Honey Bees are Harmed by Horticulture

After the winter of 2004-2005, several commercial beekeepers reported unusually high winter losses: the adult bees of many hives had simply vanished. The symptoms of these hive "collapses" were later named Colony Collapse Disorder (CCD).[1] Normal winter losses are ten to fifteen percent,[2] but some organizations lost thirty to ninety percent of hives.[3] Although the mysteriousness of CCD has won honey bees a significant amount of recent press coverage, populations of honey bees in the United States have been steadily decreasing since around 1947[4] despite a global increase in number of commercial honey bee colonies.[5] This decline is continuing despite decreased incidence of CCD since 2010.[6] Alarming in itself, loss of honey bees also correlates with agriculture's increasing reliance on honey bees as pollinators.[7] Thus part of the reason for popular concern: over ninety staple crops in the United States depend to some extent on commercial beekeeping establishments.[8] Ironically, therefore, the economic value of the honey bee is rooted within the system of monoculture that is to the bees' detriment. There are, however, many other reasons to counteract the loss of honey bees: as a memorandum issued by President Obama put it, "ensur[ing] the sustainability of our food production systems, avoid[ing] additional economic impact on the agricultural sector, and protect[ing] the health of

[1] Robyn M. Underwood and Dennis VanEngelsdorp, *Colony Collapse Disorder: Have We Seen This Before?*, 2, accessed April 24, 2017, http://ento.psu.edu/pollinators/publications/underwood.
[2] Daniel Lee Kleinman and Sainath Suryanarayanan, "Dying Bees and the Social Production of Ignorance," *Science, Technology, and Human Values* 38, no. 4 (July 2013): 500, http://www.jstor.org/stable/23474433.
[3] Sainath Suryanarayanan and Daniel Lee Kleinman, "Disappearing Bees and Reluctant Regulators," *Issues in Science and Technology* 27, no. 4 (Summer 2011): 33, http://www.jstor.org/stable/43315513.
[4] Kristine M. Smith et al., "Pathogens, Pests, and Economics: Drivers of Honey Bee Colony Declines and Losses," *EcoHealth* 10, no. 4 (2013): 435, accessed May 16, 2017, DOI:10.1007/s10393-013-0870-2.
[5] Dennis VanEngelsdorp and Marina Doris Meixner, "A historical review of managed honey bee populations in Europe and the United States and the factors that may affect them," *Journal of Invertebrate Pathology* 103, no. Supplement (January 2010): S81, accessed May 16, 2017, doi:10.1016/j.jip.2009.06.011.
[6] Smith et al., "Pathogens, Pests," 435-6.
[7] Lucas A. Garibaldi et al., "From research to action: enhancing crop yield through wild pollinators," *Frontiers in Ecology and the Environment* 12, no. 8 (October 2014): 440, http://www.jstor/org/stable/43187857.
[8] Suryanarayanan and Kleinman, "Disappearing Bees," 33.

the environment."[9] The importance of honey bees as pollinators thus makes it imperative to answer the question: what has caused these recent declines?

Theories about possible causes of CCD and the general decline of honey bee populations span the range of every observed danger to bees, from pesticides to parasites,[10] diseases,[11] severe winter weather,[12] and air pollution.[13] Studies have also focused on the detrimental effects of interactions between these different threats.[14] There is no doubt that all of these factors pose dangers to honey bees. However, scientific studies are wont to focus their theories on controlled environments, outside of bees' natural ecosystems even though ecology and hive structures are complex systems.[15] It is therefore more than likely that no one, two, or even three factors have caused the recent North American honey bee declines. Further, examinations of ecology and lifestyle of honey bees, which tend to be more realistic for real-life ecological situations,[16] have shown worrying results. Declining bee populations stretch from the end of World War II.[17] World War II was also followed by the growth of increasingly standardized and unsustainable agricultural practices that disrupt ecosystems and, by extension, wildlife. Scientists and beekeepers alike have found that these same unsustainable practices cause adverse effects for the health of honey bees and other pollinators. There are many causes of the decline of honey bees in North America, but the blame must rest with humans: threats to bees, even from seemingly unrelated sources such as parasites, can be traced back to the broader system within which bees

[9] Barack Obama, *Presidential Memorandum -- Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators* (The White House: Office of the Press Secretary, 2014), accessed April 24, 2017, https://obamawhitehouse.archives.gov/the-press-office/2014/06/20/presidential-memorandum-creating-federal-strategy-promote-health-honey-b.
[10] VanEngelsdorp and Meixner, "A historical," S84.
[11] Ibid., 585.
[12] Ibid., 590.
[13] Carol Potera, "Air Pollution: Floral Scents Going off the Air?," *Environmental Health Perspectives* 116, no. 8 (August 2008): A334, http://www.jstor.org/stable/25071121.
[14] Christopher A. Mullin et al., "High Levels of Miticides and Agrochemicals in North American Apiaries: Implications for Honey Bee Health," *PLoS ONE* 5, no. 3 (March 19, 2010): 2, accessed May 16, 2017, doi:10.1371/journal.pone.0009754.
[15] Suryanarayanan and Kleinman, "Disappearing Bees," 34.
[16] Ibid.
[17] Kleinman and Suryanarayanan, "Dying Bees," 499.

live and are exploited through the intensifying effect that pesticides have on these health problems.[18] The correlation between increasing agricultural demands for honey bee pollination and the bees' declining population is not a coincidence. Consistency between unsustainable agricultural methods, rooted in the wider context of an appallingly mismanaged agricultural system, systematically working together to weaken bees by impairing ecosystems and hive performance and the many observed positive effects on bees resulting from changes to more sustainable practices demonstrates that the agricultural system has played a vital role in the decline of honey bees.

The most widely acknowledged unsustainable practice in commercial farming is the use of pesticides. Pesticides can kill bees on contact in lethal doses and impair hive and individual functions in sub-lethal doses. Pesticides are almost universally used by non-organic agricultural operations: pesticide use has grown 263 percent since 1960 despite its inherent danger to wildlife and human life.[19] There are two broad categories of pesticide: traditional and systemic. Both have are a detriment to bees. Traditional pesticides are those applied through spraying or dusting. The severe danger they pose to bees is shown by the 2017 Environmental Protection Agency (EPA) "Policy to Mitigate the Acute Risk to Bees from Pesticide Products:" the EPA has historically been reticent to institute policies banning pesticides for the benefit of pollinators. Its "sound science" policy discredits informal observations from the field correlating pesticide use and adverse effects on bee hives and gives preference to studies that err toward false negatives rather than false positives.[20] That the EPA has made any move at all on the issue of acute poisoning demonstrates of the extensive harm that directly applied pesticides can have on bees.

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[18] Mullin et al., "High Levels," 2.

[19] United States Department of Agriculture, *Pesticide Use in U.S. Agriculture: 21 Selected Crops, 1960-2008*, by Jorge Fernandez-Cornejo, et al., research report no. 124, Abstract, May 2014, accessed May 17, 2017, https://www.ers.usda.gov/webdocs/publications/43854/46734_eib124.pdf?v=41830.

[20] Suryanarayanan and Kleinman, "Disappearing Bees," 33, 34.

Definitive action has not been taken, however: this policy is not legally binding and only gives recommendations on pesticide labelling.[21] Thus, despite that pesticide poisoning of bees is a real problem—a 2012 study showed that pesticide drift may still be causing significant bee deaths despite new technologies that supposedly prevent it[22]— the past decade has seen little policy to protect bees from traditional pesticides.

Systemic pesticides (neonicotinoids) pose different threats to hives. The method of application involves coating the seed of a plant with the pesticide,[23] which is water-soluble and thus moves through the plant as it grows into its leaves, pollen, and nectar.[24] Almost all genetically modified corn and a third of genetically modified soybeans planted in the United States use neonicotinoids, and these crops take up at least one hundred million acres of land.[25] The reason for their popularity is that they do not require periodic spraying and are therefore assumed to be less dangerous to the environment and less harmful to human health than traditional pesticides.[26] Whereas traditional pesticides often kill bees on contact, bees are continually exposed to low levels of systemic pesticides when collecting pollen.[27] Even low doses pose a serious threat. In 2004, when commercial honey bee hives were first exposed to imidacloprid, a common neonicotinoid, beekeepers noticed that the hives that collapsed due to CCD had also been exposed to the chemical.[28] Indeed, studies from France from before 2004 pointed to the possibility that sub-lethal doses of neonicotinoids—that is, doses that did not kill

[21] United States Environmental Protection Agency, "Federal Pollinator Health Task Force: EPA's Role," United States Environmental Protection Agency, last modified April 10, 2017, accessed April 24, 2017, https://www.epa.gov/pollinator-protection/federal-pollinator-health-task-force-epas-role.
[22] Smith et al., "Pathogens, Pests," 437.
[23] Alex Morris, "What Is Killing America's Bees and What Does It Mean for Us?," *Rolling Stone*, August 18, 2015, accessed May 15, 2017, http://www.rollingstone.com/politics/news/what-is-killing-americas-bees-and-what-does-it-mean-for-us-20150818.
[24] Kleinman and Suryanarayanan, "Dying Bees," 499.
[25] Morris, "What Is Killing."
[26] Kleinman and Suryanarayanan, "Dying Bees," 499.
[27] Mullin et al., "High Levels," 2.
[28] Kleinman and Suryanarayanan, "Dying Bees," 500.

them on contact—had the ability to impair bees' learning and foraging and shorten their lifespans.[29] Yet, twenty years later, these pesticides continue to be used in the United States. Many other studies have also shown negative effects of low doses of neonicotinoids including impaired immune systems,[30] learning, and memory,[31] and increased susceptibility to disease.[32] Thus, low doses of systemic pesticides can indirectly lead to mortalities by increasing susceptibility to disease or interfering with homing ability.[33] Indeed, in 2013, the European Union banned the three most common neonicotinoids due to the "risks" they pose to bees.[34] Even the EPA decided in 2016 that imidacloprid "potentially" endangers the well-being of honeybees.[35] However, its risk assessments have yet to lead to implementation of new policies.

Thus, neonicotinoids continue to endanger colonies, and these dangers are not going to go away in the near future. Sub-lethal doses of pesticides—both traditional and systemic—can persist in hives for an indefinite amount of time. A 2010 study conducted by Mullin et al. found that almost all pollen and wax samples from exposed hives had two or more different types of pesticide residue.[36] Wax, and particularly foundation wax, poses a particularly severe problem, as it is rarely replaced. Indeed, beekeepers' typical practice is to remove comb to diminish pesticide contamination but to leave the foundations.[37] Thus, both adult and developing bees are at almost continuous risk for pesticide exposure both in and out of the hive.[38] Indeed, some

[29] Suryanarayanan and Kleinman, "Disappearing Bees," 35-6.
[30] Gennaro Di Prisco 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 of the United States of America* 110, no. 46 (November 12, 2013): 18466, http://www.jstor.org/stable/23757567.
[31] Mullin et al., "High Levels," 2.
[32] Cedric Alaux et al., "Interactions between Nosema microspores and a neonicotinoid weaken honeybees (Apris mellifera)," *Environmental Microbiology* 12, no. 3 (2010): 774, accessed May 16, 2017, doi:10.1111/j.1462-2920.2009.02123.x.
[33] Smith et al., "Pathogens, Pests," 437.
[34] Morris, "What Is Killing."
[35] Geoffrey Mohan, "Bees Threatened by a Common Pesticide, EPA Finds," *Los Angeles Times*, January 6, 2016, Business, accessed May 15, 2017, http://www.latimes.com/business/la-fi-pesticide-bees-20160106-story.html.
[36] Mullin et al., "High Levels," 8.
[37] Ibid., 15.
[38] Ibid., 8.

studies have correlated hives containing pollen with high levels of pesticide residue with increased mortalities of adult bees while in the field.[39] Pesticides in bees wax could also impair the development of queens. Bad queens can in turn lead to increased winter losses or supersedure, which, if unsuccessful, could possibly cause queenlessness.[40]

Weed control strategies such as herbicides and mowing and fertilizers contribute to the decline of other pollinators and likely therefore impair the functioning of honey bees by disrupting the ecological systems within which they work. Honey bees are not native to North America,[41] but they have now been incorporated into wider ecosystems that include wild pollinators and diverse flowering plants. Both wild pollinators and non-crop flowers are removed by typical agricultural practices. Stable ecosystems are necessary to the well-being of the organisms within them, and a diversity of pollinating species creates this much-needed stability through redundancy of roles within the ecosystem[42] and by filling different niches in an ecosystem.[43] Thus, the presence of wild pollinators may "[enhance] foraging behavior of [honey bees]."[44] Yet current agricultural methods, which stress the cultivation of a single crop and are predicated on the intent to, as Dickens put it, "plant nothing else, and root out everything else," emphasize removal of weeds through herbicides and mowing to the detriment most pollinator species' ability to survive. Indeed, the growth of commercial agriculture is correlated with the recent decline of native pollinator species.[45] Much of the staggering amount of pesticide applied

[39] VanEngelsdorp and Meixner, "A historical," S88.
[40] Ibid., S89.
[41] Morris, "What Is Killing."
[42] Lucas A. Garibaldi et al., "Stability of pollination services decreases with isolation from natural areas despite honey bee visits," *Ecology Letters* 14 (2011): 1070, accessed May 16, 2017, doi:10.1111/j.1461-0248.2011.01669.x.
[43] Nico Bluthgen and Alexandra-Maria Klein, "Functional complementarity and specialisation: The role of biodiversity in plant–pollinator interactions," abstract, *Basic and Applied Ecology* 12, no. 4 (June 2011): 282, accessed May 17, 2017, http://www.sciencedirect.com/science/article/pii/S1439179110001350.
[44] Garibaldi et al., "Stability of pollination," 1070.
[45] Obama, *Presidential Memorandum*.

to crops each year is herbicide.[46] In cases where fewer herbicides are deliberately used, results have included more flowering weeds. Local bees including honey bees have benefited: the propagation of these flowers is essential to maintaining a healthy ecosystem of pollinators.[47] Mowing is another tactic used by agriculturalists to keep weeds down on field peripheries. It, too, reduces the diversity of flowering plants with similar negative effects on local pollinators. Although some argue that weeding may reduce invasive grasses that out-compete native flowering plants,[48] the comparative benefits of having weeds to having none at all are significant. After all, mono-cropped areas generally cannot support wild pollinators because of the short time span of flowering and the lack of flower diversity.[49] Beside killing pollinators and beneficial weeds, herbicides can "destabilize" pollinator ecosystems by inducing large change over a small timescale.[50] Fertilizers have a similar effect. In addition, fertilizers reduce ecological biodiversity in agricultural land by reducing the number of legumes planted in crop rotations; indeed, fertilizers reduce crop rotations generally.[51] Honey bees, however, prefer many species of legume for collecting nectar.[52]

These ill-advised practices are not to blame on their own but are a symptom of a larger problem. They are inherent to the current agricultural system, which is rooted in monoculture and standardization. Monoculture is the cultivation of one crop to the exclusion of all others. Its popularity is linked to urbanization, standardization, and homogenization of world-wide diets, and its growth is a symptom of agricultural mechanization, since big machines operate well on

[46] United States Department of Agriculture, *Pesticide Use in U.S.*, abstract.
[47] Axel Decourtye, Eric Mader, and Nicolas Desneux, "Landscape enhancement of floral resources for honey bees," *Apidologie* 41 (2010): 270, accessed May 16, 2017, DOI:10.1051/apido/2010024.
[48] Garibaldi et al., "From research," 442.
[49] Ibid., 443.
[50] Garibaldi et al., "Stability of pollination," 1063.
[51] VanEngelsdorp and Meixner, "A historical," S90.
[52] Decourtye, Mader, and Desneux, "Landscape enhancement," 270.

orderly systems: long rows and single crops.[53] Forcing nature into an unnatural order requires continual action: application of pesticides to optimize plant health and standardize size and growth patterns, application of herbicides to eliminate weeds that compete for resources, use of fertilizers to compensate for the depletion of nutrients in the soil, and many other environmentally deleterious practices. The belief that monoculture is a good idea results from a system of thought that distances consumers from the production from their food and that intrinsically values standardization and economic profit. The environments that monoculture creates and the system of thought on which it is based are detrimental to many aspects of a complex environmental system[54] and thus also to honey bee health.

The creation of an ecosystem that strives for the presence of a single organism to the exclusion of all others decreases available bee pasture and the diversity of pollen and nectar available to bees. In the modern agricultural system, many acres of land are planted with only one crop; herbicides are applied to reduce weed growth. Many crops that are cultivated in this manner require pollination.[55] The system thus requires that honey bees derive almost all of their nutrition from a single plant, since they and other pollinators are limited in their foraging by the distance they are capable of travelling: solitary bees often travel less than one kilometer;[56] honey bees can travel about four-and-a-half kilometers.[57] However, agricultural lands can stretch for hundreds of acres and generally have few pieces of land that are not planted with crops.[58] Every plant flowers for a short amount of time at a different time of year, so large expanses with only one crop entail an excess of nectar and pollen available for a short time and not enough for the

[53] Kenneth Sylvester and Geoff Cunfer, "An Unremembered Diversity: Mixed Husbandry and the American Grasslands," *Agricultural History* 83, no. 3 (2009): 353, accessed May 17, 2017, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2766303/pdf/nihms140093.pdf.
[54] P. A. Matson et al., "Agricultural Intensification and Ecosystem Properties," *Science* 277 (1997): 504, accessed May 17, 2017, DOI:10.1126/science.277.5325.504.
[55] VanEngelsdorp and Meixner, "A historical," S81.
[56] Garibaldi et al., "From research," 441.
[57] VanEngelsdorp and Meixner, "A historical," S81.
[58] Decourtye, Mader, and Desneux, "Landscape enhancement," 265.

rest of the season. Pollinating insects need access to nectar for more time than the flowering period of one plant.[59] Although increased numbers of pollinators have been observed during flowering time in a monoculture, these increases are observed during only that flowering time; one must assume that pollinators leave or die off after it is over.[60] Standardization has further reduced available forage in some areas by increasing the amount of land planted with only wind- or self-pollinated crops.[61] Thus, there is not enough forage for wild bees. This situation further affects honey bees' ecosystems. However, though wild honey bees may well be affected by this scenario,[62] commercial honey bees are usually either fed supplements when there are no nearby flowers or moved from place to place, so an absence of nectar creates a different problem for them than for other pollinators. A more direct problem for the honey bee specifically is the lack of adequate nutrition. Nectar from one plant does not provide enough different sugars, amino acids, micro-vitamins, and minerals to allow for ideal health of honey bees.[63] More open land with diverse plant species has been correlated to increased honey bee productivity[64] and thus more worker bees and more honey. Therefore, a healthy, productive colony has better chances of surviving the winter than an unproductive one. Additionally, the crops to which commercial honey bees generally have access like tomatoes are often non-ideal sources of pollen and may be less prolific than preferred plant types. [65] Conversely, increased diversity of flower species has improved resilience of pollinators[66] and can improve individual bees' production of detoxifying

[59] Garibaldi et al., "From research," 441.
[60] Ibid., 442.
[61] Decourtye, Mader, and Desneux, "Landscape enhancement," 265.
[62] Garibaldi et al., "Stability of pollination," 1069.
[63] Ibid., 1063.
[64] VanEngelsdorp and Meixner, "A historical," S90.
[65] Decourtye, Mader, and Desneux, "Landscape enhancement," 265.
[66] Garibaldi et al., "From research," 442.

enzymes.[67] Thus, it is no surprise that increased loss of hives between 1992 and 2003 may be connected to smaller ratios of open to developed land.[68]

Standardization is based on economic priorities. Modern Western agriculture is, like most aspects of Western culture, based on money-making. The economics rooted in modern agricultural practices result in practices stressful to honey bee populations. In 2004, California almond producers realized that there were not enough pollinators to support their growing crop. As a result, rental prices for bee hives increased dramatically.[69] High prices created an incentive for non-migratory beekeeping practices to begin trucking their bees across the country. However, migratory beekeeping has existed for a long time. Agriculture has become increasingly dependent on rented hives since World War II because of the decreasing numbers of native pollinators and increasing incidence of monoculture.[70] Revealingly, CCD was originally experienced by commercial migratory beekeepers.[71] Thus, there is a good possibility that colony movement is stressful to bees, increases risk of disease, or increases exposure to pesticides. Indeed, many commercial beekeepers expect ten to thirty percent losses due to transportation. [72] Another point of consideration, however, is that this continual movement has significantly changed bees' seasonal cycles; almond trees flower in February.[73] Effects are unclear, but sudden changes to bees' normal life-styles are likely explanations of adverse outcomes. Further, since the available profit from honey production in the United States is less than that available from renting hives to pollinate crops, commercial beekeepers have relatively little incentive to

[67] Smith et al., "Pathogens, Pests," 439.
[68] VanEngelsdorp and Meixner, "A historical," S90.
[69] Ibid., S87.
[70] Kleinman and Suryanarayanan, "Dying Bees," 499.
[71] Suryanarayanan and Kleinman, "Disappearing Bees," 34.
[72] Dennis VanEngelsdorp et al., *"Fall-Dwindle Disease": Investigations into the Causes of Sudden and Alarming Colony Losses Experienced by Beekeepers in the Fall of 2006*, December 15, 2006, accessed May 16, 2017, https://www.freshfromflorida.com/content/download/24049/487014/fall_dwindle_report.pdf.
[73] Alexei Barrionuevo, "Honeybees Vanish, Leaving Keepers in Peril," *New York Times*, February 27, 2007, Business Day, accessed May 15, 2017, http://www.nytimes.com/2007/02/27/business/27bees.html.

prioritize a varied diet over economic gain.[74] Other impacts of the prioritization of profit over pollinator ecology in agriculture are seen in attempts to remove bees from certain areas and thus further reduce bee foraging areas. Growers of seedless fruits want to keep bees out of their acreage. For example, one citrus grower in California petitioned the government to create a two or more square mile "no-fly zone" to prevent pollination of their crop.[75]

Trends toward standardization in the agricultural structure have moved into beekeeping practices as well and have thus further resulted in reduced stability of honey bee populations. First, beekeepers often use chemicals such as miticides, fungicides, and antibiotics to treat their bees for various illnesses and thus attempt to keep their colonies constant.[76] These chemicals build up in wax and possibly cause the same harm as pesticide residues. Further, treating for diseases may reduce viability of bees as a species by allowing weak bees to stay in the gene pool.[77] Second, beekeeping has become more standardized as the demand for hives-for-rent has increased the relative number of commercially kept colonies.[78] One example of this standardization is the general demand for Italian bees—even among hobbyists—over other breeds: they are gentle and unusually productive for their small size.[79] Thus, one subspecies is dispersed across many ranges and may adversely affect native bee populations through competition or spread of disease. Further, that queens of this subspecies are bred from only around 500 mother queens compromises genetic diversity of North American honey bees. Genetic diversity is essential to maintaining a healthful honey bee population: it enhances

[74] Smith et al., "Pathogens, Pests," 440.
[75] Barrionuevo, "Honeybees Vanish," Business Day.
[76] Ibid., 438
[77] VanEngelsdorp and Meixner, "A historical," S89.
[78] Smith et al., "Pathogens, Pests," 440.
[79] Richard H. Sprano, interview by the author, Waterbury, CT, May 18, 2014.

disease resistance, hive fitness, ability to survive the winter, and other aspects of health.[80] Third, although a diversity of pollen sources has been connected to beneficial impacts on honey bees' immune responses, a lack of available pollen leads beekeepers to feed supplemental sugar and pollen to their hives.[81] These substances endanger bees' health because they contain pesticide residues[82] and do not provide adequate nutrition: honey bees need naturally occurring nectar and pollen for maximum fitness.[83]

Unsustainable agricultural methods are clear sources of problems for honey bees, whether or not they are the major factor in North America's declining honey bee populations. However, do more "sustainable" practices really benefit honey bees? If they did not, it would be more a cause to re-evaluate definitions of sustainable practice than a signal that sustainability is not worth pursuing. However, attempts at sustainability have had positive effects on pollinators. Sustainable practices such as avoiding use of pesticides, smaller crop fields, intercropping, and semi-natural areas have been seen to help rebuild pollinator communities. Not using pesticides limits poisonings if within a large enough range. Efforts to use fewer herbicides have also benefited bee populations by increasing numbers of nearby flowering weeds.[84] As opposed to the homogeneous ecology favored by monoculture,[85] increased plant diversity in agricultural settings through institution of flower strips, hedgerows, cover crops, fallow areas, and smaller crop fields correlates with increased pollinator incidence.[86] These semi-natural areas provide more nutritional diversity for pollinators[87] and create a "buffer" to protect bees from variable resource

[80] VanEngelsdorp and Meixner, "A historical," S89.
[81] Decourtye, Mader, and Desneux, "Landscape enhancement," 265.
[82] Mullin et al., "High Levels," 15.
[83] Decourtye, Mader, and Desneux, "Landscape enhancement," 265.
[84] Ibid., 266.
[85] Ibid., 273
[86] Garibaldi et al., "From research," 441.
[87] VanEngelsdorp and Meixner, "A historical," S90.

availability.[88] Cover crops and intercropping can provide alternate sources of nectar at different times of year.[89] Fallow fields are often used to prevent erosion, enhance water quality, and more recently to provide forage for bees. When managed correctly, they have caused "colony weight and brood areas [to decrease] less during the season" than for colonies without access to fallow areas.[90] Finally, reducing the size of crop fields reduces the distance pollinators have to go to locate food and increases the likelihood of benefit from nearby semi-natural areas.[91] Tellingly, in a German agricultural area, the expansion of organic farming practices from five to twenty percent increased the diversity of the local bee population by fifty percent.[92] That simple switches to even marginally more sustainable practices has had positive effects on bees further shows the significantly harmful effects that commercial agriculture has had on honey bees' welfare.

Farmers cite many barriers to adopting these sustainable practices. The main factor is also rooted in economics: cost. For example, they often sow fallow fields with grasses instead of flowering plants because grass seeds are cheap.[93] Costs of implementing semi-natural areas and giving up cultivable land are also used as excuses to maintain unsustainability.[94] However, partial conversions are not wholly effective anyway. Limiting neonicotinoids could cause farmers to turn back to traditional pesticides.[95] There is also a possibility of pesticide contamination of orchard cover crops or of field margins when crops are sprayed.[96] Thus, it is small steps cannot by wholly effective. A total upheaval of the agricultural system is needed.

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[88] Decourtye, Mader, and Desneux, "Landscape enhancement," 267.
[89] Ibid., 266.
[90] Ibid., 267-8.
[91] Garibaldi et al., "From research," 441.
[92] Ibid., 442.
[93] Decourtye, Mader, and Desneux, "Landscape enhancement," 269.
[94] Garibaldi et al., "From research," 444.
[95] Suryanarayanan and Kleinman, "Disappearing Bees," 36.
[96] Decourtye, Mader, and Desneux, "Landscape enhancement," 266, 269.

Before scrambling to affix duct tape to a broken system through half-hearted remedies like the use of nutritional supplements, problems that directly affect simple maintenance of everyday life for honey bees should be addressed. These problems are directly related to unsustainable agriculture, and movements toward sustainability can make a difference. Yet despite some recent government moves to protect pollinators such as the establishment of Obama's Pollinator Health Task Force (memorandum), little action has been taken to address these vital concerns. Alas, the government too is based in the system of economics and standardization that led to unsustainable agriculture.

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