Approaching the Pollinator Problem Through Human-Bee Relations:
Perspectives & Strategies in Beekeeping

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Abstract

Beekeepers help to secure the pollination capacity of bees by mediating bee-stressors. This study argues that beekeeper strategies are best conceptualized as a series of specialized practices for bettering bee-health, which are mobilized by a variety of actors, including those who are not traditionally considered 'beekeepers'. The aim of this paper is to explore those human beliefs and practices which are most relevant for gaining insight into the current pollinator problem. Farmers, bee-conservationists, bee-researchers and honeybee-keepers all play an important role in securing bee health. The paper draws on the social-ecological perspective to consider alternative definitions of caring for bees, what shapes these conceptualizations and how these are reflected in beekeeper strategies, which inevitably contribute to the overall functioning of human-bee constituted systems. In the context of rising honeybee colony losses in Canada and of wild bee decline around the world, understanding the diversity of approaches for bettering bee-health is exceedingly important for initiating long-term, sustainable and multi-level bee-pollinator conservation.

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Introduction

Framing the Pollinator Problem

Despite Canada's growing utilization of managed honeybee populations for crop-pollination, unprecedented honeybee-losses threaten to profoundly transform the current agricultural system that is so dependent on them (CHC 2011, Melhim et al. 2010). Evidence suggests that the scope of the problem is not limited to honeybees but affects non-managed 'wild-bee' species as well (Decourtye et al. 2010, Packer 2011, P2C 2015, Xerces Society 2011). Governmental institutions, such as the Ontario Ministry of Agriculture, Food and Rural Affairs (or OMAFRA), the Government of Ontario and academia are making efforts to determine the most important factors related to managed honeybee losses and many scientists are expressing concern that without adequate mediating action, a *pollination crisis* could occur (Aizen & Harder 2009, Decourtye et al. 2010, Holden 2006, Nazzi et al. 2012, OMAFRA 2014).

Honeybee-keeping practices support a substantial part of the world's agriculture, providing crop-pollination services to humans and livestock. Unmanaged, wild-bees and other pollinators also support the majority of the globe's non-managed plants and animals (Chan 2012). Pollination, which is a service provided by bees and other pollinators "plays a fundamental role in sustaining ecosystems and supports all organisms that depend on resources from flowering plants" (OMAFRA 2016b: 6). A pollinator is basically a living agent of pollination. Birds, bats, flies and bees are all pollinators as they transfer pollen between flowers, thus securing the reproduction and genetic diversity of plants. "In Ontario, the majority of pollinators are insects" of which bees are the most 'specialized', "due to a variety of physical traits" that help them collect and transfer pollen (OMAFRA 2016b: 5) "While the managed honey bee is perhaps the most well-known pollinator, wild bees are more effective pollinators on a per bee basis (ibid: 6).

Pollination is what makes bee issues human issues. Our economy, and very existence is threatened by the loss of bee-pollinators. The plight of the bee is drawing increasing attention due to its importance in agricultural pollination. This growing attention is justified because bees are important not only for our current food system, but also to the functioning of the wider ecosystem (Chan 2012, OMAFRA 2016a, O'Toole 2013). Until now, research into the pollinator problem has focused mainly on honeybee pathogens and presented the situation from a very narrow toxicological lens (Decourtye et al. 2010, Philips 2014). Although extensive research has been undertaken to explain various factors inhibiting commercial pollination by managed honeybees, stressors affecting the capacity of wild bee-pollinators have been largely ignored. There is little systematic data available on bees other than the commercially managed Western honeybee, *Apis mellifera* (Aizen & Harder 2009). This is largely due to economic factors, such as funding and the relative importance attributed to different bee species by industry. I believe that this narrow-sightedness is also in part due to our long relationship with honeybees, which began with honey-gathering and later expanded to honeybee management (More 1976). Interest in quantifying the contribution of wild bees to agriculture is growing, as many are concerned that our reliance on the honeybee, the most commonly managed bee in the world (Aizen & Harder 2009), is unsustainable and inefficient in the long-term (CHAN 2014, Melhim et al. 2010, Winston 2014). Current research suggests that what may have until now appeared a narrow biological problem in honeybee disease is really a wider agro-ecological problem that involves farmers, beekeepers and the ecosystems in which they operate (Aizen & Harder 2009). I would like to highlight that it is a social issue as well, which in addition to drastically affecting food systems, would have irreversible implications for the current way of life in Canada. Therefore, what people do with bees and why is important and merits deeper consideration by social scientists. Particularly, what is lacking, is a general understanding of the various human factors affecting bee-pollinator populations most directly. How do agricultural practices such as honeybee-keeping and crop-farming affect bees and how can this relationship be leveraged to better conditions for bees? We know very little regarding the impacts of honeybee-keeping itself on honeybee health and even less about the impact direct-bee-management has on wild bee populations. How are bee-issues managed to secure bee-health? Are beekeeping strategies for wild bees and managed bees complimentary?

Anthropologists take a holistic approach to research, making them well-suited to understand broad, multi-faceted social-ecological issues, such as these. Traditional anthropological studies in the past have focused on defining unknown cultures, assumed to be relatively distinct and bound to place. This involved expeditions which sought to explore the various realities of non-local social organization, often funded through colonial enterprise. Today, we more readily see the value in studying the workings of cultures closer to home, of which we can be equally ignorant. I believe, that speaking to the parties most involved in mediating pollinator issues is an important step in making the research on bee stressors applicable in a locally relevant way. This is because understanding how conceptualizations of narrow biological problems link to practice can shed light on practical alternatives and novel solutions to current challenges “on the ground”.

Beekeeper Positionality

> Honeybees have received more scholarly attention than many other insects, but there is still limited understanding of the capacities and contexts of bees and beekeepers. Adding to this limited knowledge is a politics of recognition that favours expert toxicological assessment over other scientific or experiential ways of knowing (Philips 2014: 149).

Interdisciplinary studies in the natural and social sciences are needed to elucidate societal factors relevant to the current pollinator situation. Being a novice beekeeper, I was driven to gain a deeper understanding of the relation between beekeeping practices, the surrounding environment and the larger socio-economic context. The way we conceptualize bees is flexible and dependent on our socio-cultural environment and experiences. Those working directly with bees are well positioned to understand complex problems in bee management, due to their important role in securing bee-health as part of their regular interactions with bees.

Beekeeper perspectives of the human-bee relationship are unique because of their role as mediator between *biological* and *socio-cultural* worlds through their ability to 'provide' bee-based services and goods. Beekeepers are actively managing bees under challenging conditions, for crop-pollination and to a lesser degree, for honey production. The managerial practices of beekeepers contribute to colony health, affecting beehive strength, size, number, etc. Despite rising losses, they are managing bee population size and creating new colonies of bees to replace those lost. This suggests that many of the factors affecting bee health are being managed with some success. Because beekeepers directly mediate bee-problems, they are particularly aware of the complexity of the issues facing bees. Yet, to date there have been few studies focusing on how beekeepers see their role in the management of pollination resources. Looking at the pollinator problem from the varying perspectives and practices of beekeepers brings insight into the relationships which mediate our dependency on pollination. This is not limited to the direct bee-management of honeybees by honeybee-keepers. In Ontario, we are lucky to live amongst over 400 species of wild bees (Packer 2010). It may be surprising to some that bee-management is not restricted to practices with honeybees. Bumblebees are also managed for pollination and are used in Canadian greenhouse tomato production. *Osmia* bee species, commonly referred to as mason bees, are available commercially and are often used for orchard pollination. Artificial bee habitats for unmanaged bees are also gaining popularity in urban gardens and for bee conservation. Hopefully, with it will also come a better understanding of native bee diversity.

Approaching Solutions to Bee Problems Through Beekeeping Practices & Perspectives

Anthropological methods are well-equipped to work on an individual, or case by case basis, without losing sight of the context of the larger issues at hand. I believe they can help shed light on the role that various interest groups play in securing bee-pollinator success. In this study I explore the decision-making processes supporting individual beekeeper livelihoods, to shed light on the human systems of knowledge that affect bee success. Examining individual beekeeper practices could also help identify novel approaches to bee-management. By comparing the stress factors in the biological literature to those most often mediated by beekeepers, social scientists could also identify gaps in the research which are most relevant to those who depend on successful bee management. Social scientists could help to inform policy formation by recording the prevalence of particular bee-management strategies. I cannot completely catalogue the prevalence or full range of beekeeping practices, even within my province. What I can do as a social scientist is begin to catalogue these strategies, and to explore the rationalities driving them. Further, I can voice the practical concerns and innovations of those working directly with bees, which fail to draw adequate academic attention, and bring light to alternate schemes of bee-valuation, which go beyond biological and economic interpretations.

What is lacking in our understanding of the pollinator problem is not only the role of systemic anthropogenic practices within wider agricultural and ecological systems, but also how these relationships are viewed by the people influencing them. My study differs in two ways from most approaches taken to study pollinator problems. My background is in the social sciences. My methods for gaining insight into bee-problems, consisted of doing interviews with beekeepers and participant observation in settings for knowledge exchange on the subject of bees. My previous volunteer and work experience beekeeping, as a volunteer and employee allowed me to discuss bee-issues meaningfully with a variety of interest groups working to secure bee health. To guide my research, I drew inspiration from approaches in Biology and Ecology that are highly sensitive to the role of wild bees within the wider ecosystem (Packer 2011, Winston 2014, Xerces Society 2011). More importantly, my study also draws on anthropological theories of multispecies sociality for interpreting beekeeper beliefs and practices related to the pollinator problem. My definition of the beekeeper is broad, which led me to asses a wide range of human-bee relationships, with the aim of going beyond the species bias of most of the literature on bees. Looking into beekeeper concerns, practices and motivations recognizes that the players most intimately implicated in agricultural practices possess important experiential, insider knowledge due to their positioning. Beekeepers are not only the most affected by changes in industry, their close relationship with bees means they are intimately involved with shaping the future of managed pollinators. They hold a unique position which can be leveraged to better understand the complexities of the pollinator problem, from a human, livelihood perspective.

There is a strong argument for studying bee problems as a social scientist. Today, anthropologists and other social scientists increasingly understand that there is "a great need to recognise the more-than-human relations of beekeeping and the implications of these […] yet, on this subject, social science literature remain strangely muted" (Philips 2014: 149). This is likely due to the fact that the pollinator problem has been mainly framed as a problem facing honeybees that could only be approached by specialized biologists. Because both managed and wild bee populations are essential for pollination, I believe there is also a great need for understanding the capacities of those working to better conditions for wild bees, not only managed ones.

My thesis continues to draw attention to the asymmetrical production of knowledge on bee problems, which has long favoured research on honeybees to any other bee. Current conceptualizations of the human role in the pollinator problem disproportionately focus on practices which contribute negatively to honeybee-health, rather than strategies for ameliorating bee-health as a whole. I argue that there is a need for understanding the pollinator problem from a holistic perspective which includes multiple bee-species (bee-pollinators) and considers the many human-bee relationships various actors enter to secure bee-health. This is because the health of both wild bees and honeybees is important to securing pollination services and avoiding a pollination crisis. Such research is valuable because it broadens the discussion to include a myriad of human practices affecting bees which are rarely considered in relation to the pollinator problem. This thesis explores the perspectives of multiple key stakeholders in the pollinator problem, their relationship with bees and the various approaches they mobilize to better conditions for them. It posits that the practices of all actors who work to better bee health are important to leverage for a balanced bee-conservation strategy. People in many different communities are working to manage bee-diversity and health in many capacities. Bee-conservationists, farmers and bee-researchers interact with pollinators on an intimate level. Further, each of the above communities has members who are purposively addressing bee-health in their managerial strategies. Their positioning means they possess specialized knowledge of pollinator issues. Although they come from different perspectives, their experience can provide insight into how to approach the pollinator problem in a more comprehensive manner.

My exploratory research of beekeeper concerns and practices shows that different conceptualizations of the pollinator problem support beekeeping practices, which may or may not be complimentary. I argue that beekeeping is best understood as a continuum of specialized practices for bettering bee-health, mobilized by a variety of actors. Thus, for the purposes of understanding what is now recognized as a complex, multi-faceted pollinator problem, anyone who mobilizes strategies for bettering bee-health is considered a beekeeper.

My research shows how beekeeper conceptualizations of bee-issues are related to managerial approach and personal concerns. By drawing on the knowledge of actors in four interrelated communities, I identified strategic variants for dealing with a bee-pollinator crisis. I present the practical concerns and innovations of those working directly with bees and highlight perspectives which are underrepresented in the academic literature. I found that beekeeper conceptualizations of the pollinator problem go beyond the economic and toxicological interpretations found in much of the research. My study explores how often competing valuation systems motivate strategies for ameliorating bee health.

The importance of wild bee success to agriculture and the broader ecosystem is not widely recognized, even among beekeepers. Common interpretations of the pollinator problem among practitioners and in research fail to consider the role of non-managed bee-species. This has led me to believe that an examination of all purposive action to better bee health is needed to understand the broader agro-ecological system in which beekeepers operate. In addition to the need for a better understanding of the enacted practices which contribute to bee health, knowing the relationships between various actors in this system is exceedingly important for planning the collaboration of practitioners in future efforts to sustain managed and unmanaged bee populations. Exploring the perspectives of these actors enables a broader yet regionally-relevant assessment of the variety of human practices addressing challenges to current human-bee relations in Ontario.

Thesis Summary

In the following section, I present main concepts and discuss theoretical perspectives in the Natural Sciences as well as the Social Sciences, which are relevant to my study. In the Methodology and Research Design chapter, I summarize my research methods, my approach to filling the sample and for my overall research design. In chapter IV, I present a synthesis of reported beekeeper beliefs and concerns in relation to bees. I do this to introduce beekeeper conceptualizations of the overall pollinator problem. In chapter V, I explore the systems of knowledge underpinning the practices of beekeepers. I also discuss types of the prescriptive information that beekeepers draw on, look at how and where knowledge production and dissemination takes place. In chapter VII, I explain how I approach the analysis of beekeeper practices and strategies in my sample, I synthesize the practice-range of beekeepers and explore factors contributing to the mobilization of certain beekeeping practices over others. This is followed by an analysis and summary of beekeeper strategies. In the final chapter, I present my findings and conclusions regarding the human-bee relationships I observed in south-eastern Ontario.

Chapter II

Literature Review

Bees & Society

Throughout history, people have incorporated bees into their cultures. A large body of mythological, theological, philosophical, historical and scientific work attests to this (Horn 2012, More 1976, Morris 2004, Ransome 2004). Humans have managed bees for their products, compared the honeybee's sociality to our own, used honeybees as weapons (Kosek 2010), and as models for organization, morality and healing (Horn 2012). These practices exemplify our longstanding interaction and perhaps, perpetual fascination with bees. A comparative study of beekeeping practices across societies would be fascinating but is beyond the scope of my research.

As I discuss later in this chapter, we value bees for their honey and their pollination. Honeybees are also intimately implicated in the development of societies and even in the evolution of our species. Honey and bee larva were an important source of sugar and protein in the early hominid diet (Crittenden 2011). "[O]pportunistic honey hunting by humans goes back to prehistoric times" (Morris 2004: 93). Rock paintings of honey-collection show that the human quest for honey is ancient (Collins 2010: 12). Mobile beekeeping for crop-pollination is recorded to have been practiced in ancient Egypt (More 1976). Honey was a key ingredient in the production of early beer in Europe, suggesting that the drink may have evolved from earlier mead production (Ransome 2004). Honeybees were also important to early European settler societies in North America. Honeybee-keeping was a key source of income for many pioneer women and children, as well as a source of medicine (Horn 2005). It is clear, that we have implicated ourselves in bee success for a long time, in hope of the same in return.

My own interest in bees was sparked during my participation in a honeybee-keeping course as an undergraduate student and due to the wide media coverage of the emerging Colony Collapse Disorder phenomenon, also referred to as CCD for short (Edible Ottawa March/April 2016, Time 2015, Winston 2014). CCD affects honeybee colonies and is characterized by the disappearance of worker bees resulting in the collapse of the hive (Bekic et al. 2014). In 2006, managed honeybee losses intensified, particularly in Europe and the U.S.A (Decourtye et al. 2010), where the unexplained colony failures were attributed to the newly described phenomenon (Vardayani 2015). The literature highlighted the increasingly difficult situation facing all honeybee-keepers, whose livelihoods were being threatened due to increasing colony losses. In Canada, annual colony losses of up to 15% are considered normal (OMAFRA 2016a). Honeybee-keepers and researchers began working to identify the driving factors in colony losses and to establish if the losses could all be attributed to the yet unexplained phenomenon.

CCD. No single-pathogenic 'cause' or specific group of factors has been definitively correlated to bee declines or to the CCD phenomenon (Bekic et al. 2014)**.** This is complicated by the fact that toxicological situations vary based on locality (Decourtye et al. 2010, Jacobsen 2008, Kosek 2010). The latest approaches to the study of CCD favour dynamic models of virus and disease interaction, which include multiple stress factors, or *stressors*, working together (Vardayani 2012). Increased importance is being attributed to the role of the synergistic effects of multiple stressors in producing colony declines (Bekic et al. 2014, Vardayani 2015). CCD is not recognized as the main driving factor behind current levels of colony losses in Canada, or worldwide (Bekic et al. 2014, Guzman-Novoa 2010, Kosek 2010, Melhim et al. 2010, Nazzi et al. 2012). In Canada, the exceptionally high losses experienced by honeybee-keepers have been mainly attributed to the mismanagement and the increasing resistance of the honeybee mite, *Varroa destructor* (Guzman-Novoa 2010), not CCD. I soon realized that honeybee-colony failures are intensifying and occur for different reasons in different places**.** Below, I present how others describe current colony losses and follow this with a short description of the contributing factors discussed in the academic literature.

Honeybee Colony Failure vs. Bee Decline. Honeybee colony losses, or failures, are framed in terms of a crisis situation. The precipitous 40% drop in managed honeybee colonies in the U.S.A. and a significant decline worldwide, between 2006 and 2007, "has eclipsed all previous mass mortality in the [honey] bee world, making it the worst recorded crisis in the multimillennial history of beekeeping" (Kosek, 2010: 650). In the context of Ontario, honey-beekeepers experienced the highest *over-wintering* losses recorded (58%), coming into the 2013 beekeeping season - the highest out of any Canadian province (OMAFRA 2014).

The pollinator problem sometimes is framed more broadly as having to do with declining wild bee populations, in addition to rising honeybee colony losses. This means that wild bee species are also considered to be facing considerable challenges. According to the International Union for Conservation of Nature (IUCN), which makes available the conservation status of plants, animals and fungi, "talking only about honey bees in the context of bee decline is like talking only about chickens in the context of bird decline" (IUCN 2015). It simply fails to consider the full extent of the situation. Out of all the wild bees, we have the most data on bumblebees. Hoffman Black et al. (2016) provide an overview of bumble bees and their conservation status in North America. "28% of bumble bees in Canada, the United States and Mexico are in an IUCN Threatened category" (8).

Native Bees & Other Wild Pollinators. Only recently, have other bee species begun to gain wider academic attention amidst what many term a pollinator crisis (Chan 2012, Packer 2010).

New taxonomic technologies, such as DNA bar-coding, are currently revolutionizing the identification and study of the 22,000+ unmanaged bee species (Packer 2010). However, the emergence of these technologies also highlights how little we know about all bees overall. What were thought to be bee-species have turned out to be multiple (ibid.). Specialized entomologists do not know how many kinds of wild bee species there are, let alone how different bee-species are faring under current conditions. Biologists Aizen and Harder (2009) explain that the population composition of wild bees cannot currently be assessed because of a general lack of long-term data on their abundance; the data that is available is regionally limited and sparse. It follows that it is impossible to undertake long-term systematic studies exploring the extent to which native bee-pollinators (wild bees) have been affected by competition from agricultural practices, including honey-bee-keeping and pesticide usage.

Honeybee Pests & Associated diseases. In Canada and Ontario, the "continued management of the Varroa mite in honey bee colonies is widely recognized as one of the primary goals with respect to maintaining honey bee health" (CAPA 2014). This is due to its prevalence, resistance to medication and ability to significantly weaken colonies through the spreading of viral infections (OMAFRA 2012**,** Nazzi et al. 2012). This is highly problematic for honeybee-keepers in Ontario and in Canada, where resistance to the "fluvalinate and coumaphos [treatments] are common amongst populations of varroa" (OMAFRA 2012). Varroa mites parasitize honeybees by attaching themselves to them in hard to reach places before sucking their bee-blood (*haemolymph*), like vampires. They reproduce within the wax cells in a honeybee hive, the identical progeny emerging conveniently next to the food source (ibid.). Other pests which are cited as contributors to managed honeybee losses by the Ontario Ministry of Agriculture, Food and Rural Affairs include: American Foulbrood, Chalkbrood, Small Hive Beetle and the Wax

Moth (OMAFRA 2016b: 2).

Bee Stressors. Academic research is pointing to multiple factors that are exasperating epidemiological conditions for all bee species (Nazzi et al. 2012, Philips 2014, Winston 2014). The stress factors, or *stressors*, identified include: climate change, weather, chronic agro-chemical exposure, environmental pollution, habitat loss and lack of floral variety causing malnutrition (Decourtye et al. 2010, Kosek 2010, OMAFRA 2014**,** Philips 2014, Xerces Society 2011). These elements work together across varying scales in a complex web of interaction but little is known of their synergistic effects **(**see Dively et al. 2015 & Jacobsen 2008 regarding synergy of pesticides with other factors). Managed honeybees in particular are facing greater susceptibility to disease due to factors including: over-medication, malnutrition, chronic pesticide exposure, growing demand for pollination services and the increasing mobility and size of beekeeping operations (Aizen and Harder 2009, Brittain & Potts 2011, CHC 3 2014, Decourtye et al. 2010, Dively et al. 2010, Kosek 2010, OMAFRA 2014, Packer 2010, Winston 2014). Although less is known about the situation of unmanaged, wild-bee species, it is evident that they share many stressors with the honeybee and may suffer an increased vulnerability to them due to population size, life-span, foraging and nesting habits (Brittain and Potts 2010, Chan 2014, Packer 2010).

Much of the academic work available on the subject of bees and the *pollinator problem* comes to us from the discipline of Biology. Research in honeybee disease dominates the literature and tends to address problems relevant to honeybee management. Such research scrutinizes the internal workings of the honeybee and the systems regulating these micro-processes. Ecological approaches to bee problems widen the scope of study to include the macro scale as well, often focusing on anthropogenic factors affecting wild-bee pollination such as, the effects of insecticide exposure on wild bees (See for e.g., Brittain and Potts 2010). Many biologists agree that epidemiological factors should not be the exclusive focus of research addressing bee-declines (Aizen & Harder 2009, Brittain and Potts 2010, Decourtye et al. 2010). Researchers are calling for collaborative, interdisciplinary research (Brittain and Potts 2010, Decourtye et al. 2010), as the complexity of bee (and in turn, of pollination) problems demands *intersectional* analysis. Current work on bee declines is beginning to address the pressing need for multi-level analyses, which navigate across a wide range of interacting systems. Dynamic and complex ecologies of disease are now being examined in the study of bee declines in the natural sciences, replacing the unrealistic, single-pathogen model. Nazzi et al. (2012) call the cause of the pollinator problem 'multi-factorial' and focus on the effects of pathogen and parasite interactions on honeybee colony health. Their study looked at the relationship between Varroa mite infestation, Deformed Wing Virus (or DWV) and outcomes in colony health. *Varroa destructor* is a widely common mite that parasitizes both Western and Asian honeybees. The authors found that Varroa mite infestation levels did not directly “mirror the sudden increase in bee mortality [found under experimental conditions], suggesting that other mortality factors, interacting with the *Varroa* mite, were likely involved” (7). This research is important because it underlines the need for multifactoral research on the Varroa mite, which is currently considered the leading challenge to honeybee management in Canada and many parts of the world.

What the bees (*brood*) tested in the study had in common, is that they were affected by a mixture of pathogens and diseases, whose workings are often insignificant on their own, but which in combination can cause lower immunity in individual bees, raising the likelihood of colony failure (Nazzi et al. 2012: 2). They found that DWV virus replicates more rapidly in varroainfested bees, with honeybees "bearing viral loads 10^3 fold higher than bees exposed to lower mite pressure" (ibid. 7). Although this research acknowledges that varroa levels intensify with multiple infestations, it does not allude to the implications of this for large-scale honeybee management for pollination. These operations are characterized by a large concentration of hives in one area, which are also mobile and capable of carrying pathogens long distances, endangering other bees along the way with infestation and re-infestation, on a regular basis (Benjamin and McCallum 2009). Assessing local environmental factors which are currently synergizing with levels of varroa infestation is paramount to mediating honeybee epidemiological conditions. It has become clear over the last decades, that multiple challenges threaten the resiliency or survival of various bee populations.

Bees & Pollination. Although our reliance on insect-pollinated crops is rising (Melhim et al. 2010), the majority of agricultural landscapes consist of self-pollinating crops, which do not offer pollinator-forage or habitat (Decourtye et al. 2010; Packer 2010). North America's increasing dependency on predominantly domesticated, managed pollinator species, particularly honeybees, signals that naturally occurring ecosystem services are not capable of securing current pollination needs in agriculture. Without the large-scale management of honeybee populations, the massive insect-pollinated mono-cultures that dominate today are not possible, as these patterns of land use greatly fragment naturally occurring pollination services (Packer 2010).

Possible alternative schemes for valuating bee-pollination services are beginning to suggest themselves as new forms of beekeeping develop and knowledge of different bee-species deepens. Although mason bees and bumblebees are also managed for pollination, honeybees are unique in comparison to most other bees because their populations can be produced relatively quickly in response to agricultural needs, unlike wild bees, which are difficult to manage for commercial use. In Ontario, the majority of managed honeybees are kept to supply farmers with pollination services, for canola, blueberries and apples (CHC 2014). Honeybee-keepers, conservationists, farmers and researchers are some of the key interest groups which are concerned in securing the pollination capacity of bees.

Ecosystem Services. The term refers to a broad range of goods and processes which Dr. Seiji Ikkatai describes as 'natural capital' (2013). These are derived from "urban, farmland, forest, coastal, marine and wetland ecosystems" (ibid.). This natural capital provides the means for ecosystem services, which "vary widely from food provision to climate regulation, recreation and soil formation" (Kabaya & Managi 2013: 6). The 'natural capital' that bees provide is pollination, which is therefore an ecosystem service. Bees are valued "largely because of the role they play in the pollination of plants: they are the most important insect pollinators" (Borror & White 1970: 354). Ecosystem services occur naturally but in some cases are commodified. "Payments for ecosystem services (PES) have become a popular conservation scheme" globally (Yoshida 2013: 53), however, in the context of bee-pollinators, payments for the services of honeybees are intrinsic to Canadian agriculture. The conservation of the 'natural capital' available for the regulation of various environmental processes, such as the conservation of bees for the securing of plant reproduction, is necessary in a context where "ecosystems have been degrading at the most rapid rate ever in the history of the world" (Kabaya & Managi 2013: 229). In the face of a possible pollination crisis the almost exclusive valuation of honeybee-based pollination is problematic in terms of broader bee conservation goals, comprising broad ecosystem service management in general and agricultural pollination services in particular (Winston 2014). Nevertheless, current research makes it clear that both managed and non-managed (wild) bees are essential in securing ecosystem services in agriculture and the wider ecology (Chan 2012). It is hard to imagine, indeed it is horrific to imagine a world where the pollination needs of each plant are met only with the human intervention of using managed honeybees. Susan Chan (M.Sc in Environmental Biology) is specialized in pollination and I have seen her present multiple times, usually on the subject of squash bees (her favourite bee) but also on the importance of conserving wild bee populations on farms. In the Landowner's Guide to Conserving Pollinators in Canada (2012), she explains, that wild bees "are important for the pollination of many food crops" in addition to playing a "crucial role in most terrestrial ecosystems" (11). Orchard bees, bumblebees, miner bees and leafcutter bees are just a few of the bees that are agriculturally important, particularly for the pollination of orchards and blueberries, which they pollinate more effectively than honeybees (Chan 2012). Further, our dependence on one bee species for crop-pollination is 'risky'. "The more sustainable alternative is to have access to a wide variety of pollinators who collectively pollinate" manage and wild plants (Chan 2012: 11).

Knowledge Production, Negotiation & Transfer

To date, conventional approaches to the pollinator crisis focus on one species which then tends to overshadow the equally important and more complex goal of broader, multi-species, pollinator conservation. Unlike managed honeybees, wild pollinators are treated more as natural resources and are approached through broad conservation policies rather than direct managerial strategies of agricultural actors. A single-species approach (in agriculture, academia and policy) privileges incentives for the preservation of managed honeybees at the expense of locally-important wild-bee pollinators. This trend in the knowledge produced to try and help *save* bees is one-sided, and favours a domesticated, invasive species. "Studies on wild bees have traditionally been the seriously underfunded cousin of honeybee research, a microcosm of the broader disparity between the vast government-supported empire of conventional farming and an ecosystem-based alternative" (Winston 2014: 103). This can be seen as a continual affront to broader conservation and the development of a full understanding of the current pollinator problem, in its widest sense. These dynamics in knowledge production underline the role of human factors, on the level of society and individual practice. A deeper contextualization of these factors is needed to: a.) widen our understanding of the pollinator problem and, b.) to render narrow biological findings more relevant to policy makers, beekeepers and farmers.

Sites of knowledge production outside of academia and governmental institutions are important because they are often based in experiential knowledge and the desire to find a solution to a commonly perceived threat. Negotiating knowledge requires a discussion of alternative viewpoints. According to Young and Liston (2010), the "most promising means for industries, firms, and governments to address risk controversies is to engage publics *while at the same time* voluntarily tipping the power equation away from themselves" (1047).

The importance of inter-disciplinary and inter-professional dialogue to reaching operationalizable solutions was highlighted by the application of public consultations by OMAFRA and the Government of Ontario on pollinator health. I attended one of the public consultations held in Ontario, regarding the proposal to reduce neonicotinoid use (OMAFRA 2014) on corn and soybean by 80% over two years. The approach of holding public consultations before the implementation of the policy-measure represents a move to broaden the understanding of actor concerns in relation to proposed policy. The consultations demonstrated that many farmers and beekeepers are eager to participate in a deeper communication, as they are disproportionately affected by policies addressing the pollinator problem. The debate on reducing NNis demonstrated that perceptions of risk on both sides are asymmetrical due to actor positioning. Beekeepers were concerned about pesticide over-application and exposure to honeybees. Crop-farmers were concerned about personal exposure if older forms of pesticide were to regain wider use (particularly sprays). They also worried that a reduction in NNi usage would result in crop losses. Additionally, conservationists and governmental institutions, such as OMAFRA, were voicing concerns regarding the state of wild pollinators. Opening academic discussion to include the perspectives of all interest groups framed the human-bee relationship to agriculture as dynamic, rather than an inevitable progression. The broadening scope of viewpoints and factors being explored in relation to bee-declines highlights the pressing need for the contextualization of the problem across a variety of scales and fields of knowledge.

To address complex agro-ecological problems, interested parties need to mobilize and share contextually relevant data (Young et al. 2013). Such knowledge sharing practices respond to the perception that linear knowledge production strategies are insufficient, and that information needs to be produced in a locally relevant dialogue, while engaging all actors. In the context of salmon fisheries, which like beekeeping, straddles livestock management and the conservation of natural resources, Young et al. agree that "promoting closer collaboration among scientists and managers would enhance the legitimacy of both groups" (2013: 21). The reflexive knowledge production strategy applied at the above discussed public consultations is definitely a step in the right direction, as multiple actors and interests are important to implementing effective policy measures affecting complex agro-ecological systems.

Young et al. (2013) speak of a process within academia, which like the technology transfer model, limits the ability to include the reflexive, experiential knowledge which practitioners hold. Dissemination of information is expected to travel seamlessly after it has been produced by researchers to interested professionals, as if down a ‘pipeline’. Technology Transfer Programs depict the linearity in the organization of knowledge usually supporting industrial agriculture. Such programs basically provide a ‘package’ of prescriptive information, machinery or agrochemicals in a top-down fashion with no room for farmer input or follow-up built into the design (ibid.). Linear knowledge production obscure outcomes and limit the reflexive process by undermining the knowledge of the practitioner and creating an uneven power-dynamic. This design is also mirrored within the growth narrative in agriculture, which views the expansion and mechanization of agriculture as a means for sustaining a growing, impoverished global population (Thompson & Scoones 2009). In the context of ecosystem management (for pollination) in Canada, the continual expansion of the honeybee-based pollination industry (despite the decrease in beekeepers) can be seen as following an analogous assumption: that we can avoid resolving problems in the broader agro-ecological system indefinitely while simultaneously serving ourselves.

Anthropogenic Factors

Biological research has decidedly begun to move away from mono-factoral explanations of the problem. As noted above, scientists are now exploring multiple interacting *stressors*, or stress factors. In the past, the role of human factors on bee health had rarely been studied in relation to the narrow findings in biology (Brittain and Potts 2010, Kosek 2010)**.** Recent biological research is pointing to the importance of synergistic relationships between anthropogenic factors and other stressors in honeybee outcomes (Aizen & Harder 2009, Bekic et al., Nazzi et al. 2012). The influence of anthropogenic factors (such as pesticide use) on bee health, calls for the contextualization of epidemiological findings within a wider agro-ecological framework, reflexive to place, human systems of practice and of knowledge.

Industrial Agriculture. Research into the pollinator problem is beginning to address the role of agricultural stressors on wild bee populations. The importance of various agricultural stressors is still poorly understood on the species level. In the Journal of *Basic and Applied Ecology,* Brittain and Potts (2010) explain how the variability of 'life-history' traits can influence the vulnerability of bee-pollinators to pesticide poisoning. Life histories of bees are shaped by species characteristics, such as the overall behaviour, or 'culture' of an insect species (or sub-species). Bee population size, individual bee-size, nesting habits and foraging habits are some of the pertinent species-characteristics that influence the degree to which bees experience the effects of different environmental stressors. According to Brittain and Potts, bee-species can be vulnerable to stressors due to their morphology (327). For instance, smaller insects travel shorter distances, making them less likely to avoid insecticide applications, as their overall flight patterns are more concentrated to a specific area (ibid., see also Chan 2012) Approximately 70% of wild bee pollinators nest in the ground (Chan 2014). How variation in behaviour among species influences pesticide toxicity is clear when one considers ground-nesting bees which disproportionately have to contend with agro-chemical run-off.

At the end of their article, Brittain and Potts (2010) assert the importance of applying wider ecological approaches to the study of pollination, in relation to pesticide usage. They call for systematic studies that not only follow the insecticide-application and bee population composition relationship, but which also account for the floral situation in the areas studied. The authors suggest studying herbicide and insecticide applications in a multi-leveled analysis, as these co-occur on farmlands. The need for interdisciplinary studies which contextualize both floral composition and farming practices within a wider ecological framework, highlights the complexity of the human-bee relationships underpinning bee health.

The increasing understanding of the human contribution to bee problems highlights trends in food production which are unsustainable. "Agricultural intensification has a detrimental effect on modern apiculture, particularly in Western countries where farmers have heavily embraced agrochemicals and maximized cultivation of arable land" (Decourtye et al. 2010: 273). Our capacity to *keep* bees in all their forms depends on our successful interaction with the wider ecological system. Yet, unsustainable practices in agriculture and urban expansion are beginning to impede the functioning of vulnerable ecological systems, which is reflected by the loss of wild pollinators, as well as increasing honeybee losses. Large-scale honeybee production in response to demand in industrial agriculture has beekeepers experiencing problems common in other types of livestock industries, such as over-medication (for ex - prophylactic antibiotic or chemical treatments) and overcrowding (Chan 2012).

Neonicotinoids – NNis. In recent years, researchers and policy-makers have focused their attention on better understanding the role of neonicotinoid pesticides in relation to bee declines. Neonicotinoids, or NNis, Neonicotinoids are a new class of pesticides that are systemic - meaning that when applied, they continue to be carried by all parts of a seed and subsequently, all parts of a plant (Collins 2010, Winston 2014). These comprise a group of agricultural controls against insect-pests, which affect the neural system of exposed insects. Increasingly, wide-spread *neonicotinoid* pesticide usage in agriculture is considered a significant contributing factor in Canadian honeybee declines (CHC3 2014, OMAFRA 2015a). The impacts of chronic exposure to *sublethal* doses of this class of pesticide are now being investigated, mainly for honeybees (Dively et al. 2015, Doublet et al. 2015, Matsumoto 2013) but also wild bees (Sandrock et al. 2014). In 2016, the Government of Ontario made efforts to reduce the use of this class of insecticide, particularly on corn and soybean crops, to decrease pressure on honeybees

(OMAFRA 2014). I discuss the participatory policy-making process leading up to the measures that were implemented to reduce neonicotinoid use in Ontario crop-farming in chapter six. Despite the recent honeybee conservation efforts targeting agricultural NNi use, these insecticides are currently not considered the most important driver in colony loss by the Government of Ontario, which attributes greater importance to the Varroa mite (OMAFRA 2012). However, there is evidence suggesting that chronic NNi pesticide exposure (particularly to Imidacloprid) can exasperate Varroa conditions in honeybee hives (Dively et al. 2015), which can lead to colony failures. Dively et al. (2015) undertook a long-term, comprehensive study into the effects of a NNi pesticide on colony health. The research tested the short and long-term effects of exposure to a particular neonicotinoid pesticide - Imidacloprid - on honey-bees. Their focus on honeybees follows standard conceptualizations of the pollinator crisis.

In the *Assessment of Chronic Sublethal Effects of Imidacloprid on Honey Bee Colony Health*, the authors are the "first to examine the chronic sublethal effects on whole honey bee colonies subjected to worse-case scenarios as well as normal dietary exposure" (20). This is important because it differentiates the effects of honeybee exposure based on doses which are relevant to conditions during foraging (through the collection of contaminated pollen), as well as for bees exposed only during maturation (through contact with wax and the ingestion of contaminated honey and pollen). They found that pesticide residues were far more persistent in bee products than in bees themselves. Residues were most concentrated in honey. Almost all honey samples they measured contained "detectable imidacloprid residues […], even six weeks after exposure and more than 10 times higher than residues in bees or beebread" (16)". Honey contained residue levels "several times higher than the reported concentrations of imidacloprid in pollen, collected from seed-treated sunflower, maize and canola" (17).

The study found that the sublethal effects of this NNi were “unlikely the sole cause of colony declines” (1). However, Varroa “counts in colonies exposed to the high doses of NNI were significantly higher” (9), pointing to synergistic effects of these two factors in combination. This supports Nazzi et al.’s (2012) findings that Varroa infestation acts in synergy with other factors and that these must be explored to understand Varroa’s contribution to particular instances of colony decline. This is further complicated by the ability of many elements to work latently. Dively et al. (2015) reported that honeybees from different experimental groups showed only minimal differences in behaviour directly after exposure. “However, results did show evidence of delayed sublethal effects later […], when several colonies exposed to the higher doses […] became weak due to higher rates of queen loss and broodless periods” (18). Thus, it seems that the NNi acted in a delayed manner on the sublethal level and its effects varied from year to year. This shows that incidence of exposure may be difficult to identify directly after an event.

Economics. Economic forces are said to play the largest role in regulating bee populations on the global scale. Aizen and Harder (2009) assess the increase in honeybee losses in North America and Europe since 2007, reportedly due to the CCD phenomenon. This focus resonates with their view that the managed honeybee is the single “most important crop pollinator” (915) and is highly relevant to beekeeper concerns. The authors assessed trends in the total number of commercial honeybee-hives from data made available by the United Nations in the FAO database. Their article in *Current Biology* (2009) takes a novel approach to analyzing bee-declines (and the *pollination crisis*). Through scrutinizing both biological and economic factors, the authors present evidence the apicultural industry is struggling to keep up with pollination demands. They argue that economic demand for pollination services is a greater driver in honeybee losses than any other known epidemiological factor on its own.

They explain that despite claims of global pollinator declines, honeybee populations are growing steadily with the human population. Worldwide, commercial honeybee populations have become harder to manage, with honeybee-keepers losing a greater proportion of their bees each year. Despite this fact, beekeepers are able to respond to pollination demands in agriculture by managing population size. New colonies are created to make up for these losses. Only in the USA has the honeybee-keeping industry been unable to keep up with the mediation of colony losses and has reported steady declines in managed populations overall. This suggests that honeybee declines related to the CCD phenomenon are particular to beekeeping in the U.S.A. (see also Vardayani et al. 2015). Aizen and Harden conclude that our increasing dependency on honeybees has created a demand which cannot fully be met by beekeepers. Agricultural demand for pollinators is increasing exponentially, yet beekeepers cannot manage a corresponding growth in managed pollinators. This mechanistic model will inevitably break down under biological pressures. The need for sustaining honeybee population growth in proportion to economic demand (and agricultural expansion) may be contributing to the perception of a pollinator crisis, especially among commercial beekeepers who are facing rising losses from multiple stressors, including agricultural demand for pollination. Finally, they point out that sustaining this rhythm of honeybee production is likely to increase our dependency on managed pollinators, and is likely to disturb the biodiversity of the areas where they are most employed. Our increasing reliance on a non-native species for pollination raises concerns that their large-scale management can affect the success of local bee populations. In conservation, they are considered an invasive species because they are non-native. This means that they once occupied a smaller geographic range and now compete with species that are found naturally in its new range.

Approaching the Pollinator Problem via Practitioner Perspectives and Practices

Anthropogenic factors have been identified as being relevant to outcomes in bee-health. The broadening scope of factors being explored in relation to bee-declines highlights the pressing need for the contextualization of the problem across a variety of scales and fields of knowledge. Today, a global community of academics, policy-makers, beekeepers and farmers has mobilized around preserving one species of insect.

> In response to the [pollinator] crisis, geneticists are combing through the newly mapped bee genome, insect pathologists are trying to isolate a viral culprit, toxicologists are tracing chemical residues, and bacterial entomologists are scouring the intestines of sick bees. Few researchers, however, are systematically situating the crisis, whatever its cause, within historical, political, and economic relationships between bees and humans (Kosek 2010: 650-651)

Despite the growing acknowledgement of the relevance of anthropogenic factors to pollination problems by researchers across disciplines, social scientists are paying little attention to the social conditions related to a pollination crisis (ibid*.,* Philips 2014). In the following sections, I present some of the actors and approaches I will be drawing on to study multi-species networks, particularly the human-bee relationships involved in securing pollination.

Non-Human Actors. "Multi-species ethnographers seek new ways to explore and understand the complex kinds of relationships that humans form with other animals" (Maurstad et al. 2013: 332). Both parties in a multi-species relationship are now being recognized as playing a role in shaping the form of these relationships (ibid., Istomin & Dwyer 2010). From this perspective, the bee, "a non-human informant [is] an actor in its own right" (Moore and Kosut 2013: 3). Humans do not just keep animals, other animals are recognized as influential in how we humans live, socialize, and civilize ourselves. The bee "has its own historical and temporal social location [&] does things to [social &] cultural life" (ibid.: 9). Maurstad et al. (2013) and Istomin & Dwyer

(2010) have studied the relationship between humans and other animals in terms of a negotiated process of co-evolution, where both parties constitute the success of the other species societies. The animal has shifted in role in this discipline, from the foreign and removed ‘other’ in the background, to the intelligible and agentive partner (ibid.). Istomin (a social anthropologist) and Dwyer (an agropastoral specialist) describe this process of mutual influence as dynamic mutual adaptation (2010). Their focus is on reindeer behaviour during herding in relation to managerial strategy. They conclude that managerial differences can create different behaviours in the same animal. This was also concluded to be the case in terms of human-horse relationships, by Maurstad et al. (2013). As humans, we can manage the behaviour of other animals but only to a degree. In agricultural management, for example, in honeybee-keeping, managerial approach is not simply based on a predetermined set of prescribed practices. It is evident that our lives are shaped by the rhythms and needs of those species on which we depend. The application of treatments in honeybee-keeping must be responsive and grounded in an understanding of bee-behaviour and a knowledge of appropriate managerial responses for regulating bee-stressors.

The management of other animals is a process which is rooted in reflexivity. Practitioners adjust managerial strategies in response to the animal being managed. Their behaviour adjusts to conditions set by the other party. On the other hand, the practitioner affects animal behaviour through managerial practices, for e.g., through domestication. Humans enter various relationships with other animals for various reasons. For example, Maurstad et al. (2013) explored the evolving relationship between riders and their horses. They identify three levels of co-being from the interviews with horse-riders. People and horses meet as two self-conscious parties. On another level, they meet in moments of 'inter-corporeal mutuality' (324), such as trotting exercises. Most salient to my research though, is their description of the human-horse relationship in terms of practices, 'observations and experiences' (ibid.) related to the co-becoming process. Like Istomin and Dwyer, they describe the multi-species relationship as a process where both parties are agentive and become defined to the other based on the role they play in that relationship. In this perspective, the nature of either party becomes either reinforced or changed to accommodate the other. Animal management shows that we not only enact practices to make other animals the basis for our livelihoods, we also have to be adaptive to the conditions set by the other party. This same framework can be fruitfully applied to the human-bee relationship and help us better understand agro-ecological outcomes, the stakeholders and practices implicated in the pollinator problem.

Human Actors. How we shape bee-haviour is significant. We breed bees to make them more resistant to disease, to produce bees with traits that make them good for pollination, as well as honey production. Through genetic selection humans transform the behaviour and bodily form of other species to sustain our own socio-ecological systems. Kosek (2010) describes our impact on the honeybee, physically. Humans have selected physical aspects of the honeybee in order to redesign their morphology. They have not only grown in size significantly, but humans have also modified their behaviour. They have been selectively bred to exhibit certain sanitary traits, such as cleaning behaviours, which increase resistance to the very common Varroa mite. Through genetic selection the anatomy and behaviour of the honeybee has also been manipulated to produce 'better' pollinators (ibid.).

Our relationship with bees can be typified as co-evolutionary. During the domestication process, the "bee has experienced transformations to its exoskeleton, its nervous system, its digestive tract, and its collective social behavior. There are many sites [and] many pressures […] involved in the remaking of the bee" (Kosek 651: 2010). In the case of reindeer, horses or bees, humans have trained the other to be more docile and 'manageable'. We carry out different practices to best highlight the human-desired attributes of the other party.

Our practices with bees largely focus on securing resources from them as they are seen to have instrumental value. During the nature-cultural interaction between bees and people, bees become either 'honey-makers', or 'pollinators'. Exploring the variety in nature-cultural landscapes of a particular multi-species relationship facilitates an identification of relational commonalities, or common ways of being with the other. By looking at our ways of co-being with other species, we can analyze how we conceptualize our multi-species practices, and what this says about our needs and our role in the relationship

Actor Perspectives. Inter-species interactions between humans and other animals, such as beekeeping practices, inevitably produce conceptualizations of other animals and of our relationship to them (Maurstad et al. 2013). Our ideas about other animals vary depending on our purpose for engaging with them (Moore and Kosut 2013), as do our ideas of risk. Humans have reformulated their conceptualization of the human-bee relationship, along with changes in our beekeeping practices. Through their managerial practices, beekeepers create and interpret "the social worlds of the bee" (Moore and Kosut 2013: 2). The human-bee relationship has deeply affected humans, yet our knowledge of bees continues to be dominated by economic interests. Honeybees are imported and are by no means 'native' to North America. Nevertheless, our understanding of all other bees tends to be coloured by our obsession with managed honeybees. Communal hive structures, stingers and honey are all equated with bees in the public imagination, yet this is only descriptive of a handful of the 20,000 plus species estimated worldwide (Chan 2014, Xerces Society 2011).

Honeybee-keepers. Honeybee-keeping challenges are mounting and diversifying, with new risks associated with the management of introduced pests (primarily the Varroa mite, but also the Small Hive Beetle) and newly discovered parasitic species (such as the Parasitic Phorid fly, *Apocephalus borealis*, Core et al. 2012). As discussed earlier, honeybee-keepers are currently experiencing unprecedented losses and challenges, marking a new era of beekeeping in the Western world. Beekeepers with substantial colony losses face economic hardship and can find their livelihood is no longer viable overnight. Concerns regarding the sustainability of crop-farming and honeybee-keeping coincide with these challenges. The role of beekeepers in securing honeybee health in the context of these challenges is significant. As Aizen and Harder (2009) explain, despite increasing colony losses, managed honeybee populations are growing overall due to the intensifying nature of honeybee-keeper management practices (the creation of new colonies), which are responding to rising demands for managed pollination services. Management practices in farming and beekeeping highlight the incredible power which we possess to shape the outcomes of our relationship with bees and our direct environment.

As explained earlier, honeybee management is a process. It requires the manager to take on a reflexive and reactive relationship with the managed. The livelihoods of beekeepers depend on their capacity to mediate negative aspects of the human-bee relationship, such as anthropogenic bee-stressors. This is done through the application of specialized practices, in a manner which is reflexive of local environmental conditions. For example, the careful choice of hive-location is important, to avoid areas that are exposed to heavy agro-chemical use, particularly of neonicotinoids and insecticides in general. The honeybee-keeper must also provide favourable forage conditions for bees, by placing them in proximity to adequate floral resources throughout the beekeeping season. Further, successful beekeeping *depends* on the accurate interpretation of bee behavior (which is indicative of biological and environmental conditions) and the implementation of effective managerial strategies in response. For e.g., when honeybees are sick, beekeepers have to respond with appropriate managerial treatments and practices to reduce the spread of disease or infestation. Larger beekeeping operations require greater inputs (in terms of medication) and must pay even more attention to timing and disease-management due to the larger amount and closer proximity of colonies managed in an area. As in other forms of livestock management, honeybee diseases can spread within an apiary, particularly if livestock is overcrowded. The spread of disease within large-commercial operations is much more destructive than in a small operation, where hives can be isolated relatively easily and where each hive receives greater managerial attention.

Beekeepers face another difficulty that has to do with the fact that to some extent, bee pollinators (of all species) are a 'fluid and fugitive' resource. Fluid and fugitive resources are those which travel across boundaries, like water or air and are for this reason, more difficult to manage than other natural resources. Depending on the immediate environmental situation of the bees being managed, different responses are required on the part of the beekeeper to adequately manage them. For instance, if honeybees are overcrowded, they can exchange pathogens leading to colony failure, despite the best efforts of the beekeepers to provide proper management. Thus, the management of bees is largely dependent on ecological conditions. In this way, the rising predominance of large-scale honeybee pollination operations can be seen as concentrating risk in food production in such a way that losses amongst single beekeepers could have staggering implications for Canadian food production. The implications of this situation are likely to become greater in the Canadian honeybee-keeping industry, as we are seeing an increasing concentration of beekeeping activities in the hands of a few. A rise in the average number of colonies kept per beekeeper in Canada between 1993 and 2009 combined with beekeeper declines over the same time period (Melhim et al. 2010). In Ontario, the average number of colonies per beekeeper rose by 90% during a 34% reduction in the number of beekeepers (ibid.).

Benjamin and McCallum (2009) examine industrial pollination in the United States (mostly of almonds in California) by interviewing beekeepers. They followed mobile beekeepers to almond orchards to observe the conditions facing honeybee-keepers running such an operation. Many of the pollination oriented beekeepers they interviewed operated day and night and transported their honeybees multiple times during a season. During Benjamin and McCallum's interviews, beekeepers indicated that monocultural intensification jeopardized their bee's nutrition. Beekeepers are forced to supplement the honeybee diet with commercially available, less nutritious feed, or to transport them to a better food source (ibid. 226). They also interviewed smaller beekeepers who voiced concerns regarding the treatment, or level of care shown to bees during large-scale pollination operations. The valuation of bees, predominantly as producers for economic operations, rather than a natural and necessary ecological service, has contributed to current extractive relationships with bees (Winston 2015: EAS 2015). This becomes evident when considering that the reproduction of colonies for the provision of economically and agriculturally important pollination services takes precedence over the sustainable management of fewer, healthier colonies. The Almond Board of California clearly holds an economically-oriented perspective, which holds the belief, that 'what is good for the almond growers is good for the bees' (*ibid.* 231).This perspective is an example of an approach that favours industrialization and expansion. It is also an example of what I term an economically informed biology. While many farmers rely on commercial honeybees for pollination resources, many human factors contribute to the difficult situation facing both wild and managed bee-pollinator populations. Until now, the positionality of farmers in relation to the pollinator problem has mostly been considered in terms of negative effects. However, agricultural practices are increasingly being recognized as not only highly relevant to bee problems but also, bee-success.

Farmers. The viability of integrating conservation practices into agriculture is now being explored to better define the farmer's possible role in rehabilitating and securing wild pollination services. Research suggests that agricultural practices can contribute either to the enhancement or the deterioration of local bee habitats and forage. Although this is clear, this relationship is only partially understood. For example, Jha and Vandermeer (2010) researched the impacts of different agricultural practices on bee habitat and pollination capacity in Chiapas, Mexico. The study found that varying agricultural approaches to coffee production affected bee-density. In particular, maximizing ground cover (by planting low plants among the coffee) increased native bee activity. This is because access to diverse floral resources enhances the likelihood of long-term bee success (Carvell et al. 2017). This is strong evidence that adjustments can be made in agriculturally intensive areas, on the level of human practices, to support the pollination process. Therefore, farmers play an important role in the mediation of pollinator outcomes through their managerial practices which can affect nesting and floral forage capacity in an area. These findings suggest that farmers are able to manage their immediate agro-ecological landscape to foster relationships which benefit both crop and wild bee productivity through habitat enhancement measures. These findings also demonstrate the stewardship role of the crop-farmer as beekeeper, regardless of whether practices are purposive or not.

Decourtye et al. (2010) propose specific measures for farming to help mitigate forageshortages in Europe and North America. One such measure is the maintenance of non-chemically treated marginal lands (of approx. 12m) by farmers around main crops. This would curtail nutritional deficiencies in bees in agriculturally-intensive areas and has been successfully undertaken in many countries. Upkeep of these areas, called 'fallow lands', ensures that both managed and wild bee populations are maintained in agro-intensive areas. Interestingly, the subsidization of fallow lands was first encouraged by policies which aimed to reduce *excess* food production. Nearly 20 years ago, the practice of integrating farmland fallows into crop rotation plans was encouraged or mandated through national agricultural policies in many countries (ibid: 267). Such programs have now expanded to include pollinator conservation efforts. Other proposed measures to encourage healthy bee populations include: increasing ground cover and the sowing of bee-friendly, flowering plants in between and preceding main crops, the planting of nitrogen-fixing legumes beneath orchards, the reduction of mowing for hay, the subsidization of floral fallow land, the limiting of agro-chemical usage, the regeneration of native plants in non-cropped areas, and the diversification of landscapes in general (ibid. 268-72).

Assemblage and the More-than-human Approach. Farmers clearly contribute to the situation of both wild and managed bee-pollinators by means of how they interact with the landscape. These practices then, are just as important for bee-conservation as managerial strategies are to securing honeybee health. The way different actors contribute to the conditions experienced by bees of all sorts is relevant for resolving aspects of the pollinator problem, broadly. "At the intersection of ethnography and natural history, we have a lot to learn about how humans and other species come into ways of life through webs of social relations" (Tsing 2014: 28). "More-than human approaches" are complimentary to the study of beekeeping practices. These "pay much attention to practitioners and their interactions [with other animals,] an approach inspired by Latour's (2005) advice to 'follow the actors'" (in Philips 2014: 151). Anna Tsing (2014) agrees that the way forward in studying more-than human systems can be accomplished by paying attention to "assemblages and to form" (Tsing 2014: 31). In the context of wild mushroom management, Anna Tsing states that researchers need to map systems of sociality be they "intentional or unintentional" (Tsing 2014: 28). Paying attention to assemblage requires a consideration of how multiple elements (or actors) come together (unintentionally or intentionally) to form a particular situation. As the work of Kosek (2010) shows, form, in term of honeybee physiology is telling of earlier human-bee interactions. I approach the broader aspects of the problem by considering assemblage. I look at how beekeepers, broadly defined, come together to exchange managerial information about bee problems and also, how they interact with other actors to achieve their goals.

The Agro-ecological Perspective. Previous approaches to bee problems can generally be characterized as, what Thompson and Scoones term: a 'science of parts', i.e. an "analysis of specific biophysical processes that affect survival, growth and distribution of target variables" (2009: 387). Thompson and Scoones believe that "interdisciplinary and integrated modes of inquiry are needed for understanding and designing effective responses to human-environment interactions related to food and agriculture in a turbulent world" (2009: 387). The authors (2009) support a dynamic, interdisciplinary approach, which transgresses *extractive* narratives and recognizes the complexity of agricultural sustainability. The Agro-ecological perspective represents one such alternative, which acknowledges the multiplicity of players and practices producing agricultural organization. It is complimentary to my focus on assemblage. "It seeks to go beyond a few-dimensional view of agroecosystems – their genetics, agronomy and profitability – to embrace an understanding of ecological and social levels of co-evolution, structure and function" (ibid: 392). This would represent a shift in focus away from economically informed biological terms and towards a socio-ecologically informed biology and economy. The Agro-ecological perspective is useful for conceptualizing human-bee relations on the macro scale. Like the more-than-human approach, it is salient to conceptualizing the different knowledge systems and practices which intersect on the subject of bee-pollinators.

Theorizing Social-Ecological Systems. The agro-ecological perspective which frames my research falls into a broader category of research which looks at human/non-human interaction in terms of socio-ecological systems. Theories on social-ecological systems are relevant for the study of human-bee relations across scales. First I define social-ecological systems, along with a few perspectives and approaches for their study. Next, I discuss their relevance to the study of human-bee constituted socio-ecological systems. What is a *social-ecological system*? According to Berkes, Colding and Folke (2003), "natural systems and social systems are complex systems in themselves; furthermore, many of our resource and environmental problems involve the additional complexity of interaction between natural and social systems" (2). The authors explain that ecological systems comprise "self regulating communities of organisms" that interact with other communities and the natural world around them. There are "neither natural nor pristine systems, nor social systems without nature" (ibid.: 353.) To "emphasize the integrated concept of humans-in-nature", Berkes, Colding and Folke "use the terms social-ecological systems and social-ecological linkages" because of "the view that social and ecological systems are in fact linked and that the delineation between social and natural systems is artificial and arbitrary" (2003: 3).

Critical Realism and Social Constructionism. Social scientists working on environmental issues have approached the study of social-ecological systems from various perspectives. The above definition falls on the side of the critical realist perspective of social-ecological systems, which emphasizes the role of interaction between social and ecological realms. On the other hand, social constructionists "insist on the […] social creation of the phenomenon being studied" (Sutton 2004: 56) and focus more on how knowledge claims are constructed and environmental issues come to the fore. One of the merits of the constructionist approach is that it allows us to "locate environmental issues within social contexts" (Sutton 2004: 57). Although more widespread as an approach to studying social-ecological systems, it has been criticized by realists as running the risk of reducing "sociology to a form of discourse studies in which the only thing studied are texts" (Sutton 2004: 63). Constructionism is also criticized for being largely descriptive, rather than prescriptive, in a way which has at its worst been interpreted as "irrelevant or even politically naïve, [essentially] lending tacit support to those who would deny the need for urgency in tackling environmental problems" (Sutton 2004: 57).

'Strict' social constructionists such as Tester see-"[animals and] objects only [to] exist in so far as they are amenable to investigation" (ibid. 58), with the perspective that nature needs always first to be interpreted, is never 'unmediated' and our concepts about nature are socially constructed and so can and will change. In the context of social-ecological systems involving fish, Tester takes this position and "effectively eliminates the reality of fish, reducing them to changeable categories created by human societies" (ibid.). It is undeniable, that indeed, there "exist different social constructions of fish" (Sutton 2005: 58) but fishery problems cannot be fully understood through an examination of how humans utilize fish. Human-mediated ecological systems, such as fisheries need also pay attention to the effects of human practices on a broader, ecological scale, which requires the measurement of some biological indicators, or at least a basic understanding of the dynamic relationship between types of human action and outcomes in fisheries and in social-ecological systems in general. This is because “resource systems change as people seek ecosystem services” and become vulnerable to sudden change as we become more dependent on them (Gunderson 2003: 33).

Sustainability Research and Resilience. The concept of resilience in the social sciences offers avenues for beginning to capture dynamic subsets of processes within social-ecological systems, such as the capacity of resource-users and other relevant actors to self-organize, to learn from crisis and to “respond to environmental change” (Berkes, Seixas 2005: 971; Ostrom 2009). Berkes, Colding and Folke, define sustainability as “the capacity of ecological systems to support social and economic systems. Sustaining this capacity requires analysis and understanding of feedbacks more generally, and the dynamics of the interactions between ecological systems and social systems” (2003: 2) The term ‘resilience’ “relates to the magnitude of shock that a system can absorb and still remain within a given state, the self-organization capability of that system” (Berkes, Seixas 2005: 967). ‘Strict’ social constructionists such as Tester reduce the complexity of emergent properties in a complex system, by avoiding inquiry into the dimension of ‘feedback’, or the two-way processes of co-adaptation which occur within integrated human-non-human systems, particularly managerial systems involving natural resources.

According to Gunderson (2003), there are two competing ways in which resilience has been defined in the social sciences – “the more “common definition [of] ecological systems [considers them] to exist close to a steady-state” (34). He terms this model ‘Engineering resilience’, in opposition to ‘Ecological resilience’, which considers “multiple steady-states [as] possible” (35) However, because “the kinds of ecological processes that create these stability basins are slowly changing” (for instance, the changing availability of diverse forage for bees,) Gunderson calls for a third model, which accounts for this layer or scale of dynamism. The term ‘adaptive capacity’ is used to “describe the capacity of a system to adapt to these slower dynamics” (36).

Another concept which has been used to describe this “evolving nature of complex adaptive systems, which include social-ecological systems” (Holling 2001: 392) is that of Panarchy, or the “hierarchical structure in which systems of nature, humans, human-nature and social-ecological systems”, including “co-evolved systems of management,) [that] are interlinked in never-ending adaptive cycles of growth, accumulation, restructuring, and renewal” and take place ‘in nested sets’ working on the micro to the macro scale (ibid.).

To deal with the breadth of the task involved in studying social-ecological systems, Holling (2001) advises the production of research which balances complexity and simplicity and which pays attention to dynamic processes, since ‘surprise’ and “structural change are inevitable in systems of people and nature” (392). He argues that an understanding of dynamic processes, across scales is necessary for evaluation of their role in overall system sustainability, “to identify the points at which a system is capable of accepting positive change and the points where it is vulnerable” (ibid.).

Low, Ostrom, Simon and Wilson (2003) use the term ‘complex-adaptive systems’ to emphasize the dynamic nature of social-ecological systems (2003: 103). These are “composed of a large number of active elements whose rich patterns of interactions produce emergent properties – which are not easy to predict by analyzing the separate system components” (ibid.). Berkes, Colding and Folke posit that complex systems such as social-ecological systems, often possess “a number of attributes not observed in simple systems, including nonlinearity, uncertainty, emergence, scale, and self-organization” (2003: 5).

Because to the nature of social-ecological systems, research has to embrace, control or reduce complexity (as do Roe, Holling and Tester, respectively). One approach to studying the sustainability of social-ecological systems, is to view "complexity as anything we do not understand, because there are apparently a large number of interacting elements" (Roe 1988, cited in Holling 2001: 390). The approach, "is to embrace the complexity and resulting uncertainty and analyze different subsets of interactions" that appear "*relevant from a number of fundamentally different operational and philosophical perspectives*" (emphasis added, ibid.). In the context of beekeeping, there is an evident lack of information regarding non-mainstream (non-honeybee-oriented) conceptualizations and enactments of 'beekeeping', that is, of the breadth of practices and philosophical perspectives which drive outcomes in human-bee social-ecological systems. Smaller subsets of controlling processes, or dimensions, such as the heterogeneity of components, interactions between them and mechanisms for their enhancement are some properties of social-ecological systems (Holling 2001). In terms of human-bee systems, analyzing particular subsets of controlling processes, such as the heterogeneity of stakeholders and bee species, which are relevant to outcomes in human-pollinator networks, is useful for understanding the socio-ecological system within which the current 'pollinator problem" needs to be assessed. Instead of following one type of actor, for example bee-managers, as traditional ethnographic work often does, it is also important to consider actors who work in similar contexts but mobilize alternatives to management, which may not follow standard conceptualizations of beekeeping. An analysis of dimensions which are applied in sustainability research, such as the variety of users, mechanisms for producing novelty, innovation and the connectivity of various types of knowledge (Ostrom 2009) are very relevant to my study as these offer a deeper, more complex understanding of the adaptive process between ecological systems involving bees and social systems.

My own research follows the lead of studies on socio-ecological systems, focusing on human-mediated aspects affecting the pollinator situation. As outlined above, studies of the human practices within larger socio-ecological systems utilize a holistic approach, which is applicable to research in the interrelated areas of bee health and pollination. They also provide a theoretical avenue that is salient to the anthropologist interested in reconciling the research on biological phenomena with the study of human practices with bees. In this study, I focus on the fact that we can also be agentive partners in securing bee-success. This approach calls for an examination of how humans mediate bee-problems and mobilize strategies for bettering the situation for bee-pollinators. Thus, in order to balance the vast body of research on the biological phenomena associated with the pollinator problem, I chose to focus on the practices and beliefs implicated in the securing of pollination services. Nevertheless, I also felt it really important to incorporate biological data on the situation of multiple bee species, as well as their narrower toxicological situation and conservation status.

Humans undeniably heavily influence the functioning of today's ecological systems (agro-ecology dominates, especially in places like Ontario). Social constructionist theory, which pays great attention to the formation of knowledge claims, inspired me to look at: how different actors variously conceptualize bees, value them, utilize them, and relay information about them and how this relates to the relative positioning of actors within broader human-bee social-ecological systems. How humans perceive of and understand bees definitely shapes their ecological and social-ecological situation. As discussed earlier, the dominant view is that bees are primarily honey producers and pollinators. Phillips (2014) elaborates how our uses of bees are reflected in the relative distribution of bee species and in honeybee physiology which has been 'enhanced' for our human ends. Human categorizations of pollinators and their positioning within these systems has led to an emphasis on honeybees by researchers and policy-makers.

Finally, I drew on approaches and concepts from sustainability research, such as the notion of panarchy, resilience and feedback to orient my research. This is because "identifying factors for building resilience at the local level is an important first step that helps us understand what resilience might look like ''on the ground''" (Berkes, Seixas 2005: 973). In their case study of factors affecting the resilience of fisheries in the Ibiraquera Lagoon in southern Brazil, Berkes and Seixas identify groups of factors which either limit or promote fishery resilience. Limiting factors include "the breakdown of local institutions (defined as rules-in-use) and the traditional authority system that governed fisher behavior; (2) rapid technological change leading to [over-use]; (3) rapid socio-economic change [and] (4) institutional instability across the political scale, (968). Factors which are stated to promote the resiliency of social-ecological systems are: "strong institutions; cross-scale interactions and communication; political space for experimentation; equity; *and use of fishers' ecological knowledge as memory and a source of novelty*" (ibid. - emphasis added). They found that "cross-scale communication was important for the co-management of the lagoon using both scientific and local ecological knowledge", meaning that the integration of ecological knowledge coming from livelihood practices, are important for rendering research and policy contextually relevant. The incorporation of all of the above dimensions would have been insightful for the study of human-bee social-ecological systems but beyond the scope of an M.A. thesis. Because I am looking to contribute to our knowledge of the variety of beekeeper strategies available for dealing with a pollinator crisis, I pay most attention the 'users' (Ostrom 2009: 420) of the resource, to the processes of information production and dissemination between user groups and the role of adaptive management, which involves learning through practice and the application of variable, contextually-appropriate solutions.

In the following chapter, I describe the methodology and design I used for my research.

Chapter III

Methodology & Research Design

In order to better understand our role in the human-bee relationship, I conducted an exploratory field-study of beekeeping strategies in south-eastern Ontario over an eight month period, between April and November, 2015. I took a grounded theory (Neuman 2007) approach and applied mixed ethnographic methods to see what beekeeper practices and concerns could tell me about beekeeping strategies and the knowledge systems supporting them. I also draw on approaches in the social sciences which aim to interpret the role of human practices with other animals within larger socio-ecological systems. Different interpretations of the pollinator problem exist within the academic literature and so I also expected this to be the case for beekeepers. More specifically, I looked at how beekeepers conceptualize the pollination crisis, generate and transfer information about bee-problems and respond to them. I wanted to access the experiential knowledge of beekeepers because they are in a position to respond to bee-issues directly but also suffer the greatest from them. Because of this positioning, they are able better than others, to talk about their managerial relationship with honeybees and provide insight into specific factors that contribute to bee health. For the purposes of this study, my conceptualization of the beekeeper includes all people who mobilize strategies to ameliorate the human-bee relationship. Basically, I understand this as bee-management in all its forms. This definition refers to those who are conventionally considered beekeepers, as well as those working to restore or preserve bee-habitat, diversity and health. My definition of beekeeping thus, goes beyond traditional conceptualizations of the craft, which focus on honeybee management.

Prior to this study, I had participated in honeybee-keeping and had a decidedly one-sided view of what constitutes bee management. In the vignette below, I briefly explain how I initially got into honeybee-keeping. These experiences greatly influenced how I approached the study of the pollinator problem in this research.

Getting into Honeybee-Keeping

There is something fascinating about seeing honeybee-keepers work calmly amongst swarms of bees. The immediacy between the bees and the person opening the hive was quite unnerving to me before I began honeybee-keeping. It was also very intriguing. I was surprised at the apparent ease with which bees could be handled by honeybee-keepers. The relationship between them and their bees seemed deep and mysterious. During my undergraduate studies I took a bee-keeping course at the University of Guelph to round out my studies in the Social Sciences. I was enthralled when I tasted honey straight from the comb for the first time on a field-trip to the adjacent research apiary. There, I met the research manager and head beekeeper (#5) and his team, who provided presentations on hive inspection, showed us around the apiary, research labs and honey-extraction facility. To my great excitement, there was an entire honeybee-keeping and honeybee-research community thriving next to me. The experience catalyzed in me the will to pursue bee-keeping from then on, like a galvanized sword that is finally tuned to its' purpose. However, it had left me with so many more questions than answers. My first experience at an apiary made me realize that only practice and not theory could bring me to grasp the intricacies of bee-keeping.

Following the completion of my undergraduate degree, I decided to spend a summer volunteering at the research facility to gain experience in the craft. I realized that many of the student researchers were also honeybee-keeping for their first time, for their research at this facility. I quickly (albeit crudely) acquired many skills associated with honeybee research into disease, in addition to practical honeybee-keeping experience in the research apiaries. This permitted me to glimpse the dynamic relationship that can be held by honeybee-keeping and honeybee-research communities. It also made me wonder if these were really so different, as both practices involve human-bee interactions for bettering bee health. Networking and the transfer of bee-research skills occur effortlessly and continuously in this environment, which attracts researchers from around the world.

Each day, I was kindly greeted by the head-bee-keeper and his cheerful group of bee-keepers and researchers. Following task assignment, morning meetings often drifted to the less important task of comparing worker's tallies of bee-stings sustained over the season. Working in the apiary was always a more serious affair however, and I heavily relied on the practical experience and foresight of others to accomplish even the simplest of tasks. The mentorship that I experienced during my volunteer work at the research apiary was a crucial factor leading to my subsequent employment at my first honeybee-keeping job. Throughout my time as a beekeeper, it became clear that mastering honeybee-keeping was a long and incremental process, based on extensive experiential knowledge and mentorship-apprentice arrangements. Further, I was surprised to find out that this knowledge is indeed so specialized that most beekeepers were unable to tell me anything about the state of wild bees or about their own relationship to them.

As I came into the study with a relatively good understanding of the practices which constitute honeybee-keeping, I did not seek to emerge myself in honeybee-keeping with a honeybee-keeping mentor. Instead, I sought to gain insight into the competing ideas of bee-conservation and management that I was encountering among researchers. The more I participated in the fascinating world of honeybee-keeping and learned about bees in general, the greater was my curiosity about alternative modes of caring for bees and about the 'other' 25000+ bee-species, which honeybee-keepers could tell me little about. This led me to start my research with a broad definition of what it means to keep or manage bees, and to seek interviewees with a wide range of experiences with bees, bee management or bee research.

Sample Selection –

Due to my previous involvement with honeybee-keepers in Fergus (ON) and researchers at the Honeybee Research Centre in Guelph (2013), I began networking prior to my research. For this reason, I identified several prospective interviewees early on. However, these communities are clearly not the only ones addressing bee-problems that can lead to a pollination crisis. I knew that others are intimately working with bees as well and that I had to identify these human-bee relationships. Otherwise, I would be contributing to the trend in the academic literature which fails to address important questions about the relation of goals in honeybee management to those in broader wild-bee conservation.

Going into the study I was aware that my own perspective regarding the pollinator problem was quite one-sided, as it developed during my earlier participation in honeybee-keeping. Being a hobbyist honeybee-keeper, I wanted to gain a clearer understanding of the effects of my own practices on bees but I also wanted to explore beekeeping practices with which I was not yet familiar. I mediated my honeybee bias by broadening my sample parameters. My strategy for delineating and filling the sample was guided by my understanding that a variety of practices are targeting bee health. The criteria for choosing interviewees was based on my conceptualization of the *beekeeper*, which includes all people who *mobilize strategies to ameliorate the human-bee relationship*. Analyzing the various levels of engagement that humans have with bees, rather than assuming what beekeeping *is*, allowed me to explore an array of human-bee interactions.

Using a combination of purposive and snowball sampling, I approached prospective interviewees through the four bee-related communities I outline above. To fill my sample, I started by locating an interviewee for each beekeeping community. This usually led me to others within their professional community. Although I did not intend to limit the direct-bee management category only to honeybee-keepers, unsurprisingly, it was difficult to locate people who manage other types of bees using snowball sampling. I did not locate any commercial native-bee keepers or pollination-based honeybee-keepers. I tried to locate beekeepers that are diverse in terms of bee-related practice, age, experience, sex and ethnicity. Apart from a few student-researchers at the research facility, most interviewees are Canadians of European descent. The sex ratio in my sample is quite balanced.

Due to my initial assumption that the strategies mobilized for ameliorating bee health differ significantly between beekeeping communities, I decided to conceive and utilize a separate interview guide for each type of beekeeper and to categorize interviewee practices as part of a continuum of beekeeping strategies, mobilized by direct-bee managers, farmers, bee conservationists and bee-researchers. Another reason I had for using four interview guides was to avoid asking inapplicable questions. For e.g., to assess perspectives on recommended bee-conservation measures on farmland, I needed to formulate questions specifically for farmers (such as - *In your opinion, which of these recommendations is most feasible for Ontario farmers?*). I tried to cover the same range of topics for each beekeeper type and used the same questions when relevant. For instance, I asked all participants to describe how the disappearance of honeybees would affect them. Because the question addressed beliefs and concerns regarding the human-bee relationship, I deemed it relevant to all participants, regardless of primary beekeeper type. Most people are not neutral in how they *feel* about bees, even if they have not worked with them or know very little about them. I used interviews to further explore how and why beekeeping communities interact (e.g.: *Do you ever interact with farmers in your capacity as a* [honey]*beekeeper?*). Questions addressing networks are relevant to all respondents and were reworded to make them appropriate depending on the context. The drawback of this approach is that it is hard to categorize beekeeping practices into mutually-exclusive types ahead of time. Limited participation in a second bee-related practice is not uncommon within my sample. Despite the difficulties, this approach proved successful in assuring participant diversity overall (in terms of the four beekeeping communities), as much as is possible for such a small sample. Seventeen interviewees answered one interview guide each. Only in two cases out of nineteen did interviewees answer questions from two interview guides (3 and 5) because it was unclear which guide is most appropriate.

Many motivations and practices overlapped between beekeeping communities. I considered categorical overlap not as a draw-back but as an opportunity to understand how multiple forms of beekeeping practices fit together into a larger socio-ecological system. It also showed me that, finding strategies for ameliorating the human-bee relationship in a way that is beneficial to multiple stakeholders is possible.

Table 3.1 – Study Sample: Basic Information for All Interview Participants									
R	**Y.O.B.**	**Sex**	**Principle Beekeeping Community or beekeeper type (based on Interview Guide)**				**Is practice main form of livelihood?**	**Main Occupation**	**Participation in Other Beekeeping Activities**
			Research	**Conservation**	**Direct bee management**	**Farming**			
1	1962	F		*			No	Geography Professor - Ecology and Environmental studies	No
12	1944	F		*			Yes	Habitat Manager on conservation land	No
17	1953	F		*			No	Habitat Manager on conservation land	No
10	1958	M				*	Yes	Native-tree Nursery Owner and Operator	No
13	1963	M				*	Yes	Organic crop-farmer	No
19	1959	M				*	Yes	Conventional crop-farmer	Yes (direct-bee management)
3	1991	F			*	*	Yes (farming)	Organic crop-farmer	Yes
7	1990	M			*		Yes	Honeybee-keeper	No
11	1935	F			*		No	Hobby mason-bee-keeper (Retired)	Yes (Conservation)

14	1955	M			*		No	President of Petrochemical Co. and Conservation Co.	Yes (Conservation & Research)
15	1940	M			*		No	Retired. Hobby Honeybee-keeper	No
16	1990	F			*		Yes	Honeybee-keeper	No
18	1993	M			*		Yes	Honeybee-keeper	No
5	1958	M	*		*		Yes (both)	Apiary and Research Manager	Yes
2	1981	F	*				Yes	Biology Professor	No
4	1991	F	*				Yes	M.Sc. Biology - student-researcher	No
6	1988		*				Yes	M.Sc. Biology - student-researcher	No
8	1992		*				Yes	M.Sc. Biology - student-researcher	No
9	1990		*				Yes	Veterinary graduate - student-researcher	No

*R = # of respondent **Source: Author's sample interview data, 2015.

Beekeeping Communities. I operationalized my broad definition of beekeeping by focusing on four beekeeping communities: direct bee-managers, bee-researchers, bee-conservationists and farmers. I chose members from each of these communities due to their sustained interaction with bees on various levels**.** Direct-bee managers keep a hive or nesting structure, which they manipulate to optimize conditions for their bees. Most often, these are honeybee-keepers who keep in an apiary for either profit or as a hobby. Bee-researchers can specialize in the study of honeybees or wild bees. Bee-researchers are engaged in studies related to bee-health, which are carried out in labs and research apiaries. Examples include biologists working on honeybee pathogen exchange and ecologists working on plant-pollinator interactions. Bee-conservationists, who I also term bee-pollinator and pollinator conservationists, manage land to enhance habitat and forage for wild bees. Farmers comprise those who work with the land to cultivate plants**.** I include crop-farmers because their practices interact with bee-habitat and forage. Farmers also often host honeybee hives on their managed lands and are increasingly being considered important to wild bee conservation efforts (Jha and Vandermeer 2010).

Data Collection Strategies

I participated in beekeeping and bee-related events to familiarize myself with beekeeper practices and to examine conceptualizations of the pollination problem within different contexts. I also conducted interviews with beekeepers to learn about strategies for bettering bee-health. To identify these strategies, I synthesized reported beliefs and concerns about bee-pollinators and analyzed how these relate to beekeeper practice-range.

The primary methods I used were *semi-structured interviews* and *participant observation.* I also accessed secondary data for my research, such as relevant prescriptive texts. I list my methods and data obtained in Table 3.2, below.

Table 3.2 – Methods, Associated Data & Materials

Method	**Associated Data and Informational Materials**
SEMI-STRUCTURED INTERVIEWS *consisted of:* - 19 interviews with beekeepers	Interview responses
PARTICIPANT OBSERVATION *consisted of:* -*doing* hobby honeybee and mason-bee-keeping -*attending* beekeeper meetings, bee-related lectures, conferences and workshops -*participating in* pollinator conservation and research	Journaling & Notes
GREY LITERATURE AND PRESCRIPTIVE TEXTS *consisted of:* -*collecting* educational materials relevant to the pollinator problem -*locating* prescriptive resources available to different bee-related communities	Organizational policy, Legal documents & Prescriptive texts for bee-related professionals available online (e.g.- the Fletcher Wildlife Garden's Policy, The Ontario Bee Act, Integrated Pest Management for Farming, for Honeybee-keeping) Informational pamphlets on pollinator initiatives, educational materials from a beekeeping course, agricultural and bee-related conferences and a conservation area (the Eastern Ontario Beekeepers' Association Conference, the Guelph Organic Conference)

*Source: Author's sample interview and participant observation data, 2015.

SEMI-STRUCTURED INTERVIEWS

I conducted nineteen interviews (30-120 minutes in length) with beekeepers during a five-month period (April-August). Except for two interviews which I conducted over the phone, I carried out interviews face-to-face and voice-recorded them when granted permission. One participant declined voice-recording but consented to my writing down his responses in an abridged manner. In all cases, I conducted interviews once consent forms were signed by both parties. In Table 3.1, I indicate the interview number which I use to refer to each participant throughout the paper, their principle beekeeper type (based on the interview guide), professional affiliation and other basic information.

PARTICIPANT OBSERVATION

In addition to conducting interviews, I also did participant observation in multiple settings to gain a better understanding of beekeeping strategies and beekeeper positions on bee issues. My participant observation activities fell into three broad categories: a.) *doing* beekeeping, b.) *attending* beekeeper meetings, bee-related lectures, conferences and workshops and, c.) *participating in* pollinator conservation. I summarize these and provide relevant details such as dates and organization names in Table 3.3: *Participant Observation Overview*.

Approaching more technical managerial questions in my research required me to meet interviewees with a certain level of understanding of farming practices ahead of time. Doing participant observation and preliminary research allowed me to identify which themes are most relevant to the four beekeeping communities that I chose and gave me an idea of the questions I wanted to pose. For e.g., I decided to apply questions regarding Integrated Pest Management to both crop-farmers and honeybee-keepers (- *Do you incorporate IPM strategies into your practices?*) but not to researchers or conservationists. I made this decision because during my participant observation I established that IPM is a set of prescriptive guidelines expressly formulated for agricultural professionals (in honeybee-keeping and farming) but not for other beekeeping communities.

During the participant observation portion of my research, I made a point of seeking out wild-bee related events. This included a mason-bee nest building workshop, a presentation on wild bees by researcher Dr. Susan Chan (2014) and volunteer days in a protected pollinator meadow. I also started keeping mason-bees, fortuitously given to me by an interview participant. Networking within wild-bee-focused communities and keeping mason-bees introduced me to the pollinator problem in broader ecological terms and to perspectives in bee management which differed from my own.

My participant observation notes contain records of bee-related events that I attended, descriptions of my own experiences keeping bees, participating in bee-pollinator planting and in monitoring activities. I used them as a reflexive tool for contextualizing and reflecting on beekeeper responses to interview guide questions.

Table 3.3 – Participant Observation Overview		
doing beekeeping	*attending* beekeeper meetings, bee-related lectures, conferences and workshops	*participating in* bee-pollinator conservation and research
Honeybee-keeping	2014 - Urban Beekeeping course (Algonquin College, Ottawa) - 'Creating Pollinator Habitat', Susan Chan, public lecture (Ottawa Public Library, Main Branch) - 'Proposal for Enhancing Pollinator Health and Reducing the Use of Neonicotinoid Pesticides in Ontario', 2 public consultations (Dec. 2014 – online; Jan. 2015, Kingston)	<u>Fletcher Wildlife Garden (FWG)-</u> 3 volunteer sessions, Ottawa Wild-bee habitat enhancement: I participated in conservation land restoration (tree planting), pollinator planting upkeep (in butterfly meadow) and nest-building for bee-pollinators
Mason-bee keeping	2015 -a *mason-bee* (a type of wild native bee) nest-building workshop (FWG, Ottawa) -'Beeing Biodiverse – The Art of Spying on Wild Bees', presentations by Dr. Laurence Packer, biologist and comparative morphologist specializing in native bees, and interactive native bee-nest installation artist Sarah Peebles (University of Toronto) -'Organic Conference' approximately 5 mini-lectures (UG) '2015 Eastern Apicultural Society Conference', over 15 mini-lectures and a tour of the largest commercial beekeeper in the province (UG, Aug.)	<u>Learning Garden (LG)</u> *and associated campus gardens* (2 yrs) -Wild-bee habitat enhancement: I helped develop and maintain wild bee habitats and forage on campus through pollinator-friendly planting and gardening -Bee-monitoring and identification: As a representative of the Learning Garden I assisted in the monitoring of *trapnests* for the UO campus Pollinators

		Initiative. I took part in the monitoring of nest occupation, egg extraction, insect identification and overwintering
	2014-15 - Honeybee-keeper Meetings- (Approx. 5) -the OBA – Ontario Beekeeping Association, Wellington County -the BARN - Beekeepers' Association of Regional Niagara (City of Welland) - the EOBA – the Eastern Ontario Beekeepers' Association	Bee education: As a representative of the LG, I was funded by OPIRG to create an informational pamphlet about bees and to promote bee-related activities on UOttawa campus

*Source: Author's participant observation data, 2015.

***Doing* Beekeeping:**

I did two types of beekeeping for my research: honeybee-keeping and native-bee-keeping. I put myself in the position of 'beekeeper' to explore the frameworks of risk and success guiding beekeeping practices. I kept beehives on an organic farm outside of Ottawa over two seasons (beginning in May 2014). This allowed me to experience bee-issues from a *hobbyist* direct-bee management perspective. During the first summer, I used a wooden trap-nest (an artificial nesting structures for bees) to attract wild-bees and to learn about unfamiliar species. I treated this as a hobby but wild bees are also attracted into trap-nests for wild bee conservation, native-bee management and bee-research. During the following summer (between April and August 2015) I built a different kind of artificial nest out of paper and carton, into which I introduced mason bees (Osmia *lignaria*). Commercially produced mason-bee cocoons were given to me by an enthusiastic participant. This bee is native to my area, but is also managed for agricultural pollination. As a complete novice, I managed these to her specifications to gain insight into the challenges facing native-bee-keepers.

Keeping notes during this whole process allowed me to keep track of my beliefs, practices and concerns. It also left me with a record of my own learning process, in terms of bee-management. I used these notes to see: *if* and *how* my understanding of bee-issues changed after participating in an unfamiliar type of beekeeping practice. Effectively, participating in new practices exposed me to new understandings of the overall problem**.** Doing participant observation allowed me to develop my own perspective on beekeeping practices and to better understand the concerns of interviewees. Overall, I decided to focus less on this auto-ethnographic element and more on exploring the diversity of beekeeper practices and perspectives in my sample.

Attending* bee-keeper meetings, bee-related lectures, conferences and workshops*:

In 2014, I attended an urban beekeeping course to learn more about honeybees and their management in Canada. I also attended approximately thirty bee-related talks. To hear these talks, meet additional participants and identify the issues raised within different beekeeping communities, I went to three bee-related conferences, five honeybee-keeper meetings and a mason-bee nest building workshop**.** This introduced me to the ways beekeepers generate and transfer information on the subject of beekeeping, bees, bee-friendly practices in agriculture and more broadly, pollination. Because the chosen sites are venues facilitating knowledge dissemination, I could observe how different discourses and systems of knowledge are mobilized in relation to the current pollinator problem. This allowed me to gain insight into which bee-issues receive the most attention within different beekeeping communities and connected me with the prescriptive information offered in response.

***Participating* in bee-conservation and research activities:**

In 2014, I took part in pollinator conservation and habitat restoration projects at the Fletcher Wildlife Garden Conservation Area (FWG) to network with bee-conservationists and familiarize myself with the strategies they apply to ameliorate bee-health. I also began volunteering at the University of Ottawa's Learning Garden because it is oriented towards both people and pollinators. Gardening for pollinators connected me with participants in the conservationist community, on and off campus and gave me the opportunity to participate in conservation activities. I was graciously lent a few trap-nests by a biology professor, for the Learning Garden and for my own research. This has now turned into a larger monitoring project run by members of the biology department. Installing trap-nests, wild-bee monitoring and processing (bee-identification, overwinter-preparation) allowed me to experience biological research on a first-hand, volunteer basis. I kept notes on these practices to better contextualize interview responses and to keep track of my activities.

GREY LITERATURE AND PRESCRIPTIVE TEXTS

I collected secondary materials for my research to find prescriptive texts which are recommended to the four beekeeping communities. I consider texts which promote or regulate practices prescriptive. These texts introduced me to the policy regulating beekeeping practices. Researching these resources allowed me to better understand the professional expectations and guidelines available to beekeeping communities. I give an examples of a prescriptive text in Appendix A but did not analyze them as a dataset. I discuss the types of literature accessed by beekeepers and the different systems of knowledge underpinning beekeeping practices in the following chapter, on knowledge systems.

Summary

The above methods allowed me to: a.) observe socio-ecological systems between humans and bees through beekeeper practices, concerns and beliefs, b.) to better understand beekeeper interpretations of bee-problems from a livelihood perspective contextualized within professional knowledge systems, and c.) to identify already existing strategies for ameliorating the human-bee relationship. Overall, talking to those who are most intimately involved with bees through their work allowed me to identify ways people better conditions for bees, conceptualize bee problems and the challenges they encounter.

Chapter IV

Beekeeper Conceptualizations of Bee-Issues

In this chapter, I summarize the beliefs and concerns of the beekeepers in my sample about bee management and agriculture. I include perspectives on agriculture because the practices associated with this profession are seen as having the potential to either improve or weaken bee health. I present the key themes and concerns that emerged from the interviews, for each beekeeper type by providing a synthesis of answers to particularly relevant interview guide questions. I did this to better understand what motivates beekeeping strategies and to explore varying conceptualizations for bettering bee-health.

My definition of the beekeeper, which can be found in the previous chapter brings attention to the practitioner's position of influence in the human-bee relationship. My focus is on beekeeping strategies which aim to contribute to bee health. One of the initial underlying assumptions of my research is that practices are linked to beekeeper 'type'. As we will see later, profession as well as participation in a beekeeping community hold strong explanatory power in terms of the practice range applied. However, these fail to account for managerial differences within beekeeper communities. The diversity of specialized practices applied by members of the same beekeeping community supports the idea that many interpretations of the pollinator problem exist even within the same profession. Therefore, individual beekeeper practices cannot be equated with overarching strategies in beekeeping. What is needed in addition to an exploration of individual beekeeper practices (which I do in the 'Identifying Strategic Variants for Beekeeping Practices' chapter,) is an understanding of the underlying beliefs and concerns supporting these practices. These are important to consider if I want to identify strategic variants to beekeeping and not just a set of practices which are assumed to be based on profession alone. In the following section, I present the leading beliefs and concerns reported per beekeeping community in the interviews.

Leading Concerns & Beliefs Reported Per Primary Beekeeper Type

***Concerns & Beliefs of Crop-Farmers*.** As I explained earlier, although ameliorating conditions for bees is not the primary focus of crop-farmers, their landscape management practices do contribute to bee-health because they interact with bee-pollinator habitat and forage. In some cases this is intentional. Concerns of a *pollinator crisis* have brought researchers to study the possibility of reconciling bee-conservation measures with agricultural practices (Brittain and Potts 2011). Therefore, if we are to consider the agency of all actors involved, it is important to understand how farmers conceptualize bee-issues and envision their possible role in bee-conservation. In Table 4.1 below, I present farmer perceptions of the pollinator problem, and their thoughts on bee and crop management.

Table 4.1 - Overview of Beliefs & Concerns of Crop-Farmers

R	*How do you view the situation of bees in Ontario? Based on personal experience, are bees facing increasing challenges in recent years?*	*Biggest Concern (s)*	*Are there any changes that you would like to see in current bee-management practices in Ontario?*	*Do you believe that current agricultural patterns in Ontario are ecologically sustainable?*	*Who do you believe has the most power to impact the current pollinator situation and why?*	*Which of the following bee-conservation measures is most feasible for ON farmers? a.)-increasing fallow or unmanaged marginal lands (borders) around main crops b.)-increasing ground cover (multi-level cropping) c.)-a decreasing of mowing practices d.)-a decreasing of pesticide usage*
3	They are facing problems. -Yes	CCD NNIs	Yes - Small farmer and honeybee-keeper collaboration	No Concern: Large-scale farming	New honeybee-keepers	**A** **D**

10	They are facing problems. -Yes	-Habitat degradation -Honeybee bias	Yes - The feeding of honeybees	Yes Concern: Large-scale farming	A collective effort	**A**
13	They are facing problems. -**Yes**	NNis	Uncertain	No	Farmers	***D***
19	Positive No	Overuse of synthetic inputs	Yes - Stricter laws for farmers	Yes Concern: Large-scale farming	Large-scale farmers	***D***

*R = # of respondent
**Source: Author's sample interview data, 2015.

Overall, the crop-farmers in my sample do recognize that bees in Ontario are facing challenges although their focus on honeybees is evident. Colony Collapse and neonicotinoids were discussed in relation to honeybees. Farmers viewed the reduction of pesticide use in farming as the most important bee-conservation measure which although "a challenge, should be done" (19). Two reported the increase of fallowing marginal lands and the decreasing of pesticide usage as being the most feasible measures for farmers to take to better conditions to bees. These were considered easier to implement than increasing the amount of fallowing and marginal land or decreasing mowing practices.

Three out of four farmers believe bees are facing greater challenges in recent years. Only one farmer did not feel bees were under any significant threat (19). Despite acknowledging that there have been instances of higher than normal colony losses in Ontario, he considers the situation to be improving for honeybees. He keeps around 60 beehives on his farm for honey and pollination, a skill he learned a few years earlier. It is from the position of both a new honeybee-keeper and an experienced crop-farmer, that he sees the situation. He commented that stricter laws are needed requiring farmers to report when pesticide sprays are being applied near honeybee colonies. Only one farmer (10) explicitly commented on the state of wild bees, stating that they are in decline and that honeybee problems receive a disproportionate amount of attention from bee-researchers and the public. This was the native plant farmer. He also expressed concern about the beekeeping practice of giving honeybees artificial feed or sugar-water. His main concern however, is the degradation of bee-habitat. All other farmers also cited concerns with particular stressors which affect bee-habitat but did not view bee-habitat degradation as the main problem overall. The top concern expressed by the farmers in my sample in relation to bee-health is the improper or excessive use of chemical inputs in large-scale agriculture, particularly neonicotinoid use. This is interesting because it shows that farmers are most aware of and show the most concern about agricultural stressors affecting bees. When asked about the sustainability of farming in Ontario, beliefs ranged from: completely negative to positive. All four farmers express some level of concern regarding the sustainability of large-scale, heavily mechanized and chemically-intensive farming operations. None of the farmers I interviewed rely intensively on inorganic inputs and rely instead on organic applications, either entirely or when possible.

One farmer, also a novice honeybee-keeper, expressed the need for “more honeybee-keepers to work with smaller, more diversified agricultural operations” (3). This is because she believes these operations are better for bees. She reported concerns about the effects of neonicotinoids on bee-health, as well as the sustainability of overly-intensive farming practices which require the heavy use of inorganic treatments. She would like to see a growth of more labour-intensive approaches, which require less chemical inputs. Farmers in my sample did not agree about who holds the most power to impact the current pollinator situation but agree that large-scale farmers play an important role. New honeybee-keepers were identified by one farmer to be important actors in the pollinator problem (3). Two farmers reported that greater collaboration between beekeeping communities, a concerted effort, is needed to better the situation for bees, overall (3 &10).

Concerns & Beliefs of Bee-Conservationists. For bee-conservationists**,** measures to conserve native bee pollinator species through the rehabilitation of wild bee habitats and populations were their foremost concern. The belief that certain landscape management practices can contribute positively to pollinator rehabilitation drive them. In Table 4.2 below, I provide a simplified overview of the beliefs and concerns identified by bee-conservationists.

Table 4.2 - Overview of Beliefs & Concerns of Conservationists

R.	Based on personal experience, are bees facing increasing challenges in recent years?	How do you perceive the situation of wild bees in Ontario?	How do you perceive the situation of honeybees in Ontario?	Biggest Concern (s)	Do you believe that current agricultural patterns in Ontario are ecologically sustainable?
1	Yes	Not good	Uncertain	Habitat Loss Pesticides	No
12	Yes	Uncertain	Not good	Dog-Strangling-Vine (Invasive Plant)	Uncertain
17	Uncertain	Uncertain but Not good	**Not good**	Lack of adequate research Decrease in biodiversity Decrease in bee numbers	No

*R = # of respondent **Source: Author's sample interview data, 2015.

Conservationists in my sample express concern regarding the situation of bees in Ontario. Interviewees did not consider managed and wild bees to be in a 'dire' state (12) but no one reported bees to be in a good situation either. Interviewee 17 added that the situation is location-dependent. The state of bee-habitat is the main concern for the practitioners in this 'beekeeping community'. Habitat loss and the decrease of habitat biodiversity are considered important issues by all three conservationists in my sample. The contributing factors discussed by them were invasive plant-species (12) and human land-use patterns, including heavy pesticide usage (1).

Two of the interviewees work in a conservation area and described the difficulty of containing the range of invasive plant species (12 & 17), which threaten the biodiversity of plants there, impinging on the floral variety needed by bees. When I participated in a volunteer restoration day there, I found the invasive Dog-Strangling-Vine Plant (or DSV) very hard to weed, as the roots break off and re-grow very quickly. They described their constant battle with the spreading plant, which requires an ample volunteer base to contain within its current range. Another worry conservationists express is that information on the state of wild bees is lacking. Agricultural practices were generally considered to be unsustainable by bee conservationists.

Beliefs & Concerns of Direct-Bee Managers. The belief that humans can manage bee health and thus, productivity, underlies practices for a productive apiculture. Direct-bee managers address concerns about bee-stressors directly through their practices. Below, I present an overview of reported beliefs and concerns.

Table 4.3 - Overview of Beliefs & Concerns of Direct-Bee Managers

N.	How would you describe the current situation of both managed & unmanaged bees in Ontario?	Biggest Concern (s)	*Are there any changes that you would like to see in current bee-management practices in Ontario*	*Do you believe that current agricultural patterns in Ontario are ecologically sustainable?*	*Who do you believe has the most power to impact the current pollinator situation and why?*
3	Not Good	CCD NNis	Greater honeybee-keeper and small-farmer collaboration	Small scale: Yes Large scale: No	Young honeybee-keepers
5	Honeybees: Not Good	Varroa mites, Agrochemicals -Balancing management of all bees	Developing local bee-breeding	No	Uncertain
7	Honeybees: OK	Varroa mites Habitat loss	Better organic treatment options	No	Uncertain

	Wild bees: Uncertain				
11	Uncertain Wild bees: Not good - in decline	NNis & other pesticides,	Better practices in Mason-bee-keeping for preventing disease	Uncertain	Governmental institutions
14	Honeybees: Bad Bumblebees: Bad in decline	Decline of beekeeping	Better beekeeping equipment Development of beekeeping, bee-breeding	No	Pesticide companies
15	Not good	Agricultural chemicals Habitat loss	Less chemical inputs	No	Collaborative effort needed
16	Honeybees: Not good Wild bees: Uncertain, likely bad	Improper honeybee management	Better hive management	No	Politicians
18	Good	Habitat loss	Less chemical inputs Better treatment options Fewer migratory beekeepers	No	Consumers

*R = # of respondent **Source: Author's sample interview data, 2015.

Attitudes about the current situation of bee-pollinators range from positive to negative but mostly are negative among this category of beekeepers. One honeybee-keeper believes that the situation of honeybees has not changed much in recent years (7). Others believe that "it is getting harder to keep honeybees" (16), and that beekeepers are "barely able to keep them alive" (14). Beekeeper five explains that honeybee **p**opulations are kept up by beekeepers who face increasing hardship from agricultural chemicals & disease, particularly the Nosema virus and Varroa mite. Similarly, when asked about the current state of bees in Ontario, the novice honeybee-keeper (3) answered: "there is an issue & I think its agriculture". Four people are worried that wild bees are in decline (7, 11, 14 & 16). Honeybee-keeper 5, who also works at a conservation organization, is concerned about the difficulties involved in trying to balance goals in honeybee and wild bee management.

Direct-bee managers express concern regarding multiple factors affecting managed and unmanaged bee health. These include the prevalence of honeybee pathogens, particularly Varroa (5 & 7), NNis and agrochemicals (3, 5, 11 & 15), CCD (3), the decline of beekeeping as a common profession (14), improper honeybee management (16), and habitat loss. Their biggest concern was that environmental degradation is resulting in the loss of bee-forage and habitat (7, 18 &15). Another concern voiced is that the Ontario honeybee industry is not self-sufficient because it depends too heavily on imported queen-bees (5 & 14). Migratory beekeeping was also viewed as a challenge to bee health and as more stressful for bees than a honey-oriented operation. Migratory operations is stressful for bees which are shipped long distances for pollination, after which they are placed in monocultures amongst colonies from other operations. This can contribute to increased exposure to disease and insecticides (Collins 2010).

Only one (18) of these direct-bee managers cited chemically intensive large scale farming as problematic for bees, particularly in the context of monocultures. Others called for less chemically-intensive honeybee-keeping (15 &18). Honeybee-keepers regularly apply a mix of (cultural, organic and inorganic) controls to secure the health of their bees. One particularly devastating honeybee disease which was once more common - American Foulbrood "is kept at bay by prophylactic antibiotic treatment of all conventionally-managed hives" (Chan 2012: 10). A beekeeper at the honeybee research center believes better organic options are needed for treating honeybees, particularly for Varroa, because current organic options are harsh on the bees (7). Beekeepers also voiced a need for better treatments for American Foulbrood disease (18), and for redesigning beekeeping equipment (14).

Opinions are divided regarding who has the most power to influence the current situation of bees, ranging from young honeybee-keepers (3), governmental institutions (11), "the agricultural chemical people" (14), politicians (16) and consumers (18). One person believes it needs to be a collaborative effort between landowners, farmers, honeybee-keepers and the nursery trade (15). This points to the wide array of actors involved in securing bee success.

In terms of specific actions that can help rectify the situations, half (4/8) of the respondents in this category consider the enhancement of bee-pollinator plantings as the most important measure for the conservation of both managed and unmanaged bee-species by four direct-bee managers. Specific suggestions included cultivating bee-attractive flowers and shrubs (18) and building artificial nests for wild bees, such as mason bees, to provide habitat (11). One honeybee-keeper emphasized the importance of diversifying plant landscapes for bee conservation with a focus on less cultivated varieties (15).

Beekeepers 3 and 14 who primarily produce honey, consider buying local honey an important way people can support bee-health. This is because it supports honeybee-keepers locally. This is important because Ontario beekeepers are mostly smaller scale and honey-production oriented (Melhim et al. 2010). When we import honey it is usually from operations large enough to sell wholesale to local markets. Not only is it much harder to assess how the bees were kept and the quality of the honey when it is from a large and unknown seller, but it also undercuts local, small-scale honeybee-keepers.

Another suggestion included providing honeybee-keepers with better education, for example through broader extension programs information. I thought this to be a particularly relevant suggestion at a time when fewer honeybee-keepers are managing greater numbers of colonies. Other measures honeybee-keepers suggested for bettering conditions for bees were:

donating to bee-research and the development of a local bee-breeding program. The argument for breeding bees locally is that bees produced in the environmental conditions different to those they will encounter in their own lives (i.e. imported bees) will be weaker. Locally produced bees would be better-adapted to local environmental conditions, including epidemiological ecologies.

Concerns & Beliefs of Bee-Researchers. Bee-researchers are driven by the belief that a greater understanding of factors affecting bee-health is necessary to improve conditions for bees, both managed and unmanaged. In Table 4.4, I present an overview of bee-researcher concerns and beliefs about bees and agriculture, as reported in interviews.

Table 4.4 - Overview of Beliefs & Concerns of Bee-Researchers

R.	How do you view the situation of honeybees in Ontario?	How do you view the situation of wild bees in Ontario?	Biggest Concern (s)	*Are there any changes that you would like to see in current bee-management practices in Ontario*	*Do you believe that current agricultural patterns in Ontario are ecologically sustainable?*
2	Poor - In steady decline	Bumblebees: in decline	Agricultural chemicals & land-use patterns	Uncertain.	No
4	Uncertain, troubling	Uncertain	Habitat loss	Uncertain	Uncertain
5	Poor	Uncertain Bumblebees: in decline	Varroa Agricultural chemicals Balancing honeybee & wild bee management	The development of local bee-breeding	No
6	Uncertain	Uncertain	Varroa Small Hive Beetle	Development & access to better treatments options	Uncertain
8	Fine	Uncertain	Pesticides	Uncertain	Greater use of bio-controls needed
9	Fine	Uncertain Bumblebees: in decline	CCD	Uncertain	Uncertain

*R = # of respondent **Source: Author's sample interview data, 2015.

Bee-researchers are the most reserved when it comes to providing definite broad-sweeping answers regarding the current state of bee-pollinators or sharing their opinions on Ontario agriculture. Two respondents viewed the situation of honeybees to be fine, despite a recognition of the many stressors they face. The honeybee-research apiary manager explains that bees are facing increasing hardship but that honey-beekeepers nevertheless are managing to grow their population sizes. Three researchers expressed concerns that wild bees are in decline, particularly bumblebees, but many were uncertain about the situation of wild bees in general because not enough data is available. Four researchers expressed concerns with, or relating to habitat degradation and saw the conservation of bee-habitat as an important measure for bettering conditions for all bees. Half (3/6) cited agrochemicals in general or pesticides in particular, as a primary concern in terms of securing bee-health. Others cited unsustainable land-use patterns in agriculture (2), habitat loss in general (4), Varroa (6), CCD (9), the Small Hive Beetle (6), balancing goals in wild and honeybee management (5).

Similarly to the direct bee managers, researcher 8 believes that more bio-control options are needed (this time for crop-management), because current controls which are available can be harsh on bees. They also agree that the development of better honeybee medications is needed, in terms of cost to the beekeeper and harshness on the bees (6).

Not surprisingly, the concerns voiced among my sample of bee researchers reflect their main areas of research: mainly drivers in honeybee-disease, such as the effects of neonicotinoid pesticides on honeybees but also the effects of environmental change on plant-pollinator interactions, in general. The above concerns show that bee-researchers are attuned, varyingly, to the goals of conservationists and honeybee-keepers. Only in one case (5), was a researcher concerned about both honeybees and wild bees. This is a rare perspective to encounter and I believe that it is representative of where future research must head if we are to reconcile goals in wild and managed bee conservation.

Summary

The beliefs and concerns about bees expressed by those in my sample cover a wide range of stressors and problems, some of which can only be fully understood through experience within a particular professional framework and community, and thus reflect practitioner positionality. All communities converged in their concerns about habitat loss and chemically-intensive large-scale farming, with many pointing to the overuse of NNis.

Farmers were particularly outspoken about their worries related to chemically-intensive farming, the overuse of neonicotinoids and the resulting loss of bee-habitat. Direct-bee managers were more concerned about honeybee stressors managed in honey-beekeeping, such as Varroa and the Nosema virus. They also expressed concerns about the sustainability of honeybee-keeping as an industry, due to a lack of support for the development of local bee breeding programs, poor beekeeping practices, inadequate treatment options for honeybee stressors and the decline of honey-bee keeping as a profession. Conservationists generally voiced concerns related to wild bee conservation. Their main concerns were threats to biodiversity (from a variety of factors including the spread of invasive plant species) and the lack of research on wild bees.

Researchers echoed some of the concerns of other beekeeping communities. They too pointed to the lack of data on wild bees. They worried about the effects of current levels of agrochemical use in Ontario agriculture on bees. Other issues raised included: the loss of bee habitat, Varroa parasitization, CCD, the Small Hive Beetle, lack of local bee-breeding, inadequate treatment options in farming, and the difficulty of balancing goals in honeybee and wild-bee management.

How practices are identified and strategically chosen is largely based on personal experience, beliefs, concerns, etc. Personal experience, which dictates the concerns and beliefs of a practitioner, is relevant to beekeeper strategy and is derived from practice, networking and education. I discuss the knowledge systems and venues of knowledge dissemination underpinning beekeeper conceptualizations of the pollinator problem in the following chapter: Systems of Knowledge.

Chapter V

Knowledge Production & Exchange Among Beekeeping Communities in South-eastern Ontario

In this chapter, I explore the knowledge systems which are drawn on by beekeepers to inform their beekeeping strategies. I present examples of prescriptive information (i.e. which advocates certain desired practices) that is disseminated to members of each beekeeping community, or beekeeper type. I elaborate how this prescriptive is made available and accessed, and discuss venues for beekeeper knowledge exchange. The prescriptive texts that I introduce are: Integrated Pest management (IPM) guidelines for specific professions, elements of conservation area policy, and governmental legislation, such as the Ontario Bees Act (See Appendix 1 for an example of prescriptive material). Drawing on information reported by interviewees and my own participant observation, I provide an overview of the materials accessed by beekeepers, or provided to them at trade conferences and meetings in Table 5.1, below. In addition to examples of prescriptive texts, I also list the reported venues and organizations accessed by beekeepers in my sample, according to beekeeper type, in Table 5.1. Full names for the organization acronyms provided in the table can be found in the Glossary, under the acronym section.

TABLE 5.1 - Policy, Prescriptive Texts, Organizations and Venues for Beekeepers

Primary Beekeeping Type		Policy, Prescriptive Texts, Organizations & Venues Accessed by Beekeepers	No. of interviewees who:		
			Attended Events within their beekeeping community	**Presented or gave workshops to community members**	**Provided Education to the public or other bee-related communities**
Direct-Bee Managers	Honeybee-keepers	Integrated Pest Management Ontario Bees Act (1990) Apiaries for honey production, education or research, honeybee research facilities, honeybee-keeper meetings, conferences, internet forums e.g. – the Canadian Honey Council, the Eastern Ontario Beekeepers Association, Ontario Beekeepers' Association, Ontario Ministry of Agriculture, Food & Rural Affairs, Tech-Transfer Program	7/7	4/7 (Interviewee # = 5, 7, 14 & 16)	4/7 (5, 7, 14 & 16) Horticultural societies, farmers, the public
	Mason-bee keeping	Mason-bee farms, internet forums, conservation centers e.g. – The Fletcher Wildlife Garden Conservation Area	No	No	1/1 Conservation area workshop for the public and volunteers
Researchers		Universities, research facilities, conferences, academic journals e.g. – The Honeybee Research Center, Eastern Apicultural Society Conference	2/6 Interviewee (2, 5)	2/6 (Interviewee 2, 5)	2/6 Interviewee 2, 5) The public, Farmers, gardeners
Farming		Integrated Pest Management Farms, agricultural association meetings, conferences, trade shows, internet forums, horticultural meetings e.g. – The Ontario Federation of Agriculture, the Ontario Ministry of Agriculture, Food & Rural Affairs	4/4	1 (Interviewee 10)	1 (Interviewee 10) The public, farmers, horticultural societies

Conservation	Conservation centers, wild pollinator events, agricultural conferences, internet forums e.g. – Guelph Organic Conference, the Ontario Field-Naturalists' Club, IUCN Red List of Threatened Species	3/3	3/3	3/3 The public, Gardeners

*Source: Author's sample interview data and participant observation data, 2015.

Knowledge Systems Supporting Beekeeper Practices

Beekeepers draw on prescriptive information to gain both practical and theoretical knowledge. For purpose of analysis, beekeepers are divided into types but I also consider them communities because of how they exchange information. A variety of prescriptive texts are available to beekeepers. The information sought by direct-bee managers, bee-conservationists, bee-researchers and crop-farmers often differs because it is necessarily profession-specific. Hence, it is not surprising that honeybee-keepers access information relevant to direct-bee management and not crop-management, unless they are also interested in farming or farming policy. In the same way, crop-farmers are more likely to access information about farming than about honeybee-keeping.

Beekeepers from each of the communities I examined networked amongst themselves to exchange relevant information, through academic, amateur or professional avenues. In my sample, sixteen out of nineteen interviewees attended events within their own beekeeping community, of which ten also spoke at such events. The role of peer education within beekeeping communities is important and contributes to the dissemination of professional norms and guidelines.

Mentor-apprenticeship arrangements were most important to the honeybee-keepers in my sample. Four out of seven in my sample entered mentor-apprenticeship relationships. Mentorship arrangements are particularly useful when learning honeybee-keeping skills, as experiential knowledge is highly valuable for truly grasping aspects of highly specialized managerial practices and goals. Knowledge exchange between honeybee-keepers supports professional communities, individual livelihoods and private beekeeping operations. Interestingly, eleven beekeepers presented at events targeted at people outside of their beekeeping communities. This suggests that multiple and also, distinct knowledge systems support the practices of beekeepers, as I define them. However, it is also important to note that some sources of information are shared, as they are relevant to more than one professional community.

Prescriptive Texts for Beekeepers. As mentioned earlier, the prescriptive texts relevant to beekeepers in my sample range from broadly-applicable governmental texts on best-practices for specific professional communities, such as IPM, or can have a narrower focus, such as a conservation organization's operational policy. One example is the strategic plan for the Fletcher Wildlife Garden Conservation Area (OFNC 2011). Because the conservation area is a project of the Ottawa Field-Naturalists' Club (or the OFNC), on Agriculture and Agri-Food Canada (AAFC) land, volunteers follow policies agreed upon by these two main organizations, which are termed 'dominant shareholders' (2011: 4). The document also identifies the responsibilities of the above shareholders, as well as principles of operation for volunteers, which outlines goals and guidelines for land-stewardship practices. For example, in Section 5.2 – Habitat Improvement, protocol is provided for the enhancement of wildlife habitat, which is to be carried out "by planting native species that provide food and shelter to local wildlife" (OFNC 2011: 6). This shows that practitioners are sometimes restricted in the range of managerial approaches they may apply due to organizational affiliation. In this case however, ultimate responsibility for managerial practices is held by representatives of the FWG who lead volunteers rather than the volunteers themselves.

Beyond organizational policy, broader prescriptive texts influence practitioner strategy. Although the prescriptive material relevant to the four beekeeping communities I have chosen to explore is vast, I largely focus on practitioner adherence to IPM guidelines because it is a spectrum of best practices relevant to two beekeeping communities: honeybee-keepers and farmers. I do not discuss any prescriptive texts that are particularly relevant to bee-researchers because they are categorically different from those used by the three other beekeeping communities I identified. The bee-research community is unique when compared to the others because it is the most involved in the empirical testing of theories which contribute to policy and other prescriptive information. Policies and prescriptive texts are largely based on academic research. This points to the special relationship between bee-researchers and all other beekeeping communities, who are dependent on the prescriptive information formulated by the researchers.

Integrated Pest Management (IPM). Practitioners who implement an IPM strategy consider "all management options to maintain pests below an economic injury level" (OMAFRA 2009: para #1). This definition refers to the control of insect-pests in crop-production, but IPM is also applied to honeybee-keeping**.** The Ontario Ministry of Agriculture, Food and Rural Affairs - or OMAFRA for short, provides IPM guidelines for honeybee-keepers and crop-farmers online (OMAFRA 2016a). IPM guidelines aim to reduce honeybee-keeper and farmer dependency on any one type of (organic or inorganic) treatment by prescribing alternative management techniques. For example, by rotating medications and treating only when necessary, honeybee-keepers can avoid the development of a resistance to these medications in honeybees. Farmers can avoid pest-resistance to specific applications in the same way. IPM guidelines are promoted at various professional workshops. These include agricultural and honeybee-keeper meetings, as well as governmentally supported extension programs. One example is the Tech-Transfer Program. The program is partially funded by OMAFRA and transfers skills among Ontario honeybee-keepers, providing advice on best practices based on IPM methods (OBA 2016).

The Ontario Bees Act. This prescriptive document outlines responsibilities and regulates the practices of honeybee-keepers in Ontario. It is legally-binding, unlike IPM guidelines. This means, that the document can lead to legal recourse against any honeybee-keeper in Ontario that fails to follow the stipulations within. Adherence to the Ontario Bees Act is verified at random and in case of complaints against honeybee-keepers. This can be carried out by an official inspector, the provincial apiarist or his assistant (Bees Act 2009: Section 8). Some of the responsibilities outlined for honeybee-keepers include: the registration of bee-ownership, the reporting of disease, arranging for inspection prior to the sale of used equipment and bees and the proper disposal of old or contaminated equipment.

The above document regulates all honeybee-keeping practices in Ontario, as it targets both commercial and hobbyist operations, which shows that the prescriptive information drawn on by beekeepers can be both very specialized and quite broadly applicable. Prescriptive texts for beekeepers therefore, come in the form of governmental legislation, organizational policy and guidelines for best-practices.

Organizations, Venues & Avenues for Knowledge Production & Exchange

Professional workshops, meetings and conferences are made available for practitioners of each beekeeping community by various organizations. The Ontario Federation of Agriculture, the Eastern Ontario Beekeepers Association, the Eastern Apicultural Society and the Ottawa Field-Naturalists' Club are examples of organizations that provide specialized educational programs and resources to those in my sample. As mentioned earlier, members of the same beekeeping community network in similar settings. However, there is some overlap in networking venues between them. Moreover, some of my interviewees engage in more than one type of beekeeping practice, on an occasional or regular basis. This points to the possibility of a discursive relationship between the knowledge systems underpinning the four beekeeping communities I examine.

Collaboration between beekeeping communities I. In some cases, this discursive relationship is made explicit and leveraged for policy-formation. For example, at a series of public consultations regarding a proposed plan for the reduction of NNis on two crops in Ontario, beekeepers from all four communities came to participate and exchange concerns and opinions. To address the growing concern with NNis, Ontario preceded these events with the consolidation of research on bee issues by a designated working group, which presented a summary of their findings at the public consultations. These served primarily as a forum for all interest-groups to discuss the proposed plans for a policy aiming to reduce NNi use on corn and soybeans by 80%, over two years. Farmers, direct-bee managers, bee-conservationists and bee-researchers, all attended and through voicing their concerns contributed to policy-formation. Other stakeholders active at the meetings included representatives of relevant governmental institutions (such as OMAFRA) and of large agrochemical corporations, such as Monsanto (prior to the merger with Bayer). I present a general outline of the major issues raised at the public consultations concerning bees, discuss their purpose and effect in the following vignette.

Ontario Explores the Pollinator Crisis Via Public Consultations

In 2014, the Government of Ontario and the Ministry of Agriculture, Food and Rural Affairs (OMAFRA) launched an investigation into current bee problems in Canada. Their approach comprised of two parts. First, a Pollinator Working Group was formed to summarize the research on bee-stressors, which resulted in the formulation of the 'Pollinator Health Discussion Paper', titled: Pollinator Health – A Proposal for Enhancing Pollinator Health and Reducing the Use of Neonicotinoid Pesticides in Ontario (2014). In the Discussion Paper, all pollinators were recognized as playing a vital role in the agro-ecosystem. However, like in much other research, honeybees were considered to be of greatest importance and were the main focus. The document identifies: a.) four main stressor types: 1- pollinator habitat & nutrition, 2 - pesticide exposure, 3 - climate change & weather, 4 - disease, pests and genetics (p.6), and b.) explains the Government of Ontario's proposal for a Pollinator Health Action Plan.

The proposed action or goal, as stated in the title, was the amelioration of bee health, through the reduction of pesticide use in the neonicotinoid class. A question and answer period following brain-storming sessions in groups were the techniques used during the conferences to allow for easy communication between interested parties and representatives of the Work Group. In effect, the talks: a.) aimed to assess the challenges of implementing policy-change and, b.) began to explore if the goals of the Ontario government are complimentary to the sentiments of beekeepers who are currently dealing with these issues on the ground. Ultimately, the Working Group's recommendation of phasing out NNi pesticide usage on the two largest cash-crops in Ontario was implemented with the introduction of new regulations in 2015, concerning the sale and application of NNi treated seeds (Gov. of ON. 2015). The public consultations, two of which I participated in, presented various Ontario-specific problems and perspectives on bees and highlighted the rising concerns of beekeepers regarding agricultural intensification. The use of the new class of NNi pesticides was targeted in particular, clearly putting this stress factor at the top of Ontario's research agenda. The Pollinator Health Discussion Paper presents a perspective of the current pollinator crisis, which is informed by the demands of the larger Canadian context but understands the local Ontarian particularities of the issue to be stemming from intensive agro-chemical usage. The protection of bees has thus been conceded to be of greater import than agricultural intensification by any means.

The public consultations were used to produce policies informed by both research and actor concerns. The consultations demonstrated that many farmers and honeybee-keepers are eager to participate in deeper communication, as they are disproportionately affected by policies addressing the pollinator problem. The debate on reducing NNis demonstrated that perceptions of risk are asymmetrical due to actor positioning. Honeybee-keepers were concerned about pesticide over-application and exposure to honeybees. Crop-farmers were concerned about personal exposure if older forms of pesticide were to regain wider use (particularly sprays) and worried that a reduction in NNi usage would result in crop losses. Additionally, governmental institutions, such as OMAFRA, were voicing concerns regarding the state of wild pollinators. This shows that research is not the end point of policy production but the beginning. Research on bee problems first needs to be made contextually relevant for it to contribute meaningfully to policy production, which means that the viewpoints and concerns of leading stakeholders need also be considered.

Beekeepers therefore, meet with various beekeeping, governmental and non-governmental communities to bring attention to the issues they face, with the hope of contributing to the production of better policy. Many beekeepers also connect with the less involved public to raise awareness about bee-problems and about the issues facing their beekeeping community. For example, the native plant farmer in my sample (10) gives talks at nearby elementary schools regarding the importance of cultivating bee-friendly plants to support wild bees. A few of the bee-conservationists and wild-bee researchers in my sample presented at agricultural and apicultural fairs. Notably, many honeybee researchers co-mingled with honeybee-keepers at beekeeper meetings, honeybee conferences and a honeybee research facility. During the participant observation portion of my research, I also attended presentations by wild-bee researchers and conservationists at two agricultural fairs and an apicultural conference, which points to the connection between the two communities. Beehives are commonly kept on farmland, meaning these communities (farmers and direct-bee managers) often collaborate. In my sample, one honeybee-keeper led me to a farmer for this reason. Three of the four farmers I interviewed were closely connected to honeybee-keeping, having other beekeepers' hives on their property or keeping honeybees themselves. Therefore, beekeepers from different communities connect with each-other to benefit their own situation.

Collaboration between beekeeping communities II. The motivating factor for beekeeping communities to meet at the public consultations was the perception of a common threat and as such, was an example of knowledge exchange mobilized under special conditions. However, as mentioned above, collaboration between certain beekeeping communities is sometimes sustained and occurs because it is beneficial for both sides. For example, honeybee-keepers enter arrangements with crop-farmers, whereby beehive space is granted in exchange for honey and pollination. A similar relationship exists between honeybee researchers and honeybee-keepers, as researchers rely on keepers to gain access to bees for testing. The relationship between honeybee-keeping and honeybee-research is most evident in the research apiary, where the head honeybee-keeper is also the research manager (5). In this environment, knowledge is exchanged very quickly between bee-researchers and direct-bee-managers. The researchers depend on direct-bee managers to secure test-bees and the direct-bee managers in turn, depend on the findings of researchers, which are applied to bettering managerial strategies and products. Another example of cross-community collaboration I encountered during my research also involved bee-researchers and honeybee-keepers. Instead of a purely research setting, as in the research apiary, one honeybee-keeper (14) allowed tests to occur in his own honey-production oriented apiary. He is a definite outlier among direct-bee managers (?) due to his experimentation with a biological control for Varroa. Due to the fact that this control is not available to the other beekeepers in my sample, I discuss it below instead of later on.

A biological control, or biocontrol is a natural agent, usually an insect, which is used to control a pathogen. These are most common in crop-farming and the biocontrol noted in the experiment above, *Stratiolaelaps scimitus,* is already used in Ontario crop-farming (OMAFRA 2016). Beekeeper 14 explains that Stratiolaelaps parasitizes Varroa mites, as the mites do to the honeybee. The difference in size is about the same for both parasite-host pairs. Their minuscule size prevents single *stratiolaelaps* from being able to kill a Varroa mite but not from seriously injuring it. Their attack is sophisticated. As one honeybee-keeper explained:

> After they're done eating they tag a hormone tag onto the Varroa mite for other Strateolalaps […] saying this is food. So, the Varroa, once they're attacked, are really subject to a constant bombardment and gang-haggling by the smaller mite that drills holes in it, eats their eggs, chases the females right down into the [hive] cells, rides the Varroa drilling a hole in it... so they don't kill them and they don't eat them completely, but more than anything, they harass them, because its' like a walking hamburger for them; they take a bite (Interview 14)

This biocontrol is being tested for its' potential application in honeybee-keeping but has not been developed commercially. Interviewee 14 is participating in research into the biocontrol for honeybee-keeping purposes through his conservation organization. In this way, he is enabling cross-community collaboration and knowledge exchange, creating opportunity for beekeeping solutions which draw on farming, research and direct-bee management expertise. This is important because Varroa control currently comprises a large part of Canadian honeybee management. The development of a biological control for Varroa could mitigate problems of mite-resistance to medications, reduce stress on bees and decrease the overall difficulty of honeybee management. In terms of information dissemination, such 'symbiotic' practices show that certain knowledge systems interact on a regular basis. This also suggests that certain beekeeper practices are supported by the practices of other beekeeping communities (e.g., honeybee-keepers and honeybee-researchers). Therefore, collaboration by the multiple stakeholders implicated in the pollination problem contributes to the success of beekeeping communities.

Although interviewees generally connected me with others engaged in the same beekeeping type, there was a lack of connectivity that was noticeable among them in certain cases. During sample selection, wild-bee researchers referred me to other wild-bee researchers but not to honeybee researchers, and *vice-versa.* This mirrored the situation at conferences. Direct-bee managers who participated in honeybee-keeping could not refer me to managers of other bee-species. Interestingly, certain beekeepers interacted more with each other than with others from their own community, as I define them. For example, the mason-bee keeper I interviewed, I located thanks to conservationists, rather than direct-bee managers of honeybees. This reflects that the analytical categories I have chosen are in fact fluid and can overlap. Interest in a common theme, such as a particular bee-species or bee-community encourages networking between professions and may be a stronger basis for the categorization of beekeepers into types than broad treatment categories. I touch on this again in the final chapter.

Bee-Researchers. The bee-research community is unique when compared to the others in terms of how knowledge is produced and applied in relation to bee problems. Bee-researchers are most involved in the empirical testing of theories which contribute to policy and other prescriptive information used by other beekeeping communities. Policies and prescriptive texts are largely based on academic research. This points to the special relationship between bee-researchers and all other beekeeping communities, who are dependent on the prescriptive information formulated by the researchers. Bee-researchers are not as intimately tied to the outcomes of the bee-management strategies they may propose to other communities that work with bees. This is because their livelihood does not depend on the success of the controls applied to better bee health. Instead, it is dependent on the presentation of findings relevant to bee-health.

Summary

In this chapter, I explored the types of prescriptive texts which regulate beekeeping practices or which are accessed as guidelines for managerial advice. Beekeepers from different communities access distinct bodies of knowledge, however some beekeepers draw on more than one, pointing to the possibility of a discursive relationship between them. The role of peer-education and knowledge exchange within beekeeping communities is important, particularly for honeybee-keepers. This is likely to be the case for other beekeeping communities as well, especially in terms of learning highly specialized managerial techniques which are difficult to grasp if practitioner knowledge is purely theoretical. I looked at how certain beekeeping practices are collaborative and occur with the purposive interaction between members of different beekeeping communities. Beekeepers interact either as a result of a perceived common threat or interest, particularly if professional relationships are mutually-beneficial. Furthermore, the practices of certain beekeeping communities support others. Honeybee-keepers need to draw on research to effectively manage and sustain their operations. Researchers need honeybee-keepers to provide them with test-bees. Direct bee-managers also support farming practices through pollination arrangements and farmers exchange land or money for these services. This suggests that certain professions cannot be successful without adequate collaboration from others.

Chapter VI

Identifying Strategic Variants for Beekeeping Practices

Defining Key Terms in my Analysis of Beekeeping Practices & Strategies. Beekeeper strategies are expressed through series of specialized practices contributing to bee-health, which I call treatment techniques. These are motivated by beekeeper beliefs and concerns, as well as practitioner aim. In analyzing interview responses, I decided to treat the practices described by all interviewees as snippets from a shared broad spectrum of beekeeping techniques, each of which is applied with an underlying logic, and may or may not adhere to the prescriptive guidelines put forth by 'experts' from a practitioner's field (such as those discussed in Chapter 6). Beekeepers ultimately make managerial decisions on their own; they choose whether they want to supplement experiential knowledge with the prescriptive advice provided in professional guidelines, such as IPM. Therefore, while I analyse treatment techniques in terms of my broad categories of beekeeper types, belonging to a beekeeping community is not necessarily indicative of the guidelines actively applied by a practitioner, nor does it determine the exact range of techniques applied by an individual.

The prescriptive information that is accessed by practitioners contributes to their understanding of managerial norms, which tempers their overall approach, based in personal conceptualizations of common managerial problems. Because beekeeping strategies can be assessed only partially based on the prescriptive texts accessed and the beliefs and concerns of beekeepers, I also present the techniques they do apply as part of their practice. Before getting into specialized practices, I present basic differences in terms of beekeeper aim and practices. The treatment techniques that I cover are cultural controls, organic controls, inorganic controls and empirical testing for scientific research. I finish by presenting the range of treatment techniques (practices) reported for each beekeeping community.

Treatment Category, Level & Aim in Relation to Primary Beekeeper Type

In Table 6.1 below, I broadly classify the practices and aims per beekeeper type. I follow this with a definition of the key terms I used in my analysis of beekeeper practices and later, strategies.

Table 6.1 - Treatment Category, Level & Aim in Relation to Primary Beekeeper Type

Bee-Keeper Type	**Farming**	**Conservation**	**Research**	**Direct-Bee Management**
Treatment Category	Landscape Management	Landscape Management	Experimental Colony Management	Colony Management
Level of Treatment	Ecosystem Level	Ecosystem Level	Colony Level	Colony Level
Aim of Treatment	Productive Agriculture	Pollinator Rehabilitation	Pollinator Rehabilitation	Productive Apiculture

Source: Author's sample interview data, 2015.

Treatment Category. Due to the diversity of beekeeper practices in my study, I group these into three broad categories: landscape management, colony management and experimental colony management. The practices of each beekeeping community (or beekeeper type) fall into one of my treatment categories. Landscape management practices entail human interactions with a target environment, such as the plant-cultivation of farmers and conservation workers. Colony management involves human interaction with bee-colonies or nests. I include practices with individual bees under this designation. Experimental colony management involves interaction on the same level as in colony management but comprises a greater variety of specialized practices, in a wider variety of settings. This is because research does not only test the efficiency of managerial practices but also investigates the effects of environmental stressors on bees, such as neonicotinoid pesticides.

Levels of Treatment. Treatments span from single-species to multi-species-oriented. Interviewees that interact with bees on the colony level are single-species oriented. Those that interact with bee-resources (forage and habitat), I characterize as working on the ecosystem level. There are two basic levels at which treatments occur. Human-bee interactions at the ***colony level*** consist of practices that target bee-colonies or individuals of a single bee-species. The researchers and direct bee managers in my sample work on the colony level. Practices on the ***ecosystem level*** comprise human interactions with pollinator habitat and forage, and affect multiple bee-species at a time. This treatment class comprises practices which modify the landscape, affecting the life-outcomes of bee-species in the immediate environment. The landscape management practices of farmers and conservation workers interact with bees on the ecosystem level. These treatments interact with the resources available for both managed and wild bees without targeting specific bee nests or colonies.

Aims of Treatment. Many beekeeping practices are applied with the goal of mediating pathogenic risks contributing to bee and crop health. The type of risk addressed differs amongst beekeepers. Mediating practices affect bees but not all such practices are carried out with the aim of bettering conditions for bees. One example is the preventative application of pesticides in crop-farming for the control of crop insect-pests. I consider the practices comprising farming, bee-conservation, bee-research and direct-bee-management as types of beekeeping by virtue of their regular interaction with bee populations. For this reason, I did not exclude any reported practices because they were not purposefully aimed at bees. However, I focus on strategies for *bettering conditions for bees* and as such, do not try to characterize the negative impacts mediating practices may have on bees. I recognize that not all bee-friendly practices are purposive and are at times, a bi-product of an occupation or mind-set.

The aims motivating the practices of members from each beekeeping community can be generalized in the following manner. The aim of landscape management practices in farming is productive agriculture. In bee conservation, landscape management is done with the aim of wild-bee-pollinator rehabilitation. Colony management is carried out with the aim of securing a productive apiculture. Experimental colony management is executed by researchers to produce information relevant to pollinator rehabilitation. Bee-conservationists share with bee-researchers their aim of pollinator rehabilitation but unlike them, reach their goal by working on the ecosystem level. Conversely**,** as is the case for bee-conservationists and crop-farmers, practitioners from different beekeeping communities can share a treatment category although, the aims of these practices differ. Not surprisingly, the management practices used by different types of beekeepers vary according to their aim.

During the interview process, it became clear that engagement in one primary beekeeping community does not fully explain the aims of individual beekeepers. For example, although I characterize the aims of direct-bee managers as productive apiculture, not all honeybee-keepers interviewed conceptualize productivity in the same way. This shows that the aims that I present for practitioners from each community are only a generalization. I discuss how specific treatment practices are related to beekeeper aim in the following chapter. In Table 7.2 below, I present the range of treatment techniques per treatment category and beekeeper type.

Treatment Techniques. Each treatment category has a different range of possible treatment techniques, or specialized practices. One treatment category, landscape management, I use to characterize the specialized practices of both crop-farmers and bee-conservationists because they interact with bee forage and habitat, i.e. on an ecosystem level rather than directly with bees themselves. As mentioned above, I distinguish between four main types of treatment techniques (cultural controls, organic controls, inorganic controls and treatment techniques for empirical testing), which are implemented by the nineteen interviewees in my sample. Multiple types of treatment techniques can be applied as part of an overall strategy and are, therefore, not mutually exclusive; i.e., both inorganic and organic methods can be used by the same practitioner.

I borrow the term ‘cultural controls’ from a booklet of best-practices for honey-beekeeping (IPM 2011). Cultural controls involve the use of “physical practices to reduce incidence” of pests and diseases (ibid. – back cover). In the context of conservation, farming and direct-bee-management, they are managerial techniques which are applied to better conditions for either bees or crops, without the use medication. For instance: crop-rotation systems in farming, or the elimination of *drone cells* to reduce Varroa infestation levels in honeybee-keeping. Organic Controls are naturally-derived products which are applied to reduce pests and disease, on crops or on bees. Inorganic controls are applied for the same reasons as organic controls. They are synthetic chemicals that are applied to prevent pests and disease.

The final treatment technique class that I have chosen to designate separately is the only group of specialized practices where non-beneficial conditions are purposefully applied for research. Treatment techniques which are devised by the scientific method for empirical testing involve any combination of the specialized practices I describe above, in addition to the application of substances or conditions which are not usually applied to *better* conditions for bees, but rather to test in a controlled manner the impacts of various stressors on bee-outcomes. These are applied by researchers to managed or wild bees.

Table 6.2 – Range of Treatment Techniques in Relation to Treatment Category & Primary Beekeeping Type

Treatment Category	**Number of participants per primary beekeeping type**	**Treatment Techniques**			
		Cultural Controls (R = 13)	**Organic Controls** (R=11)	**Inorganic Controls** (R=7)	**Devised by the Scientific Method for Empirical Testing** R=6)

Landscape Management	**Farming** R = 4	4	3	1	-
	Conservation R = 3	3	-	-	-
Colony Management	**Direct Bee-Management** R = 8	8	8	6	-
Experimental Colony Management	**Research** R = 6	-	-	-	6
-Numbers do not add up to participant total because two interviewees provided data on two beekeeping types: Beekeeper #3 and #5 are represented twice.					

*R = respondent number **Source: Author's sample interview data, 2015.

All four farmers in my sample apply cultural controls, three used organic controls and one also relies on inorganic controls when necessary. All three conservationists rely purely on cultural controls. All eight direct-bee managers apply a mix of cultural and organic controls. Six also rely on inorganic controls. Due to the wide variety of specialized beekeeping practices in my sample, an exhaustive list of treatment techniques is not possible. Some of the cultural controls applied by those in my sample are: various kinds of tilling, weeding, crop-rotation, polyculture, honeybee-hive monitoring, hive expansion (for swarm-prevention) and the sterilization of tools used in the hive. Organic controls in my sample comprise medications for honeybees, crop-fertilizers and some insecticides. A few of the organic controls reported are: formic acid, Thymol (both used to control Varroa in honeybees) and crop inoculants, which are used to support bacterial ecologies that allow crops to thrive. Inorganic treatment techniques in my sample range from medications for honeybees to synthetic pesticides for agriculture. These include Apistan, Apivar (products against Varroa) and various agricultural pesticides. The controls used by researchers in my sample vary greatly but include compounds found in neonicotinoid-class pesticides, such as clothianidin and imidacloprid. Because the controls applied by researchers are subject dependent instead of professionally or community specific, I do not discuss them here.

Discussion of Practices & Treatment Technique Range

	Table 6.3 - Operation Type in Relation to Treatment Technique Ranges							
	Operation Type	Farming		Direct-Bee Management		Conservati on	Research	
		Conven-tional	Organic	Commercial	Hobby		Honey-bee	Wild Bee
Treatment Technique Range	Cultural Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Organic Controls	Yes	Yes	Yes	Yes	No	Yes	Yes
	Inorganic Controls	Yes	No	Yes	No	No	Yes	Yes
	IPM	Yes	Yes	Yes	Yes	N/A	N/A	N/A

*Source: Author's sample interview data, 2015.

While this range of treatment techniques exists, beekeepers selectively choose which to use. To identify strategic variants in beekeeping, I discuss the managerial choices faced by members of each beekeeping community, as well as the factors which contribute to treatment technique choice.

Treatment Technique Range in Farming: All farmers in my sample have the primary goal of maintaining a productive agriculture, although certain differences do exist. Three of the four farmers in my sample are cash-crop farmers whose aim is to produce large food crops of single plant species for wholesale, whereas one farmer cultivates edible and ornamental native trees for sale, individually. This suggests that the aim of successfully securing a productive agriculture is understood in more than one way in my sample. For a breakdown of participant operation type and treatment techniques, please view Table 6.4.

Table 6.4 – Overview of Farmer Treatment Techniques Per Operation Type – R = 4/19						
R.	Operation Type	Treatment Techniques				Hive # on Farm (honeybees)
		Cultural Controls	Inorganic Controls	Organic Controls	IPM	
3	Organic Cash- Crop farm	Yes	No	Yes	Yes	1
10	Organic Native Plant Nursery & Farm	Yes	No	Yes	Yes	0
13	Organic Cash-**Crop farm**	Yes	No	Yes	Yes	1
19	Conventional Cash-**Crop farm**	Yes	Yes	Yes	Yes	26

*R = # of respondent **Source: Author's sample interview data, 2015.

The farmers in my sample apply cultural, organic and inorganic controls to their land. These applications are meant to secure crop success through the management of pests and plant diversity. A mix of the three controls are applied but sometimes inorganic applications are restrained or completely avoided. Three farmers in my sample aim to maintain a productive agricultural operation using organic practices and one practices conventional farming. I designate the farmers who use only organic and cultural controls as *organic*. I refer to those using cultural, organic and inorganic controls as '*conventional*'. IPM is relevant to both operation types. The farmers I interviewed reported implementing elements of IPM, often without full knowledge of what the guidelines entail.

Farming Strategies: Decisions in Management. The farmers in my sample face managerial decisions in terms of treatment techniques and operation type (organic or conventional). They also make choices about the varieties of plants to cultivate. They can focus on producing large cash-crops, usually non-native species, can choose to diversify plant species, or can completely restrict non-native plant cultivation.

Crop-specialization. When choosing an approach for a productive agriculture, crop-farmers are faced with decisions regarding crop-specialization. They may choose to produce fewer plant varieties for wholesale at the end of the season. Another option is to cultivate a larger variety of plants which are worth more individually and are sold continuously throughout the season. The first approach emphasizes maximal crop-yield and the second, plant diversity. In my sample, the native tree and shrub farmer (10) exemplifies the approach which favours plant-diversity. This is in stark contrast to the approach of the three other farmers in my sample, who produce much larger crops of fewer plant-varieties when compared to the tree-nursery operation.

The approach of the native plant farmer differs from the other farmers, not only in terms of crop-specialization, but mechanization as well. The set-up of the tree nursery and native plant farm do not permit a mechanized approach to planting and harvesting. He grows multiple plant-species simultaneously, in large containers and in the ground. This approach allows the operation to provide a wide range of native shrubs and trees, continuously. The other three farmers rely on planting and harvesting large crops of single plant-species in the shortest amount of time possible, for maximal selling capacity. This approach to productive agriculture favors mechanization in the form of tractors, which increase the production capacity of a farmer and reduces harvesting time. Indeed, it is difficult to imagine the management of a large single-cropping style without mechanized preparation of the dirt (for e.g.: tilling and disking) or mechanized seeding.

Mechanization affects the range of crop treatment techniques available to a farmer and can also discourage a polycultural planting style. Tractors are a medium for applying controls, such as disking (a cultural control). It is also a means for applying organic and inorganic inputs, such as fertilizers and insecticides. When a crop is uniform, the controls needed are also uniform. A crop of a single plant species requires the same treatment technique throughout. However, this is not appropriate for a diversified crop. The tree nursery farmer (10) applies treatment techniques in a different way than the other farmers, although he shares the same range of controls with other organic farmers. This is due to the nature of the crops cultivated, which are essentially a poly-culture, making it more difficult to apply treatments to all plants at once. When multiple plants are cultivated, their requirements will differ, including the controls needed. One reason farmers use a poly-culture set-up is that it slows the spread of pests and diseases, which in turn, reduces the need for applying additional controls. One example of this is the planting of 'trap-crops' in organic farming systems to attract pests away from a main cash-crop. The position of the native-tree farmer is in contrast to that of the cash-crop farmers, who can apply one product to an entire crop at a time. For this reason, tractor use is something that I expected to be unavoidable where crops are planted in a large, single-cropping style. The food-crop farmers in my sample do rely more heavily on tractors when compared to the tree-farmer. Unexpectedly, the one farmer in my sample that relies on inorganic inputs (19) depends largely on his horse for working the dirt.

Treatment Technique Choice. The landscape management practices of all farmers share the use of cultural controls. Three farmers in my sample use cultural controls such as disking, or turning the top-soil in the field a few times before planting. This is done with the intention of reducing unwanted plant varieties from growing in tandem with the target-crop. These are commonly referred to as weeds. In the case of the tree-farmer, one example of a cultural control is the destruction of insect pests by hand. The cultural controls used by a farmer are dependent on the tools available (for e.g., access to mechanization) and the type of operation being run (in terms of size, aim, crop-specialization, etc.). Cultural controls minimize the need for other inputs but it is exceedingly rare that they are the only type of control used on a farm. Farmers also decide between the use of synthetic (inorganic) inputs, such as chemical fertilizers, and those which are organic, such as fish fertilizer.

Farmers can choose to run either a conventional or organic operation. The latter involves going through a certification process on the provincial level. There is an economic benefit to having an officially recognized organic operation because crops can be sold at a higher price than conventionally produced crops. It is intuitive that organic farming operations have narrower criteria for treatment technique choice than conventional farms. Organic farms are restricted in their treatment technique choice and apply only cultural and organic controls. However, the conventional farmer in my sample applies inorganic controls sparingly and shares the concerns of the other farmers regarding overly-large, industrialized farming, which is chemically-intensive. Speaking of his operation, he refers to it as: "not 100% organic but close" (19).

Treatment Technique Range in Bee-Conservation. Bee-conservationists have the narrowest treatment technique criteria for mobilizing practices for bee-pollinators, using only cultural controls. This category is the only one for which it is possible to make an exhaustive list of beekeeping strategies. Two interviewees work for a well-established conservation organization and one for a community garden. In my sample, the cultural controls used by bee-conservationists are: a.) modifying plant distribution to affect forage and habitat conditions for bees, and b.) modifying bee-habitat through the introduction of synthetic nesting structures. I refer to nesting structures as *synthetic* if they are made by humans. The treatment technique range and conservationist operation types are provided in Table 6.5.

Table 6.5 - Overview of Conservationist Treatment Techniques Per Operation Type – R = 3/19					
R	**Operation Type**	**Cultural Controls:** Habitat & Forage Enhancement		**Organic Controls**	**Inorganic Controls**
		Pollinator-Plantings	Provisioning Nesting Habitat		
1	Urban community garden	Yes	Yes	No	No
12	Conservation Area	Yes	Yes	No	No
17	Conservation Area	Yes	No	No	No

*R = # of respondent **Source: Author's sample interview data, 2015.

The conservationists I interviewed completely refrain from introducing organic or inorganic controls meant to affect bee or plant success. The treatment techniques used are cultural controls. The main form of cultural control relevant to this category is strategic habitat and forage management through the enhancement and upkeep of pollinator plantings. This involves biodiversity enhancement through: a.) the planting and cultivation of native plant varieties, and b.) the reduction of the range of invasive plant species, which outcompete native plant communities, through weeding.

In the urban garden, application of cultural controls was less conservative in terms of plant choice, as some non-native species were incorporated into vegetable plantings. Both sites provisioned nesting structures to attract bees for different reasons. Nests can be purchased and come in many forms, or can be hand-made from scrap materials, such as old raspberry canes tied together. These attract bees by providing habitat. This was done at the conservation area for biodiversity enhancement. In the campus garden, they were being attracted for a monitoring project, volunteer education and garden pollination.

Approaches in Bee-Conservation: Decisions in Management. Pollinator conservation is achieved with the use of cultural controls, which target either bee-habitat or bee-forage. Bee-conservationists can choose to manage bee-habitat either via plant-cultivation, or through the introduction of nesting-structures. Pollinator conservationists also face decisions on the level of plant species, for both habitat and forage provisioning. Conservationists may use only native plant varieties or adopt a mixed-planting approach.

Plant-Species. When managing bee-habitat and forage, bee-conservationists face a choice on the level of plant-species. There is a significant difference between the plant-cultivation of the urban gardener versus that of the conservation-land workers. The purpose foreseen for the two types of land differs to some extent but in both, pollinator plantings are maintained. Mainly, the difference is that in the conservation area, non-native plant species are not welcome. The pollinator plantings in the campus garden are mainly native plant varieties but also include a few non-native species. In contrast to the approach on conservation land, non-native plants and native plants are left to coexist and are purposefully placed among vegetable plots to encourage wild pollinators. In the conservation area, plant-species are strictly native and are planted with the aim of increasing biodiversity. There, an invasive plant-species of the *Cynanchum* genus, is affecting biodiversity and continual efforts to contain it are being made. The conservationists view this plant as particularly aggressive, as it produces enormous amounts of seed, exudes chemicals from its roots to make growing conditions inhospitable for nearby plants and steals light by climbing faster than a grapevine. Commonly known as the Dog Strangling Vine plant, it is systematically weeded out (a cultural control) to make room for native plants, which benefit a much wider array of animal species. This landscape management technique is common among conservationists and appears straight-forward. It is weeding. However, at times it is applied in a way which may be less obvious. In the vignette below, I present my experience volunteering at the conservation land to elaborate further on the decisions facing practitioners carrying out landscape management for bee-conservation.

Nesting Structures. Many bees like to nest inside of plant stems, so increasing plant varieties that are preferred by bees for nesting (like raspberries) is one way to enhance their habitat. The other way of doing so, as exemplified by two conservationists (1 and 12), is through the introduction of structures suitable for nesting. These can be made from bundles of cut stems from plant varieties preferred by bees for nesting, from wood, plastic and many other materials. Interviewee 17 manages a pollinator-meadow on conservation land and is the outlier of this group because she does not provision synthetic-nests as part of her conservation practice. Her focus is providing suitable habitat and forage by diversifying native plant species. This means that she is more likely to affect bee-habitat by introducing or enhancing plant-species, than she is to give them a ready-made nest.

Landscape management in bee-pollinator conservation.

The conservation area which hosted the mason-bee nest-building workshop I attended held frequent volunteer-days. To familiarize myself with strategies in bee-pollinator conservation, I came along to one of the work-parties in a Pollinator Meadow. We were asked to rip out as many Fleabane (*Conyza canadensis*) flowers as possible, to restore the balance between the painstakingly cultivated, rarer species and more prevalent ones. The work that I was asked to do seemed counterproductive. Essentially, our job was to rip out a field of native, bee-friendly plants.

Plant diversity is important for bee-pollinator diversity. Unlike honeybees, many bee species are specialists. Different wild bees require different types of plants to sustain them. Many have very narrow forage or habitat criteria. For example, multiple bee species nest only in plant stem hollows of a certain size. What is being addressed by the act of weeding out *fleabane*, in my understanding, is the scope of species; both plant and insect. The capacity for biodiversity is increased by making space for less robust native plant species. This activity made me realize that conservation practices are based on conceptions of management which may be difficult to communicate to the public.

Treatment Technique Range in Direct-Bee Management. All eight direct-bee managers in my sample keep bee-colonies or nests for a productive apiculture. As discussed earlier, running a productive apiculture is conceptualized in different ways based on the particular aim of the beekeeper. Seven out of eight in this group manage honeybees. Although all direct-bee managers in my sample apply various controls to ensure the success of a colony or nest of bees, treatment technique range varies drastically between the seven honeybee-keepers and the one mason-bee-keeper in my sample. As seen in Table 8.3, the mason-bee keeper relies only on cultural controls, while different combinations of cultural, organic and inorganic controls are applied by the honeybee-keepers in my sample. However, this comparison is difficult to make because I interviewed only one beginner mason-bee-keeper and seven honeybee-keepers, with a wide range of experience and aims.

Table 6.6 – Direct-Bee Management Treatment Technique Overview Per Operation Type – R = 8

	Operation Type		Treatment Techniques			Hive # per operation **owned by employer*
R.	Hobby	Commercial (Position in operation)	Cultural Controls	Organic Controls	Inorganic Controls	
Honeybees						
3	Hive on organic farm for honey & pollination		Yes	Yes	No	1
5		- Apiary for bee research, education & bee-breeding (Manager) **Sells:** Bees, Honey & other bee products	Yes	Yes	Yes	300: research 60: nucleus production
7		- Research apiary (worker) - Honey-oriented apiary (Owner) **Sells:** Honey & other bee products	Yes	Yes	Yes	100 *300
14		- (Owner) Honey & conservation-oriented apiary - 'bee-rescue' service **Sells:** Honey, Ecosystem services for conservation	Yes	Yes	Yes	100
15	Organic honey-oriented apiary		Yes	Yes	No	60
16		- Honey-oriented apiary (worker) - Honey-oriented apiary (Owner)	Yes	Yes	Yes	27 *1000

		Sells: Honey & other bee products				
18		Medium-scale honey-oriented Pollination (secondary) - blueberry & pumpkin	Yes	Yes	Yes	400
Wild Bees						
11	Hand-made mason-bee nest for education		Yes	No	No	1

*R = # of respondent **Source: Author's sample interview data, 2015.

Bee-Species Managed. In my sample, direct-bee managers mobilize strategies for a productive apiculture with either honeybees or mason-bees. Mason-bees (***Osmia lignaria***) occur naturally throughout Canada but are also managed like honeybees, in artificial nests, in (comparatively) small quantities. The main service derived from them is pollination. They do not produce an excess of honey, as do honeybees. Productivity therefore, has more to do with pollination capacity than the production of bee-based products. The operation aims of commercial honeybee-keepers focus on the production and sale of bee-derived products and bee-based services. In the context of hobbyist operations, bee-derived products and services are considered the final goal. Bee-derived products include: honey, pollen, propolis and wax.

The bee-species managed affects the range of treatment techniques used. Direct-bee management of mason-bees drastically differs from honeybee colony management. I could not compare treatment techniques among multiple mason-beekeepers so I compare these practices with those of honeybee-keepers. The range of controls applied is very narrow for the mason-beekeeper (Interviewee 11) when compared to the honeybee-keepers. In terms of treatment technique range, even the most conservative of honeybee-keepers applies a wider range of controls than the mason-bee-keeper, who only uses cultural controls.

Conventional treatment techniques in honeybee-keeping involve the use of a mixture of organic, inorganic and cultural controls. Organic honeybee-keepers apply organic and cultural controls. In this paper, the term *organic* refers to the treatment techniques applied, rather than an organic certification, as this is difficult to obtain and does not necessarily preclude an organically-run operation. The honeybee-keepers in my sample are familiar with the concept of IPM and implement at least some of its strategies. A wide range of treatment techniques are applied by the direct-bee managers in my sample, many of which are used alternately or simultaneously. Direct bee managers apply different combinations of cultural, organic and inorganic controls to ensure colony success. This is true for all honeybee-keepers but not for the mason-bee keeper, who is closest to bee-conservationists in her methods because she does not apply any treatment techniques other than cultural controls.

Unlike honeybees, mason-bees do not live in large colonies. However, multiple individuals can be placed or attracted to a shared nesting location that is managed. In brief, the cultural controls that mason-bee management requires are: the introduction of cocoons into a produced or procured nest, the placement of the nest into an adequate environment (such as an orchard) in spring, the removal of the contents in autumn for overwintering in a controlled environment (such as a fridge) and a timely repetition of the process. Cultural controls for mason-beekeeping hold some similarity to those in honeybee-keeping. The nest must be placed carefully, to maximize sun exposure and minimize damage from weather conditions. The preventative management of disease through cultural controls is present in both types of direct-bee management. A new nest-lining is necessary for each ‘batch’ of mason-bees. Nesting tubes are replaced before introducing the bees into the nest to avoid the spread of pathogens between generations of bees. Analogous practices occur in honeybee-keeping, for e.g., when hive parts are replaced and tools are sterilized.

Cultural controls are ubiquitous in direct-bee management. Like the replacement of nesting-tubes, many are preventative. However, honeybee management involves a more extensive application of cultural controls. Although both forms of direct-bee management are based on cultural controls, honeybee-keepers implement other controls as well. Cultural controls often preclude their application. For instance, checking the hive regularly for disease (a cultural control) usually precludes the choice of other treatment technique measures. In mason-bee keeping cultural controls follow an unchanging time-table based on the seasons and the mason-bee lifecycle. In honeybee-keeping, a treatment schedule may be used as a guideline for checking colony needs and assessing the incidence of disease but does not exactly predict the type of treatment technique that should be used.

Decisions & Approaches in Direct-Bee-Management. Direct-bee managers are faced with decisions regarding the bee-species they want to manage and whether or not this is to be done commercially or privately. Like farmers, they also make choices relating to operation type and treatment technique choice. Direct-bee managers can certify their operation as organic, can run a conventional apiary using a mix of controls, or can keep bees using no inorganic inputs without an organic certification. Finally, they also make decisions regarding the timing of treatment applications (or the application of treatment techniques), they can medicate their bees preventatively, upon discovery of a problem or use a mix of these strategies.

Hobbyists vs. Commercial Operations. Direct-bee management practices are productive in many ways. The definition of what constitutes a productive apiculture varies between practitioners. This is related to the type of beekeeping operation to which an individual's practices contribute. Hobbyists keep bees 'for pleasure' and do not depend on them for income (3, 11 and 15). Honeybee-keepers whose livelihood is based on their bee-keeping practices generally refer to themselves as 'commercial' honeybee-keepers (five in my sample). The managerial practices of commercial honeybee-keepers are central to their business strategy and in securing their livelihood. This is not the case for hobbyist honeybee-keepers.

Organic vs. Conventional Honeybee-keeping. As in crop-farming, the division between organic and 'conventional' operations exists in honeybee-keeping. When choosing an approach for a productive apiculture, direct-bee managers are faced with the choice of applying a smaller range of organic and cultural applications or using a wider range of treatment techniques which include inorganic controls. Organic honeybee-keepers use cultural controls and organic controls, whereas 'conventional' honeybee-keepers also apply inorganic controls. This division is less pronounced than among farmers due to the relative difficulty of certifying and sustaining an organic honeybee-keeping operation. Organic honeybee-keeping is relatively rare in Ontario, and among the honeybee-keepers in my sample that use only organic controls, neither is certified. Choosing an organic approach is an option which can be economically beneficial because organic honey is rare and has a higher market value. However, relying on a narrower range of controls certainly also increases the difficulty of colony management because fewer medical options are available. This way, risk of colony losses can be greater.

Treatment Technique Choice. Interviewee 7 who works at the research facility believes that organic treatments for Varroa management are currently insufficient. The concern is the Varroa mite is so persistent, it may not be possible to manage successfully without the use of chemical applications. Only two honeybee-keepers choose to apply only organic and cultural controls. The first is the hobby beekeeper that is also an organic crop-farmer (3) and the second is a retired commercial beekeeper, who took on an organic approach after retirement (15). Beekeeper 15 applies organic products rather than inorganic ones but even so, does so very rarely. He is more in favour of using labour-intensive cultural controls in response to current bee problems and would prefer to rely on these entirely if it were possible. The latter offers a unique vantage point for discussing the difficulty of relying only on organic and cultural controls. I elaborate on this in the vignette below.

Swarm-based Management.

Honeybee pests are commonly discussed at honeybee-keeper meetings. Questions regarding Varroa control are common because it is so prevalent and destructive (hence the name Varroa destructor). At such meetings, I commonly encountered the concern that careless management of Varroa, by either excessively large or inexperienced honeybee-keepers is resulting in the cross-contamination, or exasperation of Varroa conditions in apiaries nearby. The worry is that operations which are too large save time by overmedicating hives, resulting in the resistance of the pest to the product used. On the other hand, the worry regarding inexperienced and organic beekeepers is that they are too hesitant with the application of controls, particularly chemical controls, resulting in higher parasitization rates.

I attended a beekeeping association meeting in a small Niagara-region town in 2014. After a similar complaint, beekeeper 14 challenged the view that inorganic chemicals are necessary to have a healthy honeybee population even at current Varroa levels and invited anyone who was interested to assess the health of his apiary that he managed using mostly cultural controls. He stated he only uses organic controls when necessary but rarely needs them because the cultural controls that he uses are sufficient to provide a comparable level of productivity in his apiary. This was met with a certain level of surprise, or perhaps disbelief because he was asked how this is possible. He replied that the secret to his success without the use of inorganic controls is his focus on swarm collection. This means he allows the bees to leave (or swarm) before catching them and placing them into another hive. This is done to reduce pathogen pressures. Varroa mites live on adult bees (literally sucking their blood) but can only reproduce in a sealed brood cell (the baby bee incubation cell), where it can quickly feed on its undeveloped prey. When a colony swarms, the Varroa mites cannot reproduce as there are no cells with developing bees during the flight of a swarm and for some time afterwards. Therefore, a colony naturally reduces infestation levels by moving to a new dwelling and suspending egg-laying for a short time (Loftus et al. 2016). The bee-keeper who encourages swarming through his management facilitates this process to the benefit of the bees and the bee-keeper. The bees benefit because they are healthier and the bee-keeper saves time and money, and applies fewer controls. The above discussion shows that competing strategic variants exist for keeping honeybees.

Despite the benefits of swarm-collection, the process is rather difficult and rarely encouraged. Because half the bees leave the hive during swarming, it is generally seen as disadvantageous. This is because hives with fewer bees provide less honey. The difficulty extends beyond gathering thousands of bees from a tree. It turns out that this is not the difficult part of the task, as the bees are in a docile state and completely focused on surrounding their queen and awaiting consensus on the next destination. You can literally shake them off what they are resting on and they will drop off into a box prepared underneath. The difficulty is that it is a time-consuming process, getting them to settle in a convenient spot is hard and transporting them back to a new hive can be even trickier. In conventional honeybee-keeping, beekeepers discourage the process by applying cultural controls. They pre-emptively enlarge beehives by adding hive-parts or split large colonies. Beekeeper 15 shows that strategies for bettering bee health that are contrary to managerial norms within a profession can still be successful.

Timing of Treatment Techniques. Honeybee-keepers most often apply a mix of cultural, organic and inorganic controls. They choose if they want to apply them preventatively, once a problem has been identified, or if they prefer a mixed approach. In my sample, beekeepers: 3, 7, 14 and 15 apply either organic or inorganic controls only upon diagnosis. Beekeepers 5, 16 and 18 apply them preventatively and upon diagnosis, with the latter medicating mostly on a preventative basis. Ascribing to the principles of IPM can influence the timing of medications but does not completely regulate this choice. All honeybee-keepers in my sample follow IPM guidelines to a degree. IPM prescribes the application of controls once a problem has been found, as well as product rotation, so bees or mites do not develop a resistance to any one treatment technique. The term *rotation* in this case means that if multiple attempts are being made to fight off the same pathogen within a colony, then different products are used each time.

Two beekeepers mentioned in the interview that they treat their bees preventatively for Varroa because it is so pervasive (16 and 18). Despite this apparent inconsistency, they keep to the IPM guidelines because when they treat preventatively they use formic acid, an organic medication that is “very effective and mites cannot build any resistance to it” (18). Another reason for applying preventative controls to Varroa mites is because they spread easily. As one beekeeper explains in the interview, incidence in only one hive in a bee-yard is unlikely. “If you've got an infection in a bee-yard, you need to treat all of them, because bees frequent one another’s hives [and] carry the diseases back and forth” (14). Therefore, incidence of these pathogens in one hive can impact the timing of medical treatments in the rest of a beekeeper’s hives. Another product which is reported as being applied preventatively is Oxytetracycline for American Foulbrood which is a very serious but less pervasive honeybee disease. The reasoning behind this may be similar but my data on the subject is anecdotal.

Treatment Technique Range in Research. How researchers conceptualize bee-pollinator rehabilitation varies. Some are engaged in research pertaining to honeybee management, while others focus on one or multiple wild bee-species. I divide research into two streams: honeybee and wild bee research. I present researcher treatment technique range in the following chart. Biological research is the most common discipline in my sample, with the effects of neonicotinoid pesticides being the most prevalent subject of study.

Table 6.7 - Bee-Researcher Overview – R = 6/19			
R.	**Honeybee Research**	**Wild Bee Research**	**Treatment Techniques** a.) Inorganic Controls b.) Organic Controls c.) Cultural Controls d.) Experimental Controls for Empirical Testing
2		Biology. Effects of Environmental Change on Solitary Bees - Evolutionary Ecology of plant-pollinator interactions	d
4		Biology. Impacts of Climate Change	d
5	Biology. Bee-Breeding, Honeybee-diseases		d
6	**Biology (bio-molecular).** Deformed Wing Virus from Varroa-Honeybee interactions		d
8	**Biology**. Impacts of NNis on behavior (chlothianidin)		d
9	**Veterinary -** effects of NNi exposure on honeybees		d

*R = # of respondent **Source: Author's sample interview data, 2015.

When compared to other bee-related practices, techniques in this group are most likely to be based on theoretical interest and personal concern. This is because successful bee-management is not the focus of testing. Instead, it is the contribution of knowledge relevant to pollinator rehabilitation. Bee-research involve the measurement of colony outcomes under experimental conditions. Because the practices are experimental and not prescriptive, IPM practices are not relevant to bee-researchers. As I discuss earlier, researchers are involved, more than other beekeeping communities, in the production of information for the formation of professional policy and guidelines. The goal of honeybee research is primarily to produce information relevant to honeybee-health, which will be used to better conditions for honeybees over the long-term and aid the honeybee-keepers which manage them.

The bee-researchers that I interviewed are all connected to a university. There are no practitioner restrictions on possible applications because treatment techniques are used to test theoretical knowledge. In addition to applying those techniques which have been already described, bee-researchers also apply substances which are not meant to contribute to colony success but rather, do harm. This is due to the pressing need for the testing and documentation of the harmful effects of environmental contaminants on bee health and colony success. The most common of these in my sample is the study of the effects of neonicotinoid pesticides on honeybees (three out of six participants have this focus). I categorize the treatment techniques of all bee researchers as experimental colony management for empirical testing.

Decisions and Strategies in Research. Bee-researchers can decide to study honeybee-problems, which will support the honeybee-keeping industry, or can take on a broader approach which focuses on multiple bee species or a wild bee-species. These are more in line with a conservation approach. Wild bee research usually has a broader focus because it pays attention to the larger ecosystem whereas honeybee research tends to be focused on mediating problems which limit honeybee productivity, in the economic sense. Bee-researchers also have the choice of doing observational research 'in the field' or of collecting specimens for study in a lab or a test apiary.

Bee-Species. Bee-researchers can choose to study either honeybees or wild bees. Different biological approaches are applied to their study. The study of wild bees is less common and more difficult. Two out of six researchers work with wild bees and are a decided minority, both in the sample and in the academic world. Bee-research is carried out in a research apiary and in research laboratories. Tests are conducted on individual bees or on groups of bees from honeybee colonies or wild bee nests.

Honeybees. Honeybee researchers in my sample run tests in an apiary intended specifically for research. Tests are carried out in a few different ways. Pathogenic conditions are applied to either full colonies or to individual bees. Bees are reintroduced and colonies are then observed for a predetermined time. The same can be done without the reintroduction of the bees back into the colony. Another way that testing of honeybees occurs is through the collection of specimens which are analyzed once expired.

Wild Bees. Wild bee-researchers collect data by monitoring bees in trap-nests which are subjected to experimental conditions. In my sample this includes comparing occupancy levels and development success in relation to climactic conditions. Thus, in this context, pollinator rehabilitation is conceptualized as a wider environmental problem affecting multiple wild-bee species, rather than a honeybee problem primarily affecting various agricultural sectors.

Treatment technique choice. Treatment technique choice in this group is largely dependent on the methodology of a researcher's discipline and the subject of research. This in turn, is related to the distribution of research funds, practitioner interests, concerns and beliefs. The subject of study is one factor which can be used to explain variance in treatment technique choice. As in direct-bee management, bee-species contributes to differences in treatment technique among bee-researchers. The application of controls is much harder for those studying wild bees than for those working with honeybees. This is because honeybees live in very large colonies and are easily obtained: they are widely managed by humans. A control can be applied to an entire colony or to thousands of individuals, which are readily available for the replication of results. Applying controls for wild bee research is comparatively prohibitive. Research nests are placed into attractive habitat (a cultural control) to attract cavity-nesting bees for observational or lab research (to apply controls for empirical testing). Most wild bees are solitary and collecting enough specimens for a study is challenging, particularly if they must be alive and in their natural conditions for the research design. This is complicated further, on a practical and ethical level, when the subject of study is a threatened species.

Identifying Strategic Variants for Bettering Conditions for Bees per Beekeeping Community

Bee-researchers work to better conditions for bees by creating information relevant to the pollinator problem that is then drawn on by various interest groups. This is accomplished through what I call: experimental colony management. A few different approaches fall under this designation: identifying mechanisms driving disease or health: a.) in individual honeybees, b.) in honeybee colonies, testing controls for honeybee pathogens in c.) individual honeybees, d.) honeybee colonies and, e.) wild-bees.

The farmers and direct bee managers in my sample are comparable in the range of controls applied. Both include those who avoid inorganic controls and those who use them as part of their overall strategy. The purposive reduction, and less often, the complete avoidance of inorganic controls is a strategy used by direct-bee managers, conservationists and farmers to reduce the likelihood of resistance of organisms to chemical controls (organic and inorganic) and to reduce the negative impacts such products may have on bees, crops or biodiversity in general.

Farmers can better conditions for bees, by: a) restricting the use of synthetic inputs (inorganic controls), b) exclusively relying on cultural and organic controls, c) applying labour intensive landscape management practices (cultural controls), d) cultivating native plants with a focus on crop-diversification for sustaining local wildlife habitats, including wild-pollinator-habitat, and e) keeping fallows or marginal lands.

Direct-bee managers are most concerned with creating better conditions for bees that they keep. In my sample, they do so by implementing various managerial strategies for either honeybees or mason-bees. The mason-beekeeper applies cultural controls to reduce the incidence of pathogens but also sees her practice as a contributor to wild bee conservation. The honeybee-keepers do so by: a.) implementing a strategic mix of cultural, inorganic and organic controls, informed by integrated pest management, b.) by restricting synthetic controls in favour of organic and cultural controls, c.) by eliminating the use of synthetic inputs (inorganic controls) altogether, and d.) by focusing on labour-intensive management practices (cultural controls).

Bee-pollinator conservation workers meet the needs of wild-pollinators by modifying bee-habitat and forage for wild-bees. The treatment techniques of bee-conservationists are narrowest in range and vary the least when compared to other groups. Their strategies include: increasing plant diversity with: a.) a focus on providing bee-forage, b.) a focus on providing bee-habitat, c.) restricting non-native plant-species, d.) restricting the range of overly robust native plant species and the e.) introduction of synthetic nesting structures.

Human-Relationships Beekeeping Community Overlap

The strategies that practitioners from different beekeeping communities apply are indicative of the human-bee relationship they occupy and of their positionality within that relationship. Here, I present the kinds of interspecies sociality that I have found within my sample per beekeeper type. I address the importance of categorical outliers and cross-over at the end of each section that follows.

Farmers and Bees. Farmers interact with bees in multiple ways and thus, enter different human-bee relationships. Through plant-cultivation, crop-farmers affect the availability of bee-resources within their working environment. The human-bee relationship between bees and crop-farmers places practitioners in a position of indirect bee-resource stewardship. I term this an 'indirect stewardship' because bee-resources are being managed, not the bees themselves. Further, these practices are often non-purposive.

Non Purposive. The management of bee-resources is rarely the goal of farming, the relationship being largely a by-product of the work, rather than a purposive action intrinsic to crop-farming. In this relationship, local bee populations form an invisible ecosystem service force (via pollination) which is productively involved in securing the practitioner's livelihood. However, the farmers in my sample do not necessarily produce crops which need bee-pollination to propagate, but which increase in yield from this process.

Purposive. One of the farmers did cross over into purposive bee management, being a conscious and active steward of pollinator resources, while simultaneously running a productive agricultural operation. This was the native tree and shrub farmer, whose focus is the cultivation of plants which are beneficial to wild pollinators. Food-crop farmers differed from the native plant farmer in their relationship to bees. As expected, the food-based operations are more honeybee-oriented than their native-plant based counterpart and mobilize comparatively fewer strategies purposively aimed at bettering bee health. The native plant farm capitalizes on the relationship between naturally occurring ecosystem services (wild-bee pollination) and native-plant success. The food-crop farms keep honeybees for pollination, enabling a better crop-yield. Both rely on the ecosystem services of wild bee communities to some extent but the native plant farmer actively focuses on ameliorating conditions for them, is highly aware of the problems they face and of their importance. The food-crop farmers view the pollinator problem mostly as a honeybee problem. Farmers contribute to the health of both honeybees and wild bees by limiting or completely avoiding inorganic treatment techniques in their landscape management practices.

The presence of honeybees on cash-crop farms and not on the native-tree-farm points to a different relationship between bees and different farming types. The single-cropping farmers are most concerned about the effects of inorganic controls, particularly of neonicotinoids on honeybees. The tree-farmer is more concerned about habitat degradation in general and the focus of researchers and the public on honeybees. The difference on the level of risk between the diversified tree-farmer and the single-cropping farmers may help to explain why this is the case.

Single-cropping style farmers face greater risk because they produce fewer crop-species in larger amounts. Honeybees are often used to ensure pollination because they are easy to place where needed and are generalists. They are used as a buffer against inadequate ecosystem services from local pollinators. This makes sense because few food-crop plants are native and are usually grown in large uniform swaths. Native bees have co-evolved with native plants, are best at pollinating wild plants and are less likely to be able to have the capacity to provide adequate pollination. Single-cropping fragments wild bee-pollinator habitat. An organic buckwheat field may provide plentiful forage for wild bees but does not provide habitat; which results in overall lower wild-pollination rates, because the nesting habitat available to bees is restricted to the perimeter of the field (Jha and Vandermeer (2010). Not surprisingly, if the landscape management practices involved in the cultivation of a crop are not conducive to native-bees (such as intensive tilling), then fewer of them will be present in that area, and therefore their ecosystem services will be more spread out. For the tree-crop farmer, this risk is not perceived because he relies on native-plant-production which both supports and necessitates a variety of bee-pollinators already in the area. His style of plant-cultivation (largely in containers) reduces disturbance to wild-bee habitat, which is usually underground or in plant hollows. This is evident because his approach does not require soil disturbance on any significant scale; he does not use a tractor or horse for tilling or disking. For this reason, a greater density of wild bees is likely to be available to the practitioner who holds this relationship, reducing a perceived need for a buffer.

Outliers & Cross-over:

Farming & Direct-bee management. Some of the farmers also interact with bees by renting, owning or otherwise keeping honeybee colonies on their land. Some even maintain their own honeybee hives, therefore crossing over into direct bee management as a supplementary beekeeping practice, which is carried out to improve crop yield and honey-production. In this relationship, honeybees are rented or otherwise purchased and kept by the farmers. The bees in this relationship form a buffer against natural ecosystem service deficiencies, securing pollination services which improve the productivity of the agricultural operation. In my opinion, the ecosystem service wild pollinators provide goes virtually unnoticed. In my sample, cash-crop farmers share many concerns with honeybee-keepers, who can also be differentiated in terms of organic or conventional treatment techniques.

Farming and Bee-conservation. There is some overlap evident between the native-tree farmer (10) and conservationists. Mainly, their shared focus on native plant varieties and native-bee species. This suggests that there is some alignment in terms of approach. Farmers interact with bee habitat and resources, influencing bee outcomes. Further, the position of farmers makes them able to mobilize strategies which are productive both in terms of agriculture and bee-conservation. This shows that agricultural goals can align with those in bee-conservation, which is an important consideration for bee-conservationists. Further research is needed into the ways farmers can contribute to bee health positively, on an ecosystem level. The reduction or complete avoidance of inorganic controls is one approach to crop-farming which targets crop-health but interacts with both wild and managed bee populations, usually non-purposively. As discussed in the literature review, neonicotinoid exposure is a significant stressor to both wild and managed bees and has received much attention within the academic community (OMAFRA 2014). Therefore, both direct-bee managers and bee-conservationists have an interest in developing farming strategies which reduce chemical applications in favour of cultural controls, when possible.

Direct-Bee Managers and Bees

The human-bee relationship between direct-bee-managers and bees generally places practitioners in the position of care-giver and puts bees in the position of agricultural livestock. Much of direct-bee management involves the application of controls to fight off the Varroa mite – a ubiquitous honeybee parasite.

Non Purposive. Direct-bee managers affect honeybees purposively but their practices also interact with wild bee species and this interaction is not purposive. Honeybee-keepers in my sample were largely unaware of their effects on wild-bees and the relationship between managed and unmanaged bee success is rarely approached in the literature.

Purposive. Purposive beekeeping strategies by direct-bee managers are carried out on managed bees on the colony level. In my sample, these were predominantly honeybees but also included mason-bees. Whether a direct-bee manager derives his or her livelihood from their practices is relevant to treatment technique choice and affects the human-bee relationship. Both hobbyist honeybee-keepers in my sample apply only cultural and organic controls, whereas commercial beekeepers also apply inorganic controls. This difference does not mean that all hobbyists avoid inorganic techniques. In my opinion, it suggests a difference in relationship between hobby beekeepers and their bees and commercial beekeepers and their bees.

Beekeeper 15 hints at this in his interview. He explains that he switched to more intensive practices after retiring from commercial beekeeping because now, he has more time. With more time to spend on each hive, he moved away from inorganic controls and focused on swarm-based management. The risk associated with a move to less conventional methods was greatly diminished once he became a hobbyist because he did not have to depend on the income derived from the hives. Beekeeping based on swarm-collection shifts the focus of managerial practices away from hive expansion and the maximization of honey-production per hive to one which is perhaps, less viable commercially but also reduces bee- stressors. Therefore, honeybee-keepers face the choice of intensifying cultural control management practices (such as swarm-collection), which limit honey production but also limit the need for organic and inorganic controls, or can choose to save time and produce more honey by applying organic and inorganic controls on a regular basis. The first approach may reduce stress on honeybees because fewer medicinal products are applied and pathogens are curtailed, naturally. In the second approach, the advantage is that economic risk is actively mediated through the application of a wider range of treatment techniques. The human is placed in the role of livestock stewardship in both relationships but in one approach the practitioner encourages natural biological processes by applying more labour-intensive treatment techniques. In the other, the practitioner discourages the swarming behaviour in honeybees which functions as a natural defense mechanism against Varroa, in favour of technically advanced chemical treatments.

Outliers & Cross-over. Swarm-collection is rarely used as a treatment technique in honeybee-keeping in Ontario. It is not a hallmark of hobbyist or organic honeybee management. Aside from the swarm-management based organic honeybee-keeper, one other honeybee-keeper also collected swarms, though for different reasons. Although honeybee-keeper 14 does not usually allow his bees to swarm, swarm-collection is a significant practice for him for reasons other than pathogen control. He is part of a ‘bee-rescue’ program which responds to city-level worker complaints and simultaneously encourages the development of the honeybee-keeping profession among interested youth. When cultural controls are not applied to a beehive in time, they swarm and escape the bee-yard and often end up clumped in public places; on their search for a new nesting location. The role of the bee-rescue is to receive complaints (usually driven by worry for public safety) and to remove the traveling colonies. The beekeeper monitors swarm-collection by volunteering youth, who benefit from the practical experience and gain free bees for management. This places the honeybee-keeper in a position which is part livestock stewardship and part ecosystem stewardship.

Direct-Bee Management & Conservation. The honeybee-keeper who runs the bee-rescue program catches swarms which have escaped from other honeybee-keepers and which are on their way to becoming feral. Because they are non-native, honeybees are considered invasive. However, their capacity to live in the wild is also lessening over time, particularly due to pathogenic pressures. According to interviewees, feral colonies of honeybees were once much more common in Ontario but due to selective breeding, Varroa, and other stressors, they have lost the ability to fend for themselves in a non-managed setting. This has resulted in the perception that there are fewer feral (and invasive) honeybee colonies in Ontario than a few decades ago. From the bee-conservationists point of view, when honeybee-keepers ‘rescue’ honeybees from ‘the wild’ they are acting as ecosystem stewards by helping to prevent the disruption of natural ecosystems through the removal and management of an invasive species.

For the honeybee-keeper, this action is non-purposive - simply an extension of livestock management, which prevents livestock loss, damage, etc. However, the role of honeybee-keepers within conservation can be much greater. The same beekeeper who runs the bee rescue also owns a conservation agency, which is neither honeybee nor wild-bee centered but rather, caters to conservation initiatives in a much broader sense. Although his is similar to other commercial honeybee-keeping operations, he uses his honeybees for a broader range of purposes than other honeybee-keepers that I interviewed. As a honeybee-keeper interested in conservation, he purposively works on the ecosystem level to better bird health. He rented out one of his honeybee-hives to support the bird community within a conservation area. As is done for agricultural pollination, the honeybee-hive was rented by an interested party and transported onsite to provide an ecosystem service. This is the one case however, where the ecosystem service provided by honeybees was not pollination. In this case the beekeeper used his bees to secure feed for birds. The reason the bees were rented in the first place was because the birds were found to be dying in large numbers from starvation in the period leading up to the first hatch of mosquitos. The practices of this honeybee-keeper who is definitely an outlier, show that the relationship between direct-bee managers and bees does not have to be purely extractive, it can be conservation-oriented.

The possible role of direct-bee managers in bee conservation more specifically, is even clearer when we consider that the mason-bee keeper began her beekeeping practice with native bee conservation in mind and only after consulting with a conservationists that the bee species Osmia *lignaria* is indeed native to the area. Her goal was not to produce honey or to pollinate a garden but rather, it was to: a.) teach her grandchildren about the importance of bees, particularly native bees and, b.) to contribute to the population size of wild bees of this species. The linking of beekeeping practices with conservation practice by both a honeybee-keeper and mason-bee-keeper suggests that there is continuity behind the basic motivations for managing both species.

Bee-Conservationists and Bees

The human-bee relationship between bees and practitioners of this subcategory places conservationists in a position of bee-resource stewardship. In this relationship, bees become the object of conservation and their life outcomes are impacted by the availability of resources which are in turn, mediated by the landscape management practices of conservationists.

Non Purposive. A secondary human-bee relationship exists between bee-conservationists and managed bees. They are involved in the non-purposive management of honeybees by affecting the forage available to them. I characterize their practices as indirect management as they interact with bee resources and not bees themselves.

Purposive. The actions of bee-conservationists are purposive in terms of helping wild-bees but bee health is ameliorated indirectly, by working with bee-resources. Plantings are chosen based on attractiveness and usefulness to wild pollinators. When pollinator plantings are incorporated into a food garden, bee-conservationists become stewards of bee-resources but also are involved in the securing of resources for people. Wild bees are attracted into the garden by the provisioning of habitat, which in turn safeguards wild pollination services for the gardener.

Outliers & Cross-over. One conservationist (1) was less conservative than the others in terms of plant choice and this was likely influenced by the location of the plantings, as the other two conservationists worked on conservation land, regulated by organizational policy. This shows that practitioners can implement certain conservation-measures in a variety of settings. The bee-resource stewardship role of conservationists is not restricted to protected areas. They can be mobilized on private or public lands as well.

Bee Conservation & Bee Research. During my time volunteering at the conservation area and in the campus garden, I realized that bee conservationists can contribute to wild-bee-research. Trap-nests were installed in the conservation area and the campus garden by bee-researchers for monitoring purposes. Because of the difficulty involved in gaining wild bees for research, conservationists who attract bees but do not manage them otherwise are an invaluable resource to wild bee researchers.

Bee-Researchers and Bees

The human-bee relationship between bee-researchers and bees places practitioners in the position of tester and bees in the position of test-subjects which are often sacrificed in the process of scientific analysis. This relationship is extractive as the testing of bees is not immediately beneficial to bee health and researchers gain theoretical knowledge, academic prestige, etc. Bee-researchers contribute to bee management and bee health in the long-term through the knowledge that they produce, which is relevant to the pollinator problem.

Non Purposive. Non-purposive strategies to better bee-health are not significant within this group. Bee-research is highly purposive in terms of having the aim of bettering bee health, however it is less so than the activities of direct-bee managers, who depend on good bee health for the success of their operation.

Purposive. Because bee-research explicitly aims to better bee health, I consider their practices purposive. These strategies however, are long-term and aim to inform bee-management and conservation policy rather than to secure bee-health quickly and consistently.

Outliers & Cross-over. Another human-bee relationship is evident among a few of the researchers at the honeybee facility. At times, research necessitates researchers to also function as direct-bee managers. Although they do not keep their own colonies, they help in tasks common to direct-bee management to carry out their research. For e.g., some research involves the observation of bee behaviour within a 'normal' colony setting. This requires certain skills typical in direct-bee management, such as opening a hive and handling bees. Most of the honeybee researchers that I interviewed first opened a hive only once their research was underway, making for a very daunting research design.

The two wild-bee researchers were the decided outliers within their beekeeping community. Due to bee-species studied, trap-nests are used to attract bees for research. Bee-researchers who do not study wild bees are evidently unlikely to cross-over into honeybee management, unlike the honeybee researchers, who need a supply of managed bees. Because we do not know how or if the bee-species that they study can be managed, they depend on choosing a nesting location which is attractive to the species of interest. Wild-bee researchers differ in their relationship to bees in comparison to honeybee researchers because the latter works to secure agricultural pollination in the long-run, while the former enquires into factors relevant to wild ecosystem services. Further, honeybee-research is an accomplice in the management of bees solely for research purposes and depends on direct-bee managers for this reason. Wild-bee researchers simply cannot contribute to the growth of bee populations for research purposes in the same way that honeybee researchers and keepers can. Their relationship is dependent on the conservation of wild bee species for their study. Ultimately, they must work with what is available naturally within the ecosystem and therefore, hold a different relationship to bees.

Summary –

Bee-researchers and direct-bee managers interact with bee-colonies in a stewardship role. Professional direct-bee managers actively seek to better bee health to make a living. Bee-researchers actively work to better bee health but unlike honeybee-keepers, do not rely on sustaining conditions for optimal honeybee health as a basis for their livelihood. Researchers need to sustain healthy bee colonies but only prior to research, if the experimental design calls for the application of pathogenic conditions. Short-term colony success is not the goal of bee-research, however practitioners are directly invested in the furthering of knowledge which will ultimately contribute to the bettering of conditions for bees in the long term, once it has been disseminated to the public and beekeepers. Although, the farmer's aim of running a productive agriculture is not shared by conservationists who actively target bees through their practices, both are stewards of bee-habitats and forage, as they interact with them on the ecosystem level.

The human-bee relationship that we occupy helps to determine the range of treatment techniques we have at our disposal to affect bee success. Professional affiliation holds a certain level of explanatory power for determining practitioner approach and even conceptualization of the pollinator problem. Overlap exists in terms of approaches taken by members of differing beekeeping communities. For e.g., both farmers and honeybee-keepers expressed that a less chemically intensive managerial approach is beneficial for bees. This points to possible avenues for future collaboration on the subject of bee rehabilitation in the widest sense. It is vital to treat key stakeholders in the pollinator problem as allies because they are intimately implicated in the situation of bee-pollinators and possess specialized knowledge which must be shared if a socially and ecologically sustainable way forward is to be found. In the next and final chapter, I present a summary of approaches and my findings regarding the human-bee relationships occupied by practitioners.

Chapter VII

Human-Bee Relations in South-eastern Ontario

One of the primary aims of my research, was to explore the knowledge systems which support the practices of the various beekeepers in my sample. Identifying interactions between beekeepers has helped me understand the role knowledge networks play in beekeeping communities. Knowledge systems interact but also are rooted in human practices which support specific professions and communities. As a result, information relevant to the pollinator problem is specialized and rarely broadly applicable. For example, there is disconnect between honeybee and wild bee conservation knowledge production. Factions within beekeeping communities form causing different knowledge systems to interact less often and lack connectivity. In other cases, there is a surprising amount of connectivity between knowledge systems, with networking occurring more between different beekeeping communities. For example, honeybee-keepers interacted more with farmers than with direct-bee managers of other bee-species. Honeybee researchers worked more closely with honeybee keepers than with wild bee researchers or bee conservationists. The lack of communication between those who work to help honeybees and the others who take on a broader conservation approach (focusing on multiple wild bee species) is very clear. It is also dangerous, as this only serves to reinforce an unbalanced consideration of the elements which contribute to bee-pollinator health.

I believe that it is very important to consider the viewpoints of all major stakeholders in the pollinator problem to create a productive conversation. Addressing the strengths and weaknesses of each relevant community rather than vilifying or glorifying any one of them is far more productive a task for bee-conservation in broad terms. Outliers helped me to explain some of the overlap between bee-related communities. Highlighting continuity between approaches among different beekeeping communities proved salient for conceptualizing possible avenues for collaboration between stakeholders in terms of broader bee-conservation, which considers both managed and unmanaged bee species.

In this study I have aimed to gain insight into the positionality of beekeepers, particularly in terms of their capacity to better conditions for bees. I have included purposive and non-purposive bee-friendly practices which benefit bee health to enable a comparison of strategies across beekeeping communities. Despite the difficulty of drawing broad conclusions from such a small and self-selected sample, differences in beekeeper perspectives and capacities in relation to the pollinator problem are evident. Generally, participation in a beekeeping community, as I define in the Methodology section, can help to define the probable range of practices applied by a beekeeper. The analysis of strategic variants for practitioners approaching the pollinator problem has led me to understand however, that practices can differ greatly within a beekeeping community. This is clear when one considers the outlying practices which I identified for each community. In the chart below, I offer a summary of the conventional and outlying strategies applied by beekeepers in my sample. I purposefully divided beekeepers into groups prior to analysis, to gain insight into the driving factors behind the assemblage of key stakeholders.

Table 7.1 –Beekeeper Strategies for Ameliorating Bee-Health

		Colony level		**Ecosystem Level**	
Strategies for:		**Experimental Colony Management - Bee-Research**	**Colony Management - Direct-Bee Management?**	**Landscape Management - Farming**	**Landscape Management - Conservation**
Wild bees		Identifying mechanisms driving wild-bee disease or health -in individual bees -in groups (families or aggregations)		-the cultivation of native plant-species to provide bee-habitat and forage. - the reduction of pesticide use - increasing the amount of marginal, unmanaged lands -the avoidance of heavy mechanization	-increasing plant diversity with a focus on providing forage for wild bees -restricting non-native plant species -introducing synthetic nesting structures. -increasing plant diversity with a focus on providing bee-habitat
Managed bees	**Mason-Bees**		applying cultural controls to reduce the incidence of pathogens in managed bees		- native bee management to support population growth
	Honey-bees	Identifying mechanisms driving honeybee disease or health -in individual bees -within honeybee colonies Testing controls for honeybee pathogens -on individual honeybees - within colonies	-implementing a strategic mix of cultural, inorganic and organic controls, informed by integrated pest management to honeybee colonies -restricting synthetic controls in favour of organic and cultural controls in honeybee management -eliminating the use of synthetic inputs (inorganic controls) altogether in honeybee colonies -intensifying labour-intensive colony management practices (cultural controls)	-restricting the use of synthetic inputs (inorganic controls) -relying exclusively on cultural and organic controls, -applying labour intensive landscape management practices (cultural controls) -cultivating native plants with a focus on crop-diversification for sustaining local wildlife habitats, including wild-pollinator-habitat.	**-**Bee rescue and management of escaped honeybees -the application of honeybees as food to local native (bird) species

*Source: Author's sample interview data,
2015.

Analyzing beekeeper strategies brought multiple and distinct human-bee relationships to my attention. I found that affiliation with a beekeeping community (farming, bee-conservation, bee-research & direct bee management) does indeed affect the range of human-relationships entered by a practitioner. It is natural that commercial honeybee-keepers work with bees differently than conservation area workers. However, professional affiliation has greater explanatory power in terms of human-bee relationship. The commercial honeybee-keeper in my sample who tends to a thousand hives decidedly varies in her relationship to bees in comparison to the hobbyist beekeepers.

My original classification of practitioners as belonging to groups was made with the assumption that their relationship to bees is fundamentally different because of the varying type of managerial practices in which they engage. However, as already mentioned, outliers were present in each community, which points to differences in strategic approach within beekeeper categories and some overlap between beekeeper types as well. Analysis revealed that beekeeping communities are fluid, interact and often collaborate on a professional basis. Because beekeepers from various backgrounds interact with each other to support a broader web of socio-ecological processes (such as the availability of pollination), their beekeeping strategies are best conceptualized in terms of a continuum of specialized practices targeting bee-health. These affect bees either on the ecosystem or on the colony-level. Finally, not all members of the same profession apply the same controls to manage bees. This makes it possible for strategies to differ within beekeeping communities and for commonalities to exist between them. For instance, the farming and direct bee-management communities both contain members which run organic operations.

Summary of Findings

Ecosystem vs. Colony-Level Strategies. The bee management strategies I have discussed are based on human-bee relationships which range from *indirect* to *direct*. Practitioners manipulate factors which secure bee health *indirectly*, on the ecosystem level, by manipulating bee forage and habitat. Practitioners can also work *directly* with bees – on the colony-level, to help secure bee-success through research or direct-bee management. The above range of strategies can also be described in terms of purposive and non-purposive action. All beekeepers fall on a scale of purposive or non-purposive action. Although I term all interviewees beekeepers due to their sustained relationship with bee populations, some actively seek to affect bee-health through their practices, while others do not. Thus, both purposive and non-purposive action can be seen as relevant to bee health.

Purposive vs. Non-Purposive Strategies. Each beekeeping community that I examined contains members who mobilize strategies purposively for ameliorating bee health. I found that approaches to ameliorating bee health are rooted in human-bee relationships, forms of multi-species sociality, which involve different levels of interaction with bees on the part of practitioners. Some beekeepers affect bee health unintentionally through treatment technique choice. For example, most farming practices affect bees without seeking to do so and do so differently depending on whether they apply organic or inorganic crop treatments. Due to the land-stewardship role of the practitioner, plant diversity and thus, bee-forage and habitat is affected through their landscape management practices. Bee or pollinator-conservationists, on the other hand, are purposive stewards of bee resources, affecting wild bee health on the ecosystem level. This is also true for the larger conservation community because like bee-conservationists, they share the goal of increasing biodiversity with a focus on native plants and animals.

Findings per Beekeeping Community:

Farmers engage in both purposive and non-purposive beekeeping practices. They affect the bee-resources available to managed and wild bees indirectly, through landscape management. Their purposive beekeeping strategies involve the cultivation of native plant varieties. Non-purposive beekeeping strategies include the reduction of chemically-intensive crop management.

Direct-bee managers are involved directly in the securing of bee-health through colony-level stewardship. They hold a position unlike any other beekeeping community because the success of their practice depends on the health of their bees. Predominantly, these are honeybees. Honeybees are often kept on farmland. Honeybee-keeping thus, supports agriculture via managed pollination services which are monetized or not. Honeybee-keeping also supports honeybee research through the provisioning of test-insects and colonies.

Bee conservationists only work on the ecosystem level, encouraging the biodiversity of plant and animal systems. Their actions affect all bee populations but focus on securing habitat and forage for wild bee-pollinators. Through the securing of wild-bee-resources conservationists ensure the success of wild bee populations. The wild bees they support provide a non-monetized ecosystem service, as they contribute to crop-pollination. Through the enhancement of pollinator plantings, they also contribute to the forage available to honeybees and this is largely non-purposive. Thus, conservationists can be seen as providing a service to direct-bee managers and farmers through their plant management practices.

Bee-researchers work on the colony level. Their practices are purposive and are directly involved in securing the health of bee-pollinators because they work with bee colonies and individual bees. However, they are less involved in securing bee-health than direct-bee managers, who are dependent on bee-success for their livelihood. They are also in a unique position of influence in relation to the other beekeeping communities because they produce information relevant to each of them. All other beekeeping communities draw on research findings when they access prescriptive materials.

Beekeeper Agency & Future Avenues for Bettering the Human-Bee Relationship

Through the analysis of beekeeper practices, concerns and beliefs, I reached a synthesis of beekeeping strategies based on a sample of practitioners who were small but actually quite varied. This led me to explore a broad continuum of human-bee relationships which make up the larger agro-ecological system. I explored the human's role in these relationships, which differed in terms of direct and indirect beekeeping strategies applied either purposively, or without the knowledge of the practitioner. Therefore, multiple and sometimes competing goals motivate practices which affect bee success. I focused on the agency of the beekeeper, rather than on broad and persistent anthropogenic factors, such as NNis, which I can do little about on any meaningful scale. I realized that purposive as well as non-purposive practices affect bee health and so both must be better understood before effective mediating action can be taken to better the situation of bees.

Bee-researchers have the power to influence all other beekeeping communities because they contribute to the production of prescriptive literature. Bee-research needs to broaden in scope to include considerations of the relationship between honeybee management and wild bee success if future prescriptive materials are to contribute to the sustainability of honeybee-keeping as an industry but also within the wider ecology. Otherwise, it will continue to miss the complexity of bee-pollinator issues. Honeybee health is inextricably linked to the health and biodiversity of the agro-ecological systems within which they live. Ecologists and wild-bee researchers understand this to be the case for both managed and unmanaged bees but avoid talking about the possible role of honeybee-keepers within broader bee-conservation, even though both groups purposively work to better conditions for bees. There seems to be a divide between honeybee and wild bee researchers, where two clearly interlinked fields continue to remain separate (in terms of community interaction and knowledge exchange) despite a shared concern about bee-health. Because honeybees are non-native and function largely within highly cultivated landscapes they tend to escape the attention of conservationists, who do not consider them a 'natural' or even beneficial part of the landscape. In fact, some conservationists would not consider the honeybee an animal worth saving within the Canadian context, as it is non-native, supports mono-cultural intensification and likely has some negative impact on wild bee populations, which are comparably minuscule. Honeybee-keepers and farmers on the contrary, consider honeybee services as fundamental to agriculture and tend not to know about the important role of wild pollinators, to both crop-pollination and broader ecosystem pollination. Keeping one eye closed to the role of managed pollinators while trying to save wild bees cannot be fruitful because honeybees are an unavoidable reality of our current agricultural system. On the other hand, focusing on honeybee health only is also misguided in my opinion. It is an absurdity to place all bets on one bee-pollinator species at the expense of the conservation of all others, which may be needed in the future, were anything to happen to honeybees in Canada. The production of locally-bred honeybee queens is one way honeybee-keepers are hoping to secure honeybee success and increase industry resiliency in Ontario. Further research is needed into the effects of our reliance on imported queens. The development of local queen production is certainly a step in the right direction as it would curtail the distribution of diseases and increase honeybee resistance to stressors which are most relevant locally. It also begs the question whether other bees that are already locally-adapted would be able to support pollination needs. This of course, increasingly seems likely, as researchers are pointing to the significant role of wild pollinators in crop-pollination and more bee-species become available commercially. As mentioned before, other bee-species are currently managed for crop and orchard pollination (bumblebees and mason-bees, respectively) but significant issues have already arisen along with their management. In Canada, managed bumblebees are non-native and have invaded many agricultural areas, outcompeting local bumblebee species and spreading disease (Xerces Society 2011). This is a concern mainly for conservationists, who worry that the improper management of non-native species can negatively affect ecosystem diversity through the introduction of invasive species and pathogen exchange. The use of alternative bee species for pollination has gained the attention of farmers, particularly those in greenhouse production. This shows that farmers are open to working with multiple kinds of bees as long as they increase the productivity of their operation. It also shows that farmers are somewhat limited in terms of what bee conservation strategies they can incorporate into their managerial approach because they depend on the products available to the farming industry and on the success of their crop, and are not significantly invested in securing the health of the bees that they rent. However, there is significant potential for this relationship to be leveraged as certain practices which contribute to operational productivity and profitability are good for both wild and managed bees. Approaches which favour the use of cultural controls in farming over chemical controls better conditions for bees by reducing bee-stressors. A greater focus on cultural controls in honeybee-keeping can benefit honeybee health. Aside from bee-research, all beekeeping communities share the use of cultural controls and arguably, all can be achieved using only cultural controls through the intensification of labour-intensive inputs. This commonality should gain greater interest from bee conservationists, who champion this approach.

Conclusions

In my thesis, I looked at interview responses to identify a few of the ways that people in south-eastern Ontario work to ameliorate conditions for bees. My approach highlighted that beekeeping practices are mobilized by people from multiple communities and points to the importance of collaboration between them. I aimed to widen the definition of beekeeping and sought to inform this decision by placing just as much importance on practices in honeybee management as in wild-bee conservation. I made this decision to directly address the informational bias in the literature, which favours biological explanations of managed honey-bee problems, as well as the (honeybee-) bias in my own experience coming into the study.

At the beginning, I had a moderate knowledge of honeybee keeping practices and their associated issues but like most people, had almost no understanding of how these related to the wild-habitat conservation measures, or to the organizational structures in place for beekeepers. This has greatly changed. However, talking to beekeepers has made me realize that I had not been alone in my generally vague and one-sided understanding of the pollinator problem. There is a lot to know about bees, especially if one is trying to understand how they fit into a broader agro-ecological system. Conceptualizations of bees are ultimately based on ideas created within particular historical contexts and are often more telling of social than biological conditions. Interpretations of the problem vary according to personal interest, experience and profession. My own participation in beekeeper practices helped me to realize this.

When I was a new honeybee-keeper, I worried about CCD. When I got some experience, I was more worried about Varroa management and other common honeybee pests. When I was gifted managed native bees (*Osmia lignaria*), I became aware of the wasp and other predatory insect parasitization that sometimes occurs after the bees have completed laying their eggs in a nesting-tube. It was while learning this new practice also, that I wondered if a native bee species was perhaps a better option for managed pollination. When I tried to attract native bees into nests I had more luck on an urban campus than on a farm and realized that agricultural landscapes are not necessarily easier for bees to inhabit. This also led me to reconsider the conditions facing honeybees, as well as the possibility that current agricultural patterns would make it exceedingly difficult for farmers to support a switch to native bee-based pollination services.

When I participated in pollinator conservation work, I began to question the usefulness of artificial nesting structures, which attract many pollinators to the same spot, making them easier to reach by birds and parasitic wasps. Upon participating in wild bee monitoring and research, I realized that artificial nesting structures vary greatly and that some have disposable liners to curtail pathogen exchange from year to year. Finally, after speaking with different farmers, I found that they range greatly in terms of what they know about bees and do for them. Just as I was most aware of honeybee stressors as a novice honeybee-keeper, farmers were most aware of agricultural stressors affecting bee health. Further, because they interacted regularly with honeybee-keepers, their conceptualization of the pollinator problem tended to focus on honeybee health. The above realizations highlighted for me, the incredible importance of professional collaboration for approaching the pollinator problem. Our social history in general and our specific experiences influence how we see our relationship to bees. On a personal level, we can endeavor to have new learning experiences and to consider viewpoints which differ from our own. On an academic level, there is still much to learn about the entire scope of our human relationship to bees, bee-health and by extension, to the success of broader agro-ecological systems.

Approaching the pollinator problem through a social-ecological perspective has shown that different actor groups (beekeeper communities) tend to receive, utilize and disseminate different sets of information, depending on their positioning within that system. Positioning also affects if actors are aware of their impact on bee success and the resilience of human-bee systems. Further, depending on this positioning, stakeholders in the pollinator problem have a varying degree of control over (a.) the information they can access and over (b.) the kinds of strategies available to them for mediating bee-issues. A social-ecological approach allows us to better understand how various parts of the 'components' of a system (i.e. – the four beekeeper subcategories, the regulating institutions such as OMAFRA, wild and managed bees) and how they interact, if at all. This approach also gives us a better picture of the emergent properties of a system, resulting from these internal (and also external) dynamics. For instance, a consideration of how information about bee issues is made, by whom and for what ends allows us to better understand why the pollinator problem has been framed as predominantly a honeybee and honeybee-keeper problem. Analyzing competing and co-existing perspectives of bee issues, how they are linked to professional affiliation and how they can change allows us to see multiple alternatives to current bee problems rooted in human practice. Likewise, understanding how various humans value various species of bees takes us beyond narrow toxicological studies on honeybees or economically-oriented analyses' meant to guide policy formation for the honeybee industry. These perspectives, thus allowed me to contextualize the pollinator problem within the larger, more diverse social context of beekeeper practices which contribute to bee health.

Dimensions used for assessing the sustainability of social-ecological systems proved to be very salient to my study and helped me theorize dynamic subsets of relationships between beekeepers and bees within the larger systems they co-constitute. This perspective drew my attention to the dynamic relationship between beekeepers, bees and bee populations. Those who interact with bees on the ecosystem and colony level, regardless of their conceptualization of this relationship play an important stewardship role with human-bee systems.

My analysis of the types of practices applied by different beekeeper communities led me to better understand that different modes of learning are involved in the production of managerial knowledge concerning bees and that in reality, mods of learning were different for different purposes. For instance, keeping bees for research is less likely to involve the application of experience-based knowledge to research design, whereas mentorship is central to the development of those individuals involved in direct-bee management outside the realm of research. I also found that changes in operation type or size can strengthen or weaken mechanisms which generate innovation, as was the case of the recently retired, swarm-based honeybee-keeper. Finally, I tried to capture trends in connectivity between information and groups of people and found that information about honeybees reached more communities than did information about the status or management of other bee species, whereas alternative broader ecological approaches to bee-pollinator management remain on the sidelines.

My utilization of elements from multiple perspective underlines the vastness of the task facing social scientists approaching environmental problems holistically, through social-ecological systems. Integrating these allowed me to capture some of the dynamism and diversity within such complex systems. While the small-scale scope and time frame of my study did not allow me to focus specifically on 'sustainable development' as do Ostrom and Holling (2001), my study does begin to develop integrative avenues for future sustainability-oriented studies of agro-ecosystems, which center on understanding how different users perceive and act within larger systems to ultimately contribute to the goal of fostering adaptive capabilities and creating opportunities for more sustainable forms of interaction with pollinators, all of which are crucial to the functioning of broader socio-economic and social-ecological systems.

Appendix 1

Example of a Prescriptive Text for Beekeepers

Integrated Pest Management Options for Corn (PDF)
from 'Field Crop Protection Guide 2016–2017'

Source: OMAFRA (2016) http://www.omafra.gov.on.ca/english/crops/pollinators.html

1. Corn (Field and Seed)

Bee kill incidences in Ontario have been found to be associated with the planting of corn and soybean seed treated with neonicotinoid. Growers are encouraged to follow best management practices to protect pollinators at planting. See Health Canada's pollinator protection web page: www.healthcanada.gc.ca/pollinators and *Chapter 10. Neonicotinoid Regulatory Requirements in Ontario*, as well as ontario.ca/neonics for the latest information.

CORN INSECTS

Table 1–1. Chemical Control Options for Insects in Field and Seed Corn — Corn Rootworm

Integrated Pest Management Options	Active Ingredient	Trade Name	Rate	Comments (label precautions, re-entry periods, etc.)
CORN ROOTWORM (***Diabrotica virgifera*** **and** ***Diabrotica barberi***)				
Soil-Applied at Planting Only				
Avoid planting corn following corn. Crop rotation is the best strategy for control. Risk factors include heavier soil (clay), high beetle populations in corn of previous season and being the latest field planted in the previous season. If there is less than 1 beetle per corn plant on average throughout the month of August, then no insecticide is necessary in the following corn crop. In-furrow application is safer to the applicator and non-target mammals than T-band application. Granular insecticides are toxic to birds and small wild mammals. Any spilled or exposed granules must be incorporated into the soil or otherwise cleaned up from the soil surface.	tefluthrin	Force 3.0G	37.5 g 100-m (328-ft) row	May be applied in a T-band or in-furrow. For banded applications, place directly over the furrow in a 15 cm band ahead of the press wheel. For in-furrow applications, place all material directly in the open seed furrow, behind the planter disc openers.
	chlorpyrifos	Lorsban 15 G	75 g 100-m (328-ft) row	**Suppression only.** Must be applied in a 10–15-cm band over the row behind the planter shoe, in front of the press wheel. Do not place in direct contact with seed. 24 hr re-entry period.
		Pyrifos 15 G	75 g 100-m (328-ft) row	

1

Terminology

Acronyms

BARN - Beekeepers' Association of Regional Niagara

HRC - Honeybee Research Centre

EAS - Eastern Apicultural Society

EOBA - Eastern Ontario Beekeepers Association

FWG - Fletcher Wildlife Garden (Conservation Area)

IPM - Integrated Pest Management

LG - Learning Garden

NNi - Neonicotinoid

OBA – Ontario Beekeeping Association

OMAFRA – Ontario Ministry of Agriculture, Food and Rural Affairs

OPIRG Ottawa – Ontario Public Interest Research Group

UO - University of Ottawa

Glossary

A

American Foul Brood – a honeybee virus

Apiary – Usually refers to a honeybee operation. Can refer to a location where hives are kept or may refer to a collection of bee-yards belonging to a particular beekeeper or beekeeping company.

Apiculture – Usually refers to the practices within the honeybee-keeping profession.

Agrochemicals - Inorganic and organic treatments used to control the incidence of pests and disease on crops

B

Bee-hotel – A large wild bee nesting structure.

Beekeeper – A person who mobilizes strategies to ameliorate bee-health

-practices – Specific actions mobilized to ameliorate bee-health

Bee-related practices – Actions which interact with bees

Bee-yard – The location of multiple bee-hives. An apiary may be made of many bee-yards, or hive locations. Usage e.g.: The honeybee-keeper made a deal with the farmer he could use a parcel of his land as a bee-yard, to expand his apiary.

Biocontrol/Biological controls – An application based on the use of natural predators of target-pests in agriculture and apiculture

Brood cell – A single hexagonal chamber on a honeybee comb, where a honeybee larva is reared

C

Cash-crop – A crop of one plant-species grown for wholesale.

Chemical applications – A group of inorganic products produced synthetically in a lab that are used on crops in agriculture or on honeybees in apiculture

Clothiniadin – A common ingredient that is present in neonicotinoid pesticide products.

Colony – Usually refers to a family of honeybees which live in one hive. Is also used to refer to familial groupings of other eusocial (social) bees, such as bumblebees.

Controls(s) – Practices or products applied in agriculture and direct-bee management to curtail the effect of pathogens

-**organic**– A group of products that is applied in apiculture and agriculture. These are composed of naturally-occurring substances.

For e.g.: fish-based fertilizer used in crop-farming, or formic acid that is used on honeybees and produced by ants

--**inorganic** – A group of products that is applied in apiculture and agriculture. These are composed of substances that are synthesized in a lab.

---**cultural**– A group of practices applied in agriculture and direct-bee management that enable successful production. Accomplished through physical means, without the application of synthetic or organic products.

For e.g.: tilling the earth before sowing a crop.

----**synthetic**– see: *inorganic controls*

------**biological** – A group of practices applied in apiculture and agriculture based on the initiation of natural processes or organisms for the control of pests and diseases.

For e.g.: The application of predatory insects purposefully onto a crop for the control of insect-pests.

Crop-farm – An agricultural operation specialized in plant-cultivation

D

Direct-bee management – A set of practices that enable raising and caring for bees, usually honeybees

Disking – A cultural control in agriculture accomplished with a tractor and a specialized disking machine. Used to prepare the earth before planting by loosening up the soil and reducing weeds.

Driver – in the context of this paper, drivers refer to stressors on bee-health.

Drone – a male bee, usually refers to honeybees

-cells – Honeybees make waxen cells in their hives, in which they store food and progeny.

E

Ecosystem services – Pollination is an ecosystem service which occurs in of itself but has also been made into a commodity (through intentional bee-management). Most of these services occur as part of the normal functioning of the ecosystem, for e.g., wetlands provide storm water retention services.

Eusocial (social) – Bees which live in familial groupings. Particularly those which share a nest, such as bumblebees.

G

Generalist (bees) – Bees which forage on a wide variety of plant species, such as honeybees

Genus – the scientific name for a group of animals which are very closely related but which can still be further subdivided. For e.g., all honeybees share the Genus *Apis.* but can be further differentiated into eleven separate species, one of which is Apis mellifera, the Western honeybee.

Ground-nesting bees – those species which live and lay their eggs underground, in excavated tunnels.

H

Herbicide – An agricultural product which is applied to control the growth of weeds

Hive – The structure that a honeybee-colony lives in.

I

Imidacloprid – a component in many neonicotinoid insecticide applications

Inorganic Control – (see control)

Insecticide – An agricultural product which is applied to control damage from insect-pests

Invasive species – Plants and animals which are introduced into new geographical ranges and restrict local species.

-bees – Bees which are non-native, that have been introduced into a broader geographic range, which they did not historically occupy. For e.g, a non-native bumblebee species is used in Canadian greenhouse pollination which upon escaping, managed to establish itself in its new geographic range.

--plants – Introduced plants which compete with local species.

M

Mason-bee (Osmia spp.) – a genus of bee which is native to Ontario.

Monoculture – In agriculture, cultivation focusing predominantly on one plant variety.

Mixed-cropping – When a crop contains more than one plant-species

N

Native

-bees – bee species which occur naturally in an area, or have naturalized there.

--**plants** – plants which naturally occur, or have naturalized within a particular area.

Naturalization – In bees, occurs when a species enters a new (or wider) geographic range and successfully reproduces, eventually becoming a stable part of the local ecosystem.

> For e.g., the squash bee's geographic range used to be more restricted until plants in the cucurbitae family began to be cultivated further north, at which point the bee-species naturalizaed here.

Neonicotinoid pesticide (NNi) – a class of neurotoxic pesticides which include:

These are applied mainly in agriculture as a control for insect pests on crops and are also referred to as insecticides. Seeds are inoculated with these inorganic controls, as well as plants and full crops through foliar sprays.

Neurotoxic insecticide – agricultural controls against insect-pests that affect the neural system of exposed insects.

O

Organic Controls – see *control*

Overwinter-preparation – In honeybee-keeping, the set of practices involved in readying colonies for winter. This includes weather-proofing and hive-checks for assessing disease and honey levels.

Over-wintering – A process analogous to hibernation for bees. Bees spend the winter period in hiding, when forage is unavailable. Honeybees stay in their hives, huddling together for heat. Solitary bees do not leave their nest either and are usually in the larval stage during this time.

Oxytetracyclene – a common neonicotinoid applied in agriculture

P

Pathogen – a vector which can cause disease.

Parasitization – A process where a host is attacked by a predator. The most common honeybee parasite is the Varroa mite.

Pollinator – An animal agent of pollination.

-crisis – A blanket term referring to the perceived threat of a pollinator shortage

--plantings – Plants cultivated to provide pollinator habitat or forage.

Propolis – A product collected by bees from plant resins and harvested by humans for its antibacterial properties

S

Single-cropping– when plant-variety is consistent within a crop. Crops of one plant variety

Solitary bees – Bee-species that live on their own, usually in the ground or in hollow pant-stems

Specialist bees – Bee-species that have co-evolved with a particular plant variety or plant-family. This means that they only eat nectar and pollen from one type of plant, or from a small group of closely-related plants. For e.g., the squash bee only likes flowers from the cucurbitae family. The opposite of a generalist bee.

Split – n. Honey-beekeeper lingo describing a new colony made from another one which was growing too large. Because the colony used is divided into two, the resulting colony is referred to as a 'split'

Strateolaelaps scimitis – (formerly *Hypoaspsis miles,*) a mite used as a biocontrol in crop-farming

Stressor – A factor that contributes to the stressing of an organism.

Sublethal

-doses – Exposures to pathogenic factors which can be lethal in larger concentrations but which do not cause death upon single exposures.

--effects – What occurs to an organism after sub-lethal exposure to a chemical.

Swarm – A natural form of honeybee colony reproduction, which involves half of the colony leaving in search of a new hive location.

Swarm-collection – A honeybee-keeping practice focusing on the retrieval of bees while swarming.

Synthetic pesticide – A product for controlling unwanted insects and plants, which is created in a lab and does not occur naturally.

Synthetic nest – A dwelling for bees that is made by humans

Systemic pesticide – A product applied in agriculture as a control against insect-pests. Unlike older varieties, this class of pesticides requires minute dosages, which are usually applied to the seed because the substance enters the plant-tissues and continues to act ‘systemically’ throughout the life-cycle of the plant.

T

Tilling – Soil preparation through turning, for agricultural purposes.

Trapnest – A synthetic dwelling for wild bees. Generally, a wooden block with holes, although other materials are available.

Treatment – In this paper, a specialized practice that is carried out to better bee or crop-health.

-category – A grouping of practices which entail either landscape management, colony management or experimental colony management.

--level – whether the practice is applied to colonies or the landscape

--- schedule – a calendar with prescriptive managerial action

----technique – Treatment practices which either comprise cultural, organic or inorganic controls.

Tree-nursery – A Tree-rearing operation.

V

Varroa mite, Varroa destructor – Varroa jacobensis

– A crab-like mite which was originally only present in Asian honeybee strains but which now parasitizes the majority of managed honeybee colonies.

--count – A test for honeybee-keepers which can help them discern thresh-holds for the application of treatment products.

W

Wax – A honeybee excretion used for constructing honeycomb, where honey and developing bees are stored

Wild-bee – A bee that is native or naturalized. Non-managed bee.

Wild-bee nest – Natural or synthetic. Can be a trapnest, bee hotel or naturally occurring hollow; in the ground, in a twig and a variety of other places.

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