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Colony Collapse Disorder in North American Honey Bees: History, Economics and Policy



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Environmental Policy Senior Thesis
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“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 7 billion people.”

-- Achim Steiner
Executive Director,
UN Environment Program

Abstract

In recent years, millions of bees have died in North America as part of a phenomenon known as Colony Collapse Disorder. This thesis analyzes the importance of productive bee colonies and how their act of pollination is a vital ecosystem service to many of our economies. It identifies the major crops reliant on bee pollination and the many ecological threats that declining bee populations pose. Using data from the USDA, university studies, and other scientific research, this thesis evaluates the many reasons for the decline of honeybees as a result of the gradual decline of the nation's current agricultural system.

This thesis looks at the history of honeybees in North America as well as how the modern honeybee industry came to be what it is today. This thesis uses the discipline of economics to demonstrate the monetary value of bee pollination and other ecological services and the costs that honeybee declines pose. Finally, it analyzes the political action of other countries compared to the United States in regards to preserving the honeybee to suggest a level of inadequacy on the part of the latter. Using the success of apiaries in Vermont as a case study, it will suggest policy recommendations for the United States based on the unique factors of Vermont's agricultural system. Such policies could include banning the use of neonicotinoids and other pesticides, reducing large-scale farming operations and monocultures, education, and promoting/incentivizing organic agriculture techniques.

Introduction

American Bee Journal editor G.H. Cale once described the honeybee as “the ugly step child of agriculture.”¹ This thesis will look into the vital, yet often undermined, honeybee species as a major factor in the prosperity of many important industries that ensure food security. It will analyze the many reasons why honeybees are the most important pollinating species that exists and why we cannot afford to overlook this species any longer. In the past eight years, honeybees have been dying off at abnormal rates. Furthermore, colonies have been disappearing altogether, leaving scientists baffled and beekeepers heartbroken. There are many proposed reasons for this phenomenon, known as Colony Collapse Disorder (referred to as CCD from here on), including habitat loss and reduced forage areas, pathogens, pesticides, commercial beekeeping practices, and other environmental stressors. All of these factors collectively contribute to high amounts of stress to the bees, weakening their immune systems and causing colonies to collapse.

Like with all systems in nature, there exists a mutual relationship between honeybees and plants that has, according to Dr. Reese Halter, “served to ensure the survival of both.”² I will analyze this symbiotic relationship, explaining the complex anatomy of a bee colony and the many roles that exist in this socialist-like society. Furthermore, through an in-depth examination of the history and evolution of

¹ Horn, Tammy. *Bees in America: How the Honey Bee Shaped a Nation* (Lexington: The University Press of Kentucky, 2005), 146.

² Halter, Reese. *The Incomparable Honey Bee and the Economics of Pollination* (Toronto: Rocky Mountain Books, 2011), 11.

beekeeping, I will attempt to prove the human-honey bee partnership as what author and Vermonter Rowan Jacobsen describes as, “a classic example of coevolution” whereas our breakthroughs in beekeeping serve to benefit both the keeper and the colony.³

To further strengthen the argument regarding the importance of such species, this thesis will look into both the ecological and economic value of honeybees. While the capabilities of bees from beekeeping—from honey, beeswax, and royal jelly production—are great luxuries that we are fortunate to have, nothing can amount to the worth of pollination. Despite the existence of many pollinating species, including over twenty thousand bee species, only the European honeybee, or *Apis mellifera*, has evolved to specialize in the feeding of nectar and pollen, subsequently resulting in pollination.⁴ Without honeybee pollination, the foods we have become accustomed to eating on a daily basis would no longer be available (or their prices would be exponentially higher).

In other nations, the importance of honeybees is acknowledged to a greater extent than in America currently. Other countries have gone to greater measures to reduce the stress-inducing and harmful elements that threaten the prosperity of such species. While the Environmental Protection Agency is aware of the potential factors that contribute to CCD, there has been inadequate action in the form of policy to reduce the quantity or potency of honeybee harming elements. I will look into the history of domestic policies affecting the beekeeping industry as well as

³ Jacobsen, Rowan. *Fruitless Fall: The Collapse of the Honey Bee and the Coming Agricultural Crisis* (New York: Bloomsbury, 2008), 33-34.

⁴ Jacobsen, *Fruitless Fall*, 9.

more recent policies enacted in foreign countries as a response to staggering colony losses.

Finally, I will use the state of Vermont as a case study for nationwide policy recommendations. Despite “staggering losses” of honeybees each winter since 2006, honeybees in Vermont have fared well, reporting normal losses of 10-15% each year.⁵ Through interviews with beekeepers throughout the State, this thesis will analyze the many proposed reasons for successful apiaries in Vermont and attempt to apply these factors to a nationwide scale.

Chapter 1: Colony Collapse Disorder and the Suspected Causes

Decline. In 2007, The National Academy of Science’s “Status of Pollinators in North America” report stated, “Among the various pollinator groups, evidence for decline in North America is most compelling for the honey bee, *Apis mellifera*.”⁶ Honeybees, the primary commercial pollinators in North America, have declined from over 6 million colonies in 1947, to 4.2 million colonies in 1981 to just 2.41 million in 2005.⁷ Then, colony losses in the winter of 2006 induced panic among the beekeeping community. Author Rowan Jacobsen wrote, “Perhaps 800,000 of the 2.4 million colonies of honey bees in the United States collapsed that winter. Thirty billion bees dead, and no one knew why.”⁸ This bee plague was the first sign of

⁵ Cengeri, Ric and Patti Daniels. “VT Sees Normal Die-Off, Despite National Concerns.” *Vermont Public Radio*, May 8, 2013.

⁶ “Status of Pollinators in North America.” *The National Academies Press* (2007): 3, 75. Accessed 11 March 2014.

⁷ “Report on the National Stakeholders Conference on Honey Bee Health,” *United States Department of Agriculture* (2012): 5.

⁸ Jacobsen, *Fruitless Fall*, 64.

Colony Collapse Disorder, in which adult bees would disappear from the hives entirely, leaving behind only the queen, honey, and brood. The loss of colonies after the winter of 2006 left beekeepers startled, disturbed, and overall confused—especially given that the bodies of bees were no where to be found. Furthermore, beekeepers across the country noticed that these abandoned hives, filled with honey and defenseless young bees, were not robbed by normal predators such as wax moths, other bees, or even bears. This was a sure sign that these hives did not succumb to typical ailments. And so, the hunt for the culprit began...

False Accusations. After the winter of 2006, beekeepers, regulators, and scientists, alike, were in a scramble to get to the bottom of this phenomenon. The sooner they identified a cause, the sooner they could develop a solution. Rowan Jacobsen exemplifies this time of confusion and blame as he discusses some of the radical (and rational) theories that circulated—and the subsequent evidence that shut them down. The first theory, based off of a study on behavior and *cordless* phones (not cell phones) blamed the electromagnetic radiation from cellular phones for the disorientation of bees. While, yes, bees from the hives with the base of cordless phones below them produced less honeycomb than nonexposed bees, any changes in behavior could seemingly be contributed to the incessant ringing of a phone. Furthermore, cell phones were not even tested in the study; the media, however, still managed to get this theory afloat. Other studies have tested the effects of electromagnetic radiation from cell towers and have found similar reductions in honey and honeycomb production. However, researchers conclude that cell phone towers are not a major factor in CCD.

A more rational theory was that genetically modified (GM) crops are to blame for CCD. Although the wind pollinates corn, many people questioned what happened when bees collect pollen from GM corn, which has *Bacillus thuringiensis* in its' cells. *Bacillus thuringiensis* (*Bt*), which is toxic to insects, was developed to naturally occur within the cells of the corn, eliminating the need to spray crops with pesticides that can end up in groundwater sources.^{9a} In scientific studies, however, honeybees fed pollen from *Bt* corn showed no negative side effects. Furthermore, there are no known cases of CCD in some of the most intensive GM corn states such as Indiana and Nebraska—yet there have been reported cases in states with no GM crops, explains Jacobsen. Most importantly, CCD is ever-present in Europe despite a ban of GM crops.

The “Report on the National Stakeholders Conference on Honey Bee Health” accurately states, “No single silver bullet will solve the problems affecting honey bees...”^{9b} Rather, there is a catalogue of pathogens, parasites, stressors, and chemicals that are collectively contributing to the weakened immune system of honeybees, leading to their collapse. Through an analysis of industrial agriculture and the subsequent modern beekeeping practices that evolved, the next sections of this chapter will introduce the contributing factors to the decline of this imperative species.

Pathogens. Major die-offs of bee colonies were not unusual prior to CCD. One of the first major threats, a microscopic mite called *Varroa destructor*, originating

^{9a} Jacobsen, Fruitless Fall, 69

^{9b} “Report on the National Stakeholders Conference on Honey Bee Health,” 5.

from Asia, made its first appearance in the United States in 1987 when it was found in Florida.¹⁰ Despite quarantine on Florida bees shortly after the discovery of *varroa*, beekeepers fled with their bees and, within a year, *varroa* was everywhere. These mites take cover in the brood chambers of the hive where they suck the blood of brood and lay eggs in the chamber. The hatched eggs then subsequently suck the blood of the brood as well, reproduce, then find another chamber once the cell is opened and repeat the process. While sucking the blood of the brood does not kill them, notes Jacobsen, the open wounds allow for bacteria, fungi, and viruses to thrive and usually result in an adult bee that is “malformed, malnourished, and crippled with disease.”¹¹ Also, because varroa-sucked bees do not always develop their hypopharyngeal glands—the ducts that produce royal jelly (or “baby food”)—the next generation of bees is then in turn malnourished and shorter-lived. The ten years after varroa appeared in the U.S., it killed millions of honeybee colonies and put one quarter of professional beekeepers in the country out of business.¹²

Another more recent threat to honeybees is the parasite *Nosema ceranae*. This parasitic fungus infiltrates the gut of bees, destroying the cells lining the gut used for digestion. Bees infected with *nosema* are unable to absorb nutrients and eventually die of starvation.¹³ Like *varroa*, *nosema* originated from Asia and was not found in the U.S. until the early 1990s and Europe in the early 2000s.¹⁴

¹⁰ Halter, *Incomparable Honey Bee*, 82-83.

¹¹ Jacobsen, *Fruitless Fall*, 59

¹² Jacobsen, *Fruitless Fall*, 58.

¹³ Jacobsen, *Fruitless Fall*, 80

¹⁴ Halter, *Incomparable Honey Bee*, 84.

In 2004, Congress waived the Honey Bee Act of 1922 which prohibited the importation of foreign bees. With this waiver, the Israeli acute paralysis virus (IAPV) was said to have arrived in the US from imported bees from Australia. This virus, which causes bees to “shiver until paralysis and death,” was once considered the sole culprit for CCD, putting mass blame on Australia for allowing the importation of such bees.¹⁵ However, this theory was put to rest when USDA researchers found IAPV present in bees frozen in 2002—two years before the Aussie importation of bees.¹⁶ IAPV, then, was clearly not *solely* responsible for CCD—nor was *nosema* or *varroa*.

A densely scientific epizootiological study conducted by thirteen scientists in 2009 considered 61 different variables among 91 apiaries both afflicted by CCD and not afflicted. Much to the dismay of the beekeeping population, and on trend with other scientists, they found that, “of the 61 variables quantified...no single factor was found with enough consistency to suggest one causal agent.”^{16a} However, they did discover that, “Bees in CCD colonies had higher pathogen loads and were co-infected with more pathogens than control populations, suggesting either greater pathogen exposure or reduced defenses in CCD bees.”¹⁷ One reason for reduced defenses stems from common treatments to these popular pathogens. For example, a pesticide called Apistan was developed in the early nineties to kill varroa mites. While it worked wonders initially, varroa mites eventually developed a resistance,

^{14a} Jacobsen, *Fruitless Fall*, 60

^{14b} Halter, *Incomparable Honey Bee*, 84

¹⁵ Halter, *Incomparable Honey Bee*, 81

¹⁶ Jacobsen, *Fruitless Fall*, 79.

^{16a} Dennis vanEngelsdorp et al., *Colony Collapse Disorder: A Descriptive Study*, 2009. [10.1371/journal.pone.0006481](https://doi.org/10.1371/journal.pone.0006481)

¹⁷ vanEngelsdorp et al., *Colony Collapse Disorder: A Descriptive Study*, 2009.

prompting the development of a stronger pesticide: CheckMite. A year later, mites again developed resistance.^{14a} While commercial beekeepers still use both treatments today in an attempt to control the mites, Dr. Reese Halter points out that both of these fluvalinate pesticides contaminate beeswax and weaken the immune systems of bees. As for nosema, beekeepers commonly use the antibiotic fumagillin as treatment. Fumagillin, however, is linked “to the dramatic increase in disease loads, as it weakens the bees’ immune systems.”^{14b} This paradoxical system of treating bees with chemicals that in turn weaken their immune systems is clearly not effective—especially since hives demand greater quantities of pesticides as pathogens develop resistance to such treatments. While this is potentially one of the greatest flaws in modern beekeeping, the widespread adoption of synthetic pesticides in the past century is one of the greatest threats to bees and a healthy environment.

Pesticides. The increased use of pesticides as a result of industrial agriculture is another leading factor contributing to the collective decline of honeybee colonies. In response to the past dilemma facing the pesticide manufacturing industry—in which a chemical was needed to kill pests, protect plants, and be harmless to animals that ingested the crop—a new group of pesticides called neonicotinoids was introduced. Dr. Reese Halter explains this group as, “A neuro-active insecticide fashioned after nicotine, neonicotinoids poison nerves and prevent acetylcholine from enabling neurons to communicate with each

other and with muscle tissue.”¹⁸ A shortage of acetylcholine, he explains, results in disorientation, short-term memory loss, loss of appetite, tremors, spasms, paralysis and death. In humans, a lack of acetylcholine reception leads to Parkinson’s disease and Alzheimer’s.¹⁹ Yet, because these dementia-inducing pesticides have no effects on humans, industrial seed manufacturers soak seeds in neonicotinoids for constant pest control throughout the life of the crop.

In his chapter titled “Slow Poison,” author Rowan Jacobsen explains the reason for the success of imidacloprid—the most widely used neonicotinoid insecticide in the world. He explains that it is a *systemic* pesticide. When seeds are soaked in it, “it infiltrates the plants and manifests itself throughout the plant’s tissue: stems, leaves, roots, everything.”²⁰ This means that it is present in the plant throughout the plant’s life; it also cannot be washed away and therefore does not need reapplication. One positive to this type of pesticide is that it eliminates the need to spray crops with dangerous chemicals—a plus for both the surrounding natural environment and the applicator. Whereas with traditional pesticide application, beekeepers and farmers would coordinate so that bees were kept far away from the crops while a farmer was spraying them with pesticides, systemic pesticides eliminate the need for such coordination. However, this also means that these neuro-active insecticides are present throughout the entire life of the plant and therefore are always accessible by feeding honeybees.

¹⁸ Halter, *Incomparable Honey Bee*, 88.

¹⁹ Jacobsen, *Fruitless Fall*, 85

²⁰ Jacobsen, *Fruitless Fall*, 86

While the typical dosage of a single pesticide is not lethal to honeybees, recent studies have shown that insecticides remain in the environment longer than initially thought and that mixtures of sub-lethal pesticide dosages increase toxicity. The Pesticide Action Network of North America (PANNA) is one organization that seeks to advance alternatives to hazardous pesticides in exchange for ecologically sound and socially just alternatives. In their 2012 “Pesticides and Honey Bees: State of the Science” report, they featured numerous scientific studies that showcase the effects of sub-lethal yet chronic exposure to pesticides. As for persistence of common pesticides in colonies, a study published in the *Bulletin of Environmental Contamination and Toxicology* in 2010 tested the presence of two common pesticides used by beekeepers for treating mites in hives. They found coumaphos (CheckMite) in the royal jelly from the nurse bees and fluvalinate (Apistan) in the bodies of bees and bee larvae. They concluded that the presence of fluvalinate in the larvae “demonstrates that chemicals in the hive can be transmitted from bee to bee as well as to food and thus to larvae, spreading throughout the entire colony.”²¹ Thus, the chemicals in common in-hive treatments do not disappear once a treatment cycle is completed; they persist in the hive and spread to unborn bees.

In another study, bees were given the most commonly used neonicotinoid in industrial agriculture, imidacloprid, in various sub-lethal doses in readily available food sources over a 24-hour period. Researchers found that “imidacloprid at all doses given caused significant reductions in mobility for one to several hours” and that bees “seemed to lose their communicative ability at all doses, failing to

²¹ “Pesticides and Honey Bees: State of the Science,” *Pesticide Action Network North America* (2012): 12

coordinate their activity with other bees.”²² Another study, conducted in Italy in 2001, trapped (and tagged) bees as they drank from feeders containing various amounts of imidacloprid. The bees were then released to find their hive. Of the bees that fed on 100 ppb imidacloprid, 57 percent made it back to the hive within two hours, and 27 percent returned within 24 hours. Bees fed 500 ppb and 1,000 ppb, however, “completely disappeared both from the hive and from the feeder within 24 hours.”^{22a} While the imidacloprid probably did not directly kill the bees, the resulting disorientation and memory loss made them unable to communicate and relocate to the hive, causing them to succumb to exposure. In the following chapter on the anatomy of a productive colony, it will become clearer why the ability to mobilize and return to the hive quickly, as well as the ability to communicate with other bees, is crucial to the prosperity of the hive.

Other studies looked into the synergistic effect—that is, the ability for two or more factors to produce a combined effect that is greater than the sum of their separate effects—of pesticides, fungicides, and herbicides. In one study, three pairs of neonicotinoids and fungicides were tested for toxicity. Researchers found that when combined with common fungicides used for crop production, the toxicity of different neonicotinoids increased by 224, 559, and 1,141 times, respectively.²³ Through immense scientific studies, it is clear that the chemicals used by beekeepers to control mites, as well as various pesticides, herbicides, and fungicides used in industrial agriculture are *collectively* harming the neurological functioning

²² “Pesticides and Honey Bees: State of the Science,” *Pesticide Action Network North America* (2012): 9

^{22a} Jacobsen, *Fruitless Fall*, 88.

²³ Iwasa T, Motoyama M, Ambrose JT, Roe M, *Mechanism for the Differential Toxicity of Neonicotinoid Insecticides on the Honey Bee, Apis Mellifera*, 2004.

and overall health of bees. Given this information, regulators face the daunting task of addressing this issue and possibly reconfiguring the foundations of our current agricultural system.

Additional Stressors: Nutrition, Habitat Loss, Travel. Aside from the obvious threats to bees already mentioned, honeybees today are stressed more than ever before. This immense stress in turn makes them more susceptible to succumb to once manageable ailments. The emergence of industrial agriculture in the past century and the subsequent commercial beekeeping that followed has resulted in bees being rented out to pollinate large-scale plots of a single crop. This pollination renting entails bees being loaded into trucks and driven to various locations—sometimes even as far as Florida to California—and left in a field to feed on the crop and subsequently pollinate it. For example, South Dakota’s Adee Honey Farms, the largest commercial beekeeping operation in the U.S., sent seventy thousand hives into the California almond fields in 2008 (and lost twenty-eight thousand).²⁴ Not only is loading bee hives onto eighteen wheelers and traveling cross country extremely unnatural, but with bees coming from multiple keepers from around the country to pollinate the same flowers, it is easy for bees to contract diseases or parasites from other sick bees—a concept Jacobsen refers to as the “brothel effect.”

Another growing concern is the beekeeping community is poor nutrition. Poor nutrition can result from multiple factors. For one, bees are often fed high-fructose corn syrup in the winter. Jacobsen describes how this practice is faulty and detrimental to the health of the hive: typically, bees would begin to lay eggs and

²⁴ Jacobsen, *Fruitless Fall*, 141

make brood at the start of spring, when flowers were blooming and offering pollen. However, feeding bees corn syrup in the winter results in eggs being laid, brood developing, but no new protein sources coming into the hive. This practice results in greater populations within the hive, but weaker immune systems; therefore the protein that existed to supplement twenty thousand bees must be spread out to accommodate forty thousand.²⁵ Vermont beekeeper Ross Conrad makes sure his bees are well-nourished throughout the winter by *underharvesting* the honey they produce each season, ensuring they will have enough for themselves during the long Vermont winter. In the occasion that the bees need to be fed additionally, he concocts a fortifying sugar syrup, packed with herbs, micronutrients, and sea salt to mimic nectar.²⁶ While he admits this method is more time consuming and expensive than commercial beekeeping practices, it is vital for the health of the bees, which is his top priority. While his practices may not be adopted in the commercial beekeeping industry anytime soon, his belief in promoting the absolute health of the bees demonstrates his utmost respect for this vital species. An overall lack of respect for the natural environment and the many species that inhabit it is undoubtedly one of the major flaws of modern society.

Another reason for poor nutrition stems from climate change and the subsequent erratic climate patterns that result. Dr. Reese Halter recounts the “searingly hot springtime” during the onset of flowering in 2006, which could have caused sterile pollen in plants. Studies conducted in 2007 found “little, if any”

²⁵ Jacobsen, *Fruitless Fall*, 149

²⁶ Conrad, Ross, Interview by Lauren Marra, Middlebury, VT, March 11, 2014

protein content in almond, plum, kiwi, and cherry pollen.²⁷ In the Rocky Mountain region, snowpacks are melting earlier resulting in the emergence of glacier lilies a few weeks sooner, too. Ultimately, the lilies are blooming before the bees in that region are “waking up” and the lilies are no longer being pollinated, putting glacial lilies at risk of extinction. In Maryland, Halter writes, plants are flowering weeks earlier, causing bees to rely on later-blooming trees to produce enough honey to sustain their hive.²⁸ While climate change is an environmental stressor adversely affecting bees within an ecosystem, other major stressors stem directly from modern beekeeping practices.

California beekeeper Andy Nachbaur wrote: “Bees require a balanced diet and to get this almost always require more than one kind of pollen.”²⁹ However, there are many factors that contribute to the inability for bees to fulfill the diverse diet they need. For one, bees being rented out to pollinate monocultures only allow them to feed from one pollen source. As will be discussed in the Economics chapter, the almond orchards in California take up twelve hundred square miles and require *billions* of bees to pollinate over a month-long span. Because different pollen sources have different protein contents, it is important for bees to have a balanced diet and to forage among various plants. This has become increasingly difficult with the combination of habitat loss, industrial agriculture, and modern beekeeping practices. The USDA’s 2012 Honey Bee Health Stakeholder Committee report acknowledges that, “land use patterns have changed to an extent where there is less

²⁷ Halter, *Incomparable Honey Bee*, 85.

²⁸ Halter, *Incomparable Honey Bee*, 86

²⁹ Jacobsen, *Fruitless Fall*, 134

forage available for honey bee colonies.”^{28a} Less wild forage areas combined with forced pollination of monocrops both contribute to poorer nutrition of bees. As with humans, a poor diet as a result of malnutrition weakens the immune system making it harder to overcome once manageable ailments. The honeybee is certainly no different and the collapse of entire colonies further exemplifies that honeybees are in a state far from healthy.

In order to better understand the needs of bees, the next chapter will discuss the complex and fascinating structure of a productive hive as well as how beekeeping became what is it today.

Chapter 2: How the Honeybee came to ‘Bee’ in America

Anatomy of a Hive. European honeybees have become the main source for pollination for good reason: honeybees within a colony are a “highly efficient organization...in which all members work for the common good.”³⁰ Thanks to extensive research and observation by scientists and beekeepers alike, we now know the different roles within a hive, the lifespan and responsibilities of each bee, and the way that these tiny creatures maintain a highly functioning society.

There are three castes of honeybees: workers, drones, and the queen. While the number of bees in a colony varies by season (anywhere from 30,000 in the winter to 80,000+ in the summer), each colony only has one queen. The queen leads a leisurely life in exchange for her vital services: she is constantly surrounded, being

^{28a} “Report on the National Stakeholders Conference on Honey Bee Health,” *United States Department of Agriculture* (2012).

³⁰ Halter, *Incomparable Honeybee*, 23.

fed, groomed, and cleaned while she lays her approximate 1,500 eggs *per day*. Any unfertilized egg results in a male drone, who number anywhere from 200 to 1,000 per hive. In a light-hearted and comical comparison to stereotypical human males, author Rowan Jacobsen describes drones as:

“They have big heads and stout bodies. They hang around the hive all day and do essentially nothing. They don’t forage, don’t feed the kids [brood], don’t even build anything. They wait for females to bring them food...Other than grub, their only interest is sex.”³¹

Inseminating virgin queens is literally the only role that drones possess—and one that is rarely even fulfilled. During the daytime, drones will congregate in a cluster and wait for a queen to fly by. Once a newly hatched queen has secured her position as the sole new queen (by killing all others), she will leave the nest just once in her life to reproduce. Upon smelling her scent outside the hive, drones will chase her and—if they’re lucky—attach to her for a brief moment of bliss. After ejaculation, the drone’s phallus separates from its body, and the drone falls to the ground and dies. The more drones the queen reproduces with, the better, as it ensures diversity within the colony. Drones that were unable to reproduce during mating season will be evicted from the hive in the winter by worker bees and will soon die from the cold. With up to seven million sperm stored in a special sac in her body, the queen will continue to lay eggs throughout her 3 or 4-year lifespan. When she is no longer able to lay, she will be killed by the newly secured queen—one of her own kin. While

³¹ Jacobsen, *Fruitless Fall*, 36

the queen's constant repopulation of the hive is absolutely essential, her long life would certainly not be possible without the help of the amazing worker bees.

Female worker bees are by far the hardest workers in the hive. Despite a life span of only about 60 days, they manage to take on multiple roles and responsibilities. Bees begin life when they hatch from their egg, where they are then fed royal jelly, or "the bee equivalent of mother's milk," until they are ready to pupate within a cell.³² Once ready, a nurse bee seals the larvae within a chamber where the "kid" bee will spin a cocoon and emerge three days later as a young, fuzzy bee. The first four days of a young bee's life consists of cleaning theirs and other cells. On the fifth day, they are promoted as nurse bees where they feed the brood by squirting royal jelly from their heads into their chambers. At this stage in life, some bees may also construct new wax comb or tend to the queen by feeding her and carrying her excrement out of the hive. The excitement begins about ten days into a young bees life when they move towards the hive entrance and begin work as a receiver. A receiver's role is to collect the nectar from a forager bee. The forager passes her stored nectar from flowers from her abdomen to young receivers then immediately returns to forage some more. From there, the receiver brings the nectar to an empty cell where she then begins the amazing production of honey. A bee will pump nectar in and out of her mouth, exposing the nectar to air, which causes the water in the nectar to evaporate. Throughout the process the young bee also adds an enzyme that turns sucrose into fructose. When the water content of the nectar is below 20 percent, it is now honey. She'll then cap the cell with a wax seal

³² Jacobsen, *Fruitless Fall*, 37

and continue back to the entrance of the hive to receive more nectar. In a few days, the young bee will be ready to take on the most exciting role of her life.

After a few days of flying outside the hive to get a grasp on landmarks and location, a bee is ready to take on her last role as a forager. Foraging entails locating a flower source and filling her abdomen with nectar. Once full, she'll fly, "sputtering like an overloaded helicopter," back to the hive to unload with a receiver bee.³³

Forager bees average 10-15 trips a day and can visit between one and one thousand flowers in a single day; they may also travel up to 8 miles away from the hive for a nectar source.³⁴ Working herself to death, a bee only lasts about three weeks as a forager. One day, she'll try to take off but will be unable to fly and fall to the ground to die. As the worker bee manages to take on multiple roles throughout her short life, it becomes more evident that the term "busy bee" was clearly coined after this hardworking member of the bee society.



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Figure 1 Castes of *Apis Mellifera*. From top to bottom: the small worker bee, the long abdomen of the queen, and the large, stout drone.

³³ Jacobsen, *Fruitless Fall*, 40.

³⁴ Halter, *Incomparable Honeybee*, 33.

Communication. The success of the foragers to provide for up to fifty thousand other bees would not be feasible without the remarkable communication abilities between foragers and receivers. Through their communication, they are able to sustain an effective number of each, ensuring that there are enough bees out gathering food as well as a sufficient number of bees inside the hive to collect the incoming nectar. Honeybees achieve this effective communication through none other than dancing.

In her book *Bees in America: How the Honey Bee Shaped a Nation*, author Tammy Horn recounts how in 1944 Austrian zoologist Karl von Frisch first deciphered the meanings of two bee dances used for communication: the *round* and the *waggle* dance. Both dances are used to communicate distance and direction of the flowers as well as how many bees she wants to recruit based on the duration of the dance.³⁵ Decades of research after von Frisch's initial discovery has revealed two other primary dances: the *c-shaped* and *vibrational* dances.³⁶ A bee will perform the round dance by spinning in a narrow circle in each direction for one or two times, indicating she has found a nectar source very close to the hive. If the nectar is further away from the hive—between 10 and 100 meters away—she will perform a c-shaped dance in which the scout never completes the circle while performing.³⁶ While both dances do not tell the recruits the exact location of the nectar, bees smell

³⁵ Horn, *Bees in America*, 191.

³⁶ Halter, *Incomparable Honeybee*, 37.

³⁶ Halter, *Incomparable Honeybee*, 38.

the nectar residue on the scent gland of the dancing bee then use their remarkable sense of smell to locate the flowers.³⁷

The most intricate and advanced dance that bees use to communicate is the waggle dance. A bee performs the waggle dance by creating two semicircles connected by a straight line, similar to a figure-eight shape, indicating she has found the jackpot of nectar sources. Throughout this dance, she vigorously wiggles her abdomen causing her muscles and skeleton to vibrate. Through varying the tempo of the dance, the number of dance cycles, and the intensity of the vibrational buzzing, she is able to convey the richness of the nectar, the size of the floral patch, and the amount of honey (energy) that bees need to consume to sustain them during the foraging journey.³⁸ Even more, the waggle dance conveys the horizontal direction to the food source. Dr. Reese Halter writes,

“Research suggests that if the dancer’s beelines move straight up the wall, foragers should fly toward the sun to find the source. Running straight down the wall means they must fly away from the sun. Amazingly, the dancer will match the movement of the sun by modifying the angle of the beeline.”³⁹

Through the development of an intelligent and effective form of communication, bees are able to meet the needs of every member of the hive. Furthermore, the collective yet unselfish acts of each member of a hive are all interconnected. Any disruptions in the ability to communicate, relocate the hive, or serve the brood

³⁷ Halter, *Incomparable Honeybee*, 38

³⁸ Halter, *Incomparable Honeybee*, 40

³⁹ Halter, *Incomparable Honeybee*, 41

contribute to the failure of a colony. Furthermore, not only are honeybee colonies a model of an unselfish, community-oriented, leaderless society, their benefits to humans are virtually priceless. Before delving into the economics of their services, it is important to understand how the Western honeybee came to “bee” in America.

Honeybees in America. Of the many plant and animal species Europeans brought with them to the New World, one of them was the honeybee. The first beehives were sent by ship in the early 1620’s and were brought throughout the century by the English, Dutch, and Finno-Swedes.⁴⁰ Despite pollen-providing plants being “widely scattered,” Tammy Horn explains that colonial honeybees were very successful and managed to multiply throughout the century. Additionally, while Native Americans did not raise bees for honey or wax prior to colonization, their slash and burn method of agriculture left many dead, yet standing trees—perfect spots for colonial bees to build hives.⁴¹ Honey hunting also became one of the first American pastimes thanks to these hidden hives. Honey hunting carried on through to the nineteenth century and became so popular that it became alarming to some pioneers. Bee trees, both dead or alive, were cut down to obtain honey: about eleven trees were needed to make a barrel of honey. Reports show that in July of 1942, one hunting party was able to make seven barrels of honey.^{41a} The beekeeping laws set forth in Europe in order to protect forests and honey hunters were not yet established in the New World, allowing for wasteful practices that caused unnecessary damage to pristine forests.

⁴⁰ Horn, *Bees in America*, 21-28.

⁴¹ Horn, *Bees in America*, 34

^{41a} Horn, *Bees in America*, 74-75.

Aside from natural bee-made dwellings in trees, towns developed apiaries by housing bees in skeps. With the concept brought over from Europe as well, skeps were made from straw and were bell or cylindrical shaped. Despite minor advances in skeps between the seventeenth and nineteenth century, bee skeps were still majorly flawed. For one, they could not be opened without disturbing the bees and causing them to swarm. Therefore, beekeepers could not inspect their hive for threats such as wax moth or foulbrood. Additionally, keepers would kill bees using sulfur in order to obtain honey from the hive. This meant that the strongest hives were often killed since their honey yield was greatest. Like cutting down bee trees, killing hives for honey was just as unsustainable and inefficient. Luckily, in 1851 a man named Lorenzo Langstroth developed a hive that would change beekeeping forever.

Langstroth and 'Bee Space.' After much observation and study, Lorenzo Langstroth realized that bees leave a 0.3-inch-wide aisle between combs, a concept later coined as "bee space."⁴² This realization allowed him to develop moveable frames that could be lifted out when full of honey and replaced with a new empty frame. In this manner, the Langstroth hive "enables bees to build honeycomb and store honey in a suitable artificial environment."⁴³ Beekeepers no longer needed to use skeps to contain bees, no longer had to wonder about pests infecting their hives, and no longer had to kill their bees to obtain the honey. In addition, bees are able to spend less time producing wax to repair their comb and produce more honey for harvest. The benefits as a result of Langstroth's hive made beekeeping a more

⁴² Jacobsen, *Fruitless Fall*, 32.

⁴³ Halter, *Incomparable Honeybee*, 4.

attractive profession in the twentieth century. It also demonstrates the human-bee partnership that has since perished in the past century.



Figure 2 Left to Right: A straw cylindrical skep and a removable frame of a modern day hive.

The Start of Pollination Services. In the twentieth century, beekeepers and farmers alike began to see the attractiveness of traveling pollination services. A man named Nephi Miller became one of the first commercial beekeepers after striking a deal with the Union Pacific Railroad to transport his bees from Utah to California during the winter.⁴⁴ The start of commercial beekeeping and the pollination industry definitely had some drawbacks at first given that horse-drawn carriages and trains were the only method of transportation at the time. Bees would sting horses causing them to become fearful and difficult to handle while railroad cars could leave bees in harsh and perishable environments. With the development and eventual widespread use of the automobile, traveling with bees to offer pollination services became much easier. As Tammy Horn puts it, “Improved interstates

⁴⁴ Horn, *Bees in America*, 148-149.

provided the lifelines to the migratory beekeepers.”⁴⁵ While automobiles made it easier to transport domesticated bees, the urban sprawl and roadways that resulted from automobiles continued to destroy forests and natural bee habitats. The elaborate change in landscape in the past century also resulted in major changes in our methods of food production and demand for honeybees.

Industrial Agriculture. As America embarked on its’ journey towards becoming a superpower in the 1950’s, industrial agriculture flourished. Jacobsen notes how after the Second World War, “machinery and pesticides enabled farms to expand from family operations into vast enterprises.”⁴⁶ Subsequently, beekeepers were in demand more than ever: in California, half a million acres were designated to almonds, alone. Furthermore, crops like pumpkins, blueberries, cucumbers, cherries, and strawberries all relied on pollination as well. With the development of landscapes that could never exist in nature, such as multi-mile plots of single crops—or monocrops—migratory beekeeping for pollination became a necessity, as bees would never forage in such an environment naturally. By the later half of the century, “beekeepers had learned that migratory beekeeping was the most profitable way to stay in the industry,” especially since unregulated pesticide use caused honey prices to plummet.⁴⁵ Despite migratory beekeeping becoming the norm alongside industrial agriculture, the government never protected beekeepers as much as farmers. Therefore, they always have and still do face greater struggles than any other players in our agricultural system.

⁴⁵ Horn, *Bees in America*, 201.

⁴⁶ Jacobsen, *Fruitless Fall*, 15.

⁴⁵ Horn, *Bees in America*, 206.

Chinese Honey Laundering. Aside from the variety of pathogens that emerged in the 1980's and 1990's, one of the greatest challenges that beekeepers face is foreign competition. According to Rowan Jacobsen, about 70 percent of honey consumed in the United States is imported, with the top source being China. Chinese honey producers sell cheap—so cheap that domestic honey producers filed a lawsuit against China in 2002, resulting in levied tariffs to level the playing field.⁴⁶ However, Chinese producers found a loophole to these tariffs: other Asian countries such as Thailand, Malaysia and Vietnam—where the tariffs did not apply—began to import Chinese honey into the U.S. When U.S. Customs caught on to this “honey laundering,” they seized third-party shipments and conducted routine testing of the honey to find it was contaminated with the antibiotic chloramphenicol—a strong drug used to treat Anthrax and other severe infections.⁴⁷ Furthermore, most Chinese honey is between forty and forty-nine percent honey; the rest is corn or rice syrup. Aside from its ability to put domestic honey producers out of business, the unlabeled contents in imported honey is more than enough reason to only support local beekeepers—especially in a time where the industry is quickly collapsing.

Chapter 3: Economics of Honeybee Services

Pollination. As previously described, foraging bees fly from flower to flower to drink nectar and store it for their hive. In the process, sticky pollen grains attach to their bodies; when they fly to a new flower, this pollen is transferred to the stigma of a new flower. This transfer of genetic material to a new flower of the same

⁴⁶ Jacobsen, *Fruitless Fall*, 114.

⁴⁷ Jacobsen, *Fruitless Fall*, 114.

species is called pollination. When done successfully, this new flower will produce a fruit. This fruit results in the foods we've become accustomed to eating and without pollination, our food choices would sadly be limited.

According to Rowan Jacobsen, over one hundred crops rely on bees for some or all of their pollination. Some of these include almonds, apples, berries, cherries, melons, cucumbers, zucchini, squash, pumpkin, cacao, pears, plums, peaches, citrus, kiwis, macadamias, sunflowers, canola, avocados, lettuce, carrot seeds, onion seeds, and broccoli.⁴⁷ Unbeknownst to many, honeybees also directly affect the beef and dairy industries as they pollinate the alfalfa and clover that cattle feed on. In the U.S. and Canada, their pollination services amount for more than \$44 billion worth of food each year.⁴⁸ Today, the economic value of honey and beeswax are minimal compared to the economic value of the ecosystem service pollination.

Honey. Over 2.65 billion pounds of honey are produced each year around the world. In 2013, beekeepers in the U.S. produced 149 million pounds of honey at a record high price of 212 cents per pound (over \$2/lb).⁴⁹ Not only is honey a delicious sweetener, but it boasts a large quantity of health benefits and medicinal uses. For one, raw, unheated honey has both antiseptic and antibacterial properties and can be used to help heal wounds. It is also packed with vital vitamins and minerals such as vitamins B1, B2, B6, E, K, A, and C as well as calcium, phosphorous, potassium, iron, copper, manganese, and sulfur.⁴⁹ Honey is also inhospitable to

⁴⁷ Jacobsen, *Fruitless Fall*, 17-18.

⁴⁸ Halter, *Incomparable Honeybee*, 65.

⁴⁹ "Honey (March 2014)," *U.S. Department of Agriculture National Agricultural Statistics Service*, March 21, 2014.

⁴⁹ Halter, *Incomparable Honeybee*, 48.

microbes and bacteria due to its high acidity level, low moisture content, and natural presence of hydrogen peroxide.⁵⁰ When kept sealed and away from moisture, honey could literally last forever without spoiling. This has been proven on multiple occasions when archaeologists dug up pots of perfectly edible honey inside Egyptian tombs. Clearly, honey has many benefits aside from its' use as a sweetener and contributor to the economy; its medicinal properties are still used today in holistic medicine and apitherapy.

Beeswax. Beeswax has over 120 industrial uses. It is used for cosmetics, candles, stick colognes, antiperspirants, candies, dental impressions, furniture polishes, paint removers, and more.⁵¹ Our great demand for beeswax flourished in the twentieth century: in fact, by 1940, the United States was importing over 4 million pounds of beeswax to meet domestic needs.⁵² Today, we use 44 million pounds of beeswax—at a value of \$25 million—per year.⁵³ In 1984, a woman named Roxanne Quimby partnered with Maine beekeeper Burt Shavitz and began to make products from his excess beeswax. It wasn't until 1991 that they found their most successful product and incorporated as a company: the product was beeswax lip balm and the company was Burt's Bees. In 2007, the Clorox Company bought Burt's Bees for \$913 million.⁵⁴

The Almond Industry. It is a common belief that the rise in the almond industry has single-handedly salvaged the beekeeping industry from collapse. The

⁵⁰ Geiling, Natasha, "The Science Behind Honey's Eternal Shelf Life," *SmithsonianMag.com*, August 22, 2013.

⁵¹ Allison Benjamin and Brian McCallum, *A World Without Bees* (New York, Pegasus: 2009), 249; Halter, *Incomparable Honeybee*, 58-59.

⁵² Horn, *Honeybees in America*, 154.

⁵³ Halter, *Incomparable Honeybee*, 58.

⁵⁴ Story, Louise, "Can Burt's Bees Turn Clorox Green?" *The New York Times*, January 6, 2008.

California almond industry supplies 82-percent of the world's almond supply, with exports at over \$1 billion a year. With over 700,000 acres of almonds in California, amounting to over 1.5 billion pounds of almonds per year, there are a number of unique factors that allow for the success of this crop.⁵⁵ Almonds are the *pit* inside of a leathery, inedible fruit. In order to ensure a bumper crop of uniform nuts, nearly 100 percent pollination is needed. Furthermore, in order for an almond to result, bees must cross-pollinate with the pollen of one flower to a flower of a different variety. In Rowan Jacobsen's words, "Cross pollination of every single flower on every single tree demands supersaturation [of bees]."⁵⁶ In more tangible terms, almond growers demand an average of 2 hives per acre: with over 700,000 acres, that means about 1.5 million full-strength hives, or 75 *billion* bees needed to pollinate these mono-forests.⁵⁷

With only 350,000 hives remaining in California, almond growers are willing to pay high prices for the importation of healthy hives from other states. In 2004, almond growers paid around \$40 a hive. After the massive collapse of colonies in 2006, that number grew to over \$150 a hive. However, if they're going to shell out \$150 per hive, almond growers maintain the right to be selective in the renting process. Some almond growers inspect hives to make sure they're strong and healthy. Others hire a "bee broker" who provides growers with hives containing a certain number of frames per hive. This rejection of hives puts further strain on beekeepers. As we already know, trucking bees cross-country is stressful for bees;

⁵⁵ Halter, *Incomparable Honeybee*, 67.

⁵⁶ Jacobsen, *Fruitless Fall*, 125-126.

⁵⁷ Halter, *Incomparable Honeybee*, 69.

this travel is also costly to the beekeeper. If rejected, not only has the beekeeper wasted money on traveling, but they're left with an unhealthy hive and no flowers for their hive to feed on. In short, these hives are doomed. Furthermore, even if a beekeeper's hives are selected, the stress of the demands of almond pollination can cause hives to collapse as well. So while the almond industry seems like a saving grace to beekeepers around the country, there are still downfalls to heading West each winter.



Figure 3 Just one of many almond orchards in California. In the bottom right corner are beehives. Despite their beauty, a diet of strictly almond pollen is not good for bees.

The almond and beekeeping industry also have a somewhat paradoxical partnership. As the almond industry grows, they demand more bees. However, honeybees are steadily declining each year, and some of the causal factors can be contributed to the migration across the country to pollinate monocrops. Not only is a single source of pollen not a stable diet for bees, but when hundreds of thousands of hives are concentrated in an area, viruses can spread much easier. As almond

acreage increase, there simply will not be enough bees to pollinate all the almonds—yet alone all other crops in this country. This brings me to the costs associated to having little to no honeybees remaining...

Costs without Pollination. A study conducted by two Boston University professors in 2010 hypothesized the economic implications of pollinator declines both regionally and worldwide. They found,

“The potential adverse effects of pollinator declines include direct economic losses incurred by reduced crop yields as well as broader impacts on agricultural activity as a consequence of lower productivity in the ecosystems which sustain it.”⁵⁸

Using a general equilibrium approach that considers the price and quantity changes of global production in both the agricultural and non-agricultural sectors, they estimated yearly losses of \$138 billion and \$334 billion, respectively.⁵⁹ While this study was based on the decline of all pollinators, including but not limited to honeybees, we can conclude that with honeybees being the reigning managed pollinator the economic implications of their decline alone would be still be great.

In some regions of the world, pollinators have already disappeared. In Sichuan, China, thousands of laborers are seen in April “holding bamboo sticks with chicken feathers attached to the end, clambering among the blossom-laden branches.”⁶⁰ Closer inspection reveals that these people—ranging from children to elderly—are hand pollinating. Since the planting of orchards on every hillside and

⁵⁸ Dana Marie Bauer and Ian Sue Wing, “Economic Consequences of Pollinator Declines: A Synthesis,” *Northeastern Agricultural and Resource Economics Association* (2010): 6.

⁵⁹ Bauer and Wing, “Economic Consequences of Pollinator Declines,” 16-17.

⁶⁰ Allison Benjamin and Brian McCallum, *A World Without Bees* (New York, Pegasus: 2009), 239.

the use of insecticides, farmers haven't seen bees in years. Furthermore, migratory beekeepers won't bring their hives anywhere near the orchards due to the well-known presence of carcinogenic insecticides.⁶¹

In Mexico, laborers hand-pollinate vanilla orchids by transferring pollen with a toothpick to the stigma of the flower. The one pollinator that knew how to manipulate the unique vanilla flower, the melipona bee, disappeared with deforestation. Now, all vanilla in the world is hand-pollinated by humans.⁶²

The process of hand-pollination is slow, labor-intensive, and much less efficient than a colony of honeybees—which can visit up to three million flowers in a day.⁶³ While it may be sufficient for the pear orchards in China, or the vanilla flowers worldwide, it is not a feasible solution to the incomparable honeybee. In *A World Without Bees*, authors Benjamin and McCallum estimate the cost of labor to pollinate crops normally pollinated by honeybees. In the United States alone, with 3.5 million acres of honeybee-fertilized crops, costs of yearly labor (paying low-wages) amount to \$90 billion a year.⁶⁴ With yearly costs that high, it is safe to assume most countries would not pursue a hand-pollinating industry. The alternative of importing food from foreign nations would only drive up the cost of food (as well as contribute to carbon emissions responsible for climate change). However, because pollinator declines are occurring on a global scale we should not rely on foreign nations to support our food needs either.

⁶¹ Halter, *Incomparable Honeybee*, 77.

⁶² Jacobsen, *Fruitless Fall*, 202.

⁶³ Benjamin and McCallum, *A World Without Bees*, 240.

⁶⁴ Benjamin and McCallum, *A World Without Bees*, 240

In order to fully understand the importance of honeybee services, it is important to adopt the views of ecological economics. Traditional economic valuation of natural resources and ecosystem services is based on a belief that natural capital is interchangeable with human-made capital such as labor and technology. However, this view is severely flawed when valuing honeybees and other pollinators because human-driven technology cannot feasibly replace pollination. Ecological economics urges for the sustaining of entire ecosystems and places greater emphasis on ecosystems services than traditional economic schools of thought. In ecological economic terms, the honeybees' value also extends beyond its' irreplaceable act of pollination. Honeybees are the ultimate keystone and indicator species. A healthy honeybee population is indicative to a healthy ecosystem. Pollinated plants serve more than just human diets—most resulting seeds, nuts, and fruits from pollination serve to feed small terrestrial animals. Flowering trees, shrubs, and bushes serve as habitats for other animals as well. The disappearance of a keystone species such as the honeybee could result in catastrophic declines of entire ecosystems. Therefore, ecological economic analysis of honeybees would put greater emphasis and value on the species beyond pollination and honey production for human benefit. Rather, their value stems from their role in supporting an ecosystem. As a result, we must work to promote the strength of entire ecosystems, not just individual species. Given that policy dictates the actions and restrictions within our agricultural system, policies set in place have a direct effect on the state of our environment and honeybee species. The next

chapter will discuss the role that the political system has had in the honeybee industry both domestically and internationally.

Chapter 4: The Political System: Helping or Hindering Honeybees?

Past Policy. There is good reason why the honeybee is considered the ugly stepchild of agriculture. Compared to other agricultural actors, the U.S. government has been insufficient in promoting the welfare of beekeepers and the prosperity of honeybees. Here, I will present a brief history of both proposed and/or passed federal legislature that has had direct effects on the beekeeping industry as well as agricultural policy that indirectly affects the health of honeybees. Many of the acts discussed below are subsets of the Farm Bill, which was first created in 1933 to address low crop prices during the Great Depression.^{64a} As an omnibus bill, the Farm Bill is updated about every 5 years and addresses a multitude of policies and programs dealing with agriculture. The Farm Bill is by far the leading legislation that affects agriculture and food policy. As a result, many titles within the bill may affect the beekeeping industry.

1922- Congress passed the **Honey Bee Restriction Act**, which banned importation of foreign bees as a way to prevent foreign disease and parasites from entering the country. It was waived in 2004 when the country desperately needed more bees to meet pollination demands; bees were imported from Australia.⁶⁵

1950- As part of the **Agricultural Act of 1949** (a title within the 1949 Farm Bill), Congress passed a Honey Price Support System recognizing honey as a non-

^{64a} "The Farm Bill," *Farm Aid*, farmaid.org

⁶⁵ Jacobsen, *Fruitless Fall*, 58, 76.

basic commodity. The price support system warranted honey as a crop worthy of government support year after year in the case of risk. This federal recognition validated apiculture as a legitimate actor in the agricultural industry.^{65a} An analysis of the conversation by the Congressional Committee of Agriculture before the honey price support section of the Act reveal that the main reasons for such insurance to beekeepers was for purposes of pollination, not honey.

1985- The Senate voted and approved a farm bill amendment to remove honey from the Government's price subsidy program.⁶⁶

1986- The revised **Honey Price Support Program of 1986**, "provided more regulation of the honey industry, especially with loans and buyback policies."^{66a} In short, the revisions established lower support prices and prompted the start of the government's withdrawal from the honey industry.

1996- Congress ended the honey price support system in the **1996 Farm Bill**. The dissolution of the support system was in response to findings that a honey price support system is not necessary to ensure a supply of honeybees for pollination.

2000- After much lobbying by the honey industry, Congress reinstated the honey price support system as part of the **2000 Farm Bill**. This came at a time when distrust of Chinese honey was at an all-time high. The amended honey program gave even more subsidies and assistance to beekeepers that still continue today.^{66b}

^{65a} Lehrmann, Teagan, "Price Support For Honey: A Case Study of Non-Commodification and the Shifting Agricultural Significance of the Bee," harvard.academia.edu, 7.

⁶⁶ Schneider, Keith, "Senate Votes to Remove Honey from Farm Subsidies." *New York Times*, November, 23, 1985.

^{66a} Horn, *Bees in America*, 227.

^{66b} Lehrmann, Teagan, "Price Support For Honey," 14.

2008- Congress passed the **Pollinator Habitat Protection Act** and the **Pollinator Protection Research Act** as part of the revised **Farm Bill of 2008**. The former act works alongside prior farm bill conservation programs to promote pollinator habitats. The latter recognizes the vital service of pollination by agreeing to direct up to \$100 million towards support research and conservation measures of pollinators.⁶⁷ Both of these acts demonstrate a sense of hopelessness for the Western honeybee as they are both directed towards promoting habitat for native pollinators and wild bee species.

2013- The **Save America's Pollinators Act** was referred to a congressional committee in July 2013. The Act seeks "To direct the Administrator of the Environmental Protection Agency to take certain actions related to pesticides that may affect pollinators, and for other purposes."⁶⁸ According to *govtrack.us*, the bill has a 0% chance of being enacted.

2014- President Barack Obama signed the **2014 Farm Bill** on February 7, 2014. A provision compelling the government to address declining pollinator populations was *not* included in the final bill. It does, however, direct the USDA to encourage farmers to protect pollinator habitats as part of "voluntary conservation plans."⁶⁹

Despite the alarming decline of honeybee colonies since the discovery of Colony Collapse Disorder, the federal government has been insufficient in mediating

⁶⁷ "2008 Farm Bill: Benefit to Crop Pollinators," *The Xerces Society for Invertebrate Conservation*, July 8, 2008.

⁶⁸ "H.R. 2692: Save America's Pollinators Act of 2013," *Govtrack.us*

⁶⁹ Peterka, Amanda, "Bees Get Short Shrift in Farm Bill," *American Beekeeping Federation*, February 5, 2014.

the issue. While honey price support systems and pollinator habitat conservation efforts are certainly positive efforts, the Fed has yet to address the greater issue at hand: the inputs of industrial agriculture. With findings strongly linking colony weakness to long-term and sub-lethal exposure to neonicotinoids, one would hope that federal agencies would address the rampant use of mixed synthetic pesticides and herbicides in agriculture. The Pesticide Action Network of North America notes that most regulatory decision making regarding the toxicity of pesticides to bees is only determined by acute toxicity exposure, or the “lethal dose” in which 50% of the test populations die. Regulatory agencies do not consider tests for sub-lethal and long-term effects. In fact, the EPA has no data on “stacking” (mixed chemicals used in one application) or on the effects of combined pesticide and fungicide use. Rather, they rely on chemical companies such as Bayer, Monsanto, Dow, DuPont, and Syngenta to conduct safety tests before developing subsequent policy.⁷⁰ It becomes increasingly more difficult to lobby for effective pesticide policy due to the strong influence that corporations hold over Congress. Not only do corporations like Monsanto donate to desired federal candidates each year, but they also spend millions lobbying to de-legitimize proposed policies.

County, state, and region-wide organizations of beekeepers, conscious consumers, and sustainable agriculture advocates have banded together to form organizations that lobby for the welfare of bees and the environment. While grassroots organizations may not have a fraction of the funds that corporations do, they certainly have the potential to make an impact within their communities and

⁷⁰ Halter, *Incomparable Honeybee*, 92.

on a larger scale. The American Beekeepers Federation in conjunction with the National Honey Bee Advisory Board has built a relationship with the EPA as a stakeholder to alter the registration and labeling policies of pesticides.^{70a} The Pesticide Action Network of North America currently has a campaign that seeks to educate consumers about the correlation between pollinator declines and pesticide use. On a smaller scale, county and state beekeeping organizations lobby for effective state policy as well as educate their communities about issues such as CCD. Grassroots movements are certainly effective in raising public awareness about environmental issues such as honeybee declines.

Other nations have taken great strides to combat colony collapse disorder and protect their precious pollinators through preventative action regarding pesticide use.

Foreign Policy. After the introduction of Gaucho—a neonicotinoid containing the systemic pesticide imidacloprid—in France in 1994, bee colonies fell from 1.5 million to just below 1 million by 2001.⁷¹ After finding residues of imidacloprid in sunflower pollen, the French Agricultural Ministry placed a temporary two-year ban on Gaucho while studies could be conducted. After extending this ban for another two-year period, a major study found that seeds treated with Gaucho are a major risk to honeybees in several stages of life as these pesticides impair the neurological functioning of bees and their capability to relocate their hive after foraging. Gaucho was then permanently banned from use on sunflower crops. Commenting on the significantly better lobbying strength of the

^{70a} “Beekeeper’s Legislative Priorities of 2014,” *American Beekeeping Federation*, abfnet.org

⁷¹ Jacobsen, *Fruitless Fall*, 90.

French beekeeper's union, Rowan Jacobsen notes how in May 2004, Gaucho was also banned from use for corn, along with bans of six other systemic insecticides.⁷²

More recently, the European Commission made a drastic decision to ban three neonicotinoid insecticides: clothianidin, imidacloprid and thiametoxam. After much urgency from EU member states, the European Commission issued the European Food Safety Authority to conduct research on the acute and chronic risks these insecticides posed to bee colony health and development. Reports came back with extensive evidence of harm and a great scale of risk to bees, prompting the ban. In response to this ban, European Environmental Agency Executive Director Jacqueline McGlade said, "Based on the body of evidence, we can see that it is absolutely correct to take a precautionary approach and ban these chemicals."⁷³ Effective Dec. 1, 2013, this decision is arguably the most progressive political act taken thus far in combating Colony Collapse Disorder. A European Environmental Agency report titled "Late Lessons from Early Warning" notes that prior to this ban, individual European states were already taking precautionary measures against seed-dressing insecticides. Italy, Slovenia, and Germany all had banned the use of neonicotinoid treatment on sunflowers, oilseed rape, and maize, respectively.⁷⁴

⁷² Jacobsen, *Fruitless Fall*, 92.

⁷³ "Neonicotinoids Are A Huge Risk—So Ban is Welcome, says EEA," *European Environmental Agency*, eea.europa.eu.

⁷⁴ "Seed Dressing Systemic Insecticides and Honeybees," *Late Lessons from Early Warnings: Volume II Chapter 16*, European Environmental Agency, eea.europa.eu.



Figure 4 Thousands protest neonicotinoids in London's Parliament Square in April 2013. Days later, three neonicotinoids were officially banned from use in the EU.

While France was certainly the leader in applying the precautionary principle when banning Gaucho, the entire European Union is seemingly acting more sensibly than the United States in its' ban of certain neonicotinoids. Given the mounting evidence on the effects these chemicals have on honeybee communication and development, banning the use of them no longer seems precautionary; it seems simply necessary. As the "Late Lessons" report states, "where such evidence exists, uncertainty should not be an excuse for inaction."⁷⁵ While, yes, there are definitely unanswered questions in this honeybee death phenomenon, the known facts—based on extensive scientific research—should not be ignored. In this sense, the

⁷⁵ "Neonicotinoids Are A Huge Risk—So Ban is Welcome, says EEA," *EEA*.

United States needs to improve its' policies surrounding honeybee health before it is too late.

Chapter 5: The Buzz on How to Save the Bees

Both the success and decline of the honeybee can ultimately be attributed to human causes in the United States. After Lorenzo Langstroth developed a mutually benefitting hive structure, the development of pollination services, urban sprawl, and industrial agriculture soon followed. Within a century, honeybees were exposed to a variety of new stressors that they seemingly have been unable to adapt to.

Because the honeybee is such a crucial species to our economy and food security, people should see the urgency in acting to preserve this species. Just as there is no single cause for Colony Collapse Disorder, there is no single solution, either. Rather, it is our entire industrial agricultural system that is causing harms to honeybees, as well as countless other plant and animal species. In Dr. Reese Halter's view, the disappearance of honeybees is ultimately a warning sign from Mother Nature that our current system is simply not working—and I couldn't agree more. He refers to our industrial agricultural industry as a "deleterious system," considering the amount of chemicals needed, as well as the resulting poor nutrition and the stresses of traveling. Factor in the repercussions of climate change and increased pathogens and it seems amazing that honeybees had even made it to the start of this century.

Rowan Jacobsen notes that in maximizing "every last drop of efficiency from our agricultural system," we in turn are sacrificing resiliency. Take the almond industry for example: the entire enterprise is compacted across one state and is

reliant on the honeybee as the sole pollinator. The system as a whole is susceptible to collapse in the face of drought, disease, or rising gas prices.⁷⁶ In fact, our entire agricultural system, which prides itself on efficiency, is not only very unsustainable but highly dependent on a limited number of factors: honeybees, synthetic pesticides, a stable supply of groundwater, etc. Beekeeping, in the words of Vermont beekeeper Kirk Webster, “has the honor of being the first part of the [agricultural] system to fall apart.”⁷⁷ In this gradual systems failure, the most feasible solution is to return to local agricultural and focus less on maximum yield and more on promoting the health of the entire environment. In turn, the status of honeybees and entire ecosystems will undoubtedly improve. In this country, there is seemingly no better model State for this endeavor than Vermont.

Case Study of Vermont Agriculture and Beekeeping. While living in Vermont throughout the duration of this thesis writing, I found that being here was more conducive to my thesis in more ways than one. Aside from better scenery and inspiration, I soon learned that Vermont is the ideal state to model policy after to improve the state of honeybees. During my first personal interview with a Vermont beekeeping hobbyist, Becky Ballard-Griffin, I was quite shocked to learn that there were no known cases of CCD in Vermont. During other interviews, I began to ask beekeepers why they thought this was. Former state Apiarist of Vermont, Rick Drutchas, said that there is considerably less spraying and less systemic pesticide use in Vermont. This is seemingly because Vermont has the most organic farms per capita and organic agriculture forbids the use of synthetic pesticides, herbicides, and

⁷⁶ Jacobsen, *Fruitless Fall*, 180.

⁷⁷ Jacobsen, *Fruitless Fall*, 181.

insecticides. Ross Conrad of Dancing Bee Gardens attributes the success of apiaries in Vermont to the large number of small, diversified and organic farms, greater foraging space for wild and domesticated pollinators (honeybees), and the minimal stress put on bees. As for the reasons they hold responsible for CCD, all answers were very similar and mentioned that it was a “combination” of factors including neonicotinoids, mites and the nosema virus, monocultures, and overall “abuse” of bees through traveling.

Ross Conrad promotes the health of his current 55 hives by tending to them personally (he does not believe in having more hives than one can care for), leaving honey in the hive throughout the winter, and only offering pollination services within Addison County, where he currently resides. In his holistic approach to beekeeping and view of the land, he seeks to promote the overall health of natural systems, minimizing his impact on the land, and trusting that healthy systems will support his life better than any corporation or business could. While expecting the government to enact policies that promote such holism is beyond reality, there are certainly obtainable policy directions that we can turn towards.

Policy Recommendations. One of the major steps our country should take in improving honeybee populations is to mimic our neighboring continent and ban the use of all systemic pesticides. We cannot keep exposing bees to chemicals that persist in hives, accumulate in their bodies, and become more toxic over time, hindering the effectiveness of communication and of overall hive productivity. Furthermore, we could enact policies that limit the allowed travel distances of hives throughout a year in an attempt to minimize stress within a hive.

Other policy directions should focus on incentivizing or promoting organic farming methods. Not only do organic farms prohibit the use of synthetic pesticides and herbicides, but also they typically shy away from vast monocultures and opt for diverse crop structures. Organic farms are exponentially better for the natural environment as they attract biodiversity, build healthy soils, and reduce run-off into fresh water systems. Greater numbers of plant and animal species on organic farms result in more resilient landscapes and greater abilities to adapt to environmental changes. As for honeybees and other pollinators, researchers at Oxford University found that organic farms have up to 50% more pollinator species than conventional farms. The widespread presence of organic agricultural methods is one of the main reasons for honeybee health in the state of Vermont. As a result of organic farms, honeybees and wild pollinators have a multitude of plant species to feed on, a diverse diet, and overall healthier hives.

The switch from conventional to organic agriculture takes about 5 years, is labor intensive, and initially more costly. However, because a healthy natural environment is virtually priceless and holds intrinsic value of its own, the government needs to take greater measures to promote such transition. The Environmental Quality Incentive Program (EQIP) is a voluntary conservation program administered under the USDA's Natural Resource Conservation Service. One subset of EQIP is the Organic Initiative, which provides funds to organic producers in order to implement conservation practices and promote environmental sustainability on their organic operations. One such practice includes planning and installing pollinator habitats. The Organic Initiative is just one of many

ways for federal executive departments such as the USDA to promote the transition to organic agricultural methods.

Ideally, monetary funds should be withdrawn from subsidies given to farms owned by agri-corporations and directed towards sustaining organic operations or aiding those in the process of becoming organic producers. In our current agricultural system, multinational agricultural conglomerates control a large percentage of the world's food supply. By tempting farmers with lucrative deals and false promises, farms under contract with corporations must use the seeds, fertilizers, machinery, and processing methods that the corporation dictates. These multi-billion dollar agribusinesses either put small farms out of work or make these farmers forever indebted to them. Therefore, any government subsidy given to conventional farms under contract with an agribusiness is virtually money given to support a multi-million or billion dollar corporation. We need to keep the corporate sphere out of our food system and direct taxpayer subsidies towards organic and ecological operations.

Other policies could seek to promote wild foraging areas through conservation, reforestation, and the planting of wildflowers in urban areas. This would ensure that any and all pollinators have an accessible food source. In a time of big business and corporations, it is also important to promote smaller agricultural endeavors and local farming. Offering assistance to prospective beekeepers or farmers will likely increase the number of individuals who seek to start a farm or apiary. Rather than rely on corporations to supply our food, we, as consumers, have

the power to support local farmers and beekeepers and support production methods that will better our natural environment.

Finally, education is one of the most vital solutions to any environmental issue. The lack of knowledge regarding environmental systems, ecosystem services, keystone species, biodiversity, and more contribute to the overall careless regard towards the natural environment. In school, we should teach children about the marvels of the environment, not the marvels of technology, and how a healthy environment benefits us more than any technological development could. Rather than pollute young minds with thoughts of human dominance, we should introduce children to various environmental ethical theories and worldviews. Everyone should take the time to explore their beliefs regarding their place on this earth, their worth compared to that of other species, and whether a species such as the honeybee has an inherent right to live all on its own. Also, having a grasp on the political system is also an effective way to get people more involved with local politics. How do people feel about their tax dollars going towards farm subsidies for multi-million dollar corporations rather than their local organic farmer? By building a fire within and educating people of all ages about such injustices, there is a much greater chance of change than through no knowledge at all. It is time people understand the environment that they're so unknowingly reliant on, and from there, hopefully a passion is born.

Throughout this research process, I have come to realize how amazing the honeybee truly is. It is without a doubt one of the most important, yet undermined, species on our planet. Through our withdrawal from the natural environment, we

tend to take advantage of vital ecosystem services and overlook the benefits they provide. The benefits from honeybees are no different. In writing this thesis, I hope that readers gain a greater appreciation for the honeybee, understand the causes for its' decline, and seek to improve the future of this insect through simple lifestyle choices. At the grocery store, opt for honey from a local apiary, or buy it directly from the beekeeper at a farmer's market; support organic agriculture through buying organic produce whenever possible; plant wildflowers; eliminate synthetic fertilizers or pesticides. And most importantly, appreciate each meal that you eat and think about how hard those tiny little bees worked to make each bite possible.

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