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Bee Health: Background and Issues for Congress

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Summary

Bees, both commercially managed honey bees and wild bees, play an important role in global food production. In the United States alone, the value of insect pollination to U.S. agricultural production is estimated at $16 billion annually, of which about three-fourths is attributable to honey bees. Worldwide, the contribution of bees and other insects to global crop production for human food is valued at about $190 billion. 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.

Over the past few decades there has been heightened concern about the plight of honey bees as well as other bee and pollinator species. Although honey bee colony losses due to bee pests, parasites, and disease are not uncommon, there is the perception that bee health has been declining at a faster rate both in the United States and globally in recent years. This situation gained increased attention in late 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. In fact, 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 more than 30% annually since 2006.

To date, the precise reasons for bee colony losses are not yet known. Reasons cited for bee declines include a wide range of possible factors thought to be affecting pollinator species. These include bee pests and disease, 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 affected by cumulative, multiple exposures and/or the interactive effects of several of these factors.

USDA continues to research possible causes of bee colony losses, and has published a series of reports detailing the agency's progress in this area. In 2013, USDA and the U.S. Environmental Protection Agency (EPA) published a joint report, *National Stakeholders Conference on Honey Bee Health*. A 2007 report by the National Research Council of the National Academy of Sciences (NAS), *Status of Pollinators in North America,* also provides a detailed scientific context concerning bee health. Both USDA and the NAS report conclude that many factors contribute to pollinator declines in North America.

Following heightened concern over honey bee colony losses in 2006-2007, Congress provided for increased funding for bee research, among other types of farm program support to protect pollinators, as part of the 2008 farm bill (P.L. 110-246). In the 113th Congress, both the House- and Senate-passed versions of the 2013 farm bill (H.R. 2642 and S. 954) include provisions addressing honey bees and other pollinators. In addition, outside the farm bill debate, H.R. 2692 would suspend registrations of neonicotinoids and ban new registrations of any pesticide for use unless EPA determines the insecticide would not cause unreasonable adverse effects on pollinators, including honey bees and native bees, as well as other pollinators.

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Bees, both commercially managed honey bees and wild unmanaged bees, among many other types of insect pollinators, play an important role in global food production. In the United States, the value of pollination by bees and other insects to U.S. agricultural production is estimated at $16 billion annually.[1] Most of this estimated value (about 75%) is attributable to honey bees.

Given the importance of bees and other types of pollinators to food production, many have expressed concern about whether a "pollinator crisis" has been occurring in recent decades. Worldwide reports indicate that populations of both managed honey bees and native bees have been declining, with colony losses in some cases described as severe or unusual. In Europe, managed honey bee colony numbers have been declining since the mid-1960s, and individual beekeepers have reported "unusual weakening and mortality in colonies," particularly during the period spanning winter through spring.[2] According to the United Nations, many insect pollinator species may be becoming rarer, causing some to question whether this is a sign of an overall global biodiversity decline.[3]

In the United States, honey bee colony losses due to bee pests, parasites, pathogens, and disease are not uncommon. However, this situation gained increased attention in late 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). This issue was legislatively active in the 110th Congress and resulted in increased funding for pollinator research, among other types of farm program support to protect pollinators, as part of the 2008 farm bill (P.L. 110-246).[4]

Years later, the U.S. Department of Agriculture (USDA) reports that U.S. beekeepers continue to lose honey bee colonies each year. Since 2006, USDA estimates that overwinter colony losses have averaged more than 30% annually.[5] However, USDA reports that bee colonies have continued to decline each winter for reasons not solely attributable to CCD, which is characterized by colony populations that are suddenly lost and an absence of dead bees. (For more information on CCD, see text box on next page. Additional discussion is provided in "Factors Affecting Bee Health")

In fact, USDA claims that "beekeepers did not report CCD as a major cause of colony loss" for overwinter losses in the 2012-2013 and 2011-2012 surveys.[6] To date, the precise reasons for honey bee colony losses are still unknown.

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[1] N. W. Calderone, "Insect Pollinated Crops, Insect Pollinators and US Agriculture: Trend Analysis of Aggregate Data for the Period 1992–2009," *PLoS ONE* 7(5): e37235, May 2012. Updated values are for 2010.

[2] Ibid.

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

[4] For more information, see CRS Report RL33938, *Honey Bee Colony Collapse Disorder*.

[5] D. vanEngelsdorp et al., "Preliminary Results: Honey Bee Colony Losses in the United States, Winter 2012-2013," http://beeinformed.org/2013/05/winter-loss-survey-2012-2013/.

[6] From: K. Kaplan, "Fact Sheet: Survey of Bee Losses during Winter of 2012/2013," May 2013, http://www.ars.usda.gov/is/br/beelosses/index.htm.

Colony Collapse Disorder (CCD)

In late 2006, commercial beekeepers along the East Coast 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).

According to USDA: "The defining characteristic of CCD is the disappearance of most, if not all, of the adult honey bees in a colony, leaving behind honey and brood (immature bees confined to cells in the hive, including larvae and pupae) and the absence or dead bees (i.e., no dead bee bodies are present)." Symptoms include the following:

- rapid loss of adult worker bees,
- few or no dead bees found in the hive,
- presence of immature bees (brood),
- small cluster of bees with live queen present, and
- pollen and honey stores in hive.

Another defining characteristic that may be indicative of CCD is low levels of *Varroa* mite and other pathogens, such as *Nosema*, which are generally associated with most winter colony losses.

Since the honey bee is a very social insect and colony-oriented, with a complex and organized nesting colony, failing to return to the hive is considered highly unusual. Also, there is little evidence that the hive may have been attacked. In actively collapsing colonies, an insufficient number of adult bees remain to care for the brood. An absence of a large number of dead bees makes an analysis of the causes of CCD difficult. To date, the precise reasons for honey bee colony losses attributable to CCD are still unknown.

Reasons cited for bee colony declines include a wide range of possible factors thought to be negatively affecting pollinator species: bee pests and disease, 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 negatively affected by cumulative, multiple exposures and/or the interactive effects of each of these factors.

As reported by USDA: "While many possible causes for CCD have been proposed, reported, and discussed—both in the scientific literature and popular media—no cause has been proven."

Scientists at USDA and bee labs across the country continue to look for the cause or causes of CCD within four broad categories: (1) pathogens (such as *Nosema ceranae*); (2) parasites (such as *Varroa* mites); (3) environmental stressors (such as pesticides or lack of nectar diversity); and (4) management stressors (such as transportation stress by migratory beekeepers).

Sources: K. Kaplan, "Colony Collapse Disorder: An Incomplete Puzzle," *Agricultural Research* (USDA publication), July 2012; K. Kaplan, "Fact Sheet: Survey of Bee Losses during Winter of 2012/2013," May 2013; D. Evans, Yan Ping Chen, et al., "Predictive markers of honey bee colony collapse," *PLoS ONE*, vol. 7, no. 2 (p. e32151), 2012; NRC, *Status of Pollinators in North America*, 2007; USDA, *Colony Collapse Disorder Progress Report*, various years; and comments by Laurie Adams, North American Pollinator Protection Campaign (NAPPC), in a presentation to congressional staff on June 18, 2012. For other information, see CRS Report RL33938, *Honey Bee Colony Collapse Disorder*.

Reasons cited for honey bee population losses include a wide range of possible factors thought to be negatively affecting pollinator species. Potential identified causes include bee pests and disease, 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 negatively affected by cumulative, multiple exposures and/or the interactive effects of several of these factors.

Aside from the range of potential identified causes for bee colony declines, CRS Report R42855, *Bee Health: The Role of Pesticides*, addresses what role, if any, pesticides play in influencing the health and wellness of bees.

Given continued concerns about the health and well-being of honey bees and other pollinators, this issue has continued to be legislatively active in the U.S. Congress, and various proposals were again considered as part of farm bill debates in both the House and Senate in 2013.[7]

Overview of Selected Bee Species

More than 200,000 species of insects (bees, butterflies, moths, flies, wasps, beetles, and ants), bats (and other small mammals), and birds (including hummingbirds) are plant pollinators. This report focuses on bees—both managed honey bees and wild (mostly unmanaged) bee species.

Managed 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.[8] 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 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.

There are an estimated 115,000-125,000 beekeepers in the United States.[9] Most of these (roughly 90,000-100,000) are hobbyists with fewer than 25 hives.[10] Commercial beekeepers tend to have more than 300 hives. They migrate their colonies during the year to provide pollination services to farmers. In the United States, most pollination services are provided by commercial beekeepers.[11]

Some other types of native bees are also 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. Others are valued as primary or supplementary pollinators for members of the squash family such as cucumbers, watermelons, and cantaloupes. Some species of meliponine bees (commonly called stingless bees), which are mostly found in the tropics, were widely cultivated by Native

[7] For more information, see CRS Report R43076, *The 2013 Farm Bill: A Comparison of the Senate-Passed (S. 954) and House-Passed (H.R. 2642) Bills with Current Law.*

[8] National Academy of Sciences, National Research Council (NRC), *Status of Pollinators in North America*, 2007, p. 36; and S. Fecht, "Hive and Seek: Domestic Honeybees Keep Disappearing, but Are Their Wild Cousins in Trouble, Too?" *Scientific American*, May 8, 2012.

[9] National Honey Board, "Beekeepers and Honeybee Colonies," http://www.honey.com/nhb/media/press-kit/. Data from 2012 industry survey, *Bee Culture* magazine.

[10] A colony of bees is composed of between 250 and 50,000 individual bees (D. Sammataro and A. Avitabile, *The Beekeepers Handbook*, 4th ed.). Most larger healthy managed hives have between 20,000 and 50,000 bees.

[11] These operations are able to supply honey bee colonies during the critical phase of a crop's bloom cycle, when bees pollinate a crop as they fly from flower to flower collecting nectar and pollen, which they carry back to the nest.

Americans in Central and South America before the introduction of honey bees from Europe.[12] Roughly 500 species of bees native to North America show some degree of social behavior.

Wild Bee Species

An estimated 4,000 species of bees are native to North America.[13] With few exceptions, most of these are wild and not managed. Most types of wild bees are "solitary" bees—estimated at about 3,500 species—and do not have long-lived colonies.[14] Data and information on native bees are more limited than information on managed bees.

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. Compared to most native species, bumble bees (*Bombus)* are better studied. There are 239 species of bumble bees worldwide; of these, 60 species are found in the United States, Mexico, and Canada.[15]

Classification of Bees

Kingdom	Animalia—Animal
Phylum	Arthropoda—Arthropods
Class	Insecta—insects, hexapoda
Order	Hymenoptera—ants, bees, wasps
Superfamily	Apoidea—bees, sphecoid wasps, apoid wasps
Family	Andrenidae—andrenid bees, andrenids
Family	Apidae—honey bees, bumble bees, carpenter bees, squash bees, stingless bees
Family	Colletidae—colletid bees, plasterer bees, yellow-faced bees
Family	Halictidae—halictid bees, sweat bees
Family	Megachilidae—leafcutting bees, orchard bees, mason bees, resin bees
Family	Melittidae—melittid bees, melittids

Source: Integrated Taxonomic Information System (ITIS). ITIS is supported by a consortium of federal and international agencies and scientific organizations to provide authoritative taxonomic information on known plant and animal species. Available at http://www.itis.gov/. Condensed and slightly modified by CRS to include more common names.

Bees in the smaller Colletidae family are broader and wasp-like, and include plasterer bees. Bees in the Halictidae family include many species of sweat bees, and most have shiny metallic colored or black bodies. Bees in the Megachilidae family include resin and mason bees, orchard

[12] The shift by beekeepers to honey bees for more intensive production has also reduced the number of stingless bees.

[13] Iowa State University, "Native Bees of North America," http://bugguide.net/node/view/475348.

[14] NRC, *Status of Pollinators in North America*, 2007, p. 50; and Xerces Society, "Pollinator Conservation: Native Bee Biology," http://www.xerces.org/native-bees/.

[15] NRC, *Status of Pollinators in North America*, 2007, p. 43.

bees, and leaf-cutter bees that mostly nest in holes. Most families of bees contain some types of parasitic and cuckoo[16] bees. For a summary of the different types of wild bees see the text box above.

Importance of Bee Pollination

Worldwide, the contribution of bees and other insects to worldwide crop production for human food is valued at about $190 billion each year.[17] In the United States alone, the value of insect pollination to U.S. agricultural production is estimated at $16 billion annually, of which about three-fourths of the value is attributable to honey bees.[18]

Expressed somewhat differently, another widely cited estimate is that bee pollination of agricultural crops is said to account for about one-third of the U.S. diet, contributing to the production of a diverse range of high-value fruits, vegetables, tree nuts, forage crops, some field crops, and other specialty crops.[19]

Both managed and wild bees are critical to plant pollination and are economically valuable to U.S. agricultural production. Bee pollination of agricultural crops is said to contribute to the production of as many as 90 agricultural crops.[20] A number of agricultural crops are almost totally (90%-100%) dependent on animal pollination, including apples, avocados, blueberries, cranberries, cherries, kiwi fruit, macadamia nuts, asparagus, broccoli, carrots, cauliflower, celery, cucumbers, onions, legume seeds, pumpkins, squash, and sunflowers.[21] Other specialty crops also rely on pollination, but to a lesser degree.[22] USDA reports that native bees also provide pollination services for a number of food crops. In addition to some of the aforementioned crops, these include alfalfa seeds, almonds, canola, chokecherries, grapefruit, pears, plums, prunes, soybeans (hybrid seed production), tomatoes, vegetable seeds, and watermelons.[23]

[16] Refers to bees that lay their eggs in another bee's nest; as their eggs hatch early, the cuckoo larvae eat the other's provisions.

[17] N. Gallai et al., "Economic valuation of the vulnerability of world agriculture confronted with pollinator decline," *Ecological Economics*, 2009, 68: 810-821. Converted from the reported estimate of €153 billion (value in 2005).

[18] N. W. Calderone, "Insect Pollinated Crops, Insect Pollinators and US Agriculture: Trend Analysis of Aggregate Data for the Period 1992–2009," *PLoS ONE* 7(5): e37235, May 2012. Updated values are for 2010.

[19] M. R. Berenbaum, University of Illinois, statement before the Subcommittee on Horticulture and Organic Agriculture, U.S. House of Representatives, March 29, 2007; and J. Pettis, USDA's ARS, interview with University of Pennsylvania staff, January 23, 2007.

[20] Staple crops (wheat, corn, and rice) do not rely on insect pollination and are mostly wind-pollinated.

[21] R. A. Morse and N. W. Calderone, *The Value of Honey Bees as Pollinators of U.S. Crops in 2000*, March 2000, Cornell University; and A. M. Klein et. al., "Importance of pollinators in changing landscapes for world crops," *Proceedings of the Royal Society B: Biological Sciences*, Vol. 274, No. 1608, February 7, 2007.

[22] Crops include apricot, citrus, peaches, pears, nectarines, plums, grapes, brambleberries, strawberries, olives, melon (cantaloupe, watermelon, and honeydew), peanuts, cotton, soybeans, and sugarbeets.

[23] USDA, "Agroforestry: Sustaining Native Bee Habitat Crop Pollination," AF note-32, August 2006, http://plants.usda.gov/pollinators/Agroforestry_Sustaining_Native_Bee_Habitat_for_Crop_Pollination.pdf.

Estimated Economic Value

The economic value of pollination services provided by managed honey bees and wild bees is difficult to quantify. Most available estimates focus on crop pollination by managed honey bees. Data and information on native bees are more limited. Where few bee species are kept commercially and managed for their pollination services, wild bee species also play an important role in providing pollinator services to both commercial and small-scale home gardening systems.

Researchers at Cornell University estimate the monetary value to U.S. crops of total insect pollination—both commercial honey bees and other insect pollinators such as non-*Apis* bees and other insects—at about $16.4 billion in 2010.[24] (**Table 1**) Of the estimated $16.4 billion attributable to insect pollination in the United States, the value of pollination from honey bees is estimated at $12.4 billion, or about three-fourths of the total value. The value of pollination from other insects, including non-*Apis* bees and other insects, is estimated at $4.0 billion.[25] (**Table 1**).

Separate estimates of the economic value of only wild bee pollination services are not readily available. However, a 2011 study by researchers at the University of California estimated that wild bee species add $0.9 billion to $2.4 billion per year in value to California's agriculture through pollination services.[26] Additional efforts are underway in an attempt to estimate the value of pollination services of wild bees.

Commercial Migratory Beekeepers

In the United States, most commercial pollination services are provided by migratory beekeepers that travel from state to state and provide pollination services to crop producers. These operations are able to supply a large number of bee colonies during the critical phase of a crop's bloom cycle, when honey bees pollinate a crop as they fly from flower to flower collecting nectar and pollen, which they carry back to the nest.[27] Data from the USDA's *2007 Census of Agriculture* indicate that there were about 28,000 operations with 2.9 million bee colonies in the United States.[28] The majority of these, more than 2 million bee colonies, are reported to belong to commercial migratory beekeepers. The Dakotas accounted for a combined 27% of all bee colonies. Another one-fifth of all colonies are in California (about 14%) and Florida (7%).[29] Montana, Minnesota, Idaho, and Texas accounted for 4%-5% each of all colonies nationwide. Other states with a large number of bee colonies were Michigan, Oregon, Georgia, Nebraska, New York, Washington, Wisconsin, and Wyoming, with about 2% each. Although these

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[24] N. W. Calderone, "Insect Pollinated Crops, Insect Pollinators and US Agriculture: Trend Analysis of Aggregate Data for the Period 1992–2009," *PLoS ONE* 7(5): e37235. Updated from previous study estimates. Other available estimates for the total value of bee and insect pollination range from $5.7 billion to $19.0 billion annually (as reported in NRC, *Status of Pollinators in North America*, 2007).

[25] Other known insect pollinators are wasps, hover flies, other flies, beetles, thrips, ants, butterflies, and moths.

[26] R. Chaplin-Kramer, et al., "Value of Wildland Habitat for Supplying Pollination Services to Californian Agriculture," Rangelands, June 2011, Vol. 33(3): 33-41.

[27] Some "spillover" pollination occurs, including pollination from colonies owned by part-time beekeepers and hobbyists, or pollination of adjacent fields from commercial hives.

[28] Based on honey production statistics. USDA, *2007 Census of Agriculture*, Table 31, http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_US/st99_1_029_031.pdf.

[29] USDA, *Honey*, February 2009, http://usda.mannlib.cornell.edu/usda/current/Hone/Hone-02-27-2009.pdf.

operations also produce honey for commercial sale, their value as crop pollinators provides the greatest economic impact in the production of food and feed crops.

Table 1. Estimated Value of Insect Pollination to U.S. Crop Production, 2010

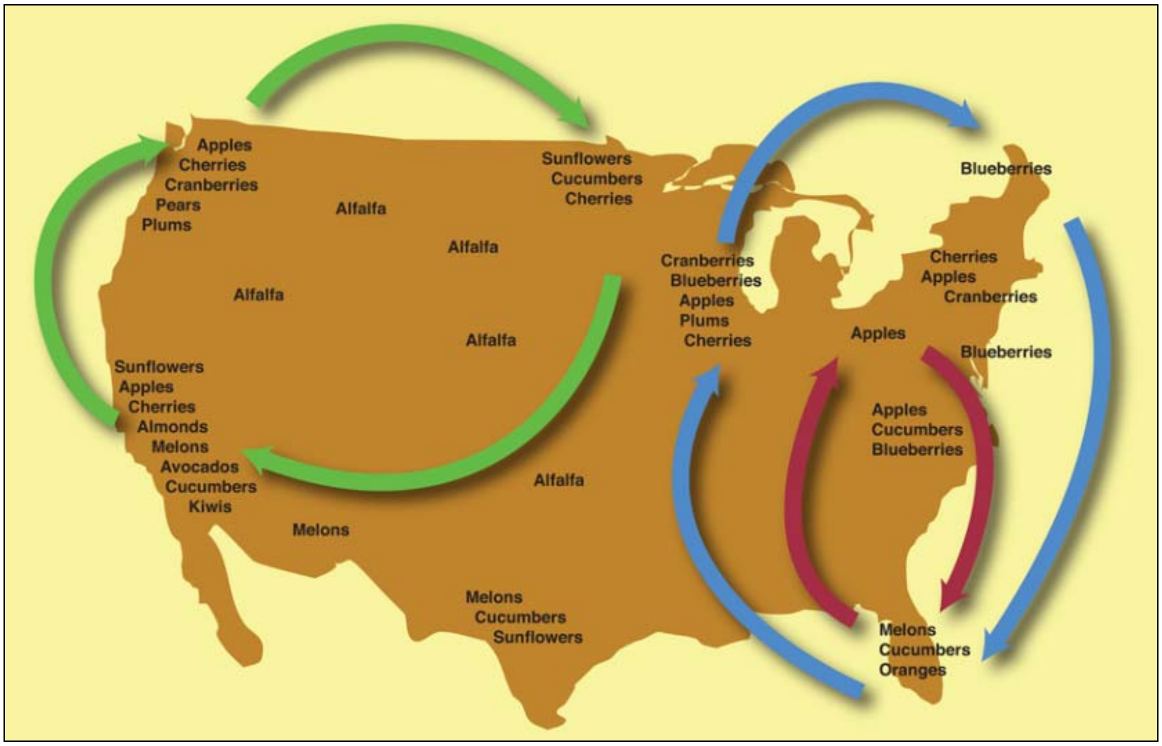
Crop Category	Dependence on Insect Pollination	Proportion of Pollinators That Are Honey bees	Value Attributed to All Insect Pollinators ($ millions)	Portion Attributed to Honey bees ($ millions)	Major Producing States
Grain and seed crops	10%-100%	20%-90%	826.9	744.2	CA, ND, SD, ID, WI
Peanuts	10%	50%	90.1	18.0	GA, FL, AL, TX, NC
Cotton (seed)	20%	80%	200.8	160.6	TX, AR, GA, MS
Apples	100%	90%	2,220.8	1,998.7	WA, NY, MI, PA
Peaches, nectarines	60%	80%	446.4	357.1	CA, SC, GA, PA, WA
Prunes, plums	70%	90%	163.2	146.9	CA, ID, MI, OR, WA
Cherries	90%	90%	685.5	617.0	WA, CA, OR, MI
Other fruit (incl. olives)	10%-90%	10%-90%	656.3	578.3	CA, FL, WA
Almonds	100%	100%	2,838.5	2,838.5	CA
Macadamia nuts	90%	90%	27.0	24.3	HI
Blueberries	100%	90%	644.0	579.6	ME, MI, GA, OR, WA, NJ
Strawberries	20%	10%	449.1	44.9	CA, FL, OR
Other berries	80%-100%	90%	551.7	496.5	WA, CA, OR
Oranges	30%	90%	580.5	522.4	CA, FL, AZ, TX
Grapefruit	80%	90%	228.8	205.9	FL, CA, AZ, TX
Lemons	20%	10%	76.1	7.6	CA, AZ
Tangerines, tangelos	40%-50%	90%	140.8	126.7	CA, FL
Soybeans	10%	50%	3,891.5	1,945.8	IA, IL, MN, IN
Cantaloupes	80%	90%	251.5	226.4	CA, AZ, GA, CO, IN, PA
Cucumbers	90%	90%	340.4	306.3	FL, GA, NC, CA, NY, MI
Squash	90%	10%	183.2	18.3	FL, NY, CA, NC
Other melons, pumpkins	70%-90%	10%-90%	489.0	356.2	IL, CA, NY, OH, PA, MI
Grapes	10%	10%	362.7	36.3	CA, OR, WA, VA
Total	—	—	**$16,345**	**$12,357**	—

Source: Compiled by CRS using values reported in N. W. Calderone, "Insect Pollinated Crops, Insect Pollinators and US Agriculture: Trend Analysis of Aggregate Data for the Period 1992–2009," *PLoS ONE* 7(5): e37235, May 2012, http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0037235. Supporting documentation provides data for individual crops from 1992 through 2009, with an update for 2010. Updates previous estimates by R. A. Morse and N. W. Calderone, *The Value of Honey Bees as Pollinators of U.S. Crops in 2000*, Cornell University, March 2000.

Notes: Value of crop production attributable to insect pollinators, including honey bees, is expressed in terms of the plant's dependence on pollination, and the insect's contribution to increased yield and quality achieved from pollination, including the indirect benefits of insect pollination required for seed production of some crops.

Of the reported more than 2 million bee colonies that are rented out to pollinate U.S. agricultural crops, an estimated 1.5 million colonies are needed each year to pollinate California's 750,000 acres of almond trees alone.[30] Increasingly, bee colony rentals are also being used to pollinate cultivated blueberries in the East Coast states and in the Midwest.[31] Other information indicates that bee colonies are also rented for apple, pear, plum, cherry, cranberry, avocado, cucumber, kiwi fruit, melon, pepper, and citrus fruit production, as well as for alfalfa, clover seed, and sunflower production.[32] (See map, **Figure 1**.) Both locally and globally, some are concerned that the availability of honey bee stocks is not keeping pace with growing agricultural demands for pollination services.[33]

Figure 1. Map of Commercial Pollination



Source: Posted at Person County (NC) Beekeepers Association by Inge Kautzmann, October 28, 2011, http://www.personcountybeekeepers.org/club-news/person-county-takes-1st-place-at-state-fair/.

Rental fees collected by commercial beekeepers for pollination services may vary by crop type, and tend to be lower for some seed crops and higher for berry and tree crops. In recent years, pollination fees paid by crop producers have increased. For example, fees paid by California's almond industry have risen from a reported $35 per colony in the late 1990s to about $75 per

[30] C. Souza, "What's the Buzz About Pollination?" *California Country* magazine, March/April 2011.

[31] "Honey Bees and Blueberry Pollination," Fact Sheet 629, University of Maine Extension, April 2002.

[32] Penn State University, "A Year in the Life of a Migratory Honey Bee Colony"; M. Burgett, *1999 Pacific Northwest Honey Bee Pollination Survey*, Oregon State University; and Pollination Map for Honey Bees in the United States, http://www.eduwebs.org/bugs/honey_bee.htm.

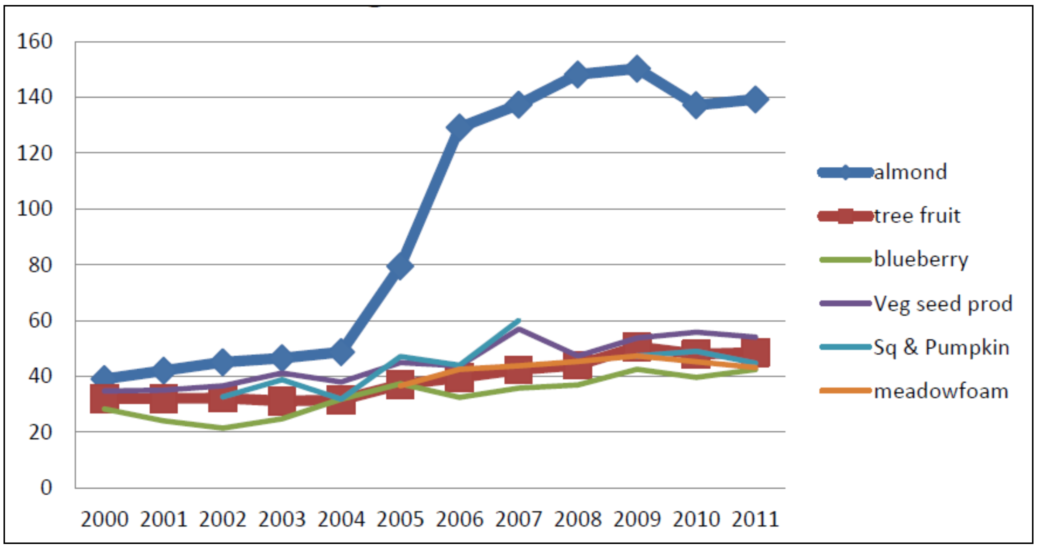
[33] See, for example, M. A. Aizen and L. D. Harder, "The Global Stock of Domesticated Honey Bees Is Growing Slower than Agricultural Demand for Pollination," *Current Biology*, May 2009.

colony in 2005. More recent estimates of fees for pollinating almond trees are even higher, at $150 per colony or more (**Figure 2**).[34] Fees may also vary by region.[35]

Among the reasons for higher pollination fees are expanding almond acreage and relatively high honey prices, but also fewer available honey bees for pollination due, in part, to colony declines and bee mortalities. In 2009, across a range of commodities (excluding almonds), average rental fees for pollination services ranged from $39 per colony to $70 per colony.[36]

Figure 2. Weighted Pollination Fee, by Major Sector, Northwest, 2000-2011

(total rental value divided by number of rental colonies [$/colony])



Source: D. M. Caron, R. Sagili, and M. Cooper, "Pacific Northwest (PNW) 2011 Beekeeper Pollination," http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/36916/SagiliRameshHorticulturePacific%20Northwest(PNW)2011Beekeeper.pdf?sequence=1.

Notes: "Weighted fee" = total rental value divided by number of rental colonies. Data for Eastern U.S. states are at D. M. Caron, "Bee Colony Pollination Rental Prices, Eastern U.S. with Comparison to West Coast," 2011, http://agdev.anr.udel.edu/maarec/wp-content/uploads/2011/02/Pollination-rentals-PNWEAST.pdf.

Changes in Bee Populations

Managed Honey Bees

USDA does not compile comprehensive annual survey data on honey bee colonies. Available data are limited and not ideal for evaluating population changes among honey bees. Annual data on the number of honey bee colonies are from statistics tracking the number of operations that produce honey for commercial sale. Additional data on all "colonies of bees" are from USDA's five-year

[34] D. M. Caron, R. Sagili, and M. Cooper, "Pacific Northwest (PNW) 2011 Beekeeper Pollination."

[35] D. M. Caron, "Bee Colony Pollination Rental Prices, Eastern U.S. with Comparison to West Coast," 2011, See table 1 (Crop Pollination in MAAREC Region (PA, DE, NJ, MD, VA, WV) and CA, 2008-2009).

[36] Ibid. Also see D. M. Caron, "Bee Colony Pollination Rental Prices, Eastern U.S. with Comparison to West Coast," 2011, See table 1 (Crop Pollination in MAAREC Region (PA, DE, NJ, MD, VA, WV) and CA, 2008-2009).

Census of Agriculture (the most recent available data are for 2007). In addition, in response to concerns about honey bee declines, USDA and the national bee laboratories have started to survey beekeepers each year regarding overwinter colony losses.

USDA data on the number of colonies in honey production are not strictly comparable. Data are compiled for different purposes—the *Census* data track all farms with bee colonies, the annual honey production data track operations that produce honey for commercial sale. Data are also compiled using different data collection techniques—one is a periodic census, the other a statistical estimate. Generally, USDA data are mostly intended to track the number of honey-producing colonies; however, it is the value of managed bees as crop pollinators that provides the greatest economic impact in the production of food and feed crops.

A 2007 study by the National Research Council (NRC) voiced concerns about the available USDA data on honey bees, cautioning against use of these data to determine changes in honey bee populations.[37] Concerns about the data include the following: the data track U.S. honey production rather than bee populations; the lack of comparability among the available data compilations; the potential for misidentification of species and miscounting because of data collection procedures; and other issues.

Notwithstanding these concerns about data availability and quality, the NRC study concluded: "Long-term population trends for the honey bee, the most important managed pollinator, are demonstrably downward."[38] Honey bee colony losses are not uncommon. The NRC study cites USDA data showing honey bee declines in 1947–1972 and 1989–1996, as well as declines starting in 2005 (despite reports of a sharp rise in 2010).

U.S. Farms with Bee Colonies

Data from the most recent USDA *Census of Agriculture* indicate that there were 2.9 million bee colonies on U.S. farms in 2007.[39] These data are based on the reported 27,908 farms with honey production during that year. Available limited historical data indicate that there were an estimated 6 million honey bee colonies on U.S. farms during the 1950s.[40] This may reflect ongoing consolidation and structural shifts in the U.S. agricultural sectors, rather than conclusive trends in species populations, abundance, and distribution.

Honey-Producing Bee Colonies

USDA annual data for honey-producing colonies are similarly inconclusive. These data show year-to-year fluctuations, but not a clear downward trend over time.

Over the 10-year period shown, the number of honey-producing bee colonies dropped from 2.6 million bee colonies in 2002-2003 to lows of 2.3 million to 2.4 million bee colonies in 2006-2008. In 2010, the sector reached a 10-year high when honey production increased and the number of honey bee colonies totaled nearly 2.7 million (**Table 2**).

[37] NRC, *Status of Pollinators in North America*, 2007, p. 3.

[38] Ibid.

[39] USDA, *2007 Census of Agriculture*, Table 31. Based on honey production statistics.

[40] Presentation to Congressional staff by Jeff Pettis, USDA/Agricultural Research Service, June 18, 2012.

After a drop to 2.5 million hives in 2011, the number of hives rebounded again to 2.6 million hives in 2012. This increase in the number of honey-producing hives may reflect efforts among beekeepers to continually replenish their hives—either in response to a colony die-off or to increase the number of hives to raise overall honey production or to provide additional pollinator services. This increase might also reflect the rising popularity of beekeeping as a popular part-time hobby.

Table 2. Honey-Producing Bee Colonies, 2002-2012

Year	Number of Honey-Producing Colonies (1,000 colonies)	Honey Production (1,000 pounds)
2002	2,574	171,718
2003	2,599	181,727
2004	2,556	183,582
2005	2,413	174,818
2006	2,393	154,907
2007	2,443	148,341
2008	2,342	163,789
2009	2,498	146,416
2010	2,692	176,462
2011	2,491	148,357
2012	2,624	147,092

Source: USDA, *Honey,* http://usda01.library.cornell.edu/usda/current/Hone/Hone-03-18-2013.pdf. Honey-producing colonies for producers with five or more colonies.

Notes: Areas with the most honey bee colonies include North and South Dakota, California, Florida, Montana, Minnesota, Idaho, and Texas. Other major states are Michigan, Oregon, Georgia, Nebraska, New York, Washington, Wisconsin, and Wyoming.

Annual "Winter Loss" Survey

Heightened attention following concerns about CCD has resulted in better tracking of annual honey bee colony losses by USDA and national bee laboratories. This effort has evolved into the collection of an annual winter loss survey, conducted by the Bee Informed Partnership[41] and the Apiary Inspectors of America (AIA), which is funded by USDA.

USDA reports that bee colony losses averaged 17%-20% per year between the 1990s and mid-2000s, attributable to a variety of factors, such as mites, diseases, and management stress.[42] By comparison, bee colony losses between the winters of 2006/2007 and 2012/2013 have averaged

[41] The Bee Informed Partnership is an extension project that seeks to decrease the number of honey bee colonies that die over the winter, in part through the creation of the so-called Bee Informed Database of honey bee health. This database will contain data collected by the Bee Informed Partnership survey efforts, as well as data from other honey bee health monitoring projects. Funding for the survey is from the Agriculture and Food Research Initiative of USDA's National Institute of Food and Agriculture. For more information, see http://beeinformed.org/about/bip-database/.

[42] Pollinator Partnership, "Helping the earth by supporting pollinators," 2009 publication. Estimates attributed to Jeffrey S. Pettis at USDA's Agricultural Research Service (ARS).

more than 30% annually. Reported annual loss rates of managed honey bee colonies from all causes nationwide are as follows:[43]

- 31% in the winter of 2012/2013;
- 22% in the winter of 2011/2012;
- 30% in the winter of 2010/2011;
- 34% in the winter of 2009/2010;
- 29% in the winter of 2008/2009;
- 36% in the winter of 2007/2008;
- 32% in the winter of 2006/2007.

Other information from USDA's 2012/2013 annual survey indicates that 70% of responding beekeepers reported losses greater than 14%—the level of loss that beekeepers say allow them to remain economically viable as a business.[44]

The first survey in this series was conducted by the AIA, covering the winter of 2006/2007.[45] Of the responding beekeepers, about one-fourth reported conditions associated with CCD.[46] The survey indicated that, among the beekeepers surveyed, more than 50% reported "abnormally heavy losses" with total colony losses of 55%. This compared to those reporting "normal losses" with total colony losses of 16%. Beekeeping operations experiencing CCD-like conditions reported losses of 45% of their managed bee colonies. Among the leading causes reported by most affected commercial beekeeping operations were pest diseases.

Subsequent survey results indicate that the number of managed honey bee colonies again dropped in each the following winters. One exception was overwinter 2011/2012, when surveyed total losses of colonies from all causes were 22% nationwide and represented a substantial improvement in mortality compared to the previous five years. The following year (2012/2013), however, total losses of managed honey bee colonies nationwide again reached more than 30% from all causes.

Based on the annual winter loss surveys, USDA estimates that overwinter colony losses have averaged more than 30% annually since 2006/2007. However, bee colonies have continued to "dwindle away" each year for reasons not solely attributable to CCD, which is characterized by colony populations that are suddenly lost.[47] In fact, USDA claims that "beekeepers did not report

[43] Past surveys are all posted on the Bee Informed Partnership website: http://beeinformed.org/category/winter-loss-survey/.

[44] K. Kaplan, "Fact Sheet: Survey of Bee Losses during Winter of 2012/2013," May 2013.

[45] D. vanEngelsdorp, R. Underwood, D. Caron, and J. Hayes Jr., "An Estimate of Managed Colony Losses in the Winter of 2006-2007: A Report Commissioned by the Apiary Inspectors of America," *American Bee Journal*, July 2007, http://www.ento.psu.edu/MAAREC/CCDPpt/CCDJuly07ABJArticle-1.pdf. Based on a survey of beekeepers that included 384 respondents representing 153,000 managed bee colonies located in AR, FL, GA, MD, MI, MS, MT, NM, ND, OH, PA, SD, TN, and WI. If the losses reported in this survey were representative of the nation, between 651,000 and 875,000 of the nation's estimated 2.4 million colonies were lost over the 2006/2007 winter.

[46] These statistics may have been misrepresented in the popular press, which often state that 25% of the nation's 2.4 million colonies have been lost (citing the AIA survey as its source).

[47] From: K. Kaplan, "Fact Sheet: Survey of Bee Losses during Winter of 2012/2013," May 2013,
(continued...)

CCD as a major cause of colony loss" of overwinter losses in both the 2012-2013 and the 2012/2012 surveys. Whether colony losses are attributable to CCD may be based, in part, on reported colony losses "with no dead bees present, which is indicative of CCD."[48]

Wild Bee Species

While managed bees are commercially important, wild bee species are important ecologically for sustainable forests and fields. However, no comprehensive formal statistics are available on populations of wild bees in the United States.

Of the estimated 3,500 species of solitary bees, none are thoroughly surveyed. Scientific literature is replete with assertions about the paucity of data on one group or another of native bees. Long-term data are particularly difficult to obtain for wild bees. As concluded by the researchers in a 2007 National Research Council (NRC) study, *Status of Pollinators in North America*, among all wild pollinators:

> There is evidence of decline in the abundance of some pollinators, but the strength of this evidence varies among taxa. Long-term population trends for several wild bee species (notably bumble bees) ... are notably downward. For most pollinator species, however, the paucity of long-term population data and the incomplete knowledge of even basic taxonomy and ecology make definitive assessment of status exceedingly difficult.[49]

In the absence of comprehensive data, as some of the studies cited below demonstrate, scientists seeking to find any data to analyze broad pollinator trends might be forced to rely on amalgamations of disparate studies, collections by citizen scientists,[50] and other unconventional approaches.

"Citizen Science" Surveys of Status

As various studies demonstrate, there have been numerous attempts to promote the use of various informal "citizen science" initiatives in California, Florida, other East Coast states, and elsewhere.[51] For example, compared to most native species, bumble bees (*Bombus)* are better studied. In part this is attributable to studies which recruit citizens to gather data—for example, forming Bumble Bee Brigades in one campaign.[52] Even so, information about wild bumble bees is not comprehensive.

(...continued)

http://www.ars.usda.gov/is/br/beelosses/index.htm.

[48] USDA, *CCD Progress Report*, June 2012, http://www.ars.usda.gov/is/br/ccd/ccdprogressreport2012.pdf, p. 9.

[49] For more information, see CRS Report RL31654, *The Endangered Species Act: A Primer*.

[50] A well-known example of citizen-scientist-based data in North America is the annual Christmas bird count, which has been conducted for nearly a century in some areas. Data may not serve for some quantitative analyses, but may be much more reliable for the presence or absence of a bird, for example. In other studies, on arrival dates at bird feeders, or bees on spring flowers, the date on which a species is first observed could be another relatively reliable observation.

[51] See, for example, the University of California's backyard bee count (http://www.greatsunflower.org/), the University of Florida's "Native Buzz" project (http://www.ufnativebuzz.com/), and the "Bee Hunt" project organized by multiple university staff, federal agencies, and private partnerships (http://www.discoverlife.org/bee/index.html).

[52] The University of Wyoming, through its Berry Center, sponsors the program. See http://www.uwyo.edu/berrycenter/citizen-science/bumblebees.html for more information.

In 2010, an international group of scientists reviewed global trends in pollinator species, including bees.[53] They cited a study based on data gathered by citizen-scientists in the United Kingdom and in the Netherlands (number of years of observation varying by location) showing that "in both countries, bee diversity has fallen significantly in most landscapes.... Analysis of pollinator traits demonstrated that in bees ..., specialist (diet and/or habitat) and sedentary species tended to decline, whereas mobile generalists tended to thrive." As the study notes, although the "dynamics between plants and their pollinators suggest a link between the two," this is correlative and the mechanism is still not known: "It could be that plant declines are caused, in part, by a lack of pollination services, or bees could be declining owing to a lack of floral resources" or both could be declining due to "shared sensitivity to environmental changes."[54]

Another North American study examined both museum collection records and intensive nationwide surveys for records of abundance and distribution of eight bumble bee species.[55] The study showed that four species of bumble bees have declined in relative abundance by up to 96%. These four species also contracted their ranges by 23% to 87%. These changes were statistically highly significant; the other four species examined showed no clear pattern in terms of range reduction. The study hypothesized that the four declining species may be affected by a pathogen (*Nosemi bombi*) as well as reduced genetic diversity.[56] The data were adequate only to show an association, rather than a cause—were the four species declining because of the disease and low genetic diversity? Or was some other factor causing these species to decline and making them more susceptible to the disease and also reducing their genetic diversity?

Endangered Species Act (ESA) Information

Another source of information about potential population changes among wild bee species includes listings under the Endangered Species Act (ESA, P.L. 93-205, 87 Stat. 884. 16 U.S.C. §§1531-1544). An ESA determination will include an analysis of the threats to a species, its current status and range, and other factors essential to its conservation.[57] For example, one bumble bee species (*B. franklini*) is thought to be extinct in its very limited (former) range in northeastern California and southeastern Oregon. The U.S. Fish and Wildlife Service (FWS) has this species under review for listing.[58] In addition, FWS has proposed seven species of yellow-faced bees (Genus *Hylaeus* in the Family Colletidae) for listing under ESA, with high priority for listing (2 on a scale of 12).[59] All members of this genus, including these seven, are found only in Hawaii.

[53] S. G. Potts, J. C. Biesmeijer, C. Kremen, et al., 2010, "Global pollinator declines: trends, impacts and drivers," *Trends in Ecology and Evolution*, v. 25, n. 6, pp. 345-353.

[54] Ibid.

[55] S. A. Cameron, J. D. Lozier, J. P. Strange, et al., 2011, "Patterns of widespread decline in North American bumble bees," *Proceedings of the National Academy of Sciences*, v. 108, n. 2, pp. 662-667.

[56] The study notes that some believe *Nosema bombi* was introduced via commercially imported European bumble bees, and North American bumble bees may therefore have less resistance to the disease than European species.

[57] NRC, *Status of Pollinators in North America*, 2007, p. 7. See also p. 88 (referring to *Bombus*, or bumble bees); p. 29 (referring to pollinators generally in North America); and p. 203 (referring to the absence of baseline data on pollinator status generally as an impediment to estimation of any decline).

[58] See FWS, "Species Profile," http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=I0IR.

[59] See FWS, "Endangered Species," http://www.fws.gov/endangered/.

Interactions with Physical Environment

Studies have showed that phenological changes[60] in flowering times are accompanied by changes in the spring emergence of bee populations.[61] Reviewing a number of previous studies on flowering times and pollination, one study found that 10 species of bees (including both solitary and social species) had advanced to earlier dates in the spring for their first emergence, and the flowering times of the plants they visited also advanced. Advances in emergence time over the period from 1970-2010 were highly significant. Various hypotheses to explain the difference were examined; the data "[support] the idea that climate change is the main factor explaining the observed phenological advances." However, the study concludes that "phenological mismatch probably has not occurred already, but that it could occur in the future, as rates of temperature warming increase." At the same time, the study noted that it analyzed generalist bees and generalist flowers—bees that visit many plant species, and plants visited by many bee species.[62] Where the life cycles of particular bee species are tied to particular plant species, different trends may occur. While no data were reported on the population sizes of these bees, in this study there was no clear connection between climate change (as measured by flowering times) and any harm to the species studied. The bees seemed to be keeping up with the changes in dates of flower availability.

The phenomenon known as *trophic cascade* may also play a role in the interaction of pollinator species. Many plants can be pollinated by more than one species, and many bee species use more than one pollen or nectar source. As individual pollinator species (bees or other species) decline, other species may take over the declining species' role. Where the data are available, evidence suggests that, where a generalist bee species is able to step in to provide pollination services (even if less able than a specialist bee), the effects of a reduced bee population may be masked by the generalist. In more concrete terms, the presence of a highly efficient generalist—like the honey bee—may mask the loss of native species (regardless of the reason for the decline of the native species). If honey bees themselves then decline, the effects of the lost population may be more severe because populations of back-up pollinators have already been reduced or eliminated. And conversely, reductions in honey bee populations may reduce competition sufficiently to allow other (reduced) bee populations to rebound to greater numbers.

Another study examined population changes in meliponine (or stingless) bees. Previously stingless bees were widely cultivated by Native Americans in Central and South America before the introduction of honey bees from Europe. However, loss of forest cover eliminates nesting sites; also the shift by beekeepers to honey bees for more intensive production has also reduced the number of stingless bees. An analysis of the effects of forestry on stingless bees in Brazil observed that most bee nests were found in hollow trees over 50 cm (~20 inches) in diameter.[63] Given the high value of the bees as pollinators for many species of plants, and the low commercial value of hollow trees, the study recommended that managed forests maintain hollow

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[60] *Phenology* refers to the scientific study of biological phenomena that are cyclical or periodic. Examples include migration, hibernation, and nesting, as well as flowering times. Phenology is particularly important in analysis of climate change.

[61] I. Bartomeus, J.S. Ascher, D. Wagner, et al., 2011, "Climate-associated phenological advances in bee pollinators and bee-pollinated plants," *Proceedings of the National Academy of Sciences*, v. 108, n. 51, pp. 20645-20649.

[62] The species studied were in four genera: *Andrena* (three species), *Bombus* (two species), *Colletes* (one species), and *Osmia* (four species).

[63] G. C. Venturieri, 2009, "The impact of forest exploitation on Amazonian stingless bees (Apidae Meliponini)," *Genetics and Molecular Research*, v. 8, n. 2, pp. 684-689.

trees as both seed sources and as homes for these bees.[64] In addition, some studies suggest that stingless bees are especially susceptible to some pesticides.[65]

Factors Affecting Bee Health

Among the factors that are thought to be harming bee health are (listed in no particular order):[66]

- **parasites, pathogens, and diseases**[67] (for a detailed listing, see text box);
- **bee genetics** including lack of genetic diversity and lineage of bees, and increased susceptibility and lowered disease resistance;
- **miticide resistance**;[68]
- **diet and nutrition** including poor nutrition due to apiary overcrowding, pollination of crops with low nutritional value, and pollen or nectar scarcity associated with invasive plants;
- **bee management issues** including transportation stress from migratory beekeeping, overcrowding, feeding practices, chemicals used by beekeepers to control mites (antibiotics and miticides), confinement and temperature fluctuations, susceptibility to disease, potential for cumulative exposure to diseases and parasites, use of bees for honey production versus pollination, chemical residue or contamination in the wax, and reliability of the queen source;
- **habitat loss, and other environmental or biological stressors** including loss of foraging area, interspecific competition between honey bees and native bees, pathogen spillover effects, and climate change;
- **pesticides** including acute or cumulative exposure to new types and combinations of agricultural pesticides through a variety of media including dust, water droplets, pollen, and nectar;
- **other agricultural practices** including the use of genetically incorporated pesticides in seeds or treated seeds, such as with bioengineered crops; and
- **potential cumulative and interactive effects** of each of these factors.

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[64] Ibid.

[65] H.V.V. Tomé, G.F. Martins, et al., 2012, "Imidacloprid-induced impairment of mushroom bodies and behavior of the native stingless bee Melipona quadrifasciata anthidioides," *PLoS ONE,* v. 7, n. 6, p. e38406, http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0038406.

[66] Compiled by CRS from multiple sources (2007 NRC study; 2013 Joint USDA-EPA report; USDA, *Colony Collapse Disorder Progress Report*, various years; comments by Laurie Adams, North American Pollinator Protection Campaign (NAPPC) in a presentation to Congressional staff on June 18, 2012.

[67] Among the leading causes of declining bee populations cited in the 2007 NRC study—which was published before CCD became a well-publicized phenomenon—were pathogens and introduced parasites, particularly *Varroa* destructor, the varroa mite. That study, among others, documents the extensive, but still inconclusive literature on honey bee population losses due to bee pests, parasites, pathogens, and disease, as well as other causes.

[68] A miticide is a pesticide intended to kill mites.

Pests and Diseases Affecting Honey Bees

As noted in the 2007 NRC study, among the leading causes of managed honey bee losses are diseases, parasites, and recently introduced competitors. Most notable are declines due to two parasitic mites, the so-called vampire mite (*Varroa destructor*) and the tracheal mite (*Acarapis woodi*). Also of concern is the emergence of new or newly virulent fungal and viral diseases. New invasive pests are also harming bees.

Below is a listing of some identified pests and diseases. For more information, see the 2007 NRC study, *Status of Pollinators in North America*. The following is excerpted mainly from *The Beekeepers Handbook*.

Honey bee diseases may be caused by a protozoan (e.g., bacteria or amoeba), fungus, or virus.

- ***Nosema* disease** is the most common adult bee disease, and is caused by a microscopic fungus (formerly considered to be a protozoan). Two *Nosema* species are found in honey bees: (1) *Nosema apis*; and (2) *Nosema ceranae* (the more virulent of the two).
- **American Foulbrood Disease (AFD)** is the most destructive of brood diseases. (Brood refers to the egg, larval, and pupal stages in bee development.) AFD is caused by a bacterium (*Paenibacillus larvae*) that occurs in a spore or a vegetative stage; the disease is transmitted by the spore and the infected brood is killed by the vegetative stage.
- **European Foulbrood Disease (EFD)** is also caused by a bacterium (*Melissococcus plutonius*) and is commonly found in colonies already weakened by lack of food or by other stressors.
- **Chalkbrood disease** is caused by a fungus (*Ascophaera apis*); adult bees can detect and remove diseased larvae; honey production may be reduced but the disease usually will not destroy a colony.
- **Amoeba disease** is caused by the amoeba *Malpighamoeba mellificae* Prell; it infests the gut of honey bees. Resistant spores (cysts) form in honey bees and can transmit the disease to other bees.
- Other less common adult diseases include **septicemia** and **spiroplasma.** Both are caused by bacteria. The former cause destruction of connective tissues; the latter infects the bees' blood. They tend to cause dysentery, and arise primarily from poor food and long periods of confinement.
- Some common **viral diseases** affecting honey bees include: Deformed Wing Virus (DWV); Black Queen Cell Virus (BQCV); Israeli Acute Paralysis Virus (IAPV); Acute Bee Paralysis Virus (ABPV); Sacbrood Virus (SBV); Kashmir Bee Virus; and Chronic Bee Paralysis Virus (CBPV).

Other pests are mostly invertebrates, but some vertebrates are problematic locally. Among these pests are parasitic mites, insects, and some larger animals.

- **Tracheal mites** (*Acarapis woodi*) are parasitic mites that live inside the breathing organs of adult bees, and eventually a newly mated female mite emerges from the old host bee.
- **Varroa mites**, now known mostly for the vampire mite (*Varroa destructor*), are large mites that feed on infested bees, resulting in disfigured, stunted adult bees and deformed larvae and pupae (varroosis).
- Emerging threats such as the parasitic **phorid fly** (*Apocephalus borealis*), known to parasitize bumble bees, have been found to also parasitize honey bees and can eventually cause bees to abandon their hives.
- **Major insect enemies** include the wax moth, and the small hive beetle.
- **Minor insect enemies** include assassin and ambush bugs, robber flies, mantids, wasps, and dragonflies.
- Various **vertebrate pests** include skunks, raccoons, bears, and mice.

One **competitor** deserves mention—the introduced Africanized honey bee. This bee is also a honey bee (*Apis mellifera*) but of a different strain from those imported from Europe. They are good foragers, but the colonies are more difficult to manage than the domestic European bee; they are sometimes called "killer bees" although an individual bee's sting is no more severe than that of a European bee. They were accidentally released in Brazil decades ago and have spread into the southern United States.

Sources: D. Sammataro and A. Avitabile, The Beekeepers Handbook, 4th Edition, pp. 189-232; Beekeepers Association of Northern Virginia, "Diseases, Parasites, Pests, and Predators," presentation materials; and for phorid flies, see A. Core, et al., "A New Threat to Honey Bees, the Parasitic Phorid Fly *Apocephalus borealis*," PLoS ONE 7(1), January 3, 2012, http://www.plosone.org/article/info:doi%2F10.1371%2Fjournal.pone.0029639.

Many of these factors were among those initially thought to be contributing to CCD.[69] As outlined in USDA's 2011 progress report, the available research over the past years has led USDA and university researchers to conclude that "no single factor or specific combination of factors has been identified as a 'cause' [for CCD]."[70] This has led researchers to further examine the hypothesis that CCD may be "a syndrome caused by many different factors, working in combination or synergistically";[71] it may also involve "an interaction between pathogens and other stress factors."[72] According to USDA: "Despite a number of claims in the general and scientific media, a cause or causes of CCD have not been identified by researchers."[73]

However, CCD may not be the single leading cause of honey bee colony losses in recent years.[74] USDA reports that in 2012/2013: "there were more colonies that dwindled away" rather than suffering from the onset of CCD, which is characterized by a sudden loss in bee colony populations.[75] Whether colony loss is attributable to CCD may be based, in part, also to on reported colony losses "with no dead bees present, which is indicative of CCD" (i.e., the absence of dead bees).[76] USDA also claims that "beekeepers did not report CCD as a major cause of colony loss" of overwinter losses reported in its 2012-2013 and 2011-2012 survey.[77]

Honey bee colony losses are not uncommon. The NRC study documents the extensive literature on honey bee population losses due to bee pests, parasites, pathogens, and disease.[78] Most notable are declines due to two parasitic mites, the so-called vampire mite (*Varroa destructor*) and the tracheal mite (*Acarapis woodi*), and also colony declines due to the pathogen *Paenibacillus larvae*. Other reasons for bee colony declines reported by the NRC include interspecific competition between native and introduced bees, pathogen spillover effects, habitat loss, invasive plant species that reduce nectar- and pollen-producing vegetation, bee genetics, and pesticides, among other factors.

Mite infestations are a relatively new occurrence. The 1980s saw two periods of large die-offs due to *Varroa* and tracheal mites: The first *Varroa* mite infestation was reported in 1987; tracheal mites were first detected in 1984.[79] *Varroa* mites are also said to have eliminated most feral bee colonies in the mid-1990s. *Varroa* parasitism affects both worker bees and male larvae and can affect the ability of the queen to reproduce. It is associated with viral pathogens and if left untreated can cause colony mortalities usually within six months to two years after the initial

[69] For more information, see CRS Report RL33938, *Honey Bee Colony Collapse Disorder*.

[70] USDA, *CCD Progress Report*, June 2011, http://www.ars.usda.gov/is/br/ccd/ccdprogressreport2011.pdf.

[71] USDA, *CCD Progress Report*, June 2009, http://www.ars.usda.gov/is/br/ccd/ccdprogressreport.pdf.

[72] D. vanEngelsdorp, J.D. Evans, C. Saegerman, et al., 2009, "Colony collapse disorder: A descriptive study," *PLOS One*, v. 4, n. 8, (August), e6481. doi:10.1371/journal.pone.0006481, http://www.plosone.org/article/info:doi/10.1371/journal.pone.0006481.

[73] USDA, "Honey Bees and Colony Collapse Disorder," http://www.ars.usda.gov/News/docs.htm?docid=15572.

[74] K. Kaplan, "Fact Sheet: Survey of Bee Losses During Winter of 2012/2013," http://www.ars.usda.gov/is/br/beelosses/index.htm.

[75] K. Kaplan, "Fact Sheet: Survey of Bee Losses During Winter of 2012/2013," http://www.ars.usda.gov/is/br/beelosses/index.htm.

[76] USDA, *CCD Progress Report*, June 2012, http://www.ars.usda.gov/is/br/ccd/ccdprogressreport2012.pdf, p. 9.

[77] K. Kaplan, "Fact Sheet: Survey of Bee Losses During Winter of 2012/2013."

[78] National Academy of Sciences, National Research Council, *Status of Pollinators in North America*, 2006.

[79] National Academy of Sciences, National Research Council, *Status of Pollinators in North America*, 2006; Interview with Maryann Frazier, Senior Extension Agent, Pennsylvania State University, January 28, 2007.

infestation. Less is known about the effects of the tracheal mite. The pathogen *Paenibacillus larvae* is the most serious honey bee pathogen and causes American foulbrood (AFB), which is a disease of larval honey bees. AFB resulted in large colony losses in the 1940s, but its incidence has been reduced by the use of antibiotics and increased apiary inspection programs. Nevertheless, mite and pathogen infestations have likely raised beekeeper operating costs to pay for miticides and/or antibiotics, labor and expenses for treatment, improved management and inspection, and colony replacement of dead bees.

Symptoms similar to those observed for CCD have been described in the past, and heavy losses have been documented. It is still not clear whether the current colony losses are being caused by the same factors or if new contributing factors are involved. Previously, similar conditions have been termed autumn collapse, May disease, spring dwindle, disappearing disease, and fall dwindle disease.

Identified Future Needs

Conclusions of USDA-EPA Joint Report

In 2013, USDA and the U.S. Environmental Protection Agency (EPA) published a USDA-EPA Joint report, *National Stakeholders Conference on Honey Bee Health*.[80] 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." A summary of the key findings of the 2013 USDA-EPA Joint report, as reported by EPA, is as follows:[81]

- **Address Risks to Honey bees from Parasites and Disease.** According to the report, the parasitic *Varroa* mite is recognized as "the major factor underlying colony loss" in the United States and in other countries. Moreover, there is "widespread resistance to the chemicals beekeepers use to control mites within the hive," and new virus species have been found in the U.S. and several of these have been associated with CCD.
- **Need for Increased Genetic Diversity in Bee Colonies.** Genetic variation improves bees' thermoregulation,[82] disease resistance, and worker productivity in colonies, and bee breeding should emphasize traits (such as hygienic behavior) that confer improved resistance to *Varroa* mites and diseases.
- **Need for Improved Nutrition for Honey Bees.** Nutrition has a major impact on individual bee and colony longevity, and a poor diet can make bees more susceptible to harm from disease and parasites. Bees need better forage and a variety of plants to support colony health, and federal and state programs should consider land management strategies that maximize available nutritional forage and to protect bees by keeping them away from pesticide-treated fields.

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[80] 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.

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

[82] Refers to the ability to keep body temperature steady even if the surrounding environment is different.

- **Need for 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 Needed.** According to EPA: "The 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 USDA Office of Pest Management Policy (OPMP), Pennsylvania State University, USDA National Institute of Food and Agriculture (NIFA), USDA Agricultural Research Service (ARS), USDA Animal and Plant Health Inspection Service (APHIS), USDA Natural Resources Conservation Service (NRCS), USDA National Agricultural Statistics Service (NASS), and EPA 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, the USDA-supported Bee Informed Partnership, and scientists at many of the land-grant universities nationwide.

USDA Actions and Funding

USDA's CCD Action Plan

USDA released its initial action plan for addressing CCD in July 2007. USDA's action plan focuses on improving coordination and redirecting existing resources and research for mitigation and prevention, including education and outreach, as well as expanding research and diagnostic resources to prevent future losses, working with the land grant universities. It also coordinates activities across three USDA agencies: the Agricultural Research Service (ARS), the Animal and Plant Health Inspection Service (APHIS), and the National Institute of Food and Agriculture (NIFA).

Under the plan, USDA would (1) conduct surveys and collect data on bee health; (2) analyze bee samples for pests, disease-causing pathogens, pesticide exposure, and other factors; (3) conduct controlled experiments to identify factors affecting bee health, including potential causes of colony collapses; and (4) develop best management practices and guidelines to improve general bee health and reduce susceptibility to colony collapses and other disorders among both honey bees and non-*Apis* bees.[83] Since 2009, USDA has published a series of annual progress reports on its CCD research.[84] The progress reports provide detailed information on the status of ongoing research under each of the four elements of USDA's action plan, including survey and (sample)

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[83] USDA, CCD Steering Committee, "Colony Collapse Disorder Action Plan," June 20, 2007, http://www.ars.usda.gov/is/br/ccd/ccd_actionplan.pdf.

[84] USDA, *Colony Collapse Disorder Progress Report*, various years, available at http://www.ars.usda.gov/News/docs.htm?docid=15572.

data collection, analysis of existing samples, research to identify factors affecting honey bee health, and mitigative and preventive measures.

Available USDA Research Funding

Funding for honey bee and pollinator research at USDA's ARS has increased since the enactment of the 2008 farm bill (P.L. 110-246) and in subsequent appropriations, which, among other things, provide additional funding for research and conservation programs addressing honey bees and pollinators. Total ARS funding for honey bee research has been as follows:[85]

- FY2007 - $7,675,000
- FY2008 - $7,798,000
- FY2009 - $8,290,000
- FY2010 - $10,000,000
- FY2011 - $9,980,000 (reduction in funding is due to the FY2011 rescission)
- FY2012 - $10,128,000
- FY2013 - $10,128,000 (as made available under the Continuing Resolution, possibly subject to sequestration)

ARS also has an "Area-wide Project on Bee Health," which consists of temporary funding of $670,000 provided in FY2008, which was scheduled to continue through FY2012 at approximately $1 million per year.[86] Additional funding is available to USDA's NIFA, and includes combined research on honey bees, funding specific to CCD and bee health, and funding for various research labs and grants. Recently, emerging issues grants were awarded to Penn State University and the University of Georgia to study the effects of pesticides, pathogens, and miticides on pollinator populations.[87]

Issues for Congress

Following concerns over honey bee colony losses in 2006-2007, Congress provided for increased funding for bee research, among other types of farm program support to protect pollinators, as part of the 2008 farm bill. Given continued concerns about the health and well-being of honey bees and other pollinators, this issue has continued to be legislatively active in the U.S. Congress, and various proposals were again considered as part of farm bill debates in both the House and Senate in 2013. In addition, various other legislative proposals have been considered outside the farm bill debate that could broadly support other types of bee and pollinator protections and habitat areas.

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[85] CRS communication with USDA personnel, December 18, 2009.

[86] CRS communication with USDA personnel, December 4, 2008; Jeff Pettis, "Colony Collapse Disorder Affecting Honeybee (*Apis mellifera*) Colonies," October 2008 presentation, http://www.epa.gov/pesticides/ppdc/2008/oct2008/session7-ccd.pdf.

[87] Statements by Jeff Pettis, USDA, to Senate Environment and Public Works committee staff, April 9, 2008.

Farm Bill Provisions

The 2008 farm bill (Food, Conservation, and Energy Act of 2008, P.L. 110-246) provided additional funding for research and conservation programs addressing honey bees and pollinators. The law reflected provisions that were included in both the House- and Senate-passed versions of the farm bill, which addressed honey bees and pollinators as part of their conservation, specialty crop, research, and miscellaneous title provisions. Many of these provisions were broadly extended through FY2013, as part of the one-year extension of the farm bill extension in the in the American Taxpayer Relief Act of 2012 (ATRA, P.L. 112-240).

As part of the farm bill debate in 2012 and again in 2013, various existing provisions would be reauthorized and other new provisions are included in both the House- and Senate-passed versions of the 2013 farm bill (H.R. 2642 and S. 954).[88]

Conservation Provisions

The conservation title of the 2008 farm bill included language that broadly encourages habitat development and protection among the administrative requirements for native and managed pollinators under USDA's conservation programs (Section 2708), and ensures that USDA's conservation technical assistance includes standards that account for native and managed pollinators (Section 2706). These provisions could broaden the focus of USDA's farm conservation programs to include pollinator habitats and habitat improvement among their goals, as well as require USDA to review its conservation practice standards with respect to managed and native pollinators.

Research Provisions

The research title of the 2008 farm bill identified pollinator protection among its so-called high-priority research and extension areas (Section 7204). It provided for research and extension grants (1) to survey and collect data on bee colony production and health; (2) to investigate pollinator biology, immunology, ecology, genomics, and bioinformatics; (3) to conduct research on various factors that may be contributing to or associated with colony collapse disorder and other serious threats to the health of honey bees and other pollinators, including parasites and pathogens of pollinators, and the sublethal effects of insecticides, herbicides, and fungicides on honey bees and native and managed pollinators; (4) to develop mitigative and preventative measures to improve native and managed pollinator health; and (5) to promote the health of honey bees and native pollinators through habitat conservation and best management practices. The 2008 farm bill, as extended by ATRA, authorized appropriations for grants at $10 million annually for FY2008-FY2013.

The research provisions also directed USDA to increase its capacity and infrastructure to address colony collapse disorder and other long-term threats to pollinator health (including hiring additional personnel) and to conduct research on colony collapse disorder and other pollinator issues at USDA's facilities. As amended, annual appropriations were authorized at $7.25 million (FY2008-FY2013), with another $2.75 million annually (FY2008-FY2013) for honey bee pest

[88] For more information, see CRS Report R43076, *The 2013 Farm Bill: A Comparison of the Senate-Passed (S. 954) and House-Passed (H.R. 2642) Bills with Current Law.*

and pathogen surveillance. The 2008 farm bill also directed USDA to submit an annual report to Congress on its response to CCD, indicating that the report should investigate the cause(s) of honey bee colony collapse and recommend appropriate strategies to reduce colony loss.

The 113th Congress would retain these provisions, and in some cases expand the level of support for honey bee research, as part of the 2013 farm bill debate. Both the House- and Senate-passed farm bills (H.R. 2642 and S. 954) would retain honey bees as a "high-priority" research area. The House-passed bill would further reauthorize pollinator protection research grants, USDA coordination efforts, and a nationwide honey bee pest and pathogen surveillance program.

Another provision in the House-passed bill only would require USDA, in consultations with the Department of Interior and EPA, to take steps to improve federal coordination in addressing the documented decline of managed and native pollinators and promote the long-term viability of honey bee, wild bees and other beneficial insects in agriculture. The House provision would require USDA to establish a federal task force on bee health and commercial beekeeping to coordinate and assess efforts to mitigate pollinator losses. The task force would report to Congress within 180 days of enactment of the farm bill. The House provision would also allow USDA to conduct a study to consider relocating and modernizing its pollinator research labs.

Insurance and Disaster Provisions

Other provisions in the 2008 farm bill supported pollinators through the bill's crop insurance and other disaster assistance provisions. One such provision identifies honey farms as possible beneficiaries of the bill's supplemental agricultural disaster assistance (Section 12033); another provision provides contracts for additional policies and studies to carry out research and development regarding insurance policies that cover loss of bees (Section 12023).

As authorized by the 2008 farm bill, USDA established the Emergency Assistance for Livestock, Honey Bees, and Farm-Raised Fish Program (ELAP).[89] This program, administered by USDA's Farm Service Agency (FSA), provides emergency relief to producers of livestock, honey bees, and farm-raised fish to aid in the reduction of losses caused by disease, adverse weather, or other natural disaster conditions, such as blizzards and wildfires. Eligible honey bee producers—those who incur physical losses of honey bees and honey bee hives because of colony collapse disorder—must provide documentation, and/or a certification that the loss of honey bees was due to CCD, from one or more of the following: registered entomologist; cooperative extension specialist; and/or land grant university. Supplemental agricultural disaster assistance under ELAP provide assistance covered certain losses that occurred on or after January 1, 2008, and before October 1, 2011.[90] ELAP expired in 2011.

The 113th Congress would re-instate ELAP, as part of the 2013 farm bill debate. Both the House- and Senate-passed 2013 farm bills (H.R. 2642 and S. 954) would extend ELAP through FY2018. The House bill would provide higher maximum funding levels for the program at $20 million annually, compared to the Senate bill at $15 million annually.

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[89] USDA, "Emergency Assistance for Livestock, Honeybees, and Farm-Raised Fish Program (ELAP)," http://www.fsa.usda.gov/Internet/FSA_File/elap_livestock_2011.pdf. Also see For more information, see [89] CRS Report RS21212, *Agricultural Disaster Assistance*.

[90] FAS, "Disaster Assistance Programs," http://www.fsa.usda.gov/FSA/webapp?area=home&subject=diap&topic=tap.

Other Provisions

The 2008 farm bill also contained provisions that generally support honey production. These include, for example, provisions pertaining to the National Honey Board (Section 10401-10402); provisions covering rates for marketing assistance loans for certain commodities, including honey (Section 1202); and provisions covering certain nutrition title provisions (such as Section 4231).

Another provision regarding honey bees and honey production in both the House- and Senate-passed farm bills (H.R. 2642 and S. 954) would require USDA to submit to the Food and Drug Administration (FDA) a report that describes an appropriate federal standard for the identity of honey, in accordance with a March 2006 Standard of Identity citizens petition filed with FDA.

Other Legislative Proposals

There have been additional legislative proposals regarding honey bees and other pollinators outside the farm bill debate.

In the 113th Congress, Representatives Earl Blumenauer and John Conyers, Jr. introduced H.R. 2692, Saving America's Pollinators Act of 2013. The bill would suspend registrations of neonicotinoids and ban new registrations of any pesticide for use on "bee attractive plants, trees, and cereals" until the EPA determines that the insecticide will not cause "unreasonable adverse effects" on pollinators, including native bees, honey bees, and other beneficial insects, as well as birds and bats. The bill also would require 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. This bill is in part a response to reports that 50,000 bees were found dead in a suburban shopping-center parking lot Oregon, reportedly due to exposure to pesticides used on trees near the parking lot to control aphids.[91]

In the 112th Congress, Representative Alcee Hastings introduced H.R. 2381, Highways Bettering the Economy and Environment Act (or Highways BEE Act). The bill would promote conservation practices on 17 million acres of highway "rights-of-ways" (managed by State Departments of Transportation), and would encourage reduced mowing and native plantings that provide improved habitat for pollinators, ground nesting birds and other small wildlife. Roadsides are recognized as a potential habitat for native wildlife, including pollinating insects.[92] The proposed bill language was not included as part of broader transportation legislation that was considered during the 112th Congress.

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

[92] R. Conniff, Green Highways: New Strategies To Manage Roadsides as Habitat," *environment360*, Yale University, June 10, 2013, http://e360.yale.edu/feature/green_highways_new_strategies_to_manage_roadsides_as_habitat/2661/.

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