to be lethal to bees, given sufficient levels of exposure; and some reports of local bee kill incidents have been well documented. Effects on individual bees may be lethal or sublethal depending on dose and other conditions of exposure.[32] A summary of the types of sublethal effects reported in bees exposed to pesticides includes[33]

- decreased navigation, orientation, and communication abilities;
- altered foraging behavior and motor activity;
- short- and long-term memory loss;
- impaired learning behavior and sensory detection;

[27] A 2012 study looked at the impact on bee health of three categories of inerts: nonionic surfactants, crop oil concentrates, and organosilicone surfactants. Bee behavior was adversely affected after ingesting organosilicone surfactant. Nonionic adjuvants also had a small effect, while the crop oil concentrates were inactive See T. J. Ciarlo, C. A. Mullin, James L. Frazier, et al., "Learning Impairment in Honey Bees Caused by Agricultural Spray Adjuvants," *PLoS ONE*, v. 7, n. 7 (2012), p. e40848.

[28] National Pesticide Information Center, Piperonyl Butoxide (fact sheet), http://npic.orst.edu/factsheets/pbogen.pdf.

[29] See, for example, C. H. Krupke, G. J. Hunt, B. D. Eitzer, et al., "Multiple Routes of Pesticide Exposure for Honey Bees Living Near Agricultural Fields," *PLoS ONE*, v. 7. n. 1 (January 2012), p. e29268.

[30] USDA-EPA joint report, p. 17.

[31] J. H. Cane and V. J. Tepedino, "Causes and Extent of Declines Among Native North American Invertebrate Pollinators: Detection, Evidence, and Consequences," *Conservation Ecology*, v. 5, n. 1 (2001), p. 1.

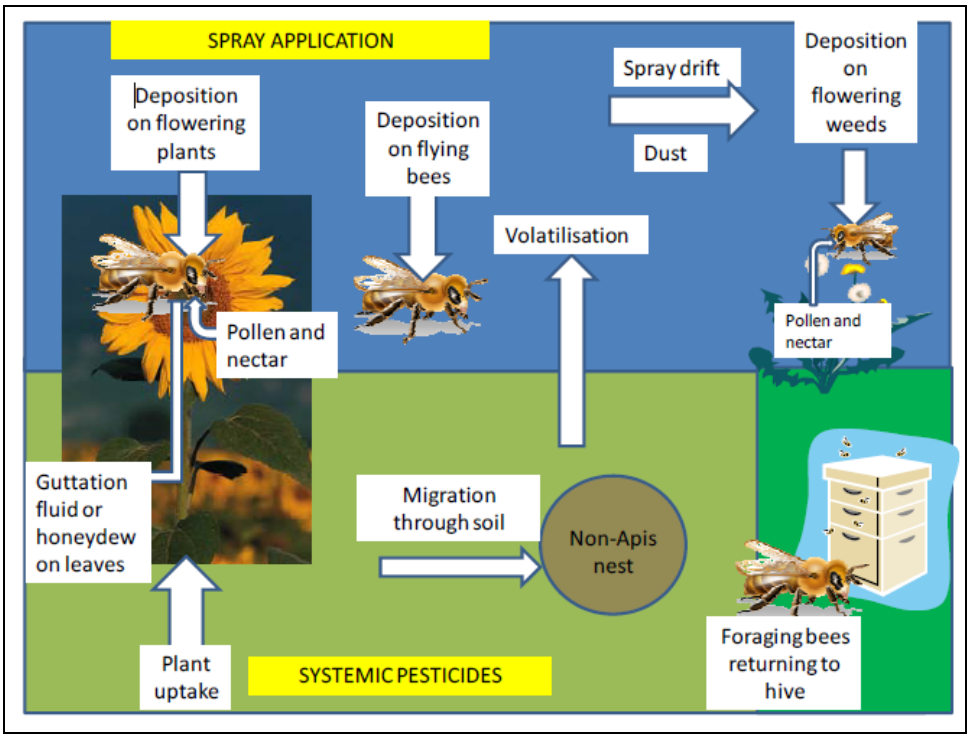
[32] Pesticides other than insecticides, such as fungicides or miticides, may be toxic to bees, although bees are insects and not the targeted species.

[33] *Neonicotinoid Pesticides and Honey Bees*, Washington State University Extension, Fact Sheet FS122E, http://cru.cahe.wsu.edu/CEPublications/FS122E/FS122E.pdf; and comments by Nathalie Steinhauer (University of Maryland) to the Virginia Native Plant Society, October 9, 2014.

- compromised immune functioning;
- increased susceptibility to diseases and pests;
- reduced fecundity (fertility and reproduction); and
- impaired reproduction and development.

Although pesticides have been shown to damage bee health, it is unclear whether the level of harm is sufficient to attribute pesticides as the single or as the major cause of honey bee population declines.

Figure 2. Major Routes of Exposure of Foraging Bees to Pesticides



Source: European Food Safety Authority (EFSA), "Scientific Opinion on the Science Behind the Development of a Risk Assessment of Plant Protection Products on Bees (*Apis mellifera, Bombus* spp. and Solitary Bees)," Figure 3.1, EFSA-Q-2011-00417, May 2012, http://www.efsa.europa.eu/en/efsajournal/pub/2668.htm.

The **Appendix** provides a summary of selected scientific literature based largely on publications in peer-reviewed journals. In addition, a number of industry and advocacy groups have compiled literature reviews regarding pesticide effects on bees, not all of which are specifically discussed in this report.[34] In general, studies looking at impacts of pesticides on other animal species, such as birds, are also not addressed.[35]

[34] For example, see J. Hopwood, et al., *Are Neonicotinoids Killing Bees? A Review of Research into the Effects of Neonicotinoid Insecticides on Bees, with Recommendations for Action*, 2012, and *A Review of Research into the Beyond the Birds and the Bees: Effects of Neonicotinoid Insecticides on Agriculturally Important Beneficial Invertebrates*, 2013 (both prepared for Xerces Society for Invertebrate Conservation); V. Kindemba, *The Impact of Neonicotinoid Insecticides on Bumblebees, Honey Bees, and Other Non-Target Invertebrates,* 2009 (Invertebrate (continued...)

Best Management Practices to Protect Pollinators

Best management practices (BMPs) are available for beekeepers, crop producers, and pesticide applicators and include environmentally responsible pest management practices to reduce risk and minimize pesticide exposure in bees.[36] A number of states have also developed guidance to protect pollinators. Some of these resources are listed on the Pesticide Environmental Stewardship (PES) website[37] and on EPA's website.[38]

For beekeepers, guidance by apiculturists and university extension services emphasizes the importance of reducing the exposure of bees to insecticides with high toxicity, recommending that if such chemicals are used in an area where bees are foraging, steps may be necessary to reduce risk of poisoning. This involves both selecting a site for an apiary in an area with low pesticide risk and notifying "growers and applicators in the area, the county agent, and the State Apiary Inspector of the location of your hives.... If the insecticide to be used has a long residual life and is being applied to a plant where bees are foraging, it may be best to move your bees out of the area."[39]

For growers, recommendations involve reducing the hazards associated with insecticides, including avoiding the use of dusts, such as those from treated seeds, and using chemicals with reduced risk to bees whenever possible. Other recommendations include applying insecticides "in the late evening, night, or early morning when fewer bees will be foraging, and when spray drift and volatilization due to extreme heat are at a minimum"; not spraying "when winds favor drifting, and us[ing] ground applications instead of air where possible"; and avoiding "spraying when the crop or other plants in the field or nearby (including weeds) are in bloom."[40] Some agricultural groups provide such guidance to their growers. For example, the Almond Board of California recommends that growers avoid applying insecticides when plants are in bloom or

(...continued)

Conservation Trust); R. Heintzelman, et al., "Overview of Recent Publications on Neonicotinoids and Pollinators," May 2012 (prepared for Bayer Crop Science); Center for Food Safety (CFS), "Pollinators and Pesticides: A Report by Center For Food Safety on Pollinator Health, Research, and Future Efforts for Pollinator Protection," September 2013; CFS, "Heavy Costs: Weighing the Value of Neonicotinoid Insecticides in Agriculture," March 2014; CFS, Pollinator Study Index (available at http://www.centerforfoodsafety.org/files/pollinator-study-index_73710.pdf); M. Simon, *Follow the Honey: 7 Ways Pesticide Companies are Spinning the Bee Crisis to Protect Profits*, April 2014; and PANNA, *Pesticides and Honey Bees: State of the Science*, May 2012.

[35] For more information, see P. Mineau and C. Palmer, *The Impact of the Nation's Most Widely Used Insecticides in Birds*, American Bird Conservancy, March 2013; and C. A. Hallmann, et al., "Declines in Insectivorous Birds Are Associated with High Neonicotinoid Concentrations," *Nature*, vol. 511 (July 17, 2014), pp. 341-343.

[36] Educational resources are available from most land grant universities and also the following organizations: Bee Informed Partnership (www.beeinformed.org); Center for Urban Ecology and Sustainability/Pollinator Conservation (www.entomology.umn.edu/cues/pollinators); National Pesticide Information Center (www.npic.orst.edu); Pesticide Environmental Stewardship (www.pesticidestewardship.org); and Pollinator Partnership (www.pollinator.org).

[37] PES, "Pollinator Protection," http://pesticidestewardship.org/PollinatorProtection/Pages/default.aspx.

[38] EPA, "Find Best Management Practices to Protect Pollinators," http://www2.epa.gov/pollinator-protection/find-best-management-practices-protect-pollinators.

[39] C. H. Krupke, G. Hunt, and R. E. Foster, "Protecting Honey Bees from Pesticides," Purdue University Extension, E-53-W, http://extension.entm.purdue.edu/publications/E-53.pdf.

[40] Ibid.

when pollen is available and honey bees are feeding.[41] Additional grower BMPs are listed in the text box below.

Almond Board of California's "Top 10 Honey Bee BMPs"

1. Communication should occur between all pollination stakeholders about pest control decisions. These stakeholders can include beekeeper, bee broker, county agricultural commissioner, grower (owner/lessee), farm manager, pest control adviser (PCA), and pesticide applicator.

2. Agreements should include a pesticide plan that outlines which pest control materials may be used. The grower and the beekeeper should agree on which products may be applied if a treatment is deemed necessary. If deemed necessary, growers should give beekeepers 48-hour notice before treatment.

3. If applying pesticides, contact your local county agricultural commissioner and give advance notification to beekeepers with nearby managed hives.

4. Avoid applying insecticides during almond bloom until more is known, particularly about their impact on bee brood, or young developing bees in the hive. If treatment is necessary, only apply fungicides and avoid tank-mixing insecticides with fungicides.

5. Any fungicide application deemed necessary during bloom should occur in the late afternoon or evening, when bees and pollen are not present. This timing avoids contaminating pollen with spray materials.

6. Provide clean water for the bees to drink. This will ensure they spend more time pollinating the crop than searching for water. Cover or remove water sources before a pest control treatment, or empty and refill water after a treatment is made. Check water levels throughout bloom and refresh as necessary.

7. Do not directly spray hives with any pesticide spray application. Ensure that the spray-rig driver turns off nozzles when near hives. Spray applications that come in contact with bee hives could adversely affect bee health and the pollination of the crop.

8. Do not hit flying bees with any spray application materials. Bees that come in contact with agricultural sprays will not be able to fly because of the weight of spray droplets on their wings.

9. Report suspected pesticide-related bee incidents to the county agricultural commissioner's office. Bee health concerns cannot be addressed without the data from these incidents.

10. The beekeeper and the grower should agree on hive removal timing. The University of California recommends bee removal when 90% of the flowers on the latest blooming variety are at petal fall. Past this point, no pollination is taking place, and bees that forage outside the orchard (up to 4 miles) seeking alternate food sources and water will have a higher risk of coming in contact with crops that have been treated with an insecticide.

Source: Almond Board of California, "Honey Bee BMPs," http://www.almonds.com/newsletters/outlook/honey-bee-bmps-pest-management-and-honey-bees. See also http://www.growingproduce.com/nuts/top-10-honey-bee-bmps/.

Pesticide applicator BMPs recommend avoiding pesticide use when crops are blooming and applying pesticides to blooming crops only after bees are done foraging for the day and preferably at night.[42] Bayer Crop Science notes the importance of following pesticide label recommendations as "naturally beneficial to bees' safety," as well as cooperation between farmers and beekeepers "to optimize spray times and minimize exposure to foraging bees."[43]

[41] Almond Board of California, "Honey Bee BMPs," http://www.almonds.com/newsletters/outlook/honey-bee-bmps-pest-management-and-honey-bees. See also testimony of Arthur Cummings, Capay Farms, at a House Agriculture Subcommittee on Horticulture, Research, Biotechnology, and Foreign Agriculture hearing, April 29, 2014.

[42] W. Buhler, "Pesticide Applicator BMPs," Pesticide Environmental Stewardship, available at http://pesticidestewardship.org/PollinatorProtection/PesticideApplicatorBMPs/Pages/Pesticide-Applicator-BMPs.aspx.

[43] Bayer pamphlet, "Honey Bee Health: Understanding the Issues, Providing Solutions."

Such BMP guidance is generally voluntary. Several studies suggest, in general, adoption of voluntary BMPs is characterized by both slow adoption rates (i.e., long lead times) and long lag times between BMP adoption and observed effects; also BMP implementation tends to be mostly self-funded.[44] Some claim therefore that reliance on voluntary agricultural BMPs regarding pesticide use and potential pollinator impacts is unlikely to produce timely behavioral changes and BMP adoption, even with a broad outreach and education program.[45]

In response to recent bee die-offs in Canada, federal agencies there have instituted additional protective requirements when using treated seed in corn and soybean production. These include required use of safer dust-reducing seed flow lubricants; adherence to safer seed planting practices; pesticide and seed package labels with enhanced warnings; and evaluation of the need for neonicotinoid treatment on certain commercial crops.[46] (More information on Canada's requirements is discussed in "Restrictions in Canada.")

Agro-chemical industry representatives maintain that unwanted pesticide exposure is best addressed through "effective product labeling and the implementation of meaningful stewardship actions that help minimize harmful interactions," along with "crop- and product-specific integrated pest management (IPM) practices and messaging to improve bee and pollinator safety."[47] However, some claim that because the use of systemic insecticides applied via seed coatings is mostly "prophylactic" (i.e., applied regardless of actual pest pressure) the use of such insecticides violates basic IPM principles, which recommend minimizing use of chemical pesticides through pest monitoring, maximizing the use of biological and cultural controls, applying chemical pesticides only when needed, and avoiding broad-spectrum, persistent compounds.[48] The text box below provides additional information on IPM practices.

Other guidance by apiculturists and university extension focuses on providing recommendations to private landowners and homeowners for proper use of pest control products on ornamental plants. One recommendation is to avoid applying any pesticides, including insecticides and fungicides, during bloom of ornamental plants that attract bees (e.g., heather, lavender, linden, rhododendron, and rose). It is also recommended that any pesticides be applied "only after flower petals have fallen, when ornamental plants are less attractive to bees," and that all specific requirements to protect bees on the pesticide label be strictly followed.[49] If pesticides are used when plants are in bloom, those that are less toxic to bees are recommended. Some recommend

[44] See, for example, E. Lichtenberg, D. Parker, and S. Lane, "Best Management Practice Use and Nutrient Management in Maryland: A 2010 Snapshot," 2010, University of Maryland; D. Stoddard, "Monitoring, Prevention and Mitigation of Agricultural Contaminant Sources," November 2006; Minnesota Department of Agriculture; M. Ribaudo, J. Savage, M. Aillery, *An Economic Assessment of Policy Options To Reduce Agricultural Pollutants in the Chesapeake Bay*, June 2014; and American Farmland Trust, "The Adoption of Conservation Practices in Agriculture," August 2013.

[45] CRS communication with the Center for Food Safety, February 13, 2015.

[46] Health Canada, "Notice of Intent, NOI2013-01, Action to Protect Bees from Exposure to Neonicotinoid Pesticides."

[47] Honey Bee Health Coalition, "Bee Healthy Roadmap," October 2014, https://www.keystone.org/images/keystone-center/spp-documents/Environment/BeeHealth/Bee-Healthy-Roadmap-October-2014.pdf. Also testimony of David Fischer, Bayer North American Bee Care Center, at a House Agriculture Subcommittee on Horticulture, Research, Biotechnology, and Foreign Agriculture hearing, April 29, 2014.

[48] CRS communication with the Center for Food Safety, February 13, 2015 (citing D. Goulson, "An Overview of the Environmental Risks Posed by Neonicotinoid Insecticides," *Journal of Applied Ecology*, vol. 50, issue 4 (2013), pp. 977–987.

[49] See, for example, Washington State Department of Agriculture (WSDA), "10 Ways to Protect Bees from Pesticides," AGR PUB 701-388, http://agr.wa.gov/fp/pubs/docs/388-TenWaysToProtectBeesFromPesticides.pdf.

using certain pesticides—including products containing clothianidin, dinotefuran, imidacloprid, and thiamethoxam—only after flower petals have fallen, and avoiding soil drench or tree injection methods when using these products for plants known to attract bees because "these methods may contaminate nectar and pollen for up to several years after the insecticide is applied," or, alternatively, recommend against buying plants treated with insecticides containing these ingredients.[50]

What Is Integrated Pest Management (IPM)?

Integrated pest management (IPM) refers to practices that have been developed to improve pest control while also minimizing risks to beneficial species, including pollinators. IPM combines pest control with an understanding of the underlying ecology of the species and the environment where it occurs. The University of California Statewide Integrated Pest Management Program (UC IPM) defines IPM as:

> an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment.

EPA further states: "IPM relies on easy-to-implement, environmentally sensitive practices that prevent pests from becoming a threat. These practices involve monitoring and identifying pests and taking preventive action before pesticides are used. If pesticides are needed, methods such as targeted spraying may be used." In IPM strategies, pesticides may be considered part of IPM but generally are intended as a last resort, after other non-chemical methods have been exhausted or proved to be ineffective or are not available. According to UC IPM, pesticides are used "only when needed and in combination with other approaches for more effective, long-term control," and "are selected and applied in a way that minimizes their possible harm" to humans and other organisms, as well as the environment (air, soil, and water quality). The U.S. Fish and Wildlife Service (FWS) further states that in addition to reducing risks from pests and pest management-related strategies to people, property, resources, and the environment, one of the other benefits of IPM is the ability to "decrease or eliminate unnecessary pesticide use."

In January 2014, EPA announced it had awarded nearly $500,000 in agricultural grants for IPM practices to reduce the use of potentially harmful pesticides and lower risk to bees. These grants are intended to expand public-private stewardship efforts and reduce pesticide risk in agriculture. These IPM grants were awarded to Louisiana State University, Pennsylvania State University, and the University of Vermont.

Source: UC IPM website: http://www.ipm.ucdavis.edu; FWS, "Integrated Pest Management: Reducing the Risks to Pollinators from Pest Management Activities;" and EPA's press release, "EPA Awards Almost Half a Million in Funding to Three Universities for Projects to Reduce Pesticide Risk Including Risks to Bees," January 8, 2014. See also USDA, Natural Resources Conservation Service (NRCS), "Integrated Pest Management Plan Criteria Practice/Activity Code (114) (No.)," September 2011.

Consumer campaigns have been initiated to encourage businesses and home gardening centers to stop selling certain pesticides or plants treated with these products because of concerns about the effects on bees and other pollinators.[51] A consumer campaign initiated by the Center for Food Safety highlights that more than 60 commonly used home and garden products contain neonicotinoid pesticides and recommends that homeowners avoid certain commonly used pesticide products.[52] In addition, concerns have been raised about the use of mosquito control

[50] Ibid.

[51] See, for example, Xerxes, "Protecting Bees from Neonicotinoid Insecticides in Your Garden," 2013; J. Hopwood and M. Shepherd, "Neonicotinoids in Your Garden," 2012; and Friends of the Earth, *Gardeners Beware: Bee-Toxic Pesticides Found in "Bee-Friendly" Plants*, June 2014 (updated).

[52] For a listing of these products, see Center for Food Safety, "Help Save the Bees," April 2013, (continued...)

services by some homeowners, because of potential adverse effects to bees and other beneficial insects that might feed on plants or be exposed to pesticides within the sprayed areas, as well as effects to species on adjacent or nearby property due to drift.

Federal Agency Efforts

National Pollinator Health Strategy ("Presidential Memorandum")

In June 2014, the Obama Administration issued its Presidential Memorandum, "Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators," directing federal agencies to take steps to protect and restore domestic populations of pollinators.[53] It established a "Pollinator Health Task Force," co-chaired by USDA and EPA, with representatives of the Departments of State, Defense, the Interior, Housing and Urban Development, Transportation, Energy, and Education; among other agencies and offices.

The task force is directed to develop a National Pollinator Health Strategy, which is to include a Pollinator Research Action Plan to "focus federal efforts on understanding, preventing, and recovering from pollinator losses." Among the many activities expected to inform the action plan is "identification of existing and new methods and best practices to reduce pollinator exposure to pesticides, and new cost-effective ways to control bee pests and diseases." Task force member agencies will develop plans to increase and improve pollinator habitat. These plans may include "use of integrated vegetation and pest management," among other actions. Member agencies will also "make any necessary and appropriate changes to enhance pollinator habitat on federal lands through the use of integrated vegetation and pest management and pollinator-friendly best management practices." The task force is expected to release its National Pollinator Health Strategy in spring 2015.[54]

In November 2014, USDA and EPA held a number of public listening sessions to inform the task force members. Concerns about pesticide use were among the major discussion points. Commercial beekeepers, environmental groups, and some food businesses[55] continue to push for restrictions on pesticide use and question whether other factors, such as parasitic mites, are the primary driver behind bee declines. Most pesticide industry groups and commercial growers continue to encourage broader consideration beyond pesticides and claim that some alternative pesticides are more toxic than neonicotinoids.[56]

(...continued)

http://www.centerforfoodsafety.org/files/pesticide_list_final_59620.pdf.

[53] White House, "Presidential Memorandum—Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators," June 20, 2014, http://www.whitehouse.gov/the-press-office/2014/06/20/presidential-memorandum-creating-federal-strategy-promote-health-honey-b.

[54] Announcement by Michael Stebbins, White House Office of Science and Technology Policy, at the 14th annual conference of the North American Pollinator Protection Campaign (NAPPC), October 22, 2014. Other information is available in CRS Report R43191, *Bee Health: Background and Issues for Congress.*

[55] See, for example, letter to U.S. President Barack Obama from more than 100 environmentally friendly food companies urging the Administration to protect bees and other pollinators from pesticides, January 13, 2015.

[56] J.R. Pegg, "Neonicotinoid Controversy Hits Pollinator Health," *Food Chemical News*, December 3, 2014.

Currently, at EPA, the agency's pollinator strategic plan outlines efforts to advance scientific knowledge and assessment of pesticide risks to pollinators; improve management tools for mitigating risks to pollinators; and increase and broaden communication and public outreach.[57]

USDA-EPA Joint Report

In 2013, USDA and EPA published a joint report, *National Stakeholders Conference on Honey Bee Health*.[58] Among the goals of the conference were to "synthesize the current state of knowledge regarding CCD, bee pests, pathogens, and nutrition, potential pesticide effects on bees, and bee biology, genetics and breeding." The report's key findings include recommendations to address risks to honey bees from parasites and disease; increase the genetic diversity in bee colonies; and improve nutrition for honey bees. In addition, regarding pesticides, the report acknowledged the following needs:[59]

- **Collaboration and Information Sharing.** Best management practices (BMPs) associated with pesticide use and bees are known but are not widely or systematically followed by U.S. crop producers. "Informed and coordinated communication between growers and beekeepers" is needed, along with "effective collaboration between stakeholders on practices to protect bees from pesticides." Beekeepers have identified the need for "accurate and timely bee kill incident reporting, monitoring, and enforcement."
- **Additional Pesticide Research.** According to EPA, "[t]he most pressing pesticide research questions relate to determining actual pesticide exposures and effects of pesticides on bees in the field and the potential for impacts on bee health and productivity of whole honey bee colonies."

The National Honey Bee Health Stakeholder Conference Steering Committee is made up of representatives from Pennsylvania State University; from USDA's Office of Pest Management Policy (OPMP), National Institute of Food and Agriculture (NIFA), Agricultural Research Service (ARS), Animal and Plant Health Inspection Service (APHIS), Natural Resources Conservation Service (NRCS), and National Agricultural Statistics Service (NASS); and from EPA's Office of Pesticide Programs (OPP). Much of the current research on bee health is being conducted by scientists at USDA and its Beltsville bee laboratory, by the USDA-supported Bee Informed Partnership, and by scientists at many of the land-grant universities nationwide.[60]

[57] EPA, Pollinator Protection Strategic Plan, http://www2.epa.gov/pollinator-protection/pollinator-protection-strategic-plan.

[58] USDA, *Report on the National Stakeholders Conference on Honey Bee Health*, National Honey Bee Health Stakeholder Conference Steering Committee, May 2013, http://www.usda.gov/documents/ReportHoneyBeeHealth.pdf.

[59] EPA news release, "USDA and EPA Release New Report on Honey Bee Health," May 2, 2013.

[60] More information is available in CRS Report R43191, *Bee Health: Background and Issues for Congress.*

Environmental Protection Agency

EPA's Pesticide Registration Review of Neonicotinoid Pesticides

Neonicotinoid pesticide registrations are being reviewed by EPA. According to EPA:[61]

> Some uncertainties have been identified since their initial registration regarding the potential environmental fate and effects of neonicotinoid pesticides, particularly as they relate to pollinators. Data suggest that neonicotinic residues can accumulate in pollen and nectar of treated plants and may represent a potential exposure to pollinators.
>
> Adverse effects data as well as beekill incidents have been reported, highlighting the potential direct and/or indirect effects of neonicotinic pesticides. Therefore, among other refinements to ecological risk assessment during registration review, we will consider potential effects of the neonicotinoids to honeybees and other pollinating insects.

Review of several neonicotinoid pesticide registrations began December 2011, with review of imidacloprid starting a few years earlier, in December 2008 (**Table 1**). EPA aims to review all neonicotinoids as a group.

Table 1. Schedule for EPA Review of Neonicotinoid Pesticides

Chemical Name and Docket Number	Initiation	Data Generation	Projected Completion
Imidacloprid (EPA-HQ-OPP-2008-0844)	Dec. 2008	2010-2015	2016-2017
Clothianidin (EPA-HQ-OPP-2100-0865)	Dec. 2011	2013-2016	2017-2018
Thiamethoxam (EPA-HQ-OPP-2011-0581)	Dec. 2011	2013-2016	2017-2018
Dinotefuran (EPA-HQ-OPP-2011-0920)	Dec. 2011	2013-2016	2017-2018
Acetamiprid (EPA-HQ-OPP-2012-0329)	Dec. 2012	2014-2017	2018-2019
Thiacloprid (EPA-HQ-OPP-2012-0218)	Dec. 2012	2014-2017	2018-2019

Source: EPA's website, http://www2.epa.gov/pollinator-protection/schedule-review-neonicotinoid-pesticides.

In July 2014, the Natural Resources Defense Council (NRDC) petitioned EPA to conduct an emergency review of the impacts of neonicotinoid pesticides on bees and to complete its review within one year.[62] At an October 2014 meeting, an EPA official indicated that the agency would move up its dates for its review of neonicotinoid pesticides from 2018-2019 to 2016-2017.[63]

Currently, among the neonicotinoid pesticides under review, some products are being used under a "conditional" registration, while some products are being used under an "unconditional" registration. FIFRA provides that EPA register a pesticide if, among other findings, it meets the statutory standard, namely: (1) the pesticide will perform its intended function without

[61] EPA, "Groups of Pesticides in Registration Review," http://www2.epa.gov/pesticide-reevaluation/groups-pesticides-registration-review.

[62] NRDC, "Petition for Interim Administrative Review of Neonicotinoid Pesticides," filed July 7, 2014, http://docs.nrdc.org/health/files/hea_14070701a.pdf.

[63] Public statements by EPA's Assistant Administrator for the Office of Chemical Safety and Pollution Prevention, Jim Jones, at the 14th Annual NAPPC International Conference, October 22, 2014.

unreasonable adverse effects on human health and the environment, and (2) the pesticide will not generally cause unreasonable adverse effects on human health and the environment when used in accordance with widespread and commonly recognized practice. Under an unconditional registration, after reviewing the data and information submitted to support an applicant/registrant's pesticide product application under consideration, if EPA determines that the pesticide meets the statutory standard and there are no outstanding data requirements, the agency may approve an "unconditional" registration.[64] If, however, EPA finds that the pesticide meets the standard for registration, but there are outstanding data requirements, the agency may, under certain circumstances, grant a "conditional" registration.[65] Before granting a conditional registration, EPA must determine that, although an application lacks some of the necessary data, use of the pesticide would not significantly increase the risk of unreasonable adverse effects on the environment during the time needed to generate the necessary data. A product's "conditional" or "unconditional" status is determined on a product registration by product registration basis, and not for the pesticide's active ingredient as a whole.[66] An indication of a product's current status can be found at EPA's searchable label database.[67]

The U.S. Government Accountability Office (GAO) has conducted studies that are critical of EPA's pesticide registration process, particularly regarding the program's conditional registrations.[68] Environmental and other groups argue that conditional registrations are a loophole in EPA's requirements, allowing pesticides onto the market that might not otherwise be allowed under a thorough agency review.[69] These groups further claim that EPA has overused conditional registrations and that the agency does not have a reliable data-gathering system to track conditional registrations.[70] GAO's 2013 report states that "the total number of conditional registrations granted is unclear" due to database inaccuracies and confusion in EPA's recordkeeping system for tracking pesticides.[71]

In the process of reviewing registrations for neonicotinoids, EPA has revised its risk assessment process "to reflect advancements in the state of the science that underlie bee exposure and effects assessments."[72] The draft risk assessment policy was released to the public, and materials were distributed and discussed at a FIFRA Scientific Advisory Panel (SAP) meeting in September 2012.[73] The final risk assessment guidance was released in June 2014.[74] The guidance is founded

[64] FIFRA section 3(c)(5).

[65] FIFRA section 3(c)(7).

[66] For more information, see EPA's website: http://www2.epa.gov/pesticide-registration/conditional-pesticide-registration.

[67] A pesticide's labels and the indication of their current conditional (or not) status at EPA's Label database:EPA, "Pesticide Product Label System," http://iaspub.epa.gov/apex/pesticides/f?p=PPLS:1.

[68] See, for example, GAO, *EPA Should Take Steps to Improve Its Oversight of Conditional Registrations*, GAO-13-145, August 2013; and GAO, *EPA's Formidable Task To Assess and Regulate Their Risks*, RCED-86-125: April 1986.

[69] J. Sass and M. Wu, "Superficial Safeguards: Most Pesticides Are Approved by Flawed EPA Process," *NRDC Issue Brief*, IB: 13-01-B, March 2013, http://www.nrdc.org/health/pesticides/files/flawed-epa-approval-process-IB.pdf.

[70] Ibid.

[71] See, for example, GAO, *EPA Should Take Steps to Improve Its Oversight of Conditional Registrations*, GAO-13-145, August 2013.

[72] EPA, Environmental Fate and Effects Division (EFED), EFED Response to Comments Submitted to the Clothianidin Registration Review Docket (docket: EPA-HQ-OPP-2011-0865), June 11, 2012. References EPA's interim guidance from 2011, *Pesticides: Science and Policy, Interim Guidance on Honey Bee Data Requirements*.

[73] Meeting materials and public comments are posted in the regulatory docket (docket: EPA-HQ-OPP-2012-0543). EPA, "Proposed Decision Framework for Assessing Risks of Pesticides to Honey Bees," presentation at the 2012 (continued...)

on EPA's ecological risk assessment framework, integrates an analysis of honey bees and other pollinators within the agency's broader components of ecological risk assessment, and was prepared in collaboration with Health Canada's Pesticide Management Regulatory Authority and California's Department of Pesticide Regulation. The guidance describes the basic framework of the risk assessment process and the data used to support risk management decisions, and includes a process to assess both foliar spray applications and soil/seed treatment applications.

Some groups argue that EPA does not take into account chronic, sub-lethal effects in its risk assessments, nor synergistic effects with other compounds used in real field settings, such as fungicides, adjuvants, and inerts.[75] These groups also claim native and wild bee species are generally not addressed as part of EPA's risk assessment. Since most native bee species (about 70%) are ground nesting,[76] these groups further claim that the use of systemic insecticides poses risks to native bees from exposure through their habitats in the ground. Native and wild bee species are also generally not addressed as part of EPA's pesticide labeling approach (discussed in "EPA's New "Bee Advisory" Labeling Requirements").

As part of EPA's overall review, the agency has conducted a study of the benefits of neonicotinoid seed treatments for insect control in U.S. soybean production.[77] EPA's analysis concluded: "these seed treatments provide little or no overall benefits to soybean production in most situations. Published data indicate that in most cases there is no difference in soybean yield when soybean seed was treated with neonicotinoids versus not receiving any insect control treatment."[78] Reportedly, EPA also studied the potential benefits of neonicotinoid seed treatments to corn production but has not published those findings.[79] In 2013, EPA and USDA conducted a summit with stakeholders on reducing exposure to dust from treated seed and potential acute exposure of honey bees and pollinators to pesticides. Information and stakeholder presentations from the summit are at EPA's website.[80]

EPA's Consideration to Modify Thiamethoxam Tolerance Levels

In September 2014, EPA announced that it had received "several initial filings of pesticide petitions requesting the establishment or modification of regulations for residues of pesticide chemicals in or on various commodities," including a petition by Syngenta that EPA increase the allowable threshold for residues of thiamethoxam.[81] Syngenta's petition would apply to alfalfa,

(...continued)

FIFRA SAP meeting. Also see EPA's presentation, "Ecological Risk Assessment Process for Honey Bees."

[74] EPA, *Guidance for Assessing Pesticide Risks to Bees*, June 19, 2014, http://www2.epa.gov/sites/production/files/2014-06/documents/pollinator_risk_assessment_guidance_06_19_14.pdf.

[75] CRS communication with the Center for Food Safety, February 13, 2015.

[76] USDA, "Enhancing Nest Sites For Native Bee Crop Pollinators," *Agroforestry Notes*, AF Note 34, September 2007.

[77] EPA, "Benefits of Neonicotinoid Seed Treatments to Soybean Production," October 15, 2014, http://www2.epa.gov/sites/production/files/2014-10/documents/benefits_of_neonicotinoid_seed_treatments_to_soybean_production_2.pdf.

[78] EPA, "Benefits of Neonicotinoid Seed Treatments to Soybean Production," October 15, 2014. See also http://www2.epa.gov/pollinator-protection/benefits-neonicotinoid-seed-treatments-soybean-production

[79] Public statements by EPA's Assistant Administrator for the Office of Chemical Safety and Pollution Prevention, Jim Jones, at the 14th Annual NAPPC International Conference, October 22, 2014.

[80] EPA, "Summit on Reducing Exposure to Dust from Treated Seed," http://www2.epa.gov/pollinator-protection/2013-summit-reducing-exposure-dust-treated-seed.

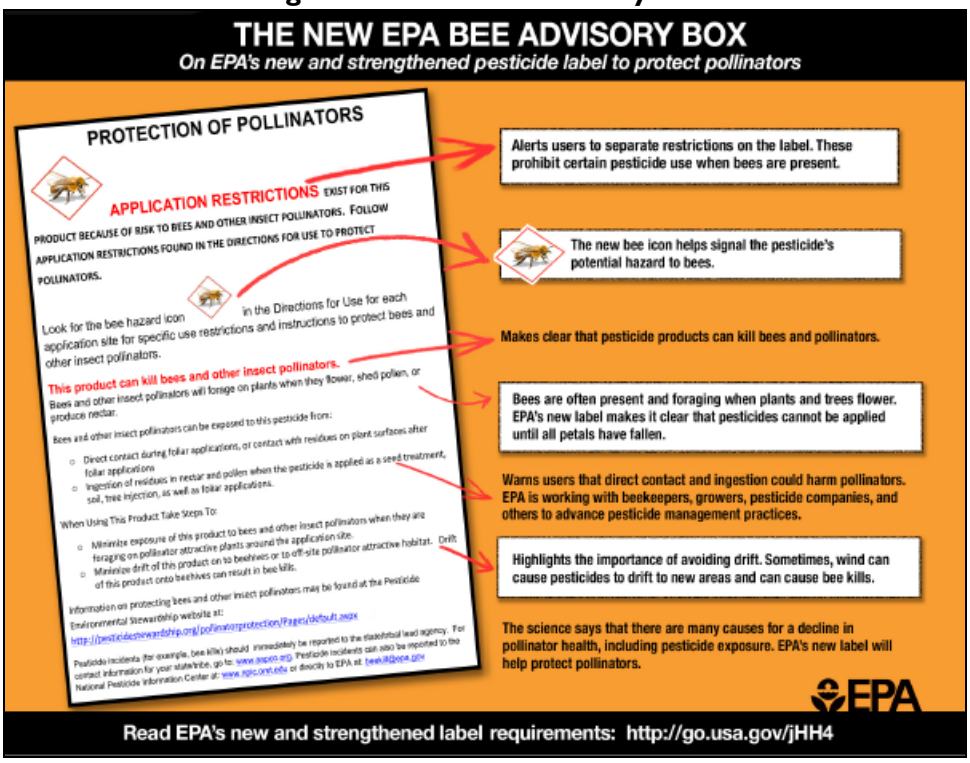
[81] 79 *Federal Register* 172: 53009: September 5, 2014.

barley, corn and wheat, both the crop itself and the straw and stover[82] left over after cultivation. According to some reports, the petition seeks to increase the tolerance levels ranging from about 1.5 times current levels for stover from sweet corn to about 400 times current levels for hay from wheat.[83] EPA's review of this request is still pending. Thiamethoxam is one of the neonicotinoid pesticides banned for use in the European Union.

EPA's New "Bee Advisory" Labeling Requirements

In August 2013, EPA announced that it had developed new pesticide labels that prohibit use of some neonicotinoid pesticide products where bees are present. The new requirements apply to foliar applications of products containing imidacloprid, dinotefuran, clothianidin, thiamethoxam, tolfenpyrad, and cyantraniliprole.[84] Exceptions apply under certain conditions for agricultural crops and commercially grown ornamental plants. The new labels require a "Pollinator Protection Box" (or "bee advisory," **Figure 3**) and bee icon with information on routes of exposure and spray drift precautions, as well as new language added under "Directions for Use."

Figure 3. EPA's Bee Advisory Box



Source: EPA, http://www2.epa.gov/sites/production/files/2013-11/documents/bee-label-info-graphic.pdf.

[82] Stover refers to the leaves and stalks of field crops, such as corn or soybeans, commonly left in a field after harvest.

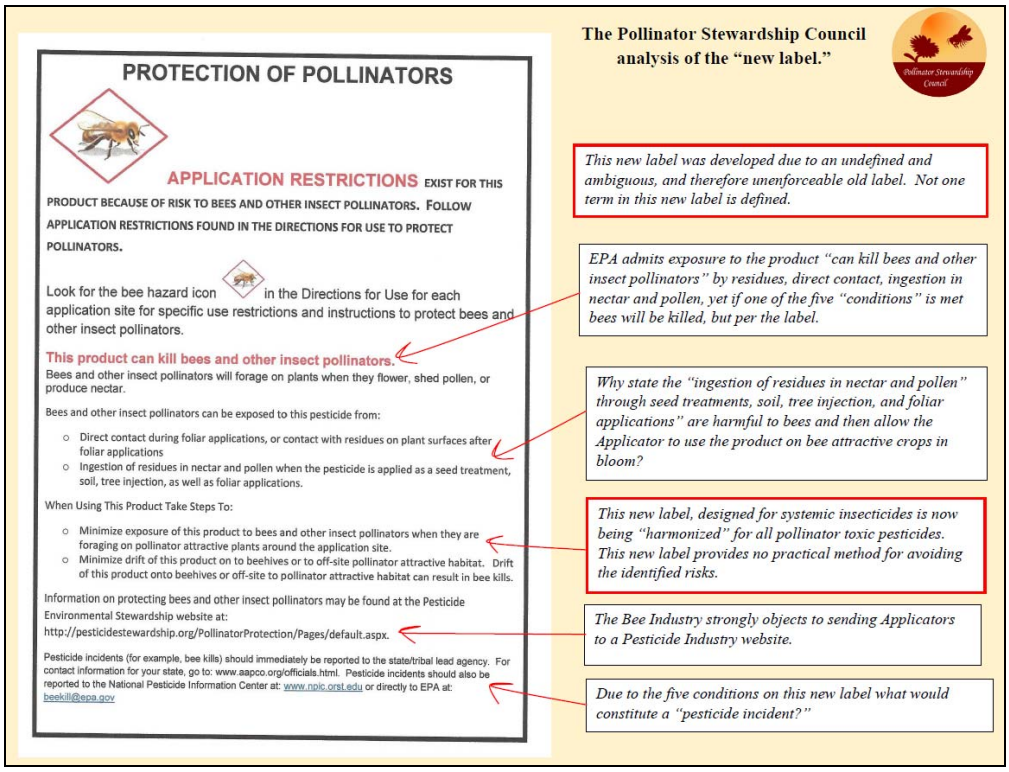
[83] T. Stecker, "Syngenta Asks EPA to Raise Tolerance Level for 'Bee-Killing' Chemical," *Greenwire*, September 5, 2014.

[84] EPA, "New Pesticide Labels Will Better Protect Bees and Other Pollinators," press release, August 15, 2013; and letter from EPA's Office of Investigations to the Pollinator Stewardship Council, February 28, 2014. See also letters from EPA to registrants of nitroguanidine neonicotinoid products, July 22, 2013, and August 15, 2013.

The bee advisory will, among other things, alert pesticide applicators to restrictions regarding certain pesticides when bees are present; clarify that pesticides cannot be applied until all petals have fallen; and emphasize the importance of avoiding pesticide drift (for example, due to wind) to other areas where bees may be present. The new bee icon will signal the pesticide's potential hazard to bees, and warns that direct contact and ingestion can harm pollinators. Information is at EPA's website.[85]

EPA's new labeling requirements have received mixed reviews from beekeepers, who argue that the new labels are inadequate and include exceptions that may make them less protective for bees and other pollinators.[86] Groups, such as the Pollinator Stewardship Council, have expressed concerns about EPA's label as well as concerns about the conditions under pesticide applications would be allowed. **Figure 4** shows some of this group's concern with EPA's label, including concerns that none of the terms in the label is defined and many are ambiguous (which they claim makes the requirements unenforceable), as well as the concern that the label refers applicators to a pesticide industry website, among several other issues.[87]

Figure 4. Pollinator Stewardship Council's Analysis of EPA's Bee Advisory Box



Source: Pollinator Stewardship Council. Other comments regarding exceptions to the label's requirements are at http://pollinatorstewardship.org/wp-content/uploads/2014/02/PSC-label-layout-of-concerns.pdf.

[85] EPA, "New Labeling for Neonicotinoid Pesticides," http://www2.epa.gov/pollinator-protection/new-labeling-neonicotinoid-pesticides.

[86] J. R. Pegg, "State Pesticide Officials, EPA Ready to Join Forces on Pollinator Protection," *Food Chemical News*, December 10, 2014.

[87] For more information, see Pollinator Stewardship Council, "Analysis of the New Label," http://pollinatorstewardship.org/wp-content/uploads/2014/02/PSC-label-layout-of-concerns.pdf.

Some groups, including the Pollinator Stewardship Council, have voiced concerns about EPA's exceptions to the new labeling requirements, which would allow application under certain conditions.[88] Exceptions to the labeling requirements are as follows.

For "**Crops Grown Under Contracted Pollination Services**," the label for some neonicotinoid pesticide products states: "Do not apply this product while bees are foraging" or "until flowering is complete and all petals have fallen." Exceptions are allowed for in cases where "an application must be made when managed bees are at the treatment site, the beekeeper providing the pollination services must be notified no less than 48 hours prior to the time of the planned application so that the bees can be removed, covered or otherwise protected prior to spraying."

For "**Food Crops and Commercially Grown Ornamentals not Under Contract for Pollination Services But Attractive to Pollinators**," the label for some products also states: "Do not apply this product while bees are foraging" or "until flowering is complete and all petals have fallen." Exceptions are allowed for in cases where:

- The application is made to the target site after sunset.
- The application is made to the target site when temperatures are below 55˚F.
- The application is made in accordance with a government-initiated public health response.
- The application is made in accordance with an active state-administered apiary registry program where beekeepers are notified no less than 48 hours prior to the time of the planned application so that the bees can be removed, covered, or otherwise protected prior to spraying.
- The application is made due to an imminent threat of significant crop loss, and a documented determination consistent with an IPM plan or predetermined economic threshold is met. Every effort should be made to notify beekeepers no less than 48 hours prior to the time of the planned application so that the bees can be removed, covered, or otherwise protected prior to spraying.

Among the expressed concerns regarding EPA's exceptions to its label advisory are:[89]

- harm caused by foliar application of the affected pesticides will be the responsibility of the beekeeper, including damage or die-off from applications allowed for under the labels exceptions;
- uncertainty about what constitutes notifying a beekeeper to move their bees, and concern that native bees will be harmed since they are not similarly managed;
- foliar application of adjacent or nearby sites may affect bees since they have a 3-mile to 7-mile forage range;
- exceptions to applications made when temperatures are below 55˚F may affect bees that forage at temperatures as low as 45˚F; and

[88] Letter from EPA to registrants of nitroguanidine neonicotinoid products, August 15, 2013.

[89] Pollinator Stewardship Council, http://pollinatorstewardship.org/wp-content/uploads/2014/02/PSC-label-layout-of-concerns.pdf. See also blog posting, March 21, 2014, http://pollinatorstewardship.org/?p=2143.

- other labeling issues, including who decides when foliar treatments are needed, what are the criteria for determining whether treatment are needed, where should beekeepers transport bees during applications, and who determines what mitigation measures are appropriate.

Exceptions do not apply to non-agricultural crops, such as ornamental crops grown by homeowners, and the pesticide label requires that the product not be applied while bees are foraging or when plants are flowering.

EPA Support of State Pollinator Protection Plans

EPA is working with states to draft guidance on the development of EPA-approved, state-managed pollinator protection plans. Guidance is being developed by EPA's State FIFRA Research and Evaluation Group (SFIREG), and will outline a process for reviewing and accepting state pollinator protection plans as part of EPA's broader pollinator protection efforts related to pesticides. The draft guidance was presented at a December 2014 meeting of the Association of American Pesticide Control Officials (AAPCO),[90] and contained information on the core elements for EPA-approved state pollinator plans, the process for EPA review and updating of state plans, how to reference state plans through labeling requirements, and how to access recommended best management practices.[91] Pollinator protection plans are in place in several states, including California, Colorado, Florida, Mississippi, and North Dakota.[92] Other states are considering similar initiatives.

EPA Development of Voluntary Controls for Pesticide Drift

In October 2014, EPA announced a new voluntary Drift Reduction Technology (DRT) program to encourage the use of verified, safer pesticide spray products to reduce exposure and pesticide movement, and also to reduce costs to farmers from pesticide loss. EPA defines pesticide spray drift as the "movement of pesticide dust or droplets through the air at the time of application or soon after, to any site other than the area intended."[93] More information is at EPA's website.[94] A similar effort—the DriftWatch Specialty Crop Site Registry—provides for a voluntary communication tool between crop producers, beekeepers, and pesticide applicators, and is intended to protect high-value, pesticide-sensitive crops and commodities before applying pesticides.[95] The program is currently in use in many midwestern and mid-Atlantic states.

[90] SFIREG Full Committee meeting, December 8, 2014, http://aapco.org/meetings/agen-120814.pdf.

[91] C. Purdy, "EPA to Review State Pollinator Protection Plans," *Politico Morning Agriculture*, December 9, 2014.

[92] J.R. Pegg, "State Pesticide Officials, EPA Ready to Join Forces on Pollinator Protection," *Food Chemical News*, December 10, 2014.

[93] EPA, "Introduction to Pesticide Drift," http://www2.epa.gov/reducing-pesticide-drift/introduction-pesticide-drift. Pesticide droplets are produced by spray nozzles used in application equipment for spraying pesticides on crops, forests, turf, and home gardens. Dust formulations refer to very fine dry particles of pesticides.

[94] EPA, "Reducing Pesticide Drift," http://www2.epa.gov/reducing-pesticide-drift.

[95] Information is at DriftWatch's website: https://www.driftwatch.org/.

Fish and Wildlife Service Memorandum

In July 2014, the U.S. Fish and Wildlife Service (FWS) in the Department of the Interior announced that it would phase out the feeding of genetically engineered crops to wildlife and the use of neonicotinoid pesticides in all of its wildlife refuges by January 2016.[96]

Initially this decision was meant to phase out the use of neonicotinoids in Region 1 only, which covers Oregon, Washington, Idaho, Hawaii, and the Pacific Islands.[97] Under the guidelines, refuge managers will also need to comply with new mandatory requirements for all chemically treated seeds on refuge lands.[98]

In early 2013, Representative Austin Scott, chairman of a House Agriculture subcommittee, indicated that the committee would direct FWS to undergo "a uniform risk assessment process ... when making decisions on products already approved" under FIFRA and/or the Plant Protection Act.[99] To date, no such action has been untaken.

Other Ongoing Efforts

Restrictions in Some U.S. Cities and Counties

A number of cities and counties, among other local jurisdictions, have instituted restrictions on the use of neonicotinoid pesticides in an effort to protect pollinators. In March 2014, Eugene, Oregon, became the first U.S. city to restrict neonicotinoid use. (Despite the ban, a mass die-off of bees was reported in June 2014 at an apartment complex in northwest Eugene. It was attributed to insecticide sprayed on blooming linden trees.) Since then other cities have also instituted bans, including Seattle and Spokane in Washington; Shoreline, Minnesota; and Skagway, Alaska. Other cities and counties, such as Tucson and Pima County in Arizona, and Boulder County in Colorado, also are considering restrictions. Some state legislatures, including Alaska, California, Maryland, Minnesota, New York, New Jersey, Oregon, and Vermont, have considered legislation to further study and/or restrict neonicotinoid use. Some localities also have instituted other types of pesticide restrictions, such as with disclosure laws in the county of Kaua`i in Hawaii. Other localities have implemented programs to encourage households and municipalities to pledge to create "pollinator-friendly, toxin-free ecosystem habitats," such as in the city and county of Denver, Colorado. Some state agencies are actively studying the issue.[100]

[96] FWS memorandum, "Use of Agricultural Practices in Wildlife Management in the National Wildlife Refuge Service," July 17, 2014, http://www.peer.org/assets/docs/fws/FWS_Memorandum.pdf.

[97] T. Stecker, "FWS Bans GMO Feed, Bee-Killing Chemicals Nationwide," *Greenwire*, August 1, 2014.

[98] See Region 1 FWS memorandum, "Guidelines Regarding the Interim Use and Phase Out of Neonicotinoid Insecticides to Grow Agricultural Crops for Wildlife on NWRs in the Pacific Region," June 9, 2014.

[99] OpEd by U.S. Representative Austin Scott, "Protecting Bee Health Is a Long-Term Commitment," *Agri-Pulse*, 2013.

[100] See, for example, Minnesota Department of Agriculture Pesticide and Fertilizer Management Division, *Scoping a Review of Neonicotinoid Use, Registration and Insect Pollinator Impacts in Minnesota*, March 2014 (draft).

In addition, several states—California, Colorado, Florida, Mississippi, and North Dakota—have state pollinator protection plans in place, and other states are considering similar initiatives.[101] (For information, see "EPA Support of State Pollinator Protection Plans")

Restrictions in the European Union

Like the rest of the world, the countries of the EU have experienced overwinter honey bee colony losses. As reported by the nonprofit honey bee research association, COLOSS,[102] overwinter colony losses averaged 9% in 2013/2014, the lowest since the group began collecting such data in 2007.[103] Across countries, losses ranged from 6% to 12%. This is lower than results reported for 2012/2013, when overwinter losses ranged from 6% to a high of 37% across all reporting countries.[104] Another report commissioned by the European Commission and EU member states concluded honey bee colony mortalities were "better than previously expected" and "higher than normal in certain countries, with significant regional (and possibly temporal) differences."[105]

In response to concerns about declining bee populations, in May 2013, the European Commission (EC) adopted Regulation No 485/2013 banning the use of certain neonicotinoid pesticides for a period of two years, among other proposed limits on the use of other pesticides.[106] The regulation includes the following provisions:

- use of three neonicotinoid pesticides—clothianidin, imidacloprid, and thiamethoxam—is restricted for seed treatment, soil application (granules), and foliar treatment on bee attractive plants and cereals;
- any authorized uses are available to professionals only;
- any exceptions to these restrictions are limited to treating bee-attractive crops in greenhouses or in open-air fields after flowering; and
- restrictions are to be maintained for two years, effective December 1, 2013.

As new information becomes available, the EC will review the approval conditions for these three pesticides and take into account relevant scientific and technical developments. Previous mitigation measures (EC Regulation No 1107/2009) restricted spraying of insecticides on bee-attractive flowering crops.[107]

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[101] J.R. Pegg, "State Pesticide Officials, EPA Ready to Join Forces on Pollinator Protection," *Food Chemical News*, December 10, 2014.

[102] COLOSS (Prevention of honeybee COlony LOSSes), http://www.coloss.org/, collects data from 19 European countries, and also from Israel and Algeria.

[103] COLOSS, "Losses of Honey Bee Colonies over the 2013/14 Winter," July 18, 2014.

[104] COLOSS, "Losses of Honey Bee Colonies over the 2012/13 Winter," July 24, 2013.

[105] EpiloBee, "A Pan-European Epidemiological Study on Honeybee Colony Losses 2012-2013," August 2014. See also OPERA Research Center, *Bee Health in Europe—Facts & Figures* and *Bee Health in Europe, An Overview, 2012*, http://www.operaresearch.eu/.

[106] Regulation (EC) No 485/2013 of 24 May 2013 amending Implementing Regulation (EU) No 540/2011, as regards the conditions of approval of the active substances clothianidin, thiamethoxam and imidacloprid, and prohibiting the use and sale of seeds treated with plant protection products containing those active substances. See also European Commission, "Bees & Pesticides: Commission Goes Ahead with Plan to Better Protect Bees," http://ec.europa.eu/food/archive/animal/liveanimals/bees/neonicotinoids_en.print.htm.

[107] Restrictions were placed in some member states, such as Italy (ban on corn seed coating), Slovenia (ban on corn and (continued...)

The EC's 2013 regulatory action was in response to the European Food Safety Authority's (EFSA)[108] scientific assessment that identified "high risks for bees for some uses of three neonicotinoids (imidacloprid, clothianidin and thiamethoxam) and fipronil," such that "the approval criteria of these pesticides were no longer satisfied."[109] Regarding the three restricted pesticides, EFSA identified "high acute risks" for bees from exposure to pesticides associated with the production of several crops such as corn, grains, and sunflower, as well as exposure to residue in pollen and nectar in certain crops.[110]

The EU Commission has further proposed to restrict the use of fipronil, an insecticide which EFSA has identified as posing an acute risk to Europe's honey bees when they are exposed to seeds treated with the chemical.[111]

Other reports, such as a study published by the United Kingdom's Department for Environment, Food and Rural Affairs (DEFRA), dispute some of the findings linking bee health and exposure to neonicotinoids.[112] Other studies also highlight the likely multifaceted nature of possible factors contributing to pollinator declines.[113] Researchers in Europe continue to study this issue and reportedly are in the process of completing a large-scale study reviewing the landscape-scale effects of neonicotinoid use on crops.[114] Some member state officials are also questioning the ban and its possible effects on agricultural production.[115]

(...continued)

sugar beet seed coating), France (ban on corn and canola seed coating), and Germany (ban on corn seed coating). M. Dermine, "Neonicotinoids in the European Union," presentation at November 4, 2014, webinar.

[108] EFSA is an agency of the European Union that provides independent scientific advice and communication on existing and emerging risks associated with food and feed safety.

[109] EC, "Bee Health: What Is the EU Doing? Questions and Answers," April 7, 2014 http://europa.eu/rapid/press-release_MEMO-14-260_en.htm. See also EC press releases, "Bee Health: EU-Wide Restrictions on Pesticide Use to Enter into Force on 1 December," May 24, 2013; and "Bees and Pesticides: Commission to Proceed with Plan to Better Protect Bees," April 29, 2013.

[110] Regarding the EFSA study, EPA claims its own scientific conclusions "are similar to those expressed in the EFSA report with regard to the potential for acute effects and uncertainty about chronic risk," but notes "the EFSA report does not address risk management" which is a requirement for EPA under U.S. law. See EPA, "Colony Collapse Disorder: European Bans on Neonicotinoid Pesticides," August 2013, http://www.epa.gov/pesticides/about/intheworks/ccd-european-ban.html.

[111] EC, "Bee Health: EU Takes Additional Measures on Pesticides to Better Protect Europe's Bees," July 16, 2013, http://europa.eu/rapid/press-release_IP-13-708_en.htm. EFSA's analysis, "Conclusion on the Peer Review of the Pesticide Risk Assessment for Bees for the Active Substance Fipronil," *EFSA Journal 2013*, 11(5):3158, 27 May 2013, http://www.efsa.europa.eu/en/efsajournal/pub/3158.htm.

[112] See, for example, DEFRA, Food and Environment Research Agency (FERA), "Effects of Neonicotinoid Seed treatments on Bumble Bee Colonies Under Field Conditions," March 2013.

[113] See, for example, a 2013 study by the European Landowners' Organization (ELO), the European Crop Protection Association (ECPA), and the European Initiative for Sustainable Development in Agriculture (EISA), "Pollinators and Agriculture: Agricultural Productivity and Pollinator Protection."

[114] P. Case, "Neonicotinoid Field Studies to Assess Effect on Bees," *Farmers Weekly*, September 26, 2014. Reportedly, large-scale field experiments will look at the effects on bees of two seed treatments—clothianidin and thiamethoxam.

[115] See, for example, N. Robinson, "Neonic Ban Threatens UK Mustard Crop," *FoodManufacture*, August 19, 2014; and M McGrath, "Scientific opinions differ on bee pesticide ban," *BBC News*, April 23, 2013.

Restrictions in Canada

In Canada, the Canadian Association of Professional Apiculturists (CAPA) reports that overwinter honey bee colony losses in 2013/2014 averaged 25% across Canada, but some provinces, such as Ontario, reported wintering losses of 58%.[116] In addition, in 2012, Health Canada's Pest Management Regulatory Agency (PMRA) began reporting higher bee mortalities associated with pesticide applications in some areas as part of its pesticide incidents reporting.[117]

In April 2012, PMRA reported a "significant number of honey bee mortality reports" in the provinces of Alberta, Manitoba, Saskatchewan, Nova Scotia, Quebec, and Ontario. Most reports were from southern Ontario, involving more than 40 beekeepers and 240 different locations, with also one report from Quebec involving eight bee yards. Health Canada concluded "an unusually high number of reports of honey bee mortalities were received from beekeepers in corn growing regions of Ontario and Quebec.... Timing and location of these honey bee mortalities appeared to coincide with planting corn seed treated with insecticides."[118]

PMRA's preliminary findings conclude "there is an indication that pesticides used on treated corn seeds may have contributed to at least some of the 2012 spring bee losses that occurred in Ontario."[119] The agency continued to "receive a significant number of pollinator mortality reports from both corn and soybean growing regions of Ontario and Quebec, as well as Manitoba" in spring 2013.[120] A 2013 field study by researchers at the University of Guelph reported no link between bee health and pesticide applications.[121]

Following this investigation, PMRA determined that "current agricultural practices related to the use of neonicotinoid treated corn and soybean seed are affecting the environment due to their impacts on bees and other pollinators."[122] The agency implemented measures to reduce honey bee exposure to dust generated during planting of treated corn seed, including "communication of best practices to reduce the exposure of honey bees, labelling of treated seed, a treated seed dust standard, and development of technical solutions to reduce dust, including developments in the areas of seed coating quality, seed flow lubricants, planting equipment, and disposal of treated seed bags."[123] For the 2014 planting season, PMRA issued additional protective measures for corn and soybean production.[124] PMRA has continued to re-evaluate nitro-guanidine neonicotinoids to

[116] CAPA, "CAPA Statement on Honey Bee Wintering Losses in Canada (2014)," July 2014. Losses in prior years are available at CAPA's website, http://www.capabees.com/.

[117] See, for example, Health Canada, "2012 Report on Pesticide Incidents," available at http://www.hc-sc.gc.ca/.

[118] Health Canada, "Evaluation of Canadian Bee Mortalities that Coincided with Corn Planting in Spring 2012," http://www.hc-sc.gc.ca/cps-spc/pubs/pest/_decisions/bee_corn-mort-abeille_mais/index-eng.php.

[119] Health Canada, "Ontario Bee Incidents 2012-Update," September 2013, http://www.hc-sc.gc.ca/cps-spc/pubs/pest/_fact-fiche/bees-incidents-abeilles-2012/index-eng.php.

[120] Health Canada, "Notice of Intent, NOI2013-01, Action to Protect Bees from Exposure to Neonicotinoid Pesticides," September 2013, http://www.hc-sc.gc.ca/cps-spc/pest/part/consultations/_noi2013-01/noi2013-01-eng.php.

[121] Presentation by C. Scott-Dupree, "Field Study Reliability: A Honey Bee & Neonicotinoid Perspective," University of Guelph, http://sesss08.setac.eu/embed/sesss08/Cynthia_Scott-Dupree_Field_study_Reliability_-_A_Honey_bee__Neonicotinoid_PERSPECTIVE.pdf.

[122] Ibid.

[123] Health Canada, "Pollinator Protection: Reducing Risk from Treated Seed," April 2013, http://www.hc-sc.gc.ca/cps-spc/pubs/pest/_fact-fiche/pollinator-protection-pollinisateurs/index-eng.php.

[124] Health Canada, "Notice of Intent, NOI2013-01, Action to Protect Bees from Exposure to Neonicotinoid Pesticides."

determine if further regulatory action was needed.[125] PMRA is reportedly also planning to implement label changes similar to those being considered by EPA in the United States (see "EPA's New "Bee Advisory" Labeling Requirements").

In November 2014, the province of Ontario announced a proposal to reduce the use of neonicotinoid-treated corn and soybean seed (based on acreage of treated seeds planted) by 80%.[126] If approved, the new regulations would go into effect by July 1, 2015, prior to the 2016 planting season. Manufacturers of the chemicals claim the decision is not supported by science. The Canadian industry association, CropLife Canada, is also urging the Canadian government to broaden its examination of bee population declines beyond pesticides and neonicotinoids.[127] The Canadian government continues to study this issue.[128]

In September 2014, two large beekeeping operations filed a class-action lawsuit[129] on behalf of Canadian beekeepers against several chemical manufacturers, claiming thiamethoxam (and its predecessor, imidacloprid) and its breakdown product clothianidin led to more than C$450 million (about US$410 million) in total damages from 2006 to 2013.[130] The alleged chronic effects of the use of these pesticides include "bee deaths; impaired reproduction; immune suppression; behavioral abnormalities resulting in hive loss; reduced honey production; impacts on the quality of honey; contamination of hive equipment; loss of queen bees; breeding stock; and difficulties fulfilling honey product or pollination contracts." The lawsuit alleges that Bayer and Syngenta were "negligent in their design and development of the neonicotinoid pesticides," and were and continue to be "negligent in their distribution and sale of the neonicotinoid pesticides," as well as "negligent in permitting or failing to prevent the damages caused by the neonicotinoids to the beekeepers." The plaintiffs further claim that Bayer and Syngenta "knew or ought to have known that the neonicotinoids would cause damage to the property" of beekeepers, since they allege that the harm to the beekeepers was "reasonably foreseeable."

Legal and Other Actions by Some Interest Groups

Selected Actions by Environmental Groups

A number of environmental and food safety advocacy groups, along with individual beekeepers, have remained active in pressing federal and state authorities on policies and issues pertaining to

[125] PMRA, "Re-evaluation Note REV2012-02, Re-evaluation of Neonicotinoid Insecticides," June 12, 2012, http://www.hc-sc.gc.ca/cps-spc/pubs/pest/_decisions/index-eng.php.

[126] See Ministry of the Environment and Climate Change, "Reducing Pesticide Use and Protecting Pollinator Health Ontario Sets Goal to Reduce Neonicotinoid Use by 80 Per Cent," November 25, 2014; and the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), "Pollinator Health: A Proposal for Enhancing Pollinator Health and Reducing the Use of Neonicotinoid Pesticides in Ontario," November 2014.

[127] "Canadian Industry Seeks Broader Approach to Bee Problem," *Food Chemical News*, November 15, 2013.

[128] See, for example, Environmental Commissioner of Ontario, *Managing New Challenges*, Annual Report 2013/2014.

[129] Sun Parlor Honey Ltd. and Munro Honey v. Bayer CropScience Inc., Bayer Inc., Bayer AG, Syngenta Canada Inc. and Syngenta International AG, Court File No.: CV-14-21208 (Ontario Superior Court of Justice, Ontario, Canada), September 2, 2014. The complaint is available at http://www.ontariobee.com/sites/ontariobee.com/files/DOCSLIB-%232440628-v1-AMENDED_Claim.pdf.

[130] The lawsuit seeks C$400 million (about $370 million) in general and specific damages and C$50 million (about $46 million) in punitive damages, plus interest and legal costs.

the approval and use of neonicotinoid pesticides, among other agrochemicals. Among these are the Center for Food Safety (CFS); Earthjustice; Pesticide Action Network North America (PANNA); Beyond Pesticides; Friends of the Earth; Sierra Club; and the Center for Environmental Health. These groups have published a series of widely available reports supporting their policy positions and/or have posted literature reviews on their organization's websites, and also have undertaken a series of legal challenges in these matters.[131]

In March 2013, CFS and a coalition of four beekeepers and five environmental and consumer groups filed a lawsuit against the EPA to stop the use of pesticides containing clothianidin and thiamethoxam, which beekeepers in the case claim is damaging the central nervous system of their bees.[132] The lawsuit also challenges EPA's risk assessment framework for determining whether pesticides harm pollinators and questions EPA's approval of certain neonicotinoids. An opening brief was filed in December 2013 further challenging EPA's risk assessment framework and requesting that the court reverse EPA's decision to register sulfoxaflor.[133] In July 2014, CFS, Earthjustice, PANNA, and Beyond Pesticides challenged California's approval of new agricultural uses for two neonicotinoid pesticides, Venom Insecticide and Dinotefuran 20SG.[134]

Previously, in 2005, two beekeepers residing in Minnesota sued the state's Department of Natural Resources for losses incurred from spraying of a pesticide, carbaryl. In that case, the pesticide users reportedly offered to settle, and the state's Department of Natural Resources stopped using the pesticide.[135]

These legal challenges follow previous requests for EPA to restrict the use of certain pesticides. In a March 2012 citizen petition, CFS and a coalition of beekeepers along with PANNA filed an "Emergency Petition" with EPA asking for a suspension of the use of clothianidin until it is proven safe to pollinators and the environment.[136] EPA responded in part to the petition in July 2012.[137] A few weeks later, EPA announced that it was denying the request to suspend

[131] For example, CFS, "Heavy Costs: Weighing the Value of Neonicotinoid Insecticides in Agriculture" (March 2014) and "Pollinators & Pesticides" (September 2013); PANNA, "Honey Bees and Pesticides: State of the Science" (May 2012); and Friends of the Earth, "Follow the Honey" (April 2014) and "Gardeners Beware" (October 2013, June 2014).

[132] Steve Ellis, Tom Theobald, Jim Doan, Bill Rhodes, CFS, et al. v. Steven P. Bradbury and Bob Perciasepe, U.S. Environmental Protection Agency, Case No. 3:13-Cv-01266-Lb (U.S. District Court for the Northern District of California, San Francisco Division), May 31, 2013. In addition to CFS, the coalition is represented by Beyond Pesticides, Pesticide PANNA, Sierra Club, and the Center for Environmental Health, as well as four beekeepers with operations located in California, Colorado, Florida, New York, and Minnesota. The amended complaint is at http://www.centerforfoodsafety.org/issues/304/pollinators-and-pesticides/legal-actions. For more information, see CFS, "CFS, Beekeepers and Public Interest Groups Sue EPA over Bee-Toxic Pesticides," March 21, 2013, http://www.centerforfoodsafety.org/issues/304/pollinators-and-pesticides/press-releases.

[133] Pollinator Stewardship Council et al. v. USEPA and Dow Agrosciences, Case No.13-72346 (U.S. Court of Appeals for the 9th Circuit), December 13, 2013. The amicus curiae brief is at http://www.centerforfoodsafety.org/issues/304/pollinators-and-pesticides/legal-actions.

[134] PANNA, CFS, and Beyond Pesticides v. California Department of Pesticide Regulation et al., Case No. RG14731906 (Superior Court for the State of California for the County of Alameda), July 8, 2014. The original complaint is at http://www.centerforfoodsafety.org/issues/304/pollinators-and-pesticides/legal-actions.

[135] Jeffrey Anderson, et al., v. State of Minnesota, Department of Natural Resources, A03-679 (State of Minnesota in Supreme Court), March 3, 2005 (posted: http://www.beyondpesticides.org/documents/MNSUPREME_Decision.pdf).

[136] Emergency Citizen Petition to the United States Environmental Protection Agency, March 12, 2013 http://www.centerforfoodsafety.org/files/cfs-clothianidin-petition-3-20-12_57213.pdf.

[137] EPA's response: S. P. Bradbury, EPA Office of Pesticide Programs, letter to Peter T. Jenkins, Center for Food Safety and International Center for Technology Assessment, "Clothianidin Emergency Citizen Petition dated March 20, 2012," July 17, 2012. The petition and numerous supplemental submissions of research reports and opinions are posted (continued...)

registrations "to prevent imminent harm" because the petitioners did not meet the burden of proof for registration suspension.[138] However, EPA received public comments on this decision and may revisit its decision as it reviews neonicotinoid registrations. Again, in July 2014, NRDC petitioned EPA to conduct an emergency review of the impacts of neonicotinoid pesticides on bees, and to complete its review within one year.[139] For more information, see "EPA's Pesticide Registration Review of Neonicotinoid Pesticides."

In June 2013, a coalition of advocacy groups, including CFS, sent a letter to President Obama asking him to order EPA to ban use of neonicotinoid insecticides for at least two years.[140] The letter asserts that the registration process lacks consideration of pesticide effects on colonies and focuses exclusively on acute mortality, rather than on sublethal effects of repeated exposure. Another letter followed in January 2015 from commercial beekeepers, environmental groups, and some food businesses, who continue to push for restrictions on pesticide use.[141]

Selected Actions by Agrochemical Companies

Some major agrochemical companies—in particular, Syngenta AG (a global Swiss agribusiness company) and Bayer AG (a global German company)—have been actively engaged in defending the use of neonicotinoid pesticides, among other agrochemicals, and claim there is no evidence to support a systematic correlation between honey bee colony mortality and the use of neonicotinoids.[142] Bayer's bee care pamphlet claims "poor bee health is correlated with the presence of *Varroa*, a parasitic mite, viruses and many other factors, but not with the use of insecticides."[143] These companies and other industry groups, as well as the trade association CropLife Amercia,[144] have published commissioned reports supporting their policy positions,[145] and have supported various pollinator health[146] as well as lobbying efforts.[147]

(...continued)

in the regulatory docket (docket: EPA-HQ-OPP-2012-0334-0015).

[138] 77 *Federal Register* 145: 44233-44234, July 27, 2012. Other information is in the regulatory docket (docket: EPA-HQ-OPP-2012-0334).

[139] NRDC, "Petition for Interim Administrative Review of Neonicotinoid Pesticides," filed July 7, 2014, http://docs.nrdc.org/health/files/hea_14070701a.pdf.

[140] The June 20, 2013, letter is available at http://www.centerforfoodsafety.org/files/final-neonic-letter-62013_43430.pdf. Also see P. Ambrosio, "Environmental Groups Urge President to Ban Neonicotinoids over Threat to Bees," *Bloomberg BNA Daily Environment Report*, June 24, 2013.

[141] See, for example, letter to U.S. President Barack Obama from more than 100 environmentally friendly food companies urging the Administration to protect bees and other pollinators from pesticides, January 13, 2015.

[142] "Crop Protection Industry Plans Response to EPA on Neonicotinoids," *Agri-Pulse*, October 29, 2014.

[143] Bayer pamphlet, "Honey Bee Health: Understanding the Issues, Providing Solutions."

[144] CropLife represents "companies that develop, manufacture, formulate and distribute crop protection chemicals and plant science solutions for agriculture and pest management" including Syngenta, Bayer, Dow, Dupont, and Monsanto.

[145] See, for example, Ag Infomatics, "Value of Neonicotinoids in North American Agriculture" (October 2014); and CropLife Foundation, "The Role of Seed Treatment in Modern U.S. Crop Production" (December 2013).

[146] For example: Bayer's "Bee Care Center" in North Carolina; Syngenta's funding of research grants to study causes of pollinator declines; and Monsanto's purchase in 2011 of the Beeologics research organization in Missouri.

[147] See, for example, postings by Corporate Europe Observatory, "Pesticides Against Pollinators: Private Letters Reveal Syngenta and Bayer's Furious Lobbying Against EU Measures to Save Bees," April 11, 2013, http://corporateeurope.org/agribusiness/2013/04/pesticides-against-pollinators.

According to news reports, both Syngenta and Bayer are legally challenging the EU's neonicotinoid ban.[148] Syngenta claims these pesticides are not responsible for the pollinator population declines, which they claim are instead the result of disease, viruses, habitat loss, and poor nutrition.[149] According to reports, Syngenta wants to reverse the EU ban but also wants to be compensated for damages and "defend our reputation which has been significantly damaged."[150] Syngenta claims the EU's decision to ban the pesticides is based on "a flawed process, an inaccurate and incomplete assessment by the European Food Safety Authority and without the full support of EU Member States."[151]

Syngenta also has petitioned EPA to increase the allowable threshold for residues of thiamethoxam. EPA published its proposal in September 2014.[152]

Congressional Consideration

Given continued concerns about the health and well-being of honey bees and other pollinators, this issue has continued to be legislatively active. The 2014 farm bill (P.L. 113-79) reauthorized and expanded provisions supporting research on honey bees and other pollinators that were enacted in the 2008 farm bill. In previous Congresses, bills were introduced to promote and improve habitat for honey bees and wild bees, among other pollinators.[153] Still other introduced legislation would address a range of pesticide issues affecting pollinators. Over the past few years, Congress has conducted hearings on this issue[154] and hosted a series of congressional briefings to discuss these and related issues representing a broad range of interested groups.[155]

For the 114th Congress, Representative Rodney Davis, the incoming chairman of the House Agriculture Subcommittee on Biotechnology, Horticulture, and Research, is quoted as saying that bee health will be a top issue for his subcommittee.[156]

[148] T. Rabesandratana, "Pesticidemakers Challenge E.U. Neonicotinoid Ban in Court," *Science*, August 28, 2013, http://news.sciencemag.org/europe/2013/08/pesticidemakers-challenge-e.u.-neonicotinoid-ban-court.

[149] Syngenta, "Syngenta Submits Legal Challenge to EU Suspension of Thiamethoxam," August 27, 2013, http://www.syngenta.com/global/corporate/en/news-center/news-releases/Pages/130827.aspx.

[150] T. Rabesandratana, "Pesticidemakers Challenge E.U. Neonicotinoid Ban in Court," *Science*, August 28, 2013, http://news.sciencemag.org/europe/2013/08/pesticidemakers-challenge-e.u.-neonicotinoid-ban-court.

[151] Syngenta, "Syngenta Submits Legal Challenge to EU Suspension of Thiamethoxam," August 27, 2013, http://www.syngenta.com/global/corporate/en/news-center/news-releases/Pages/130827.aspx.

[152] 79 *Federal Register* 172: 53009: September 5, 2014. For more information, see "EPA's Consideration to Modify Thiamethoxam Tolerance Levels."

[153] For more information, see CRS Report R43191, *Bee Health: Background and Issues for Congress.*

[154] See, for example, "Subcommittee Examines Research Efforts to Combat Pests and Diseases of Pollinators," House Agriculture Subcommittee on Horticulture, Research, Biotechnology, and Foreign Agriculture hearing, April 29, 2014.

[155] For example: "Impacts of Pesticides on Birds, Bees, and Broader Ecosystems" (March 2013); "Honey Bee Colony Health" (April 2013); "Applied Bee-Nomics" (June 2013); "What's Killing Our Bees?" (October 2013, December 2013); and "The Threat of Neonicotinoid Pesticides to Bees and Other Organism, and Risks to Human Health" (September 2014).

[156] T. Stecker, "New House Subcommittee Chief Will Push Forward on Bee Issues," *Environmental and Energy Policy*, December 16, 2014.

Saving America's Pollinators Act

In the 113th Congress, Representatives Earl Blumenauer and John Conyers Jr. introduced H.R. 2692, the Saving America's Pollinators Act of 2013. The bill would have suspended registrations of neonicotinoids and banned new registrations of any pesticide for use on "bee attractive plants, trees, and cereals." This bill was initially introduced, in part, as a response to reports that 50,000 bees were found dead in a suburban shopping-center parking lot in Wilsonville, Oregon, in June 2013, reportedly due to exposure to pesticides used on trees near the parking lot to control aphids.[157]

Specifically, the bill would have required EPA to "suspend the registration of imidacloprid, clothianidin, thiamethoxam, dinotafuran, and any other members of the nitro group of neonicotinoid insecticides to the extent such insecticide is registered, conditionally or otherwise," under FIFRA (7 U.S.C. 136 et seq.) "for use in seed treatment, soil application, or foliar treatment on bee attractive plants, trees, and cereals."

These suspensions on existing registrations and restrictions on new registrations would remain until more research is conducted and EPA determines that the insecticide will not cause "unreasonable adverse effects" on pollinators, including honey bees, native bees, and other pollinators. Such an assessment would be based on an evaluation of the published and peer-reviewed scientific evidence and a completed field study. The bill also would have required the Department of the Interior to coordinate with EPA in monitoring the health and populations of native bees, and annually report to Congress on their health and population status.

H.R. 2692 was similar to proposals being implemented or considered in the EU and Canada. In particular, the bill's language regarding "bee attractive plants, trees, and cereals" is similar to that under the EU's ban of the use of three neonicotinoid pesticides—clothianidin, imidacloprid and thiamethoxam—for "seed treatment, soil application (granules) and foliar treatment on bee attractive plants and cereals."[158] However, the EU's restrictions provide for certain exceptions (such as greenhouses and open-air fields after flowering), which are not provided for in H.R. 2692. (See "Restrictions in the European Union" for additional information on the EU's ban.)

In September 2014, the sponsors of H.R. 2692, along with 58 other Members of the U.S. House of Representatives, sent a letter to EPA urging the agency to "restrict and/or suspend the use of neonicotinoids on bee-attractive crops and ornamental application," including restricting the "times, methods of application, and location" for use of these pesticides, as well as urging EPA to review its policies related to EPA's pesticide registration, among other recommendations.[159] EPA received a similar letter from many environmental and sustainable agriculture organizations, including CFS, Friends of the Earth, Food and Water Watch, and other groups.[160]

[157] See, for example, press release on the bill by Representative Earl Blumenauer's office.

[158] Regulation (EC) No 485/2013 of 24 May 2013 amending Implementing Regulation (EU) No 540/2011, as regards the conditions of approval of the active substances clothianidin, thiamethoxam and imidacloprid, and prohibiting the use and sale of seeds treated with plant protection products containing those active substances.

[159] Letter to EPA Administrator Gina McCarthy from Representatives Earl Blumenauer and John Conyers and 58 other House of Representatives Members, September 30, 2014.

[160] Letter to EPA Administrator Gina McCarthy from Representatives Earl Blumenauer and John Conyers and 58 other House of Representatives Members, September 24, 2014.

Groups opposed to restrictions on pesticide use contend that comprehensive studies "challenge unsubstantiated claims against pesticides as a significant cause of colony decline" and note that "infrequent accidental exposures are not indicative of the general health of honey bee colonies."[161] Some further claim "there is no evidence linking neonicotinoids to bee declines" or to adverse health effects on bees.[162] They generally challenge studies that target neonicotinoids as the sole factor contributing to pollinator declines, and further maintain that unwanted pesticide exposure may be best addressed through "effective product labeling and the implementation of meaningful stewardship actions that help minimize harmful interactions."[163] Others question whether crop-applied pesticides pose a major risk to bees, given current approved uses and beekeeping practices.[164]

Expedited Pesticide Registration for Managing Parasitic Pests

In the 113th Congress, Representative Austin Scott introduced H.R. 5447, which would have amended U.S. pesticide laws (FIFRA; 7 U.S.C. 136a(c)(10)) to provide for expedited registration of pesticides that "improve managed pollinator bee health, including managing resistance to parasitic pests" and for expedited review of a pesticide registration that is "reasonably expected to improve the health of managed pollinator bees, including managing resistance to parasitic pests of managed pollinator bees," such as miticides. H.R. 5447 would have also required reports to Congress from both USDA and EPA. The report required from USDA would address the "extent and scope of the threat to the health of managed pollinator bees" from pathological factors (such as the parasitic mite, *Varroa destructor*; other arthropod pests; and fungal, microbial, and viral diseases) and from environmental factors (including habitat, forage, beekeeper practices and husbandry, and nutritional needs of managed bees). The report required by EPA would address the availability of pesticides to manage parasites and also EPA's efforts to expedite approvals of new products to control parasites of managed bees. The bill would have defined "managed pollinator bee" to mean "any bee that is raised and housed in a managed hive or other appropriate housing and used for honey production, managed pollination of crops, or breeding for commercial purposes." The bill was supported by some U.S. crop producers and other industry groups.

Some advocacy groups were opposed to H.R. 5447 and contend that "fast-tracking pesticide approvals" has contributed to current concerns involving bees and pesticides.[165] They further complain that focusing attention on other factors contributing to bee declines (such as mites) tends to shift attention away from remedies that could address beekeeper concerns about pesticide exposure, such as instituting agricultural best management practices (BMPs) that might avoid application of insecticides during bloom, and minimize exposure to bees by avoiding applications when pollen is available and bees are feeding.[166]

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[161] Testimony of David Fischer, Bayer North American Bee Care Center, at a House Agriculture Subcommittee on Horticulture, Research, Biotechnology, and Foreign Agriculture hearing, April 29, 2014.

[162] Statements by CropLife representatives reported by J. R. Pegg, "Groups Press EPA, California to Protect Bees from Neonicotinoids," *Food Chemical News*, July 14, 2014; also written correspondence from David Fischer, Bayer CropScience LP, to members of the North American Pollinator Protection Campaign (NAPPC), November 18, 2014.

[163] Testimony of David Fischer, Bayer North American Bee Care Center, at a House Agriculture Subcommittee on Horticulture, Research, Biotechnology, and Foreign Agriculture hearing, April 29, 2014.

[164] See, for example, A Fairbrother et al., "Risks of Neonicotinoid Insecticides to Honeybees," *Environmental Toxicology and Chemistry*, vol. 33, no. 4 (April 2014).

[165] CFS press release, "New Pollinator Bill Helps Pesticide Industry, Not Bees or Beekeepers," September 12, 2014.

[166] Pollinator Stewardship Council, "House Subcommittee Forgot to Ask Beekeeping Industry," May 2, 2014.

In February 2015, EPA announced its intentions to fast track approval of oxalic acid dihydrate for use as a miticide in beehives.[167] Oxalic acid has been used against varroa mites and is generally considered more safe compared to other higher risk chemicals. It has been approved for use in Canada since 2010, where a government analysis there claims: "An evaluation of available scientific information found that under the approved conditions of use the product has value and does not present an unacceptable risk to human health or the environment."[168]

[167] 80 *Federal Register* 23: 6084-6085, February 4, 2015.

[168] Canadian Honey Council, "Oxalic Acid," http://www.honeycouncil.ca/oxalic_acid.php.

Appendix. Review of the Scientific Literature[169]

Following is a summary of selected scientific literature based largely on publications in peer-reviewed journals.

Bee Exposure to Pesticides

Researchers at USDA and others found that "high levels" of fungicides were present in both crop and non-crop pollen collected by bees, and that "real world pollen-pesticide blends affect honey bee health."[170] These scientists found very high levels of the fungicide chlorothalonil in pollen and wax,[171] and found high levels of at least four insecticides, three other fungicides, and an herbicide. Chlorothalonil and the two miticides, fluvalinate and coumaphos, were most frequently detected in pollen and wax. A 2010 study tested samples of beebread,[172] trapped pollen,[173] brood nest wax,[174] beeswax foundation,[175] and adult bees and brood and found a broad range of pesticides, including acaricides (which kill arachnids like spiders, ticks, and mites), fungicides, insecticides, and herbicides.[176]

Bees can be exposed to neonicotinoids in many ways. One study identified multiple routes of exposure to low levels of neonicotinoids for honey bees living and foraging near agricultural fields planted with corn or soybeans.[177] The highest potential exposure to the pesticides appeared to occur during planting season, when bee mortality was also high. Clothianidin was found in about half the bee-collected pollen sampled, thiamethoxam (which is quickly metabolized to become clothianidin) in 3 of 20 samples, and fungicides in all pollen samples. Levels of clothianidin in some pollen were high enough to kill bees. Clothianidin was detected in all dead and dying bees but in no healthy bees. Although corn is not an insect-pollinated crop, this research demonstrated that bees forage for corn pollen and take it back to the hive. About half the hive pollen sampled came from corn in this study. In addition, the study documented high levels of pesticide in exhaust material from mechanical planters when pesticides and talc were used to coat seeds, and found clothianidin in soil samples from planted and unplanted fields.

[169] This section was originally prepared by CRS Analyst, Linda J. Schierow, now retired.

[170] J. Pettis, E. Lichtenberg, M. Andree, et al., "Crop Pollination Exposes Honey Bees to Pesticides Which Alters Their Susceptibility to the Gut Pathogen *Nosema ceranae*," *PLoS ONE*, v. 8. n. 7 (2013), p. e70182.

[171] Fungicides typically are applied to blooming plants which may be visited by bees. Labels on fungicides recommend such application for control of certain pests.

[172] Beebread is a pollen mixture stored in honeycomb cells and used with honey by bees as food. Beebread provides nutrition for the queen and brood.

[173] Trapped pollen refers to pollen collected at the entrance to the hive, removed from bees with the use of a trap.

[174] This is wax originating in the area of the hive where brood is reared.

[175] Foundation is the hexagonal sheets of wax and or wax/plastic combination that serves as a basis for comb construction by honey bees.

[176] C. A. Mullin, M. Frazier, J. L. Frazier, et al., "High Levels of Miticides and Agrochemicals in North American Apiaries: Implications for Honey Bee Health," *PLoS ONE*, v. 5, n. 3 (2010), p. e9754.

[177] C. Krupke, G. Hunt, B. Eitzer, et al., "Multiple Routes of Pesticide Exposure for Honey Bees Living near Agricultural Fields," *PLoS ONE*, v. 7, n. 1 (2012), p. e29268.

Other studies have measured neonicotinoids in pollen and nectar of canola (rape seed),[178] corn,[179] and sunflowers[180] grown from seed coated with pesticides. Levels found were below those known to be acutely toxic. Other studies have found that imidacloprid and thiamethoxam concentrations in nectar were greater in squash[181] and pumpkin flowers[182] when insecticide was applied to the soil than they were in canola and sunflowers grown from seed treated with neonicotinoids. Researchers also found metabolites of imidacloprid and thiamethoxam (clothianidin) in all parts of squash plants, along with the parent compound.[183]

A 2012 study found levels of neonicotinoids in bee-collected corn pollen that were similar to levels of imidacloprid determined by other scientists to have sublethal effects potentially affecting colony health.[184] Similarly, a subsequent study in 2013 found that imidacloprid levels in pollen gathered from bees in the field were high enough to cause sublethal effects on honey bees and bumble bees, based on laboratory research.[185] A 2013 study by the European Food Safety Agency (EFSA) of three neonicotinoid pesticides—imidacloprid, clothianidin, and thiamethoxam—determined that bees faced several risks including exposure to pollen and nectar, dust, and guttation fluid from maize.[186]

Another potential source of exposure was suggested by another 2012 study, showing that bees might be exposed to neonicotinoids in the corn syrup they are sometimes fed during the winter by

[178] G. C. Cutler and C. D. Scott-Dupree, "Exposure to Clothianidin Seed-Treated Canola Has No Long-Term Impact on Honey Bees," *Journal of Economic Entomology*, v. 100 (2007), pp. 765-772.

[179] J. M. Bonmatin, P. A. Marchand, R. Cahvet, et al., "Quantification of Imidacloprid Uptake in Maize Crops," *Journal of Agricultural and Food Chemistry*, v. 53 (2005), pp. 5336-5341; and C. Krupke, G. Hunt, B. Eitzer, et al., "Multiple Routes of Pesticide Exposure for Honey Bees Living near Agricultural Fields," *PLoS ONE*, v. 7, n. 1 (2012), p. e29268.

[180] F. M. Laurent and E. Rathahao, "Distribution of [^{14}C] Imidacloprid in Sunflowers (*Helianthus annuus L.*) Following Seed Treatment," *Journal of Agricultural and Food Chemistry*, v. 51 (2003), pp. 8005-8010; R. Schmuck, R. Schoning, A. Stork, et al., "Risk Posed to Honeybees (*Apis mellifera* L, Hymenoptera) by an Imidacloprid Seed Dressing of Sunflowers," *Pest Management Science*, v. 57 (2001), pp. 225-238.

[181] K A. Stoner and B. D. Eitzer, "Movement of Soil-Applied Imidacloprid and Thiamethoxam into Nectar and Pollen of Squash (*Cucurbita pepo*)," *PLoS ONE*, v. 7, n. 6 (2012), p. e39114.

[182] G. P. Dively and A. Kamel, "Insecticide Residues in Pollen and Nectar of a Cucurbit Crop and Their Potential Exposure to Pollinators," *Journal of Agricultural and Food Chemistry*, v. 60 (2012), pp. 4449-4456.

[183] K. A. Stoner and B. D. Eitzer, "Movement of Soil-Applied Imidacloprid and Thiamethoxam into Nectar and Pollen of Squash (*Cucurbita pepo*)," *PLoS ONE*, v. 7, n. 6 (2012), p. e39114.

[184] C. Krupke, G. Hunt, B. Eitzer, et al., "Multiple Routes of Pesticide Exposure for Honey Bees Living near Agricultural Fields," *PLoS ONE*, v. 7, n. 1 (2012), p. e29268. The study references other studies with similar findings, including H. V. V. Tomé, G. F. Martins, M. August, et al., "Imidacloprid-Induced Impairment of Mushroom Bodies and Behavior of the Native Stingless Bee *Melipona quadrifasciata anthidioides*," *PLoS ONE*, v. 7, n. 6 (2012), p. e38406; D. M. Eiri and J. C. Nieh, "A Nicotinic Cacetylcholine Receptor Agonist Affects Honey Bee Sucrose Responsiveness and Decreases Waggle Dancing," *Journal of Experimental Biology*, v. 215, n. 12 (2012), pp. 2022-2029; A. Decourtye, E. Lacassie, and M. Pham-Delegue, "Learning Performances of Honey Bees (*Apis mellifera L.*) Are Differentially Affected by Imidacloprid According to the Season," *Pest Management Science*, v. 59 (2003), pp. 269-278; or V. Mommaerts, S. Reynders, J. Boulet, et al., "Risk Assessment for Side-Effects of Neonicotinoids Against Bumblebees with and Without Impairing Foraging Behavior," *Ecotoxicology*, v. 19 (2010), pp. 207-215.

[185] J. Pettis, E. Lichtenberg, M. Andree, et al., "Crop Pollination Exposes Honey Bees to Pesticides Which Alters Their Susceptibility to the Gut Pathogen *Nosema ceranae*, *PLoS ONE*, v. 8. n. 7 (2013), p. e70182; P. R. Whitehorn, S. O'Connor, F. L. Wackers, et al., "Neonicotinoid Pestide Reduces Bumble Bee Colony Growth and Queen Production," *Science*, v. 336 (2012), pp. 351-352; and T. Blacquiere, G. Smagghe, C. A. M. van Gestel, et al., "Neonicotinoids in Bees: A Review on Centrations, Side-Effects and Risk Assessment, *Ecootoxicology*, v. 21 (2012), pp. 973-992.

[186] EFSA press release, "EFSA Press Release: EFSA Identifies Risks to Bees from Neonicotinoids," January 16, 2013.

beekeepers.[187] However, the researchers did not sample corn syrup actually fed to bees, but rather showed that bees would consume sufficient imidacloprid to produce toxic sublethal effects if they were provided contaminated corn syrup in the hive. Other research found no pesticides in samples of high-fructose corn syrup obtained from three major suppliers.[188]

Pesticide Effects on Bee Health

According to research cited in a 2007 study by the National Research Council (NRC), "the application of pesticides, especially insecticides used to control crop pests, kills or weakens thousands of honey bee colonies in the United States each year."[189] Nevertheless, the study concluded that *local* bee kills "likely have not contributed significantly to the recent *national* decline in colony populations" [emphasis added].[190]

Recent studies have begun to identify mechanisms by which some chemical interactions occur.[191] For example, some fungicides may inhibit an enzyme that bees need to detoxify miticides.[192] However, further research is needed since measurement difficulties continue to complicate study of this issue, including difficulty testing the in-field or field-realistic doses; effects at different life stages; how to account for cases of accidental exposure or exposure to multiple different types of pesticides; and how to account for species diversity (e.g., between honey bees and native bees), differences in nutritional needs/access and nesting sites, biological organization, and floral specialization.[193]

Generalizations about the relative importance of pesticides for global bee health cannot be drawn from available data, given the disparate study designs and results. Moreover, research has been and continues to be conducted, with most scientists focusing on a single pesticide or pathogen at a time. Consideration of interactions has been minimal—whether exposure from different types of chemicals or exposure from chemicals in combination with other factors. One study explains:

> Attempts to correlate global bee declines or CCD with increased pesticide exposures alone, have not been successful to date.… Pesticide interactions among various mixtures as well as with other stressors including *Varroa* and *Nosema*, IAPV, beneficial hive microbes, and impacts on bee immune systems all require further study. It seems to us that it is far too early to attempt to link or to dismiss pesticide impacts with CCD.[194]

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[187] Chensheng Lu, K. M. Warchol, and R. A. Callahan, "In Situ Replication of Honey Bee Colony Collapse Disorder," *Bulletin of Insectology*, v. 65, n. 1 (March 2012), pp. 99-106.

[188] G. DeGrandi-Hoffman, D. Sammataro, and R. Simonds, "Are Agrochemicals Present in High Fructose Corn Syrup Fed to Honey Bees (*Apis mellifera* L.)?" *Journal of Apicultural Research*, v. 51, n. 4 (2012), pp. 371-372.

[189] C. A. Johansen and D. F. Mayer, 1990, *Pollinator Protection, A Bee and Pesticide Handbook*.

[190] 2007 NRC study, p. 79.

[191] W. Mao, M. A. Schuler, and M. R. Berenbaum, "CYP9Q-Mediated Detoxification of Acaricides in the Honey Bee (*Apis mellifera*)," *Proceedings of the National Academy of Sciences of the United States of America*, v. 108, n. 31 (2011), pp. 12657-12662; and R. M. Johnson, H. S. Pollock, and M. R. Berenbaum, "Synergistic Interactions Between In-Hive Miticides in *Apis mellifera*," *Journal of Exonomic Entomology*, v. 102, n. 2 (2009), pp. 474-479.

[192] R. M. Johnson, L. Dahlgren, B. D. Siegfried, et al., "Acaricide, Fungicide and Drug Interactions in Honey Bees (*Apis mellifera*)," *PLoS ONE*, v. 8, n. 1 (2013), p. e54092.

[193] T. Blacquiere, et al., "Neonicotinoids in Bees: A Review on Concentration, Side-Effects and Risk Assessment," *Ecotoxicology*, vol. 21 (2012), pp. 973-992; and also comments by Nathalie Steinhauer (University of Maryland) to the Virginia Native Plant Society, October 9, 2014.

[194] C. A. Mullin, M. Frazier, J. L. Frazier, et al., "High Levels of Miticides and Agrochemicals in North American (continued...)

The study noted that the doses of individual pesticides found in bees were not concentrated enough to be lethal, but the authors remained concerned about possible chronic problems caused by long-term exposure and possible additive or synergistic effects of exposure to the combinations of pesticides found.[195] For example, numerous pesticides classified as pyrethroids that were found in the field have been shown to cause disorientation in honey bees.[196]

It is important to note that virtually all information about pesticide risks to bees derives from studies in cultivated fields or laboratories. There is little or no information about the possible impacts on bee populations of pesticides applied by homeowners (for example, to control mosquitos) or to ornamental plantings.

Nevertheless, a sizeable and growing body of scientific research presents compelling evidence suggesting that pesticide exposure may be harmful to bees and other animal species. For example, a 2014 meta-analysis covering 800 peer-reviewed reports over two decades examined the reported effects of systemic pesticides on ecosystems and a range of animal species—terrestrial invertebrates, including insect pollinators; aquatic invertebrates; and birds.[197] The analysis, conducted by entomologists and ornithologists based in Europe, concluded that neonicotinoid pesticides "pose a serious risk to honeybees and other pollinators such as butterflies and to a wide range of other invertebrates such as earthworms and vertebrates including birds."[198]

In response to reports that honey bees are disappearing and causing hives to collapse, recent studies of the impacts of exposure to imidacloprid and other neonicotinoids[199] have focused more on their potential to affect complex behaviors in insects, including flight, navigation, olfactory memory, recruitment, foraging, and coordination.[200] One study reported sublethal effects of neonicotinoid pesticides on honey bee foraging behavior that may impair the navigational and foraging abilities of honey bees.[201] Another study found a reduction of foraging activity and

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Apiaries: Implications for Honey Bee Health," *PLoS ONE*, v. 5, n. 3 (2010), p. e9754.

[195] C. A. Mullin, M. Frazier, J. L. Frazier, et al., "High Levels of Miticides and Agrochemicals in North American Apiaries: Implications for Honey Bee Health," *PLoS ONE*, v. 5, n. 3 (2010), p. e9754.

[196] H. Thompson and S. Wilkins, "Assessment of the Synergy and Repellency of Pyrethroid/Fungicide Mixtures," *Bulletin of Insectology*, v. 56 (2003), pp. 131-0134; and R. L. Cox and W. T. Wilson, "Effects of Permethrin on the Behavior of Individually Tagged Honey Bees, *Apis mellifera* L. (Hymenooptera, Apidae)," *Environmental Entomology*, v. 13 (1984), pp. 375-378.

[197] Findings of the task force (which is affiliated with the International Union for Conservation of Nature) are at http://www.tfsp.info. The published study is M. B. van Lexmond, et al., "Worldwide Integrated Assessment on Systemic Pesticides," *Environ Sci Pollut Res*, August 2014. See also M. Chagnon and D. Kreutzweiser, et al., "Risks of Large-Scale Use of Systemic Insecticides to Ecosystem Functioning and Services," *Environ. Sci. Pollut. Res.*, July 2014. See also D. Gibbons, C. Morrisey, P. Mineau, "A Review of the Direct and Indirect Effects of Nenicotinoids and Fipronil on Vertebrate Wildlife," *Environ. Sci. Pollut. Res*., June 2014.

[198] Press release, "Systemic Pesticides Pose Global Threat to Biodiversity and Ecosystem Services," June 24, 2014.

[199] D. Cox-Foster and D. vanEngelsdorp, "Solving the Mystery of the Vanishing Bees," *Scientific American*, March 31, 2009; Northwest Coalition for Alternatives to Pesticides, "Imidacloprid, Fact Sheet," *Journal of Pesticide Reform*, Spring 2001 (http://www.pesticide.org/imidacloprid.pdf); and Apiculteurs de France, "Composite Document of Present Position Relating to Gaucho, Sunflower and Bees" (http://www.beekeeping.com/articles/us/gaucho/manifestation_paris_us.htm). See also J. Cummins, "Neonicotinoid Insecticides Used in Seed Dressing May Be Responsible for the Collapse of Honeybee Colonies," Institute of Science in Society, April 24, 2007.

[200] BNA's *International Environmental Law Committee Newsletter*, vol. 11, no. 1, February 2009.

[201] M. Henry, M. Beguin, F. Requier, et al., "A Common Pesticide Decreases Foraging Success and Survival in Honey Bees," *Science*, v. 336, n. 6079 (2012), pp. 348-350; and K. A. Stoner and B. D. Eitzer, "Movement of Soil-Applied Imidacloprid and Thiamethoxam into Nectar and Pollen of Squash (*Cucurbita pepo*)," *PLoS ONE*, v. 7, n. 6 (2012), p. (continued...)

homing behavior of honey bees exposed to treated crops at certain exposure levels of neonicotinoids.[202]

Scientists at Bayer Crop Science argue with the findings of these and other studies, claiming that the dose of pesticide delivered to bees in some studies is not "field-relevant," resulting in findings obtained "under artificial conditions" and "in conflict with" earlier studies.[203] Some of the statements made in the 2012 Bayer Crop Science review of the scientific literature have been rebutted by researchers at Purdue University and Pennsylvania State University, based on comments submitted by the Center for Food Safety as part of EPA's public rulemaking docket.[204] Among a list of concerns regarding various statements in the Bayer Crop Science report, Professor Frazier from Pennsylvania State University states: "To object to a specific dose on the basis of an estimated level without giving the reader the actual basis for this neglects not only good science protocol, but also obfuscates any arguments."[205] Among other comments, Professor Krupke from Purdue University further acknowledges: "These data suggest that there is a strong likelihood that the neonicotinoids thiamethoxam and/or clothianidin were responsible for the bee kills we investigated."[206]

EPA has determined that clothianidin "has the potential to be highly toxic on both a contact and an oral basis" to honey bees.[207] EPA also has reported that one honey bee field study submitted to the agency indicates that "mortality, pollen foraging activity, and honey yield were negatively affected by residues of clothianidin," but the residue levels causing the effect were not reported. Acute effects also have been demonstrated in another field study. It showed that honey bees can be killed by exposure to pesticide-contaminated talc if they fly through dust clouds associated with planting,[208] but mortality appears to depend on high levels of humidity.[209] Health Canada has concluded that corn planting also was implicated in bee mortalities in Ontario during the spring planting season in 2012.[210]

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[202] C.W. Schneider, J. Tautz, B. Grünewald, et al., "RFID Tracking of Sublethal Effects of Two Neonicotinoid Insecticides on the Foraging Behavior of *Apis mellifera*." *PLoS ONE*, v. 7, n. 1 (2012), p. e30023.

[203] Bayer Crop Science, "Overview of Recent Publications on Neonicotinoids and Pollinators." Paper was prepared by Richard Heintzelman, Iain D. Kelly, David L. Fischer, and Christian Maus, May 23, 2012 (referred to here as Heintzelman et al.). Paper was submitted to CRS from Jean Reimers (CropLife America), June 20, 2012.

[204] Opinions submitted by Christian Krupke (Purdue University) and James Frazier (Pennsylvania State University) in response to a review of publications on neonicotinoids and pollinators prepared by Heintzelman et al. (May 23, 2012). These comments are contained within Appendix A and Appendix B, respectively, as part of public comments submitted to EPA by the Center for Food Safety (docket: EPA-HQ-OPP-2012-0334). The Center for Food Safety's own review of the scientific literature is titled "Pollinators and Pesticides," 2013.

[205] Ibid. Appendix B, "Opinion of Prof. James Frazier," June 14, 2012.

[206] Ibid. Appendix A, "Opinion of Prof. Christian Krupke," June 7, 2012.

[207] J. DeCant and M. Barrett, 2010, "Environmental Fate and Ecological Risk Assessment for the Registration of Clothianidin for Use as a Seed Treatment on Mustard Seed (Oilseed and Condiment) and Cotton," EPA/Office of Prevention, Pesticides and Toxic Substances, Office of Pesticide Programs, Washington, DC, p. 14.

[208] A. Tapparo, D. Marton, C. Giorio, et al., "Assessment of the Environmental Exposure of Honeybees to Particulate Matter Containing Neonicotinoid Insecticides Coming from Corn Coated Seeds," *Environmental Science & Technology*, vol. 46, no. 5 (2012), pp. 2592–2599.

[209] V. Girolami, M. Marzaro, L. Vivian, et al., "Fatal Powdering of Bees in Flight with Particulates of Neonicotinoids Seed Coating and Humidity Implication," *Journal of Applied Entomology*, v. 136, n. 1-2 (2012), pp. 17-26.

[210] Health Canada, "Evaluation of Canadian Bee Mortalities that Coincided with Corn Planting in Spring 2012," 2013.

Research has shown that honey bee exposure to sublethal levels of pesticides, including neonicotinoids, exhibit impaired brood development,[211] impaired olfactory associative behavior,[212] and impaired homing ability.[213] Exposure to sublethal levels of neonicotinoid has also been associated with higher rates of *Nosema* infection,[214] and also reduced immune functioning in those bees infected,[215] making bees more susceptible to viral infections.[216] In another study, responsiveness to sucrose and the bee's "waggle dancing" abilities[217] were adversely affected when honey bees ingested imidacloprid.[218] Another study alternatively fed honey bee hives corn syrup treated with imidacloprid, while other hives were fed untreated corn syrup. After 6 months, nearly all the treated hives collapsed, while the untreated control hives remained healthy.[219] Another study showed that imidacloprid ingestion by larvae of the stingless bee (*Melipona quadrifasciata anthidioidides*) resulted in decreased survival rates, negatively affected development of a specific region of the bee brain, and impaired walking behavior of newly emerged adult worker bees.[220]

A 2013 study found that exposure to a combination of an insecticide (imidacloprid) and a miticide (coumaphos) impaired learning and memory formation, important behaviors involved in foraging, in honey bees exposed under "field-realistic concentrations."[221] A similar study also showed

[211] Judy Y. Wu, Carol M. Anelli, and Walter S. Sheppard, "Sub-Lethal Effects of Pesticide Residues in Brood Comb on Worker Honey Bee (*Apis mellifera*) Development and Longevity," *PLoS ONE*, v. 6, n. 2 (2011), p. e14720.

[212] En-Cheng Yang, et al., "Impaired Olfactory Associative Behavior of Honeybee Workers Due to Contamination of Imidacloprid in the Larval Stage," *PLoS ONE*, v. 7. n. 11 (November 2012), p.e49472.

[213] T. Matsumoto, "Reduction in Homing Flights in the Honey Bee *Apis mellifera* After a Sublethal Dose of Neonicotinoid Insecticides," *Bulletin of Insectology*, vol. 66, no. 1 (2013), pp. 1-9.

[214] J. Y. Wu, M. D. Smart, C. M. Anelli, et al., "Honey Bees (*Apis mellifera*) Reared in Brood Combs Containing High Levels of Pesticide Residues Exhibit Increased Susceptibility to *Nosema* (Microsporidia) Infection," *Journal of Invertebrate Pathology*, v. 109 (2012), pp. 326-329; and J. Pettis, D. vanEngelsdorp, J. Johnson, et al., "Pesticide Exposure in Honey Bees Results in Increased Levels of the Gut Pathogen *Nosema*," *Naturwissenschaften*, v. 99 (2012), pp. 153-158.

[215] C. Alaux, J.-L. Brunet, C. Dussaubat, et al., "Interactions Between *Nosema* Microspores and a Neonicotinoid Weaken Honeybees (*Apis mellifera)*," *Environmental Microbiology*, v. 12 (2012), pp. 774-782; J. Y. Wu, M. D. Smart, C. M. Anelli, et al., "Honey Bees (*Apis mellifera*) Reared in Brood Combs Containing High Levels of Pesticide Residues Exhibit Increased Susceptibility to *Nosema* (Microsporidia) Infection," *Journal of Invertebrate Pathology*, v. 109 (2012), pp. 326-329; J. Pettis, D. vanEngelsdorp, J. Johnson, et al., "Pesticide Exposure in Honey Bees Results in Increased Levels of the Hut Pathogen *Nosema*," *Naturwissenschaften*, v. 99 (2012), pp. 153-158; and J. Pettis, E. Lichtenberg, M. Andree, et al., "Crop Pollination Exposes Honey Bees to Pesticides Which Alters their Susceptibility to the Gut Pathogen *Nosema ceranae*, *PLoS ONE*, v. 8. n. 7 (2013), p. e70182.

[216] G. Di Priscoa, V. Cavaliereb, D. Annosciac, et al., "Neonicotinoid Clothianidin Adversely Affects Insect Immunity and Promotes Replication of a Viral Pathogen in Honey Bees," *Proceedings of the National Academy of Sciences*, v. 110, no. 46 (2013), pp. 18466–18471. See also F. Sánchez-Bayo, "The Trouble with Neonicotinoids," *Science*, v. 346, issue 6211, November 14, 2014.

[217] Waggle dancing refers to when a bee communicates food locations to nest mates.

[218] D. M. Eiri and J. C. Nieh, "A Nicotinic Cacetylcholine Receptor Agonist Affects Honey Bee Sucrose Responsiveness and Decreases Waggle Dancing," *Journal of Experimental Biology*, v. 215, n. 12 (2012), pp. 2022-2029.

[219] Chensheng Lu, K. M. Warchol, and R. A. Callahan, "In Situ Replication of Honey Bee Colony Collapse Disorder," *Bulletin of Insectology*, v. 65, n. 1 (2012), pp. 99-106.

[220] H. V. V. Tomé, G. F. Martins, M. August, et al., "Imidacloprid-Induced Impairment of Mushroom Bodies and Behavior of the Native Stingless Bee *Melipona quadrifasciata anthidioides*," *PLoS ONE*, v. 7, n. 6 (2012), p. e38406. The mushroom body refers to a specific region of the bee brain.

[221] S. M. Williamson and G. A. Wright, "Exposure to Multiple Cholinergic Pesticides Impairs Olfactory Learning and Memory in Honeybees," *Journal of Experimental Biology*, v. 216, n. 10 (February 2013), pp. 1799-1807.

cognitive impairments from exposure to these same pesticides.[222] Studies also have found increased honey bee susceptibility to and mortality from *Nosema*[223] after exposure to sublethal concentrations of some pesticides (fipronil, amitraz, fluvalinate, chlorothalonil, pyraclostrobin, and imidacloprid).[224] Another study concluded that high levels of the fungicide chlorothalonil in pollen and wax may be associated with entombing behavior,[225] a sign that a hive has been poisoned. These and other pesticides commonly used to control mites have also been shown to have toxic effects on developing honey bee larvae at levels currently found in hives.[226]

A 2014 study reported linkages between CCD and sublethal exposure of neonicotinoid pesticides—imidacloprid and clothianidin—which affected the winterization of the bees, comparing exposed bee colonies to a control of non-exposed bee colonies.[227] In the study, one-half the bee colonies exposed to neonicotinoids exhibited symptoms resembling CCD and had abandoned their hives during the winter, whereas one-sixth of the control colonies were lost exhibiting *Nosema ceranae* symptoms. The control colonies did not abandon their hives but re-populated quickly; the surviving exposed colonies were small and either without queen bees or had no brood, according to the study. Some have criticized this study for its small sample size, lack of replication at each location, and the use of pesticide doses that may not reflect realistic field conditions.[228]

Researchers at USDA and affiliated bee laboratories at land grant universities throughout the United States continue to study the effects of neonicotinoids and other pesticides, including the effects of interactions between pesticides and other stressors.[229] Some of these studies demonstrate that exposure by bees to certain pesticides and/or combinations of insecticides (e.g., neonicotinoids with miticides) may affect the bee's overall energy budget, including its metabolism, physical activity, digestion, and immunity; cause other types of physiological effects;

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[222] M. J. Palmer, et al., "Cholinergic Pesticides Cause Mushroom Body Neuronal Inactivation in Honeybees," *Nature Communications*, v. 4, n. 1634 (March 2013).

[223] *Nosema* disease is a common bee disease, caused by a microscopic fungus (formerly considered to be a protozoan).

[224] J. Aufauvre, D. G. Biron, C. Vidau, et al., "Parasite-Insecticide Interactions: A Case Study of *Nosema ceranae* and Fipronil Synergy on Honeybee," *Scientific Reports* vol. 2 (2012), no. 326; C. Vidau, M, Diogon, J. Aufauvre, et al., "Exposure to Sublethal Doses of Fipronil and Thiacloprid Highly Increases Mortality of Honeybees Previously Infected by *Nosem ceranae*," *PLoS ONE*, v. 6, n. 6 (2011), p. e21550; and C. Alaux, J. Brunet, C. Dussaubat, et al., "Interactions Between *Nosema* Microspores and a Neonicotinoid Weaken Honeybees (*Apis mellifera*)," *Environmental Microbiology*, v. 12, n. 3 (2012), pp. 774-782; and J. Pettis, E. Lichtenberg, M. Andree, et al., "Crop Pollination Exposes Honey Bees to Pesticides Which Alters Their Susceptibility to the Gut Pathogen *Nosema ceranae*, *PLoS ONE*, v. 8. n. 7 (2013), p. e70182.

[225] Entombing refers to when bees seal up hive cells containing pollen to remove them from use and protect the hive from their contents. D. vanEngelsdorp, J. D. Evans, L. Donovall, et al., "'Entombed Pollen': A New Condition in Honey Bee Colonies Associated with Increased Risk of Colony Mortality," *Journal of Invertebrate Pathology*, v. 101 (2009), pp. 147–149.

[226] W. Zhu, et al., "Four Common Pesticides, Their Mixtures and a Formulation Solvent in the Hive Environment Have High Oral Toxicity to Honey Bee Larvae," *PLoS ONE*, v. 9, n. 1, p. e77547.

[227] Chensheng Lu, K. M. Warchol, and R. A. Callahan, "Sub-Lethal Exposure to Neonicotinoids Impaired Honey Bees Winterization Before Proceeding to Colony Collapse Disorder," *Bulletin of Insectology*, v. 67, n. 1 (2014), pp. 125-130.

[228] Comments attributable to Jeff Pettis (USDA) and other university researchers, and also representatives of the agro-chemical industries. See, for example, A. Boyle, "Hope for the Honeybees?" *NBC News.com*, May 14, 2014; and T. Philpott, "Did Scientists Just Solve the Bee Collapse Mystery?" *Mother Jones*, May 20, 2014.

[229] For example, presentations of preliminary findings of ongoing studies by Stephen Cook (USDA ARS Beltsville Bee Lab) to DC Beekeepers Alliance, September 17, 2014; and presentations of unpublished work by Nathalie Steinhauer (University of Maryland) to the Virginia Native Plant Society, October 9, 2014.

and affect different parts of the bee's nervous system, depending on the type or combination of insecticides studied among other variables, including diet and nutrition.[230]

A few studies have examined the effects of pesticides on various species of bumble bees. One study found that bumble bee exposure to imidacloprid may affect bee brain functioning, as well as colony growth and nest conditions.[231] Another study found that bumble bee colonies exposed in a laboratory to low levels of imidacloprid had a significantly reduced growth rate and an 85% reduction in queen production relative to untreated colonies.[232] Other studies have found that exposure of neonicotinoids could adversely affect foraging behavior,[233] reproductive success,[234] and locomotor behavior.[235] Another study showed effects following direct contact with a range of pesticides, including shortened life spans and inability to produce brood in worker bees; however, some pesticides and all fungicides tested reportedly did not result in sublethal effects.[236] Yet another study reported no adverse impacts on brood production or other sublethal effects on bumble bees from exposure to the neonicotinoid thiamethoxam.[237] One study showed that chronic exposure to two pesticides, one a neonicotinoid, at concentrations close to those found in fields "impairs natural foraging behavior and increases worker mortality leading to significant reductions in bumblebee brood development and colony success."[238] Bayer Crop Science argues that the results of some of these studies were also obtained "under artificial conditions and are in conflict with" earlier studies.[239]

A 2013 study examining the health of bumble bee colonies placed near crops treated with neonicotinoids were inconclusive due to weather and insufficient data, underlining the need to conduct further field studies that complement laboratory studies.[240] Some cite this study as evidence against the need to impose restrictions on the use of neonicotinoid pesticides,[241] while others criticize some of the study's published sources and research methodologies.[242]

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[230] Presentations of preliminary findings of ongoing studies by Stephen Cook (USDA ARS Beltsville Bee Lab) to DC Beekeepers Alliance, September 17, 2014.

[231] C. Moffat, J.G. Pacheco, S. Sharp, et al., "Chronic Exposure to Neonicotinoids Increases Neuronal Vulnerability to Mitochondrial Dysfunction in the Bumblebee (*Bombus terrestris*)," *Journal of the Federation of American Societies for Experimental Biology (FASEB)*, January 29, 2015.

[232] P. R. Whitehorn, S. O'Connor, D. Goulson, et al., "Neonicotinoid Pesticide Reduces Bumble Bee Colony Growth and Queen Production," *Science*, v. 336 (2012), pp. 351-352.

[233] V. Mommaerts, S. Reynders, J. Boulet, et al., "Risk Assessment for Side-Effects of Neonicotinoids Against Bumblebees with and Without Impairing Foraging Behavior," *Ecotoxicology*, v. 19 (2010), pp. 207-215.

[234] I. Laycock, K. M. Lenthall, A. T. Barratt, and J. E. Cresswell, "Effects of Imidacloprid, a Neonicotinoid Pesticide, on Reproduction in Worker Bumble Bees (*Bombus terrestris*)," *Ecotoxicology*, vol. 7 (2012), pp. 1937-1945.

[235] J. E. Cresswell, et al., "Clearance of Ingested Neonicotinoid Pesticide (Imidacloprid) in Honey Bees (*Apis mellifera*) and Bumblebees (*Bombus terrestris*)," *Pest Management Science*, v. 70, no. 2 (February 2014), pp. 332–337.

[236] See, for example, A. E. Gradish, et al., "Effect of Reduced Risk Pesticides for Use in Greenhouse Vegetable Production on *Bombus impatiens* (Hymenoptera: Apidae)," *Pest Management Science*, v. 66, no. 2 (2010), pp. 142-146.

[237] C. Elston, et al., "Sub-Lethal Effects of Thiamethoxam, a Neonicotinoid Pesticide, and Propiconazole, a DMI Fungicide, on Colony Initiation in Bumblebee (*Bombus terrestris*) Micro-Colonies," *Apidologie*, 2013.

[238] R. J. Gill, O. Ramos-Rodriguez, and N. E. Raine, "Combined Pesticide Exposure Severely Affects Individual- and Colony-Level Traits in Bees," *Nature*, v. 491, n. 7422 (2012), pp. 105-108.

[239] Bayer Crop Science, "Overview of Recent Publications on Neonicotinoids and Pollinators." Unpublished paper received from Jean Reimers (CropLife America), June 20, 2012.

[240] UK Department of Environmental Food and Rural Affairs (DEFRA), Food and Environment Research Agency, "Effects of Neonicotinoid Seed Treatments on Bumble Bee Colonies Under Field Conditions," March 2013.

[241] See, for example, J. Entine, "Bee Deaths Reversal: As Evidence Points Away from Neonics as Driver, Pressure (continued...)

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Builds to Rethink Ban," opinion piece published in *Forbes* magazine, February 5, 2014.

[242] See, for example, comments by University of Sussex professor Dave Goulson, "One More unto the Breach; a Look at DEFRA's Stance on Neonicotinoids," September 13, 2013, http://splash.sussex.ac.uk/blog/for/dg229.