FEMINIST SCIENCE AND THE CONSERVATION OF WILD BEES IN URBAN GARDENS

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Science and politics are inextricably entwined. Scientists must understand how their political opinions sway the course of their research. Without this insight, scientists may unintentionally support political ideologies that they actually find morally reprehensible. Scientific thought aims to understand and harness services of the natural world. Feminist theory of science is a critical framework that rejects the inherent arrogance in this goal. Controlling nature is particularly pertinent in agricultural pollination, as farmers often rely on agrotechnology to sustain a single species of bee, honeybees, to pollinate all crops. Honeybees can be prohibitively expensive or complicated to maintain, so that some farmers can't access this resource. The cultivation of wild bee communities for agricultural pollination is a feminist method of decreasing farmer's reliance on honeybees. By cultivating wild bee habitat and forage, farmers can encourage sustainable and resilient pollination systems. Sustainability and resilience of ecosystem services are key feminist ideals. Feminists aim to construct methods of science that prioritize the conservation of natural ecosystems while addressing human needs. Human needs are especially important when they are voiced by groups of people who are systematically denied control over their own lives, based on their race, gender, class, sexuality, or other features of their identity. Ecologists often share these goals, so ecology is a prime field for exploring the overlap between scientific and feminist thought. Urban farms are an important space for combining bee conservation, ecological research, food access, and community involvement. By doing research and conservation on urban farms, scientists can accomplish the feminist goal of involving community members in scientific work to mutual benefit.

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PREFACE

I am wholly appreciative of the many people and groups who made this thesis possible. The University of Pittsburgh Honors College, for providing the resources needed to start this project and for funding my trip to the 2013 International Conference on Pollinator Biology, Health, and Policy, where I met many researchers and students who helped me shape my interests. I am also indebted to the Biological Sciences Department at Pitt, which hosted my thesis defense and surrounded me with faculty and peers who engaged me in ecological thought. I would specifically like to thank my Ecology major cohort, and the many members of Dr. Jonathan Pruitt's lab: all my friends, mentors, and allies.

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1.0 INTRODUCTION

Scientific research is widely respected as a source of answers about human life and the natural world. When disparate theoretical fields of scientific work can be combined with these real-life problems, the application of science gives clear, pertinent purpose to this industry of knowledge production. Ideally, the smooth export of theory to practice would lessen the hurt of inequalities in resources and opportunities between the human populations of the world, but in truth, the boundaries of research and application leave some people woefully underserved.

When scientific research is done, who benefits? Other scientists certainly do, in their ability to understand and collaborate with the ideas of their colleagues. Policymakers benefit from the support of statistics and hypotheses that drive change domestically and abroad. Individuals and organizations with the financial capital to influence the flow of technological innovation can use science to further their particular aims. The people who most control science are those who already have control over the political, economic, and academic structures of our world. This generalization is not necessarily negative. However, the benefits of science are not geared toward people who *need* change, but those who already have the power to effect it.

Considering the ideas, opinions, and needs of people who are often ignored is not just a matter of empathy, but also one of good science. Diversity of scientific thought is necessary for good scientific practice. Science as an institution cannot be the objective pursuit of truth if its practitioners privilege the thoughts of the same groups of people generation after generation.

Accurate, useful science is built by a diverse base of knowledge and experiences. But how is this done? And how is this done in my chosen field of study, ecology? In exploring these questions, I searched for a critical framework from which to look at the practice of research and conservation. I found that feminist scholars of science had many of the same questions that I did: How is objective work produced by biased people? What about the natural world have scientists erroneously ignored? How can the science that I do connect to people who need change? My argument is that feminist theory of science can be used to understand how ecologists can get at the root of ecological issues, such as wild bee conservation and crop pollination, while addressing human needs. The best way to address the needs of bees, scientists, and local communities is by doing bee ecological research and conservation in urban gardens. To understand how feminism and science are connected, I will first describe how bees are threatened by dominant agricultural practices, next address how feminism critiques scientific research and suggests alternate methodology, and finally apply these methodologies to agriculture, conservation, and sustainable development.

2.0 WHY ARE BEES IMPORTANT?

The decline of pollinating species is a popular topic of discussion in science and news media; however, the solutions offered are overly simplistic. A large proportion of crop pollination in the US is done by honeybees, a single species of bee (*Apis mellifera)* threatened by pesticide use, disease, and hybridization (reviewed in Committee on the Status of Pollinators in North America 2007). However, the honeybee was introduced into North America a few centuries ago: before that, pollination was done entirely by thousands of local wild bee species. Though we know little about these bee species relative to the pool of research on honeybees, several studies indicate that these species are also declining (reviewed in Committee on the Status of Pollinators in North America 2007). There are two possible strategies to addressing pollinator decline: to increase the efficiency of agrotechnology to support honeybee pollination on farms, or to deemphasize our reliance on agrotechnology and instead focus on conserving wild pollinators by providing them with ample forage and habitat. Apiarists (i.e. people who keep honeybees) must be able to invest money, time, and a large amount of acquired skill for their bees to prosper. This second strategy is a feminist strategy, because it is more accessible to farmers in a range of different locations, who have varying amounts of material, financial, and educational resources.

The conservation of wild bee species and the pollination services they provide is more than just an interesting ecological quandary. The diversity and abundance of crop yields connects the ecology of bees to human cultures and health worldwide. Bee ecology is a great site for the application of feminist methodologies of science because of its useful applications. A major concern of feminist science is the collection of knowledge outside of traditional scientific structures. The contributions of knowledge from farmers, apiarists, and other community members, which are voices that feminists emphasize, are invaluable in studying bees and agriculture. By working with existing farms and farmers, researchers have found data that have ecological significance and practical applications. For example, the presence of wild bees can increase the efficiency of honeybees as target pollinators in agricultural systems (Greenleaf and Kremen 2006). The researchers studied 16 farms in northern California to conclude that the presence of wild bees effectively doubled the efficiency of honeybee pollination. In a similar vein, Winfree, Williams *et al.* (2007) studied watermelon crops at 23 farms in New Jersey and Pennsylvania to find that wild bees can support agricultural ecosystems in the decline or absence of honeybees (2007). Doing ecological work in agricultural settings allows scientists to communicate and even collaborate with farmers to mutual benefit. The studies described above have clear applications for both bee conservation and crop yield, as both scientists and farmers are interested in the relative importance of honeybees and wild bees in crop pollination services. For over a decade, ecologists have rejected the lay assumption that honeybees have an irreplaceable hand in the animal-pollinated foods we grow. In fact, honeybees are not effective pollinators of many crops, including almonds, blueberries, watermelon, coffee, raspberries, blackberries, field tomatoes, and cherries (reviewed in Klein, Vaissiere et al. 2007). Globally, wild bees are the dominant pollinators, enhancing the fruit set of crops regardless of whether or not honeybees are present (Garibaldi, Steffan-Dewenter et al. 2013). In addition, many wild bees are solitary species, meaning it's possible that they spread pathogens less rapidly than bees in densely crowded social hives. Wild bees are generally not subject to many of the same pests that are currently plaguing honeybee populations (Committee on the Status of Pollinators in North America 2007). Thus, the conservation of wild bees could be more important to crop pollination than searching for ways to keep honeybee populations artificially large through the use of intensive chemical management.

Ecologists can also synthesize research and conservation by creating bee habitat to study, or by studying unconventional habitats like those found in urban environments. Several studies have shown that gardens can support a surprising diversity of bee species in cities such as Vancouver, Canada (Tommasi, Miro et al. 2004); Belo Horizante, Brazil (Nemésio and Silveira 2007); New York City (Matteson and Langellotto 2009); and cities throughout California (Frankie, Thorp et al. 2005, Frankie, Thorp et al. 2009). James Cane found that the species richness of bees is not heavily affected by the level of urbanization of a given habitat, and more influenced by the presence of a particularly important plant species (Creosote bush, *Larrea tridentata*) (2006). Gordon Frankie *et al* (2009) found that a predictable swathe of bee species could be attracted to California gardens by planting particular ornamental plants. Frankie *et al* demonstrate that urban gardens are community-building and biodiversity tools:

> ...There is still much to be learned about how to convey scientific knowledge in user-friendly language to urban audiences. Native bees can be used as "tools" for a range of activities, including habitat gardening, environmental education and scientific inquiry to solve current environmental problems... It is noteworthy that urban landscape gardens may be more suitable for monitoring certain bee pollinator species than wild areas because urban plants are usually intensively managed. (2009)

Here, Frankie *et al* suggest that sustainable conservation should not be limited to ecosystem modifications. Instead, those who work on sustainable development should prioritize collaboration with their community to share ideas, resources, and education.

Community-wide efforts to conserve species richness might seem somewhat sentimental compared to technological attempts to save pollination such as genetic engineering and chemical pest control. However, there is little evidence that requiring a small handful of species to fulfill the pollination needs of industrial agriculture is a better solution. Relying on one or a few species for crop pollination can lead to a loss of pollination services and be detrimental to the ecological community. This is because members of the same species tend to be vulnerable to many of the same threats, so that the accumulation of adverse conditions can impact a large portion of the species. Colony Collapse Disorder in honeybees is a prime example of the danger of relying too heavily on one species for an ecosystem service. It is generally agreed that Colony Collapse is caused by harmful pesticides, pathogens, and ecological change such as the movement of species outside of their native range (Committee on the Status of Pollinators in North America 2007, National Honey Bee Health Stakeholders Conference Committee 2012). All three of these issues are exacerbated by agricultural intensification. Harmful practices such as these often prevail because they can be financially efficient, but that does not ensure that they are in the best interest of environmental sustainability or human health. A feminist scientist view of pollination would note how contemporary reliance on honeybees is not only risky to ecosystems but also human needs, as humans rely on bee pollinated crops as a major part of their diet. Due to this connection, human health is directly linked to pesticide use, bee diseases, and bee hybridization.

The use of pesticides to control the weeds, fungi, and insects that plague crop plants is a widely debated practice. The European Union recently set a two-year-long restriction on the use of some neonicotinoid pesticides, to allow for further research into the effect of these chemicals on ecosystems and human health (Commission 2013). The EU based this legislation on studies that emphasize neonicotinoid's detrimental effects on honeybee health and behavior. Such pesticides are linked with mortality, loss of olfactory ability, memory loss, decreased mobility, and a decreased ability to navigate home after foraging (reviewed in Pilatic 2012). It's unknown whether these pesticides have the same effect on other bee species; however, if the honey bee, a species we rely on for agricultural production, is threatened by chemicals we also rely on for agricultural production, then it seems prudent to study the range of effects these pesticides have on pollination services from a variety of perspectives. Feminist theory of science would advocate that pesticides need to be studied comprehensively, on a range of organisms under different environmental conditions with an emphasis on at-risk groups of humans. This view is not unique to feminists. Many scientists who do research on ecotoxicology, the impact of toxins such as pesticides on ecosystem functioning, support the practice of studying pesticide effects under relevant ecological conditions (Blaustein and Kiesecker 2002, Relyea 2005, Jansen, Coors et al. 2011, Hua, Cothran et al. 2013). However, the US Environmental Protection Agency (EPA), which regulates the approval, use, and sale of pesticides, has a simpler and less informative approach. The EPA accepts or rejects a pesticide based on lab studies of how likely a given amount of pesticide is to kill organisms that are not it's intended target:

> Risk assessments try to predict the effects from using a pesticide. A risk assessment compares the predicted exposure an organism will receive, to the toxic effects that compound produces at different exposure levels (the amount of exposure to a pesticide often determines an organism's toxicological response). Thus, the risk assessor's job is to

> determine the relationship between possible exposures to a pesticide and the potential for harmful effects as a result…. If a pesticide can be used in a way that minimizes exposure to levels below the point at which there are no effects, EPA concludes that the pesticide is not likely to harm non-target organisms, including bees. (EPA 2013)

This research, which is done by the companies that produce pesticides, does not consider how pesticide toxicity might change when non-target organisms are subject to multiple pesticide types, multiple treatments at different life stages, or realistic ecological field conditions. By undergoing more thorough testing, species that are pivotal to human needs are less likely to be threatened.

Relying heavily on one species for agricultural pollination is also threatened by the rapid spread of diseases between conspecifics (i.e. members of the same species). Honeybees are often shipped around the United States as either "packages" sold to apiarists to establish hives or as existing hives moved among farms to provide pollination services. This practice is a red flag for feminist scientists and many ecologists, who aim to maintain native ecosystems whenever possible. The transport of a non-native species across the many U.S. ecosystems makes honeybees agents of ecological change that may have far reaching effects on native ecosystems. For example, moving animal populations around can result in the spread of disease. There are several main pathogens that plague honeybees, such as mites like *Varroa destructor* and various *Nosema* species, as well as a fungal infection called chalkbrood. *Varroa* mites have been found to jump from honeybees to closely related congeneric species (i.e. species within the same genus) (Committee on the Status of Pollinators in North America 2007). Honeybee pathogens such as deformed wing virus and *Nosema ceranae* can be spread to wild bumblebees, threatening their already declining populations (Fürst, McMahon et al. 2014). Chalkbrood fungus can jump from the managed pollinator *Megachile rotundata* to the wild species *Megachile pugnata* and *Megachile relativa* (Goerzen, Dumouchel et al. 1992). Some of these pathogens, including *Nosema ceranae* have synergistic, negative effects with pesticides (Pettis, Johnson et al. 2012). While pathogens are not exclusive to managed bees, there is still much to be learned about wild bee's pathogen load (Goulson 2010). The transfer of diseases between and within species makes the transport and high-density management of bee species a risky strategy for pollination.

Introduced, managed bee species also threaten novel environments when they hybridize with native species. The global trade of certain *Bombus terrestris* subspecies can threaten the propagation of local races, which could result in an overall loss of genetic diversity (Goulson 2010). A specific example of this is in Japan, where interspecific mating between *B. hypocrita* and *B. terrestris* decreased the amount of viable offspring from *B. hypocrita (Goulson 2010).* In the United States, hybridization has created troublesome populations of Africanized honeybees. The 1956 importation of African bees (*Apis mellifera scutella*) to Brazil for the purpose of crossbreeding with European honeybees (*Apis mellifera mellifera*) (Rinderer, Stelzer et al. 1991) produced hybrid bees with increased dispersal ability and aggression; the bees are responsible for massive stinging attacks on humans, with risk of shock, hypoxia, organ damage, and systemic anaphylaxis for those who are attacked (Schumacher and Egen 1995). The risk of bee hybridization on ecological and human health is another risk of relying on a few species of managed pollinators. Once more, feminist science advocates an ecological evaluation of the impact of honeybee management. It's possible that transporting managed bees into nonnative ecosystems solely for financial benefit threatens the health of both bees and the ecosystems to which they travel.

The majority of food production in the United States is done by large monocultures of a small number of crops (USDA 2009) that rely on chemical fertilizers and pesticides (USDA 2012) to produce high yields and thus high profits. As such, conventional agriculture is a threat to native ecosystems and wild bee diversity. Wild bees are essential to successful agricultural production; their presence increases the fruit set of plants regardless of whether or not honeybees are present (Garibaldi, Steffan-Dewenter et al. 2013). In contrast to conventional farming, organic farming can be a way to help sustain communities of wild bees. While conventional farms have decreased species richness in the center of cultivated fields, possibly limiting the amount of pollination that can occur in those microhabitats, organic farms don't suffer this same loss (Holzschuh, Steffan-Dewenter et al. 2008). The increased diversity in the middle of organic fields may be a product of the more hospitable living environment that organic landscapes present to nesting or foraging pollinators. Clearly, both organic farming and land management need to be taken into account to preserve species richness (Holzschuh, Steffan-Dewenter et al. 2008). In a New Jersey and Pennsylvania study, organic farming made no difference in bee diversity, possibly because both conventional and organic fields had similar proximity to natural habitat (Winfree, Williams et al. 2007). Organic farming can sometimes compensate for isolation between farmed and unfarmed landscapes in the effort to preserve biodiversity (Bengtsson, Ahnström et al. 2005), though it is no panacea. Land management may be more important. Agroecosystems with semi-natural habitats in close proximity are more species rich in pollinators (Steffan-Dewenter, Münzenberg et al. 2002, Williams, Crone et al. 2010). In fact, the farther a growing crop is from natural habitat, the greater the decrease in pollinator visitation to that crop (Ricketts, Regetz et al. 2008). This compartmentalization of land use into "natural" and "managed" spheres is particularly harmful to the largest and most effective pollinators which rely on these landscapes (Larsen, Williams et al. 2005). Incorporating unmanaged plant and animal communities into agricultural areas is effective in the preservation of wild bee species and improving pollination services.

Natural landscapes help wild bee populations thrive by providing them with ample foraging and nesting resources. Bees require a diversity of floral resources to gather nectar, pollen, and other plant derivatives. Diversity of flowers is directly correlated with wild bee abundance and species richness (Potts, Vulliamy et al. 2003, Fenster, Armbruster et al. 2004). Bees also require habitat for laying eggs, storing excess pollen and nectar, and possibly overwintering. Bee species require a diversity of nesting resources including bare ground, sloped ground, cavities, and plants with pithy stems (Potts, Vulliamy et al. 2005). Above-ground nesting bees tend to be less abundant in areas of intense agriculture where there are few suitable locations for nest building, and below-ground nesting bees are threatened by agricultural practices like tilling, which disturb their nesting sites (Williams, Crone et al. 2010). Nesting resources can be easily planted or built by conservationists, making projects for the conservation of wild bees ideal for combining useful science and community involvement. Developing these resources on or near a community farm or garden can provide refugia for wild bees, which could be an asset to the pollination of those spaces. Cultivating wildlife habitat to improve ecosystem services this way embody the feminist science ethos that non-scientists, such as community gardeners, can be involved in conservation efforts.

Wild bee conservation fits well with the demands of feminist science. It’s important that the manipulated restoration of species or ecosystem services is minimally invasive to natural landscapes. Conservation work should also be made available to a range of interested parties by reaching out to non-scientist community members and considering their needs and desires. By avoiding the use of expensive technologies, communities can undertake conservation work on their own prerogative. Wild bee management can be a boon to pollination in urban gardens, benefitting the needs of communities that want more control over their food system. In addition, sustainable agricultural practices can be simple, easy to communicate, and easy to do without an abundance of resources. Conserving wild bees through sustainable agriculture fits perfectly with the ideals of feminist science because it builds a resilient support network for an essential ecosystem service.

3.0 WHAT IS FEMINIST SCIENCE?

One of feminism's premises is that inequality exists in the world where it need not. Due to their gender, sexual, racial, class, sexuality, or other identity, certain groups of people are denied control over their own lives. There is an array of feminist philosophies: different types of feminism may see gender, race, or class as the chief vector of oppression. While some feminists believe that social and political power structures can be reformed to address inequality, others feel that these must be overturned to make way for a better, more egalitarian world. Feminists have traditionally described the systemic privileging of men's interests and needs over those of women as patriarchy. Feminists argue that both men and women suffer from this because gendered oppression is structural, thus feminists remove the onus of blame off of individual men. Instead, both men and women find themselves in social roles that limit their ability to connect to each other and define themselves as individuals. A more encompassing term for the limitations of our social system is kyriarchy, coined by Elisabeth Schüssler Fiorenza. Kyriarcy is a system in which race, class, sexuality, and other identity categories create a web of inequalities that individuals must navigate (1992). In acknowledging that gender is not the only basis of inequality, feminists must aim their epistemology and activism towards all forms of systemic oppression, not just gender issues. Good feminist theory and activism should follow wherever kyriarchical structures have silenced discussion about structures of power in our culture, such as those that shape scientific practice.

Science, much like the world at large, is fraught with inequalities. This is inevitable: research is a process, and researchers must prioritize which questions are most important to answer. However, problems can arise when scientists claim to do work that directly benefits humanity, yet become so objectively distant from their field of study that they cannot adequately connect it to human needs. Some feminist scholars argue that the history of science makes it irreparably kyriarchical, because scientific research reinforces existing structures of power. Science as a philosophy stresses objectivity and universality. The overarching goal of scientific work, then, is to understand how natural processes work, to be able to replicate and control these systems, and to be able to apply that knowledge across the globe. This vision of science can sometimes be interesting and helpful in aiding human needs. However, idealizing science in this way is extremely arrogant. It's also relevant to note that early, formal science was done almost entirely by European men of high socioeconomic class. These men were not representative of the global range of peoples and cultures that we acknowledge as equally valid today. Feminism is interested in diversifying strategies of problem solving so that one demographic group of people is not responsible for the most valued knowledge of modern societies. In addition, feminists question the arrogant proposal that science as practiced can control nature to serve all human needs. A feminist vision of science would be localized to the system and culture that contextualize scientific research. Feminist influence in ecology is then particularly appropriate, as ecologists often question the role of anthropogenic change in natural ecosystem function.

Ecological research is well suited to considering how scientific and feminist thought can be combined to mutual benefit. Both feminists and ecologists are interested in conserving ecosystem services that are important to human and environmental needs. The methods that ecologists use to study ecosystem are sometimes well suited to the interests and abilities of scientists. Often, ecological data can be collected and discussed by someone who doesn't have a degree in ecology. Agroecology is particularly important to these connections. Agriculture has obvious importance to human needs, and farms often impact the ecosystem of which they are a part. Pollinator health is a specific intersection of human and ecological interest. Pollinators are necessary for many of the crops that humans rely on to survive. Pollinators are also threatened by agricultural practices such as pesticide use and habitat destruction. In considering that conservation, gardening, and bee health are popular topics in contemporary culture, scientists can capitalize on this wave of interest by involving non-scientists in ecological thought.

In order to remain relevant to human needs, a feminist approach to science considers the contributions and knowledge of a wide range of groups, not just scientists and policymakers. To do this effectively requires that non-scientists' informed opinions are valued by individual scientists and by scientific industries more broadly. The ideology of scientists as elite guardians of knowledge is often harmful to non-scientists (Merchant 2001). For agroecology, the use of ecological research in agriculture, this includes the secrecy or lack of information available to the public about agricultural technology (called agrotechnology). Agrotechnology includes the use of chemical pesticides that may harm pollinators and the cross continental transport of honeybees as the dominant pollinator in agriculture, as well as synthetic fertilizers, genetically modified crop plants, and hybrid crop strains. Agrotechnology is not designed with the intent that the average consumer or farmer can understand exactly what it is they're eating or growing. Also, agrotechnology can be prohibitively expensive to small farmers, which make up the majority of US farmers (USDA 2009), and are responsible for the majority of direct sales between farmer and consumer (USDA 2009). My argument is that a feminist approach to agroecological work would deemphasize our reliance on agrotechnology and instead focus on the restoration of ecosystem function for the services we rely on. That's not to say that agrotechnology and conservation are mutually exclusive paths towards sustainable agriculture, just that the latter is undervalued and aligns with feminist ideals.

Feminists prioritize involving non-scientists in scientific production and thought to diversify the knowledge base from which science draws, while addressing a wider swathe of human interest. Of course, it's important to know the diversity of scientists that already exist. By looking at the existing science workforce, it is possible to see that some groups of scientists are denied opportunities to succeed. Statistics from the National Science Foundation show that among scientists and engineers, white men and women and Asian men are less likely to be unemployed than Asian women or people of any other racial or ethnic group. 51% of all scientists are white men, 18% are white women, and 13% are Asian men. The other 18% represent Asian women and all black, Hispanic, or other people of color combined. Within academia, of all full-time, full professors, only 22% are women, and only 5.9% are non-Asian people of color. White and Asian men are also more likely to receive federal grants than all women and other minorities (Foundation 2013). Science faculty of any gender are more likely to hire male applicants over females for jobs, even if they are identically qualified, and to offer male applicants a higher salary and more opportunities for mentorship (Moss-Racusin, Dovidio et al. 2012). This bias culminates in a gender discrepancy amongst highly cited researchers in ecology and environmental science, of which only 5.5 - 7.2% are women (Parker, Lortie et al. 2010). More egalitarian peer review is not complicated to accomplish; gender inequality in publishing can be ameliorated simply by removing authors' names from papers sent to reviewers (Budden, Tregenza et al. 2008). It's important to not dismiss these discrepancies as the ghosts of sexism past, trends that we will outgrow as younger generations age. Racial and gendered inequalities are caused by kyriarchical structures of oppression, not the evildoings of white men. The people who are encouraged to become scientists are people who have learned about science in school, are able to afford college, are able to spend time doing research instead of some more lucrative pursuit, and, most importantly, are people who feel that they personally have a connection to scientific work. Every step in this pathway is supported by the privilege some groups of people are accorded, based on their race, class, and gender. The fact that white and Asian men are, on average, rewarded more heavily for doing scientific work is obviously a problem for women and people of color, but it should also be recognized as an issue for privileged men as well. As any individual white or Asian male scientist achieves more in his scientific career, he can be increasingly sure that some portion of his success has nothing to do with his own talent or abilities, but is only based on his social status.

Biases in hiring and rewarding researchers are a problem for people who do science and for the work that they produce. It's entirely possible that a homogenous pool of researchers may lack the diversity needed to analyze the natural world with novel and creative thoughts. For example, the field of primatology underwent an important expansion in the mid twentieth century when women began to do primatological research and use their own life experiences to consider new perspectives. Londa Schiebinger describes how primatology changed in the mid-to-late twentieth century as female researchers such as Jane Goodall, Birutė Galdikas, Jean Altmann, Sarah Blaffer Hrdy, and many more began work in a previously male dominated field:

> The composition of the profession has changed dramatically from the 1960s, when American women received no Ph.D.s, to today when they receive 78 percent of Ph.D.s in primatology granted each year.... Only in the 1960s did primatologists begin questioning

stereotypes of male aggression and dominance and begin looking seriously at female behavior. They began studying the significance of female bonding through matrilineal networks and analyzing female sexual assertiveness, female social strategies, female cognitive skills, and female competition. Today, in a turnabout from the 1960s, conventional wisdom on baboons recognizes that females provide social stability, while males move from group to group. Changes in primatology have been so foundational that at least one mainstream primatologist, Linda Fedigan (1997), has pronounced it a feminist science. (Schiebinger 2000)

If a field as well known as primatology can change with a large handful of new researchers, how might other fields of science change as they diversify? Twentieth century primatology research highlights how scientists in a given field might be missing some aspect of analysis that underrepresented groups find easier to see.

Sexual selection research has seen a similar conflict in how studies are communicated by relying on harmful and inaccurate human tropes. Publications about interactions between different sexes of animals tend to use loaded, anthropomorphized terms to describe study species. Female animals are seen as passive, weak, and solely important as the object of male activity (Karlsson Green and Madjidian 2011). The exception is in publications about sexual cannibalism, when females become unreasonable aggressors playing their male victims cruelly (Dougherty, Burdfield-Steel et al. 2013). It is not particularly difficult to see how these descriptions may be rooted in similar portrayals of women in popular media. Using science to reinforce negative generalizations can be harmful. Because science is seen as an objective truth, generalizations in research lend themselves to conclusions about what essential traits certain groups of people are fated to, such as the idea that apes are inherently patriarchal or that females are all pretending to be passive while waiting to attack. By encouraging a diversity of scientists to contribute to various fields, useless and offensive generalizations may be more easily identified and disproven.

It's important to recognize that issues of bias and generalization within science will not magically disappear with the equal incorporation of women and people of color on research teams. Changing science to incorporate useful feminist ideals requires consistent mindfulness by all scientists, not just a handful of women. There is an important difference between "feminists" and "women." Both are valuable to scientific efforts, but feminism is often derided as controversial and difficult while women can be expected to maintain the status quo:

> For many, feminism is still a dirty word, even among those who support the advancement of professional careers for women. Especially within the sciences, people seem to prefer to discuss women rather than feminism. This refusal to acknowledge politics- to call a feminist a feminist- has led to a simple equating of women entering the profession with change in science. Many women scientists, however, have no desire to rock the boat, and women who consider themselves "old boys" often become the darlings of conservatives. (Schiebinger 2000)

Feminist analyses may not focus on gender roles, and women scientists may not be drawn to structural change in science. Diversity amongst scientists is useful in rooting out possible routes of change, but it is not the only way that change will be accomplished.

While scientific research is sometimes targeted by feminist theorists as problematic, the difficulty inherit in rejecting the scientific method is that there are not many obvious alternatives. Vandana Shiva, an Indian nuclear physicist, agricultural activist, and ecofeminist, argues that traditional knowledge and practices are more useful to agricultural production than modern agroecology, synthetic pesticide use, and genetic engineering. Shiva describes how propagating this agrotechnology in developing countries is a method of imperialism:

> The western systems of knowledge have generally been viewed as universal. However, the dominant system is also a local system, with its social basis in a particular culture, class and gender. It is not universal in an epistemological sense. It is merely the globalised version of a very local and parochial tradition. Emerging from a dominating and colonizing culture, modern knowledge systems are themselves colonizing. (1993)

Traditional knowledge about agriculture certainly has value in that practitioners can draw on the experiences of farmers from generations past to make decisions about their farms and gardens. There are few clear-cut differences between using the scientific method to solve problems and looking for traditional knowledge for answers. The traditional agricultural knowledge that Vandana Shiva is referencing was created over many generations of artificial selection of plant cultivars, experimentation with farming practices, and diffusion of advice and ideas between different farmers. Traditional knowledge and modern agroecology are not mutually exclusive. Both are interested in finding adaptive plant cultivars, running experiments on the efficiency of different farming methods, and sharing ideas between practitioners. The difference is that this latter methodology privileges novel technology and formal data collection done by scientists. The use of these practices may be expensive, and therefore inaccessible to some people. Acquiring formal scientific knowledge can also be expensive and exclusionary. However, in a world of rapid anthropogenic change, including global climate change, air, water, and soil pollution, and booming human populations, perhaps there is a need for formal scientific research in ascertaining the best ways to deal with imminent environmental problems within a single generation. It’s entirely possible that novel environmental issues caused by the rapid spread of industrialization over the past few centuries can’t be solved with centuries-old knowledge, and therefore must rely on formal scientific research.

Doing science in this conventional way can be incredibly productive in abetting human needs: curing diseases, connecting loved ones, and building civilizations. Where scientific research can be useful, feminists would call for a scientific system that finds a way to consider the needs of working class people, people of color, people of all genders, and the environment. Feminist scholar’s suggestions about how to reform science are generally pretty vague. This is due in part to the wide range of sciences that exist. There is no one-size-fits-all approach to doing better science, it is instead important that individual fields of study, research groups, and scientists decide for themselves how to do work that does not disclude the interests of often overlooked peoples. They argue that science should be practiced in a way that allows for people of various identities to contribute and then benefit equally from scientific exploration.

Medical research is one example of a field in which major discrepancies exist between those who benefit and those who do not. In the United States, our largely privatized systems of medicine development, production, and distribution is tied to market-based demand for products that can be sold at high prices. Prescription drugs and other medical treatments can be prohibitively expensive for low-income people, particularly the elderly (Soumerai and Ross-Degnan 1999). And there’s not always a guarantee that this medicine is equally effective for all genders and ethnicities of people. Medical trials have traditionally underrepresented women (Vidaver, Lafleur et al. 2000, Ramasubbu, Gurm et al. 2001), the elderly (Lee, Alexander et al. 2001), and minority ethnic groups (Bartlett, Doyal et al. 2005). A huge amount of research goes into creating medical therapies, but it's clear that those efforts are funneled toward a certain demographic of people- the people who are likely to have money to spend. Of course, the exclusion of vulnerable communities from drug trials has not exempted these people from all medical services, just that they have historically been denied when and how they participate. For example, eugenics research aimed to be productive and useful science, and was done primarily by studying the physiology of women and people of color. We generally associate eugenics with the horrendous experiments that Nazis did on concentration camp prisoners (Glover 1998), but those same ideas and practices have been done by US physicians well before and after the 1940s. The sterilization of poor women and women of color either without their consent or without providing these women with safe and easy access to alternative methods of reversible birth control was a popular US initiative from 1907 (Dula 1991) into the mid century. Forced or coerced sterilization of Native American women (Lawrence 2000), Puerto Rican women, and black women (Dula 1991) was fueled by pseudoscientific ideas of how biology could determine the fate of the United States. Based on a weak understanding of genetics, proponents believed that eliminating some minority populations, particularly individuals with disabilities, from the American gene pool would benefit US society. Most notably, North Carolina's Eugenics Board was authorizing eugenic sterilizations up until 1975. The board focused their efforts on those who had mental diseases, epilepsy, or were otherwise "feeble minded," yet specifically targeted their efforts at low-income women of color, often with no evidence that these women had disabilities of any sort (Schoen 2001). It's tempting to conclude that these crimes are anachronistic past wrongs, but important to note that many of the women who underwent these procedures are still alive today. These crimes were committed by individuals that believed they had the weight of scientific reasoning behind their actions; however, they failed to consider the racist political agenda they were furthering.

While all feminists should we wary of the racist, sexist attacks against women's autonomy, the range of feminist analyses of science is almost as wide as feminism itself. Different feminist schools of thought generally agree that structural oppression and inequality are unacceptable, but factions may emphasize a particular priority in the struggle for better opportunities: liberal feminism is the popular, traditional feminism that advocates mainly for the causes of upper and middle-class white women, the many forms of black feminism prioritize the interests of black women and also black men, Marxist feminism is organized around the needs of working class women, and ecofeminists attempt to meld the needs of women and the environment. This is only a small and superficially described selection of feminist fields, chosen to represent the structures of society most relevant to this paper. Liberal feminism is in many ways the most conservative body of feminist thought. The basic premise of liberal feminism is that women should have the same rights and opportunities as men, and that it is mainly up to individual women to work hard to achieve these goals. Liberal feminist theory of science states that the main conflicts between gender and science can be solved by simple reforms, such as encouraging girls and women to study science and prioritizing gender-neutral attitudes about science (Rosser 2001). Liberal feminist theory has no issues with the overall structure of scientific thought, such as the scientific method. Despite the hopes of liberal feminists, structural inequalities in science cannot be avoided without structural change. Simply bringing more women and people of color into universities and research labs is probably not enough. More radical fields of feminism have valuable insight about how race and class pervade the production of scientific thought and how these features of scientists' identities are important tools in their interpretations of the natural world. Black feminist scholars argue that race is the organizing principle around which human struggles for power exists, meaning that racial distinctions are what separate those who do and do not have the power to assert change in politics, economics, media, and science. Black feminists find that the construction of scientific thought has been overwhelmingly Eurocentric and therefore not possibly objective, as generations of white scientists have placed their interests separately and above those of people of color (Rosser 2001). Marxist feminism argues that class is this organizing principle instead of race. Marxist feminists argue that all knowledge is socially constructed: objectivity is impossible, and knowledge is gained only to the benefit of the dominant, bourgeois class (Rosser 2001). Extreme ecofeminists reject the scientific method and its institutions for being inherently masculine and therefore too biased to be useful to global needs (Kerr 2001). Sue Rosser describes the difficulty of specifying which feminist philosophy a scientist can ascribe to in her analysis of how these methodologies of science can be and are put into place:

> The jumble of descriptors for feminist methodology- rejects dualisms, is based on women's experiences, shortens the distance between observer and object of study, rejects unicausal, hierarchical approaches, unites application with problem- seems contradictory when portrayed as feminist methodology. They become more understandable when viewed as lumping together of possible methodological implications for science resulting from different feminist theories. (2001)

Because there is a range of feminist philosophies and possible methodological implications, feminism cannot assert one monolithic change to the way that science is done. Instead, it is best to look at scientific fields and questions one by one, and to consider how feminist methodologies could be used to improve specific goals in research.

The root of the disconnect between science and human needs is the idealization of objectivity, a value that is impossible to achieve. It's true that some parts of the scientific method, such as calculations and statistical analyses, are nearly impossible to sway with individual beliefs. However, reducing our interpretations of the natural world to a group of numbers and statistics does a disservice to the complexity of scientific thought. There are elements of the scientific method that rely heavily on subjective decision-making: collecting observations, making analyses about what those observations mean, and interpreting the quantifications used to define them are all activities that can be influenced by an individual's previous knowledge and life experiences (Lederman 2001). A good, if fairly benign, example of subjective decision-making may be the distinction between "lumpers" and "splitters" in creating phylogenies. A phylogeny is the evolutionary relationship between a range of species, genera, or populations of organisms. In determining these relationships, some scientists, lumpers, may place several closely related groups into one taxonomic classification, while other scientists, splitters, may see important differences between these groups that merit individual labels. Two different people can look at the same data and analyze it differently, leading to different "objective" results. While most scientists understand how fickle these conclusions actually are, this subtlety may not be well communicated to people who do not have a degree in biology. If two different groups have conflicting agendas for why they need a particular phylogeny to be described their way, their individual knowledge and experiences becomes very important in deciding whose analysis is more useful. Scientists who identify as feminist practitioners have tried to strike a balance between the objectivity required of science and the inevitable biases of their life experiences:

> Feminist practitioners' recognition of the way in which subjectivity shapes scientific practice, and therefore knowledge, challenges the way in which the rhetoric of objectivity is currently being used to stifle radical research. They accept that the production of knowledge is socially shaped; and want to bring the subject back into scientific writing; and to show respect for nature. This does not, however, entail a complete rejection of objectivity, because certain aspects of objectivity remain important, for example, tests that eliminate particular biases in the data and an acceptance of reductionism where it is more appropriate. A tolerance of diversity in methodology, explanations, and theories in science is another important aspect of feminist practitioners' argument. (Kerr 2001)

In studies of bee ecology, it's important to consider how human economic and agricultural needs bias research. Because we eat food, humans are inclined to find simple and economically efficient solutions to the decline of pollinating species, such as relying on one bee species to dominate pollination services, and using technological innovations to create large monocultures, or clumps of vegetation where only one plant grows, of a few basic crops. It is not always clear how these practices may influence long-term environmental health or human quality of life. More broadly, how can ecologists study natural ecosystems without oversimplifying or damaging them? A feminist approach would find ways to acknowledge the complexity of ecological relationships that are impossible to fully replace by anthropogenic, or human driven, processes or technologies in the hopes that their approach could preserve ecosystem services. Conservation of ecosystems, then, is not the work of a small group of biologists preserving a single species, but the integration of broad societal interests with the preservation of whole habitats and communities.

Because there are so many conflicting questions about how to approach science as an institution, I thought it would be best to focus on a single scientific issue. How can feminist thought be utilized to explore a single ecological problem? My interest in wild bee community ecology seemed distant from the concerns of kyriarchical oppression. However, if the flaws of scientific practice are truly systemic, then the opportunities to apply feminist methodologies in research and practice should be quite broad. In studying wild bee pollination of crops in urban gardens, these feminist science practices are the most important: involving community members in research and conservation projects, considering how research impacts different groups of people, pursuing a better understanding of other cultures' relation to and study of the environment, searching for different and possibly better ways of running experiments, acknowledging my own subjectivities and biases instead of just trying to affirm my sense of scientific objectivity, and considering the conservation of broad ecosystems in an attempt to preserve ecological, cultural, and economic services. A good way to combine these goals is by setting ecological research about bees on urban farms.

4.0 HOW IS CONSERVATION DONE?

Popular representations of conservation tend to focus on individual species with obvious commercial appeal. Panda bears, bald eagles, and sea turtles draw in sympathy and financial support from the American public. Yet these species are not necessarily the most important targets for conservation. The decline of top carnivores and other large-bodied species can be good indicators that an ecosystem is suffering; however, saving those species will not necessarily save the ecosystem in which they live. Honeybees are an interesting and example of conservation in contemporary popular media. Apiculture, the management of honeybees for agricultural pollination and honey production, is a lucrative industry, valued at up to $19 billion annually (reviewed in Committee on the Status of Pollinators in North America 2007). Feminist scholars of science might question whether the conservation of individual species is more helpful to financially lucrative ventures or actual environmental significance. Which has more value to human societies? It's true that humans have legitimate, sentimental attachment to certain species. However, it's also true that most human societies rely on functioning ecosystems and ecosystem services. A feminist approach to conservation, then, focuses on the conservation of whole habitats and organism communities, not just individual species.

The conservation of the natural world is limited by our understanding of what the natural world is and how we as humans should prioritize the needs of the organisms around us.

Choosing to conserve one particular species or population may cause a cascade of effects in an environment. Sometimes this cascade is intentional, and benefits the function of that ecosystem, such as the reintroduction of wolves into Yellowstone National Park, which restored the local carnivore, herbivore, and plant populations (Smith, Peterson et al. 2003). However, conservation efforts can have unintended detrimental effects, such as the restoration of the white-tailed deer population in the northeastern US. White-tailed deer are currently at artificially high population numbers; they overbrowse communities of understory wildflowers, devastating both those communities (Rooney and Dress 1997) and also the bees that rely on those flowers for foraging (Cane 2005). Vandana Shiva defines the two major causes of worldwide biodiversity losses as anthropogenic: habitat destruction from the building of dams, highways, mines, and cities; and economic cultivation of land for agriculture, silviculture, and the cultivation of livestock (Shiva 1993). Urban communities are particularly at risk as they selectively exclude organisms that may preserve ecosystem function. The animal and plant species that survive urbanization tend to be only a subset of the native population (Shochat, Warren et al. 2006) that have been preadapted to the novel environmental conditions.

Bees' response to urban development varies by species, and many species are able to thrive in urban environments. Bees can find habitat in urban areas not traditionally associated with conservation: cemeteries, railroad tracks, and under transmission lines, for example (McKinney 2002). Bee species live in a wide range of habitat features, including grasses, forbs, shrubs, and dead trees (Williams, Crone et al. 2010) and underground in loose sand, dunes, loams, clays, flat ground, or banks (Cane 2005). These various habitats can be found in cities, though they are often highly fragmented and located in uncultivated areas. The loss and fragmentation of natural habitat leads to decreased gene flow between conspecifics and lowered persistence of metapopulations (Hanski and Ovaskainen 2003, Zayed, Packer et al. 2005). Although it's unclear exactly how urban habitat fragmentation affects all bee species (Kremen, Williams et al. 2007), urban land use has been found to limit regional bumblebee gene flow (Jha and Kremen 2013). By focusing on whole communities, conservationists are not forced to prioritize individual species of concern. Prioritizing what parts of nature are important can only be done by prioritizing groups of human voices, which means excluding the needs of undervoiced groups: a particularly non-feminist approach. Overall, focusing conservation efforts on a single species may not be the best way to preserve ecosystem services; instead, it is important to consider the conservation of a whole habitat that influential species need to survive.

Habitat conservation can support the survival of interconnected communities of organisms. In ecology, a community is defined as a collection of different species that interact with each other. Plants and pollinators are a good example of a complexly connected community. The decline of pollinating species is directly connected to a decline in plant species diversity (Biesmeijer, Roberts et al. 2006), though the relationship between these two groups can be more subtle. Sometimes loss of a single pollinating species has little influence on the success of a plant species, as redundancy of pollinators ensures that there are more pollinating animals that will service the plant; however this safety net doesn't always last in the long term, as pollinator loss can lead to a loss in overall plant-pollinator interactions (Burkle, Marlin et al. 2013). Additionally, the loss of species from communities is not random. A species' trophic level, connections to other organisms, and ability to change habitat are important factors in its survival. In bee communities, the first species to become locally extinct are specialist pollinators, parasites, and cavity nesting bees (Burkle, Marlin et al. 2013). Because the constituent species of a community use different resources in different ways, studying the health of communities allows us to study many facets of ecosystem functioning all at once. For example, the range of bee species in pollinator communities may have more or less adaptive responses to land use change (Kremen, Williams et al. 2007), potentially limiting the bee species that can survive after anthropogenic disturbance. The amount of variation in bee communities is directly related to plant species abundance (Tscharntke, Gathmann et al. 1998). Correspondingly, bees will forage in greater numbers and with greater species richness on less attractive plants if those plants are in a diverse flower community and more attractive species are also present (Frankie, Thorp et al. 2005). Habitat conservation is important because it manifests in the preservation of complex community dynamics.

Human survival relies on ecosystem services, meaning that the conservation of these services has weighty political significance. Ecosystem services are the benefits that humans derive from plant and animal communities: climate regulation, water purification, soil formation, pollination, formation of fuel and food resources as well as cultural identity, recreation, and ecotourism (Dobson, Lodge et al. 2006). It's difficult to quantify exactly how ecosystem health is related to ecosystem services, and even harder to recreate those connections after environmental change. Poor choices in habitat management can create an extinction debt of species. An extinction debt is the long-term loss of species as an indirect result of environmental change: species might not immediately go extinct, but the disruption of ecological interactions lowers the fitness of involved species and decreases their ability to survive over multiple generations (Haughton and Hunter 2003). Various ecosystem services respond to disturbance with a range of severity. Some ecosystem services are more resilient to species loss than others. Pollination has intermediate resiliency, meaning that there is a roughly linear relationship between loss of pollinating species and detriment to pollination services (Dobson, Lodge et al.

2006). However, the same study showed that this relationship is much more brittle in cultivated landscapes, where a small number of specific pollinators may be required for the success of a particular crop. The loss of some pollinating species in agricultural ecosystems could have devastating effects on the plants that are able to grow there. Ecosystem services are interconnected; for example, bees pollinate clover and legumes that fix nitrogen in the soil, a necessary nutrient for plant growth in wild and cultivated ecosystems (Cane 2005). This means that losing bee species may have far-reaching effects beyond just the loss of a few crop plants. That's not to say that pollinating crops isn't important. The value of global pollination services ranges from $112-200 billion per year (Costanza, d'Arge et al. 1997, Kearns, Inouye et al. 1998); the majority of this work is done by wild pollinators (Garibaldi, Steffan-Dewenter et al. 2013). Crops that don't need insect pollination are, as a whole, 5 times less valuable in world production than insect-pollinated crops (Gallai, Salles et al. 2009). A lack of wild pollinators in an agricultural ecosystem can cause a dearth of pollination needed for crops, as seen in sunflowers (Greenleaf and Kremen 2006). Ecosystem services such as pollination have economic and environmental significance for humans, proving the importance of habitat and community conservation that supports these services. By conserving many pollinator species, scientists can better approach the structural flaws in our agricultural and land management systems.

The United Nations has set up a network of biosphere reserves that falls in line with feminist principles by conserving whole communities instead of focusing on individual issues. Biosphere reserves are almost as old as the concept of formalized US resource conservation itself, and were given definition in the 1970's (Batisse 1982). There are 621 reserves in 117 countries around the globe, each focusing on conserving local ecosystems, culture, and economy in the pursuit of researching sustainable development (UNESCO). The emphasis on conserving human societies is intended to occur synergistically with ecosystem management, so that valuable land can be used for human needs without disrupting ecosystem services, as "Conserving an ecosystem should not imply it cannot be changed, used or developed by people…" (Bridgewater 2002). Moreover, decisions about human needs and ecosystem health can be made by the individuals who live in these reserves; participation of local communities is vital to the success of conservation efforts (Stoll-Kleemann and Welp 2008). However, it's good to be cautious about this success. There is little information on the quality of life of people in these reserves, and whether or not these communities feel that their needs are adequately addressed. Overall, though, biosphere reserves may be a good example of how conservation can be done on a broad scale while embracing feminist principles of community access. However, conservation in smaller spaces may not have access to the same resources as the United Nations. Some of this conservation must be done on a small scale, cultivated by interested communities in densely populated neighborhoods. Conservation within cities may take on a different role than conservation within biosphere reserves.

5.0 HOW CAN AGROECOLOGY IMPLEMENT FEMINIST SCIENCE?

Agroecology, the combination of agricultural work with ecological research, can embrace feminist principles by prioritizing the sharing of information between scientists, farmers, and other community members; by designing agricultural procedures that can be adapted to local conditions; and by conserving biodiversity. Vandana Shiva argues that biodiversity conservation has to be integrally linked to the humans and industries that rely on natural services:

> This separation of production and consumption [of food] with 'production' being based on uniformity and 'conservation' desperately attempting to preserve diversity, guarantees that biodiversity will not be protected. It can only be protected by making diversity the basis, the foundation, the logic, of the technology and economics of production. (2001)

For US agriculture, this means acknowledging that the rise of large-scale industrial farming and apiculture is a threat to bee health and biodiversity, an idea that is not at all new to most ecologists. These practices shouldn't be accepted as the standard of how we do things now, when alternatives still exist which may be safer, more productive, and healthier. To determine when to invest in these various alternatives, community input is important. Agroecological sciences should seek to gather information from a variety of sources (including farmers, activists, and consumers) to conserve ecology while helping to decrease resource disparity between human populations. This can be done by involving citizen-scientists in research projects and surveys, working closely with farmers to implement practical conservation strategies, and holding community education workshops. This can also be done by building sustainable urban community gardens: this maximizes the possibilities for building pollinator habitat in depauperate areas while providing food, jobs, and psychological benefits to dense human communities and providing opportunities for engagement and educational outreach for lots of people.

Agricultural practices in urban gardens should be fit to each community's suite of natural and economic resources while maximizing opportunities for wildlife conservation. Sustainable agriculture practices are inherently feminist, because feminists prioritize methods of growing and distributing food that are minimally damaging to farm workers, food consumers, and the environment. These practices must be flexible in nature, so that they can be customized and adapted by groups of people with varying resources in different areas of the world. It's also important that information about sustainability methods can be spread through formal and informal means: word of mouth, local newsletters, small workshops, etc. With these ideals, agriculture need not be exclusive to farmers who produce small amounts of food and may to have a bounty of resources to work with. Sustainable agriculture methods also decrease reliance on agrotechnology by supporting wildlife communities and the ecosystem services they represent. For example, intentional non-crop plantings allows for movement of pollinators and other beneficial insects to crops. The National Resource Council recommends hedgerows, weed borders, insectary strips with insect-beneficial plants, and wildflowers planted in fallow fields (2007). In-field practices can also assist pollinator populations: using shallow irrigation to avoid flooding underground burrows, cover cropping, and no-till planting (Committee on the Status of

Pollinators in North America 2007). No-till farming preserves soil ecology and wildlife habitat and can be done differently depending on climate and soil conditions of a particular area. No-till is the loosely defined practice of leaving soil undisturbed, except for small strips that seeds are planted in using minimally invasive tools. No-till farming can preserve habitat for ground nesting bees (Committee on the Status of Pollinators in North America 2007). The practice of no-till agriculture spread through a series of workshops and the communal exchange of information between farmers in the 1960s (Coughenour 2003). No-till farming is a method of practicing agriculture in a way that respects ecosystem functioning and can be customized for use under different farm conditions, two qualities that are encouraged by feminist science.

Integrated Pest Management (IPM) is another loosely regulated series of steps used to lessen the impact of harmful pest species, such as weeds, pathogens, and herbivores, on crop plants. IPM uses targeted, minimally invasive pest treatments to effectively maintain low levels of garden pests. Practitioners attempt to avoid the flaws of relying solely on synthetic insecticides, such as pest resistance, resurgence of pests, uptake of secondary pests, and environmental contamination (Kogan 1998). IPM doesn't necessarily mean using fewer pesticides, just that those treatments are used in conjunction with other control and monitoring techniques and are specifically targeted to the pests in question (Sandler 2010). IPM-produced fruits are found to have significantly lower pesticide loads than conventionally produced food (Baker, Benbrook et al. 2002). Various levels of IPM intensity are practiced. Basic IPM is more popular and includes practices such as crop rotation, farmers' field scouting for pests, and selective use of pesticides. More involved and less popular forms of IPM include considering the interactions between multiple crops and multiple pests, and managing wildlife habitat (Kogan 1998). IPM draws on older American farming traditions, particularly from the late 1800s and early 1900s, to look for techniques that exist independently of modern conventional pesticides (Kogan 1998). In this way, IPM is an example of applied ecology that considers total ecosystems and how human input changes ecosystem interactions over time. These practices preserve native habitat and flowers for wild bees, two resources that are integral to bee conservation, and can be customized to the human communities who want to support sustainable food production.

Integrated Crop Pollination (ICP) is a project that holds promise for reducing agricultural reliance on the intensive management of a few pollinating species. ICP aims to build a framework for using many species of pollinators to accomplish crop pollination. ICP was spearheaded by Rufus Isaacs and is currently being studied on a variety of crops in Michigan such as blueberries, apples, and cherries. At this stage, researchers are surveying the abundance and species richness of bees and their pollination efficiency at a few sites (Isaacs 2013). Quantifying the impact of bees helps to develop ICP strategies that minimize the risk of pollination deficits (Isaacs and Kirk 2010). The ICP program has goals that include reducing pesticide use, supplementing honeybee pollination, and incorporating other species of managed and wild pollinators in pollination strategies. The program is supported by the US Department of Agriculture and the Xerxes Society for Invertebrate Conservation, amongst other academic research teams and organizations. Gordon Frankie notes that fledgling ICP programs have focused on fitting ICP management techniques to individual farms, not just having a one-size-fits-all approach (quoted in Rosner 2013) and taking time for community outreach by teaching over 20,000 farmers and policy makers about native bees. By diversifying strategies to support pollination, an essential ecosystem service, scientists, policymakers, and other interested parties are working toward responsible environmental and economic sustainability.

Community action can help to conserve wild bee communities. Individuals can be engaged in pollinator conservation and food production by participating in community gardens or by planting their own gardens in place of or adjacent to depauperate lawns (Tu 2013). Non-scientists can support wild bee communities by building habitat and planting floral resources in their private and community gardens, by participating in citizen-science projects and workshops, and by seeking education on ecological communities and agricultural systems. Changing zoning legislation allows for urban agriculture and apiculture, allowing communities to become educated about food production and have more control over how food reaches them. This change is currently occurring in Pittsburgh, where Forest Hills Borough passed legislation this past summer to allow beekeeping and chicken coops in residential areas (Brown 2013). Buying local produce and honey at farmer's markets or through community supported agriculture (CSA) programs can support urban gardens. Maintaining this environmental stewardship requires a change in dominant ideologies about how food is produced and how ecosystem services are maintained: creating surplus food isn't better if it isn't distributed well, there is not one magic solution to reversing pollinator species loss, and human communities should be involved in the development of agroecological systems.

6.0 HOW CAN CONSERVATION BE DONE IN URBAN SPACES?

Urban ecosystems present a particular challenge to conserving wildlife habitat, communities, and ecosystem services due to their unique features. Though there is no broadly accepted ecological definition of an urban environment (Imhoff, Bounoua et al. 2004), there are general characteristics of environments saturated with large human populations and infrastructure. The abiotic, or nonliving, features of urban environments can vary dramatically from the land around them in respect to wind turbulence, precipitation, cloud cover, humidity, and temperature (Chandler 1976, Wheater 2002). Cities can be viewed as "pseudo-tropical bubble" regardless of latitude due to the increased temperatures made possible by heat absorbing pavement and rooftops (Shochat, Warren et al. 2006). The built environment of cities causes severe habitat fragmentation, which reduces species diversity; however, fragments can also be reserves of biodiversity in an otherwise depauperate landscape. Cities also provide a wide range of environmental conditions relative to the surrounding landscape, creating a range of microhabitats that can support small numbers of many species (Rebele 1994). The unique abiotic features of urban environments lead to changes in the biotic environment, composed of living organisms, found in cities. Smaller-bodied species, particularly amongst arthropods, proliferate in urban microhabitats (Wahlbrink and Zucchi 1994). Herbivorous species benefit from the longer plant growth season supported by warmer urban temperatures (Wheater 2002). For plants, this earlier spring blooming may be a tradeoff with photosynthetic activity during the summer months (Imhoff, Bounoua et al. 2004). The anthropogenic features of urban environments cause a gradient in species composition where nonnative species increase in population size toward centers of urbanization, often at the expense of native species (McKinney 2002). Urban arthropods such as bees are often controlled by bottom-up competition for limited foraging and habitat resources (Faeth, Warren et al. 2005). Thus bees' responses to urbanization are best predicted by their foraging and nesting habitats; cavity nesting species thrive in cities, while ground nesting species decline (Cane, Minckley et al. 2006). Urban environments can be built while considering the needs of wildlife, creating small-scale reserves of biodiversity that integrate human populations with ecosystem services.

Conservation in urban environments presents a particular opportunity for the preservation of bee communities and pollination services. Legislating the protection of large game lands or endangered species is not always easy or even sufficient, particularly when the most effective conservation efforts would include a wide range of species and their coordinated habitat needs (Haughton and Hunter 2003). Attempting to separate human cities from "pure" natural landscapes overlooks the needs of people who live in rural areas and might need access to infrastructure that could damage the natural environment (Rocheleau 1991), as well as robbing urban inhabitants of the opportunity to connect with natural ecosystem activities. Land set aside solely for wildlife conservation may seem only peripherally important to human communities who have not experienced the full benefit of ecosystem services. If these communities have been denied experience with preserved wildlife habitat, they may not be willing to contribute the appropriate resources to the habitat's survival, especially if that land becomes important for anthropogenic development such as mining, oil extraction, or building. Conservation areas in urban environments place the benefits of wildlife conservation side-by-side with the humans who are integrally tied to conservation success. This could be done with legislative protection of or incentivization for multi-use urban environments, such as urban farms and gardens, as is already done with some city park systems. An important difference between a city park and a city garden is that gardens are built and shaped by community members, instead of just used as a resource. Parks tend to be managed by specialized groups such as conservancies, whereas gardens must be managed by engaged individuals living in the local neighborhood. This means that gardens can be more flexible in their responses to community needs and have the potential to empower community members who participate in their cultivation. It is possible that gardens could have a greater benefit to habitat conservation and human community building than parks alone. Cultivating urban wildlife habitats rather than merely observing them can nourish community interest and investment in wildlife conservation. Urban gardens benefit bee communities. Community gardens and naturescape parks have higher bee diversity and abundance than smaller flowerbeds and backyards (Tommasi, Miro et al. 2004), and newly planted bee-friendly urban gardens have the potential to attract diverse seasonal bee taxa if temporally diverse floral resources are present (Wojcik, Frankie et al. 2008). Protecting sustainable urban habitats may make anthropogenic co-existence with healthy wildlife communities possible while sustaining the ecosystem services we use to survive.

Urban agriculture is an exciting pathway towards building sustainable human communities while conserving wild bee species. I use the terms “urban farm” and “urban garden” interchangeably here, as the specifics of agricultural features are not particularly important to this topic outside of their ability to produce food and conserve bees. Urban farming can be highly productive and versatile, making the venture possible for volunteers, schools, or private landowners. Regardless of who owns the garden, cultivated urban green spaces have the potential to improve the quality of life for the whole human community that works with, purchases from, passes through, or just happens to notice the garden. Using permaculture techniques in the cultivation of urban spaces may optimize wildlife habitat conservation while retaining ecosystem services such as food production, aesthetics, and the psychological benefits of connecting with natural landscapes. Permaculture is a portmanteau of "permanent agriculture," a nebulous body of sustainable agricultural thought that emphasizes non-intensive, long lasting methods of producing foods while preserving environmental resources (Copeman 2007). The land that food is grown on is an important environmental resource. The loss of net primary productivity, defined as the energy captured by producers in an ecosystem, due to anthropogenic land use change in the US is comparable to the food requirements of 16.5 million people (Imhoff, Bounoua et al. 2004). Agriculture can be made more efficient. Dick Copeman's outline of permaculture principles mentions a few ideals that are particularly appropriate to the conservation of wild bees on urban farms and gardens:

- Incorporating local details into design patterns
- Integrating agricultural systems
- Prioritizing community action (Copeman 2007)

The principles are also inherently feminist. They involve all members of a local community in food production, and connect those people to important ideas about sustainability, wildlife protection, and healthy diets. The applicable principles of urban permaculture to wild bee conservation provide novel opportunities to do feminist conservation.

Copeman's first principle is ideal for cities because of the range of goods and services available in densely populated human communities. By considering the limits and opportunities of urban environments, habitat conservation and urban gardening can be done on unconventional spaces where access points to heat and light are already abundant, such as rooftops and empty lots. Finding spaces for habitat cultivation requires knowledge of local climate and geography, the needs and abilities of neighboring humans, and the materials and services that are easy to attain in a particular city. This means that existing community members of the city are probably best able to use this knowledge to transform urban spaces. Copeman's ideal of integrating agriculture with other human sectors is easily applied to urban gardens surrounded by human neighborhoods. By combining the residential, retail, and agricultural activities of a neighborhood, people are better able to exchange mutually beneficial resources. Finally, urban agriculture requires the support of its community and is thus ripe for community action. Allowing community members to share responsibility for the production and distribution of food can be empowering and important to the nutritional health of a community. There are also ample opportunities for education in urban farms and gardens: in agriculture, gardening, ecology, wildlife management, retail, food preparation, etc. Urban farms and gardens are prime candidates for sustainable agriculture.

Conserving wild pollinators is important not only because of their role in pollination but also as a case study in the way that scientists view ecological problems. There is an important difference in ideology between trying to save an ecosystem service by looking for one species or piece of technology that might do it, and by considering the ecological changes that have led to a problem and trying to find comprehensive solutions. Pollinator management in the US over the past few centuries is an example of the former strategy. Farmers and scientists have attempted to control ecosystems by moving managed pollinators, especially honeybees, between sites in bulk numbers. There are a small handful of managed pollinator species used for different crops or in different areas of the world: honeybees, *Apis mellifera*; Alkali bees, *Nomia melanderi*; Alfalfa Leaf Cutter bees, *Megachile rotundata*; and several bumblebee species, *Bombus spp.* George Bohart's 1972 description of wild bee management for crop pollination is a particularly good example of how scientists engage with the natural world with the mindset of controlling it. Bohart advocated for replacing the alkali bee (*N. melanderi*) with the alfalfa leaf cutter bee (*M. rotundata*), outlining the disadvantages he saw in the former pollinator without discussing the ecological consequences of encouraging the population growth of the latter, a foreign species in North America that had a large growth in population after its mid-century introduction (Bohart 1972). While many introduced species can be essential to how we live, it's important to at least consider the ecological consequences of moving species around haphazardly. The ideology of controlling nature continues today in popular media treatment of pollinator decline. There are many calls to save the honeybee, but this fails to explore the complexity of the issue from an ecological standpoint- generally looking for quick fixes such as banning neonicotinoid pesticides (Entine 2013) or investing in mechanical or manual pollination (Walsh 2013). These quick fixes may solve problems for individuals whose finances rely on agricultural production, but they do not fix ecosystem functioning. Moving pollinating species around like building blocks can have detrimental consequences for some ecosystems. The intentional movement of invasive, non-native bumblebees from Europe to Japan, Chile, and Argentina, poses risks to native bumblebees in those regions such as competition, hybridization and subsequent loss of locally adapted ecotypes, and introduction of nonnative diseases (BBSG 2013) In describing this issue, the IUCN Bumblebee Specialist Group advises that local bumblebee species and subspecies should be specifically targeted for commercial development and managed within native ranges.

Exploiting new opportunities for conservation of whole habitats is preferable to trying to manage one ecosystem service at the expense of other components of an environment.

Organic agriculture is a common path towards building sustainable food systems that is sometimes- but not always- beneficial to pollinators. Organic farms produce food without the use of synthetic pesticides and fertilizers, instead using biologically produced alternatives as well as maintaining soil ecology through cover cropping, green manure, crop rotation, and composting. This produces crop yields similar to conventional methods (Bates and Hemenway 2010). Organic agriculture has mixed effects on bee populations. Abstaining from spraying synthetic chemicals may have no effect on bees at farms that have other key conservation features: diversity of plantings, habitat heterogeneity, and proximity to natural habitat (Winfree, Aguilar et al. 2009). However, organic agriculture can create important reserves for bee biodiversity in intensively managed landscapes(Holzschuh, Steffan-Dewenter et al. 2008). Organic agriculture can have drawbacks, though. Being certified organic costs farmers money and time, limiting the farmers to whom this is an available option (Gallagher 2012). While sustainable agriculture is important to wild bee conservation, that doesn’t necessarily mean that organic farming is the only or best way to be sustainable.

Community Action is an important resource for agricultural, scientific, and environmental work, particularly on urban farms that preserve wildlife habitat. Traditionally, conservation scientists have sought to prove that:

biodiversity → ecosystem function → ecosystem services → human well being

assuming that proving the connection between these first two components would make connections through to human well-being intuitive (Naeem, Bunker et al. 2009). However, there has been limited application of the significance of this chain of effects in management and policy. By involving “ordinary” people (not scientists, farmers, or policymakers) into the development of scientific knowledge about biodiversity and ecosystem functioning, these individuals may be better able to understand how biodiversity conservation is related to their own health and happiness. Connections between scientists and non-scientists can happen in volunteer and citizen-science projects. Community farms and gardens are a great draw for volunteers, who benefit from more than just the food produced. Volunteers also have the opportunity to spend time outside, find significance in their community, socialize, and share ideas (Dazé 2013). World Wide Opportunities on Organic Farms (WWOOF) is a good example of how non-farmers are drawn to agricultural work. The program connects thousands of volunteer workers with 1600 organic farms in the US (and thousands more around the world) for farm work in exchange for housing, food, and agricultural education (WWOOF-USA). This is not intended as a substitute for jobs, but merely an interesting way for travelers and vacationers to spend a temporary amount of time learning about the connections between their lives and food production. Community involvement in conservation also opens up opportunities for citizen-science projects. A feminist scientist would argue that removing barriers between scientific practice and community members in this way is of supreme importance. Allowing for a diversity of input and knowledge from practitioners can strengthen the quality of the questions that scientists ask by allowing for novel insights and creative analysis. In addition, citizen-science projects make research more relatable for non-scientists and can be used as a tool for education and community support. Elaine Evans’ account of using citizen-scientists to gather data in a survey about bumblebees in Minnesota mentions that after she initially recruited a few volunteers, she found that in subsequent field seasons she had many interested community members approaching her because interest was so high (Evans 2013). People are eager to be involved in science. In fact, the National Resource Council's 2007 report on pollinators suggests using citizen-science to monitor pollinator levels based on the success of similar programs in Europe (Committee on the Status of Pollinators in North America 2007). Other citizen science projects have involved using volunteers to observe the pollinator community visiting *Claytonia virginica* (Thomson 2013), and using text message data from students in Bolivia and Peru to gather data about pollinators and environmental conditions in community gardens (Ebersole 2013). Sustainable communities can thrive through a combination of discourse, field experience, expert advice, research, and mentoring (Haughton and Hunter 2003). Citizen science and volunteer projects in agroecological research can be beneficial to scientific development and feminist science goals.

Urban gardens allow people to participate in community decision-making, target local issues, and resist aspects of food production that they don't feel are suitable (Okvat and Zautra 2011). The mere presence of gardens is correlated with decreased domestic violence (Sullivan and Kuo 1996), property and violent crimes(Kuo and Sullivan 2001), ADHD symptoms in children (Kuo and Taylor 2004), need for pain medication in hospital patients (Ulrich 1984), and risk of dementia in the elderly (Fabrigoule, Letenneur et al. 1995). Gardens can also be important for building communities. Daze's study of volunteers in an urban garden found that gardening brings together people with a variety of skills that might not otherwise interact with each other (2013), allowing for formal and informal learning between volunteers. The same study found that the benefits of gardening can go even deeper, as gardening can have therapeutic benefits for gardeners, visiting community groups, children, and people with disabilities. Anecdotal evidence of the community-building nature of gardens is seen in New York City's citywide flower competition. Some residents organized a neighborhood watch out of their windows to make sure the garden was safe from passers-by (Kaplan and Kaplan 1989). A major draw for community gardeners is their ability to control the food that they eat. Structural denial of wholesome food to low income people and people of color is prevalent in many US cities and is seen in the prevalence of supermarket redlining, the practice of supermarket chains choosing to not sell food in inner city neighborhoods, or charging more for the food they sell (Bybee 2012). The food that is available in these communities is often low in nutrition; the number of fast food restaurants in a city block is correlated with the percentage of black families that live there, regardless of their income. Insufficient access to food is correlated with infectious disease spread, school and work absences, fatigue, and difficulty concentrating (Wehler 1991). By growing food in the middle of densely populated neighborhoods, human communities benefit from having increased control over their diets and access to natural spaces.

Community gardening is an intriguing solution to many of the issues that urban neighborhoods face, but it is important that urban gardens and farms be fit to the community in which they are placed. A city neighborhood may not be able to find a suitable place for a large urban farm if space is better put to use in infrastructure for housing and jobs. In these areas, it's possible that rooftop gardens or small microhabitat patches are the best way to focus on conservation. Many urban farms face insecurity of land tenure (Bryld 2003), so it is up to the gardeners of a particular area to decide if their efforts are best supported by local legislation, neighborhood groups, private interests, or some combination of these. In protecting the products of the garden or farm, some gardeners may find it necessary to put up locked fences; conversely, those barriers may make the garden exclusionary. Some gardens may be able to turn a profit, but some might not need to, or might seek well-justified subsidies for providing food and environmental protection. Some urban gardens have chosen to be profitable by growing specialty crops to sell to expensive restaurants or upper-class consumers, choosing not to contribute to food security of a given neighborhood (Thompson 2012). A given garden or farm may choose to partially adapt this strategy, growing a range of crops for a range of consumers. Urban gardens and farms should aim for representative governance that includes the voices of the differently raced, gendered, and socioeconomic members of their community. It's important to remember that farms and gardens aren't always suitable for a city, and are certainly not the only solution to environmental, economic, and agricultural problems. However, when urban agriculture does fit into a community, it can be a positive force of change in densely populated human environments.

7.0 HOW SHOULD SUSTAINABLE DEVELOPMENT BE DONE?

Environmental degradation, pollinator loss, and poverty are connected phenomena: true sustainability must deal with the root cause of these issues to create any long-lasting change in human well being. The connection between these three conflicts is our distribution and use of resources, particularly land and food. Of the 320 million people in the United States, 82% live in urban areas (FAOStat 2014). 18% of the land that the US covers is occupied by crops, producing 3666 kilocalories of food for each person to eat each day (FAOStat 2014). On average, adults of the US self-report that their calorie intake per day is 1785 kilocalories for women and 2640 kilocalories for men (USDA 2010). Despite this abundance, 14.5% of households in the US were not able to provide food to each family member at some point in 2012, even though the majority of those households (59%) participated in a federal food and nutrition assistance program. The most conservative estimate of US food waste estimates that 30% of the food that the US produces is never eaten (Alisha Coleman-Jensen 2013). Food access is not evenly spread across communities of the US. Poor neighborhoods and neighborhoods with high concentrations of black and Latino residents have less access to supermarkets (Cotterill and Franklin 1995, Powell, Slater et al. 2007), and are thus forced to spend more money on lower quality foods. A truly sustainable food system should work to address how food can be produced, distributed, and consumed in such a way that an individual’s ethnicity or occupation is not a factor in how likely they are to go hungry. Creating a sustainable food system requires that economic, environmental, and cultural systems work together to create infrastructure that will last over many generations.

It is important to not overlook ideological sustainability as a facet of sustainable development, as future generations need to continue to develop and implement sustainable practices even after it is no longer fashionable or seems imminently necessary. For example, saving bees is currently a popular idea in science media, but bee species will still need habitat and foraging resources after that interest has dried up. Sustainability programs can't be solely focused on bees or even pollination, and instead must be tied to a larger social movement, such as the implementation of urban gardens and farms that maintain natural habitat. Of course, the decline in pollinator populations is tied to the impetus toward scientifically based development of human infrastructure in previous generations without enough regard for social and ecological considerations. The popularity of beekeeping and gardening, particularly by young people, can be seen as part of a trend toward independence from conventional, corporate structures of food production and distribution. In the United States, we have a wealth of technological, medical, and agricultural products, yet many people are lacking basic resources such as food, education about food and the environment, and even environmental stability. People who feel conflicted about this inequality may search for ways to feel they can have an effect on immense problems in the economy and environment (Moore and Kosut 2013) There are various ways that non-scientists "save" bees: by gardening, beekeeping, and buying local produce and honey. All of these methods are countercultural and therefore trendy, which says good things for bee populations right now, but only over a short time scale. This search for influence is also tied to popular resistance against the "cultural forgetting of how to do basic things" (Moore and Kosut 2013) in other fashionably countercultural activities such as canning foods, baking bread, brewing beer, DIY building and fashion, and otherwise not relying on capitalist ways of consuming resources. Urban farming can be embraced in this era of not relying on conventional and clearly flawed systems of agriculture, economy, and food distribution. Effective adoption of urban gardening into long-standing cultural values can create a platform for food production and wildlife conservation that is ideologically sustainable.

Sustainability of ideas can only persist if those ideas can be molded to different cultures and regions: too often, western ideals of development take precedence even in areas of the world where they are not applicable. "Development" very often means privileging white, western, middle class norms of consumption and production. As a form of development, the mass intensification of agriculture for corporate profit has been detrimental to sustainability and the equal distribution of resources in the United States. Development is often not a global goal, but a goal serving the interests of western economic powers that has been spread to postcolonial countries (Shiva 1993). By extension, these development strategies may be implemented without enough regard for alternative pathways that embrace local knowledge, prioritizing technological solutions. For example, Shiva describes the dangers of the Green Revolution in India, run by the International Centre for Maize and Wheat Improvement replaced the thousands of wheat crop strains maintained by indigenous peoples with a strain that western scientists deemed to be best for foreign agriculture, though that strain came from a narrow genetic base of only three parent plants: a hybridization of Japanese, American, and Mexican stock (1993). Shiva argues that the limited genetic diversity of these seeds is not a better alternative to the many strains of wheat maintained by traditional farmers, and that the Green Revolution strains have consistently proven to be susceptible to disease and adverse weather conditions, threatening the livelihood of Indian farmers. She explains how the globalization of scientific knowledge is often detrimental to non-western cultures:

> The disappearance of local knowledge through its interaction with the dominant western knowledge takes place at many levels, through many steps. First, local knowledge is made to disappear by simply not seeing it, by negating it's very existence. This is very easy in the distant gaze of the globalizing dominant system. (1993)

Indian farmers still have the ability to draw on the immense agricultural and botanical indigenous knowledge. This is not the case in the US, because indigenous people here were largely either killed or removed from their land by colonizing forces. This was often done with the explicit intent of removing native peoples from good agricultural land so that European colonists could take it over, divorcing Native American's from their local agricultural knowledge base and substantially changing their cultures (Jensen 1977). In addition, the spread of industrialization over the past few centuries in North America has lead to a fundamental disconnect between the average citizen and the ecosystems on which they rely, as seen in the decreased visitation to US parks since the 1980s (Pergams and Zaradic 2008). In this country, agricultural affiliations and outdoor activities often run along class, race, and regional lines. The struggle for control over agriculture is generally depicted as being between large industrial farms that receive government subsidies, and small, sustainable, family run farms. For these reasons, the US is vulnerable to further unsustainable development: we have very little precedent for how we should grow and distribute food, and we cannot assume that strategies that work in one part of the world will necessarily work across the US. Therefore we must constantly test both traditional ways of knowledge and forthcoming technologies, in the face of growing environmental issues such as species loss and climate change.

In acknowledging the place of scientific and non-scientific thought in building sustainable food systems, it's important to consider how scientific thought can be shared with and made by people who are not professional scientists. For agroecology, this range of groups includes farmers, community members, and consumers. Involving non-scientists in science can be a good way of encouraging individuals in underrepresented communities to become scientists and thus encourage diversity in life experiences of people who contribute to scientific thought (Kerr 2001). The tools and ideas shared in agroecology can be useful to non-scientists; conversely, bringing a variety of life experiences into scientific research can make studies stronger. A sampling of volunteers at a London urban garden bring a range of skills to the table that can be useful in constructing and supporting habitat conservation: including computer knowledge, plant and bird identification, photography, cooking, networking, health and safety policy, and knowledge of local legislation (Dazé 2013). By sourcing knowledge to and from a variety of people, conservation practices can become more resilient, even in areas and times where the value of wildlife and nature is not widely acknowledged. In fact, urban wildlife management can be a respected tradition to non-scientists; for example, in immigrant, ghetto, and working-class neighborhoods, bees, chickens, and pigeons have been kept for centuries (Moore and Kosut 2013). This is not a part of media or scientific dialogue, yet it contributes to food availability and conservation. Engaging in conversations about science with non-scientists, who have a role in passing environmental legislation and participating in economic exchanges, can be a useful platform for "not presenting scientific results as the objective truth but as a partial picture of nature, and therefore open to debate" (Kerr 2001). Some feminist scholars see biology as the core of most contemporary human disciplines, due to its relevance in education and careers. Donna Haraway states that, “there is almost nothing you can do these days that does not require literacy in biology” (Goodeve 2000). Engaging non-scientists in scientific pursuits is important to the spread of scientific ideas that matter to the general population.

Engaging with non-scientists is also important for professionals who do good research. The National Academy of Sciences argues that thinking outside of the conventional realm of scientific endeavors challenges scientists to acknowledge the suppositions and beliefs behind their own work so they can advance their research. This can be done by scientists looking more deeply into other fields such as arts, history, and ethics (Sciences 2001). Science is inherently powerful because of the way that it organizes the world into testable objects and services. Thinking of biological processes as ecosystem services shows how entrenched the natural/biological and economic/cultural worlds are in each other. For better or worse, biology looks at nature through the lens of efficiency and productiveness (Goodeve 2000). Optimistically, blurring the lines between scientific and non-scientific endeavors will help to create true diversity in scientific thought, a value that Londa Schiebinger calls for specifically:

> Neither changing women to fit science nor changing science to incorporate conventional feminine ideals will be sufficient...What is needed are collaborations between scientists, historians, and philosophers that will foster not only a diverse community of scholars but scientists critically attuned to their place in nature. (2001)

Acknowledging the politics behind scientific thought may be far more important to doing useful research, conservation, and sustainable development than striving for unattainable objectivity can possibly be.

CONCLUSION

Feminism is important to wild bee conservation because it encourages sustainable urban gardening and general environmental stewardship that aids both human and animal communities, and requires that we think differently about how both science and agriculture are connected to the average person. Bee conservation is important to human nutrition, economy, and culture for ecological reasons that are easy for non-scientists to understand. Bee conservation also opens up opportunities for communication between scientists, farmers, and neighbors by using urban farms as a space for research, food production, and community building. Feminist science advocates that deemphasizing the use of agrotechnology can help to connect human needs, environmental sustainability, and interesting ecological research.

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