BEEKEEPING IN THE ANTHROPOCENE:
THEORIZING CONFLICTS OVER HONEY BEE HEALTH

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Eleanor Snow Andrews

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Eleanor Snow Andrews, Ph. D.

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Managed honey bees in the US have periodically faced challenges around pests and infectious disease. As beekeepers have responded with a range of different management practices, they have clashed over what it means to be responsible and the degree of control that is possible or desirable. Many of these conflicts hinge on the inherently dual nature of the honey bee, which is both a livestock animal but also wild in many ways. To understand these politics, the three papers of this dissertation draw on participant observation, interviews, observation of beekeeping clubs and workshops, a statewide survey, and archival research, based largely in New York State.

"To save the bees or not to save the bees: Honey bee health in the Anthropocene" (published in *Agriculture and Human Values*, 2019): This article situates contemporary honey bee health challenges, particularly debates over how to manage parasitic mites, within the literature on the Anthropocene.

"'The main objection to numerous small bee keepers': Biosecurity and the professionalization of beekeeping" (published in *The Journal of Historical Geography*, 2020): This article describes the origins of the beekeeping institutions that

arose in the late nineteenth and early twentieth centuries, particularly extension, and how they promoted a particular vision of "good beekeeping" based on biosecurity. It details how an "envirotechnical regime" behind beekeeping promoted norms as a part of the modernization of American agriculture.

"Hybridity for health: Converging learning curves in beekeeping" (unpublished): This paper argues that the idea of hybridity, and specifically nature-society and wild-livestock hybridity, can be a useful guide for keeping honey bees healthy and other quandaries of the Anthropocene. I show how individual beekeepers' understandings of honey bees shape how they start to develop the skills to manage parasitic mites in their colonies. As beekeepers continue to climb different learning curves, their understanding of bees is either reshaped or limits how successful they will be.

Together, these papers contribute to theory in scholarship on food systems, historical political ecology, and literature on biosecurity (particularly within geography), as well as topically clarifying one of the primary dilemmas over good practices within beekeeping today.

BIOGRAPHICAL SKETCH

Eleanor (Ellie) Andrews has a master's degree in Geography (Penn State University, 2012) and a bachelor's degree in Political Science and French (Amherst College, 2006). In 2017-18, she taught in the Environmental Studies department at Hobart and William Smith Colleges.

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LIST OF ABBREVIATIONS AND TERMS

BIP	Bee Informed Partnership, a national survey on honey bee health
CCD	Colony Collapse Disorder
IPM	integrated pest management
USDA	United States Department of Agriculture
Drones	male bees
Brood	immature bees (eggs, larvae, or pupae)

INTRODUCTION

What can be learned from a study of the practices and politics of beekeeping? Let me start with some of last month's headlines.[1]

An astonishing one-quarter of the world's pigs have died or been killed in recent months in response to the spread of African swine fever. The disease spread due to its infectious and untreatable nature, the difficulty in reaching large numbers of small farmers across the Chinese countryside and the Chinese government's bungling of their response, in policies that discouraged compliance. As pig farmers across Asia pick up the pieces, the government is planning for future such outbreaks by building larger-scale farms with infrastructure more compatible with a particular vision of hygiene and biosecurity (Bradsher & Tang, 2019).

In New Jersey last week, the state government failed to pass a bill that would have tightened the requirements for vaccinations, as anti-vaccine protesters surrounded the state building. The bill would have ended the religious exemptions that have almost doubled in recent years and that are likely linked to ongoing outbreaks of measles. A *New York Times* article quoted the exasperated Senate President, "It's just remarkable how people are looking at this and not trusting the science on it at all. They're trusting the internet" (Otterman & Tully, 2019).

In the national budget passed last week, Congress for the first time set aside money for the National Oceanic and Atmospheric Administration (NOAA) to study geoengineering, or "climate interventions" (Temple, 2019). The agency will receive

[1] These headlines are from November and December 2019. But the events of 2020 – the global coronavirus pandemic and the associated conflicts and dilemmas around health – would serve equally well as an introduction to the themes of this dissertation.

$4 million to evaluate proposals to put materials in the stratosphere. A California Congressman has also put forward a bill suggesting a structure to put together a research agenda. Few people *want* geoengineering, but more and more are beginning to think that it is necessary.

I see an article about the new "Cosmic Crisp" apple, selected out of thousands of new crossbred apples based on its taste, texture, and relatively low perishability (Spencer, 2019). Twelve million Cosmic Crisp apple trees have already been planted. The author describes it as the "apple of the *near* future," "normal," but not "ideal": it will work in the short term, in the contemporary industrial agricultural system. But it will in the end be vulnerable to disease (those twelve million trees are all clones of one another) and may be vulnerable in the market, too, as more consumers are seeking foods that they understand to be more sustainable.

Taking a break from the news, I might go see "Dark Waters," a film currently playing in theaters. It is based on the true story of a lawyer who sought to hold the chemical company DuPont accountable for contamination downstream of a landfill in West Virginia. Numerous health problems in livestock and people were traced back to a synthetic chemical in the water: PFOA, used in manufacturing Teflon. For decades, DuPont concealed the toxic effects of PFOA, but eventually settled with the EPA for millions of dollars and ceased to produce PFOA in 2013 (Rich, 2016). But PFOA can still be found in the blood and organs of humans and other animals around the world, and the alternative that DuPont began to manufacture instead has also been under scrutiny.

These stories – about the spread of pathogens, divergent assumptions around who is better equipped or more responsible for biosecurity, the balance between individual autonomy and collective cooperation for scale-jumping problems, the corporate food regime, the popular re-valuation of diversity in the food system, misgivings about anthropogenic control over the environment, stopgap measures that show how constrained the available choices are, all against the backdrop of polluted landscapes – together, all these stories characterize life in the Anthropocene.

To examine beekeeping is to consider these same themes in a different story. My dissertation, *Beekeeping in the Anthropocene: Theorizing Conflicts over Honey Bee Health*, is an attempt to do so through examining contemporary and historical conflicts over beekeeping practices and honey bee health, and the broader political divides that underpin these conflicts. As I show in the following pages, the idea of the Anthropocene, despite the many critiques of the term, has been a useful analytical tool to break out of binaries, as well as capture in shorthand some of the constraints that shape beekeeping today.[2] The "theory" (of the title) comes from multiple disciplines: geography – particularly animal geographies and scholarship on biosecurity, anthropology, environmental history, and environmental humanities more broadly. My work is perhaps closest to political ecology, but as I explore individual subjectivities more than the broader political economy of agriculture and land use, my work does

[2] Briefly, there is some debate over when the Anthropocene "began," with proposed dates ranging from the advent of agriculture roughly 10,000 years ago to the first nuclear explosion in 1945. The social and political debates relevant to my work (grappling with ecological change and responsibility) go back more than a century, so I use the term "Anthropocene" to describe my whole dissertation, including the paper on the late nineteenth- and early twentieth-century growth of the beekeeping industry.

not take a conventional political ecological approach. I therefore use the broader descriptor of “theory,” rather than name a particular field.

The result of my research is three papers: “To save the bees or not to save the bees: Honey bee health in the Anthropocene,” published in *Agriculture and Human Values* in 2019; “‘The main objection to numerous small bee keepers’: Biosecurity and the professionalization of beekeeping,” published in *The Journal of Historical Geography* in 2020; and “Hybridity for health: Converging learning curves in beekeeping,” unpublished. Briefly, the first paper analyzes conflicts over whether it is possible or desirable for beekeepers to take a less interventionist and more “natural” approach to managing honey bee parasites. The second describes the origins of the beekeeping industry in the US in the late nineteenth and early twentieth centuries and the ways in which concerns over disease shaped discourses and norms in the nascent industry. The final article returns to the present, to understand how individual beekeepers learn to manage the many challenges to their bees’ health; I suggest that the idea of “hybridity” is both a theoretical and practical tool to ease conflict and help beekeepers develop all the necessary skills to keep their bees healthy. Because these are standalone papers, there is some minor repetition of ideas and points (e.g., the ubiquity of parasitic mites in honey bee colonies), including specific quotes or references that support those ideas.

My research methods are described at length in Appendix I: “Plan Bee,” where I also reflect on my positionality throughout the process. Briefly, from 2013 to 2019, I conducted interviews with beekeepers and others (66); made observations of beekeeper club meetings, classes/workshops, and conferences (22 organizations) across New York State and beyond; conducted an online survey of beekeepers across New York State; and did archival research at the Cornell University Archives at the Kroch Library. But as I was and am also a beekeeper myself, my approach to collecting data was participatory in many senses. Since 2010, I have managed between zero and six colonies at a time, taken beekeeping classes, and been an officer since 2014 in my local club, the Finger Lakes Beekeepers Club. In this role, I organize beginners' workshops, occasionally write newsletters, set up "mentor matches" among our membership, mentor new beekeepers myself, and more. In 2016, I was also hired to help design Cornell's new Master Beekeeping course alongside the Honey Bee Extension Associate. These activities gave me many insights into how beekeepers learn to keep bees, and particularly their introduction to health and disease issues. They also gave me a more interdisciplinary perspective, as I worked closely with natural scientists in several of these contexts. To those ends, the conclusion is a set of reflections on my methodological approach, particularly the interdisciplinary and engaged nature of the research and the related epistemological and practical challenges.

But let me back up, back to the bee-ginning…[3]

Honey bees as a "gateway bug"

I began keeping bees in 2010, an act that had a transformative, domino effect on my life. Beekeeping is shockingly intimate, a dizzying rush with all five senses engaged simultaneously. It is humbling: to inspect a hive is to handle alien creatures

[3] I have only permitted myself five such bee puns in these ~200 pages.

that appear to scarcely notice the beekeeper, but that also could attack en masse at any moment. It was only much later that I heard them described as a "gateway bug," but it was that idea – that keeping bees can lead someone to make new connections in the landscapes around them – that prompted my research, as I wanted to understand how widely my experiences were shared. Over time, as I learned to care for my colony (later, colonies), I came to feel that I had a stake in the local environment and flora, as my bees gathered nectar for honey from the flowers across several square miles around their hives. I began to pay more attention to the succession of blooms, grateful for the earliest maple flowers in spring, the last asters in fall, and the abundance in between, especially of those plants that I had once taken for granted: dandelions, clover, sumac, goldenrod. I checked the weather more often, worrying when a dry summer stayed dry. "We begin with noticing," declared a recent essay: we are caught up in so many ecological entanglements that we often overlook (Tsing et al., 2017, p. M7). Noticing was how I began.

Beekeeping is a *just* a beginning; the theory is that more intimacy with and more knowledge of wild bits of nature is the necessary basis for a deeper and broader effort to protect it. Writer Paul Kingsnorth's "Confessions of a Recovering Environmentalist" suggests that this kind of "emotional reaction to the wild world" or a "real, felt attachment" to the Earth, is a more powerful motivation than more abstract notions of "sustainability" or "the planet" (2017, pp. 68, 72). That is the rationale for the many calls for "reconciliation with nature" through activities like farming and gardening, voluntary simplicity, and ecotourism (von Essen & Hansen, 2019, p. 1). These activities are a challenge to what Holly Jean Buck has called the "disenchanted"

Anthropocene, where news of environmental change feels far-off and hypermediated, with long and complex supply chains and the butterfly effects of consumers' choices contributing to individual alienation (2015). She writes, by contrast, that "enchantment can enable the passion, care, revulsion, action, networks, sense of place, relationships, and so on that help bring about these socioecological transformations, offering greater momentum for mobilization" (Buck, 2015, p. 372). Beekeeping was my avenue of enchantment.

Indeed, one key site of "reconciliation" or "enchantment" is relationships to nonhuman animals, evidenced in the rich and growing literature on animal studies. Anthropologist Donna Haraway's *When Species Meet* is perhaps the definitive scholarly reference on such relationships or encounters. Haraway writes about how we might recognize and build on human alliances with nonhumans, humans in particular "learning to pay attention" (similar to the above observations about noticing) and being responsive to and respectful of our companion species and others with which we are interdependent (2008, p. 19). Paying attention to these creatures often means paying attention to where they are; scholarship in animal geographies emphasizes the importance of spaces and places in human-animal relationships (Philo & Wilbert, 2000). And crucially for my work, such relationships and encounters with nonhuman animals are facilitated by certain sorts of "embodied practices," practices that are intimate and immediate, and that "open relationships with nonhuman nature" (Buck, 2015, p. 372). Along the same lines, environmental humanist Stephanie LeMenager has written about "skilling up" as a way to think about these relationships with other species and a necessary task of the Anthropocene (forthcoming).

I am not the first to find the concept of "skill" useful in the context of beekeeping: UK researcher Emily Adams recently published a piece on acquiring such skills, with a focus on the sensory and social aspects of the process (Adams, 2018). She cites anthropologist Tim Ingold's definition of skill as "knowledgeable practice and practical knowledge" (Adams, 2018, p. 33; Ingold, 2000, p. 316). For Adams, skill is also about learning to pay attention, as it was in my experience. She notes how beekeepers must develop the ability to "read" the bees and their work in the hive (2018), gaining "skilled vision" and the "education of attention" (Grasseni, 2007; Ingold, 2000).

I hope here to take another theoretical step, building on Adams' work to further emphasize how skill must be responsive to context and conditions, negotiating the limits of other materials or creatures. The examples given by Adams of skill more generally are taxidermy, vine cultivation, and yoga, from other literature; these are also good examples for my point. Keeping dead, stuffed animals from falling to pieces (taxidermy) entails some non-negotiable principles. Vines will grow as they will grow; the skill is in stimulating and directing that growth. The body has limits in how far it can bend; yoga is a discipline to find and push those limits, not to overcome them entirely. In the same way, for LeMenager, skills are in part about "working with recalcitrant non-humans" (forthcoming). And so it is for beekeeping. Beekeeping is a set of skills that must take into account certain unyielding biological and ecological phenomena that cannot be controlled, such as bees' collective response to pheromone levels, the seasonality of plants, the daily weather, and so on. And while any agricultural endeavor requires at least some attention to basic natural phenomenon in order to meet the needs of the plants and animals being raised, beekeeping arguably requires more such attention than most, as bees fly and forage freely. Less can be controlled in beekeeping; more must be responded to. This point is further elaborated below.

Skill, then, is at the nexus of the wider nonhuman environment, the things we cannot control, and agricultural endeavors, or the things we aim to control. A beekeeper must accept what cannot be changed or undone (such as the succession of blooms across a given landscape or the presence of parasitic mites across most of the world) and also change what she can, if necessary (by medicating the bees, moving them, replacing the queen, or any number of other actions). The skilled beekeeper, of course, knows the difference between the two. (This formulation is derived from the well-known "Serenity Prayer" (*God, grant me the serenity to accept the things I cannot change, courage to change the things I can, and wisdom to know the difference.*) which has been suggested as a kind of mantra for the Anthropocene (Robbins & Moore, 2013); I will return to it several times.) Recalling Ingold's definition, skill is not just doing; it is knowing, and knowing more can often mean doing less. A skilled beekeeper can do less than one who is still learning, by knowing enough to take anticipatory actions, for instance, staying a few steps ahead of a colony that might swarm. The skilled beekeeper also knows when not to meddle; from the outside of the hive, she can see what foragers are bringing back or whether bees from other colonies are robbing her hive. She may be able to tell enough by such observations to delay opening the hive for an inspection. These are advanced skills, but there is also a minimum floor: if beekeeper is not sufficiently skilled to manage the many threats to her colony – pests and disease, starvation in lean months, their exposure to pesticides – her colony is nearly guaranteed to die. It is worth noting briefly that "skills" might not necessarily be politically progressive: LeMenager refers to gun usage and survival skills learned by preppers or Libertarians or evangelicals, while in my research, beekeepers learn to skillfully apply pesticides to honey bee colonies to kill parasites.

It may take years for someone to learn these specialized skills. And for what? Successfully keeping a hive alive in the backyard does not solve the world's problems. The implied theory of change behind such lifestyle choices and activities, that small efforts will somehow lead to large-scale social transformation, has been derided by one author as "widespread magical thinking" (Maniates, 2017, p. 4). This is the trap of "environmentality," a thoroughly apolitical and neoliberal focus on the subjectivities of individual actors, which locates responsibility for environmental protection at the level of those individuals, rather than larger-scale structures or policies (Agrawal, 2005; Dowling, 2010; Kent, 2009; Maniates, 2002; Thoyre, 2015).

But, to reiterate an earlier point, while learning to keep bees healthy and even productive is not a substitute for political change, it can enable certain kinds of transformations. Both Buck and LeMenager are clear that these skills and the intimate relationships that they enable are just a start. Buck writes, "[e]nchanting practices are no stand-in for large-scale political change, but … they can help create [a] critical mass of engagement and care" (Buck, 2015, p. 376). Similarly, LeMenager stresses that "[t]o think about skill is to think small, not in order to turn away from the vastness of the crises at hand but rather to re-ground oneself in first principles that may represent paths forward" (forthcoming). Along these lines, Donna Haraway has written that we have to "embrace" technical projects as routes to "staying with the trouble," which is to say making and maintaining connections in a turbulent world (2016, p. 3). Beekeeping can be such a route. It allows us to connect in specific places to specific other creatures, becoming more of who we are, more "entangled and worldly" (Donna Haraway, 2016, p. 4). This is the kind of specificity that Kingsnorth has called for, which reminds us what we are all part of, what we are fighting for.

Still, the fight is not always clear-cut. Learning to keep bees requires making subjective and political choices, as scholars developing a political ecology of education have made clear (Meek & Lloro-Bidart, 2017). There is a quote popular among environmental educators: "In the end we will conserve only what we love, we will love only what we understand, and we will understand only what we are taught" (from Senegalese environmentalist Baba Dioum). Viewed from one angle, this idea is a rousing but benign call to action to teach and learn more about the natural world. Viewed from another, it is a reminder that what we are taught, formally and informally, is the political economic product of many actors and interest groups, and is likely limited because of that.

In this sense, different approaches to beekeeping demand different sets of skills, which are valued differently by different actors. Adams describes beekeepers as a "community of practice" to underscore the social dimensions of learning (2018). This is an insightful characterization of what it means to learn to keep bees, but it falls a bit short: beekeepers are in fact divided into multiple and overlapping communities of practice, each prioritizing different skills and trajectories of becoming a member.

And these differences are largely based on different understandings of honey bee health challenges. Indeed, if the first thing a beekeeper learns is how to pay attention to the ways that her bees are situated in a broader environment – and therefore how she is, too, and how her practices must be, in order to be skillful – the second thing is the long list of pests and diseases that threaten those bees, as well as the divisions among beekeepers over how best to approach them. In what follows, I will spell out the central concerns around honey bee health, the implications for beekeeping, and my research trajectory to understand them.

Honey bee health

Honey bee health is devilishly difficult to define and measure (Silverman, 2013). The foremost reason for this is that bees are a collective superorganism, living in colonies with tens of thousands of loosely related individuals. Said more poetically, "[y]ou cannot keep just one bee" (Morrow, 2004, p. 94). Even if an individual bee is sick or if there are pathogens circulating in the hive, the colony may still be healthy. As Chloe Silverman has written, "A sick colony […] is something other than a colony with some sick bees" (2013). Health is more about the total social organization, and the breakdown of that coordinated social behavior is a signal that the colony is approaching its final demise (Rosenkranz et al., 2010, p. S103).[4]

[4] The first thing that likely comes to most readers' minds when they think about honey bee health today is Colony Collapse Disorder (CCD). I mention it here for that reason, although it was not important to my research. Briefly, CCD made headlines in 2006 and beyond, and the number of diagnoses in the years immediately following was high: fully 60% of the dead colonies in one study exhibited symptoms of CCD (vanEngelsdorp et al., 2008). More recently, a 2019 study by the USDA reported that over 330,000 colonies that had died the previous year presented symptoms associated with CCD (National Agricultural Statistics Service (NASS), 2019). But these figures are suspect: one of the foremost experts on CCD, a

Institutionally, until 2017, honey bees were outside the provenance of veterinarians (and are now only seen by veterinarians in limited circumstances). They have also largely been outside the provenance of economic entomology, which has conventionally had killing insects as its mandate, rather than protecting them. This has retarded a scientific understanding of how bees are threatened by pesticides, as insects have conventionally been seen as "'target' taxa—organisms to kill, not preserve" (Kleinman & Suryanarayanan, 2013, p. 506). The "epistemic form" of economic entomology lent itself to studies on how pesticides killed insects outright and little consideration of how a sublethal dose might affect bees, which today is a more common concern (for example, that a pesticide might affect the learning and memory of individual bees or impact the fertility of male bees, contributing to a colony's eventual demise but not killing it directly) (Kleinman & Suryanarayanan, 2013, p. 497).

Honey bees, therefore, are often the odd one out. One beekeeper has called them the "stepchild" of agriculture, meaning that they are imperiled by the forces of industrial agriculture but also a key part of it (Oliver n.d.). That observation is key to my analysis of their health. Honey bees are hybrid. They are both livestock and wild

scientist who helped name it, has not seen a case since 2011 (Nordhaus, 2016). Today, CCD is far from the most important driver of honey bee deaths and population declines – and it may never have been. But it swept up the US in a panic, in part because it was widely conflated with other issues: other causes of mortality, a downward trend in the total number of hives in the US because of shifting markets for pollination and honey, and declines in populations of native / wild bees (not honey bees) (Watson & Stallins, 2016). CCD was not important to my research, since most beekeepers contend with, more common health challenges, although it did have an indirect effect, as it motivated a new wave of beekeepers whose entry into the industry heightened existing divides over beekeeping practices – and it was this clash that was the starting point of my research. (Still, I should admit that my heartbeat quickens every time I open up my hives and see the initials of a beekeeper from whom I bought some equipment, Chad C. Draper.)

creatures. This hinges in large part on the fairly simple fact that they fly freely: unlike most creatures kept for food or other functions, honey bees fly free in a wide radius around their home.[5] This is not a particularly novel insight about honey bees; they have been long been recognized as occupying an in-between space, a “species on the cusp of culture and nature” (Waring, 2015, p. 17). But it is also a logical extension of two related lines of scholarship.

The first typologizes (nonhuman) animals and kinds of considerations that humans ought to extend to them. For example, a recent book suggests that there are three types of animal citizens: “sovereign” animals in the wild, animals who opportunistically move in and out of human spaces, and domesticated animals who have been bred for interdependence with humans, with implications for how we treat these different categories of animal (S. Donaldson & Kymlicka, 2013). Another text, on philosophical approaches to how we ought to treat different animals, suggests that “the ethic of care seems to ‘fit’ our relations to domestic animals, while the ethic of justice seems to ‘fit’ our relations with wild animals” (Clement, 2007, p. 313). The author demonstrates that these ethics are in fact not dichotomous – but neglects to point out that the initial distinction between wild and domestic animals itself is not so clear either.

Another line of scholarship points to the many ways that the broader idea of “wild” is part of a false dichotomy. Timothy Morton has called the idea of nature and wildness “dubious intellectual constructs,” part of a modern ordering of the world wherein “Nature” and the wild are seen to be outside what is human (Morton, 2015).

[5] This is also true of pigeons kept for a variety of reasons and hawks and other raptors used for falconry. I am not making an argument that honey bee hybridity is one-of-a-kind, just rare.

In the same way, geographer Kay Anderson has called for the "relaxation of rigid oppositions of civility and wildness" (1997, p. 481) and geographer Henry Buller has called the wild/not wild duality "simplistic" (2014, p. 242). Recognizing the hybridity of the honey bee, given their position at the interface of agriculture and the environment, is in keeping with these anti-dualist conceptions of nature.

Recognizing honey bees' dual nature provides insight into their health challenges as well, including the discourse around their health and population. It is commonly noted that approximately one third of honey bee colonies in the United States have perished every year over the last decade or so (Bruckner et al., 2019). These losses are due to the variety of factors, which are described below. However, this number – the annual rate of losses – is largely unrelated to (although it is often conflated with) the total number of hives in a given country or other locale over time. One reason is that colonies can be split one or more ways, so such losses are not cumulative. But the more important distinction between annual losses and population trends is that the latter is for the most part economic. Figure 1 shows the change in the number of colonies managed in the US over time (Oliver, 2013). It is evident from the figure that there were colonies in the US during World War II than at any other time. This was due in large part to the good markets / high prices for honey

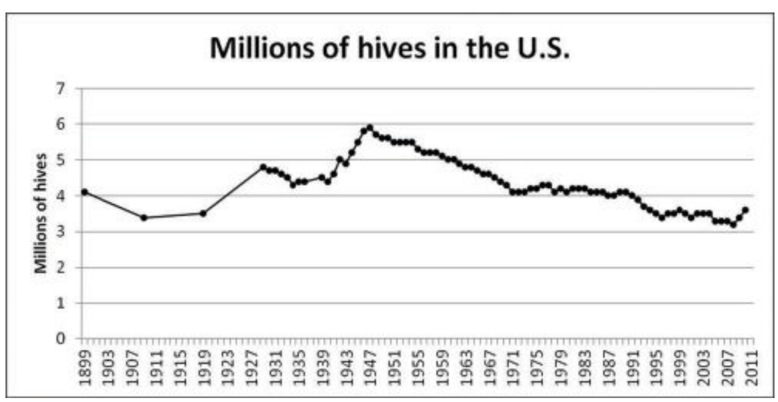

Figure 1: Number of colonies in the United States, 1899-2011 (Oliver, 2013)

(a sugar substitute) and wax (for military uses). So comparing the current population to any "baseline" population from between about 1950 and 2010 would give the decontextualized appearance of bees in decline – and most comparisons do indeed choose a year from that span. Not shown on this figure is a similar global phenomenon, which is also illustrative of this point: the most precipitous drop in the total number of honey bee colonies globally was in the 1990s (Aizen & Harder, 2009). The drop was the result of the end of government subsidies for beekeeping in Eastern Europe in the wake of the fall of the Soviet Union. Honey bee health, therefore, and population levels, have to do with their status as livestock, as much or more than their identity as free-flying, wild creatures.

Not only population levels but also individual colony survival is linked to bees' identity as livestock. It is commonly said that honey bee health is imperiled by the "four Ps": poor nutrition, pesticides, parasites, and pathogens (Downey, 2017).[6] The four Ps interact synergistically: for instance, a poorly nourished colony is more likely to be sick or less likely to be able to withstand exposure to pesticides. Poor nutrition refers to the decline in the quality and quantity of flowering plants across most landscapes. (Flowers provide bees with their two main sources of nutrition, nectar and pollen.) The decline in flowering plants is largely due to land use change for development and agricultural intensification. The second P, pesticides, include insecticides as well as herbicides and fungicides for agriculture (which can directly or indirectly harm insects even if insects are not the target), and, to a lesser degree, insecticides for insect pests such as mosquitoes. These two threats are linked to honey

[6] I use this framing in the third paper.

bees' encounters with the wider environment outside of their hives and outside of the control of the beekeeper, and their identity more broadly as wild creatures.

The third and fourth Ps, parasites and pathogens, are a long list including mites in honey bees' breathing tubes, fungal gut parasites, bacterial infections, and more. But the number one direct stressor within this category and, importantly, across all of the four Ps, is the *Varroa* mite (*Varroa destructor*), which vectors viruses and drains bees of the insect equivalent of blood and fat. A colony in the US that is not actively managed for mites today is nearly guaranteed to die within two years (Genersch, 2010). Even if a colony has zero mites at the beginning of the spring, there will likely be some by the fall; in areas densely populated by bees, there is said to be a "permanent exchange of mites," mostly hitchhikers on bees entering hives that are not their homes (Rosenkranz et al., 2010, p. S102). The mites are so ubiquitous that one beekeeping guide suggests thinking of them as a fourth caste in the colony, alongside the queen, the workers, and the drones (male bees) (Sanford & Bonney, 2018). The most elegant description that I have heard of the mites' impact on beekeeping was by a recent speaker at my local beekeeping club, who said, "Modern beekeeping is an exercise in learning as much as possible about the biology of two organisms: [t]he honey bee, and the *Varroa* mite." The control of mites has therefore become a necessary routine, making "good beekeeping" ever more "laborious, costly, and time-consuming" (Lezaun, 2011, p. 742).[7] In practice, controlling mites often means using pesticides (miticides) inside of hives, to the point that those miticides are now most

[7] This point is central to my research and I make it in both of the papers on contemporary beekeeping (the first and third).

prevalent pesticides found in hives (Mullin et al., 2010). Miticides can also cause harm to bees, although the cure is not typically as bad as the disease, so to speak.

These two Ps, parasites and pathogens, are linked to honey bees' nature as livestock, as the arrival and persistence of mites and other stressors is a consequence of the intensification of apiculture, meaning the increasing density and uniformity of bee stocks in a given operation, the ways that colonies are manipulated for particular ends (usually pollination contracts or honey), and the global trade and transport of bees. Bees' diminished ability to ward off disease also likely stems at least in part from beekeeper selection pressures over many years that favored larger colonies (which are on average more susceptible to mites), bees that collect less antimicrobial resin to line their hive (because it is a sticky nuisance for beekeepers), and more. As geographer Jake Kosek has pointed out, bees have been "remade" over centuries (2010):

> The honeybee in modern history is so bound to industrialism, modern capitalist agricultural production, contemporary forms of breeding, and genetic manipulation that to call the bee fully nonhuman is to miss the intimacy of the relationships that have made not just the environment but the bee itself—its nerves, digestive tract, skeleton, flesh, size, behavior (individual and social), and its molecular and genetic structure. (Kosek, 2010, p. 671)

Thus, honey bees, which have been at least partly remade by human desires, are not just wild creatures, but also livestock, dependent on human actions. By that logic, parasites and pathogens are also the most amenable to being mitigated by management practices (skills), as beekeepers (more or less skillfully) manipulate different parts of the hive, move the hives, feed their bees, reduce the levels of parasites, protect the colonies from various pests, and more.

Another, similar way of categorizing these four Ps comes from geographer Tony Weis. He has written about the twin trajectories of animal life in the contemporary era of the Anthropocene: there are the "things" of industrial livestock that have undergone commodification (or, as he puts it, "commodi-faunation") and "ghosts" being pushed out of their native landscapes by agriculture and other land use changes. He showed a version of figure 3 at a talk in 2015 to illustrate the extent of "commodi-faunation" around the world.

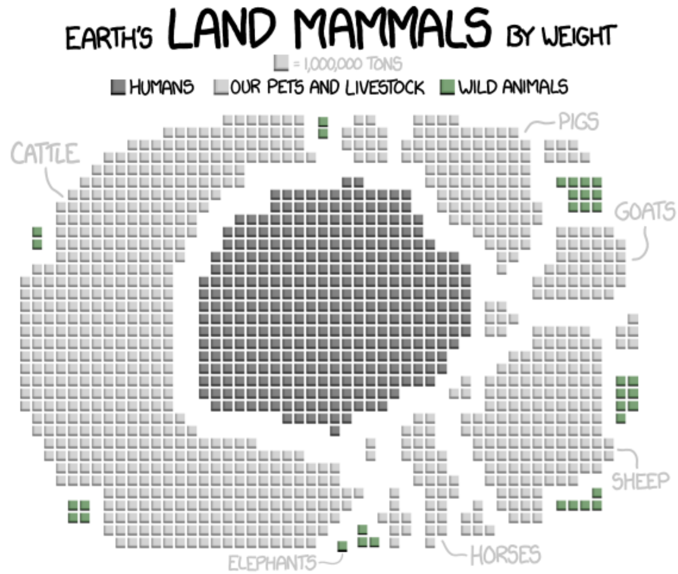

Figure 2: An image shown by Tony Weis, to illustrate the "commodi-faunation" of many of the world's animals (xkcd comics)

Bees are often characterized as "ghosts" (like the Honey Nut Cheerios campaign #BringBacktheBees that depicted only the dotted outline of their bee mascot on selected cereal boxes). They are recognized as being imperiled by pesticides and changing landscapes, just like other wild creatures who have shrinking habitats and resources.[8] But bees are also "things" and their transport across the country in

[8] Briefly, honey bees differ significantly from non-managed bees and other pollinator species. Most things that are good for the health of the latter are also good for honey bees: diverse flowers for food, particular species of flowers for food. Some things are bad for both, such as the direct impacts of pesticides, although being managed (housed, fed, medicated) makes honey bees less vulnerable, all else being equal. (A few other bee species are managed for pollination.) But some things are bad for wild bees but good for honey bees in various ways:

refrigerated trucks, the prophylactic use of antibiotics (until recently), and other such stressors of commodification no doubt shorten their lives. In another sense, however, commodification has been good for them. Their economic value motivates a certain minimum of care. The key is that both of these identities are in play at the same time, and that duality helps explain both the nature of honey bee health problems and the related conflicts.

The second theoretical tool for analyzing honey bee health is the concept of the Anthropocene. The idea of the Anthropocene dispenses with the idea of untouched, nonhuman nature, although of course critiques of wilderness and scholarship on "industrial organisms" and "natureculture" and "monsters" and more predate the popularization of the term (Sutter, 2013; Latour, 2011; Donna Haraway, 2008; Tsing et al., 2017; Cronon, 1996). There is much to say about each of these, but I use them here together as shorthand for how the Anthropocene is a reminder of the fundamental fusion of the human and nonhuman and the misplaced sense of nostalgia for "pure" nature, which, together, complicate imperatives around conservation and sustainability today.

As I have alluded to several times, I take the spread and ubiquity of *Varroa* mites to fall into the category of "what cannot be changed" (again, in the spirit of the Serenity Prayer). Beekeepers today may be stewards of their bees, but they are doing

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some invasive species, some aspects of industrial monoculture. And evidence suggests that honey bees may introduce or vector diseases that infect native bees and/or they may compete with native pollinators for resources. Still, native pollinator declines are mostly due to other factors (Geldmann & González-Varo, 2018; Mallinger et al., 2017). The particulars matter, but the point more broadly is simply that there is not a perfect overlap between what is good or bad for managed (honey) bees and what is good or bad for unmanaged bees, for a variety of reasons: the habitat they thrive in, the resources they need, and the way that they are in relationships with human actors.

so against shifted ecological baselines: the global spread of not just *Varroa* mites but other pests and diseases, so-called novel ecologies, unprecedented land use change, and what one set of authors have called a "permanently polluted world" (Liboiron et al., 2018, p. 332).

The inability for beekeepers to avoid these problems, and their need therefore to make difficult decisions about how to respond, was brought home for me when I interviewed a woman about my age who had just started helping keep bees on a small farm. She said:

> You want to let [the bees] do their own thing. But is that even possible anymore in our climate and in this environment? … it's like the vaccine debate… I don't want to use antibiotics and prescription medicine for every little thing that I do, and I want to live a healthy life, where I can prevent most ailments, but at the end of the day, I need vaccines for certain things, because it's just impossible in our current world to prevent myself from getting things that you need to get vaccinated for. Why would it be any different with farming? …That's just how our world is, whether we want to accept it or not.

As I describe in the first paper, beekeepers are divided about how to manage their mites, mostly along the lines of what is considered "natural" or "necessary." Conventional and commercial beekeepers largely insist on the need to treat hives for mites with miticides, but a significant fraction of beekeepers, particularly newer ones, see miticides (pesticides) as anathema to caring for bees. For me, the idea of the Anthropocene has helped me analyze this conflict – and make management decisions about my own bees.

Positioning my work in scholarly literature

My research focus on parasites and pathogens is unusual in the social scientific literature on bees. Simply disentangling different factors in honey bee health is a contribution to the existing literature, which typically provides an undifferentiated list of honey bee health factors, such as the following examples (in-text citations removed):

- "[Insect population declines] are driven by a series of interlocking factors, including climate change, habitat loss, changing pathogen dynamics, invasive species, and pesticide use" (R. A. Ellis et al., 2020, p. 438).
- "[M]anaged bee losses are due to multiple drivers, including parasites such as Varroa mites, pathogen and disease, pesticides, reduced floral resources, and the loss of nesting and foraging habitat" (Durant & Otto, 2019, p. 1).
- "The parasite Varroa destructor, sparse and poor nutrition, constant exposure to agricultural chemicals, and beekeepers' practices such as regular transportation and relocation regardless of seasons all weaken bees" (Cilia, 2020, p. 84).

After such lists, most social scientific articles go on to focus on pesticides and poor nutrition, the two Ps emblematic of the challenges that honey bees face by virtue of their wild side. These are more "environmental" threats, outside of beekeepers' control. For instance, Sainath Suryanarayanan and Daniel Lee Kleinman have studied the politics over pesticides (2013; Suryanarayanan, 2014). Geographer Becky Ellis has written about Ontario's partial ban on a particular class of pesticides called neonicotinoids and how agrochemical corporations inserted themselves into the debate (2019). Jenny Durant's work has focused on beekeepers' changing access to forage (the P of "poor nutrition") (2018). One article on the narratives around Colony Collapse Disorder described the overall picture of honey bee health with ten sentences on pesticides and poor nutrition, versus three on parasites and pathogens and three more on unspecified stresses associated with "[i]ndustrial-scale migratory beekeeping" (Watson & Stallins, 2016, p. 225). One exception is recent work by Catherine Phillips, who has written about the preparations underway in Australia for the seemingly inevitable arrival of the *Varroa* mite (C. Phillips, 2020).

Indeed, my work is meant in part to be a counterweight to scholarship that distances itself from the conventional approaches to managing mites. For instance, in describing the irony of beekeepers applying pesticides to their hives, one article states briefly that "in-hive miticides, the technoscientific products of agrochemical commerce, research, and regulation, came to be seen as essential to the commercial interests of beekeepers" (Suryanarayanan & Kleinman, 2013, p. 221). The phrase "came to be seen as" is accurate, in that commercial beekeepers *do* see miticides as necessary to keep their bees alive; most would likely say that more labor-intensive methods of keeping mite levels in check are effectively impractical for beekeepers managing a minimum number of hives (hundreds or more, perhaps). But the phrase "came to be seen as" implies that miticides should be seen in a different way, as *in*essential to their interests or perhaps counter to them.

I believe that most of the social scientific literature focuses on the two "wild / environmental" Ps, because they are seen as being foisted onto beekeepers, rather than being risks that they choose to engage with. In one recent article, sociologist Laurent Cilia describes the work of the "Scientific Beekeeper" Randy Oliver,[9] who promotes the idea that:

> beekeepers are responsible for their own fate… While blaming pesticides would locate the problems beyond beekeepers' reach, his position entails that beekeepers must improve their management practices… he advocates for a science-based, data-informed beekeeping, subsequently putting the responsibility onto the beekeepers' shoulders. (Cilia, 2020, p. 92)

While Cilia does not take explicit issue with this framing, he quickly moves on to broader questions of sustainability and a concern with the "toxic" landscape, effectively choosing a different framing that renders beekeepers blameless or at least powerless against other, larger interests in agriculture, and therefore worthy of more social protection. The article as a whole dismisses "techno-science" and advances in management practices that do not seek to change the underlying conditions for bee health.

But these concerns do not preclude beekeepers from *also* conducting science-based and data-informed beekeeping, and taking responsibility for the things that they do have the capacity to manage, such as mites. And it cannot be decided unilaterally which sorts of proposed solutions to honey bee health are just "silver bullets" (Cilia, 2020, p. 99). With my two articles on contemporary conflicts (the first and third articles) I hope to take seriously the threat of *Varroa* mites and associated pathogens, which is what the mainstream, scientific (and somewhat conservative) sector of the

[9] Randy Oliver is a well-known beekeeper who runs ScientificBeekeeping.com and runs home trials on mite management, bee nutrition, pesticide issues, and more.

beekeeping community says is most important.[10] These articles are based in the ecology and biology within hives and their many inhabitants, an attempt to keep the ecology in political ecology (Walker, 2005). These articles are also therefore somewhat contrarian in their insistence that conventional beekeeping is mainstream for a reason: more bees survive when their inevitable mites are managed, and managing those mites chemically is typically the most practical, or at least achievable, way to do so.

At the same time, beekeepers should of course not be expected to shoulder all of the risks of pesticides and poor nutrition as a part of such risks being more broadly socialized. I worry sometimes that I have let the pendulum swing too far, letting these more positivist questions about beekeeper motivations and practices eclipse broader questions about the political economy of honey bee health or environmental health more broadly. To put this in the terms of my third paper, a focus on mite management foregrounds bees' role as livestock, and arguably neglects the environmental dimensions of honey bee health. It is discomfiting to realize that a focus on mites may play into the hands of a widespread corporate PR campaign by Bayer and others, which seeks to downplay the dangers of pesticides by emphasizing mites instead (Simon, 2014). Reports and statements from industry interest groups like the American Council on Science and Health, the Competitive Enterprise Institute, or the

[10] I am inspired here in part by my former advisor geographer James McCarthy and his call for "First World political ecology" (2002). He did not support the (conservative) Wise Use movement himself, but took his fellow political ecologists to task for their assumptions about it: that it was a "corporate front," with participants "cynically deploying cultural arguments… [or] succumbing to corporate-orchestrated false consciousness" (McCarthy, 2002, p. 1282). Such claims are routinely, if not explicitly, made about some conventional beekeepers today; see my first article below.

Genetic Literacy Project get many of the facts right: the global rise in the number of colonies, the misuse of the term "CCD" and misunderstandings about the threat it poses to most honey bees, and more (Entine, 2018; Logomasini, 2015). But they also contain half-truths and cherry-picked data to conform with a narrative about the urgency of limiting regulation, which I can only understand as a cynical ploy to put profits over the health of living creatures. So how can I focus fixedly on mites and provide individual beekeepers with information to keep their own colonies healthy without losing sight of the political economy of agriculture and health?[11] I aim in this dissertation to give the necessary attention to "complexity and hybridity [without] creating a haze of moral relativism" (Sutter, 2013, p. 119).

In the same way, I do not want a focus on individual beekeepers' practices and the responsibility of members of the beekeeping community to one another to be interpreted as displacing risk and responsibility onto individuals who do not have the resources or other capacity to meet those exigencies. The literature on "neoliberal natures" has rich analyses of this asymmetry, where "local institutions and actors [are] given responsibility without power, while international institutions and actors [gain] power without responsibility" (MacKinnon & Derickson, 2012; J. Peck & Tickell, 2002, p. 386). For example, even though there is much to celebrate as beekeepers ascend the learning curves described in my third paper, such beekeepers may be

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[11] *The birds are all gone, the robins don't sing / Seems to me it's Silent Spring. / I wonder why among apologists / There's so goddamn many entomologists.* (This UC-Berkeley bathroom stall graffiti was brought to my attention by Jen Sedell at the 2019 Dimensions of Political Ecology conference and speaks specifically to the dilemmas that economic entomologists face in supporting industrial agriculture.

substituting success in their own operations for accountability by corporate actors and the captured state.

In an effort to elevate some of the broader social and political conditions that construct the possibilities of honey bee health or death, with my second article, I try to understand the history and political ecology of the beekeeping industry and extension in upstate New York with a critical look at the origins of the conventional model of beekeeping. That extension and other personnel at land grant institutions contributed to the consolidation of a certain model of agriculture in the US is not a new story (Buttel & Busch, 1988; Goldstein et al., 2019; Hightower, 1973). My particular contribution is to emphasize the role that disease and biosecurity played in the construction of that model. The beekeeping institutions created at the turn of the twentieth century – which still exist today – were designed to protect and support the industry at a time of widespread infectious disease: American foulbrood. Foulbrood was contagious across landscapes, the same way that *Varroa* mites travel, making concerns about neighborly responsibility paramount. Institutions therefore promoted a particular vision of "good beekeeping," by beekeepers who were "proficient" and "financially interested" (E. F. Phillips, 1909, p. 61). In other words, beekeeping was professionalized in the name of biosecurity. This institutional preference for a certain kind of beekeeper (as defined by size and motivation) persists today. When *Varroa* mites first arrived in the United States in the 1980s, one beekeeping extension agent suggested that they were "welcome" since the "marginal beekeepers … causing most of the problems … would inevitably be eliminated, leaving a stronger, more vibrant beekeeping industry."

Although that paper is implicitly critical of conventional beekeeping and the ways that the earliest proponents deployed the trope of neglectful and unskilled beekeepers, I have tried to refrain from arguing what is “best” for the bees beyond the level of the hive. The point is not to pick a side in these conflicts. Nor is it to draw a bright line between all of these factors behind honey bee health problems, but rather to come to a better understanding of their interrelationships by analytically disentangling and categorizing them, and to use that analysis to help bridge some of the conflicts among beekeepers today. The politics over honey bee health, and which factors are most important to address, are emblematic of the uneasy tradeoffs of the Anthropocene, and the much bigger debates over how to feed the world, indeed, how even to live in the world (Mann, 2018).

My research is therefore a response to work by Erica von Essen, who has described “people-people reconciliation” as a fundamental step in “people-nature reconciliation,” or repairing alienation and reconciling people with “nature” (von Essen & Allen, 2019, p. 55). That is where this introduction began, with a call for shifting individual subjectivities and specific practices. But people-people reconciliation must happen alongside these individual trajectories, and we must learn to live with “different and contradictory worldviews of nature, the environment and its meaning for us” (von Essen & Allen, 2019, p. 55). A recent study of urban beekeeping in Germany called for “a new political ecology of human–bee coexistence … [and] new modes of managing these relationships … [that account] for the practical interdependencies of humans and honeybees” (Lorenz & Stark, 2015, p. 124). I hope my work is a beginning of this new political ecology and a contribution to urgent conversations about conservation and agriculture in the Anthropocene.

PAPER 1: TO SAVE THE BEES OR NOT TO SAVE THE BEES: HONEY BEE HEALTH IN THE ANTHROPOCENE

Abstract

Every year for the last ten years, over a quarter of the honey bee colonies in the United States have died (Bee Informed Partnership (BIP), 2018). They are facing deaths by a thousand cuts, including pests, disease, and changed landscapes. Beekeepers are split about how best to respond, and their divide illuminates some of the dilemmas of agriculture and animal husbandry in the contemporary era of the Anthropocene. Drawing from scholarship on multispecies and animal geographies, I analyze the tensions between conventional beekeepers and a new wave of beekeepers hoping to "save the bees" with a more "natural" approach to beekeeping. These different approaches are both constrained by the reality of the Anthropocene: novel ecologies, shifting baselines, and the hybridity of honey bees themselves – part wild animal and environmental indicator, part industrial organism, embedded in circuits of migratory pollination. Changing beekeeping practices are part of a broader discussion about whether honey bees are wild or domesticated, and what their hybridity means for production and conservation goals (Hovorka, 2018; Weis, 2015). In short, thinking with the Anthropocene troubles what it means to "save the bees" and whether they even need saving at all.

Keywords

Anthropocene, beekeeping, hybridity, novel ecologies, animal geographies

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SYMPOSIUM/SPECIAL ISSUE

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To save the bees or not to save the bees: honey bee health in the Anthropocene

Eleanor Andrews[1]

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The Anthropocene

In 2000, the "Anthropocene" was proposed as a name for the contemporary era, in recognition that that the magnitude of human activities is now so large as to be visible in Earth's geological records, with changes in atmospheric chemistry, ocean acidification, global declines in biodiversity, and more (Crutzen & Stoermer, 2000). The term quickly entered popular discourse and scholarly literature, as a shorthand for the transformation for the planet. A key dimension of these changes are "novel ecologies" which, by turns, have been described as "rambunctious" gardens that we humans have made but do not fully control, "monsters" that we have made and to whom we owe our care, and "sites of struggle" in political economy (Latour, 2011; Marris, 2011; Robbins & Moore, 2013, p. 12; N. Smith, 1996). The Anthropocene has also drawn together the physical and social sciences, challenging that stubborn and vexing nature-society divide (Lorimer, 2012). Other sorts of binary thinking, black-and-white ethical reasoning, and outmoded categorizations have been similarly scrambled (e.g., species characterized as weedy or welcome, wild or domestic, invasive or native, etc.) (Lorimer, 2012).

Despite – or perhaps because of – its popular and scholarly adoption, the term is widely contested. Does it signal resignation or responsibility? What does it mean to accept human domination of the environment (Crist, 2013)? What does it tell us about the place and power of humans? It seems paradoxically to make humans seem all-powerful on the one hand, but powerless on the other, different from other animals, but ultimately one of them ourselves, subject like any other to changes in the environment around us. Does the narrative of the Anthropocene justify questionable interventions, particularly those that entrench economic and environmental policies favoring the few over the many (Crist, 2013; Johnson et al., 2014)? And does it effectively collapse responsibility for global environmental change, pinning the blame on an undifferentiated “humanity” instead of the smaller subset of humans largely responsible for planet-wide changes (Malm & Hornborg, 2014)? Does it distract from the political economy of environmental change, and would it be better called the Capitalocene (Haraway, 2015)? At worst, perhaps, it does all of these things. But at best, it might be understood as a conceptual upgrade that helps us better understand the empirical reality of environmental change. Perhaps it can be harnessed as a crisis or a moment of productive reckoning, as it shows divergent paths, new spaces for creative and democratic experimentation, and new forms of agency in a “permanently polluted world” (Buck, 2015; Collard et al., 2015; Johnson et al., 2014; Liboiron et al., 2018, p. 332).

And what has the Anthropocene meant for nonhuman life? Other species are going extinct at a rapid clip in what has been called the “sixth extinction” (Kolbert, 2014). Even species not considered threatened are experiencing localized declines, extinctions, and range contractions, as part of a more generalized “de-faunation” (Young et al., 2016). These missing animals have been called “ghosts” (Tsing et al., 2017; Weis, 2015). But the Anthropocene is about animal life as much as animal death. Some generalist animals are more abundant than ever before; these are the ones, like rats and pigeons, that we often call pests. Humans have become a force in evolutionary biology, transforming animal bodies into industrial organisms through selection and breeding (Russell, 2011; Schrepfer & Scranton, 2003). Indeed, the contemporary era is marked by animals' "confinement, incarceration, discipline and subjection," exemplified by zoos, labs, and concentrated animal feeding operations (Collard, 2014; Watts, 2000, p. 295). A few species of animals are therefore growing in absolute numbers, as billions of animals are raised every year as livestock or for other human uses. Tony Weis has called this "commodi-faunation": the exploding numbers of some species that are ever more deeply integrated into global industrial agricultural circuits and transformed into commodities (2015). This is not new; the 20th century saw the increasingly efficient conversion of grain to meat and other animal products (Boyd, 2001; Cronon, 1991). But these trends continue, with the increasing production of these animals ever more hidden from sight, even as their consumption is growing and growing.

A particularly fruitful vein, therefore, of the scholarly literature on the Anthropocene is in animal studies writ large (including contributions from geography, science and technology studies, anthropology, and more), with its meditations on multispecies encounters, the posthuman and more-than-human, and new sorts of "kin" and "companion species" (Collard, 2014; Haraway, 2008, 2016; Hovorka, 2016; Human Animal Research Network Editorial Collective, 2015; Kirksey & Helmreich, 2010; Lorimer, 2012; Philo & Wilbert, 2000; Weis, 2015). Scholars in this "species turn" are reconceptualizing human-nonhuman relationships and ecologies as assemblages (Comaroff, 2017). Calls for inclusive relationality is key, moving away from control and a turn towards "living with" nonhumans (Haraway, 2008; Lorimer & Driessen, 2013). Much of this work insists on the possibilities for new kinds of care, "respectful and accountable relationships with multispecies," while being careful not to overlook or understate power relations (Collard et al., 2015, p. 323; Comaroff, 2017). Scholarship on ongoing efforts to “rewild” animals and spaces have been described in this vein as a challenge what have been called the Edenic sciences: conservation biology, restoration ecology – fields that seek to undo the damage that humans have wrought (Lorimer et al., 2015; Robbins & Moore, 2013).

In using animals to “think with” (in the tradition of Lévi-Strauss), it has been discovered that insects are particularly good, because of their tangled relationships to humans – and bees, perhaps, “best of all” (Beisel et al., 2013; Nimmo, 2013). Indeed, honey bees (*Apis mellifera* L.) bring into relief some of the major issues within the Anthropocene: the many facets of the human-honey bee relationship (Lezaun, 2011; Moore & Kosut, 2013; C. Phillips, 2014), their species-being and our social construction of it (Kosek, 2010; Nimmo, 2013; Tsing, 1995), the complexity and normativity of science, including its biases and blind spots (Kleinman & Suryanarayanan, 2013; Maderson & Wynne-Jones, 2016; Silverman, 2013; Suryanarayanan & Kleinman, 2016; Watson & Stallins, 2016), to name just a few. Despite the wealth of social scientific literature on the human-honey bee relationship, I hope nonetheless to add something new to the conversation, with an especially empirical approach focused on on-the-ground debates and strategies to sustain honey bee health. Despite the many incisive critiques of the term described above, I believe the idea of the “Anthropocene” clarifies the dilemmas beekeepers face as they try, simply, to keep their bees alive.

Honey bee health challenges

Modern beekeeping is over a century old. Some challenges are perennial: cold winters in the North, queen failure, pests, diseases, and more. Success in beekeeping depends on careful observation and experience, tacit knowledge, familiarity with the local environment, and a little bit of luck. But it has become even more difficult in recent years. A parasitic mite, *Varroa destructor*, was introduced to the United States in the 1980s and has begun to vector increasingly virulent diseases. Microsporidian diseases like *Nosema* are widespread, with infection patterns changing and no effective treatment available. Pests and pathogens quickly spread, as migratory pollination operations put honey bees from all over the country in contact with one another. These direct stressors are exacerbated by a decline in the acreage of honey bee forage in the US, because of agricultural intensification and development. Furthermore, some pesticides pose a problem. Their effects are increasingly sublethal, meaning that they do not kill bees directly on contact, but there is increasing evidence they interact synergistically with one other, as well as with ingredients such as fungicides, previously considered to be safe and therefore not subject to label restrictions (Mullin et al., 2010). Indeed, *all* of these direct and indirect factors interact; for instance, diseased and poorly nourished bees are less able to withstand exposure to pesticides. Thus, the beekeeping literature, "once pastoral and instructional is now a bookshelf of books on disease treatment, migratory beekeeping, killer bees, urban beekeeping, and colony collapse disorder" (Mason, 2016, p. 1).

In recent years, annual losses have averaged about 30% (Bee Informed Partnership (BIP), 2018).[12] While these losses are not cumulative, as colonies can be replaced by splitting existing colonies in two, keeping bees alive from year to year has become more difficult. Indeed, there two ways of measuring the health of managed honey bees: the yearly rate of losses and the total number of colonies (Steinhauer et al., 2018). The two numbers are only somewhat related: honey bee colonies can be split into multiple colonies in a year (usually not more than two or three). So although annual losses are likely higher than they were a few decades ago, the percentage of annual losses is different from the total number of colonies. In the US, the total number of colonies – has declined steadily since World War II, except for a slight rise in the last decade, a trend that will be further discussed below (National Agricultural Statistics Service (NASS), 2017).

Unfortunately, much of the media and even social scientific literature has muddied these issues, conflating Colony Collapse Disorder (CCD) with broader challenges and declines (Nimmo, 2015; Watson & Stallins, 2016). CCD was identified in 2006 after some colonies dwindled and died in unusual circumstances, and in the years that followed, it was a source of concern for many beekeepers, possibly responsible for a double-digit percentage of total colony losses. Its incidence has since dramatically decreased, to the point that one leading apicultural scientist said in 2016 that he had not seen a case in five years (Nordhaus, 2016). It is difficult to estimate the total number of colonies that perished from CCD, given the lack of colony-level data, the possibility of error or deception in self-reporting as well as the inability to verify

[12] This survey data on colony losses has many limitations, but it is the best available.

those reports, and the inconclusive nature of the main symptoms, many of which may indicate other maladies or manifest differently in different regions (vanEngelsdorp et al., 2010). These factors are wrapped up in competing visions of what is at stake in the industry, the tension between precaution and action, and a broader political economy of epistemology, making debates over CCD contentious and fraught – just as they are for honey bee health more broadly (Kleinman & Suryanarayanan, 2013; Suryanarayanan & Kleinman, 2016; Watson & Stallins, 2016). Relatedly, an arguably disproportionate fraction of media attention has focused on the risks of pesticides, which are an important dimension of honey bee health, but only one of several, interacting factors.

More broadly, measuring the health of a superorganism is complex, or, put more bluntly, "Defining a dead colony… is not so straightforward" (Silverman, 2013; Steinhauer et al., 2018, p. 1). Identifying health problems is more difficult than in the past in part because stress and disturbance now are a regular part of the colonies' environment (Silverman, 2013). Furthermore, the synergistic interaction of factors has produced a diversity of discourses around honey bee health issues: some parties are attempting to isolate singular causes, others are trying to understand multiple, interacting factors; and yet others are pointing to industrial agriculture more broadly as the culprit (Suryanarayanan & Kleinman, 2016; Watson & Stallins, 2016).

Beekeeping has had to keep up with these threats, becoming more "more laborious, costly, and time-consuming" (Lezaun, 2011, p. 742). As one researcher described it during a bee conference, what beekeepers must do today is "not like your grandfather's beekeeping, and not like your father's beekeeping – not even like your own beekeeping” from years past. But there was already a kaleidoscope of different beekeeping practices. These are based on local environmental conditions (hence the saying among beekeepers that “all beekeeping is local”) and beekeeper motivations and preferences (hence another saying, “two beekeepers, three opinions”). More significantly, beekeepers are loosely divided into hobbyists and commercial beekeepers. While nearly all of the colonies in the US are managed by commercial beekeepers, who depend wholly on beekeeping for their livelihood, these commercial operators are vastly outnumbered by hobbyists.

These different beekeepers have taken different approaches to honey bee health challenges (Maderson & Wynne-Jones, 2016; Suryanarayanan & Kleinman, 2016; Watson & Stallins, 2016). Scholars have described the divide between “natural” and “conventional” beekeeping, or “backwards” and “scientific” beekeeping (Moore & Kosut, 2013, p. 56). (“Backwards beekeeping” is a description embraced by some practitioners.) More colorfully, one writer has called it “the Hatfield-McCoy treatment-nontreatment feud” (McNeil, 2016, p. 1139).

To be clear, this divide in practice is more of a continuum; beekeepers in the real world make choices that place them along it, rather than entirely at one end or the other. Sociologists Lisa Jean Moore and Mary Kosut profile a “center left” beekeeper who uses chemical treatments sparingly, when he feels there is no other choice (2013, p. 56). But the rift has been significant and bitter, and so while Richie Nimmo has written that “CCD is exactly the sort of crisis that we should anticipate facing with increasing frequency if we are living in the Anthropocene,” it is perhaps not for the reasons that he describes, namely the physical unsustainability of modern agricultural systems and our increased dependence upon them (2015, p. 195). It is instead the contentiousness of this divide, the politics and pushback around what is seen as natural or necessary that makes honey bee health problems so emblematic of the Anthropocene.

Methods

This analysis of beekeeping comes from five years of participant observation and interviews (2013 to 2018). During this time, I observed clubs, classes, and conferences (20 organizations, at least 35 meetings, including 20 full days of classes or statewide, regional, and national conferences). I conducted 54 semi-structured interviews with beekeepers, beekeeping educators, extension agents, and apiculture research scientists.[13] These individuals are mostly based in New York; a handful with a national or regional profile are based in other states or provinces. Their experience ranges from zero to forty or more years of beekeeping, and over half of them make some money from beekeeping, in a variety of ways. Several are or have been employed in the apiculture industry: government inspection programs or university extension, a beekeeping magazine, and a beekeeping supply company. I oversampled respondents that I expected to explicitly describe their approach as more "natural," for instance, by recruiting heavily from one bee club under a larger organizational umbrella called the Local Living Venture (formerly known as the Sustainable Living Project) and attending classes by beekeeping educators advertising a more natural or

[13] Informed consent was obtained from all individual participants included in the study.

organic approach to beekeeping. My respondents therefore are not representative of beekeepers in the US or New York more broadly.

The conventional approach to honey bee health

The advent of modern beekeeping in the 19th century produced a network of professional beekeepers, researchers, and educators across agribusiness, government, and academia (particularly agricultural colleges). In the 21st century, in response to CCD and other honey bee health challenges, this small but active network marshaled its resources for research and outreach, leveraging existing programs in institutions across the country, including, for example, the five existing federal honey bee labs. The 2008 Farm Bill mandated research and reporting on CCD, to identify the causes, increase colony survival, and improve the overall profitability of the industry.

But even as these programs were put in motion and concern over CCD faded, colony survival did not measurably improve. The industry continued to conduct research, developing genetic stocks of bees resistant to *Varroa* mites, new formulations of feed and dietary supplements, and chemical and non-chemical pest controls. With new technologies, researchers began to identify ever more pathogens at the molecular level, and integrate environmental and in-hive data from smart sensors. New regulations were passed to address the global trade and domestic transport of honey bees and the use of pesticides and antibiotics. Extension programming grew to include a range of education, outreach, and business support for commercial beekeepers, including disseminating best management practices through tech transfer teams and online resources, and Master Beekeeping programs. In 2015, a federal-level

Pollinator Health Task Force provided further funding for research and directed federal agencies and state governments to create plans to protect pollinators, including honey bees. While the plans have been contentious (largely around questions of stakeholder representation), they have attempted to clarify best management practices, and provided funding for habitat enhancement as well as research, outreach, and education more broadly. This approach to honey bee health is not a dramatic overhaul, but has supported beekeeper livelihoods and a profitable industry more widely through a continued reliance on research and a focus on the management of mites and other pests.

A more "natural" approach?

While the beekeeping industry was working to produce new tools and techniques to manage honey bee health, mainstream media picked up on Colony Collapse Disorder and the other challenges. A broad interest in honey bee health was launched, attracting a new wave of beekeepers across the US. By all accounts, club memberships around the country grew rapidly, with a new wave of beekeepers very different from the old guard. Many of these new beekeepers were out to "save the bees" and thus approached beekeeping differently, diverging from conventional beekeeping both practically and philosophically.

One beekeeper I interviewed contended that "the most common starting point for novices is a tacit rejection of 'traditional beekeeping,'" including fruits of the sort of research described in the previous section. Indeed, a recent article that describes "bee-centred beekeepers" notes that there is "considerable disagreement about what these methods should and do entail," simply that it stands "in stark contrast to large-scale, commercial beekeeping" (R. Ellis, 2019, p. 116). Much new information in books, blogs, and classes is structured as a critique of the conventional approach and industrial agriculture more broadly, skeptical of the system that "keeps beehives moving in the short term while contributing to their overall demise in the long run" (Suryanarayanan, 2014, p. 266). And while most adherents to this approach are new, the critics also include the former president of the American Beekeeping Federation, a lifelong commercial migratory beekeeper with more than 12,000 colonies, and at least one well-established apicultural scientist and author of a classic textbook on honey bees, Mark Winston. His recently published manifesto calls for a rethinking of beekeeping practices wherein "every idea goes against conventional wisdom" (2015).

To these ends, many beekeepers are trying to pioneer innovative approaches, experimenting with what is variously called "treatment-free," "apicentric," or "natural" beekeeping. Treatment-free beekeepers are wary of chemical treatments for *Varroa* mite infestations. They may use essential oils or probiotics, even organic acids, but not synthetic miticides, seeing the cure (for mites) as worse than the disease, and pointing to studies that show that most of the pesticides in hives are in fact the ones that beekeepers apply themselves, to manage mites and other problems (Mullin et al., 2010). Indeed, one of my contacts, who occasionally attended meetings of his local club, had been dissuaded by keeping bees himself because of the "diseases and mite, insect, and mammal pests that pose challenges [and the] toxic materials that are represented as being likely needed to manage [them]." Many treatment-free beekeepers also try to approximate the conditions that feral honey bees survive in, with different hive styles, less equipment (e.g., plastic or wax guides for bees to build comb on), and fewer hive manipulations.

Framed generously, this wave of beekeepers is a band of plucky new freethinkers helping to save the bees by moving away from an overreliance on industrial agriculture, trying out unconventional methods for sustainable stewardship, approaching beekeeping holistically and with care, and rejecting easy solutions like synthetic chemicals and dietary supplements. But many conventional beekeepers are frustrated with this narrative, and claim that these new, treatment-free beekeepers are in fact contributing to the very problem that they claim to want to solve. First, they say, this approach results in elevated honey bee mortality. The principles of evolutionary selection behind treatment-free beekeeping are predicated on the thesis that only the strong survive, which, by extension, means the weak perish. One interviewee suggested that "if the Humane Society knew what was going on, [it] would probably have a word or two to say" implying that treatment-free beekeepers are letting their colonies suffer. This is because while treatment-free beekeeping may in many ways be a simpler approach, that simplicity is deceptive, and it is more difficult in practice to keep colonies alive. Managing disease with fewer tools requires a deep understanding of the intricacy of colony dynamics, such that beekeepers must be "better biologists than almost everybody" (according to one interviewee). Or, as one of my interviewees colorfully complained, "if it was as simple as sticking your bees in a top bar hive [a common alternative and more "natural" style of hive], do you not think that we would have [expletive] done that? Do you really think that… commercial beekeepers literally don't care enough to do something that [expletive] easy?!" Finally, even if adherents to treatment-free beekeeping are willing to tolerate higher losses in the short term, for the sake of longer-term shifts in beekeeping practices and agriculture, their neighbors might not be. Untreated bees can spread parasites and disease if they become "mite bombs": colonies that, collapsing under mites or other pressures, may be abandoned by their bees or visited by bees that rob the honey from the dying colony – both of which can spread hitchhiking *Varroa* mites or other diseases. These bees are thought to be responsible for late summer spikes in neighboring hives' mite populations, making those colonies more susceptible to collapse. Infestations can spread as many as four miles in just a few months, given how far bees fly (McNeil, 2016). Some even suggest that annual losses may have in fact risen in recent years precisely because of the new wave of beekeepers. Thus noninterventionism comes instead to look more like irresponsibility.

So, while some alternative approaches may seem promising, they tend to avoid a serious consideration of the demands of commercial beekeeping and idealize the ability of colonies to fend for themselves. One interviewee lamented how the new wave of beekeepers were doing a disservice to the industry by framing commercial beekeepers "forced by circumstance" to use strong chemical miticides as "uneducated or cruel or stupid or counterproductive to the welfare of bees as a whole." Indeed, this commercial/hobbyist difference is key, even though it is not the only axis of difference between conventional and treatment-free beekeepers. Hobbyist beekeepers can take a more experimental or laissez-faire approach, since their livelihoods do not depend on the health of their bees. They can lose bees and money, absorbing the costs of failure in the service of a larger endeavor. But this very freedom and low stakes may also simply lower the engagement and responsibility of the beekeepers; several interviewees said they had seen lots of people start in the last 5-10 years but only a few who had stuck with it. The one to two thousand commercial beekeepers in the US, by contrast, have invested some or all of their livelihoods in beekeeping, and there is evidence that they lose a smaller fraction of their bees every year (McNeil, 2016, p. 1141). So, at worst, the new beekeepers look well-meaning, but also clueless and even dangerous as they ignore a hard-won scientific consensus about what the main honey bee health problems are, minimize the expertise and investment of individuals with decades of experience, let their own bees suffer, spread disease and parasites, and quit after a few years of failure.

A brief episode from one club exemplifies the divide: a novice beekeeper posted on the list-serv to ask for help with an unconventional hive style and mentorship from an "organic" beekeeper. The primary authority within the club wrote back with the provocation that "many of the people promoting natural beekeeping [know] very little about beekeeping," comparing them to beekeepers from the 1700s who believed fanciful myths. He continued, "there is not one right way to do things… However, there is an infinite number of wrong ways." Another member chimed in, writing: "We all want to become NATURAL beekeepers, but without Bees we are Not Beekeepers!" (meaning that beekeepers who adhere to such methods exclusively are risking their colonies). But another member of the club suggested that his more conventional friend (the initial authority figure) was acting as a "voice for the chemical industry" in echoing the sorts of recommendations made by task forces stuffed with agribusiness representatives. Indeed, conventional beekeepers have not always had the last word. One of my interviewees gently mocked a commercial beekeeper in his club who had boasted that he was going to "show amateurs how to keep bees" by overwintering some colonies in upstate New York (rather than bringing them south for the season, as is typical for commercial operators) – but then lost them all.

Finally, it is important to remember that this divide is really a continuum. So while the distinction is analytically useful in some ways, in the end, to classify real beekeepers as one or the other oversimplifies complex approaches. Beekeepers themselves do use the categories – but usually to define and disparage *other* people's approaches. Most of my interviewees did not fall neatly into one category or another, particularly those with more than just one or two years of experience. They were conflicted about whether to use synthetic mite treatments: some had changed their practices over time; others did one thing and taught another. Several more conventional beekeepers did not treat chemically for mites ("I haven't treated my bees ever. I've never put poison in my hives.") and one formerly treatment-free beekeeper, after having lost all of his colonies several times, has begun to try some (organic) treatments, as well as feeding his bees when forage is scarce, and educating himself more. Interviewees across the spectrum spoke about both individual management challenges and broader environmental stressors, even though conventional/scientific beekeepers tended to frame bee health as an issue at the level of the individual operation, and natural/backwards beekeepers tended to frame it as a symptom of broader environmental degradation. One successful part-timer spoke about both in the same breath: “We want to try to get rid of many of those terrible pesticides, but I think most of the dying, most of the collapse of hives, are due to poor management.”

Apiculture in the Anthropocene

What follows is an analysis of how beekeepers on both sides of this divide articulated dilemmas around management choices for honey bee health. At the time of the interviews, I was aiming to understand divergent approaches to so-called “sustainable beekeeping.” As I began to analyze the interviews, however, it became clear that many of my respondents were describing the limitations of their management choices in the “post-wild world” of the Anthropocene (Marris, 2011).

Novel ecologies and shifting baselines

Beekeepers with several decades of experience have seen firsthand how the environment has changed (Maderson & Wynne-Jones, 2016). The bloom calendar has shifted to the extent that, in the northeastern US, some flowers bloom on average nearly two weeks earlier than they once did. One respondent from a beekeeping family complained that “my grandparents kept a pretty good record of when the flows started… [but the old calendar] doesn’t work anymore, because the environment has changed.” Agricultural practices increasingly limit the amount of bee forage available around the edges of fields and roadsides. Pesticides contaminate the landscape, and although the new formulations rarely kill bees outright, they do interact with each other, accumulate in wax, and weaken bees against other maladies, plus residues of past generations of pesticides can remain in the soil and wax for decades. New pests and pathogens have arrived (*Varroa* and tracheal mites in the 1980s) while others have changed (e.g., a new form of *Nosema* disease has different symptoms than the old). In the 1980s, a new subspecies of Africanized honey bees was introduced, and these "killer bees" now outcompete European honey bees in parts of the southern US.

On the plus side, some new (invasive) plant species have turned out to be good honey plants (e.g., purple loosestrife and Japanese knotweed), making honey bees more reliant on disturbed landscapes, particularly edge areas and along roads (vanEngelsdorp & Meixner, 2010). Indeed, mowing less and expanding these weedy strips is touted as a win-win solution for pollinator health and saving on municipal upkeep. This is true in urban areas as well: one beekeeper in New York City described a "smorgasbord" of "infinite nectar" for his bees, as landscapers across the city – and particularly in the nearby conservatory garden – regularly rip out plants that have stopped flowering and replace them with new ones in bloom during the growing season.

How does this shape beekeeping today? One new beekeeper spoke about the framework that she uses to situate herself among different approaches, one that expressly takes into account today's changed environment:

> You want to let [the bees] do their own thing. But is that even possible anymore in our climate and in this environment?... I think that we should do things that are most environmentally sustainable, rather than "natural" … it's like the vaccine debate … I don't want to use antibiotics and prescription medicine for every little thing that I do, and I want to live a healthy life, where I can prevent most ailments, but at the end of the day, I need vaccines for

> certain things, because it's just impossible in our current world to prevent myself from getting things that you need to get vaccinated for. Why would it be any different with farming? … That's just how our world is, whether we want to accept it or not.

Interviewees repeated this over and over: "how we deal with our bees cannot be the same way that I was taught to deal with my bees even 15, 20 years ago." When I asked one beekeeper and apicultural scientist about whether "sustainable" was a useful concept, she replied "If we didn't have mites, yes. The problem is we have mites." Another explained that "a lot of the practices that… the newer beekeepers want to participate in are really very much reminiscent of the way we used to keep bees, before there were lots of pest and agricultural problems." He was sympathetic to these practices but did not think they were possible without "massive changes in… agriculture." Another beekeeper told me that the "old model doesn't work anymore, just like you can't farm like Dad used to." Beekeepers must account for these new species and relationships or their bees will likely die.

A few participants described the limits and counterproductivity of trying to control the environment. One, a biology professor and hobbyist beekeeper, described how reducing the number of insect species in a field leads to "huge imbalance problems" where the remaining species "become pests themselves." She explained that when "you try to limit or control [the bees'] environment in some way, you're having massive effects in subtle ways that you can't even appreciate until it's right in your face." Other beekeepers in New York State have begun lobbying against efforts by the state government to control the invasive species that their bees make a substantial crop of honey from.

And these "novel ecologies" of the 21st century are only the latest change (Davis et al., 2011). Honey bees themselves were brought from the Old World in the 17th century (although there are thousands of species of native bees). One respondent said that beekeepers were responsible for honey bee health "because we brought them over here," presumably meaning North America. Others described how beekeeping itself was "unnatural," making a more "natural" approach to it nonsensical: "There is a push where we don't do anything with our bees, we don't treat them, we just leave them, basically, in a natural environment. But I think as soon as you put them in a box, that's unnatural. So, my take is that we need to do everything we can for them." In the same way, one considered a treatment-free approach an "oxymoron": "You're putting them in a box, so that's not free of any treatment at all." In other words, in beekeeping at all, beekeepers are engaging in some sort of implicit contract (as they are in relationships to other livestock and pets [Weis, 2013]).

Finally, the changed environment has made scientific research more difficult, given the impossibility of maintaining control colonies and isolating experimental variables. One bee researcher presenting to a bee club meeting lamented several times that "we could actually do real experiments back then," a decade or two ago, before certain viruses and pesticides were so widespread. Another scientist had determined through previous work for the Environmental Protection Agency that nowhere in the US is completely free of pesticides. Now, when conducting any research on bees, he tests even his control colonies for pesticide residues in the wax, pollen, and bees' bodies, which might interfere with experimental conditions. In sum, many respondents expressed the need for beekeepers to take care of bees as they are, and where they are, not as they would like them to be.

Hybridity

Bees as "ghosts"

Honey bees' health problems would seem to give them membership to a not-so-exclusive club of threatened and disappearing animals, or "ghosts" (Tsing et al., 2017; Weis, 2015). For example, Time Magazine's cover story in August 2013 was on "a world without bees"; more colorful approaches have imagined "Colony Collapse Cuisine" – a cookbook for a world without bee-pollinated plants (The Center for Genomic Gastronomy, n.d.). More to the point, honey bees are often seen as wild creatures, impossible to fully domesticate or control, with no convincing evidence that they can recognize their keepers. As self-sufficient superorganisms, they lead lives alien to most human pursuits. More poetically, Henry David Thoreau likened their keeping to the "directing of sunbeams" (Hyde, 2002, p. 48).

Managed honey bees are generally not confined, except when they are transported. To eat and mate, they depend on diverse swaths of land too large for humans to control, up to 50,000 acres (about 80 square miles) surrounding a hive. Bringing in nectar and pollen (and sometimes things that only resemble nectar and pollen) from a wide swath of usually mixed-use land, they are unavoidably exposed to whatever is in the environment. This has most commonly been taken to mean pesticides, but more benignly, it includes whatever plants are available. And as different agricultural crops have waxed and waned in price and popularity, the forage for bees has shifted: for example, in New York State, buckwheat gave way to alfalfa, which then gave way to corn and soy, each transition less nutritious for the bees. Bees' reliance on landscapes that are not managed to protect them has left them vulnerable to environmental changes in ways that most "domesticated" livestock are not subjected to. Many of my interviewees described how their bees were imperiled by a broad range of environmental factors outside of their control.

Bees as "things"

But bees are perhaps more comparable to chickens and cows than to their native pollinator cousins. This is not a new observation; they have been called "Lilliputian livestock" and their hives are emblematic of agricultural "legibility," designed for the needs and convenience of the human beekeeper (Buchmann & Nabhan, 2013, p. 25; Nimmo, 2015; Scott, 1998, pp. 2–3). To improve their chances of survival, they are heavily managed: fed (with sugar syrup or high fructose corn syrup) when there is little forage available, medicated against infectious diseases, and given shelter that is for the most part more secure than what they can find in the wild. Furthermore, the bees themselves have been physically, behaviorally, and socially "remade" over centuries of selective breeding. They are now bigger and hairier, with thicker exoskeletons and changed digestive tracts (Kosek, 2010, p. 651). Colonies tend to be less defensive and more productive than they once were.

More relevantly, today, most of the 2.5 million colonies in the US are intensively managed, "bound to industrialism [and] modern capitalist agricultural production" (Kosek, 2010, p. 671; Suryanarayanan, 2014). Nearly two-thirds of them are embedded in circuits of migratory pollination. These bees spend the early winter in the South, being fed (usually high fructose corn syrup) and growing in population. Most are then trucked to California in February to pollinate the growing number of almond orchards. From there, some colonies go to apple orchards in Washington State, or citrus groves in Florida, or blueberry farms in Maine. Most of these colonies are consolidated into a small number of operations with hundreds or thousands of colonies.

Thus colony numbers fluctuate based in large part on the demand (and price) for pollination contracts, honey, and wax, plus subsidies or other government or market forces, which is to say the change in the total number of colonies from year to year, both domestically and globally, is more about agricultural economics than environmental health. For instance, competition from imported honey, cheap sugar, and sugar substitutes has driven declines in the number of colonies in industrialized countries (K. Smith et al., 2013). Even social and political events shape the number of colonies: the collapse of the Soviet Union and the end of government financing for beekeeping halved the number of colonies in eastern Europe in the 1990s (K. Smith et al., 2013). Therefore, while the number of colonies in the US is roughly half of what it was in the middle of the 20th century, it was in fact the war effort that drove the numbers to an all-time high in the 1940s (because of the rationing of sugar and the use of wax for military purposes), and the numbers have been dropping ever since (vanEngelsdorp & Meixner, 2010).

There is little risk, therefore, that honey bees will go extinct. Their health problems are analogous to the periodic outbreaks within industrial livestock operations such as avian or swine flu, in contrast to the implied mystery or environmental causes often described in the media. Indeed, "saving the bees" is in fact, ironically, a call to stabilize the industrial agriculture and that the very stakes of honey bee health seem so high is due to their integral role in industrial agriculture (Nimmo, 2015). As one interviewee predicted:

> The beekeeping of the future is going to become much more… of a husbandry type industry than it has in the past… more like a lot of the other farming industries have become… There's going to be a lot more protection. We're going to be doing a lot more monitoring, and it's going to become much more like raising poultry or dairy farming.

He expected increased control over bees' nutrition and increased efforts to overwinter them in "environmentally controlled buildings," concluding, "we're really going to have to treat them more like a domesticated animal than a wild insect."

Bees as both?

Honey bees thus embody both halves of the twin rise of "defaunation" (declines in animal abundance and extinction) and "commodi-faunation," or the industrial-scale commodification of animals for meat and other products (Weis, 2015; Young et al., 2016). They are threatened by the degradation of the landscapes that they depend on, but they are also deeply embedded in agriculture, such that they would not exist in such great numbers if it were not for that relationship. This hybridity is not a new observation: Claude Lévi-Strauss claimed that honey bees were in a "liminal zone" in between nature and culture (Nimmo, 2015, p. 186). Anna Tsing has written about the social construction of bees' domesticity alongside their independence (1995).

Briefly, the perceived relationship of honey bees to other, native pollinators is instructive, insofar as it helps pin down what a honey bee is and is not. Some authors draw a contrast between them, fearful that a focus on honey bees could diminish efforts to conserve wild species, and even contribute to further declines, as the different species compete for resources and share diseases (Geldmann & González-Varo, 2018). Others have found the conflation useful: the federal-level Pollinator Health Task Force report tacks between a discussion of native plants, pollinators in general, and 15-billion dollar pollination industry, in an effort to describe (and construct) what is at stake (2015).

Being "kept" has in some ways been bad for the bees – as they give their honey up to their keepers, face the stresses of hive inspections, and more. One of my interviewees joked that the "best thing to ever happen to beekeeping was the development of [the modern hive] and the very worst thing that ever happened to bees was the invention of [the modern hive]." But kept bees are also fed and sheltered, and are likely much more numerous than they would be without such a relationship to humans. Perhaps they have domesticated us, using us for their own ends, rather like Michael Pollan's tulips and potatoes (2001).

Not-so-natural selection and fitness

Finally, one area of overlap between the two approaches to beekeeping stands out. Today, some of the most respected figures in beekeeping are looking to develop a long-term solution by breeding stocks of bees that are resistant to or tolerant of mites and other pests and diseases. One long-time honey bee behavior researcher, Tom Seeley, has introduced the idea of "Darwinian beekeeping," where genetic traits that confer better resistance to or tolerance of mites such as hygienic or grooming behavior, are promoted through a mix of genetics and limited management (Neumann & Blacquière, 2017; Seeley, 2017). This hands-off approach entails keeping smaller colonies that are less concentrated (fewer hives per apiary) and allowing colonies to swarm (or reproduce by splitting into two, sending one half of their population out into the wild – a behavior largely suppressed by beekeepers). In short, it suggests that beekeeping should support colonies that are leaner and possibly meaner – meaning more defensive and difficult for beekeepers to handle – and not managed for maximum honey production or pollination services.

In the same vein, many beekeepers I spoke to – especially in more northern climes – are converging on the need for locally adapted populations, promoting genetics that help bees adapt to varied climates and microclimates (McNeil, 2016). One interviewee described a sustainable approach as requiring "breeding and selection and… really paying attention to the genetics." She described her process of genetic testing on different bees, and how she selected certain queens. A similar project is underway at Cornell University to breed and evaluate locally adapted bees with other stocks developed for mite resistance.

In many ways, genetics go hand-in-hand with localization: the bees that fare well in south Florida are not the same bees that can survive a winter on the St. Lawrence Seaway. One respondent was clear that his bees had to be regionally adapted to the Northeast. But localization has its limits. I lurked during heated list-serv discussions about whether and how quickly population dynamics can reflect local environmental pressures. A state apiarist also described the need for genetics to promote behavior to make bees easier to transport, like staying calm in a moving vehicle – genetics that would be valuable for commercial beekeepers, but not hobbyists who keep their bees in their backyard.

So, despite the apparent convergence on the theory behind genetic tools, they have not actually brought the different camps together in practice: one interviewee complained that she had seen beginner beekeepers take just one piece of a successful treatment-free approach, and try to practice it without the rest of the required manipulations, meaning that they would simply buy bees and let them die of diseases: "They're not doing anything to select for better bees. The only way that that works is if the surviving ones are then the ones you breed the next year."

Conclusion

So what does it mean to "save the bees" in a world of novel ecologies and shifting baselines, where the bees themselves are a hybrid creature? Managed honey bees are emblematic of the Anthropocene – animals husbanded as gardens are tended, "monsters" shaped by scientists and bred by commercial beekeepers, and sites of struggle around the political economy of agriculture (Robbins & Moore, 2013). It is not that one group of beekeepers is right or the other is wrong; rather, each has different visions of the honey bee, and in trying to save it, each is trying to save something different. One is trying to save a modern beekeeping industry that goes back more than a century, conventional agriculture with its large and distant monocultures, the livelihoods that support and depend on it, an entire way of life for much of the global North. The other group is trying to save something even bigger: an idea of "nature" that flourishes outside of human control.

Bruno Latour has written about how today's world is a bit like Frankenstein (2011). In Mary Shelley's original story, the sin was not the making of the monster; it was its abandonment. Only in its abandonment did the monster became a threat. In the same way, we have (re)made our world, including the bees, and we cannot abandon them to a world for which they may no longer be fit (Lorimer & Driessen, 2013). But it is not yet clear what taking responsibility for it means. And as the bees are unlikely to go extinct with or without our help, the issue is not about honey bee survival; it is about whether we think honey bees can suffer and what our responsibility is for individual colonies. More broadly, it is about our relationship to agriculture, our expectations from farmers, whether we should welcome the international trade and transport of organisms or try as much as possible to contain them, and more. There are no straightforward "solutions," just a long series of conversations about values and priorities, the slow establishment of new norms, updates to institutions like cooperative extension programs. So, despite scholars' skepticism of the human-centric focus of the Anthropocene, I conclude this article with a focus on the beekeepers themselves. They must continue to learn, and learn to live together, with what one interviewee called "beginners mind." The changes in the landscape in the decades that this particular beekeeper had kept bees have forced him to rethink what he thought he knew, what used to work. As the past is not erased, but is not a good referent anymore, it is not clear yet what sorts of knowledges will be the most useful (Adams, 2018; Maderson & Wynne-Jones, 2016). Let the Anthropocene be a call for clear-eyed responsibility in a changed world.

PAPER 2: "THE MAIN OBJECTION TO NUMEROUS SMALL BEE KEEPERS": BIOSECURITY AND THE PROFESSIONALIZATION OF BEEKEEPING

Abstract

In the mid nineteenth century, advances in apicultural science and new technologies made beekeeping more efficient and profitable, and it rapidly went from being a cottage industry to a commercial one. But the very technologies and practices that revolutionized beekeeping led directly and indirectly to the spread of an infectious honey bee disease called foulbrood. This was true most of all in upstate New York, which for many decades was at the center of the scientific, technological, and commercial advances, as well as the outbreaks of foulbrood. In this article, I draw on USDA publications, articles from trade magazines, personal papers, and other texts from the late nineteenth and early twentieth centuries to show how the institutions that arose to protect and support the industry formed an "envirotechnical regime" that promoted a particular vision of "good beekeeping." The regime characterized foulbrood as manageable only by beekeepers who were "financially interested" or "more deeply engaged in the industry." This set of beekeepers was contrasted with a second class of smaller scale beekeepers, which was framed as "negligent" and discouraged from continuing to keep bees. This article shows how efforts to professionalize beekeeping were made in the name of biosecurity and contributes to scholarship more broadly on how norms and institutions developed as a part of the modernization of American agriculture.

Keywords

agricultural modernization, biosecurity, envirotechnical regimes, beekeeping, professionalization, "good farming"

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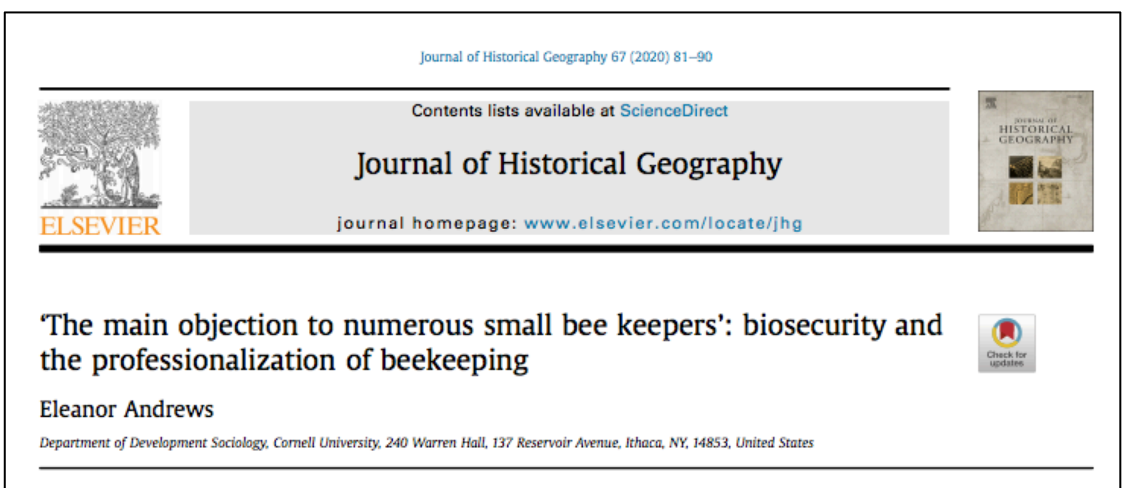

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'The main objection to numerous small bee keepers': biosecurity and the professionalization of beekeeping

Eleanor Andrews

Department of Development Sociology, Cornell University, 240 Warren Hall, 137 Reservoir Avenue, Ithaca, NY, 14853, United States

Beekeepers have been keeping honey bees in hives for thousands of years. But in the mid to late nineteenth century, the invention of a new style of hive and a suite of related technologies and practices thoroughly transformed beekeeping, and it grew from a cottage industry to a commercial sector in just a few decades. This transformation was most evident in upstate New York, a hub of innovation in agriculture and a major producer of honey for decades. But the very technologies and practices that revolutionized beekeeping also changed its ecologies, leading to the spread of an infectious honey bee disease called foulbrood. As the heart of the beekeeping revolution, New York State was also the epicenter of foulbrood, and home to many of the institutions, such as Cornell's beekeeping extension program, that emerged to protect and support the industry by containing the disease.

These institutions promoted a vision of beekeeping predicated on biosecurity, emphasizing beekeepers' individual and collective responsibility for the health of their bees. Specifically, foulbrood was characterized as manageable only by "progressive" or "expert" beekeepers (in contrast to "negligent" ones) who were "financially interested" or "more deeply engaged in the industry" (E. F. Phillips, 1909, p. 61). Then as today, the beekeeping industry was composed of two overlapping groups: the few men who had come to rely on beekeeping as a significant source of income, and the much larger number of hobbyists. The distinction generally correlates to the number of colonies managed, although the number is only a rough indicator of profit and management style. But however blurred the lines may have been in practice, the agents of modern beekeeping insisted on the difference, calling for the replacement of small, household scale apiaries with "fewer and more expert" beekeepers who managed more intensive or extensive operations (Holloway, 2019; E. F. Phillips, 1909, p. 61). Thus beekeeping came to be professionalized based on a particular vision of honey bee biosecurity that grew out of the unforeseen consequences of the new hive design and associated technologies and practices.

Some parts of this history have been chronicled elsewhere. The patenting of the new hive design is widely regarded as a watershed moment in the history of beekeeping (Ebert, 2009; Kritsky, 2010; Oertel, 1971). Within the industry, beekeepers themselves are cognizant of the differences between commercial operators and hobbyists. More broadly, scholars have established that agricultural extension programs and other institutions that contributed to the modernization of agriculture were productivist and exclusionary, historically favoring bigger commercial operators. Literature on biosecurity emphasizes the inherently political nature of trying to halt or divert the flows of organisms. With this article, however, I seek to draw together and contribute to several scholarly conversations by demonstrating how beekeeping institutions were part of an "envirotechnical regime" with institutions that promoted new norms around what "good" and responsible beekeeping entailed, based on a contagionist understanding of disease (Haggerty et al., 2009; Pritchard, 2011). My analysis of the modernization and professionalization of beekeeping connects scholarship on envirotechnical regimes and norms in farming with political ecological work on biosecurity by laying out a historical case that continues to resonate in the beekeeping industry today.

Modernizing agriculture: new geographies, new risks, new norms

Agriculture was technologically, economically, and socially transformed in the nineteenth and twentieth centuries in the United States. The rapid industrialization of the manufacturing sector served as a "template," as farms were encouraged to become more like factories (D. K. Fitzgerald, 2003, p. 5). They were to increase the scale, speed, and efficiency of their operations and undergo standardization, routinization, and specialization within the labor force to increase yields and profits. Such "industrial logic" required coordination, achieved through emerging agricultural institutions that were woven together in a "matrix of technical, social, and ideological relationships" (Cohen, 2011, p. 4; D. K. Fitzgerald, 2003, pp. 6, 5). Individual farmers were enrolled into this matrix as they took up particular elements of modern agriculture, as described by agricultural historian Deborah Fitzgerald: "[w]hen a farmer adopted a tractor, for example, he tacitly adopted a whole host of other practices and entered into a new set of relationships" with new people (2003, p. 5).

But an agricultural system is a "rearrangement, not a repeal" of natural processes, and as a system becomes more intensive or more extensive, it creates new ecologies that can threaten its continuation (Boyd, 2001, p. 635; Worster, 1990, p. 1094). The unintended consequences of the acceleration and simplification of biological processes and their incorporation into industrial systems has been shown time and again. For these reasons, it has been suggested that we call agriculture "risk agriculture" (along the lines of Ulrich Beck's "risk society") (Beck, 1992; Law, 2016, p. 237). Such risks often arise due to new spatial relationships, as the high density and uniformity of modern farming increases the concentration of various flora and fauna, “invit[ing] epidemics” of weeds, pests, plant pathogens, or animal diseases (epizootics) (Scott, 1998, p. 268; Worster, 1990, p. 1105). Animal pests, like the muskrats and beavers that destroyed newly dug irrigation canals in western Canada in the late nineteenth century, plant pests such as the Russian thistle that spread along those same irrigation canals, and diseases that plagued the nascent poultry industry — all of these thwarted the growth and intensification of agricultural systems (Beck, 1992; Boyd, 2001; Evenden, 2006). Such spatial effects are true beyond agriculture: crowding among wild birds in the late nineteenth and early twentieth century proved to be deadly, as was the “biotic homogenization” of the cities that were home to large urban herds of horses (Kheraj, 2018; McShane & Tarr, 2011; Wilson, 2011).

The matrix of institutions that arose to support modern agriculture across the United States was designed in large part to safeguard against these risks of pests and disease, across different sectors and states (Stoll, 1995). For instance, the United States Department of Agriculture (USDA) and private industry erected infrastructure at state, regional, and national levels to coordinate their approaches to disease within the poultry industry (Boyd, 2001). Similarly, California’s vast network of government agents, industry representatives, and research scientists from the public university and agricultural experiment station came together at the turn of the century to support industrializing farmers against insect pests (Palladino, 1994; Stoll, 1998). Sociologist Chris Henke argues that such institutions, including extension and the broader assemblages of agricultural science, established their expertise by identifying problems they could repair and then performing those repairs — even if such problems had grown directly out of their earlier interventions (2008, p. 7; T. Mitchell, 2002, p. 42).

This matrix might also be called an "envirotechnical regime," or the "institutions, people, ideologies, technologies, and landscapes that together define, justify, build, and maintain a particular environmental system as normative" (Pritchard, 2011, p. 23). The word "regime" draws attention to how these constellations are "prescriptive," justifying and promoting particular practices as normative. In agriculture, these norms are produced by "clusters of practices, signifiers and relationships that constitute and reproduce … the culturally valorized understanding of 'good farming'" (Burton, 2004; Haggerty et al., 2009, p. 768). In other words, as agricultural institutions developed, they set out to promote a vision of a "good farmer." This has mostly been equated with productivism; much of the scholarship on the institutions of modern agriculture, such as cooperative extension, has focused on how productivism privileged certain scales and benefitted some producers over others (Hightower, 1973).

But today and historically, "good farming" has not only been geared toward production and profitability; it has also hinged on the idea of biosecurity, or efforts to manage risks to health and life through preventing and containing disease among crops and livestock (Hinchliffe & Bingham, 2008). Preventative or reactive practices to halt or slow the spread of visible or invisible organisms include vaccinations, quarantines, protecting or cleaning organisms (including people) or things that might move between these spaces, culling infected animals, and more. Many such practices are inherently spatial: geographers Nick Bingham and others have noted that ongoing biosecurity efforts seek to “monitor, regulate, and/or halt the movements of various forms of life” (2008, p. 1528).

Biosecurity has been identified with being a “serious” farmer, in contrast to “hobbyist” farmers, who are framed as “necessarily ignorant and risky” (Holloway, 2019, p. 27). Farmers sometimes have trouble articulating a positive definition of good farming, but they are quick to distinguish themselves from its opposite; indeed, recent scholarship has described conflicts among different groups of producers over biosecurity and what it means to be a “good farmer” (Naylor et al., 2018). The view of “smallholder and domestic production [as] a threat” to biosecurity is relatively widespread, wherein small scale farmers are believed to be endangering the livestock of other, neighboring larger scale farmers (Holloway, 2019, p. 19). One history of the transformation of cattle ranching in the southern United States describes how cattle ranchers with different markets managed tick infestations differently. Those who raised cattle for smaller, local markets or subsistence saw ticks merely as an “annoyance” that did not need to be managed as intensively (Strom, 2009, p. xv). But tick-ridden cattle posed a risk of infection to those owned by the ranchers who wished to sell their livestock at bigger markets, keeping their animals from being more widely marketable. As the eradication of ticks was an “all-or-nothing proposition,” the relationship between the two groups of ranchers was fraught (Strom, 2009, p. xv). More recently, in the 2006 outbreak of avian flu in Egypt, the government blamed household poultry production and culled those birds, citing the ability of veterinarians to control disease in bigger farms (Hinchliffe & Bingham, 2008).

But commercial farming practices may be "immanent[ly] patholog[ical]," as much or more than those of smallholders (Holloway, 2019, p. 27). It is often the efforts to manage biosecurity that contribute to bio*in*security. In other words, actions taken to diminish risk are often in fact "part and parcel of [its] social and material generation" (Bingham et al., 2008, p. 1529). Such an irony makes it all the more evident that the management of contagious diseases is both cause and consequence of "epistemic frameworks and power relations" (Lynteris & Poleykett, 2018, p. 433). Indeed, Andrew Donaldson has described biosecurity as produced as much through "glossy leaflets and video tapes of distributed guidance and the paperwork of farm health plans … as through cleansing and disinfecting, isolation, and movement controls" (2008, p. 1555).

In the late nineteenth century, a "contagionist" approach to biosecurity was prevalent, in contrast to a more environmentalist or "localist" outlook, which points to the role of the local environment, such as the presence of standing water, climatic conditions, or a lack of sanitation (Ackerknecht, 1948; Baldwin, 2005, p. 4). The contagionist approach usually entailed quarantines and was therefore more interventionist, requiring bureaucratic control. Historians Clay McShane and Joel Tarr have analyzed how contagionism became doctrine in managing horse health, increasing the power of professional veterinarians (2011; Nash, 2007). Such interventions have often been framed as "antipolitical," their deeply political nature is obscured, deliberately or otherwise, by a more technical framing (A. Donaldson, 2008). But the management of human and nonhuman lives in the name of biosecurity has a long political history. Statecraft in the nineteenth and twentieth centuries was shaped in part by “epistemologies of epidemics,” as officials sought to reconcile individual and collective needs for health and security (Baldwin, 2005). Risk more broadly has been described as “a way in which we govern and are governed” (A. Donaldson, 2008; O’Malley, 2000, p. 459).

The spatial and political dimensions of biosecurity are especially relevant in histories of bugs and bacteria, populations that are relatively difficult to see and control. Mosquitoes, for example, underpin Timothy Mitchell’s retelling of Egyptian history (2002). Their control, or governance, is far from straightforward, and different institutions have taken contrasting approaches to it. One position privileges and responds to microvariability in mosquito habitat, for example, in rooting out the tiny possibilities afforded by flowerpots or old tires; the other position takes a more totalizing approach, by spraying more or less indiscriminately (Shaw et al., 2010). Along similar lines, geographer Dawn Biehler has described dueling “spatial imaginaries” behind different approaches to managing flies in urban landscapes, based on what reformers believed they could control more effectively: the movement of flies or the actions of the city’s human inhabitants (2010, p. 69).

Briefly, there is an ongoing scholarly debate about the degree to which nature and nonhuman animals have agency in driving change (Ritvo, 2017). Biehler shows how flies reordered urban spaces, but in the case of honey bees, the arrow of causality points both ways, meaning that bees and their relationships to bacteria were both cause and consequence of changing beekeeping practices (2010, p. 69). Bees’ behavior as well as their preference and tolerance for particular kinds of spaces drove the development of hive and apiary configurations and associated practices, but in turn, as new practices rendered both the bees and more mobile, there were further unintended effects. This article therefore accords with environmental historian John Soluri's emphasis on "entanglement" in the complex history of banana cultivation, as well as Steve Hinchliffe and others' idea of a "disease situation" (rather than an "assemblage") to describe the "potentiality" of particular combinations of human and nonhuman agents (Hinchliffe et al., 2016, p. xv; Soluri, 2005, p. 217). Relatedly, recent political ecological literature on health has described the emergent nature or "second-order properties" of disease, meaning that it is produced synergistically through different components of a disease situation that combine into more than the sum of their parts (Senanayake & King, 2019, p. 714).

As I describe below, the institutional agents of beekeeping preferred a broad, almost universal approach to biosecurity that would streamline beekeeping practices — but they wanted this approach precisely because of the fine-grained attention to bees and bacteria that such an approach would bring to bear on foulbrood. This article contributes to scholarship at the intersections of historical geography, historical political ecology, and environmental history, describing how emerging institutions sought to stem the spread of honey bee disease by calling for specialization among beekeepers and the professionalization of the industry.

To assemble this history, I drew on extension publications from the late nineteenth and early twentieth centuries, as well as personal papers and other contemporaneous documents.[14] Articles and letters from beekeeping trade journals

[14] These publications are spread across several libraries and collections at Cornell University, including the Kroch Library Rare and Manuscript Collections, the Everett F. Phillips' Beekeeping Collection at the Albert R. Mann Library, and the digitized Core Historical

(*Gleanings in Bee Culture*, *American Bee Journal*, and *American Bee-Keeper*) shed light on the national and regional context. Government extension publications from the Bee Culture division of the Bureau of Entomology (within the United States Department of Agriculture) provided historical background and a snapshot of the scientific understanding of honey bee health and honey production at the turn of the century. Cornell Cooperative Extension pamphlets and newsletters from the 1910s to the 1930s gave a boosterish summary of ongoing activities. The personal papers and published work of Everett Franklin Phillips, the first professor of apiculture at Cornell, were most useful, as well as correspondence among some of his contemporaries in beekeeping and entomology.

A major gap in the sources is the voices of the smaller scale beekeepers of New York.[15] To address this pitfall, I have triangulated the archival materials from Cornell's collections with assorted letters and other contributions to beekeeping trade journals from a wider range of authors. These other sources likely also overrepresent elite and educated journal subscribers, and further, a subset of those with the time and inclination to send correspondence. Still, those journals were widely read by hobbyists and novices and not just commercial operators, and the conversations within seem to represent a varied cross section of the era's beekeepers.

Literature of Agriculture collection. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

[15] This gap might also include the voices of honey bees themselves; one beekeeper told me that "the very best thing that ever happened to beekeeping was the development of the [modern hive] and the very worst thing that ever happened to the bees was the invention of the [modern hive]".

The beginning of modern beekeeping

The origins of the beekeeping industry differ markedly from those of other agricultural sectors. Beekeeping has been called the “ugly stepchild of agriculture,” since while honey bees are key pollinators and produce valuable products (honey and wax), they are often overlooked or even endangered by the larger sectors of agriculture (Oliver, 2009). The nascent industry did not benefit directly from many of the advances in fertilizer, feed, and farm machinery in the late nineteenth and early twentieth centuries. Land use and land cover change resulting from agricultural changes impacted the available forage for bees, and the spray chemical industry that was so integral to the modernization of agriculture posed risks to bees. Nor did beekeeping fit into many entomology programs, whose relationship to most insects was decidedly less nurturing (Suryanarayanan & Kleinman, 2013).

Nevertheless, the mid to late nineteenth century was a heady time for beekeepers in the United States. In 1852, Reverend Lorenzo Lorraine Langstroth of Philadelphia patented a revolutionary hive design that is widely considered to mark the beginning of modern beekeeping, as it came to almost entirely replace other sorts of structures, such as woven straw skeps, hollowed-out logs, and other boxy designs (Kritsky, 2010; Pellett, 1938, p. 14). The new hive style allowed beekeepers to open their colonies and inspect them more closely than ever before, literally shedding new light on the bees and revolutionizing so-called “old-fashioned” and “crude” practices (Sechrist, 1918, p. 3).

The new hive design had frames of honeycomb that could be removed because they took advantage of an important dimension of honey bee behavior and natural hive architecture, namely that if the space between two wax combs is of a precise size, the honey bees maintain that space — any larger, and they fill it with more wax, any smaller, and they plug it with a sticky resin called propolis (Langstroth, 1860, p. 96). This dimension, approximately three-eighths of an inch, is called "bee space." "Bee space" is perhaps not the same sort of space that geographers are usually attentive to, but its identification and application allowed Langstroth to design a hive with regular frames of honeycomb that would not be stuck together by wax or propolis and could therefore be removed without cutting or destroying them (Fig. 4). This allowed beekeepers to conduct inspections of their hives periodically, to evaluate the health and development of the colony, something that had previously been impossible. Beekeepers could also harvest some, but not all, of the honey in a hive: enough to maximize their production, but not so much as to risk the starvation of the colony over winter. In this way, hives became "knowable and manageable"; indeed, this modern hive design served as the initial analogy for the concept of "legibility" developed by anthropologist James Scott, a beekeeper himself (1998, p. 2).

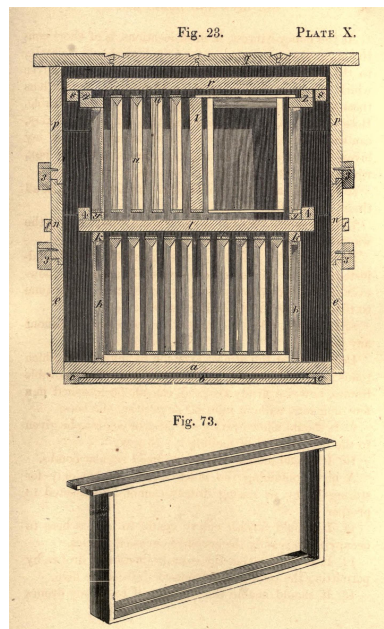
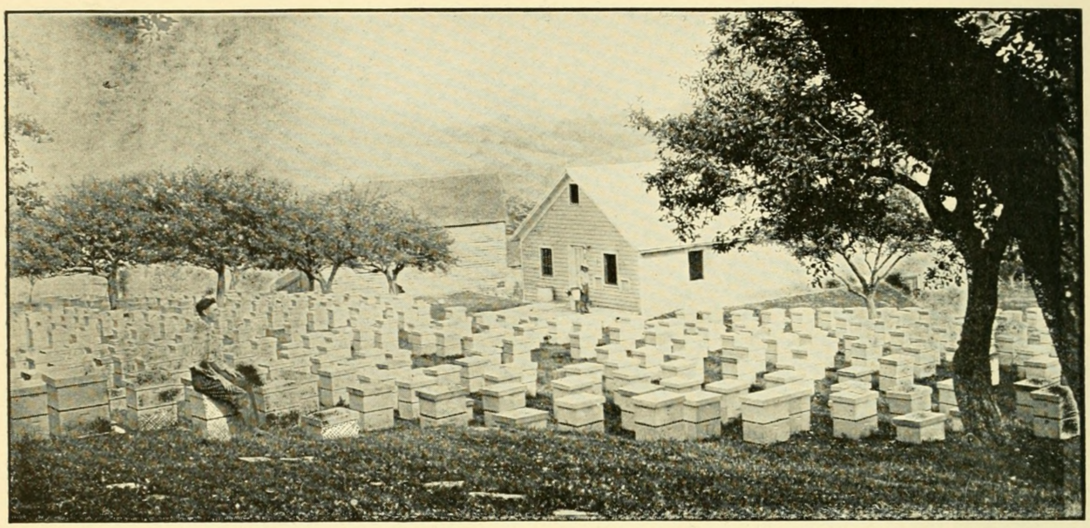


Figure 3: An image from the 1860 edition of Langstroth's book shows the cross-section of a two-story hive. The hive architecture conforms to the strictures of bee space (Biodiversity Heritage Library)

With the newfound ability to inspect honey bee colonies and manage them more precisely, apicultural science quickly progressed, transforming a sleepy pastoral pastime into what one onlooker in 1907 called “the most thoroughly scientific of all the pursuits which … make up the general science of agriculture” (Boyden, 1907; Lawes, 2011, p. 14). By 1909, it was said that “[f]ew rural pursuits have made greater progress during the past half century than [beekeeping]” (E. F. Phillips, 1909, p. 59). The accrual of scientific discoveries contributed to a positive feedback loop of change, growth, and profitability. Inventions compatible with the new hive design were collectively developed and shared, including an extractor that streamlined honey harvesting and sheets of wax foundation that guided bees to build more regular and standardized honeycomb (Pellett, 1938). These innovations allowed honey to be harvested without destroying the honeycombs, which could be returned to the hive and reused from season to season. The reuse translated into the production of even more honey, since bees need to consume honey in order to generate wax and (re)build wax combs (Ebert, 2009). And so just as agriculture was over time structured to be more compatible with the machines and tools that performed much of the work, so beekeeping came to be structured around the new hive architecture.

This was the “Golden Age” of beekeeping, and it played out nowhere more than in upstate New York (Borst, 2013; Pellett, 1938). In 1860, New York was the most populous state in the country, with more farms, fruit production, and livestock than any other state. The state had the “right ingredients” at the right time for apicultural industrialization: “geography, climate, capital, entrepreneurs, laborers” (D. K. Fitzgerald, 2003, p. 9; Pawley, 2009). Upstate geography was especially advantageous, as it included a vast acreage of bee forage (largely buckwheat and clover), the space to manage huge apiaries, and proximity to the markets of New York

City. New York was therefore home to some of the first industrial scale commercial apiaries in the country, and was in the top handful of honey- and wax-producing states for decades (D. K. Fitzgerald, 2003, p. 9; E. F. Phillips, 1909).[16] In just a few decades, the upstate operations of some individual beekeepers grew from dozens to hundreds to thousands of hives (Fig. 5) (Orton, 1908, p. 1504). Honey production in the state nearly doubled in the ten years after the Civil War, and doubled again by the turn of the century, peaking at over three million pounds in 1910, roughly equivalent to the amount produced in the state today (Borst, 2013; National Agricultural Statistics Service (NASS), 2019).



THE ALEXANDER APIARY, FROM THE NORTHWEST.
There is probably not another apiary in the world consisting of 700 colonies.

Figure 4: In 1908, beekeeper E.W. Alexander was said to have the world's largest apiary, about twenty-five miles west of the Hudson River in upstate New York.

New York Quaker Moses Quinby was the first man to manage hundreds of colonies prior to the Civil War, although he is better known today for having invented the smoker, an essential beekeeping tool. Quinby's bees along the Erie Canal

[16] Now New York is only occasionally in the top ten.

doubtless mingled with those of Captain John E. Hetherington, who was said to have produced "more honey than any beekeeper who had ever lived" from after the Civil War until his death in 1903 (Borst, 2013; Edwards, 2014, p. 80). The following year, Lamar Coggshall took the crown with over three thousand hives in and around Tompkins County (by then home to Cornell University), helping make it the number one honey producing county in New York and possibly the world (Morse, 1967a). Beekeepers around the country read about Coggshall's methods in trade magazines that described the fast paced assembly line with a team of men and boys who opened hives, drove off the bees, and extracted honey in record time (Borst, 2013). Individual beekeepers also extended their holdings through outyards or "outapiaries." With the growing availability of cars and trucks, beekeeper were advised to "study carefully [their] territory for 100 miles in each direction" in order to site their bees in the most productive and profitable spots, and temporarily move their bees to where forage was in bloom, to be able to produce more honey (Rucker & Thurman, 2019, p. 10). Coggshall had outapiaries in 1878, at a time when most beekeepers still had their hives closer to home (Borst, 2013).

Thus New York had all the makings of agricultural modernization that Fitzgerald has identified as important: "specialized machines" such as hives, extractors, and wax foundation; "standardization of processes and products" including the interchangeable parts of the hives; "large-scale production" in record setting operations; the "evocation of 'efficiency' as a production mandate" in talk of the honey saved through reuse of wax; and a "reliance on managerial (rather than artisanal) expertise," embodied in Coggshall's rapid fire assembly line (D. K.

Fitzgerald, 2003, p. 5; E. F. Phillips, 1909, p. 79). But the very innovations that modernized apiculture also aggravated existing problems, as the new hive style, the suite of practices that went along with it, and the attendant growth in businesses together paved the way for a devastating plague of disease called American foulbrood.

A "veritable scourge"

American foulbrood was not new to the United States, having been a "nuisance" since honey bees had first been imported from Europe in the seventeenth century (Ebert, 2009, p. 197). But the rise in its incidence made it a "veritable scourge" as it wiped out entire apiaries and depressed honey production across the United States for decades (vanEngelsdorp & Meixner, 2010). It is caused by spore-forming bacteria (*Paenibacillus larvae*) that affect honey bee larvae and pupae, called brood. The name comes from the characteristic unpleasant odor of advanced cases, but the disease is also recognizable through a visual inspection, as the larvae is discolored or stringy, and the wax cappings that cover the pupae may be sunken or punctured. A foulbrood infection in its early stages may only be visible in a few out of the tens of thousands of brood cells in a hive and therefore difficult to detect until a later stage. An infected colony, even one that is otherwise healthy, will die, but its death is not sufficient to end the risk of disease for nearby colonies, as infectious spores can remain in old equipment or wax for decades.

American foulbrood can quickly spread and the emerging suite of "standard beekeeping practices," such as of concentrating many hives in a single apiary or reusing hives, honeycombs, and equipment, tended to increase its spread (Fries &

Camazine, 2001). Foulbrood is most commonly spread when healthy bees rob other hives and bring home honey with spores. Robbing is usually only a problem in hives less than a mile from a foraging bee's home hive, but bees can fly much further and may rob honey from hives further away (Lindström et al., 2008). This route of transmission is exacerbated by the fact that colonies weakened by disease are more likely to be robbed, since they have lowered defenses. There are other routes of foulbrood transmission as well. A new colony may become infected if it occupies the hive where a diseased colony had once lived; the bees may be put there by a beekeeper or they might move into the empty hive on their own. Bees carrying spores may join and infect new colonies if they are leaving a collapsing colony or if they mistake a different hive for their home hive; this is more likely when hives are crowded. Finally, when a colony swarms, meaning half of its population leaves the original hive to start a new colony in a new location, the swarm may bring spores with it to the new nesting site. This happens naturally but can also be induced by a beekeeper splitting his or her colonies. In short, despite the many creative efforts to rid hives of the disease without losing the colonies, a beekeeper has little recourse but to incinerate affected hives, bees and all, to prevent the spread of foulbrood.

Foulbrood's epicenter was New York, and it was for a time called "New York bee disease," much to the consternation of local beekeepers (White, 1906). In some years, it spread widely; in others, outbreaks were limited. In 1870, the statewide beekeepers' association noted that it was not as bad as it had been ten years earlier, but the lull was followed by another outbreak in the mid 1890s, which led to the identification of a second, less virulent strain, European foulbrood (Morse, 1967a).[17] European foulbrood was also most problematic in New York: a 1906 USDA publication explained that European foulbrood had recently spread from New York to neighboring states (White, 1906). Foulbrood of both kinds was again rampant in the state in the 1920s (Morse, 1967a).

The use of the Langstroth hive and the practices that grew out of its adoption inadvertently spread the disease. Most straightforwardly, as operations grew bigger and more concentrated, growing from dozens to a hundred hives in one yard, foulbrood spread more easily among colonies. Beekeepers could also vector the disease if they used the same equipment to inspect multiple colonies throughout or between apiaries or moved honey or brood between different hives (done to support weaker colonies by using resources from stronger ones). The growing trade of secondhand supplies was also a vector.

Other new practices also contributed to outbreaks. The modern honey extractor allowed for wax combs to be reused from year to year. But what had come to seem wasteful — the destruction of the comb, in the old way of extracting honey — was also more hygienic. Furthermore, it had once been a relatively common practice for beekeepers to harvest all of the honey from their most and least populous colonies before winter (in more northern climates), leaving the bees for dead or killing them outright. The logic was that the biggest colonies usually had the most honey, and all of it could be taken if the bees were killed and

[17] The science of foulbrood took some time to work out: there were conflicting reports and confusion between the two varieties (American and European) well into the 1900s. American foulbrood was so called because it was first studied in the United States; the other strain was given the name European foulbrood in 1906 for similar reasons. The American variety is more virulent, and is the one referred to in this narrative as foulbrood, except where the distinction is necessary (E. F. Phillips, 1918).

did not need any to survive the winter. All of the honey could also be taken from the smallest colonies, which were unlikely to survive anyway. But beekeepers could now extract some honey from most or all of their colonies and try to keep more of them alive, perhaps by giving them honey or brood from another colony. But harvesting all of the honey from the smallest colonies and leaving them to die had curbed the spread of disease, as the smallest colonies were generally the ones afflicted by disease, and they died before it could spread (vanEngelsdorp & Meixner, 2010). In the new effort to overwinter more colonies, beekeepers kept their small, failing ones alive longer, likely contributing to the infection of other, nearby colonies. In sum, while some previous management practices may have been needlessly destructive and inefficient, they also maintained selective pressures that kept infectious disease in check.

An emerging envirotechnical regime in beekeeping

As bees across the United States continued to suffer from foulbrood, a growing web of institutions came to support the nascent industry, making up an envirotechnical regime in beekeeping with apicultural scientists, government inspectors, beekeepers, extension agents, and more. The federal government first set aside money for apicultural research in 1885, through the USDA's Bureau of Entomology. Early work was largely focused on disease, although other perennially popular topics for pamphlets were honey production, winter management, and regional considerations (Fig. 6).[18] In 1903, USDA researchers isolated the bacterium responsible for American foulbrood, and ten years later, proved that a different species was behind European

[18] The original bulletin was published in 1918 with a different cover image; the edition shown here was printed in 1932.

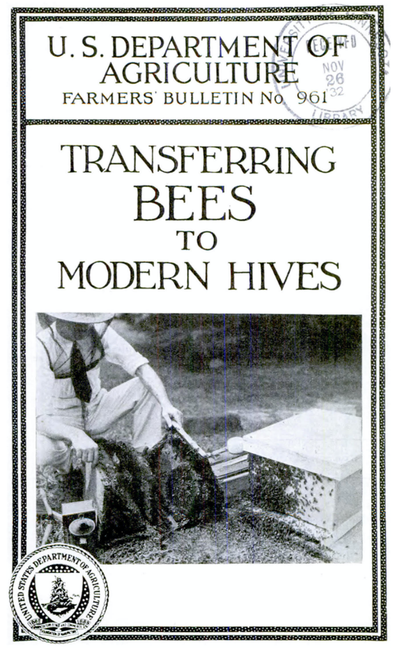


Figure 5: A USDA pamphlet stressed the productivity of 'modern hives.' (Farmers' Bulletin, issues 951–975, US Government Printing Office)

foulbrood (Pellett, 1938, p. 190). Much of this work was a correction to earlier texts that had conflated American and European foulbrood and wrongly suggested that foulbrood was spread from animal carcasses or a result of insufficient honey and pollen (White, 1906, p. 31). The federal government also employed beekeeping extension officers starting in 1888, efforts which grew further in 1914, when the Smith-Lever Act expanded the cooperative extension system to land grant colleges and universities. Across the nation, men were hired by the federal Bureau of Entomology to run education and outreach activities. New York was the second state to receive such personnel focused on beekeeping, and from 1917 until at least the 1930s, federal agent George H. Rea and others visited apiaries and gave demonstrations to beekeepers across the state ("Extension Work in Beekeeping Resumed," 1919, p. 62).

New York's beekeepers repeatedly endorsed the extension program, asked for specific research, and planned association meetings around events. A statewide association was meeting regularly by 1870, to swap ideas about disease management, marketing strategies, new technologies, bee breeding, and more (Morse, 1967a). It tracked outbreaks of foulbrood and marshaled its members to respond collectively, calling for more scientific research and trading information through national journals such as the *American Bee Journal* (from 1861 onward) and *Bee Culture* (from 1873 onward). The group also sought resources and research from the state government and Cornell.

In 1899, the club successfully lobbied the governor of New York State — Theodore Roosevelt — to appoint statewide bee inspectors to halt the spread of foulbrood and require the destruction of infected colonies and equipment by burning.[19] The new cadre of inspectors had the authority to destroy infected hives against the wishes of their owners and could fine or even jail beekeepers who did not comply. In just a few years, thousands of colonies were condemned and burned: in 1901, for example, about fifteen thousand colonies were examined, nearly a third of those found to be diseased, half of those condemned, and several hundred finally destroyed (Morse, 1967a). Ironically, the law also required beekeepers to move their bees into modern hives, since only those hives could be inspected, but that only increased the likelihood of the further spread of disease (Pellett, 1938).

Beekeepers came to regret their enthusiasm, so the law was quickly amended to allow them to attempt to cure the disease before being required to destroy their hives, generally by moving the adult bees into new hives with new wax combs, a practice with limited results.[20] Beekeepers also grumbled about the qualifications of the state inspectors, suggesting that they may have unwittingly been propagating foulbrood, depending on how carefully they managed the vectors by which it could spread. One letter to the editor of the *American Bee-Keeper* warned against inspectors who did not disinfect their clothing between visits to different apiaries, or who did not

[19] Similar laws had recently passed at the state or county level in California, Wisconsin, and Michigan (vanEngelsdorp & Meixner, 2010).
[20] Hinchliffe and Bingham note that biosecurity measures might not only be contradictory but also concessionary, nicely illustrated in this reform of inspection laws (2008, p. 1547).

give proper advice to beekeepers, effectively keeping themselves in a job by increasing the need for further inspection (Forward, 1897). Despite this mistrust, the program continued largely as it had originally been envisioned, and by the summer of 1920, sixteen men were combing the New York countryside for foulbrood. It should be noted, however, that the head of the USDA's Bureau of Entomology admitted the following year that the efforts to manage foulbrood through inspection were largely ineffective and perhaps counterproductive, as the incineration of infected hives made inspectors unwelcome – most of all in those apiaries where they may have been most needed (E. F. Phillips, 1921).

The other major part of New York State's apicultural regime was Cornell University, which from its earliest decades had recruited and developed expertise in entomology. Apiculture courses, in which students each cared for their own colony of bees, were celebrated by one beekeeping magazine in 1887: "progressive and scientific apiculture is now being taught as a practical pursuit in several of the colleges of America" (Comstock, 1953; Newman, 1887, p. 323; Oertel, 1971). Such courses were suspended during the first world war (1917–1922), at the same time that extension work took off (New York State College of Agriculture, 1920).

The first extension communication from the college that went out to the hundreds of beekeepers around the state concerned foulbrood, in 1918 (Morse, 1967b). The same year, Cornell agents put together a correspondence course on beekeeping, Beginnings in Beekeeping, and organized local study groups. Agents also began to organize beekeeping groups at the county level to provide instruction for the growing number of novices. Cornell boasted of their work forming these groups around the state as they grew from roughly ten in 1918, to twenty in 1919 and thirty in 1920, with a total of fifteen hundred members. Much of this growth was due to the rush of new beekeepers during the war, when the price of honey and wax rapidly increased (vanEngelsdorp & Meixner, 2010). When prices dropped after the war, most groups disappeared (Morse, 1967b).

Cornell also provided instruction to commercial beekeepers. In 1919, it hosted a free short course for commercial beekeepers on campus, the first of its kind in the eastern United States (Morse, 1967b). Participants discussed management practices such as winter preparation, honey marketing, and of course, disease. It attracted 145 commercial beekeepers from New York and nearby states and provinces, with an average of over one hundred colonies each. The instructors included experts from the USDA's Bureau of Entomology, the current federal extension agent, the editors of two trade magazines, and several commercial beekeepers. Similar weeklong courses were offered nearly every year until 1931.

It was around this time that the university situated itself at the forefront of apicultural research and extension by hiring the head of the Bee Culture division of the USDA's Bureau of Entomology, Everett Franklin Phillips. Phillips had worked with Cornell over the years, teaching short courses, managing the beekeeping related correspondence during staff turnovers, and providing other services. In 1924, beekeepers of New York State successfully petitioned the state government to provide Cornell with funding to appoint a professor of apiculture. The chair of Cornell's Entomology Department wrote immediately to Phillips, explaining, "We have had no one in mind for this professorship but you …. You will be free to make what you choose of it" (Needham, 1924). Phillips left Washington, DC, where he had been the director of the Bee Culture division for nearly twenty years, and moved to Ithaca.

Phillips' career was superlative in research, teaching, and extension. He made enormous advances in understanding foulbrood, published hundreds of articles and bulletins, and founded a world-famous beekeeping library at Cornell. Under his leadership, the correspondence course was rewritten, more short courses given (attended by over twenty-five hundred people in twenty-five full days during 1929), and a network of demonstration apiaries developed across the state. With Phillips at the helm, Cornell embodied the precepts of modern and progressive beekeeping.

"Two classes of beekeepers"

Phillips' demonstration apiaries were managed following protocols outlined by Cornell experts. These apiaries served as experiments where extension agents did things the old-fashioned way, or "in the manner that the beekeepers of the country are using," and the modern way, or "the method as recommended by the College," to demonstrate the superiority of the latter (New York State College of Agriculture, 1930, p. 70). This distinction reflected the division of the beekeeping industry into two main groups, hobbyists and commercial operators. In Phillips' nearly 450-page book from 1915, *Beekeeping: A Discussion of the Life of the Honeybee and of the Production of Honey*, the very first subsection is called "Two classes of beekeepers," which describes amateurs in contrast to professionals, or "specialists" (1915, p. 2). The book goes on to explain that in the case of an outbreak of brood disease, an amateur is "not financially interested to an extent which will compel him to care for the disease … The small beekeeper usually becomes a menace to the industry in such an outbreak" (E. F. Phillips, 1915, p. 16). Phillips believed that the ideal beekeeper was a professional, and sought to discourage half-hearted beekeeping. In 1909, he wrote: "[t]he persons interested but little are a serious detriment to the industry, especially in regions where bee diseases exist" (1909, p. 80). He reasoned that smaller hobbyist beekeepers who lacked the financial incentive to address contagious diseases like foulbrood would put their beekeeping neighbors at risk. He went on:

> The main objection to numerous small bee keepers, rather than fewer and more expert ones deeply engaged in the industry, is, that when the larger number is interested it can not be hoped that all will become proficient … when some contagious disease is present in a region this becomes a serious matter … [T]he negligent bee keeper keeps property which, if diseased, constitutes a nuisance, and is constant menace to the progressive man … If progress is to be made … it must be done by progressive bee keepers financially interested to an extent sufficient to compel them to combat disease. (E. F. Phillips, 1909, p. 61)

Along the same lines, Phillips wrote elsewhere that "the development of beekeeping to its true place in American agriculture depends on the making of a large number of professional beekeepers and this in turn implies the elimination of the beekeeper with a few colonies, little interest and still less of willingness to work for the industry" (1915, p. 17). He did believe that an important dimension of the inspection program was to educate the beekeepers whose hives were checked for disease. Amateur beekeepers were "a source of future commercial beekeepers" if they learned enough (E. F. Phillips, 1915, p. 2). But the wartime surge of beekeepers was disheartening for

Phillips, who wrote some years later that “thousands of persons [went] into beekeeping without adequate knowledge of its problems” and that the “vast majority of these ill-advised projects ended disastrously” when honey prices again fell (Morse, 1967b, p. 27).

These concerns were echoed by other agents at Cornell. The university’s correspondence course, authored by a Cornell graduate, William Prindle Alexander, maintained that “no one should keep bees who … does not know how to recognize and control the common bee diseases” (1918, p. 77). George Rea, the federal beekeeping agent based at Cornell, wrote in 1921 for *The Cornell Countryman* that the unselected bees in the “average farmer’s apiary” threatened the industry because of their vulnerability to European foulbrood, in contrast to the hardier subspecies managed by dedicated beekeepers (1921, p. 444). In the same article, Rea also lamented the loss of colonies in winter, which were similarly differentiated by class of beekeeper: “the heavy winter losses are not suffered so much by those who specialize in beekeeping as by the farmer beekeepers and by men of shiftless methods” (1921, p. 445).

Commercial beekeepers had their own set of concerns. Some did not want more beekeepers to join the industry. They “opposed [Cornell’s extension work] actively” with an “indifferent attitude and lack of cooperation,” according to one Cornell extension agent (Morse, 1967b, p. 26). Protesting Cornell’s correspondence course, they claimed that it and the other activities to organize clubs and share knowledge freely with beginners were likely to glut the honey market and depress prices (Morse, 1967b, p. 27). But it was not just competition they feared; like Cornell’s agents, they described the incompetence of beekeepers both new and old as a threat to their colonies. In 1908, a contributor to the widely circulated magazine *Gleanings in Bee Culture* complained, “I moved to this locality last spring, and found I got into a hotbed of foul brood. There are some old mossbacks here who keep their bees in old gums” (a gum is a section of a hollow tree, traditionally a gum tree, which was a common style of hive before Langstroth’s invention) (Wright, 1909, p. 113). A 1916 article in the *American Bee Journal* stressed the need for more education, in order that there be “more professional beekeepers and less bunglers” (“Beekeeping at Washington: What Uncle Sam Is Doing for the Beekeeper,” 1916, p. 46).

This vision of more professional beekeepers came largely to pass. The size of individual holdings and the number of out-apiaries increased, which the editor of the *American Bee Journal* credited in 1919 to “the initiative of the modern beekeeper, who keeps bees for a living, rather than as a side issue” (Dadant, 1919, p. 367; Rucker & Thurman, 2019). Another commentator in the late 1930s noted that “expansion [had become] the rule” (Pellett, 1938, p. vii). In 1940, Phillips noted with satisfaction that the number of beekeepers had halved since 1920, and some of those who remained had considerably enlarged their operations. Another commentator described in 1961 how “[t]he successful husbandry of honey bees began [in the early part of the century] to concentrate in the hands of men making a specialty of their care” (Myers, 1961, p. 230). It is not clear what effect the bifurcation of beekeepers had on the spread of disease. The incidence of American foulbrood in New York State was as high as seven per cent in the early 1930s, with another slight rise during the second World War, but rates again dropped after the war, and are nearly negligible today (Morse, 1967a, p. 34).

Conclusion

This history contributes to several ongoing and interrelated conversations among geographers, political ecologists, and others concerning norms in agriculture and the politics of biosecurity. Unlike most other livestock, bees cannot be enclosed, and may mingle with bees whose hives are several miles away. In other words, beekeepers are effectively unable to quarantine their bees, and having neighbors who manage and prevent the spread of contagious disease is an especially important line of defense for beekeepers. Normative tools are therefore among the most important tools for biosecurity in beekeeping. This illustrates a point from the literature that biosecurity entails the "differential valorisation of flows and circulations rather than pure quarantine" (Bingham et al., 2008, p. 1528). The envirotechnical regime that supported the modernization of apiculture in the United States relied in large measure on discourse that valorized one approach over others, despite the contradictions that made that approach less effective in stemming the spread of disease than might have been hoped. Furthermore, these normative tools are based on the "perceptions and moral judgements concerning *other* groups' knowledges, skills, practices and suitability to keep animals" (emphasis added) (Holloway, 2019, p. 27). The prescription and justification for a certain vision of the beekeeping industry was based on perceptions of and assumptions about the knowledge-practices of particular producers — what they did and did not know or would or would not do to keep their bees healthy as the ecologies of beekeeping changed. Indeed, this case exemplifies a "shift … in the subjective content of the culturally valorized construction of 'good farming,'" with such shifts held to be "key to understanding … outcomes in agriculture" (Haggerty et al., 2009, p. 776). Changes in what was seen as necessary for "good beekeeping" and who was considered to be capable of enacting it in the early twentieth century is a key part of the historical and ongoing professionalization and specialization within beekeeping.

Today, new parasites and diseases have continued to make "good beekeeping" ever more "laborious, costly, and time-consuming," the professionalization and specialization within the industry has accelerated (Lezaun, 2011, p. 5). Different camps of beekeepers are again at odds with one another over who is to blame for the spread of these parasites and diseases, and who is better equipped to keep their bees (and their neighbors' bees) healthy. Phillips' vision is echoed in informal conversations and formal extension and outreach programs today: when the most troublesome parasite first arrived in the United States in the 1980s, one beekeeping extension agent suggested that it was "welcome" since the "marginal beekeepers … causing most of the problems … would inevitably be eliminated, leaving a stronger, more vibrant beekeeping industry" (Sanford, 1992). Thus the apparent institutional preference for a certain kind of beekeeper is persistent. Indeed, this case is a reminder of biosecurity's long history. Much of the scholarship on biosecurity in agriculture is focused on current risks, emphasizing the "unprecedented scale" of livestock operations today (Hinchliffe et al., 2016, p. 13). But the shift in the late nineteenth and early twentieth centuries was equally unprecedented in its own time, as beekeeping was quantitatively and qualitatively transformed. Then just as today, norms and institutions in apiculture were shaped by an approach to biosecurity that aligned with a vision of specialization and professionalization.

PAPER 3: HYBRIDITY FOR HEALTH: CONVERGING LEARNING CURVES IN BEEKEEPING

Abstract

Honey bee health challenges are emblematic of the ecologies and politics of the Anthropocene epoch: bees face multiple threats and beekeepers are apparently divided about how to address them. But bees are emblematic in other ways as well: the Anthropocene as a concept blurs the binary distinctions between nature and society, just as honey bees blur the lines between wild and domesticated. Indeed, the hybridity of honey bees, the consequences of that hybridity for their health, and the subsequent lessons for beekeeping practices make them a useful case for thinking about health and sustainability in the Anthropocene more broadly. In this paper, I draw on participation observation and interviews to trace beekeepers' learning trajectories. Most beginners tend to envision honey bees either as wild creatures or as livestock, and it is only those who come to understand honey bees as hybrid beings who develop the wide range of skills necessary to keep their colonies healthy. The challenges to and conflicts over honey bee health are therefore a window onto anxieties in the Anthropocene, debates over health and hygiene, control and responsibility, and what is seen as natural or necessary in a changing environment. Using literature on biosecurity and animal geographies, I fill in a gap in the social scientific scholarship trying to make sense of honey bee health challenges, and suggest a new framework for thinking about health in the Anthropocene.

Keywords
Anthropocene, hybridity, health, honey bees, beekeeping

Introduction

Honey bees and their seemingly calamitous losses have become a powerful symbol of the Anthropocene. They are seen by many as a kind of canary in a coalmine, representing large-scale ecological declines. But while honey bees *are* a powerful symbol, I argue that it is for a different reason. Rather, (to use another animal idiom) it is because they are neither fish nor fowl. The Anthropocene as an idea upends the distinctions between nature and society, human and animal, and, in similar ways, honey bees are widely recognized to be hybrid creatures, domesticated but wild. It is the hybridity of honey bees, the consequences of that hybridity for their health, and the subsequent dilemma in beekeeping practices which make them a useful case for thinking about health and sustainability in the Anthropocene more broadly.

In this paper, I draw on participation observation and interviews with beekeepers to show how individuals who begin to learn beekeeping tend to envision honey bees either as wild creatures or as livestock. This would appear to require beekeepers to choose between conflicting communities of practice, where they learn different skills. But this apparent conflict, I argue, is in fact a set of multiple learning curves for different beekeepers, where the different visions of the honey bee both shape individuals' learning trajectories and are reshaped along the way. Those individuals who come to understand honey bees as hybrid natureculture beings (Haraway, 2008; Hovorka, 2018) are those who are eventually best able to keep them healthy. The challenges to and conflicts over honey bee health are therefore a window onto anxieties in the Anthropocene, debates over stewardship, control, and responsibility, and what is seen as natural or necessary in a changing environment.

Using literature on biosecurity and animal geographies, I fill in a gap in the social scientific scholarship trying to make sense of honey bee health challenges, and, I hope, clarify to novice beekeepers the best choices available to them.

Dualities of the Anthropocene

The name "the Anthropocene" was initially proposed for the current era because of how dramatically human activity has affected ecosystems and more around the world (Steffen, 2013). But the term sparked academic and popular debate and has come to stand in for the many ambiguities and contradictions of the modern era, such as feeling torn between mourning loss and the need for hope, and the uncertainties about the most relevant timescales for comparison. Sociologist Richie Nimmo describes one of these dualities well:

> Anthropocene discourse contradicts itself: pointing to the organic interconnection of humanity and the natural world, as evidenced by our impact upon the Earth and the coming consequences of this for human society; while demanding that we rise above nature by taking control of our collective species activity and consciously modifying it. (Nimmo, 2015, p. 195)

In other words, while there are many interpretations, popularly and scholarly, of the idea of the Anthropocene, the conversation it has engendered reframes the relationship of humans to the rest of nonhuman nature: are people a part of the natural world? Debates over the "starting date" or "golden spike" of the Anthropocene (Bauer & Ellis, 2018) ask the next logical question: if humans are not a part of the natural world, when did they stop being a part of it? These questions are central to the bind between taking steps for more control, more overrides, more human management of the system, and stepping back and leaving more room for nonhuman others to exercise their autonomy (along the lines of Charles Mann's idea of the "wizard" and the "prophet" [2018]). Said another way, "[i]n the Anthropocene, the wild meets domestic" (Graef, 2020, p. 523).

A wave of recent scholarship, in geography, environmental history, and other fields has in the same way challenged the idea of the "wild," seeking to understand the many nature-society hybrids that call into question the idea of the "wild" by their very existence: "second nature," "organic machines," "eco-technological systems," "industrial organisms," "creole ecologies," and "monsters": "all concepts that embody the hybrid world" (Latour, 2011; Sutter, 2013, p. 118). This work is not new: environmental historian Bill Cronon's work on the "trouble with wilderness" is a key reference in doing away with the idea of wilderness (1996). This in turn is based on the many critiques of the nature-society divide, the stubborn ontological foundation of (the idea of) modernity and dualistic mode of organizing the world (human / animal, nature / culture, wild / domesticated, conservation / agriculture, social science / physical science, expert / lay) (Braun, 2004; Latour, 1993). It is worth noting briefly that "wild" and "natural" are two ideas that are often elided.

To break down these binaries, some have suggested that the idea of "wildness" ("a post-wilderness concept of wildness" [Collard, 2014]) is a more generative concept, which celebrates the autonomy and agency of a wide scope of nonhuman natures without locating them "out there." This wildness is "exuberant, transgressive, vivid; it blends categories" (Graef, 2020, p. 525). Others have suggested using the idea of hybridity as a tool to understand the *both/and*-ness of the Anthropocene: hybrids "transgress… boundaries between binary divisions and in doing so produce something ontologically new" (Rose, 2000, p. 364). This is particularly true in animal studies, where the conceptual framework of "hybridity" is gaining ground as a conceptual tool (Hovorka, 2018).

Some of the best examples of the blurring of the distinction between "wild" and "domesticated" animals is in recent work on "farmed wild birds" in China, where geese who transgress conceptual boundaries, aided by poultry breeders who "actively recompos[e] the qualities of wildness and domesticity in their husbandry" (Fearnley, 2015, p. 13). Similarly, animal geographer Henry Buller has written about two "competing philosophies of nature – the one driven by notions of biosecurity, the other by concerns for biodiversity" (Buller, 2008, p. 1583). This observation comes from his analysis of how wolves are construed in the public imagination in France and elsewhere. Buller articulates the difference between biosecurity and biodiversity as "the relationship between the tame or tamed (essential, controlled, fixed, known, and secure) and the wild (diverse, shifting, unknown, and therefore an element of risk)" (Buller, 2008, p. 1592).

Hybridity and health

There is a rich and growing literature on health as biosocial, or a "nature-society question" (Mansfield, 2008). It is both a physical and social phenomenon in terms of causes, interventions, and effects. Geographer Katy Wilkinson and others have written about the difficulty of "pris[ing] apart the natural phenomena of disease and the social phenomena of the drivers, impacts and regulation of disease" (2011, p. 1933).

While much of this work, especially on the political ecology of health, concerns human health, it synergizes with critical literature on animal health and particularly the management of agricultural pests and outbreaks of disease among livestock (A. Donaldson, 2008; Hinchliffe et al., 2016; Hinchliffe & Bingham, 2008; Holloway, 2019; Nerlich et al., 2009). This body of literature seeks to understand the social and political dimensions of practices such as vaccination, quarantines, medication, and other actions to maintain hygiene and support animal health. Most relevant here is the insight that discourses and practices around animal health often hinge on a distinction between "wild / natural" and its perceived opposite, and corresponding orientations toward more or less control. This distinction is based on the well-known "hygiene hypothesis" and an understanding of health and thriving as more "natural" conditions (Nerlich et al., 2009, p. 568).

Many farmers understand their animals' immunity as something that can be "'naturally' acquired" (Holloway, 2019, p. 24). This is part of a broader conversation about how to characterize the health of livestock and those animals' contact with other, unmanaged animals: is "nature" (sometimes conceived of as the "forest edge" [Hinchliffe et al., 2016, p. 8]) a source of danger and stress or a source of immunity and strength? The work on "wild bird farms" in China investigates perceptions around the origins of novel strains of avian influenza, which move from unmanaged to managed, domesticated animal populations and eventually humans (Fearnley, 2013).

Another study on avian flu illustrates the contrasting discourses around disease among so-called factory farmers and organic / free-range farmers:

> Factory farmers blame free range and organic farmers for increasing the risk of bird flu, as their birds are exposed to *wild birds* and therefore to "dirt" in the form of bird droppings, disease and related threats… Free range and organic farmers blame factory farmers for increasing the risk of bird flu by not exposing their birds to *natural* pathogens and by also exposing them to more stress, thereby depleting their immune system and making them more susceptible to disease. (Nerlich et al., 2009, pp. 568–569, emphasis added)

These authors draw a distinction between "hygiene" and "health": factory farmers structure their management around the former, seeking to control their animals and limit exposure, while the organic and free-range farmers base their practices on the latter, a broader, more diffuse, notion. The conventional institutional responses to infectious diseases often "close down" around short-term efforts that seek greater control and stability and "occlude attention to vital longer term, less controllable dynamics" (Leach et al., 2010, p. 370).

As I describe below, honey bees are themselves a hybrid creature, livestock but also wild, representing both of these seemingly opposed values of biodiversity and biosecurity. They have long been a "species on the cusp of culture and nature," and "discursively positioned in some ambivalent conceptual space between 'wild' and 'domesticated'" (Nimmo, 2015, p. 186; Waring, 2015, p. 17). And tussles over how best to manage their health challenges, particularly parasitic mites, often hinge on the distinction between "health" and "hygiene."

Honey bee health

Honey bee health is imperiled by multiple stressors. One popular mnemonic device for comprehensively naming those stressors is the "four Ps": poor nutrition, pesticides, parasites, and pathogens (Downey, 2017).[21] While the four Ps interact synergistically – a poorly nourished colony is more likely to be sick or less likely to be able to withstand exposure to pesticides – it is important to understand each separately. Poor nutrition refers to the decline in the quality and quantity of flowering plants across most landscapes, flowers that provide bees nectar and pollen, their two main sources of nutrition. This decline is largely due to land use and land cover change through development and agricultural intensification, as hedgerows and other wild strips of land have given way to expanding fields, leading to less diverse forage. Furthermore, many of these crops (such as soy and corn) do not produce sufficient quantities or sufficiently high-quality pollen or nectar. The second P, pesticides, includes insecticides, herbicides, and fungicides, which can kill or weaken colonies and are now routinely found in wax and honey (Rubio et al., 2013). These two Ps are widely recognized and publicized, which is why they are only briefly described here.

The other two Ps, parasites and pathogens include a range of different pests and diseases that have long plagued bees, and which are less familiar to the general public: bacterial infections, fungal gut parasites, and more, but most importantly, the parasitic *Varroa* mite (*Varroa destructor*). *Varroa* is the number one stressor of honey

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[21] There is some place-based variation in honey bee health challenges. In most of the United States, *Varroa* is the number one cause of mortality, while other areas may have a different balance of concerns; Australia, for example, is free from *Varroa* mites.

bees in the United States and many other places in the world; one recent article in *Scientific American* made this point: "Virtually everyone in the beekeeping business will tell you that the biggest threat facing honeybees isn't pesticides [or] starvation… When asked to cite the three biggest risks to honeybees, [one] renowned expert on bee breeding … says, '*Varroa*, *Varroa*, *Varroa*'" (Embry, 2019). The mites arrived in the United States in the 1980s and have devastated managed and feral populations. One team of researchers has called *Varroa* "the greatest threat for apiculture," as "[n]o other pathogen has had a comparable impact … during the long history of apiculture" (Rosenkranz et al., 2010, p. S96). Colonies typically succumb not (or not only) to the direct effects of the mites, but the indirect effects of the viruses vectored or exacerbated by them, the "pathogens" of the fourth P. A colony whose mites are not controlled will likely die within two years.

Mite control is therefore a necessary routine, an "integral part of the beekeeping practice" (Genersch, 2010, p. 89). Indeed, it has been suggested that the mites have led to the effective domestication of honey bees, not through breeding but through the attention and care that the mite obliges, which has led to the bees' "functional dependence on humans" (Silverman, unpublished). To be clear, bees have been kept by humans in hives for thousands of years. The difference is that now they must be more than just housed at a minimum; they must also be tended to, to protect them from mites, or they will die.

A central challenge is that mites spread easily among hives, up to four miles in a few months (McNeil, 2016).; in areas with high number of hives, there is a "permanent exchange of mites" (Rosenkranz et al., 2010, p. S102). A hive that is overrun with *Varroa* mites and collapsing is colloquially called a "mite bomb" (Burnham, 2016; Connor, 2015; McNeil, 2016; D. T. Peck & Seeley, 2019) and they are said by some to be responsible for late summer spikes in neighboring hives' mite populations. So a beekeeper whose mite counts are high and whose hives are being robbed by bees from nearby hives may be impacting the health of the surrounding colonies and undermining the mite management strategies of the keepers of those colonies. But beekeepers' approaches to controlling mites vary widely, which has led to a simmering conflict, "the beekeeping forums … awash with angry, polarized, language" (Milbrath, 2020). I will describe the options available to beekeepers and then the conflicts that have ensued, in enough detail to underscore the necessary skill that beekeepers must develop and the tradeoffs that they must evaluate.

The principles of integrated pest management (IPM) call for periodically monitoring the *Varroa* mite levels to evaluate the need for different management strategies, although many beekeepers treat their colonies for mites without monitoring, anticipating that they will need to do so anyway. Monitoring requires some skill and specific equipment, and there are trade-offs around accuracy, ease, time required, killing the bees that are sampled, and more.

Mite management strategies can largely be categorized as chemical ("hard" or "soft"), biological / cultural, and genetic, although many beekeepers do not manage their colonies for mites at all. Synthetic chemical treatments are pesticides (miticides) that are used on most hives in the United States, leading one research team to suggest that beekeeping, once "one of the world's most chemical-averse agricultural industries" is now "one of its most chemically-dependent" (Berry et al., 2013, p. 1).

Indeed, the most prevalent pesticides found in hives today are those used to control mites (Mullin et al., 2010; Owen, 2017). And while these chemicals are the most immediately effective avenue against mites, they can also be toxic to both beekeepers and bees, are less effective over time as the mites develop resistance, and are seen to contribute to the general load of synthetic pollutants in hives and across the landscape. Many smaller-scale beekeepers therefore choose "softer" chemicals which include organic acids and compounds with essential oils. These vary in their efficacy, cost, and application methods; some are simpler and others are more complicated. Many are still toxic to beekeepers and bees, although less so.

Other (non-chemical) methods of managing mites, often referred to as biological or cultural methods, depend on understanding and interfering with mite reproduction and development, and therefore require more refined knowledge and skills. There are also tradeoffs, for instance, if a beekeeper temporarily halts mite reproduction through temporarily halting bee reproduction, her bee population and honey production will decrease. The window for these methods can be limited if they must be coordinated with seasonal activities of colony. And as these methods cannot be relied on to reduce mite populations to the extent that the chemical methods do, they often eventually have to be supplemented by those chemical methods (Delaplane et al., 2005).

One final route for managing mites that is gaining interest is breeding, which was recently described by two entomologists as a "glimmer of hope" (Meixner & Le Conte, 2016, p. 274). Hygienic behaviors and other traits that decrease bees' vulnerability to *Varroa* infestations are genetic at least in part. The idea of "Darwinian beekeeping” theorizes that beekeepers can benefit from natural or artificial selection if it promotes genetic traits that confer better resistance to or tolerance of mites (Neumann & Blacquière, 2017; Seeley, 2017). In practice, this means dispatching unfit colonies or allowing them to die, leaving only the fittest (most resistant to mites). However, successfully selecting for these behaviors is difficult: beekeepers need a sufficient number of colonies to select from, as well as the time and skills to do so.

Many beekeepers are reluctant to use chemical methods of mite management or do not have the skills to use other approaches. Differences in mite management largely correlate to the kind of beekeeping operation: hobbyist beekeepers (with 1-50 colonies) largely monitor and treat less, and lose more colonies than intermediate-scale beekeepers (with 51-500 colonies) or commercial beekeepers (with more than 500 colonies) (Bee Informed Partnership (BIP), 2019). But the divide over mite management represents more than just more than operation size and type; it also represents broader philosophical differences and approaches to beekeeping (Andrews, 2019; Lorenz & Stark, 2015).

Analyzing the conflict over mite management

Honey bees are livestock. They are kept in hives, their colonies manipulated to meet the needs of beekeepers, and fed honey and pollen (or substitutes) to meet their nutritional needs. But honey bees are also wild, free-flying creatures, unusually independent for livestock. One of the first tenets that a new beekeeper learns is that “all beekeeping is local,” which is to say that more than other forms of agriculture and animal husbandry, keeping healthy and productive colonies or bees is subject to landscape-level dynamics outside of the hive or the control of the beekeeper: the local flora, weather and microclimates, seasonal variations, and more. Today, *both* of these identities – bees' domesticated nature as well as their wildness – pose hazards to bees' health and welfare. Indeed, the four Ps described above can be conceptually divided into two different types of threats: agricultural and environmental. This categorization is attributable to honey bees' dual nature.

The two Ps of parasites and pathogens are for the conventional beekeeping community the most important direct stressors of honey bee colonies in the US (in contrast to pesticides and poor nutrition). Most beekeepers and scientists would agree that all of these issues need to be addressed, but in general, they prioritize *Varroa* and associated threats. While the spread of *Varroa* relates to the bees' ability to fly and leave their hive, as the mites move between hives on bees, in general the mite problem and the first-order solutions are linked to honey bees' nature as livestock. Honey bees are both deeply integrated into industrial agriculture, as a valued commodity and service provider. Larger-scale commercial beekeeping operations would not exist were it not for the industrial agricultural model, with possible trickle-down effects on smaller-scale operations. The pollination contracts that underpin much of the industry are a direct result of the monocultures and other aspects of contemporary industrial agriculture that necessitate that managed pollinators be brought in to do what wild pollinators might have otherwise done. But of course bees are harmed by this arrangement, too, and the spread of mites is arguably an inevitable consequence of the intensification of apiculture (meaning the high density and uniformity of bee stocks in a given operation and the global trade and transport of bees. In this vein, the conventional wisdom, promoted by extension agents, federal and state agricultural agencies, and most commercial beekeepers, emphasizes mite management as the primary tool in sustaining honey bee health, which often translates into chemical treatment.

It is the other two Ps, and pesticides in particular, that have received the lion's share of attention in popular media and scholarly work. Much of the discourse around honey bee health in popular media is accompanied by the phrase "save the bees," implying that bees are wild creatures rather than livestock like cows or chickens (as it would be odd to call for "saving" those populations).[22] This focus implicitly or otherwise frames honey bees as imperiled foremost by broader environmental degradation, foregrounding their identity as wild animals, freely foraging on the ten thousand or more acres of land around their hives. To focus on the threats to bees that derive from their identity as wild creatures is an implicit or explicit invocation of biodiversity. Indeed, honey bees, like Buller's wolves, are "newly minted ecological icons" for much of US society (Buller, 2008, p. 1587).

The same focus is true of most of the social scientific scholarship on honey bee health, which locates the challenges to honey bee health outside of beekeeping practices and in the broader environment. One author recently wrote that beekeepers' "commitment to techno-scientific solutions… distracts them from the larger deleterious ecological conditions that are the normalized externalities of the current industrial agriculture" (Cilia, 2020, p. 84). The word "distract" implicitly designates

[22] Honey bees are often conflated with wild bees and portrayed as the "'poster child' of pollinator declines" more broadly, although many of the challenges to their health are different (Goulson and Nichols 2016, p. 313).

the most important challenge to honey bee health as those “larger deleterious ecological conditions,” or the latter two Ps. Another scholar has railed against the “heady cocktail of pesticides to control parasitic mites” (Suryanarayanan, 2014, pp. 265–266). For all these reasons, many beekeepers see using miticides that can and sometimes do harm individual bees, whole colonies, and potentially the broader environment, as anathema to sustainable beekeeping, and so many dedicate themselves to not using such miticides, or “treatment-free” beekeeping. The rationale for managing mites without chemicals (or not managing them at all) is embedded in the nature-society duality described previously. From the idea that wildness confers a certain kind of vitality or degree of protection, it is only a short step to the idea that keeping bees more “naturally” has a similar effect.

A recent study of beekeeping in Berlin has called for an approach to beekeeping that does not hinge on a conception of what “nature” is, as it is an idea that “neither accounts for the practical interdependencies of humans and honeybees nor will it provide the foundations for negotiating them” (Lorenz & Stark, 2015, p. 124). Indeed, I might add that much of this line of thinking is not new. Sociologist Richie Nimmo, cited above, has written about how beekeeping is a hybrid sort of activity, where hybridity refers to an “interspecies collaboration” in which both sides benefit (2015, p. 189). For him, these conflicting but complementary approaches to understanding bees as wild and bees as livestock are best understood by posthumanist literature and critical animal studies, in turn. Others have similarly pointed to the multiple discourses around honey bee health (Watson & Stallins, 2016).

Beekeepers also recognize these dynamics. Meghan Milbrath, a beekeeper, educator, and researcher in Michigan, has written about how although it may seem as though there are "two camps of beekeepers," those camps are in fact the same people: "most beekeepers have been in both of these camps and more at different times of their lives" (Milbrath, 2020). She goes on to describe the typical trajectory of a beekeeper who starts out hoping to manage her mites without miticides but who eventually recognizes the need for using chemical treatments, at least for a time. My approach to these issues here is similar, in that my data is largely centered around how beekeepers learn to keep bees, documenting the choices and trajectories of individual beekeepers and the experiences of educators as they try to provide their beekeeper-students with information that accords with their growing skillset and awareness of honey bee hybridity.

Methods

This article is the result of several years of interviews, observations, and participant observation in keeping bees and organizing educational opportunities for other beekeepers. From April 2013 onwards, I interviewed 66 beekeepers, educators, research scientists, and extension personnel, in person or over the phone. These individuals were mostly based in New York State, with a handful from other states or provinces contacted because they were involved with teaching beekeeping through the Eastern Apicultural Society, a regional network of beekeepers. Interviewees had a range of experience (from zero to more than forty years) and were a mix of commercial beekeepers, sideliners, hobbyists, extension personnel, and research scientists. They are not representative of beekeepers more generally, as I sought out beekeepers with particular attributes for different parts of my research. To understand the process of learning and becoming part of a community of practice, I asked newer beekeepers about their motivations for keeping bees, their learning process and sources of information, and their approach to mite management. I also sought out beekeepers who were educators: people who had organized local or regional beekeeping classes, the author of a well-known textbook, the editor of a national beekeeping magazine, and more. In these interviews, I asked about their approach to beekeeper education and how they taught their students the issue of mite management. As I was interested in how different beekeepers conceived of "sustainable" or "natural" beekeeping, I oversampled respondents that explicitly described their approach as such.

I also attended meetings of bee clubs, classes / workshops, and other conferences held by non-profit and for-profit groups across New York State and the East coast. In the end, I observed at least 35 meetings of 22 organizations, including 19 full days of classes or conferences. These groups included local clubs around the state, the Empire State Honey Producers Association of New York State, regional groups (both the Eastern and the Western Apiculture Societies), and the 2016 Bee Audacious conference, which was national in scope.

My participant observation has skewed heavily toward the side of participation. From 2010 onward, I have kept bees, and since 2014, I have served as an officer in my local club, with duties that include organizing the mentor match program, a workshop for beginners, and otherwise communicating with our general membership. I have also mentored novices myself. Finally, in 2016 and 2017, I was an extension assistant at Cornell's Dyce Lab for Honey Bee Studies, working with the extension associate to put together the curriculum for the university's revised Master Beekeeping course, a four-part online class. Putting together the course and making choices about what information to include, what not to include, and how to present it shaped my own approach to teaching mite management.

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Findings and analysis: converging learning curves

Briefly, my fieldwork substantiated the outlines described above, in that mite pressure has made the process of learning to keep bees more fraught in two ways. The obvious point is that the mites kill the colonies they infest if left uncontrolled, and beginner beekeepers in particular struggle with the additional layer of observations and actions required for controlling mites. One educator likened learning to keep bees to being on a ladder: "we're all on this ladder of beekeeping: some people are below us and we have to help pull them up, and there's always somebody above you, helping pull you up." All beekeepers are on this progression somewhere. Other educators give talks on "working *toward* treatment free" or "*towards* treatment free" (emphasis added), implying that many beekeepers want to learn more to be able to stop treating their bees with miticides. In what follows, I flesh out an empirical vision of hybridity and how it is manifested through what beekeepers learn and do with their bees. In the end, I settled on describing these trajectories as “learning curves.” These learning curves, of individual beekeepers, serve as a “bridge” between conceptualizing bees as wild or as livestock (Keenan et al., 2020; Lewicki et al., 2002). In other words, these learning curves integrate multiple points of view, without contradicting or undermining different sides: indeed, beekeepers *need* both points of view in order to successfully keep their colonies alive, and will vary in the degree of control exercised over their bees. But it is not just that there is an ideal “middle ground.” One interviewee spoke derisively about certain beekeepers’ “philosophy” that “bees will cure themselves, so less intervention … we should not be putting any chemical into a hive, etc.” He pointed out that insisting on purity can do the bees and their new keepers a disservice. At the same time, he was also frustrated by commercial beekeepers’ reliance on miticides. This is where the vertical axis becomes relevant – skill. Mite management choices, as well as other strategies to mitigate environmental threats, depend on the learning trajectories of individual beekeepers.

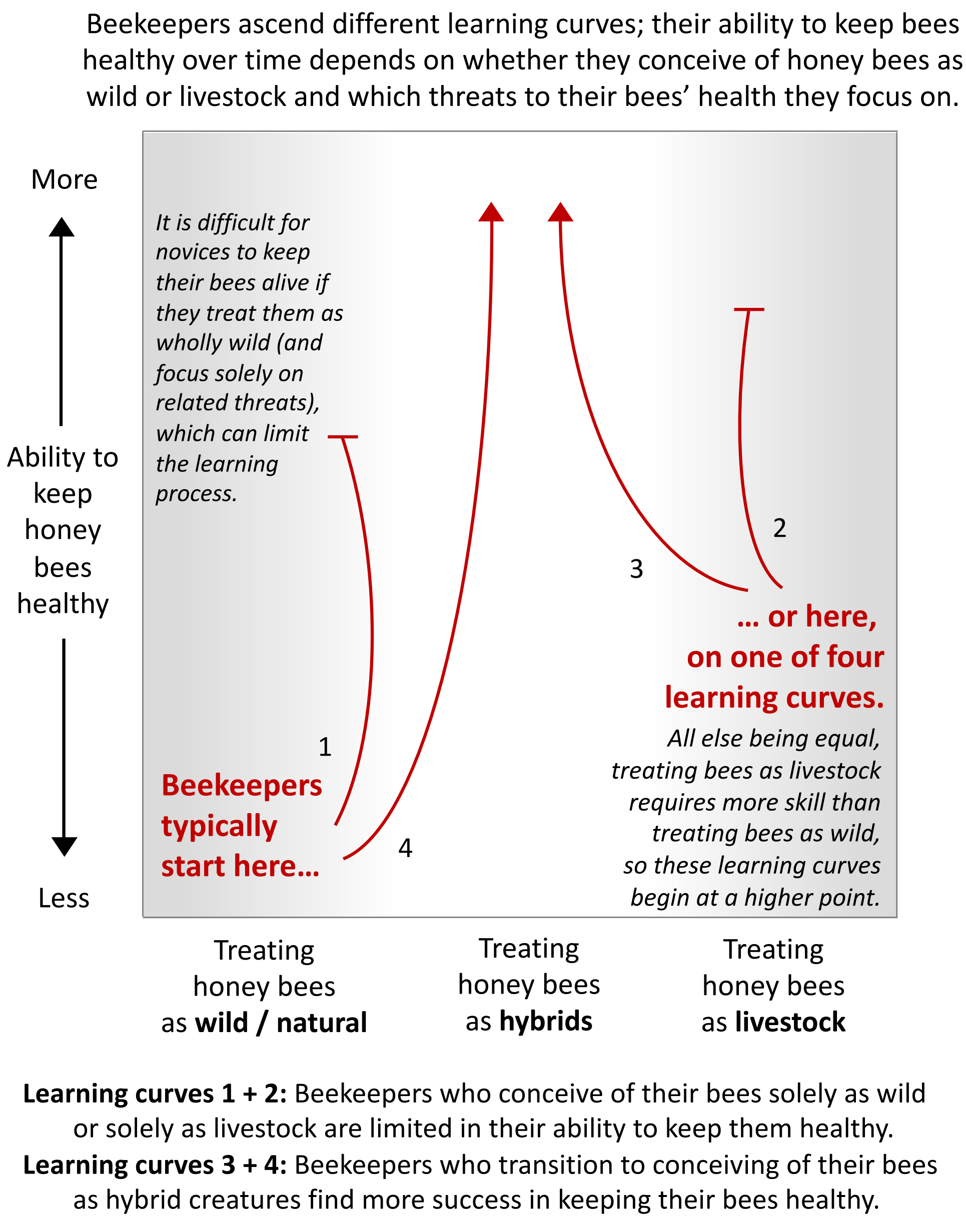

Figure 6: Multiple learning curves for beekeeping

Four learning curves emerged from the data. The first is that of beekeepers who conceptualize bees as wild creatures. As described previously, this is how many people today begin beekeeping. When this belief translates into a disinclination to manage mites, the bees typically die and these beekeepers are therefore limited in their ability to progress. By contrast, people who conceptualize their honey bees as livestock ascend the second learning curve. To find the success that enables them to stick with beekeeping – a virtuous cycle – a beekeeper must begin to shift her thinking and see her bees as livestock as much as a part of the broader environment, moving to a learning curve with more potential. They control their mites chemically with greater or lesser degrees of skill and success. But this group is also limited in their ability to skill up; as one respondent said, "the reality is it's simpler to use the chemicals." Beekeepers who come to conceptualize their bees as hybrids, however, typically experience greater success in keeping them healthy. They may still use chemical treatments to control mites, but they do so skillfully, through IPM techniques, and at the very highest levels, beekeepers can maintain healthy colonies with little to no usage of miticides. The diagram above shows these four learning curves, which are explained in more detail below.

Managing bees as wild

At its best, managing bees as though they were wild creatures, naturally and without toxic pesticides (miticides) sounds ideal. But interviewees repeated over and over that most novice beekeepers who thought of their bees as wild and emulated the practices of successful treatment-free beekeepers did so unsuccessfully, as they did not have a complete understanding of all of the pieces:

> [A well-known treatment-free beekeeper, Kirk Webster, says] *I'm not feeding my bees; I'm going to let my population duke it out against Varroa mites…*

> The real key is he's breeding from his survivors. But… these beginner beekeepers buy a package out of… Georgia, bring it up, they're like, live and let live… The only way that that works is if the surviving ones are then the ones you breed the next year… They take this little piece of Kirk's philosophy, which is genuine.

This educator went on to describe some of the other problems that treatment-free beekeepers unwittingly create for themselves by only understanding one, isolated piece of the puzzle: many such beekeepers prefer to let the bees build their own honeycomb because prefabricated wax comb often has residual pesticides in it. But bees left to their own devices tend to build more honeycomb cells for raising male bees (drones), which mites preferentially reproduce in, therefore reproducing more quickly. "The natural beekeeper is essentially loading their hive with Varroa, and not knowing it. They haven't gotten that far, to understand the Varroa mite lifecycle. As far as they've gotten is reduced pesticides." A relatively new beekeeper I spoke to had precisely this (limited) reasoning: he believed that allowing his bees to build their own comb because the cell sizes are slightly smaller than the prefabricated wax comb cells: "in theory, from the books that I've read, the natural-sized comb is a little bit smaller and therefore is less incubation period for the larvae… so the mites don't like it as much." But his hive likely had *more* (large) drone honeycomb inside it, which is to say more suitable habitat for mite reproduction, because the bees were not constrained by the prefabricated honeycomb. Tellingly, he went on, "Honestly, I don't know, because I don't really open it up that much."

I did not follow up with this particular beekeeper about whether he had lost colonies, but I did speak to a handful of other beekeepers on this curve. One had not treated after three years of keeping bees with limited success and expected to quit the following year. Another pointed to environmental stressors, agrochemicals, and imported pests as necessitating that beekeeping could not be a pre-packaged series of steps "1-2-3." He was adamant about not treating with chemicals, but had struggled for several years, and by 2018, five years after we initially spoke, he had given up and sold his equipment. One research scientist I interviewed suggested that the novices who "want to become a savior of the environment by starting a bee colony" are more likely to balk at the idea of using miticides in the hive. But when their bees die, they are typically not motivated to stick with it. Again, the scientific literature asserts that any colony left untreated for mites will usually die within two years. So beekeepers do not typically stay on this learning curve for more than a few years; they either experience so many losses that the frustration and expense of buying new bees outweigh the pleasure of keeping bees and they stop, or, with personal dedication and/or external support, they begin to see their bees differently and learn the skills necessary to control the mites. Beekeepers whose livelihood does not depend at all or in part on beekeeping may have a higher tolerance for the expenses, but they will likely leave this learning curve in time as well. One long-time educator spoke without blame about people who did not manage mites or disease properly: "it's a self-remedying situation. If you don't learn how to keep bees correctly, you lose them and then you're out. You're not going to last long. It's not going to be a problem."

Not everyone was so nonchalant. One complained about the "[treatment-free] people who don't know what they're doing… [who] fling [the bees] out there and wish that they would live." He was critical of those beekeepers who, in trying to select for *Varroa*-resistant colonies, neglected to dispatch any dying colonies in advance of their collapse and the subsequent migration of mites to neighboring hives. Another compared such beekeepers to a wave of "let alone" beekeepers from the 1970s, who spread serious diseases by being non-interventionist. One of the members from my club chimed in to the list-serv, "We all want to become NATURAL beekeepers, but without Bees we are Not Beekeepers!" (meaning that natural methods cannot always protect a colony from disease or pests, and beekeepers are risking their bees to adhere to such methods exclusively).

Managing bees as livestock

The second learning curve is based on an idea of bees as livestock, the recognition that keeping bees by definition is a form of agriculture (although beekeepers more often analogized to pets in urging their fellow beekeepers to use miticides: "if the dog has fleas, you give it Frontline.")

Mites have been a game-changer. One long-time apicultural scientist told me, "for the same input in the 70s, 80s, you got decent returns, but today that is not possible – need more inputs, more care for the colony, more learning about bees, mite control." Another beekeeper said, more simply, "the old model doesn't work anymore, just like you can't farm like Dad used to." This was echoed over and over. I asked one interviewee, a research scientist, whether there was such a thing as "sustainable" beekeeping, and she responded, “if we didn’t have mites, yes. The problem is we have mites.” A novice recalled starting out: “I took comfort in knowing that bees have been around for a long, long time… Do something, do nothing, they’re still going to be there. Except for if they have mites. Then you definitely have to do something.” One educator told me, “You can have pretty decent success, knowing almost nothing, because the bees have such a will to survive that if you don’t fuck them, they pretty much can do it, aside from the Varroa mite.” A novice beekeeper wrestling with mite management similarly said “you want as little intervention as possible with the bees, and I think in a lot of ways that helps, but… then, the mites…” I was struck by the similarity of these responses, where mites were a coda, but one that was absolutely central to individual beekeepers’ learning processes. I emphasize this point through repetition because it is the premise on which much of my analysis depends, and because the mites have been an underreported part of the story in most of the social scientific literature published to date.

Anticipating resistance from beekeeping students, some educators elaborate on why “natural” beekeeping is a misnomer. As one interviewee pointed out, “you’re putting them in a box, so that’s not free of any treatment at all or natural.” In other words, the moment of choosing a more natural treatment for the bees is well upstream of choosing how to manage mites. One educator starts her beginners class by describing where most of her students’ bees come from: large commercial operations in the South, which put several pounds of unrelated bees into a box, not a “swarm factory in the sky.” (She says that some students look at her “like I’m from Monsanto,” but provides this information nonetheless, as a way emphasize the bees’ very domestic origins.) In the same way, Another educator, the leader of one club who also operates a beekeeping business, including a supply store, talked about his own efforts to educate his club members about mite treatment strategies:

> Our club, when we got into it, was very anti-treatment… [I] made it a point to bring in – like every other speaker was going to be talking about mite treatment, and every *other* speaker was going to talk about mite counts! … We got a good group of speakers come in that really drove the point home that you need to know what's going on in the colony, so that you can make an educated decision on whatever you're going to do.

One speaker that he invited was a representative of the company who makes chemical treatments popular among hobbyists, who explained why and how to treat a hive with it. In the store, the club leader saw the difference: "before, I would never stock treatments. They never sold; no one asked about them. Now I have more people coming in saying *we did a sugar shake; we have X amount of mites… what should we do? We talked about Mite Away, is that what you use?*" He admitted to benefitting personally from the popularity of those products, but his point was that his position behind the counter showed him the impact of the speaker line-up, in that people from the club were coming in more than they ever had before to purchase products for mite management once they had been educated on the perils of mites and the options available to them.

While the adherence to educating people about chemical *Varroa* management in the above case is not surprising, it was in other cases. I attended a class by an organization that advertised itself as practicing "natural/organic beekeeping with a biodynamic influence.” The class included lots of elements for which there is little scientific basis: a suggestion that the zodiac influences bee behavior (and related advice not to extract honey on “root days” versus “leaf days,” calculated based on astrological signs), using dowsing rods to site hives so that they are centered on magnetic fields, bees’ ability to see human auras, bees’ propensity to sting people on their bodies’ meridians where they have pain, and the possibility that the bees may have sensed an illness in one of the instructors before she knew she had it. Despite the instructors’ beliefs in these very unconventional and unprovable phenomena, they also framed *Varroa* as “one of the things killing our bees the most” (fieldnotes 2/5/2017), to be controlled through “soft” chemical treatments. They discussed the pros and cons of different chemical treatments, demonstrating how to fumigate a hive with organic acids, and stressing the need for a respirator when doing so. I believe that while the other beliefs do not actually affect the health of their colonies, a reluctance to use chemical methods of managing *Varroa* would, and if they did not do so to at least some degree, they would have had difficulty staying in business.

I spoke to many relative novices who had recently moved to this way of conceptualizing their bees. One sideliner remembered, “I was pretty hands-off; I was trying to go the most natural way I could, and I did at one point, at about my second or third year, have a pretty bad case of Varroa.” He had therefore begun using one of the “soft” chemical treatments. Another said, “I have gone from not using any chemicals at all…” to listing three “soft” and “hard” treatments that he had used or was intending to try. Using these treatments requires a certain level of knowledge: one novice asked rhetorically, “Do you use the chemicals, do you not use the chemicals, what chemicals do you use? I found that the most frustrating, that there wasn't… just one way of doing it." Another beekeeper, contributing to an international list-serv on beekeeping and honey bee biology, wrote in: "the dizzying array of treatment options, how and when to apply them, the effects on beekeepers (like needed respirators or chemical gloves), the effects of treatments on bees (ever look in a hive during the first three days of a formic treatment?) can be a bit overwhelming to the new beekeeper." Similarly, an extension agent recalled sitting down with beekeepers to plan their treatment regimens: "we sit down with them, we ask when do you [make honey?] If you're going to use [a chemical treatment] and your [boxes for honey] are going on in the middle of May… and you need to make sure you have thirty days plus two weeks, then the [treatment] is going to go on in April… Sitting down and writing it all out was so helpful for people." Beekeepers must consider the length of time that different treatments require relative to the bees' annual reproductive cycles or when they want to extract honey. New York State law limits which chemical treatments can be used while producing honey.

But despite the complexity around safety and timing, these chemical treatments are still relatively unskilled compared to other methods of managing mites, and many respondents saw their use as a first step. One recalled, "When I taught beekeeping, I would tell new beekeepers that I thought it was wise for them to use synthetic acaricides [miticides] for the first two years. They have a reliability to them: when your colony dies, you know why it died. Because if it dies and you don't know why, then you can't learn." In other words, by controlling mites and therefore more of the factors that could contribute to a colony's death, the new beekeeper could hone her other skills more effectively, without the mite pressures eclipsing all of the other factors that she needed to take into account, simply by process of elimination: if it was not the mites that killed her bees, maybe it was a different disease or a mishandling of the queen.

To these ends, the international list-serv described above was recently the site of a debate over whether new beekeepers should be encouraged to "treat by the calendar," meaning treat their bees chemically without determining the level of mites in advance to see whether treatment was warranted. One contributor wrote: "I suppose one could think of treating by the calendar as using training wheels on a bike, something to be outgrown ASAP… But if treating by the calendar keeps the bees alive for another season and also keeps the beekeeper in bees, maybe it is for the good." But another warned, "if treating by the calendar is an excuse for folks not leaning to monitor/test for Varroa, then the negative of this strategy definitely outweighs the potential positives." Another chimed in, "I strongly disagree with teaching new beekeepers to prophylactically treat for mites; I understand the why's of it, but think it undermines good beekeeping skills that these beginners are needing. Nothing is better than mite inspections and getting into those hives and observing and listening."

Indeed, the protocols of integrated pest management (IPM) require monitoring the levels of mites, which itself requires a set of skills that push a beekeeper further up the curve. One educator described how complicated it can be: "if you're going to think about [sampling the bees for monitoring] … can you identify your queen or not? Are you going to be too paranoid to do it because you think you're going to kill your queen?" A beekeeper has to be certain that the queen is not in the sample of bees that will be killed or shaken up to dislodge the mites for counting, but finding a queen amid thousands of workers can be difficult, not just looking for a needle in a haystack, but a slightly longer and fatter piece of hay in a haystack (plus all of the pieces of hay have stingers and are getting increasingly irritated!). Taking samples effectively also requires understanding the biology of the mite and the internal organization of the hive. A woman whom I mentored had checked on the mite levels in her colonies, but she had sampled bees working on the outer edges of the hive. Those bees typically do not carry as many mites, and so her estimates of the mite infestation were below the treatment threshold. When we sampled together, with "house bees" from the center of the hive, at least one of her colonies was over the treatment threshold for the season.

Finally, educators debated how prescriptive to be when teaching novices who are by definition as yet unskilled. One explained how he gave his students the choice:

> There are a lot of different approaches to beekeeping… I lay them all out. I say, look, *you can approach this from a conventional, traditional way, you can use natural beekeeping, you can use organic beekeeping, you can use the biodynamic techniques…* I say to all my students *you, your beekeeping practice, have to develop your management style, based on your goals as an individual…* With mite treatments, it's exactly the same way. When I go through the battery of potential mite techniques, we'll start out with coumaphos and Apistan strips, the way I was taught when I first started, and then we'll move into acids and essential oils and powdered sugar and screened bottom boards and drone comb. I'll just do it all.

Another educator agreed, “I dump the decisions on them.” But others took a more prescriptive approach: “Start with tried and true, standard equipment, standard methods, get to know bees, seasons, other beekeepers… and keep your bees alive for 5 years. Then you can start trying other things.” Another tells her students what to buy: “boom, boom, boom, this is the deal. And people like it, and are successful.” She referenced the idea of gaining facility over time:

> I’m going to give you… the advice to get to your own skill level that you’re going to get good enough that you can figure out what’s going on, that you can then start making decisions on your own, but until that point, this is the least upsetting to the bees, the most helpful, the least impact on the environment that you can do, and this is my recommendation.

Indeed, most educators encouraged beekeepers to start with more tried-and-true approaches to managing their bees, and then skill up and learn IPM techniques, as chemical treatments have the potential to close down a beekeeper’s observation and skill; one educator calls miticides “dumb chemicals for smart beekeepers.” Even though such treatments do require knowledge of the chemical risks to humans and the bees, they “do not require refined knowledge of the mites’ biology,” as one researcher puts it (Rosenkranz et al., 2010, p. s108). As an agronomist at an Eastern Apicultural Society meeting put it, “sustainable ag is not simple; simple ag is not sustainable.” Staying on this learning curve, which entails treating for mites unskillfully, is the “simple ag” in that formulation, likely unsustainable in the long term. And ultimately, beekeepers who treat their bees for *Varroa* still lose, on average, 35% of their colonies (Bee Informed Partnership (BIP), 2019). This is about ten percentage points fewer than those who do not treat, but still high. There is more, happily, that a beekeeper can learn and do.

Managing bees as hybrid creatures

The most dedicated beekeepers end up on the third and fourth curves of the figure (which one depends on their individual beginnings), often still managing mites chemically, but with fewer inputs than those who do not integrate bees' biology and into their management practices. They also lose fewer bees than those who are not cognizant of bees' wild nature.

Only a small number of beekeepers reach the level of expertise necessary for remaining largely or entirely treatment-free and keeping their bees alive. One bee breeder was proud to tell me that he had gone for fourteen years without chemical treatments. Another helped manage the hives for the Sustainable Honeybee Program in Virginia without chemical treatments since 2006 and with over 90% winter survival. Sam Comfort of Anarchy Apiaries said that he had not treated his bees with chemical treatments in ten years when I heard him give a talk in 2015. Others I only heard about secondhand, like a Mennonite man near the New York-Canada border who shares lessons with others in his club, or Kirk Webster of Vermont (recently profiled in Bill McKibben's book, *Oil and Honey* [2015]). Some beekeepers are purist about not using chemical treatments, but the one quoted above used cultural methods as needed. That is again in keeping with the principles of IPM, where such practices may only delay chemical use, but are still valuable.

The educators among them were aware that their level of beekeeping was not yet available to the novices they taught. One recalled talking to beginners in her classes: "you're like *okay, I'm not going to treat for Varroa*, which means you then need to have excellent manipulation skills… I do a lot of not treating, but that's because I have skills." These interviewees learned to be treatment-free after a period of time relying on chemical mite management. One beekeeping educator and extension agent has put together a "Varroa treatment decision tree" online. The first decision is based on the answer to the question "Is it early in the season, and are you good with hive manipulation?" If yes (meaning if the beekeeper was sufficiently skillful), then she recommends some of the biological and cultural methods; if not, then other questions determined which chemical methods were most appropriate (Milbrath, 2018). Again, skill here means the ability to manage mites without chemical treatments.

But what is key to these two final learning curves is a return to the factors other than *Varroa*. Even with mite management, many colonies will likely succumb to these many other challenges, especially the "environmental" Ps (pesticides, poor nutrition), and, again, these pressures are synergistic, in that a colony weakened by Varroa is less able to withstand increasing loads of pesticides, and vice versa. To ascend a learning curve to the highest levels of skill, a beekeeper must begin to use agroecological principles, incorporating "environmental" factors into "agricultural" practices: an awareness of honey bee biology, broader ecologies and phenology, seeing honey bees as hybrid. Indeed, if the second learning curve represented a narrowing of practices in order to allow for more controlled conditions of learning, these two curves begin to open those practices back up. These beekeepers control what they can, but let go of or learn to work around what they cannot. To return to the literature on health, hygiene, and control, these beekeepers manage to institute both the short-term stabilizations (managing mites through whatever means necessary) and address the longer-term, wider-scale, and "less controllable" dynamics (Leach et al., 2010, p. 370).

An important (but difficult and elusive) strategy for beekeepers on these curves is artificial and natural selection for resistance to *Varroa*. Across the country, there are coordinated efforts by researchers, extension programs, individual beekeepers, and collectives working to breed more resistant strains of bees. As one interviewee described, beekeeper Kirk Webster manages to remain treatment-free because he breeds from his surviving colonies, selecting for specific behaviors to combat *Varroa* infestations. That is the basis for what many of my interviewees considered truly "sustainable" beekeeping: "it's breeding and selection and it's really paying attention to the genetics." Another one spoke with admiration about the beekeepers who are continually selecting for bees that are "doing it themselves, they're handling the situation themselves."

Breeding bees is a dance between opening up and closing down possibilities. Some approaches are more interventionist and controlling, seeking to maintain the purity of particular lines through artificial insemination, isolating particular bee populations on islands, or cementing traits that make bees more manageable by humans, for example, ones that are not "nervous" on trucks (according to one conversation I had). Other breeders actively seek out feral bees or bees of unknown origin to diversify their bees' population genetics, especially "local" bees that may have survived in the wild without human management of their mites. But even without that particular focus, all breeding is local (just like beekeeping), as particular traits that promote the survival of a given population may only be expressed or relevant in particular contexts, as a function of the local climate, available flora, and more. There is currently a robust discussion among beekeepers about whether stock improvement or local adaptation is even possible, given that the majority of honey bees are moved around the country for pollination or honey pasture, intermixing with one another to a degree that local populations may not be distinct. Nonetheless there are still many beekeepers who are skillfully attempting to bring together these agricultural and environmental considerations to breed more resilient bees. To return again to the distinction between simple versus sustainable ag, this learning curve is perhaps the most sustainable, but the least simple, of all.

Conclusion

In sum, framing beekeeping practices as a set of multiple learning curves instead of as a conflict or diffuse set of opinions helps with a more analytic understanding of the learning process, moves away from the "two sides" framing, and clarifies to novices the best choices available to them. Neither conceptualizing honey bees as wholly wild nor wholly domesticated livestock is sufficient on their own – each require learning different skills and taking different actions that must be taken together; beekeepers with the most skill and experience conceptualize and treat their bees as hybrids. I hope that this is the beginning of a definition of "bee-centred beekeeping" (as the only definition so far has been negative, that it "stands in stark contrast to large-scale, commercial beekeeping" and that there is "considerable disagreement about what these methods should and do entail" (R. Ellis, 2019, p. 116).

There is still a need for political pressure around these broader environmental issues – and the popular framing of bees as wild creatures has helped mobilize such support. As one interviewee stated, "beekeepers can only do so much on their own. We really need the assistance from the wider agricultural community." Another interviewee agreed that the attention to pesticides was largely positive:

> it's good that people will be more aware of the crazy damage that we are doing to the environment and… say, *now we need to listen, we need to go against all of these corporations, Bayer, that are the enemy,* even though it's not killing the bees. Seriously. If it's a good cause to do that, I'll take it… We want to try to get rid of many of those terrible pesticides.

Indeed, it is dangerous to designate health as solely the responsibility of individual beekeepers and not hold corporations accountable or demand changes in land use regulation (see Julie Guthman on "healthism," a neoliberal framing of well-being [Crawford, 1980; Guthman, 2011]). But the beekeeper quoted above also went on in the same breath to say, "But I think most of the dying, most of the collapse of hives, are due to poor management." Beekeepers need to be aware of both.

With this article, I extend theory on hybridity and the Anthropocene, to incorporate scholarship on the health/hygiene relation. My aim is to make some practical recommendations for beekeepers, following a line of inquiry from geographer Sarah Whatmore. She has written about "hybrid geographies" as engaging with knowledge practices, including the “know-hows, tacit skills and bodily apprehensions” of daily life (Whatmore, 2002, p. 6) and a more actionable “more than human ethical praxis” (Whatmore, 2002, p. 160). For her, what is useful about such theory is how it helps people navigate difficult choices. In the case of beekeeping, that means the difficult choices over how to manage mites, rather than a simple “anti-science metaphysics [or] a demonology of technology” (Whatmore, 2002, p. 162, citing Haraway, 1985, p. 100). Similarly, political ecologists who study health see such hybrids as practically useful: “seeing health and disease outside of the binary of biology versus society … forces us to focus on new ways of doing things: it is, as Mol puts it, the politics of ‘what to do?’” (Mansfield, 2008, p. 1016).

Indeed, individual learning, cognition, and skill are a central focus here, in large part because accommodating both of the value systems at play in the Anthropocene imagination requires what the English Romantic poet John Keats called “negative capability,” or being “capable of being in uncertainties” (in an 1817 letter to his brothers). A more squarely dualistic version of the same idea is F. Scott Fitzgerald’s famous description of a “first-rate intelligence,” or the “ability to hold two opposed ideas in mind at the same time and still retain the ability to function” (1936, p. 41). Geographers Paul Robbins and Sarah A. Moore have written more specifically about the “discomfort, conflict, and ambivalence” among ecologists searching for resolution between “conjoined concerns,” or opposing value systems, to guide them as they effectively chronicle the losses of the many nonhuman lives around us (2013, p. 3). There is a collective and political dimension to the work of this epoch, but individuals, too, must learn to live with this cognitive balance and use it as a guide for their new knowledges, skills, and practices in the Anthropocene.

CONCLUSION, OR THE BEE-ALL END-ALL

Introduction: hybrid theory and research topics

In this conclusion, I reflect on my efforts to work alongside natural scientists (entomologists) and beekeepers, where those efforts worked, and where they fell short. The research questions I asked were inherently interdisciplinary, seeking to explain honey bee health challenges through interlaced biophysical, cultural, and political lenses. In a similar fashion, my methods of conducting research were engaged and – to an extent – my questions and conclusions co-produced. My conclusion is straightforward and not especially novel: in order to draw useful conclusions about nature-culture hybrids (such as honey bees), research needs to be both interdisciplinary and engaged. It is a messy process; the many sprawling threads of my dissertation are evidence of that. But this varied disciplinary theory was illuminating for me and there are many lessons to take forward into future projects; I hope the same is true for readers of my work.

To study honey bee health in the Anthropocene is to study intersecting naturecultures (Donna Haraway, 2003). As I have described in the preceding papers, honey bees have long been recognized as a hybrid creature, both domesticated livestock and a wild animal. This hybridity maps onto a larger bridge of being both “nature” and “culture” and has implications for honey bee health (Nimmo, 2015; Tsing, 1995; Waring, 2015). Indeed, my initial recognition of hybridity came out of geographer Tony Weis’ language around “ghosts” and “things” (2015) – different ways in which wild and domesticated animals suffer or are in poor health. In my first and third articles, I describe how there is little agreement on what the “problem” is: many observers see honey bee health challenges as indicative of broader ecological health and prescribe actions that would support both. Others see it as a different, but familiar sort of problem in managing livestock and their pests and pathogens, and the necessary actions are therefore also familiar, in managing those pests and pathogens in various prescribed ways. It may be that the notion of hybridity is so useful in thinking about honey bee health because health more broadly is a hybrid phenomenon of its own.

This research focus fits in with scholarship on the Anthropocene, which, at its most basic, calls for a recognition of the relationship between humans and the broader environment and dialectical reasoning. In my first article, I described the concept of the Anthropocene and what I find most useful about it. One way I present the Anthropocene in shorthand to my students is that it describes the moment when geologists went from thinking of human impacts – bits of plastic or a layer of ash or radiation or disturbed agricultural soils – as “noise” that was interfering with the signal of geologic change over time, to being the “signal” itself. More broadly, the Anthropocene eschews the idea that there was ever anything pure: “there is no primordial state we might wish to get back to, no Eden we have desecrated, no pretoxic body we might uncover” (Shotwell, 2016, p. 4).

While there are many scholarly critiques of the idea and framing of the “Anthropocene,” also described throughout the dissertation, I continue to find the concept useful, in large part because of the cross-disciplinary and engaged nature of my research. The Anthropocene as an idea has been celebrated for its encouragement of interdisciplinarity and apparent ability to mobilize diverse publics. Anthropologist Todd Braje recently echoed this line of thinking in a scholarly forum on the topic: "debate about the Anthropocene… produces dialogue across disciplines and with the public about how humans have helped create the global environmental crisis and why we need to do something about it" (Bauer & Ellis, 2018, p. 215). The Anthropocene as a distinct geological era was coined in the natural sciences.[23] But its very name speaks to the role of society and culture in shaping biogeophysical processes, and its implications are humanistic questions about values, emotions, cognitive dissonances, and connections. The affective dimensions in particular have spurred widespread public engagement. It is therefore a useful device for teaching and for communicating with a wide range of stakeholders and audiences.

Crossdisciplinarity

There is widespread agreement that collaboration across the "cultures" of social and physical/natural sciences can help scholars clarify their ideas, go in new directions, gain insights, strengthen policy implications or other avenues of influence, and more. This rationale for interdisciplinary scholarship, simply put, is that it has the potential to be more accurate and comprehensive. But this is only one of several logics for such work (Barry et al., 2008). More to the point for my research, the "hybrid nature of sociotechnical and socioenvironmental phenomena" seemingly necessitate

[23] The often-told story of the genesis of the Anthropocene is about atmospheric chemist Paul Crutzen having a "eureka" moment while at a conference. His colleague Will Steffen recalls a conference where scientists were continually referring to the Holocene as the context for their work. (The Holocene is the current geological epoch.) Crutzen interrupted, "Stop using the word Holocene. We're not in the Holocene anymore. We're in the… the… the… (searching for the right word)… the Anthropocene!" (Steffen, 2013, p. 486).

interdisciplinary methods (Whatmore, 2009, p. 591). This is not simply because a topic such as honey bee health has "both" physical and social dimensions, but because, as I have outlined above, it "raise[s] fundamental questions concerning the very distinction between the natural and the social" (Barry et al., 2008, p. 37). Said another way, "operationalizing hybridity conceptually requires interdisciplinarity practice" (Hovorka, 2018, p. 455).

Calling research cross-, inter-, multi-, or trans-disciplinary is typically based on the degree to which different disciplines are synthesized. In multidisciplinary projects, researchers come together with their different disciplinary tools, although they might answer different questions. In cross- and inter-disciplinary projects, there is more of an effort to synthesize the different contributions. In transdisciplinary work, there are explicit efforts to transgress disciplinary norms and other divisions in knowledge production, an idea that has more in common with co-production and engagement, described below. While it might seem like more (interdisciplinarity) is better, some scholars have warned that retaining difference and distance is in fact productive; Donna Haraway and others have remarked: "Collaboration does not mean you need to fuse the disciplines to make some new hybrid. No, you are allies! You [should] keep your disciplinarity… because you only get a creation of something new, when you have differences to begin with, to interact with" (2016, p. 552).

There are other ways to slice and dice interdisciplinarity. For instance, geographer Andrew Barry and others describe a typology of several modes of interdisciplinarity, based on the relationships of different disciplines to the others: there is what they call a integrative-synthesis mode, a subordination-service mode (where one or more disciplines are used in service to others), or an agonistic-antagonistic mode ("driven by… criticism of or opposition to the intellectual, ethical or political limits of established disciplines") (2008, p. 29). In other words, the intentions of the interdisciplinarity vary from project to project. Within my own work, I operated in each of these modes at different times.

That interdisciplinary work continues to be explicitly called for and celebrated when it does arise is (somewhat counterintuitively) evidence for the fact that it remains relatively rare. There are epistemological challenges to integrating the characteristics of different disciplines, which might include different standards of evidence, use of hypotheses, and conceptions of what constitutes an "argument" or "what is assertible and why" (S. M. Donovan et al., 2015; Laursen, 2018, p. 76). One irony is that even in those research topics understood (by social scientists at least) to necessitate a sociological (political, etc.) perspective, such a perspective may still be marginalized. Even in apparently welcoming research settings, subtle preferences or opaque processes may continue to stymie efforts to include them, particularly when such contributions do not appear to fit in easily (Castree et al., 2014; Lahsen, 2016). Sociologist Elizabeth Shove has critiqued what she calls the "dominant paradigm of 'ABC,'" or *a*ttitude, *b*ehavior, and *c*hoice (Shove, 2010). This is the (mistaken) idea by physical scientists that social scientists only bring to the table simple questions about what consumers or citizens want or how they might act, a conception of social science that sets aside broader questions about structures and systems. The social sciences are more epistemically diverse than the physical and natural sciences, a kind of "Tower of Babel" (Phillipson et al., 2009, p. 261). There are unanswered questions about how critical social science can be adequately integrated when so much of it in political ecology and other fields are explicit or implicit critiques of regimes of knowledge production in economic theory and the natural sciences, especially as they have been intertwined with power and authority (Lave, 2015).

But many challenges to interdisciplinary work are simply practical and logistical, whether such work is conducted by one person or more. When it is a collaboration between two more or more scholars from different fields, there is an additional layer of interpersonal considerations.[24] But sole-conducted work, such as the work that goes into a dissertation, has its own limitations. For instance, the work is necessarily shallower as it widens to multiple disciplines: one researcher cannot read all of the relevant literature or use many methodologies proficiently. It is difficult to know which conferences to attend, where to publish strategically, where to find funding. Some of these are challenges for any individual cross-disciplinary researcher, but they are more acute at the early stages of a career.

In the most fields that my research is positioned in, there have been many calls for more interdisciplinary research and celebrations of what already exists. In animal geographies, for example, Henry Buller recently called for “mov[ing] away from the traditional… separation of social and natural science to establish a set of concepts and methodologies that addresses what matters for both human and non-human animal subjects” (2015, p. 376). Along the same lines, there is a wealth of scholarship that takes an interdisciplinary approach to health; most relevant here is new work on the

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[24] In 2019, I organized a panel at the Dimensions of Political Ecology conference entitled “The payoffs and pitfalls of collaborative research with physical scientists” where presenters (political ecologists with social science training) shared their experiences conducting research alongside physical scientists.

political ecology of health (Jackson & Neely, 2015; King, 2010) as well as other cross-disciplinary approaches to understanding the health of nonhuman animals, most notably a special issue of the journal *Philosophical Transactions of the Royal Society B* on "Interdisciplinary perspectives on the management of infectious animal and plant diseases" (Wilkinson et al., 2011). Wilkinson et al. note that the physical sciences alone cannot solve animal health problems, lamenting the "great divide between the natural and social sciences… [and] the resulting fragmentation of knowledge [that] hinders progress in understanding and dealing with disease" (Wilkinson et al., 2011, p. 1933). They identify the two main drivers of the spread of animal diseases to be phenomena that clearly illustrate the interplay of the social and the physical: climate change and globalization. In the same vein, social scientific work on integrated pest management (IPM) underscores the social values and calculation of trade-offs inherent to decisions over pesticides, as well as the uneven distribution of risks and benefits (Metcalf, 1987). In other words, an individual's health is not solely impacted by, say, a virus; what matters is their vulnerability to it, which is itself a product of numerous social, political, and economic factors. In IPM, a decision to use or not use a particular pesticide is not solely determined by its physical characteristics; the decision is shaped by economic and sociological factors as well (Metcalf, 1987, p. 24).

Engagement and co-production

Interdisciplinarity goes hand-in-hand with more engaged research. Indeed, the other main divides being breached or at least muddled by researchers in the Anthropocene are those around knowledge production and, relatedly, accountability to actors within or outside of the academy. It is difficult to know where to begin in the vast literature (peer-reviewed and otherwise) on engaged research. The broad idea of "engagement" goes by a variety of names, all with different connotations: "co-production," "participatory research" or "participatory action research" (PAR), "hybrid research" (Batterbury et al., 1997), "transdisciplinarity" (which includes attention not only to interdisciplinary in the sense described in the previous section, but also the lay-expert divide [Barry et al., 2008]), among others. Here, I will largely use the term "engaged."

Each of these terms have a different lineage and focus, but most center around the core commitment to co-create knowledge with research participants, to varying degrees. Together, these approaches together represent a shift (return?) towards the increased legitimation of knowledge not backed by formal, academic credentials. More tangibly, that might mean that one or more steps in the research process (however muddy the boundaries are between those steps) are done in tandem with the people who are ostensibly research subjects, and most importantly, the upstream or early-stage framing of the problem or development of the research question. Again, this collaboration might manifest to varying degrees, along the lines of the famous "ladder of citizen participation" by Sherry Arnstein (1969). More participation and input are equated with power, less with tokenism, and little or none with exploitation. It is not a leap to apply this framework to research more specifically, where at the top of the ladder, a research project is co-designed and knowledge co-produced with the conventional researcher and other stakeholders in largely equal roles. Moving down the ladder, ownership of and responsibility for the project is increasingly one-sided, in the hands of the formal researcher.

Co-production and engaged research are guided by logics similar to those described above for interdisciplinary work. Much research on agricultural and environmental issues, the broad topics most relevant to my work, is calling for methodologies that explicitly involve relevant stakeholders and find ways to honor and embrace epistemological differences. This is especially true for researchers whose work is taxpayer-funded or who benefit from public resources (such as those at a land grant university) and are therefore already accountable to the public in a broad sense. This is part of a larger turn wherein conceptions of scientific research as autonomous are giving way to conceptions of such research as accountable to the larger society (Barry et al., 2008). Engaged work at its best is a way to discharge that responsibility.

Such calls are punctuated by statements such as: “Co-production promises to address the complex nature of contemporary sustainability challenges better than more traditional scientific approaches” (Allen et al., 2014; Murphy, 2011; Norström et al., 2020, p. 182). In other words, like interdisciplinary work, engaged research is said to be more accurate and comprehensive. It is also said to be an avenue for creating ontological change, as it shifts research questions; indeed, for many, that is the whole point. Just as it upends the relationship between the researcher and the subjects of research, it can upend how those distinctions are even conceived. By inviting into the process people and communities who have not conventionally been a part of it, engaged research can overturn assumptions around appropriate research methodologies. And it may often be explicitly critical: much engaged and participatory research seeks to be accountable to a smaller slice that is underrepresented or disadvantaged, with the explicit goal of lifting that slice up and contributing to social change.

Geographer Laura Pulido has described the notion of accountability in engaged research as follows:

> … [S]cholar activists are not lone mavericks… you are embedded in a web of relationships, some of which demand a high level of accountability to a community or other group of individuals. It is accountability that will hopefully ensure the relevancy of your work in the effort to create social change. Accountability requires seeing yourself as part of a community of struggle, rather than as the academic who occasionally drops in. (Pulido, 2008, p. 351)

And accountability stretches across the entire length of a project. Scholar-activist Richa Nagar has written about how researchers share the results of their work. She quotes a community member, who wonders:

> … why is it that when they return to their institutions, they frequently write in ways that are totally inaccessible and irrelevant to us? … The question of access is not just about writing in English. It is about how one chooses to frame things, how one tells a story … [Suppose] you tell my story in a way that makes no sense at the conceptual level to me or my community, why would we care what you have to say about my life? (Nagar, 2002, p. 179).

In other words, to be committed and accountable to a community means making the products of research (at the very least) available, accessible, and relevant to them. This is not a new or unique idea. One of the basic tenets of writing is to write for a particular audience, which means make the topics and concepts and conclusions both legible and relevant to that audience. But it remains difficult to do so well.

Despite the persuasive force of these logics, however, engaged research remains a minority of scholarly work. For a time, epistemological objections may have been paramount, along the lines of Robert Merton's mid-twentieth century ideal of "disinterestedness" among scientists (1973). A century of more of these researcher-researched distinctions is difficult to overturn. But there are also practical challenges, similar to those that face the interdisciplinary work described above. There are "extra" burdens of conducting engaged work well at all or most stages of a project, from upstream conversations about the research questions to outputs in the months and years following. Much time, energy, and resources must be committed for an endeavor to be genuinely collaborative. Political ecologist Tracy Osborne has tried to address the need for "triangulating research to both serve the needs of community partners while meeting academic requirements" in her call for "public political ecology" (2017, p. 854). In the spirit of Laura Pulido's work, quoted above, she notes that the challenges seem especially important to address at early stages of one's career; her piece is directed towards such academics "wondering if and how they can negotiate the seemingly disparate demands of political engagement and academic performance" (2008, p. 341). I turn now to my own negotiation of these demands and my successes and failures as I sought to conduct interdisciplinary and engaged research.

Bee-ing cross-disciplinary

One of the faculty in my department is evidently proud to have been described by another as "not a thoroughbred."[25] I hope I might be described the same way. My undergraduate degree is in Political Science and French, my master's degree was in Geography with some publications through Agricultural Economics and Rural Sociology, and my PhD will be in Development Sociology (now Global Development), with support from faculty in Natural Resources and Science and Technology Studies. My doctoral work has also been supported by funding from the Entomology department, American Studies, and the campus writing center, minus the year I took off to teach in an Environmental Studies department. The conferences I attend most are in political ecology and geography. The total is more than ten different fields and subfields, nearly all of which are interdisciplinary in their own right.

But I am not a 50-50 social-natural scientist. My core fields, above, and my research questions are social scientific, as I sought to understand the conflicts in the beekeeping world over honey bee health and beekeeping practices, taking as my objects of analysis some of the conventional wisdom in beekeeping. So most of what I have learned has been in service to my sociological questions. I remember looking at my notes in one quiz for a Master Beekeeping class, knowing that I would never need to know the difference between the tarsus and the metatarsus, and that what would serve me better was a broad look at honey bee biology and beekeeping. In taking the course, I kept up with the material while also cataloguing how the course instructors organized the material, what they elevated as important at that level of beekeeping

[25] www.devsoc.cals.cornell.edu/research/faculty-research-projects/wendy-wolford

instruction, in an ongoing meta-reflection (for instance, I did not agree that being able to identify the tarsus and the metatarsus had any practical value whatsoever). Very little of what I know about honey bees can I relate to other insects or animals except in a broad analytical sense of how vulnerability to disease is a function of politics and management by humans.

Still, to answer my research questions, I needed to learn a lot about honey bee anatomy, physiology, nutrition, and biology. As both a formal student and teacher of beekeeping, I have learned to be precise with language, naming particular maladies, distinguishing between different modes of reproduction, eschewing the use of the term "colony collapse," and more. Keeping bees healthy is in the details. And it was by approaching beekeeping with a more explicit attention to the relevant entomological and biological sciences that I came to understand them as hybrid creatures, following Barry et al.'s insights that objects of interdisciplinary study are not inherently interdisciplinary, naturally demanding such research methods, but rather "constituted" as such (2008, p. 30).

In the end, I took them seriously enough that my research was what Barry et al. call "agonistic-antagonistic mode," or explicitly positioned as a corrective to existing (social scientific) work on beekeeping, which took very little notice of *Varroa* mites and their spread (Barry et al., 2008, p. 29). Indeed, what is puzzling about much of the social scientific literature on bee health is that they largely ignore the threats that are most central to bee health. Social scientific work has rightfully pointed to broader political economy of corporate agriculture and campaigns of misdirection, the nature of many scientific endeavors that oversimplify complex relationships in a search for a single, uniting cause for a problem, with a narrow focus on "individual factors" and a neat cause-and-effect (Kleinman & Suryanarayanan, 2013, p. 497; Suryanarayanan & Kleinman, 2016; Watson & Stallins, 2016). All of these things are important, but their political ecologist authors and others risk seeming far-sighted, or missing the trees for the forest.

Of course, other social scientists studying beekeeping work alongside beekeepers. But they privilege the voices of some beekeepers over others. For instance, one study implicitly sympathizes with beekeepers "primarily motivated by environmental concerns," who are "often criticised by both the scientific community and other beekeepers" (Maderson & Wynne-Jones, 2016, p. 94). These authors therefore focus on the "small but significant number of beekeepers" who question the advice of the (UK) government's beekeeping office (to monitor and manage mites), apparently because they, too, question that advice (Maderson & Wynne-Jones, 2016, p. 93). Political economist Andrew Sayer, who has warned against supporting "subjugated knowledges" simply because they are minority beliefs. In an analysis of what qualifies as "critical" scholarship, he points out that this blanket approach "provides no particular rationale for favouring progressive knowledge" (Sayer, 2009, p. 771).

Perhaps for these reasons, those beekeepers who were *not* consulted have pushed back against some of this scholarly work. Sainath Suryanarayanan authored an article in 2013, calling for a "socio-ecological systems approach… less concerned with isolating individual factors and more attentive to the interactive and place-based mix of factors affecting honey bee health" (Suryanarayanan, 2013, p. 153). Its publication provoked exasperation and rebuke on a national beekeeping list-serv, with contributors defending the ongoing scientific work to understand honey bee health. One wrote sarcastically, that "according to [Suryanarayanan], they - whomever they are - would be far better at explaining these complicated issues they know nothing about than the current experts in the field who are too narrowly focused on subjective things like 'facts and data.'" This beekeeper (who has since become a friend and mentor) excerpted a passage from the article calling for "transdisciplinary collaborative research" (p. 162) on the effects of pesticides in the field. Suryanarayanan envisions a study that is less controlled than the conventional approach, using qualitative and quantitative data, looking for correlations (and presumably not so focused on causation), and erring on the side of false positives over false negatives. The "collaborative" part means, in part, recruiting people from a wide range of stakeholder groups, and collective deliberation measured in years, not months, to design experiments directly useful to multiple parties.

But several of the beekeepers on the list-serv pushed back on how both the interdisciplinarity and the collaboration were framed:

> …what's up with using a phrase like *academic disciplinary silos*? He may be the one who is in a silo, since he seems unaware of the networks already established between stakeholders. The researchers I know are actively involved with the industry and each other, not generally working in isolation on pet projects as he contends.

I think that Suryanarayanan's critiques of conventional approaches to entomological studies are valid and intriguing. There is much scope to work alongside new research partners to re-shape questions, methods, and other aspects of study design. But he has not endeared himself to beekeepers to make such a study possible. As another contributor to the list-serv added, “the author’s unnecessary use of pejorative language throughout the article did little to encourage the assumption of good faith.”

Still, my own efforts to contribute to interdisciplinary projects, where I was the lone social scientist among physical scientists (and economists) were not so successful either, even if my contributions were better received. (Although it has been noted that such failures are apparently “routine” in collaboration (Sacco, 2020, p. 489).) I will describe each in turn, with an emphasis on how we integrated these different fields. Relative to my broader dissertation research, my participation in both projects was brief, but took on an outsized significance because of my interest in working across disciplines.

The first was a pilot study conducted by Cornell beekeeping extension personnel, which is housed by the Entomology department. There was an idea to undertake a breeding project that would combine research on the mechanisms of mite resistance by feral bee populations and outreach, first crossing bees from those populations with other, locally adapted populations, and then distributing any such crosses to beekeepers across the state. I was invited to join in 2018 after the initial idea was conceived. My role was to collect data (through a survey and interviews) on what sorts of efforts in breeding were already underway and the sorts of genetic traits that the state’s beekeepers were looking for when they purchased bees. This information was intended to help us decide whether and to what ends Cornell researchers might get into the bee breeding business. This social scientific data was widely seen as the necessary first step upon which later steps were contingent and around which they would be shaped. In the end, however, the information was used to promote breeding efforts across the state after the project was halted for other reasons. The other researchers have shared some of the results publicly, although the project was ended before a complete analysis of the data, and I hope to use them as the basis for a paper on breeding bees in the future. One happy side effect was that, for publicizing the survey, I created a list of all the known beekeepers in New York State, a list that has been useful for other research and outreach.

The other proposed research project did not get very far either. In the spring of 2017, I was invited to join a team writing what was eventually $6.3 million grant proposal for the USDA. The project aimed to understand what makes a honey bee queen high quality, and why queens seem today to be of lower quality than previously. The team had about a dozen other apicultural scientists (two economists, several entomologists, a mathematician / modeler, and more) from different institutions around the country. I was the most junior and the only social scientist, invited to join as a potential post-doc, and my role felt like more of an afterthought or pet project by the PI, based on the sense that interdisciplinary work would be more likely to be seen favorably and funded.

My role was initially conceived of by the PI as "translat[ing] whatever findings we derive to the industry" and thinking through "barriers to adoption" of any management practices that the team might come up with. This conception of my contribution, I thought, was limited, and I wanted the sociological dimensions of the issue to be addressed more upstream in the project. In other words, there should be sociological research integrated into the project, and my role therefore more than just communication. But I was not very successful in demonstrating to my new colleagues how that might work, which can be seen in the visual (Fig. 8) that we generated of how all the project would fit together. It shows the different pieces chronologically; the results of all the studies for Objective 1 would feed into Objective 2 and so forth. Different team members were responsible for different objectives, with their photos next to those objectives. My photos are highlighted in yellow.

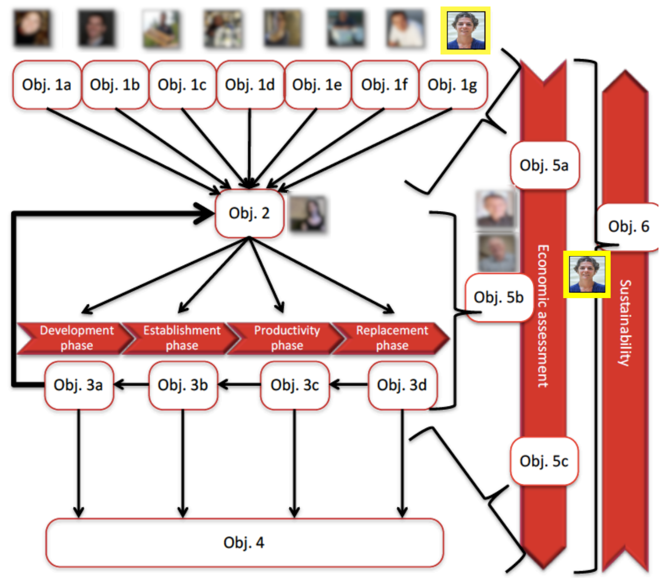

Figure 7: Organizational chart of proposed interdisciplinary research

Objective 1 was to evaluate different factors that play into queen quality through a set of self-contained research studies on the queen's microbiome, nutrition, infections, parasites, pesticides, genetics, etc. I was tasked with determining the motivations of beekeepers for different choices they made around rearing queens. The results of those students would then be mathematically modeled and tested on queens at different life stages, resulting in the generation of some best practices to share with beekeepers. Objective 5 was to be conducted in parallel with the other studies, an economic analysis of the market for queens and the costs of queen failure. Finally, Objective 6 was the overall goal of "sustainability."

In the end, the project was not funded, largely because the funders did not believe that honey bees qualified as a "specialty crop" (something that should have been made clearer in the initial rounds of review!). One reviewer explicitly took issue with Objective 6, sustainability, saying "it's not clear to me why this is even an objective or what the aim is here." The PI responded to me kindly and in private, "[I]t's a pity they didn't see how that objective [on sustainability] was interwoven and central to the entire narrative." But I cannot fault the reviewer. "Sustainability" was not the best word for what we wanted to do, which was better equip beekeepers to improve the health of their queens and therefore the health of the honey bee population at large, with attention to the structural or other reasons that that may be more difficult than simply following recommendations. And whatever we wanted to call it, it needed to be everyone's job, not mine alone. I wish I had lessons from a more successful project. Still, one lesson that I can glean is that I would not likely have been welcome to the project if I had begun with a criticism of the very nature of large-scale beekeeping or the goals of the government grant of increasing profitability and productivity in agriculture, both of which are key to the funding agency.

Bee-ing engaged

My attempts to make my research more collaborative and engaged were also made in good faith, but they too were fraught and fell short. Still, I am proud of the effort. Accountability over the long term is hard, and I sought to make it easier by focusing close to home, in the spirit of Laura Pulido's work. As I describe in the appendix on my methods, I was from the beginning an actor as much as an analyst in a local and regional community of beekeepers. I did not explicitly seek input on the design of my research and there are many other ways that my research around beekeeping and honey bee health might have qualified as "engaged," but this is the balance that I found: immersing myself in this social world, as a beekeeper, local leader (as an officer in the local bee club), educator, and mentor. (The particulars are described at more length in the appendix on methods.)

These efforts have not always been seen as enough to warrant describing as engaged: a few years ago, I submitted a draft paper to a journal and had to check off the boxes that best described my methodology (a limited way to do so, I thought). I chose "case study" and "action research." I would have preferred "participatory action research," but that was not an option. One reviewer wrote: "I certainly do not think that this is action research." I find this to be a narrow view of action research. There is plenty I did not do; for instance, I did not design my research questions directly alongside other beekeepers, and I collected my own data (largely interviews and observations). But there was plenty that I *did* do to strengthen the beekeeping community and support honey bee health across New York, and I think that my work does qualify as action research.

The core of my approach was getting my hands dirty, literally: smudged with sticky, fragrant resin from the hives, or swollen after a sting, or dusted with gold as I gingerly helped my husband saw off his wedding ring after a bad sting of his own. I progressed along a long-term learning curve myself, losing several colonies over the years, likely because of poor mite management. Embarrassingly, my mite counts were sky-high the one year that my colonies were a part of a Cornell Entomology study monitoring mites, meaning that my colleagues there saw my failure for themselves. Even in the better years, there is regular work to avoid such losses (monthly mite checks during the summer and fall, hive manipulations to reduce mite numbers, the application of miticides, ideally re-checking mite numbers after such interventions). The experience of all of this time and effort and money and worry kept *Varroa* centered in my research over and above other factors in honey bee health, as I knew it was centered for so many other beekeepers. In the same vein, being a beekeeper myself also served (serves) to remind me continually of the costs of labor and the difficulty of acquiring knowledge and skill. Many scholarly critiques of development warn against the substitution of labor and skill by “overrides” (Weis, 2013), false economies of scale, or other forms of capital and equipment. I wrestled with those choices regularly: *do I use a mite management technique that has a low tolerance for error and requires more trips to the hive, but which is not as hard on the bees than one that is simpler and faster to administer?* In making these choices myself, I came to appreciate why the easier overrides or other substitutions have gained so much ground: it is much easier to call for labor intensification on small farms when I am not performing that labor myself!

Furthermore, as more than just a beekeeper, but also a mentor and educator, I integrated basic pedagogical principles into my analysis of different mite management strategies, and benefitted from the insights that this gave me. To effectively mentor novice beekeepers, I had to find out where they were coming from – and finding out where they were coming from reduced my sense of there being a two-sided, antagonistic conflict. I came to think of beekeeping as scaffolded instead (in the educational sense), which gave rise first to the concept of learning ladders and later learning curves, for the third paper. In one instance, in my club's workshop for beginners (March 2015), the lead instructor insisted that we not frighten the beginners by talking about mites and other diseases and pests, that they would learn all about it soon enough. At the time, I did not agree, and I raised mites in at least one personal conversation with a participant. Now, however, I do agree: there is so much else to learn and mite populations often do not rise to levels high enough to endanger the colony in the first year, so I have come to joke with new beekeepers that they get a "bye" in their first year.[26] In this sense, I have begun to apply the learning curves I described in paper #3, recognizing that novice beekeepers first need to understand the fundamental interactions between the environment and their hives (for example, the seasonality of particular honey bee behaviors), before zeroing in on the mites, and then zooming back out again to the ecological interrelationships that their bees are a part of.

Indeed, being a part of the beekeeping community shaped my questions and my analysis significantly. It contributed to my focus on the immediate, individual level: I did not study the beekeeping industry, nor large-scale beekeepers engaged in migratory pollination. I studied the process of learning and the cultural politics around different approaches to beekeeping, which is what I was experiencing and seeing all around me. I described in the introduction my opportunistic approach to collecting data and the ways that particular talks or fragments from interviews planted the seeds of insights and claims. Of course other researchers encounter such seeds in their more formal, less immersive approaches. But being immersed made the ground more fertile

[26] As in so much in beekeeping, it depends. The degree to which a first-year beekeeper must actively manage mites is partly a function of how s/he obtains her bees.

where these seeds fell, given my perspective on the wider context or lived experience. In this way, it was my commitment to working with entomologists and with beekeepers which came first; the relationships that ensued gave me various insights.

Being a part of the broader beekeeping community also keeps me humble. One of my interviewees once described attending her first Eastern Apicultural Society (EAS) annual meeting. EAS is a regional organization that draws beekeepers of all levels from up and down the East coast for a yearly conference. She described the effect of attending these meetings on a beekeeper's confidence in quick fixes: "It's pretty hard to go to EAS and then come back and be like, *oh, yeah, I think all I need to do is put my bees in this oval or whatever…* You'd be like, *clearly, there's people who've thought about this a lot more than I have!*" To extrapolate from her comments to my own experience, not just in beekeeping but in thinking about beekeeping, there are people who have already thought about it a lot more than I have: educators, hobby historians, research scientists, extension agents, and more. I have continually been reminded of how much more there is to learn, and how much more I learn when I listen.

Finally, I intend for my work to be accessible to beekeepers and students as well as more a specialized, scholarly audience. I hope that it is usefully simple, even elegant, along the lines of geographer Don Mitchell's 2014 essay against "complicating" things. He writes:

> Our job as scholars is *not* to 'complicate.' It is to analyze and explain, and especially to explain clearly. To 'complicate' is to turn our job on its head. There is no doubt at all that the world—and the things we study—are

> complicated… Our job is to cut through that complexity. (D. Mitchell, 2014, p. 125).

My aim is to better understand the dilemmas over how best to care for bees, whether by using difficult theory from Donna Haraway or simple, broad distinctions, like the one between "environment" and "agriculture," anything that clarifies the issues. I have sought to provide each audience the angle that it is missing: for a social scientific audience, the specificities of honey bee health and the reasons that those details matter; for beekeepers, a broader sense of the historical and socio-ecological context within which they are operating. Indeed, this research also provided an opportunity to educate beekeepers and research scientists about the relevance of the social sciences. Most of the grant money available to study honey bees and beekeeping is explicitly or implicitly accessible only to researchers in STEM fields, and beekeepers tend to think of scientists as those in STEM fields. When I introduced myself as a social scientist studying beekeepers, not bees, interlocuters did not understand at first what I was studying, but were receptive (usually after a joke about what an oddball group my research subjects are). They recognize the politics over biosecurity, even if they would not call it that.[27]

Concluding thoughts

Although I have described interdisciplinary and engagement separately, it is difficult to disentangle their combined effect on my research. And while I believe that

[27] A few explicitly rejected the word "politics"; one beekeeper responded to a question about it: "I… disagree with your word "political"… it's more of a beekeeping technique or choice than a political thing."

they had broadly beneficial ontological outcomes, there were epistemological challenges as well. In fact, the challenges are perhaps most instructive: more difficult but more rewarding, in providing clarity around my own research aims. I will share an example of such a challenge before some brief parting words.

I fretted for a long time about “mite bombs,” (discussed briefly in papers #1 and #3). This was part of a broader dilemma, as I vacillated between taking statements made by beekeepers or scientists at face value, as the basis on which later analysis was built, and taking them as objects of analysis in their own right. (One of my committee members once helpfully commented, “Your narrative voice oscillates between wanting to problematize these categories and divisions, and at times reproducing them uncritically.”) A mite bomb is a collapsing colony that bees are leaving, in order to join another hive. Those bees are carrying *Varroa* mites on their bodies which therefore leads to spikes in the mite populations of neighboring colonies (whose mites are otherwise being managed by beekeepers). This idea plays a big role in discourses around the responsibility of beekeeping neighbors to one another: if mite bombs are real, then beekeepers arguably owe their neighbors the courtesy of keeping their own colonies from collapsing from high mite loads. If not, then to each her own.

At first, I tried to treat the idea of mite bombs more neutrally, remaining agnostic as to their existence and effect, interested more in the effects of the discourse than the veracity of the claim. This was in line with the “strong programme” in sociological studies of knowledge (Bloor, 1991). But as an actor in the beekeeping world, an educator and mentor, I also wanted to understand what was “true,” what I could tell beekeepers asking how to be a good beekeeper. I dove more deeply into the peer-reviewed literature and discovered that it is for the most part more restrained in its conclusions than the popular frustration among beekeepers would imply (Frey & Rosenkranz, 2014; D. T. Peck & Seeley, 2019). The data show that bees do carry mites on their bodies from their collapsing home hive to any new colony that will accept them. But the significance of these mites within the total mite population in neighboring colonies seems to be limited. One research scientist and extension educator who I interviewed said, “I have never seen any science, hard science, that shows that [beekeepers whose colonies collapse under mite pressure] are as big a risk as it’s made out to be.” And over time, conducting engaged research and practical outreach also reminded me that it hardly matters in practice. Whether or not “mite bombs” are a real threat is in fact much less important than the many other reasons beekeepers would want to keep their mite levels down and there is more specific advice to give if they are truly interested in breeding bees for *Varroa* resistance. So, to any beekeeper who asks, I underscore the consequences of not managing their mites and help them appreciate that a regional population of bees shares diseases and genetics, but I do not focus on mite bombs.

There are many such truth-claims that are widely contested or poorly understood: debates over the degree to which certain behaviors or characteristics are genetic, whether there are distinct local populations of honey bees within the US, and whether honey can help people who suffer from allergies to pollen (this last one was not central to my research, but was a common topic of conversation when I was selling honey at the Ithaca farmers’ market). For each of these, the claim might be an object of analysis or taken as a given, depending on the questions I am asking or the role I am playing. In other words, I am not trying to have it both ways, but, like so much else in beekeeping, it depends.

These lessons are no more important in the Anthropocene than at any other time, except perhaps that it is a time with additional ambivalence and an urgent need for clarity. Geographers Paul Robbins and Sarah A. Moore have reviewed the "discomfort, conflict, and ambivalence" of scientists in the Anthropocene (2013, p. 3), work which I briefly cited in the conclusion of the third paper. Robbins and Moore identify two opposing strains of political and normative thought: the first is the fear that (we) scientists have not voiced their concerns about environmental degradation strongly enough, not been activist enough in trying to redress the rising risks; they call this "anthrophobia," or response to humans' negative influence on nonhuman nature. The other is the fear by scientists that much of their work is "overly normative and culturally freighted," what they call "autophobia" (Robbins & Moore, 2013, p. 3). We on Earth are losing something, and I struggle with squaring the feelings of losing something with the need to be precise about what, exactly, we are losing. Honey bees have proven to be a tricky subject in this regard, because of their hybrid nature, and my research has positioned me in this ambivalent space: it implicitly accepts honey bees' presence (as a non-native species that can have some negative effects on other wild and native pollinators). But I hope that my work does manage to advocate for engagement and advocacy in a "hybrid world" (Sutter, 2013, p. 119).

There is more research that I would like to do, with more potential for interdisciplinarity and engagement: policy and regulation around honey bee health at the state level was largely left unexamined in my dissertation, and there is an opportunity to intervene in conversations as changes to bee laws are currently underway. There is also much more to be understood about the search for genetic tools to address honey bee health; breeding bees to be *Varroa*-resistant is widely considered to be at the top of the learning curves, but there are many questions about its overall feasibility, the degree to which beekeepers need to cooperate (precedents are mixed), and how it fits in with discourses around nature, technology, and health. Beyond bees, I am interested in further understanding how approaches to engagement and interdisciplinarity vary across research on agricultural production and environmental change. I will approach these projects with lessons drawn from these concluding reflections: the advantages of *not* being a thoroughbred, the need to approach collaborators in good faith – and with evidence of it, the importance of getting my hands dirty, and a dose of humility regarding how much more there is to learn.

APPENDIX I: PLAN BEE (METHODS)

I began this dissertation with a brief quote by anthropologists about "noticing"; the same authors call for combining critical theory, scientific observation, and ethnography (Tsing et al., 2017, p. M7). I have tried to enact these diverse methods: the critical theory, I hope, has been evident throughout; scientific observation was a combination of conventional social scientific methods and secondary literature on honey bee health. In this brief section, I describe my direct engagement with beekeeping and the broader community of beekeepers through ethnographic and participatory methods. This approach was central to my research goals, insofar as I wanted to understand the dilemmas inherent to keeping honey bees healthy.

I was from the start inspired by "First World political ecology" (McCarthy, 2002) and related literature, which celebrates "the long intellectual journey home" for scholars who began their research in the global South (Fortmann, 1996; Schroeder et al., 2006).[28] In other words, I was interested in applying theory on development to my own home, places and communities that I was already a part of. In this appendix to my dissertation, I hope to shed light on what was gained by approaching my dissertation research in such a participatory way: being a beekeeper, beekeeping educator, club officer, vendor at the farmers' market, and more. Briefly, the answer is that it helped me to have good access to beekeepers, research scientists, and beekeeping extension agents. It gave me a fuller understanding of the degree to which good beekeeping is difficult and often discouraging. It pulled me towards debates outside of academia;

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[28] Although I had not done research abroad, I served in the Peace Corps in north Africa and worked for an international NGO at UN headquarters in Geneva, Switzerland and New York before beginning graduate school.

although my research questions were my own, they were derived from conversations and observations over the initial years in this community. And, I hope, it will help my research ultimately have more of an impact in the beekeeping world.

At the same time, it has been difficult. I have had to repeatedly confront and articulate my own stance(s) in answering beekeepers' questions, mentoring new beekeepers, being a leader in the local club (I am now probably among the half of members with more experience), and writing the curriculum for the Master Beekeeping program. I have not always been able to elegantly balance being an actor within the world of beekeeping and simultaneously an analyst of that world. In what follows, I address these pros, cons, and other issues. I have not included a standalone literature review on methods, but literature is cited where relevant.

Conventional data collection

Much of my dissertation research, which started in April of 2013, has been conventional, centered around 1) semi-structured interviews with beekeepers, 2) observation of beekeeper club meetings, classes/workshops, conferences, and other gatherings; 3) archival research; and 4) a statewide survey. The research was largely delimited to New York State, because it was my home for the duration of my doctoral work and because I was interested in conducting local research for personal and other professional reasons, namely, to be able to put down roots in a particular place and focus on teaching.

Interviews

I interviewed 66 people: novice and experienced beekeepers, hobbyist and commercial beekeepers, educators, extension personnel, and apiculture research scientists. Informed consent was obtained from all participants, according to IRB guidelines for exempted research. Identifying information was not included in any of my writing, except for a small handful of public figures. My respondents are not representative of beekeepers more generally, as I sought out beekeepers with particular attributes for different parts of my research. These individuals are mostly based in New York; a handful with a regional or national profile are based in other states or provinces. Interviews were conducted over the phone or in person; most were recorded and then transcribed. Transcriptions or interview notes were coded according to different research aims.

Category*	**Number of interviewees**
Novices	15
Hobbyists	12
Sideliners	10
Commercial beekeepers	13
Educators (scientists, extension agents, Master Beekeepers, etc.)	16
Total	**66**

*Some interviewees fit into multiple categories; for instance, most of the novices are hobbyists. This table lists only the primary affiliation for each interviewee, counting each person once.

To understand the process of learning and becoming part of a community of practice, I asked newer beekeepers about their motivations for keeping bees, their learning process and sources of information, their approach to mite management, and their thoughts around expertise and authority within the beekeeping world. I also sought out beekeepers who were educators; this mostly included people who had organized local or regional beekeeping classes as well as those involved in regional and statewide Master Beekeeping programs, the author of a well-known textbook, the editor of a national beekeeping magazine, and more. In these interviews, I asked about their approach to beekeeper education, changes that they had seen in beginners' motivations over the years, and how they addressed the thorny issue of mite management. As I was interested in how different beekeepers conceived of "sustainable beekeeping," I sought out respondents that I expected to explicitly describe their approach as such, for instance, by recruiting beekeepers from the Local Living Venture (formerly known as the Sustainable Living Project) and attending classes advertised as promoting "Natural/Organic Beekeeping with a Biodynamic influence," such as those taught by the HoneyBeeLives organization.

Finally, to understand different approaches to breeding bees, I conducted interviews with beekeepers who were breeding bees in New York State, recruited from a larger pool of beekeepers who sell bees in the state, based on personal contacts and online information. I asked whether they managed particular races or stocks in their operations; whether, how, and how successfully they were breeding them for particular traits; and how that complemented or otherwise shaped their management practices.

The usual limitations to interviews apply: selection bias, the difficulty of comparing semi-structured interview transcripts, interviewees' faulty memory or incomplete knowledge, the inability to do a longitudinal analysis, and more. I also oversampled beekeepers connected to clubs and other organizations, since I mostly recruited participants through beekeeping clubs.

Observations of beekeeper groups

I observed meetings (including conferences, classes, and workshops) of 22 organizations at the local, statewide, regional, and national level. This includes the vast majority of local clubs in New York State.

Organization	Type	Level	Notes
Akwesasne Community Bee Group	club	local	
Catskill Mountain Beekeepers Club	club	local	
Delaware County Beekeepers	club	local	
Finger Lakes Beekeepers Club	club	local	I have been an officer since 2014.
Geneva Bee Conference / Greater New York Bee Conference	conference	local	I volunteered at several day-long conferences.
HoneybeeLives	for-profit association	local	
Local Living Venture – Bees and Beekeeping group	club	local	
New York City Beekeepers Association	club	local	
NYC Beekeeping	club	local	
Ontario-Finger Lakes Beekeepers Club	club	local	
Rochester Beekeepers	club	local	
Soaring Capital Beekeepers Association	club	local	
Southern Adirondack Beekeepers Association	club	local	
Steuben County Honey Bee Association	club	local	I gave a talk to the club in 2016, separate from observing a meeting.
Syracuse Area Beekeepers Club	club	local	
Ulster County Beekeepers Association	club	local	I gave a talk to the club in 2018, separate from observing a meeting.
Empire State Honey Producers Association	professional association	state	I attended eight one- or two-day meetings.
New York Bee Wellness	nonprofit educational organization	state	

New York State Fair	state fair	state	I volunteered and sold honey for several years.
Eastern Apiculture Society	nonprofit educational organization	regional	I attended two several-day conferences.
Western Apicultural Society	nonprofit educational organization	regional	
Bee Audacious	conference	national	I volunteered at a several-day conference.

Archival research

My archival research, to understand the historical professionalization of apicultural science, was fairly light, in part because my aim was not to uncover something new that had been hidden away in the archive, but to reinterpret and make relevant historical documents that were widely available. I was largely focused on the papers and publications of Dr. Everett Franklin Phillips, who was the head of the Bee Culture division of the USDA's Bureau of Entomology before moving to Ithaca to accept a position as the first professor of apiculture at Cornell. He is an important figure in American beekeeping history and many of the works he authored while at the USDA and at Cornell are available online. It was in the first few pages of his nearly 450-page book from 1915 that I found the discourse around disease and responsibility that so neatly paralleled the present.

Some of his papers are only available at Kroch Library, such as correspondence between him and the one-time chair of the Entomology department at Cornell. These were interesting and lent some color to my description of the events that brought Phillips to the university, but were not especially useful in the final analysis.

Statewide survey

In the summer of 2018, I joined Cornell's extension program and the Dyce Lab for Honey Bee Studies for a project on bee breeding (working with Scott McArt, Assistant Professor in Entomology, and Emma Walters (Mullen), Cornell's Honey Bee Extension Associate). They were considering breeding bees in the Lab, mating locally adapted bees with other stocks developed for mite resistance (although they decided not to in the end). They wanted to learn how well beekeepers across New York State understood breeding, the degree of interest in particular genetic traits, and what sorts of efforts in breeding were already underway. To these ends, I designed a survey of beekeepers in New York State on whether they managed particular subspecies or stocks of bees, whether they sought particular traits, whether they promoted particular stocks in their operations, and more. These beekeepers were identified through club memberships, public listings, previous interactions with the Dyce Lab, and other lists. We received responses from 291 people across the state, with a total of about 58,000 colonies. There are an estimated 100,000 colonies in the state, meaning that the survey captured a significant fraction of the total.

Other

I follow a few bee clubs on Facebook: the statewide association and a few nearby clubs, the Dyce Lab, the Bee Girl. I receive news bulletins from Bee Culture ("Catch the Buzz"), American Bee Journal, and a very active list-serv with an international set of contributors (BEE-L). I quote anonymously from the BEE-L conversations in the two papers on contemporary bee health. My methods here were somewhat haphazard, but staying up to date with current events in the beekeeping community was enormously helpful to my overall research.

Participant observation

Becoming a beekeeper

While the bulk of the data that I use explicitly as "evidence" in the three papers comes from the conventional data collection methods described above, my analysis of that data is informed by my extensive participant observation, where I have achieved full membership in the dispersed beekeeping community of New York State as a beekeeper, bee club officer, mentor, and educator. This means that I have done a lot of "hanging out," in the anthropological fashion, although since beekeeping communities are not residential, this has looked more like making friends, going to weddings, meeting people at the county fair, and carpooling to far-off bee meetings. Gaining entry to this community was not difficult because of the number of formal events that welcome newcomers and eventually give way to more informal interactions.

Lots of authors have beautifully chronicled their trajectories in learning to keep bees, overcoming their initial fears and discomfort (Hubbell, 1988; Waring, 2015). This is also a feature of more scholarly writing: in Lisa Jean Moore and Mary Kosut's "multispecies participant observation," they describe being sweaty and itchy, abandoning their veils and gloves over time (2014). My own trajectory over these last ten years has not been so different, and there is no need for me to do the same sort of narrative.

I have forgotten how I responded in 2010 when my then-boyfriend, Tyler, asked if I were interested in keeping bees. I knew nothing about it, did not much care for honey, and was mostly alarmed by the prospect of being stung. But I was game. So we moved in together into a rental with a small orchard in the yard. We ordered bees and equipment, and went to a beginners' class. I was a little overwhelmed; in an email to my sister that winter, I wrote:

> There are lots of resources online, library books, and now this seminar that we took… The package of bees arrives April 17th and then we're hopefully good to go. It doesn't sound terribly complicated, but there are more diseases and pests these days to keep track of, apparently, and debates over using antibiotics and such.

I read *Beekeeping for Dummies*. We watched a few YouTube videos on how to get the bees in the hive ("enough YouTube videos now that I feel pretty confident," in another email). We registered our colony, which is required in Pennsylvania, and managed to keep some bees alive for a few years. One year, we entered our honey in the local Grange Fair and won first place (out of a total of one entry). We learned through experience and problems: losing a queen and ordering a new one to be shipped, getting stung while harvesting honey.

Our learning curve on disease and pests was slow but steady. Some emails make me cringe (July 2010: "i didn't know we had mites! i guess it's not a superbig deal"). When an apiary inspector visited our bees in 2011 (as they are required to do every two years in Pennsylvania), we learned about how to monitor for *Varroa* mites and then asked around our club for what to do about our mite count. Memorably, some equipment that we had stored in our apartment became infested with wax moths (a common pest), which we only noticed when the moths started fluttering around our main living area in large numbers. Like other hobbyist beginners, we proudly documented the first few weeks and months, in photos that I now recognize as clumsy or miscaptioned.

It was a few years in that I hatched the idea to study beekeeping academically. I have had one to four colonies most years since, adding to the apiary by purchasing colonies, capturing feral swarms, and accepting colonies as gifts from other beekeepers. I jumped in with both feet more than I would have were beekeeping not the subject of my dissertation – and have had lots of unanticipated fun: judging mead entries at the statewide competitions held by the Empire State Honey Producers Association meetings, selling honey at the farmers' market for my friends and neighbors who run Bright Raven Apiary, volunteering at the New York State Fair's honey table, and more. More importantly, I have become a part of social networks that span the state, and many beekeepers are now my friends. I look up to many of them: my friend Pete who writes histories of beekeeping and mentors anyone who asks, a handful of women in leadership roles across the Eastern US, beekeepers who try to maintain "beginners mind" even after many years, people coming together for regional projects around breeding or education, in short, everyone who has dedicated the time and effort to understand and care for these creatures and help others do the same.

I should briefly mention the role that my social identity has played in my fieldwork. I cannot get away from who I am and how I fit into the existing community of beekeepers. As a young female hobbyist originally from the suburbs, I am likely seen as being a part of the new wave of save-the-bees beekeepers (Moore & Kosut, 2013) and assumed to be not very skilled or invested in my bees. Among beekeepers, women are outnumbered about two to one (and the much smaller number of commercial beekeepers is much more heavily male) (Schweigert & Krengel, 2010). The industry is welcoming on its face, but has some gendered hangovers from an earlier era, such as statewide “Honey Queen” competitions and frequent references to the “girls” (as most of the bees in the colony are female) or even “gorgeous blonde” queens (as one interviewee put it). Most beekeepers are older, although the average age has declined in the new wave of hobbyists. Many beekeepers are well educated; one survey found that two-thirds of beekeepers had a college degree or more (Schweigert & Krengel, 2010). Most beekeepers are also white, with many potential beekeepers of color likely dissuaded. According to the same survey, “commercial and sideliner beekeepers tend to be politically conservative-leaning moderates, while the hobbyists are more liberal-leaning moderates” and commercial beekeepers are less confident that anthropogenic climate change is occurring (Schweigert & Krengel, 2010, p. 67). Perhaps the biggest factor in a person’s perceived credibility is whether s/he is from more of a rural background or urban / suburban, and seen to have a related “common sense” around animal husbandry. Still, understanding my position within this social world is just a first step; there is more than just “identity-based reflexivity” (Nagar, 2002, p. 183), as discussed in the Conclusion.

Mentorship and classes

In our first year, Tyler and I joined a club where we joined in collective hive inspections, asked for advice on requeening and mite management, and borrowed equipment. I therefore understood from the beginning the important role that the beekeeping community plays for novices, and designed my pilot research around the Finger Lakes Beekeepers Club. I joined as I was developing my research proposal and began to attending meetings alongside conducting interviews and a small focus group among club members.

The club meets once a month for a talk and general Q&A (usually a couple dozen people attend, out of the approximately 150 dues-paying members). There is an active list-serv, club hives, a mentor match program, and equipment to share among members. Members have a wide range of expertise: one member is a former commercial beekeeper and state apiary inspector, and writes regularly about bees for national outlets. Most members are novices. In 2014, I became an officer, welcoming new members, preparing the newsletter and email communications, planning meetings, helping with regional beekeeping events, organizing the mentor match program, and contributing to decisions about club activities. I have also mentored several new beekeepers, but I took notes mostly closely on my experiences with a man in 2015 and 2016 (at least seven visits and many more emails) and a woman in 2017 (at least eight visits, to her bees or mine). Acting in this role required me to articulate my own recommendations while taking into account their preferences and values in managing their colonies for mites and other issues.

My experience with the male beekeeper was frustrating, as he solicited my advice, but largely did not take it. At one point, I wrote in my notes that his hive was "a little neglected." One summer, I reminded him to monitor for mites, and he admitted that he had not been in the hive since we had last gone in together (two and a half months prior, much less than is advisable). He admitted to being wary of bee stings, as his reaction had become stronger, and suggested that he could skip monitoring and just apply the treatment. I wrote back to explain that his reactions to stings would likely be less severe in time, with some advice on how to work his bees so that they would be less defensive. I also explained briefly why his bees needed an inspection, not just for mites, but other diseases and their overall development. He never responded. My female mentee seemed to be better braced for the lows of beekeeping (stings, inevitable high mite counts, unwelcome decisions about mite management strategies). We sampled for mites on multiple occasions, and learned in the late summer that her colonies had reached a treatment threshold. She was disappointed to have reached the threshold but also willing to treat as needed, so I sent her information about options.

Just as I first benefitted from mentorship from more experienced beekeepers and then later tried to repay my debt by mentoring novices, I also found myself on both sides of the classroom. In the first few years of this research, I audited a course in Cornell's Entomology Department and took an online Master Beekeeping course through the University of Montana (which has a well-regarded beekeeping extension program). And in time, I was able to teach others. In 2016 and 2017, I worked as a honey bee extension assistant at Cornell's Dyce Lab for Honey Bee Studies (full-time in the summer of 2016 and for a few hours a week thereafter). My primary role was to help the extension associate, Emma Walters, put together a curriculum for Cornell's new and improved (online) Master Beekeeping course. I am grateful to have had the opportunity and proud when someone recognizes me from my "talking head" videos. Indeed, that work was probably the most impactful part of this entire project!

As I described in the introduction, bees were a "gateway bug" for me in that they opened up a new world of animal husbandry and a sense of connection to broader landscapes. In the first few months of beekeeping in 2010, I emailed a friend that one of the things I loved most about my new hobby was "looking at old things in a new way… i see blossoms and i think bee food!" I hope that my work has helped Cornell's Master Beekeeping students, the other beekeepers I have mentored, and you, dear reader, to see the art and science of beekeeping in a new way.

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