An overview of the potential impacts of honey bees to native bees, plant communities, and ecosystems in wild landscapes: Recommendations for land managers

The Xerces Society for Invertebrate Conservation
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Introduction

The question of whether introduced honey bees belong on public lands and natural areas in North America has been debated for decades (Pyke 1999, and references therein). As more areas of natural habitat that formerly provided resources for pollinators are converted to agricultural and suburban uses, the pressures for the beekeeping industry to find pesticide-free areas for honey bees to forage when the bees are not actively pollinating crop fields are increasing. As a result, there is a critical need to present evidence-based considerations for landowners and managers of public lands and natural areas to review when deciding whether honey bees would be appropriate in these landscapes, and if so, the timing, duration and numbers of hives that should be allowed. At present, more research needs to be conducted to determine appropriate stocking rates and the least intrusive locations of hives for both honey bee and native bee health.

In recognition of the potential risks that honey bees pose to native pollinators and their associated landscapes (see below for details), the final decision about whether to allow honey bees access to public lands and natural areas should be left to land managers who have the best understanding of the local conditions, local management goals, the needs of the flora and fauna, and the sensitivity of the habitat. We also recommend that land managers consider any federal or local laws pertaining to natural areas management. These laws include, but are not limited to: the National Environmental Policy Act (NEPA), the National Forest Management Act (NFMA), the Clean Water Act, the Endangered Species Act, and all relevant state and municipal legislation.

Honey bees are critical for agriculture, and honey production is an important industry. Plus, beekeepers – professional and hobbyist alike – are some of the most engaged advocates for improved pollinator habitat across the U.S. Xerces does want to ensure, however, that native pollinators and other land management or conservation goals are considered in decisions about apiary placement on public lands and natural areas.

Recommendations for Land Managers

Where local and federal laws permit the placement of honey bees, and managers are deciding whether to include hives on their land, we suggest that managers consider the following potential impacts of honey bees. Below this set of recommendations is a review of the literature relevant to these issues.

Are populations of endangered or threatened pollinators present on the land?

- If rare species of bees and butterflies, including threatened or endangered species, are known to exist within the flight area where the hives are to be placed, assessment of potential risks to these populations should be undertaken.

- If it is possible that rare or declining pollinator species can be found in the area, efforts should be made to determine if they are present. Consulting scientists with expertise in pollinator surveys and species identification is recommended. In cases where a particular pollinator species is critically imperiled, every remaining population and individual may be essential to the species' immediate and long-term survival. There is potential that honey bees may transmit diseases to native bees (e.g. spread of deformed wing virus from honey bees to bumble bees causing wing damage) and may compete for floral resources (e.g. decreased fecundity in bumble bees).

Are there invasive plant populations, or ongoing efforts to eradicate invasive plant species, that would be affected by the inclusion of honey bees?

- Honey bees may not be compatible with invasive plant species management. If honey bees pollinate and increase seed production of the invasive species in question (e.g. yellow star thistle), land managers may want to exclude honey bees during periods of bloom.

What are the potential impacts to other wildlife?

- Are there bears in the area that will be attracted to the apiary as a food source? Land managers need to work with beekeepers to determine if placement of an apiary will increase the potential for human–bear conflicts. If this is a risk, then electric fencing and maintenance of that fencing to prevent intrusion from bear should be mandated on public lands to avoid bear damage to apiaries and to prevent habituation of bears to hives.

Is there sufficient infrastructure to support the drop-off and storing of the proposed operation?

- Commercial beekeepers may bring anywhere between 4 and 400 hives, depending upon the size of the operation. Hives are delivered using a range of vehicles from flatbed trucks to semi-tractor trailers. Access roads must be appropriate for the required transport, and should not result in excess erosion, road damage, or other infrastructure challenges.
- Apiary sites also must be of sufficient size, with level and firm ground to accommodate small forklifts or bobcats used to move pallets of bees. An apiary location will also need sufficient space for trucks to turn around.

A summary of the potential impacts of honey bees on native ecosystems

The importance of honey bees and native bees

Pollinators support the reproduction of nearly 85% of the world's flowering plants (Ollerton et al. 2011) and 35% of global crop production (Klein et al. 2007). The great majority of pollinators are insects, including bees, wasps, flies, beetles, ants, butterflies, and moths. Bees are considered the most important group of pollinators in temperate climates. There are nearly 4,000 species of bees in North America – north of Mexico (Michener 2007); almost all of these are native.

The honey bee (*Apis mellifera*) is not native to North America and was introduced in the early 17th century by Europeans for honey and wax production (DeGrandi-Hoffman 2003). As honey bees were moved around for honey production the value of their contribution to pollination services on farms became apparent. Eventually, with the advent of the removable frame beehive in 1852 by L.L. Langstroth, modern apiculture took shape, and honey bees began their long-standing relationship with North American agriculture (LeBuhn 2013).

The honey bee (*Apis mellifera* L.) is the most widely managed crop pollinator in the United States. Studies indicate that honey bees are important for more than $15 billion in crop production annually (Morse & Calderone 2000; Calderone 2012). However, the number of honey bee colonies has been in decline over the past half-century because of disease, parasites, and other factors (Berenbaum et al. 2007), and since 2006 beekeepers have experienced record high annual hive losses of 22% to 36% (Bee Informed Partnership 2014).

Native bees are also important crop pollinators. A recent survey found that native bees universally increased fruit set in 41 crop systems worldwide, independent of honey bee presence (Garibaldi et al. 2013). Native, unmanaged bees provide free pollination services, and are often more efficient than honey bees on an individual bee basis at pollinating particular crops, such as squash, berries, and tree fruits (e.g. Tepedino 1981; Bosch & Kemp 2001; Javorek et al. 2002; Garibaldi et al. 2013). Native bees are important in the production of an estimated $3 billion worth of crops annually to the United States economy (Losey & Vaughan 2006; Calderone 2012). Beyond agriculture, pollinators are keystone species in most terrestrial ecosystems: they pollinate the seeds and fruits that feed everything from songbirds to grizzly bears. Thus, conservation of pollinating insects is critically important to conserving both biodiversity and agriculture.

Evidence of honey bee and native bee decline

Little is known about the population status of most of North America's nearly 4,000 species of native bees, especially across the entire range of individual species. However, what little information we do have suggests that many native species are experiencing population declines similar to, or more severe than, the declines that we have seen in honey bees. For example, a recent analysis of North America's bumble bees (*Bombus* spp.) conducted by the International Union for the Conservation of Nature (IUCN) Bumblebee Specialist Group indicates that one quarter of North America's bumble bees have experienced significant declines (Hatfield et al. 2015). These include several bumble bees that were formerly among our most common species. This analysis is corroborated by many recent studies that have documented bumble bee declines throughout North America (Colla & Packer 2008; Evans et al. 2008; Grixti et al. 2009; Colla & Ratti 2010; Cameron et al. 2011; Colla et al. 2012; Koch & Strange 2012; Bartomeus et al. 2013).

The ultimate cause of bumble bee and other native bee declines continues to be investigated, although many factors appear to be contributing. While land use change and habitat fragmentation are likely contributors to decreasing populations in some species (Williams et al. 2009; Potts et al. 2010), disease (Thorp et al. 2003; Colla et al. 2006; Williams et al. 2009; Cameron et al. 2011; Koch & Strange 2012), pesticide use (Whitehorn et al. 2009; Desneux et al. 2007; Laycock et al. 2012, 2013; Fauser-Misslin et al. 2013; Baron et al. 2014; Feltham et al. 2014), and climate change (Williams et al. 2009, Kerr et al. 2015, Miller-Struttman et al. 2015) are all also likely significant factors (Goulson et al. 2015).

Because of concerns about high annual honey bee losses, and declines in native bee species, national policies are in development with the explicit goal of helping honey bees and native bees. Most importantly, the 2008 and 2014 Farm Bills make pollinators a conservation priority for USDA agencies like the Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA). As a result, Farm Bill conservation programs are now providing farmers and ranchers with technical and financial assistance to create pollinator habitat on their lands. Because of the ongoing honey bee hive losses each winter and the challenges this poses to the beekeeping industry, the USDA also launched a special initiative in March 2014 specifically targeting $3 million to plant honey bee forage in five Upper Midwest and Northern Plains states where 65% of honey bee hives are rested in the summer. This was followed in October of 2014 by an additional $4 million effort. This initiative is part of a larger effort at USDA to ensure that agricultural lands are able to support honey bee colonies.

Overall, the increased focus on bee health reflects a growing awareness of the importance of pollinators, and a motivation by government agencies and the public to take action. While the Xerces Society applauds all efforts to conserve pollinators, there is a need to ensure that actions to help beekeepers also benefit, and do not negatively impact North America's native pollinators

Our increasingly complex, fragmented landscape makes public lands and natural areas an important resource for the conservation of native pollinator communities. These public lands and natural areas have served as refugia for native bees and other pollinators for decades. These same public lands also hold the potential to provide pesticide-free forage for honey bees. There are, however, inherent possible risks to populations of native bees presented by the large scale placement of honey bees on public lands and natural areas. The purpose of this report is to provide a summary of the current research that addresses the real, or potential threats that managed honey bees pose to native bees and native plant communities, so that the managers of public lands and natural areas can be informed when deciding whether or not to allow managed honey bees access to these areas.

Do honey bees pose a risk to wild bees, plant communities, and other wildlife?

While honey bees are essential pollinators in our agricultural environment, their role in public lands and natural areas is less clear. Though research examining the effects of honey bees on wild bees and plant communities has conflicting results, there is evidence that, at least in some cases, honey bees can alter plant and native bee communities because of their foraging habits, relatively high level of pathogen loads, degree of resource (pollen and nectar) removal, and their interactions with native bees.

Competition with native bees:

A single honey bee colony requires substantial resources to survive. Estimates of single hive consumption vary from 20-130 lbs/year for pollen and 45-330 lbs/year of honey – representing 120-900 lbs/year of nectar (Goulson 2003, and references therein). Depending on the environment and the density of honey bee hives in an area and the time of year, this could represent a substantial percentage of the resources available. The proportion of resources used by honey bees, as well as the effects of this resource depletion on the native bee community, are likely to vary by location, the time of year, the species involved, floral abundance and diversity, and climatic and other environmental conditions.

Recent research documented that under controlled conditions honey bees displaced native bees from flowers, altered the suite of flowers that native bees were visiting, and had a negative impact on native bee reproduction (Hudewenz and Klein 2015). While there remains a need for additional research, there is also further evidence that honey bees can potentially impact the native bee community by removing the available supplies of pollen and nectar (Anderson & Anderson 1989; Paton 1990, 1996; Wills et al. 1990; Dafni & Shmida 1996; Horskins & Turner 1999), or by competitively excluding native bees, thus forcing them to switch to other, less abundant, and less rewarding plant species (Wratt 1968; Eickwort & Ginsberg 1980; Pleasants 1981; Ginsberg 1983; Paton 1993, 1996; Buchmann et al. 1996; Horskins & Turner 1999; Dupont et al. 2004; Thomson 2004; Walther-Hellwig et al. 2006; Tepedino et al. 2007; Roubik 2009; Shavit et al. 2009; Hudewenz & Klein 2013; Rogers et al. 2013; but see Butz-Huryn 1997; Steffan-Dewenter & Tscharntke 2000; Minckley et al. 2003) – but none of these studies have addressed population level effects on native bees. The long-term implications of this shift in resource use are not entirely clear, although there is a growing body of research on bumble bees that demonstrates negative competitive effects of honey bees on bumble bees, including lower reproductive success, smaller body size, and changes in bumble bee foraging behavior – notably a reduction in pollen gathering (Evans 2001; Goulson et al. 2002; Thomson 2004, 2006; Paini & Roberts 2005; Walther-Hellwig et al. 2006; Goulson & Sparrow 2009; Elbgami et al. 2014).

Additional evidence shows that honey bees are regularly using, and depleting, the most abundant resources in the surrounding environment (Paton 1996; Mallick & Driessen 2009; Shavit et al. 2009), and that upon removal of honey bees, native bees exhibit signs of competitive release by returning to plants that were formerly used by honey bees (Pleasants 1981; Wenner & Thorp 1994; Thorp 1996; Thorp et al. 2000). A number of studies have shown more neutral effects (Steffan-Dewenter & Tscharntke 2000; Minckley et al. 2003; Forup & Memmott 2005; Hudewenz & Klein 2013). The effects on other species of native bees, such as ground-nesting solitary bees, have not been well documented due to the difficulty in studying their rates of reproduction.

Disease transmission to native bees:

The spillover of infectious disease from domesticated livestock to wildlife populations is one of the main sources of emerging infectious disease (Daszak et al. 2000; Fürst et al. 2014). While this phenomenon has not been well studied in invertebrates, there is recent evidence of the transmission of pathogens from commercial bumble bees to wild bumble bees (Colla et al. 2006; Otterstatter & Thomson 2008; Murray et al. 2013). Recent evidence has also emerged demonstrating that honey bees can transmit diseases to many different species of native bees, including bumble bees, when they interact at shared flowers (Singh et al. 2010; Fürst et al. 2014). Bumble bees placed close to honey bee hives were found to have an 18% higher prevalence of *Critidia bombi*, than bumble bees placed away from honey bees (Graystock et al. 2014). A number of RNA viruses that were formerly thought to be specific to honey bees have now been reported to infect bumble bees (Genersch et al. 2006; Morkeski & Averill 2010; Singh et al. 2010; Meeus et al. 2011; Evison et al. 2012). The virulence of most of these RNA viruses in bumble bees has not yet been evaluated or demonstrated. However in at least one study (Genersh et al. 2006) bumble bees infected with Deformed Wing Virus (DWV) developed malformed wings. Another recent study showed that DWV significantly reduced survivorship of bumble bees (Fürst et al. 2014). The same study (Fürst et al. 2014) showed that bumble bees with an overt inoculation of DWV produced non-viable offspring and had reduced longevity. In addition, while the primary disease implicated in recent bumble bee declines is the microsporidian *Nosema bombi*, bumble bees have recently been seen to harbor *Nosema ceranae*, a common disease of honey bees that can be particularly virulent to honey bee colonies, and has been implicated as a factor in Colony Collapse Disorder (Paxton 2010; Graystock et al. 2013; Fürst et al. 2014;). *Nosema ceranae* has recently been detected in honey bees in Canada, and the United States (Williams et al. 2008), and more recently been detected in bumble bees in South America (Plischuk et al. 2009). It is likely only a matter of time until this pathogen is detected in wild bumble bees in North America.

A recent review paper that looked at disease transmission between managed and wild bees concluded that the commercial use of pollinators is a key driver of emerging disease in wild pollinators, and that avoiding anthropogenic induced pathogen spillover is crucial to preventing disease emergence in native pollinators (Manley et al. 2015). To help mediate this potential, the authors suggest that it is crucial to prevent the introduction of diseased pollinators into natural environments (Manley et al. 2015). Another recent review paper looked at the global effect that managed pollinators (including commercial bumble bees and honey bees) are having on wild bees (Graystock et al. 2015a). Graystock et al. (2015a) documented three mechanisms for managed bees causing negative effects on wild bees including pathogen spillover, pathogen spillback (the transmission of pathogens from wild populations to managed pollinators, where the pathogen becomes more prevalent and then is further transferred back to other populations/areas), and facilitation (making wild bees more susceptible to disease because of stress due to competition). Graystock et al. (2015b) also documented that pathogen transmission occurs between bumble bees and honey bees at shared flowers, showing a clear mechanism and vector for infection. Since small, fragmented, and declining populations are especially susceptible to infectious disease (Fürst et al. 2014), and disease is already implicated as a likely causal factor of some native bee declines in North America (Cameron et al. 2011), this emerging body of research suggests that caution should be exercised when considering the placement of managed bees of any species in habitat that supports vulnerable or declining native bee populations.

Risks to Native Plant Communities:

Since more than 85% of all flowering plants depend upon an animal pollinator for reproduction (Ollerton et al. 2011), healthy pollinator populations are essential to the maintenance of plant communities. Since the early Cretaceous period, native plants and pollinators have been coexisting in a symbiotic relationship that is essential to ongoing biodiversity. Today, our public lands and natural areas serve as important refugia for the many native plant species that are otherwise threatened by habitat fragmentation (due to agricultural intensification and urban expansion), climate change, invasive species, and a host of other pressures.

Non-native pollinators are a potential threat to native plant populations as they have been shown to exhibit a preference for invasive plants in their foraging habits (Thorp et al. 1994; Butz-Huryn & Moller 1995; Morales & Aizen 2002; Hanley & Goulson 2003). There is evidence that, particularly for self-incompatible plants (see Butz-Huryn & Moller 1995), honey bee visitation increases seed set, and may initiate an invasive mutualism between the two species (Barthell et al. 2001, 2005; Morales & Aizen 2002; Hanley & Goulson 2003; Goulson 2005). The risk of increasing the spread of invasive plant species by increasing the abundance of their key pollinators could cause significant economic and ecological damage to ecosystems (Goulson 2005) and at a significant cost to native plant populations (Brown et al. 2002).

Moreover, while honey bees are effective pollinators of the majority of plants that they visit (Butz-Huryn 1997 and references therein), research from several regions of the world suggests that honey bees are only collecting pollen from 25-42% of plant species available in natural areas (Wills et al. 1990; Thorp et al. 1994, 2000; Buchmann 1996). Further, approximately 15,000-20,000 species of flowering plants are more efficiently pollinated by a behavior known as buzz pollination (De Luca & Vallejo-Marín 2013), which is something that many native bee species can do quite well, but that honey bees are incapable of performing. Thus, if an ecosystem were to become dominated by honey bees, with a concomitant decline in the abundance of native bees, many species of native plants may potentially be left under-pollinated.

In a recent review paper, Dohzono and Yokoyama (2010) looked at studies on the effects of introduced honey bees and bumble bees on native plant populations. They found that while these introduced bees are unlikely to affect the pollination system in bird pollinated plants, they can exhibit potential negative effects on native plant populations generally in the form of (1) decreased pollen transfer, (2) competition for resources and exclusion of native pollinators, and (3) changes in native pollinator visitation rates and efficiency. However, negative effects in most systems have not been quantified. So, while the mechanisms for the negative impacts of honey bees do exist, there are few studies that clearly document negative effects on plant populations due to pollen limitation. Therefore, while it is possible that the disruption of native pollinators by non-native bees disrupts plant populations, it is also possible that non-native bees may alter native pollinator populations (items 1-3 above) without having a net negative effect on plant populations (for more details see Dohzono & Yokoyama 2010). More research in this area is needed, but finding locations for comparative studies without non-native pollinators is an increasingly difficult challenge.

Based on best available research, honey bees can be described as good pollinators of some native plants. However, they cannot be considered effective pollinators of all native flora, and are not essential to the pollination of native plant populations (Wills et al. 1990; Thorp et al. 1994, 2000; Buchmann 1996; Butz-Huryn 1997; De Luca & Vallejo-Marín 2013).

Risks to other wildlife:

An additional concern is that black bears may try to get at honey in hives, and become more habituated to feeding on these hives. As bears are increasingly interfacing with humans, and as beekeepers seek high quality forage for their apiaries, bear-honey bee conflicts are likely to increase (Caron & Bowman 2004). The economic effect of black bears on honey bee operations is significant (O'Brien & Marsh 1990). Less well understood are the effects of these depredation events on black bears. Electric fences have proven to be an effective measure to protect apiaries from bear depredation, and therefore bears from human-bear conflicts. Where bears pose a risk to apiaries, fences should be erected and maintained (Clark et al. 2005).

Summary

Pollinators are essential to ecosystems and their contributions to biodiversity are well documented. As such, efforts to maintain a diverse suite of pollinators should be a priority for all public lands and natural areas. Honey bees, while non-native to North America, play an essential role for pollination in agriculture. Conservation measures, particularly the creation of high quality, insecticide-free foraging habitat in agricultural landscapes, are necessary for long-term honey bee health. Whether public lands and natural areas can be a part of the conservation equation for honey bees will likely vary by location and the time of year.

Public lands and natural areas are essential for our native pollinator and plant populations as they serve as important refugia from ongoing threats in more populated and manipulated landscapes. Evidence exists to suggest that through competition, disease transmission, and foraging habits (e.g. preference for invasive plant species) that honey bees have the potential to negatively affect native bee and plant populations in these habitats, particularly under certain environmental conditions. The degree of these effects is variable, and certainly warrants further investigation. Yet, while counter examples are available, negative effects have been documented and the threats from these effects have the potential to alter native bee populations.

Because of the potential threats to our native pollinators, until additional evidence exists documenting that honey bees have a net neutral effect on our native biota, we urge land managers to consider these potential impacts and their relevance when making a decision about the placement of apiaries on public lands and natural areas. Importantly, land managers need to ensure that honey bee placement is consistent with existing legislation and with ongoing and future management priorities.

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