Protecting our Food Systems:

Responding to Honey Bee Population Decline in Michigan

Mike Bianco, MFA 2015
Penny W. Stamps School of Art and Design

Jenny Cooper, MBA/MS 2015
Stephen M. Ross School of Business/School of Natural Resources and Environment

Michelle Fournier, MS 2014
School of Natural Resources and Environment

Betsy Riley, MPP/MS 2014
Gerald R. Ford School of Public Policy/School of Natural Resources and Environment

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"The way humanity manages or mismanages its nature-based assets, including pollinators, will in part define our collective future in the 21st century. The fact is that of the 100 crop species that provide 90 per cent of the world's food, over 70 are pollinated by bees. Human beings have fabricated the illusion that in the 21st century they have the technological prowess to be independent of nature. Bees underline the reality that we are more, not less, dependent on nature's services in a world of close to seven billion people."

- Achim Steiner, UN Under-Secretary-General and UNEP Executive Director, 2011[1]

[1] United Nations Environment Programme, "Bees Under Bombardment: Report shows multiple factors behind pollinator losses. From Chemicals to Air Pollution, New UNEP Report Points to Multiple Factors Behind Pollinator Losses," March 10, 2011.

I. The Road to Honey Bee Population Decline in Michigan

If you travel to the end of Michigan's famed highway 22, you'll find yourself in the Eden of Michigan: the Leelanau Peninsula. Lelenau, the pinky finger of the Michigan mitten, is a rolling landscape of apples, pears, cherries, and grapes. Dotted among the orchards are fields of corn and soy, and patches of young woods. If one didn't know any better, the environment of the Leelanau Peninsula would appear to be an agricultural paradise. But where the asphalt turns into rough dirt at the dead end of the peninsula, you will find a bee yard strewn with discarded barrels of corn syrup and stacks of beehives from dead colonies. The bee yard belongs to Mr. Adams,[2] a beekeeper who has kept honey bees almost his entire life. With almost 10,000 hives, Mr. Adams maintains one of the largest commercial beekeeping operations in the state, and he is the first to acknowledge that his business, and the orchards that surround his bee yard, are endangered.

It's just not what it used to be, Mr. Adams explains. *It used to be you were just a beekeeper. You raised some bees, you made some honey, and you helped out the orchards by giving them bees to pollinate their crops. But now beekeeping has gotten so complicated that in addition to being a beekeeper, I've got to be a scientist, a politician, an organizer, an academic, not to mention a businessman. The whole business has gotten so complicated that I spend more time trying to keep my bees alive than I do with my family. But what am I supposed to do?*

Since 2005, Mr. Adams, and other beekeepers around the world, has been experiencing unprecedented levels of colony failure. He is no stranger to major bee losses. In the mid-1990s Mr. Adams reported losses of nearly 80% of all his colonies as a result of a tracheal mite epidemic. However, he, like other beekeepers who reported major losses, recovered his honeybee populations quickly as a result of a national tracheal mite mitigation campaign. The majority of commercial beekeepers in the U.S. recovered from the tracheal mite problem of the 1990s. However, beekeepers in the U.S. are quick to clarify that the consistent losses they have experienced since 2005 are unprecedented in severity and mystery.

If one were to travel as the crow flies from the "Cherry Capital of the World" in Traverse City to the research hub of Ann Arbor, one would follow a path flanked on either side by some of the most important voices in the wicked problem of honey bee population decline, including pesticide companies, legislators, farmers, and both commercial and hobby beekeepers.

[2] Name has been changed to protect confidentiality.

At the beginning of the path you would find yourself surrounded by some of the nation's most robust crops of apples, blueberries, and cherries, all dependent on pollination services. Heading south and to the east is Midland, home of Dow Chemical Company, a Fortune 50 corporation and one of the world's largest producers of pesticides. Further south and to the west is Lansing, the state's capital, and home to the state Department of Agriculture and Michigan State University. In sum, Michigan is exemplary of the diversity of voices invested in protecting our food systems, and dealing with the crisis of honey bee population decline on a national and state level.

You know, I tell ya, Mr. Adams said, *if things keep up like this in Michigan, we might be forced to leave. Now, I don't want to go. I'm a Michigan native, and I want to be here, but with all the stressors that go into being a commercial beekeeper in Michigan, I might just need to pick up and move to a state with more friendly conditions.*

This paper represents a one year investigation into the complex causes and consequences of the current honey bee population decline, and includes potential ways that key stakeholders in Michigan can respond to the problem. Based on our research, this paper identifies sustainable on-the ground mitigation techniques for farmers and beekeepers, and concludes with recommendations for combating honey bee population decline at an institutional level in Michigan.

II. Honey Bee Population Decline

Honey bees (*Apis mellifera*) are currently in a state of rapid decline in many places around the world. Since 2005, colony collapse disorder (CCD) and other causes of honey bee mortality have resulted in the loss of about 30% annually of all honey bee colonies in the United States.[3] CCD, which is characterized by the mysterious disappearance of honey bees from their hive, is one of the most perplexing manifestations of an overall decline in managed honey bee populations and health. Research to date has not definitively identified the factors contributing to the high mortality rates of honeybees, especially with respect to CCD, but many beekeepers and scientists have suggested that the problem results from a lethal combination of multiple

[3] vanEngelsdorp, et al, 2012, A national survey of managed honey bee 2010-11 winter colony losses in the USA: results from the Bee Informed Partnership, Journal of Apicultural Research 51: 115-124.

stressors,[4] including pathogens and parasites, current land management and commercial beekeeping practices, and certain pesticides. Since honey bees pollinate almost all of the fruits, vegetables, and nuts grown domestically, honey bee population decline is emerging as a significant threat to food production in the United States and many other countries.[5]

Even without considering the implications of honey bee losses for our food system, statistics regarding the magnitude of bee deaths are shocking. The Bee Informed Partnership (coordinated by the International Bee Research Association) conducts an annual survey of beekeepers across the United States about honey bee colony losses. For the winter of 2010/2011, over 5,400 beekeepers responded, representing nearly 310,000 living colonies. By April 2011, the same beekeepers reported a loss of 38% of their colonies, even though they had a net purchase of more than 70,000 colonies.[6] Beekeepers said that they consider acceptable colony losses to be around 13%, and researchers consider a normal background mortality rate to be about 15%.[7] The average annual honey bee colony losses experienced over the last seven years (see Table 1), therefore, are about double the background rate.

Michigan beekeepers have also been hard-hit by colony losses. During the 2010/2011 winter, they reported the highest percentage of colony losses in the whole United States—62.7% on average. This represents a loss of 34.8% of the total colonies in the state in just one winter.[8]

In spite of growing scientific and public awareness of these massive die-offs of honey bees, as of yet isolated efforts have been unable to ameliorate the problem at the national level. The lack of consensus among the scientific, corporate, farming and beekeeping communities about the causes of colony collapse disorder and honey bee declines in general has presented a major barrier to comprehensively combating honey bee losses. There is, however, an extensive and growing body of research on the issue, and there is enough evidence to begin drawing preliminary conclusions and taking action based on the results of existing studies.

Table 1. Total estimated honey bee colony losses in the United States since the emergence of colony collapse disorder.

[4] Potts, S., et al, 2010, "Global pollinator declines: trends, impacts and drivers," *Trends in Ecology and Evolution* 25: 345-353. Williams, G, et al, 2010, "Colony Collapse Disorder in context," *Bioessays* 32: 845-846.
[5] Potts et al. 2010.
[6] VanEnglesdorp, et al, 2012, A national survey of managed honey bee 2010-11 winter colony losses in the USA: results from the Bee Informed Partnership, Journal of Apicultural Research 51: 115-124.
[7] Rucker, R., et al, 2011, "Colony collapse and the economic implications of bee disease."
[8] VanEngelsdorp et al, 2012.

Winter season	Estimated percentage of total colony losses in the US
2006/2007	32%
2007/2008	36%
2008/2009	29%
2009/2010	34%
2010/2011	30%
2011/2012	22%
2012/2013	31%

Source: VanEngelsdorp et al. 2012; Bee Informed Partnership 2013

Causal Factors

Research to date has identified several factors that are likely contributing to honey bee declines and CCD, and it seems probable that the negative effects of multiple different stressors are combining to create very difficult conditions for honey bees. Rather than focusing on individual stressors, then, it is useful to consider the factors contributing to the current extremely high rates of honey bee mortality as part of a web of causality (Figure 1). Scientists and beekeepers have identified various potential causal factors which can be divided into four main categories: parasites and pathogens; environmental stressors; pesticides; and industrial beekeeping practices. Since colony collapse disorder is just one manifestation of an overall decline in managed honey bee populations and health (albeit the most severe), it is important to consider factors that are likely contributing to both. As some researchers have pointed out, "we must be careful to not synonymize CCD with all honey bee losses.[9]"

[9] Williams, G., D. Tarpy, D. vanEngelsdorp, M. Chauzat, D. Cox-Foster, et al. 2010. "Colony Collapse Disorder in context." *Bioessays* 32: 845-846.

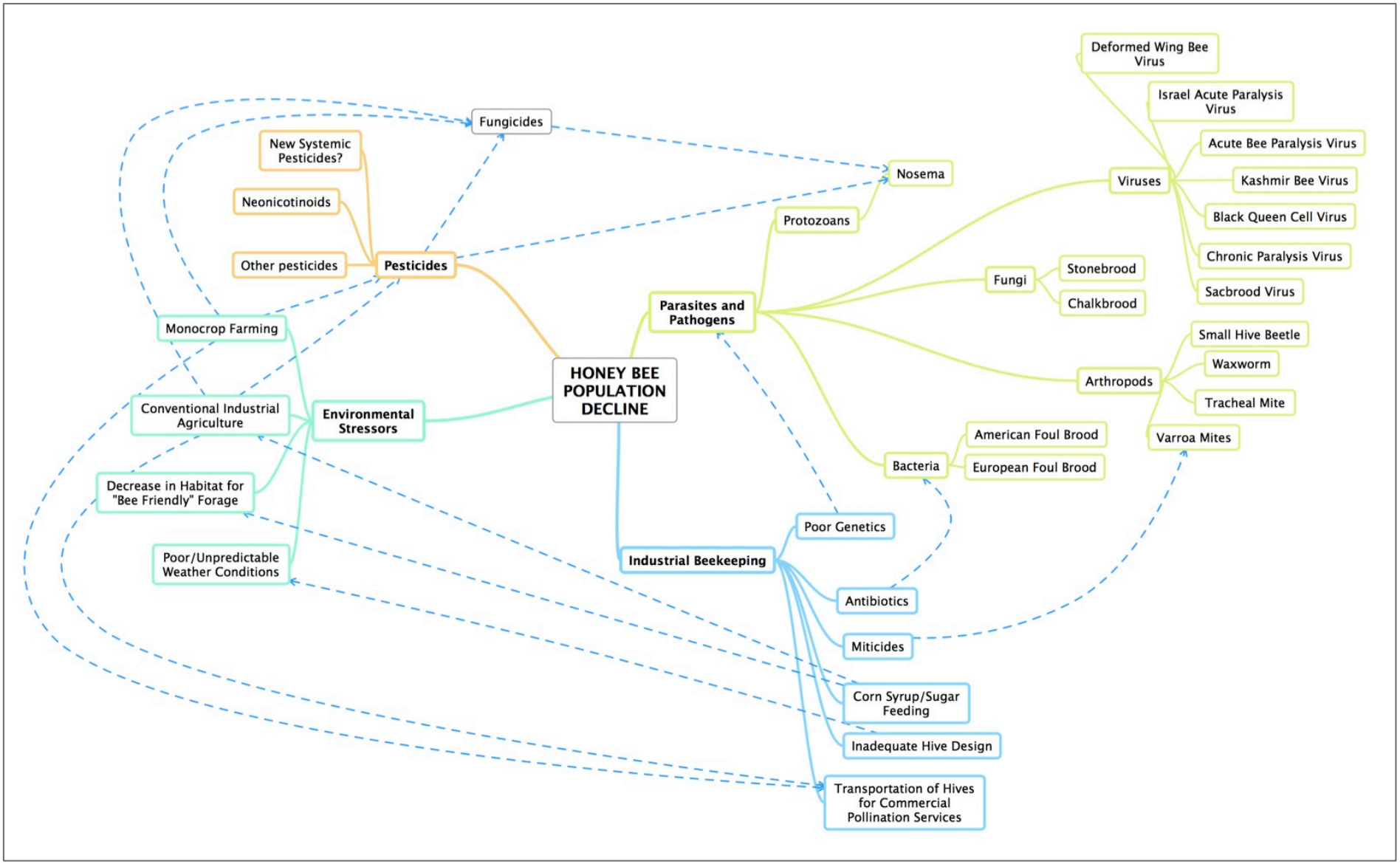

Figure 1. Web of causality for the current high mortality rates of honey bees, including from colony collapse disorder, in the United States and other countries.

Pathogens and Parasites

Pathogens and parasites are considered by many to be "principal actors" in the high losses of bees that are occurring in many countries in the northern hemisphere.[10] In particular, the parasitic mite *Varroa destructor* has received much of the blame for honey bee colony failures, especially because of their ability to serve as a vector for bee viruses.[11] Three viruses in particular seem to be associated with heavy losses of honey bees during the winter: deformed wing virus, acute bee paralysis virus, and Israeli acute bee paralysis virus.[12] Other viruses that could be contributing to the problem include Kashmir bee virus, black queen cell virus, chronic paralysis virus, and sacbrood virus.[13] *Nosema*, a type of microscopic parasitic fungus, has also been identified as a potential agent contributing to honey bee losses, though its role remains unclear.[14] These pathogens and parasites represent a small portion of the many viruses, fungi, bacteria, and arthropods that endanger the health of managed honey bee colonies.

Management and Environmental Stressors

There are several stressors resulting from current commercial pollination practices that likely contribute to the weakening of honey bee colonies and colony losses. Prolonged exposure to moisture in the hive is a major threat to honeybees. Many beekeepers are debating whether the current industry standard Langstroth hive design provides adequate wicking of moisture in winter conditions. If this design is failing to do so it could be one factor jeopardizing overwintering colonies.[15] Other research suggests that current honeycomb foundation patterns are set to a diameter conducive to *Varroa* mite infestation, and the reduction of cell size may be a viable option for combating mites.[16] Therefore, while current commercial hive designs may be conducive to large-scale pollination services, the design may in fact be endangering honey bee populations. As a result, many treatment-free beekeepers are looking to alternative top-bar hive

[10] Dainat, B., et al, 2012, "Predictive markers of honey bee colony collapse," *PLoS ONE* 7: e32151.
[11] Martin, S., et al, 2012, Global honey bee viral landscape altered by a parasitic mite, *Science* 336: 1304-1306.
[12] Dainat et al, 2012.
[13] Chen, Y. and R. Siede, 2007, "Honey bee viruses," *Advances in Virus Research* 70: 33-80.
[14] Chen, Y., et al, 2008, "*Nosema ceranae* is a long-present and wide-spread microsporidian infection of the European honey bee (*Apis mellifera*) in the United States," *Journal of Invertebrate Pathology* 97: 186-188.
[15] Pacific Northwest Treatment-Free Beekeeping Conference 2013.
[16] Piccirillo, G. and D. De Jong. 2003, "The influence of brood comb cell size on the reproductive behavior of the ectoparasitic mite *Varroa destructor* in Africanized honey bee colonies," *Genetics and Molecular Research* 2: 36-42.

designs that allow bees to dictate their own cell diameter as a means to combating honey bee losses.[17]

In addition to potentially deleterious hive design, commercial beekeepers also typically rely on high fructose corn syrup (HFCS) to feed their bees in the absence of viable nectar sources and during transportation. Current research suggests that the use of HFCS may be dangerous to honey bee digestion because it may form potentially toxic compounds under certain conditions.[18] As if these stressors were not enough, conventional beekeeping practices often utilize miticides and antibiotics to treat infections and infestations in honey bee hives. While these treatments seem successful, some beekeepers are concerned that they, paradoxically, may strengthen honey bee pests and pathogens, leading to the development of "superbugs.[19]" Finally, research has shown that a lack of genetic diversity among honey bee populations significantly lowers the probability of colony survivorship.[20] This lack of genetic diversity is a result of the way that honey bees have been bred and managed.

Aspects of the environment that honey bees live in, including "natural" variables such as the climate—including extreme weather events and shifts in the global climate regime—"can have a direct influence on honey bee behaviour and physiology," potentially "giv[ing] rise to new competitive relationships among species and races [of honey bees], as well as among their parasites and pathogens.[21]" While beekeepers have no control over the weather, this factor needs to be taken into consideration, in particular how unfavorable weather may have synergetic effects in combination with other variables (discussed below).

Pesticides

There are an increasing number of studies demonstrating the probable central role of some pesticides in contributing to high rates of honey bee mortality. Honey bees can be exposed

[17] Piccirillo, G. and D. De Jong. 2003. "The influence of brood comb cell size on the reproductive behavior of the ectoparasitic mite *Varroa destructor* in Africanized honey bee colonies." *Genetics and Molecular Research* 2: 36-42.
[18] LeBlanc, B., et al. 2009, "Formation of Hydroxymethylfurfural in Domestic High-Fructose Corn Syrup and Its Toxicity to the Honey Bee (*Apis mellifera*)," *Journal of Agricultural and Food Chemistry* 57: 7369-7376.
[19] Pacific Northwest Treatment-Free Beekeeping Conference 2013.
[20] Potts, S., et al., 2010. "Global pollinator declines: trends, impacts and drivers." *Trends in Ecology and Evolution* 25: 345-353.; Tarpy, D., et al, 2013, "Genetic diversity affects colony survivorship in commercial honey bee colonies," *Naturwissenschaften* 100: 723–728.
[21] LeConte, and Navajas, 2008, "Climate change: impact on honey bee populations and diseases," *Revue Scientifique et Technique (International Office of Epizootics),* 27: 499-510.

to pesticides and other chemicals commonly used in agriculture via a number of different pathways, including direct exposure (pesticides applied while bees are foraging in the field, for example), exposure through the pollen and nectar of plants treated with systemic pesticides, and exposure through the food that beekeepers feed to bees, such as corn syrup.

A type of systemic insecticides called neonicotinoids, which is the most widely used pesticide in the world including the United States, is increasingly being implicated in honey bee declines. The neonicotinoid class of insecticides include acetamiprid, clothianidin, dinotefuran, imidacloprid, thiamethoxam, and others, manufactured under many different trade names in the US mainly by Bayer CropScience and Syngenta. A growing number of studies are finding that "at field realistic doses, neonicotinoids cause a wide range of adverse sublethal effects in honeybee and bumblebee colonies, affecting colony performance through impairment of foraging success, brood and larval development, memory and learning, damage to the central nervous system, susceptibility to diseases, [and] hive hygiene[22]". Researchers recently concluded that initially sub-lethal exposure of honey bees to thiamethoxam later causes high mortality due to homing failure.[23] Another study found "convincing evidence that exposure to sub-lethal levels of imidacloprid in HFCS causes honey bees to exhibit symptoms consistent to CCD 23 weeks post imidacloprid dosing[24]".

Because of evidence from a growing number of studies, the European Union tightly restricted the use of three types of neonicotinoids (clothianidin, imidacloprid and thiamethoxam) in 2013, though Bayer CropScience and Syngenta have sued to overturn the ban.[25] The US Environmental Protection Agency "is not currently banning or severely restricting the use of the neonicotinoid pesticides," although "based on currently available data, the EPA's scientific conclusions are similar to those expressed in the [European Food Safety Authority's] report with regard to the potential for acute effects and uncertainty about chronic risk[26]".

A new type of systemic insecticide that many beekeepers and others have expressed concern about is sulfoxaflor, produced by Dow AgroSciences. Sulfoxaflor is acutely toxic to honey bees, but it has a very short half-life in the environment which is supposed to reduce the

[22] Van der Sluijs, N., et al, 2013, "Neonicotinoids, bee disorders and the sustainability of pollinator services," *Current Opinion in Environmental Sustainability* 5: 293-305.
[23] Henry, M., et al, 2012, "A common pesticide decreases foraging success and survival in honey bees," *Science* 336: 348-350.
[24] Lu, C., et al, 2012. "*In situ* replication of honey bee colony collapse disorder," *Bulletin of Insectology* 65: 99-106.
[25] United States Environmental Protection Agency. 2013. "Colony Collapse Disorder: European Bans on Neonicotinoid Pesticides." Gross, M., 2013, "EU ban puts spotlight on complex effects of neonicotinoids," *Current Biology* 23: R462-R464.
[26] EPA, 2013.

risk to bees.[27] Because it has only recently gained EPA approval, few independent studies have been published about its effects on pollinators. The National Honey Bee Advisory Board, national beekeeping organizations and individual beekeepers filed an appeal to EPA in 2013 to rescind the approval of sulfoxaflor on the grounds that it has not been proven safe.[28]

Interaction Effects

Further complicating the picture, there are not just multiple factors that are likely contributing to honey bee losses, but also various synergistic interactions between factors. For example, researchers have demonstrated that exposure to sub-lethal doses of imidacloprid or clothianidin may weaken bees' immune systems, making them more vulnerable to pathogens and parasites such as *Nosema* and deformed wing virus.[29] The susceptibility of honey bees to pathogens and parasites is also likely influenced by the weather. For example, in warm winters, such as 2011/2012 in the US (see Table 1), there seem to be significantly fewer colony losses.

Consequences of Honey Bee Decline in Michigan

The sharp decline in the number and health of honey bee colonies is a problem here in Michigan as many crops rely on the pollination services provided by managed honey bees. These crops generate significant income for producers, as well as contributing to Michigan's food system and the cultural identity of the state. The agriculture and food industry in Michigan contributes over $90 billion annually to the state's economy, with the largest growth sector coming from farming.[30] Michigan also stands 9th in the nation in terms of honey production. This is a drop from 7th in the nation last year.[31] Pollinated crop production has dropped dramatically—by hundreds of millions of pounds produced in some cases—since 2006. Apple production in

[27] Personal communication with Ray Brinkmeyer, Daland Juberg and Vince Kramer, Dow toxicologists, 7/10/2013.
[28] Earthjustice, 2013, "Beekeeping industry sues EPA for approval of bee-killing pesticide."
[29] Di Prisco, G., et al, 2013, "Neonicotinoid clothianidin adversely affects insect immunity and promotes replication of a viral pathogen in honey bees," *Proceedings of the National Academy of Sciences* 110: 18466–18471. Pettis, J., et al, 2012, "Pesticide exposure in honey bees results in increased levels of the gut pathogen Nosema," *Naturwissenschaften* 99: 153-158.
[30] MDARD, 2013, *Facts About Michigan Agriculture*. Retrieved from Michigan Department of Agriculture and Rural Development.
[31] The Associated Press, April 06, 2013, *USDA says Michigan drops to 9th in honey production*, Michigan Radio: New for Michigan.

particular has dropped far behind Washington and New York,[32] even taking into account the damage caused by warm winters.[33]

Fruit and tree nut production in the state was worth an average of $344 million annually over the years 2008-2012, with the potential value being even higher (in 2007 these crops were worth just shy of $420 million).[34] Vegetable production generated an average of $249 million from 2008 to 2012.[35] In addition, some of these crops have significance for the cultural identity of Michigan and also contribute to tourism revenues (such as from the National Cherry Festival held in Traverse City).

Apples, blueberries, cherries, cucumbers, peaches, pears, plums, and squash are all produced in Michigan. All of these, and many more fruits and vegetables, require pollination by bees to produce fruit.[36] The yields of other crops, such as soybeans and grapes, may be greater and of a higher quality when pollinated by honey bees.[37] To our knowledge, estimations have not yet been made as to how much crop production has likely been lost in Michigan due to the decline in honey bee availability for crop pollination. But given the critical importance of pollination for the successful fruiting of so many crops produced in the state, we can expect increasing impacts of honey bee decline on the agricultural sector if the crisis is not rapidly mitigated. As just one example, the USDA's National Agricultural Statistics Service reported that in Michigan, usually the largest producer of tart cherries in the United States, "the majority of growers lost all of their harvestable crop" in 2012 due to atypical weather and the fact that "pollination conditions were poor." This resulted in a drop from 157.5 million pounds of tart cherries harvested in 2011 to a forecasted 5.5 million pounds in 2012.[38]

In addition, with the currently high rate of honey bee mortality, Michigan farmers are faced with elevated and increasing costs of commercial pollination services. According to a local commercial beekeeper, the current price is $65 - $75 per hive in Michigan. In California, where there is now a shortage of honey bees due to heavy losses from colony collapse disorder, growers

[32] National Agricultural Statistics Service. Statistics By State: Michigan: Publications: Annual Statistical Bulletin: Statistics 2013: Fruit.
[33] National Agricultural Statistics Service. Statistics By State: Michigan: Publications: Annual Statistical Bulletin: Statistics 2011: Fruit.
[34] National Agricultural Statistics Service, 2013.
[35] National Agricultural Statistics Service, 2013.
[36] Jaycox, E., 1976, "Pollination by honeybees," *Beekeeping in the Midwest,* Urbana-Champaign: University of Illinois.
[37] Ibid.
[38] National Agricultural Statistics Service of the US Department of Agriculture, 2012, "Press release: Washington and US sweet cherry production higher."

pay $145 - $165 per hive—more than triple the average cost before the emergence of CCD in 2005.[39]

III. On-The-Ground Approaches to Mitigate Honey Bee Population Decline in Michigan

Considering the complex web of causality that is likely leading to the steep losses of honey bees we are currently experiencing in Michigan, it is probable that multiple actors are contributing to the problem either directly or indirectly. In addition, it is clear that honey bee population declines are having negative effects on large- and small-scale farmers, commercial and backyard beekeepers, the food processing industry, Michigan produce consumers, and many others. So what can be done to tackle honey bee declines in our state? Because the problem has multiple and interwoven contributing factors, many different actions from a variety of stakeholders will be necessary. It cannot be over-emphasized that we need a multi-pronged approach to deal with honey bee population declines, both on the ground in farm fields and bee yards, and at the level of institutions for multi-stakeholder problem solving. This section will introduce some strategies that farmers and beekeepers can implement to reduce the number and intensity of stressors on honey bees, leading to healthier and more resilient colonies and a reduction in the incidence of colony collapse disorder. These strategies promote the development of agricultural environments that are more conducive to honey bee and native pollinator population health, which we call "bee friendly." A bee friendly environment is one that:

- Contains significant areas of habitat with diverse bee forage, including melliferous species of trees and native vegetation that provide ample protection, nesting sites, nectar, and pollen-producing sources on a constant blooming cycle
- Provides an adequate supply of clean water
- Reduces or eliminates the use of pesticides and other agrochemicals.

[39] 2012 Almond Pollination Update. American Beekeeping Journal. April 2012.

Farming Practices and Farm Land Management

One thing is clear: farmers of many different Michigan crops, such as apples, cherries and berries, rely on honey bees and native pollinators to get good yields. In general, the fruit set of these and many other crops tends to be lower, and of lower quality, without good pollination. Many Michigan farmers require the services of pollinators, and disruptions in these services have far-reaching effects that farmers will need to adapt to in order to continue farming successfully.

Below are some practices that farmers can implement in their farming and land management that would improve the quality and quantity of pollination services provided by honey bees, and in most cases also native pollinators.

- Planting more areas with native vegetation that provides a range of food sources for honey bees and native pollinators throughout the spring, summer and fall
- Reducing monocropping in favor of intercropping (planting multiple types of crops in the same area)
- Carefully following instructions for insecticide use, and ensuring that honey bees in the area are not present during application and for a certain period of time afterward through clear communication with beekeepers
- Reducing or eliminating insecticide and other agrochemical applications
- Keeping honey bee hives permanently on the farm

Diversification of Food Sources: Native Vegetation Plantings and Intercropping

Planting more areas with native vegetation that provides a range of food sources for honey bees and native pollinators throughout the spring, summer and fall is an important step in making industrial agricultural landscapes more bee friendly. Native vegetation planting, including buffer strips, would be beneficial both to native pollinators and stationary honey bee hives, in addition to providing healthy forage for migratory commercial pollinator services. A reduction in monocropping in favor of intercropping (planting multiple types of crops in the same area) can also provide bee forage for a longer period of time, reducing the problem of bees having an abundance of food for a short time while a crop is blooming and a “food desert” at other times of the year.

We recognize that these mitigation techniques may initially be difficult to implement because they will result in the loss of some area of valuable cropland. However, as honey bee populations continue to decline, the price for their pollination services is increasing.[40] If the problem of honey bee population decline continues unabated, commercial pollination may simply become unavailable, leaving no other viable option. An early investment in native pollinators and bee friendly farming practices could provide a buffer for these increased honey bee rental prices.

Insecticide Use

Almost all brands and types of insecticides are toxic to honey bees, making application practices the main method currently available for protecting the vulnerable species. When insecticides are used, several measures should be taken to reduce the risk of pollinator mortality:

- Communicating closely with beekeepers within a 6-mile radius of the insecticide application site to ensure that honey bees are kept away from the crops during and after pesticide application (how long after depends on the type of insecticide)
- Making sure to treat crops long before blooming occurs to reduce the number of pollinators in the vicinity and ensuring that the chemicals have more time to break down
- Not contaminating buffer strips and other areas of native habitat with pesticides, which can decimate natural pollinator populations

However, as mentioned above, systemic pesticides such as neonicotinoids may be concentrated in the food sources that honey bees bring back to the hive, leading to delayed weakening or mortality. Therefore, honey bees and native pollinators, as well as all of the people that rely on them for pollination, would greatly benefit from the reduction or elimination of insecticide and other agrochemical applications.

[40] Sumner, D., and Hayley Boriss, "Bee-conomics and the Leap in Pollination Fees," Agricultural and Resource Economics Update, Vol. 9, No. 3, Jan/Feb 2006, University of California, Giannini Foundation of Agricultural Economics.

Honey Bees on the Farm

Because of honey bee population endangerment, Michigan beekeepers and farmers are looking at an unsustainable future. Beekeepers are a powerful force in deciding our agricultural future in Michigan because apple, berry, and cherry farmers are highly pollinator dependent. Thus far, the main response by beekeepers to falling bee populations has been to increase prices for their pollination services.[41] This makes sense from an economic perspective, but has limited efficacy in improving future conditions for bees.

Pollination Discounts

In the short term, beekeepers should begin to offer discounts on pollination services to farms that have a bee friendly environment. Beekeepers should do this to provide an economic incentive for farmers to pursue more sustainable practices. Beekeepers themselves would benefit through improved honey bee health and lower colony mortality rates. Over time, bee friendly discounts will become increasingly attractive to farmers as the price for pollination services continues to rise. Additional incentives could be provided by government conservation programs in the form of subsidies for certified bee friendly farms.

A "bee friendly" environment that could qualify for a pollination discount is one that:

- Contains significant areas of habitat with diverse bee forage, including melliferous species of trees and native vegetation that provide ample protection, nesting sites, nectar, and pollen-producing sources on a constant blooming cycle
- Provides an adequate supply of clean water
- Reduces or eliminates the use of pesticides and other agrochemicals.

A New Definition of Pollination Services

The current system of transporting bees across the nation is unsustainable. Honeybee transportation stresses colonies as it exposes bees to a wide array of pesticides, while at the same time promoting conditions conducive to cultivating parasites and pathogens. Such transportation practices, however, have been necessary under the current industrial agriculture system.

[41] "2012 Almond Pollination Update," American Beekeeping Journal, April 2012.

A more sustainable long-term alternative to transient pollinator services is for farmers to return to beekeeping as an integral part of their agricultural practice. This would permanently ground honey bees in place, and prevent the strain on them associated with transient pollination services. Although many growers consider pollination a service for hire, farm-raised bees would alter the relationship between bees and farmers, and transform honey bees into a central asset for the farmer. We recognize that many farmers will be unwilling or unable to add beekeeping to their practice, and will continue to rely on outside beekeepers for pollination services. In such instances, farmers should look to local beekeepers and actively pursue pollinator discounts as described above.

Localized beekeeping has the potential benefit of dramatically reducing the stressors associated with honey bee population decline, including CCD. Localizing populations of honey bees would allow for them to adapt to their specific climate, developing regionally specific bees and increasing the diversity of the national honey bee gene pool. Furthermore, localized bees would incentivize farmers to use bee friendly practices, and encourage farmers to be cognizant not only of the health of their bees, but the quality of their land and the land of their neighbors. Finally, as the price for transient pollinations services continues to rise, keeping honey bees permanently on farms would offer farmers the opportunity to stabilize the cost of pollination services.

The mitigation techniques we have suggested are to increase bee friendly habitat; reduce and stabilize the cost of pollination services; reduce the necessity of long distance transportation of honey bees for pollination services; increase honey bee genetic diversity and support the development of climate-hardy, regionally adapted honey bee populations; mitigate the stressors associated with current commercial pollinator services; and potentially inhibit the loss of pollination services all together.

IV. Institutional Approaches to Mitigate Honey Bee Population Decline in Michigan

Facilitated Multi-Stakeholder Discussion, Legislation, and Litigation

Throughout the course of our research, it has become clear there are on-the-ground mitigation strategies that the agricultural and beekeeping communities should pursue. But to reduce the threat of continued honey bee population decline, synergetic solutions at multiple

scales of decision making must be pursued. By zooming out from the local to a more state-level perspective, we have identified three main avenues to protect our food systems from honey bee population collapse: facilitated multi-stakeholder discussion, legislation, and litigation.

These three paths are not mutually exclusive and should not be pursued in isolation. Rather, these three avenues are interrelated, and if done without open communication among stakeholders, could prove counterproductive to effectively mitigating honey bee population decline. For example, in the absence of attempted open dialogue, the path of litigation could result in inhibited information sharing and communication. Communication is critical to resolving the interwoven set of challenges associated with honey bee population decline. Similarly, legislation in the absence of open dialogue and stakeholder engagement can produce policy that fails to comprehensively address the challenges of honey bee population decline. Lastly, open dialogue can arguably only go so far; in the absence of changing policy—whether governmental or organizational—discussion can have limited impact.

Facilitated Multi-Stakeholder Discussion

Taking into consideration these interconnections, and the dearth of inter-sectoral collaboration on this issue, our recommendation is to create an inclusive, facilitated set of discussions among key stakeholders. Stakeholders should represent expertise in diverse areas related to pollinators, honey bee population decline, and the food system. This stakeholder engagement process would start in Michigan, but could serve as a model for similar processes regionally and nationally.

There are many models for stakeholder engagement; however, given the diversity of key actors impacted by honey bee population declines in Michigan, it is critical to design a stakeholder engagement model that builds trust, transparency, and communication, and facilitates collaborative and effective solutions. A successful model to look to in seeking such a dynamic is the work and experience of Sustainable Harvest, a coffee importer founded in 1997. This company, which has experienced rapid growth over the past decade, has been remarkably successful in tackling sustainability challenges through hosting annual "Let's Talk Coffee" gatherings, a series of events aimed at facilitating international, inter-sector, intra-supply chain

collaboration.[42] (See Appendix B for a description of the "Let's Talk Coffee" model for collaborative problem solving, multi-stakeholder engagement, and relationship building.)

Sustainable Harvest provides an innovative, scalable model that could inspire multi-stakeholder discussion to mitigate honey bee population decline in Michigan. Additional lessons can be taken from stakeholder engagement experiences such as the Pebble Mine in Bristol Bay, Alaska, and the Dow Chemical Company's partnership with People for the Ethical Treatment of Animals (PETA). While both of these cases have lengthy histories and warrant further study, the two most applicable lessons to the challenge of mitigating honey bee population declines in Michigan are:

- *A neutral third party should convene the discussion series as well as choose the facilitator to mediate the process*. Pebble Limited Partnership (PLP)—a large company that proposed a copper mine near Bristol Bay, Alaska, hired the Keystone Center—a policy resolution group, to review the project and convene a stakeholder dialogue about mining in the area. However, the US EPA as well as other science-based entities had already done extensive research and published findings on the impacts of mining in the Bristol Bay region and the potential impacts of the Pebble Mine. Thus, key stakeholders in the process saw PLP's hiring of Keystone as an insidious move and not one that built trust.[43] This example shows that effective stakeholder dialogue around contentious and wicked problems, is best when convened by a third party and when that third party selects the facilitators (as opposed to a party with vested interests taking the lead).
- *Productive, lasting partnerships, common ground, and collaboration can be cultivated between entities with seemingly divergent objectives*. The Dow Chemical Company and PETA have starkly different missions—one a leading chemical and plastics company, the other an international non-governmental organization dedicated to the ethical treatment of animals. However, the two entities have found some common ground and a strong partnership through a lengthy process that included shareholder petitions followed by open dialogue.[44]

Weaving these lessons from Sustainable Harvest, Pebble Mine, and the Dow/PETA partnership together, an effective multi-stakeholder discussion series could be designed to find

[42] Sustainable Harvest, 2103, <http://www.sustainableharvest.com/about/>; Let's Talk Coffee, 2013, <http://www.letstalkcoffee.org/#about>; Let's Talk Roya, 2013, <http://www.letstalkroya.org>.

[43] Reynolds, J., "Independence or Co-Dependence: The Keystone Center and the Pebble Mine," Switchboard, from Natural Resources Defense Counsel, 2012.

[44] Personal communication with Gregory Bond, Corporate Director of Product Responsibility at Dow Chemical, October 2013.

solutions to mitigate honey bee population decline in Michigan. A consortium of universities around Michigan, such as the University of Michigan, Michigan State University, Michigan Tech, Central Michigan University, and Wayne State, could serve as a convening body and provide or help select facilitators. The National Science Foundation, American Association for the Advancement of Science, Environmental Protection Agency, the US Department of Agriculture, and other federal or state funding opportunities could be pursued, as well as Michigan-based foundations that may be invested in the issue. The multi-stakeholder discussion would include participants from the government, the private sector, NGOs, and research universities, representing a diverse array of fields including, but not limited to:

- Agriculture (industrial, small-scale, organic)
- Apiculture (commercial and non-commercial, treatment-free and conventional)
- Entomology
- Toxicology
- Agricultural chemical production and sales
- Ecology
- Climate science
- Biology (including entomological neuroscience and neurology)
- Law
- Local, state, and federal policy (including legislators, EPA, and the Michigan Department of Environmental Quality)

The objective of the discussion series would be to share cutting edge research findings and best practices in a manner that enables and expedites constructive, scalable approaches to mitigating honey bee population decline and CCD, and ensuring the health of honey bees in perpetuity. This type of multi-stakeholder discussion series could take many forms, but looking to lessons learned from similar processes yields recommendations that the discussions would be most effective if they had the following elements:

- Convened by a neutral third party
- Facilitated by a neutral third party agreed upon by both public and private sector participants
- Objectives and timeline agreed upon by all parties
- Conducted using Chatham House rules[45] (or similar to ensure candid participation from stakeholders)

[45] Chatham House Rule, <http://www.chathamhouse.org/about-us/chathamhouserule>.

- Located in an environment and setting that facilitates both formal and informal interactions, community, and group cohesion (e.g., around communal meals, collaborative projects/activities)

Legislation and Litigation

Facilitated multi-stakeholder dialogue has the potential to catalyze trust and collaboration across sectors to develop strategies to mitigate honey bee population decline; however, in concert with discussions, the need for legislation and/or litigation may arise. Legislation and litigation have the potential to be collaborative, but if done in the absence of efforts to engage in constructive dialogue, can be divisive and antagonistic. Given the scale of the challenge of pollinator decline both in Michigan and the United States, there is a dire need for policy change via state and federal legislation on the issue as well as internal policy shifts within entities that impact pollinators.

Legislation is currently pending in the United States House of Representatives that aims to, at least in part, address some potential causes of honey bee population decline. The legislation, titled "Save America's Pollinators Act of 2013" (H.R. 2692) is sponsored by Michigan Representative John Conyers, Jr. and directs the EPA Administrator to suspend the registration of neonicotinoids until scientifically proven that such pesticides do not "cause unreasonable adverse effects on pollinators, including honey bees." H.R. 2692 also calls on the EPA Administrator to conduct a series of additional studies regarding the impacts of neonicotinoids on pollinators. The bill has bipartisan support, 39 co-sponsors, and as of August 2013 was referred to the House Subcommittee on Horticulture, Research, Biotechnology, and Foreign Agriculture.[46]

The introduction of H.R. 2692 demonstrates that the issue of honey bee population decline is of national importance. As the legislation goes through the process of committee mark-up, it would greatly benefit from additional stakeholder input. To be more comprehensively effective, the scope of the legislation should be broadened from addressing the "nitro group of neonicotinoid insecticides" to "systemic insecticides, including the nitro group of neonicotinoid insecticides and sulfoximines."

[46] The Library of Congress, "Bill Text 113th Congress (2013-2014) H.R.2692 IH."

Although these national policies would impact pollinator-related sectors in Michigan, state level legislation should also be pursued. Like national policy, state legislation should be developed as a collaboration among beekeepers, farmers, pesticide companies, environmental advocacy groups, and legislators. Such collaboration would not only strengthen the efficacy of pollinator legislation, but also prevent the promulgation of policies that threaten pollinator health.

V. A New Path Forward

In the face of major honey bee population declines around the world, many beekeepers and farmers are taking positive action on a local level. Some of the best examples of sustainable pollinator practices can be found right here in Michigan. Farmers such as Jim Koan, owner of Almar Orchards, an organic apple farm and cider brewery, is an important reminder of viable solutions to protect honey bee populations in Michigan. Jim's orchard features a variety of melliferous crops maintained by agroecological methods that promote integrated pest management and a bee friendly landscape. Jim has demonstrated that a bee friendly farm can adequately satisfy the triple bottom line of social, environmental and economic sustainability, and can produce some of the finest quality agricultural products available in the state of Michigan.

Some Michigan beekeepers are working towards sustainable practices as well. One such beekeeper is Dr. Smith,[47] a veterinarian in southeast Michigan who began beekeeping four years ago. *Bees are by far the most fascinating animals I have ever encountered. When I heard they were having a hard time I decided I would just jump in and learn how to be a beekeeper. There's just nothing like it.* Dr. Smith has committed herself and her resources as a veterinarian to fighting honey bee population declines. *I went to over fifteen beekeeping conferences last year, from Portland, Oregon to Kiev, Ukraine. You have to try and stay on top of this thing and be in contact with as many people as possible to know what's going on, and the best place to do that is to connect with beekeepers as much as possible at these conferences.*

Dr. Smith is also a treatment-free beekeeper. *I don't use anything in my hive that the bees wouldn't use for themselves. No miticides, no antibiotics, no sugar. We have to raise stronger bees that can live with mites, and I just don't want anything getting into my wax or honey that*

[47] Name has been changed to protect confidentiality.

could be potentially dangerous to me, my family, or my community. But despite her dedication to being a treatment-free beekeeper, Dr. Smith is moderate in her political approach to the problem. *Look, this is a complicated situation. The jury is still out on honey bee losses, and I want hard science. Chemical companies aren't going away, and they know they've got a problem on their hands. So do farmers. And it's not like the commercial beekeeping industry is perfect either. We need to speak to each other. We need to work on this together because in the end this is going to hit ALL of us.*

Dr. Smith is a model for small-scale beekeepers deeply committed to good practices. She keeps extensive journals for each colony to monitor conditions of the hive in relationship to the environment; she regularly checks her bees and monitors potential parasites and pathogens; and she communicates with the farmer next door and locks her bees in when she knows the fields around her hives are going to be sprayed. *I don't like it, but I'm doing the best I can. I think this is the best we can all do right now, and we need to be doing a lot more of it. Communication is key.*

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Appendix A: Resources for Farmers and Beekeepers

Created by Betsy Riley, November 2013

Farmers and Colony Collapse Disorder: Mitigation Techniques for Large Scale Farmers

One thing is clear: Farmers will continue to farm, with or without strong bee populations. Current farming practices have traditionally relied on the services of pollinators, and disruptions in these services will have far reaching effects that farmers will need to adapt to in order to continue farming successfully. This section will explore methods that farmers can take to reduce the negative impacts that CCD will inevitably have on their crop yields, mitigating the effects until a solution is achieved.

It should be noted that many mitigation methods will inevitably result in the loss of some measure of valuable cropland. Farmers are well acquainted with the laws of supply and demand however, and as bee numbers decrease, prices for their services will increase. If the problem of CCD continues unabated, commercial pollination may simply become unavailable, leaving no other viable option. An early investment in alternative pollinators and pollinator maximization techniques could provide a buffer for these increased bee prices. Negotiations with beekeepers could result in a discount for fields that include bee friendly land. And, if worst comes to worst and the bee die-offs become too great, such an investment in natural pollinators may be the only way to access pollination of any sort—a boon that will greatly outweigh the losses experienced in upfront costs of yield decreases.

Natural Pollinator Habitat

Honey bees are not the only pollinators of crops, nor (recent research suggests[48]) are they the most effective. Research indicates that although native pollinators (which includes such species as other bee types, butterflies, etc.) have shorter ranges and do less per capita pollination than honey bees, the *quality* of pollination is extremely high, meaning there is less inbreeding (pollinating a plant with itself) and a greater number of flowers that turn into fruit. This same research found that a combination of both honeybees and native pollinators is the most effect

[48] Garibaldi, Lucas, et al. 2013. Wild Pollinators Enhance Fruit Set of Crops Regardless of Honey Bee Abundance. *Science* 339, 1608-1611.

pollination combination.[49] Honeybees have been prized pollinators for other reasons, including being reliable and efficient in what they do and, due to their hive structure, can be moved from place to place as the pollination season demands, making the colonies an easy choice for farmers looking for pollination services. But as honey bee numbers are reduced, crops requiring pollination will begin to require more and more help from natural pollinators.

Promoting native pollinators is straightforward: install more native pollinator habitat. Unlike honey bees, which can travel many miles in search of nectar, most natural pollinators are much more limited in their range. Research suggests that for every .6 mile away that an agricultural crop is from natural pollinator habitat, crops experience a 16% decrease in fruit set, or the probability that a pollinated blossom will bear fruit—a direct impact on total yield. Natural pollinator habitat will look different depending on what sort of crop is being produced. For orchards with tall trees, this may mean planting habitat around trees themselves. For crops that involve long fields to be harvested, or fields of smaller trees, increasing the number of buffer strips is an easy solution. These strips can be seeded with flowering plants that resemble the flowers of the crop (native plants, preferably, to reduce upkeep and the potential for invasive species removal requirements) to attract the right kind of native pollinator.

This strategy has multiple benefits. Including these rows not only grants a farmer greater access to natural pollinators in the short term, but the rows of natural vegetation also make excellent bee habitat. As beekeepers grow increasingly concerned about the health and welfare of their bees, they may begin refusing to move their bees to cropland which does not support healthy bee populations, making buffered land an excellent location for beekeepers to ply their trade—at potential discounts to the farmer. This is in addition to the anti-erosion benefits of buffer zones, which already qualify cropland for government sponsored environmental reward programs, further reducing the cost to farmers of implementing these measures.

Buffer Strips and Pesticide Use

Buffer strips are an investment in natural pollinators, and this investment should be protected by making sure that these pollinators are able to do their job. This section of the paper is by no means suggesting that all farmers should swear off pesticides, but insecticides are

[49] Garibaldi, et al. 2013. Wild Pollinators Enhance Fruit Set of Crops Regardless of Honey Bee Abundance. *Science* 339, 1608-1611.

designed to kill insects, and there no doubt that pesticides *do* kill bees. Don't be fooled into believing that "bee friendly" pesticides don't kill bees. Some pesticides are truly less destructive to bee populations than others (see discussion on neonicotinoids below) but many chemical companies openly suggest that the best way to be bee friendly is to avoid contact between the pesticide and bees entirely.[50] If the idea of natural buffer strips is to improve pollinator access to your crops, this connection cannot be overlooked.

Buffer strips can reduce the need for pesticide applications by providing habitat for the predator insects that feed on insect pests. As every farmer knows, today's monocropping practices makes entire fields full of desirable food to some of farming's most notorious pests, including lygus on cotton farms,[51] the coddling moth in apple orchards,[52] and the cherry bark tortrix that frequents cherry orchards.[53] Buffer strips would not only provide habitat to natural pollinators, but to insect pests' natural predators as well, who would love nothing more than to have better access to the insect pests that they prefer to feed on. If this route is chosen, however, these buffer strips should be specifically tailored to provide ideal habitat to predators and parasitoids that feed on pest insects (including providing a form of winter habitat, and perhaps attracting alternative prey species that don't affect the crops), rather than relying on the buffer strips alone to do the job, as some research has suggested that increasing plant diversity alone can have adverse effects on pest populations.[54] There could very likely be a sweet spot, where a reduced pesticide application could be compensated for by the natural predators that live in the more frequent buffer strips, although the exact number of buffer strips and amount of pesticide application will differ with crop and pesticide type.[55]

The Low Down on Pesticides

Some types of pesticides are more bee friendly than others. Anyone keeping up with the news on CCD knows that neonicotinoids have been a hotly debated topic in the bee circle for a long time, in some cases resulting in the pesticide class being outlawed completely.[56] This has been an issue for farmers, who have seen neonicotinoids as a chance to be both environmentally

[50] Dow AgroSciences, 2013.
[51] Dow AgroSciences, 2010.
[52] Barrett, 2001.
[53] Miles, Roozen, & King, 2012.
[54] Gurr, 1998.
[55] Landis, Wratten, & Gurr, 2000.
[56] Rabesandratana, 2013.

friendly and maintain solid business practices. It is not possible that this branch of chemicals is alone responsible for CCD, but evidence suggests that it could be a big red flag on the list of bee death instigators.

Almost all brands and types of pesticides are highly toxic to bees, making application practices the main method currently available for protecting the vulnerable species. Several methods have been proposed to reduce the number of pollinator deaths:

- Applying the pesticide when the bees are least active, such as at dusk, can protect pollinators from the worst effects of the chemicals.
- Finding a way to remove the pollinators from treated fields until the pesticide has been given a chance to at least partially break down.
- Making sure to treat crops long before blooming occurs can reduce the number of bees in the vicinity and ensure that the chemicals have more time to break down before bees do start frequenting the area.
- For buffer strip users: Avoid contaminating buffer strips with pesticides. Doing so can decimate natural pollinator populations.

Proponents of neonicotinoids would be quick to point out that using this type of chemical greatly reduces the need to do any of these practices, as the pesticides reduce the amount of pesticide that needs to be applied and it's usually applied to the roots or seeds, rather than to the body of the plant where most pollinators would come into contact. This is only a superficial analysis of the problem.

Neonicotinoids have been singled out by beekeepers as particularly dangerous for bees due to their long term toxicity. Neonicotinoids were originally hailed as a great environmental alternative to widely sprayed pesticides due to their ability accumulate in the plant and retain their toxicity over every inch, reducing the need to treat crops and thus reducing the amount of chemicals that ran off into waterways. Unfortunately, this very benefit makes it particularly dangerous to bees. Bees come into regular contact with the pesticides through pollen, getting hit with doses of the pesticide again and again over the course of their daily foraging as no amount of rain or weather will wash away the chemical. This trait makes neonicotinoids particularly feared by beekeepers and dangerous to pollinators.

The Future of Beekeeping: Where the Industry Might Go from Here

Michigan beekeepers are looking at an unsustainable future, and some movement must happen for the industry to continue. Nevertheless, beekeepers are a very powerful force in deciding what direction this movement should go in. Apple farmers *must* have pollinators. As must berry farmers. Without pollinators, these crops will not grow. At the moment, no other viable pollination service is available for these crops on a scale that can rival honeybees. For these types of crops, beekeepers have a monopoly on pollination.

Thus far, the main response by beekeepers to falling bee populations is to increase prices for their pollination services. This makes sense from an economic perspective and is an excellent first step, but has limited effectiveness in improving long term living conditions for bees. It also puts all the risk of CCD on beekeepers. Below are some policy and economic ideas for bringing farmers on board with creating bee friendly environments, starting with basic concepts and ending with some ideas of where the future of beekeeping might lead.

Pollination Discounts

Few farmers understand honeybees as well as beekeepers and these pollination customers are unlikely to take the initiative to learn on their own without understanding how it will help them in their business. Farmers, however, are experts at responding to new science and market forces. Beekeepers can tap into this drive and push the agricultural industry in the right direction. The simplest way of doing this is by offering discounts to farmers who install bee friendly highlights to their farms. Such a method has two valuable components: 1.) it lays out clearly what steps farmers should take, and 2.) it provides an economic incentive that farmers will pay attention to. Farmers will have incentive to adopt these habitat improvements as the prices per hive become high enough that the losses incurred by farmers by installing these highlights is outweighed by their savings in pollination services. Beekeepers can tips the scales on this calculation by decreasing the cost of pollination services even more—even if it means taking a loss initially and recouping this cost from the higher prices imposed on farmers who do not implement the measures. Some methods could qualify the farmer for additional savings through government conservation programs which could be mentioned as additional incentive.

Below is a short list of potential bee friendly activities that farmers can undertake that could earn discounts on pollination services. Other ideas could be equally or more effective depending on the needs of different hives:

- Increased installation of buffer strips
- The planting of bee-friendly plants in their fields to supplement bee diets
- Carefully following instructions for pesticide use, using only specific pesticide products at specific times
- A reduction or elimination of pesticide use
- The planting of multiple crops on the same field (reduction of monocropping)

Creating bee friendly environments can reduce the strain on bees as they move to new places and can produce healthier honey bees.

A Political Voice for Bees

While some active groups exist, beekeepers in general are woefully underrepresented in the halls of Lansing. This makes no political sense, as beekeepers are a powerful force in Michigan business. The agriculture and food industry in the state contributes over $90 billion annually to the state's economy, with the largest growth sector coming from farming.[57] Michigan also stands 9th in the nation in terms of honey production. This, it turns out, is a drop from 7th in the nation last year.[58] Pollinated crop production has dropped dramatically—by hundreds of millions of pounds produced in some cases—since 2006. Apple production in particular has dropped far behind Washington and New York,[59] even taking into account the damage caused by warm winters.[60]

And yet little to no effort has been made to link these production drops to pollinator decline. Little to no effort has been made to impress upon representatives in Lansing how many more losses could be suffered as pollinators continue to decline. This is surprising considering it was a Michigan Representative in Washington that co-sponsored the "Save America's

[57] MDARD, 2013.
[58] The Associated Press, 2013.
[59] National Agricultural Statistics Service, 2013.
[60] National Agricultural Statistics Service, 2011.

Pollinators Act" (H.R. 2692) in July 2013.[61] If beekeepers wish to prevent potentially destructive policies such as star thistle and knapweed extermination efforts,[62] a greater effort must be made to organize into a single, powerful political voice to lobby for pollinator interests.
Unions started in Michigan. It may be worthwhile to see if something similar will work for bees.

A New Definition of Pollination Services

Beekeepers only want to do what's best for their bees, but the current system of moving bees from place to place creates a great deal of strain on hives, in addition to exposing them to a wide array of pesticide types. All this strain on bees wreaks havoc on bee immune systems, making them more susceptible to CCD. Such movement practices, however, have been necessary under the current system of pollination services.

An alternative method would be to sell the farmer the *hive* and manage it for a fee. This would prevent the strain on bees and reduce beekeeper liability if a hive dies. Such a system would redefine how pollination services is currently thought about, and at face value, has obvious drawbacks. Each potential problem is discussed below in turn, in a question and answer format.

Do farmers even know how to take care of bees?

Farmers are experts at farming, but to many growers, bees are considered a service—something that is delivered occasionally, but ultimately the responsibility of someone else. This system would alter that relationship, turning the bees into an asset and the beekeepers themselves into the service being provided. Rather than selling the farmer the hive and then walking away, beekeepers could sell the hive in one lump sum, then have the farmer pay them a relatively low fee after installation for regular upkeep (every three weeks to once a month) in which the beekeeper would monitor the hive for the health of bees, parasite infestation, and other warning signs, and then take action if it looks like the hive is in danger.

Such a system would fundamentally alter the relationship between bees, beekeepers, and farmers, but has the benefit of dramatically reducing the stress placed on bees due to frequent movement throughout the year. It would allow bees really move in, adapt to a single location,

[61] GovTrack.us, 2013 .
[62] Runk, 2010.

and begin to genetically localize their populations—creating even hardier bees better adapted to the region they're living in. In addition, it creates incentives for farmers to use bee friendly practices, since the bees would belong to them and they are assuming some of the risk. Farmers would naturally begin to pay more attention to ensuring their land—and the land adjacent to theirs—is bee-friendly.

So beekeepers would become caretakers? They wouldn't raise bees at all? That doesn't seem like a very sustainable business.

Beekeepers would be much more than caretakers. By removing some of the risk that they face to farmers, beekeepers could begin to focus more closely on breeding their bees to withstand the environmental challenges that have been facing them. Excellent work in this regard is already being done.[63] Bees with more selective breeding (to withstand *varroa* mites, extreme cold, etc.) could be sold at higher prices with higher guarantees.

In addition, not all farmers will be interested in such an arrangement, and would much prefer to continue paying for pollination services as they currently stand. It is unlikely, at least in the beginning, that offering this type of service will dramatically change current beekeeping practices.

Why would farmers want to assume that level of risk?

Farmers are currently caught between a rock and a hard place. Currently, they can either pay the high prices for pollination services—prices that are skyrocketing more and more every year—or they can choose not to pollinate their crops—an extremely poor business decision. This method would allow farmers to stabilize the cost of pollination. Regardless of what is happening in the rest of the bee market, the cost of having someone monitor your hive should remain relatively stable and predictable, with only occasional costs associated with a failed hive or the cost of hive treatment.

Risks to hives are also mitigated by this technique. In addition to the reducing bee stress by giving them a more permanent home, having the bees spread out around farms, rather than clustered together on the property of beekeepers, reduces their risk of catching *varroa* mites or other diseases from nearby hives. Other risk management techniques, including creating bee

[63] Boswell, 2013.

friendly habitat to protect bees and controlling pesticide applications—arguably the biggest risk to bees—can be managed better by farmers who have an investment in keeping their bees safe. But they'll need beekeepers handy to know what that involves.

Farmers could also choose what level of risk they want to face. As beekeepers focus more on selective breeding, farmers can choose to spend more on higher quality bees that have a higher likelihood of withstanding the negative environmental forces linked to bee die-off. They can choose to pay less for bees with less breeding. This would not be difficult to communicate to farmers, who have extensive experience with the benefits and risks of different seed types. Partnerships with farmers could greatly improve prospects for both sides. Beekeepers can provide a certain amount of insurance based on the number of hives a farmer is willing to buy. If the farmer buys 10 hives, for example, the beekeeper could reimburse them for 1 collapsed hive. In exchange for assuming this risk, beekeepers would have the ability to choose a new hive from a recently split colony for breeding purposes.

Beekeepers have to make a profit. Where is the profit coming from?

For the farmers that are interested in this arrangement, there are multiple ways that beekeepers could turn such a system to their advantage.

- **Cost Reduction:** Bees would not need to be transported beyond moving to their new home, greatly reducing transportation costs, including fuel and syrup for bees to eat during transit.
- **Cost Reduction:** Decreased strain on these transportation vehicles also greatly reduces the annual wear on these large capital costs.
- **Cost Reduction:** Supply costs for the bees, such as treatment costs if a hive is infected with *varroa* mites, will be borne by the farmers.
- **Revenue Source:** Beekeepers will be paid for their work in taking care of the farmers' bees, including installation, monitoring and maintenance, any necessary hive treatments, and winterizing hives.
- **Revenue Source:** Selling the hives themselves will be a source of revenue, and, if such a program is agreed upon, getting an occasional healthy free hive when a large hive is split ensures a regular supply of healthy bees for breeding.

- **Revenue Source:** Farmers may be interested in renting bees to their nearby neighbors at their own risk and expense. Beekeepers already have this equipment on hand, and can be paid for transporting the hives.
- **Cost Reduction by Risk Reduction:** The system provides something of a safety net for beekeepers. Under the current system, beekeepers assume all the losses if their hives go under. If catastrophe strikes their bees, they have no other way to make a profit. By widening the range of services offered, beekeepers diversify their risk, having a backup system in place in case one location with bees goes under.

Not all farmers would be interested in this sort of arrangement. Many farmers would choose to pay a premium to have the bees shipped in rather than undergo the effort of having their own bees. Beekeepers may not consider it feasible to offer the service to farms that are too far away, thus requiring extreme transportation costs for a weekly check in. So even under such a system, much about the beekeeping business will remain the same.

Farmers will want a profit for doing something like this, too. Why should farmers want to go through all this trouble for a once-a-year pollination service?

Farmers would gain control over new bee hives and honey production. New swarms would belong to the farmer (aside from any partnership agreement with the beekeeper) and honey produced could go to the farmer as well (aside from a fee to beekeepers for harvesting it).

The real benefits are in the form of price stabilization for pollinator services, discounts on these services (as they're paying for maintenance only), and a decreased risk of losing pollination services altogether (no little thing since the cost of pollinator failure is a failure of the entire farm).

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Appendix B: Sustainable Harvest "Let's Talk Coffee" Model

Sustainable Harvest is a certified B Corporation, purchasing coffee from 84 producer organizations in Latin America and Africa. Their work supports nearly 200,000 farmers. In addition to its commitment to building strong partnerships among its suppliers and buyers, Sustainable Harvest is committed to using data-driven analysis both on the farm level and throughout the supply chain.[64]

Each year, Sustainble Harvest hosts a gathering called "Let's Talk Coffee," which brings together (by invitation) key actors in the coffee supply chain, as well as experts in related subjects, for a multi-day conference aimed at relationship building, and "cultivating a community of trust[65]". The conference includes workshops, lectures, communal meals, and time for informal interactions and collaboration. Attendees include coffee producers (both large and small), coffee roasters (both large and small), corporate executives from large-scale coffee buyers/sellers (e.g., Walmart), politicians, agronomists, climate scientists, and many others.[66] All of the participants work and lives are intertwined with the coffee business in the fields, markets, and laboratories.

In addition to the annual "Let's Talk Coffee" gathering, Sustainable Harvest has recently started hosting a "Let's Talk Roya," a similarly structured conference that is aimed at bringing "together those impacted by Roya in Latin America to learn about the disease, coordinate recovery, and mitigate the long term consequences of the outbreak." Roya, also known as Coffee Rust, is a pest wreaking havoc on coffee production in Central America, exacerbated by climate change.[67]

[64] Sustainable Harvest, 2013.
[65] Let's Talk Cofee, 2013.
[66] Sinclair, L., "Let's Talk Coffee: 5 Takeaways," sprudge.com, 9 October, 2012.
[67] Let's Talk Roya, 2013.