Do Honey Bee Apiaries Ever Have Positive Impacts On Native Bees?

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Abstract

Worldwide insect declines have added urgency to growing concerns that managed bees may have negative impacts on native pollinators by outcompeting and spreading disease to them as well as altering native plant communities. This paper builds on a literature review that examined the effect of non-native bees on native bees and plants (Mallinger et al., 2017). We examine whether the studies compared sites with/without non-native bees or at varying distances from hives; which native bee or plant endpoints were studied and the reported outcomes for those endpoints; the number of managed bees used; and how the managed bee populations studied compare to numbers of honey bees permitted on public lands. Eighty-eight studies are included in this analysis, representing a subset of the 146 studies reviewed by Mallinger et al. The 88 studies in this analysis were selected because they examine specific native bee or plant endpoints and the managed bee species is non-native to the study area. The majority (67%) of these 88 studies did not compare sites with/without non-native bees or at varying distances from managed hives, and a majority (64%) did not employ any managed bee hives, but instead studied naturalized populations of non-native bee species. Very few studies (9%) used ten or more hives, while most (81%) honey bee apiary permits allow ten or more hives[1]. Most reported outcomes of specific endpoints were negative for native bees in the areas of competition (61%) and disease (67%). No studies reported a positive outcome for native bees when investigating competition or disease transmission from non-native bees. The only positive impacts of honey bee presence were from studies that examined outcomes for particular species of native plants, in which a minority (40%) of endpoint measurements were positive. We conclude that there is strong scientific evidence that permitting honey bee apiaries on public lands will almost inevitably negatively affect native bees and may negatively impact certain native plant species.

[1] Permit documentation received through Freedom of Information Act requests for permits on the Colorado Plateau by the Grand Canyon Trust. See Appendix D for details.

Introduction

Healthy ecosystems on public lands require a diverse assembly of native pollinators, including native bees, which provide necessary pollination services in both natural landscapes and resilient agricultural systems (Ollerton, 2017 and Winfree et al., 2007). However, recent reports indicate that native bees and other pollinators have been decreasing precipitously worldwide. One such report estimates that 40% of the world's insect species could go extinct in the next few decades if current rates of decline continue (Sánchez-Bayo and Wyckhuys, 2019). In light of these declines, it is critical to carefully analyze the impacts of activities that can affect native bee populations. Several factors, including habitat loss, disease, pesticide use, and climate change are causing native bee declines (Potts et al., 2010; Sánchez-Bayo and Wyckhuys, 2019; Cameron and Sadd, 2019; Kerr et al., 2015). Nevertheless, scientists have also found detrimental impacts of non-native, commercially used (managed) bee species on native bees.

Given this context, in 2019 and 2020 the Grand Canyon Trust systematically examined the practice of permitting honey bee apiaries (groups of hives) on national public lands on and around the Colorado Plateau. The number of honey bee hives within a given permit on and near the Colorado Plateau currently ranges from 6 to 800, with 10,000-60,000 honey bees per hive.[2]

Fig. 1 Honey bee apiary on national forest land in Utah

The following summary examines data within 88 studies that measured impacts – positive, no effect, or negative – of non-native, commercially used bee species (i.e., *Apis mellifera*[3] and non-native bumble bees) on native bees or on native plants. We report on the research questions asked, the methods used

[2] Permit documentation received through Freedom of Information Act requests by the Grand Canyon Trust. See Appendix D for details.
[3] Eight studies used the Africanized honey bee, a subspecies of *A. mellifera*.

to answer those questions, and when applicable, whether the number of managed bees used in the specific study is comparable to the large numbers of honey bees allowed per permit on public lands.

Methods

The studies included in this summary were cited in Mallinger et al. (2017), the most comprehensive collection of research on the impacts of non-native bees on native bees and plants available to us. Only those studies in which the commercially used bee species was non-native to the study area were included in our review. The most common commercial bee being permitted on public lands is the honeybee, *Apis mellifera*. Sixty of the 88 papers we reviewed studied *A. mellifera*, seven studied both *A. mellifera* and one or more commercially used bumble bee (*Bombus*) species, and 21 studied one or more commercially-used *Bombus* species only. Although all of the 88 studies investigate a non-native commercially-used bee *species*, the *populations* studied are naturalized in 56 studies, compared to 32 studies involving actively managed populations (i.e., bees in hives). Throughout this summary, this distinction is made by using “managed bees” to refer to populations of non-native bees that are in hives, rather than naturalized. Fifty-seven papers from the Mallinger et al. review were excluded from our review due to lack of a specific endpoint, lack of quantitative measurements of an endpoint, not directly investigating the behavior/impacts of non-native bees on native bees, the commercially-used bee species being within its native range, or the study area being on a small island off a region within the commercially-used bee species’ native range. Appendix A, Table A-1 details studies included as well as excluded and the rationale for each exclusion. Our analysis refines the Mallinger et al. review by describing: (1) outcomes of specific endpoints (rather than of a multiple-endpoint study overall); (2) outcomes based on whether the study compared endpoint(s) in the presence versus absence of non-native bees; and (3) outcomes based on the number of managed bees used. This enables an understanding of exactly which endpoints and research methods have reported positive impacts of honeybees, when the majority of studies found negative impacts or did not detect positive or negative impacts.

Mallinger et al. assigned to each of their 146 studies a “reported effect” (of non-native bees on native bees or plants) rating of “0”, “+”, “-”, or some combination thereof if multiple endpoints or native bee species were investigated in a single study. For example, Thomson (2006) measured abundance and foraging behavior, and found a negative impact of non-native bees on native bee abundance but no effect on foraging behavior, which resulted in a “-/0” rating. Alternatively, a study may have measured the abundance of several native bee species and found a negative impact of non-native bees on one native species but no effect on the others, which would also have resulted in a “-/0” rating. Mallinger et al. organized the studies into three broad categories: Competition, Pathogens, and Plant Communities (see Appendix B for the process used by Mallinger et al. to categorize studies and determine reported effect). In our analysis, we used the same “reported effect” ratings (0, +, -) to describe the outcomes for native bees or plants, and maintained the same broad categories (Competition, Pathogens, and Plant Communities) for organizing the studies.

In the context of this summary, an *endpoint* is the factor or behavior that a study measured for native bees or plants to determine if it was impacted by non-native bees. For example, one endpoint is amounts of brood, honey, & pollen in nest – this is a measurable aspect of native bee reproduction that non-native bees could potentially impact. Likewise, seed set is an endpoint in studies of plants – a native plant may produce greater, fewer, or the same number of seeds depending on whether it was pollinated by a native or non-native bee. One study may have measured multiple endpoints, and one endpoint may have been measured by multiple studies. In order to investigate trends in the reported outcome of individual endpoints, given that the reported effect ratings by Mallinger et al. were for a study overall, endpoints from each study were assigned an outcome as follows:

- All endpoints within a study that received a purely negative, no effect, or positive rating were recorded as having that same rating individually (e.g., a study which measured abundance, visitation rate, and diversity of native bees and had a negative rating would be counted as one negative rating for abundance, one negative rating for visitation rate, and one negative rating for diversity)
- Endpoints within a study that received a mixed rating, due to different impacts found for different endpoints, were assigned the part of the overall rating that corresponded to that endpoint (e.g., a study which measured abundance and visitation rate, and had a -/0 rating due to finding a negative impact of non-native bees on native bee abundance but no impact on visitation rate, would be counted as one negative rating for abundance and one no effect rating for visitation rate)
- If a study that received a mixed rating only measured one endpoint, generally meaning the impact of non-native bees differed among several native species of bees or plants, this was recorded as two instances of that endpoint, one with each rating that made up the mixed outcome. For example, a study which measured only native bee abundance but found a negative impact on one native bee species and no impact on another would be counted as one negative rating for abundance and one no effect rating for abundance. Although this process does essentially give such studies more data points, it was only necessary for eight studies, and gives equal weight to both effects included in the overall reported effect.

Thus, in the Results below, an endpoint “measurement” is an individual instance of a negative outcome, positive outcome, or no effect being reported for a particular endpoint, even if in some cases more than one type of impact (e.g., positive and negative) was reported for the same endpoint in one study. Additionally, three of the 88 studies included in this summary measured endpoints in both Competition and Plant Communities, i.e., both native bee and plant endpoints. In these three cases, Mallinger et al. assigned these studies a reported effect independently in each category (i.e., Competition or Plant Communities), essentially treating each study as two separate studies. This summary has taken the same approach when analyzing endpoint measurements or study-level reported outcome.

In this review, we asked the following questions about the 88 studies we reviewed:

- How frequently did the studies compare scenarios with/without non-native bees or at varying distances from managed hives?
- When managed bees were used, what numbers were used?
- What native bee endpoints were most often measured?
- Were any particular endpoints or categories consistently negative, no effect, or positive?
- Are there differences in reported outcomes when studies compared:
    - presence/absence of non-native or managed bees, or varying distances from managed hives?
    - number of managed bees used?
- How do the managed bee populations studied compare to the number of honey bees commonly being permitted on public lands?

Results

A. Presence/Absence of Non-Native or Managed Bees, or Varying Distance from Managed Bees, and Number of Managed Bees

Only 33% (29) of the studies included in this summary compared environments with and without non-native bees or at varying distances from managed bee hives. Other ways of approximating comparisons included:

- Measuring endpoints for native bees before and after introduction or removal of managed bee hives to/from a site
- Measuring endpoints for native bees or plants across several sites, where non-native bees were present in some, but not all sites
- Measuring endpoints for native bees at several set distances from hives
- Measuring plant endpoints when visited by native bees or non-native bees (generally by either bagging flowers with various sizes of mesh to allow different pollinator species in, or by excluding all pollinators after a single visit by a native bee or non-native bee)

Similarly, only 36% (32) of studies included managed bees, as opposed to studying naturalized populations of non-native bees. When managed bees were present, studies frequently did not provide detailed information on both the number of hives and size (number of bees/hive) of hives used. Of the 32 studies with hives, only 34% (11) reported both number and size of the hives (Table 1).

Table 1. Studies by managed hive information

Managed Hive Information	Count of Studies	Percent of Total	Percent of Total w/ Managed Hives
No Managed Hives (Naturalized Populations Only)	56	64%	--
Number and Size	11	13%	34%
Number of Hives Only	11	13%	34%
Size of Hives Only	1	1%	3%
Number and Size Unknown	9	10%	28%
Total	88	100%	100%

The 22 studies that did quantify at least the number of hives were at a small scale, with 64% (14) using <10 hives. Four studies included 10-49 hives, one study used 50-99 hives, and only three used >100 hives (Table 2).

Table 2. Studies by number of hives

Size Category	Count of Studies	Percent of Total	Percent of Total w/ Managed Hive #
?*	10	11%	
<10 hives	14	16%	64%
10-49 hives	4	5%	18%
50 – 99 hives	1	1%	5%
100+ hives	3	3%	14%
Naturalized Populations or N/A	56	64%	
Total	88	100%	100%

* This category includes studies where managed hives were present but number and size were unknown, although in some cases, given the context of the study, commercial scale was probable

B. Measured Endpoints and Outcomes

Overall, 59 distinct endpoints were measured across all studies. These were grouped into subcategories within the three main categories of Competition (33 endpoints), Pathogens (12 endpoints), and Plant Communities (15 endpoints). Within Competition, the most studied subcategories were:

- Abundance/Visitation (e.g., how many native bees were observed or various measures of how often they visited plants)
- Foraging Behavior
  - Plant Use/Preference (e.g., how many or which plants native bees visited and/or preferred over other plants in the study area)
  - Resource Collection (e.g., quality or quantity of pollen and/or nectar collected)
- Reproduction/Survival (e.g., number of native bee nests, number or size of offspring)

Within Pathogens, most endpoints were in the subcategory of Pathogen Extent/Severity (e.g., how widespread the pathogen is and how severe its impacts are), and within Plant Communities most endpoints were in the subcategory of Plant Reproduction (e.g., measures of reproductive success, especially how many seeds or fruit a plant produces) (Table 3).

Overall, over half of endpoint measurements (59%) recorded a negative outcome for native bees or plants; 28% recorded no effect, and 13% recorded a positive outcome. No positive impacts on native bees were reported for Competition (61% of endpoint measurements were negative; 39% no effect) or Pathogens (67% negative; 33% no effect). The only positive outcomes were recorded for Plant Communities, in which 52% of endpoint measurements were negative, 40% were positive, and 8% were no effect (Table 3).

The most frequently measured Competition subcategories had majority negative outcomes with the exception of Foraging Behavior – Plant Use/Preference, which had 40% negative endpoint measurements and 60% no effect. The distribution of reported outcomes for endpoints in the Pathogen Extent/Severity subcategory did not differ from the larger Pathogens category, (i.e., 67% negative; 33% no effect). Outcomes in the Plant Reproduction subcategory closely followed trends for the larger Plant

Communities category, with 55% having a negative outcome, 10% no effect, and 36% a positive outcome, nearly always depending on plant species.[4]

Table 3. Endpoint measurements within category/subcategory by reported outcome

Category	Subcategory	Negative	No Effect	Positive
Competition	Abundance/Visitation	68% (25)	32% (12)	-
	Direct Competition	100% (1)	-	-
	Foraging Behavior – Plant Use/Preference	40% (6)	60% (9)	-
	Foraging Behavior – Pollinator Efficiency/Effectiveness	-	100% (1)	-
	Foraging Behavior – Resource Collection	67% (6)	33% (3)	-
	Foraging Behavior – Time/Duration	100% (2)	-	-
	Population Level Measures	67% (2)	33% (1)	
	Reproduction/Survival	56% (5)	44% (4)	
Competition Total		61% (47)	39% (30)	-
Pathogens	Pathogen Extent/Severity	67% (8)	33% (4)	-
	Pathogens – Other	67% (4)	33% (2)	-
Pathogens Total		67% (12)	33% (6)	-
Plant Communities	Plant Abundance/Distribution	67% (2)	-	33% (1)
	Plant Genetics	-	-	100% (3)
	Plant Reproduction	55% (23)	10% (4)	36% (15)
Plant Communities Total		52% (25)	8% (4)	40% (19)
Total Endpoints		**59% (84)**	**28% (40)**	**13% (19)**

C. *Outcomes based on Presence/Absence of Managed Bee Populations, Varying Distance from Non-Native or Managed Bee Populations, and Number of Managed Bees*

Studies that compared presence/absence of non-native or managed bees, or varying distances from managed hives, generally reported impacts of non-native bees based on the relationship between those differences and endpoint measurements for native bees/plants. For example, Paini & Roberts (2005) measured the reproduction of native bees at 14 sites, half of which had honey bee hives present. They found that the native bees produced fewer nests at sites with honey bees, and reported a negative impact of honey bees on native bee reproduction.

[4] In a few isolated cases, positive impacts of honey bees could also have been due to a lack of native pollinators, or sheer numbers of honey bees increasing their importance as a pollinator.

However, studies that could not make these comparisons identified impacts through other means, often by correlations between endpoints for native bees and non-native bees across years or sites. For example, Gross (2001) measured the visitation rate of non-native and native bees at two sites, found that there was an inverse relationship between the number of non-native bees foraging and the number of native bees foraging, and reported a negative impact of the non-native bee on native bee visitation. Based on overall study-level reported effect ratings, reported outcome did not differ substantially between studies that compared presence/absence or varying distances from non-native or managed bee populations and those that reported endpoints without such comparisons (Table 4).

Table 4. Studies by presence/absence or varying density of managed bees and reported outcome

Presence/Absence or Varying Densities of Managed Bees	Negative	Negative/ No Effect	No Effect	Positive/ No Effect	Positive
Yes	57% (7)	10% (3)	17% (5)	3% (1)	13% (4)
No	52% (32)	15% (9)	20% (12)		13% (8)
Total	54% (49)	13% (12)	19% (17)	1% (1)	13% (12)

Based on individual endpoints, the greatest difference in reported outcome between these two groups was in the proportion of no effect ratings, which was larger for studies that did not compare presence/absence or varying distances from non-native bees (Table 5).

Table 5. Endpoint measurements by presence/absence or varying density of managed bees and reported outcome

Presence/Absence or Varying Densities of Managed Bees	Negative	No Effect	Positive
Yes	62% (29)	21% (10)	17% (8)
No	57% (55)	31% (30)	11% (11)
Total	59% (84)	28% (40)	13% (19)

With only 22 studies specifying the number of bee hives used and such a small number definitively using more than 10 (eight studies reported more than 10 managed bee hives and only four of those reported more than 50), data are not sufficient to make meaningful comparisons of reported outcomes for endpoints by number of managed bees used. Studies with any managed bee hives had slightly higher negative reported outcomes and slightly lower positive outcomes compared to studies of naturalized populations (Table 6).

Table 6. Studies with vs. without managed bee hives by reported outcome

Size Category	Negative	Negative/ No Effect	No Effect	Positive/ No Effect	Positive
Any Managed Hives	58% (19)	18% (6)	18% (6)	0% (0)	6% (2)
Naturalized Populations or N/A	52% (30)	10% (6)	19% (11)	2% (1)	17% (10)
1% (1)(	54% (49)	13% (12)	19% (17)	1% (1)	13% (12)

Discussion

A. *Presence/Absence of Non-Native or Managed Bees, or Varying Distance from Managed Bees, and Number of Managed Bees; Number of Managed Bees Studied Compared to Number of Honey Bees Permitted on Public Lands*

There are three notable problems with the 88 studies, especially in the context of permitting honey bee apiaries on public lands: 1) few studies compared environments with/without or at varying distance from non-native/managed bees; 2) the high proportion of studies that had only naturalized non-native bees present; and 3) the small number of hives.

A direct comparison between outcomes for native bees in an environment with and without non-native bees gives stronger evidence that observed impacts are caused by non-native bees compared to studies employing other variations across sites or years that may influence the endpoint studied. Studying environments with naturalized populations of non-native bees is also potentially very different from environments where massive numbers of hive bees are present, because naturalized populations are likely much smaller or of lower density than hive bees, and may have already altered the suite of native pollinators and/or plant-pollinator relationships prior to the study.

In the Grand Canyon Trust review of current (as of 2020) beekeeping permits on Forest Service and Bureau of Land Management lands on the Colorado Plateau, the average number of hives per site is 64 (i.e., 640,000 - 3.8 million bees). Since apiary permits introduce massive numbers of managed bees to relatively natural areas with no or low numbers of naturalized honey bees present, the ability to predict the potential severity of outcomes for native bees or plants in environments with/without or at varying distances from managed bees is critical to anticipating the impact of apiary permitting.

The differences between number of managed bee hives present in the 32 studies that had hives and the number of honey bee hives permitted on public lands are also notable. Through a series of Freedom of Information Act requests, the Grand Canyon Trust obtained and organized records of apiary permits on or near the Colorado Plateau (i.e., Utah, northern Arizona, and western Colorado, see Appendix D for a list of permits). The number of managed bee hives permitted per site by the Forest Service and Bureau of Land Management within this region varies, but most permits active within Spring 2018 – 2020 are for 10-49 hives or 100+ hives, with only 6% (1) of the permits issued for <10 hives (Figure 2). However, among the 88 Mallinger et al. studies utilizing managed bee hives, nearly half (44%) utilized <10 hives and only three (9%) utilized 100+ hives (Figure 2).

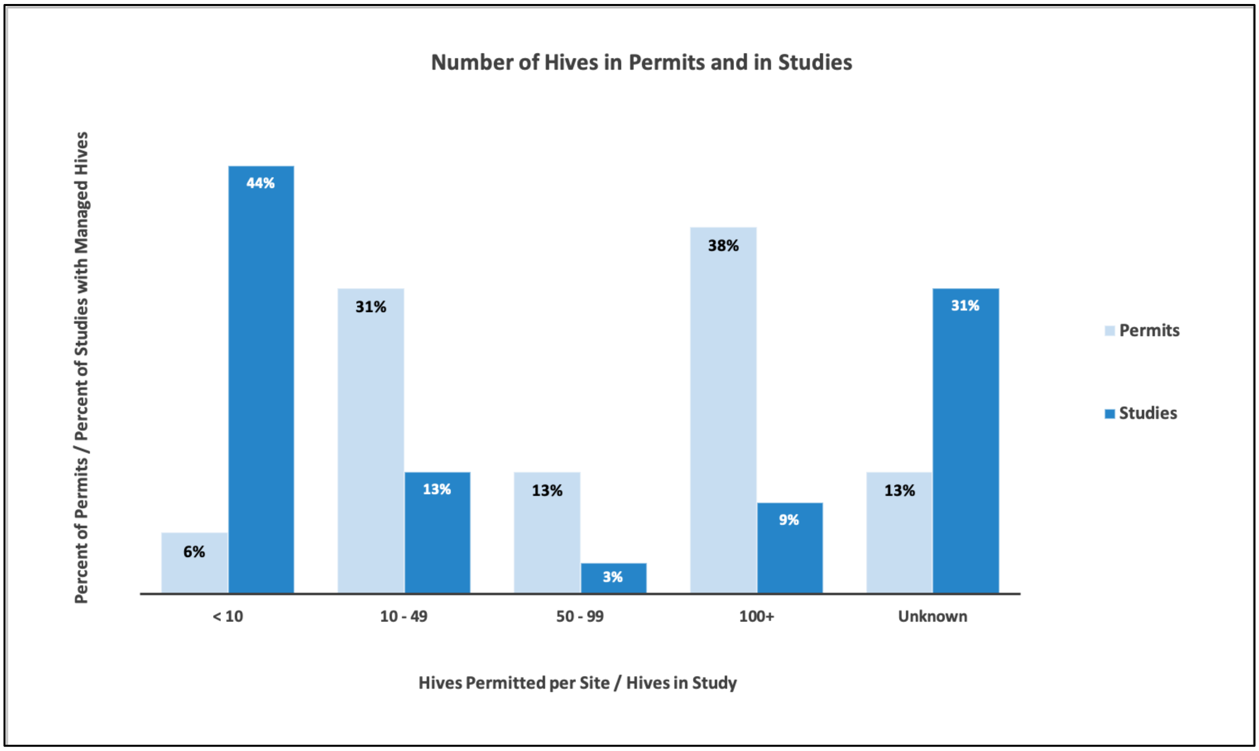

Fig. 2 Number of hives in (a) recent and active BLM and Forest Service apiary permits on or near the Colorado Plateau (n=16) and (b) Mallinger, et al. studies with managed bee hives (n=32).

Overall, only eight (9%) of the 88 studies definitively had 10 or more managed bee hives present, while 81% of permits on Colorado Plateau Forest Service and BLM lands allow 10 or more honey bee hives per site (Appendix D).

B. Endpoints Measured and Reported Outcomes

The overall weight of evidence when looking at endpoint measurements is striking –the vast majority indicate a negative impact or no effect and more than half indicate a negative impact. Across all endpoint measurements in the 88 studies, none showed a positive outcome for native bees in terms of Competition and Pathogens. Only 13% showed any positive impact – all for particular native plant species. Non-native bees having a positive impact on particular native plant species is not necessarily a positive outcome overall, because increasing certain plant species may still disrupt plant communities and plant-pollinator relationships in ways that negatively impact the ecosystem overall. These figures provide strong evidence that permitting apiaries on public lands will likely result in honey bees competing with and transmitting disease to native bee populations, as well as potentially negatively impacting native plants. Furthermore, these findings nearly always result from studies employing much lower numbers/densities of hives and non-native bees than those authorized in apiary permits, at least on the Colorado Plateau.

Importantly, in the more commonly studied subcategories, those that trended the most negative are all directly linked to native bee survival: Abundance/Visitation (68% of endpoint measurements negative); Foraging Behavior – Resource Collection (67% negative); and Pathogen Extent/Severity (67% negative). If native bees are less abundant, visiting flowers less frequently, collecting fewer resources, and encountering potentially widespread and debilitating diseases due to non-native bees, serious population declines are a reasonable likelihood.

C. Associations Between Presence/Absence or Varying Distance from Non-Native or Managed Bee Populations, or Number of Managed Bees, and Reported Outcomes

The difference in number between studies that compared the presence/absence or varying distance from non-native or managed bees (Group 1) and those that did not (Group 2) made detailed comparisons between these two groups difficult. However, looking at proportions of both studies and individual endpoint measurements by reported outcome, there was a trend of Group 1 having a greater proportion negative and smaller proportion no effect compared to Group 2 (Tables 4 and 5). Thus, it appears that study designs which do not allow for comparison between presence/absence or varying densities of managed bees will more likely report no effect, while those which do facilitate this comparison will more likely find negative impacts. Given that a comparison between an environment with/without the presence of managed bees at high densities is a closer approximation of the reality of honey bee permitting, this trend also suggests permitting apiaries may have an even greater negative impact on native bees and plants than indicated by the studies included in this summary.

Finally, although a detailed comparison between reported outcomes based on number of managed bee hives was not possible as noted in “Results,” comparing studies with any managed bee hives, even an unknown number, to those with no managed hives suggests the potential for more negative outcomes with the presence of managed bee hives. A higher proportion of those with managed bee hives had a negative reported outcome (58% vs. 52%) and a lower proportion had a positive outcome (6% vs. 17%).

Conclusion

This paper found that scientific research clearly demonstrates non-native managed bees will likely negatively impact native bees via competition and disease transmission, and will have no positive outcomes in these areas. Even with some evidence for the positive impact of non-native bees on plant communities, most reported outcomes for native plant endpoints were negative. Real-world negative outcomes of honey bee apiary permitting for native bees are almost certainly more severe than those documented in these studies, given that the number of honey bees permitted is frequently much greater than the number of managed bees studied (if indeed managed bees were employed at all, and they were often not). The infrequency with which studies compared sites with/without or at varying distance from non-native bee hives also suggests the evidence presented here may, if anything, underestimate the negative impact of managed bees on native bees and plants.

Mallinger et al. note that “in order to limit the impact of managed bees, public land managers should consider site-specific attributes such as the species of managed bee and whether it is native to the region, the proposed densities of managed bees, relative resource availability (i.e. landscape diversity), whether managed bee colonies have been evaluated for pathogens and parasites, and whether there are declining wild bee species of conservation concern in the region before allowing managed bees on public lands” (Mallinger et al., 2017, p. 27). Not only are such provisions absent from the current documented permitting process, they are largely beyond the Forest Service or Bureau of Land Management’s capabilities. These agencies simply do not have the resources necessary, in terms of staff time and/or expertise, to evaluate resource availability or population trends of native bees. So-called “best management practices” such as placing apiaries at some distance from known populations of rare, insect-pollinated plants are also simply infeasible given the staffing levels and expertise of public lands managers, and at best can only minimize negative impacts native bee species. The only realistic option to adequately protect the native bees, plants, and biodiversity of our public lands is to prohibit honey bee apiaries on these lands.

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Appendix A – Details of Studies Included and Excluded from Summary

Table A-1 Studies included in this summary

Category	Reference	Managed bee species (* indicates exotic range)	Native bee species	Location	Managed bee metric (independent variable)	Native bee/plant metric (dependent variable)	Native bee/plant metric category	Reported Overall effect	Control (y/n)	Managed Hive Information	Size Category
Plant Communities	Abe et al. 2011	Apis mellifera*	Xylocopa ogasawarensis & others	Asia (Japan)	visitation rates	fruit set	Plant Reproduction	-	y	No Managed Hives	No Managed Hives / N/A
Competition	Aizen & Feinsinger 1994	A. mellifera*	Many	South America (Argentina)	visitation rates	visitation rates	Abundance/Visitation	-	n	No Managed Hives	No Managed Hives / N/A
Competition	Aizen et al. 2011	Bombus ruder-atus*	Bombus dahlbomii	South America (Argentina)	foraging behavior (floral preferences, nectar removal), visitation rates	foraging behavior (floral preferences, nectar removal)	Foraging Behavior - Plant Use/Preference	0	n	No Managed Hives	No Managed Hives / N/A
Pathogens	Arbetman et al. 2013	Bombus ruderatus*, Bombus terrestris*	Bombus dahlbomii	South America (Argentina)	presence/ absence	parasite presence/ absence	Pathogen Extent/Severity	-	n	No Managed Hives	No Managed Hives / N/A
Competition	Badano & Vergara 2011	A.mellifera*	many	North America (Mexico)	abundance	diversity	Population Level Measures	-	n	Number/Size Unknown	?/?*
Plant Communities	Barthell et al. 2001	A. mellifera*	many	North America (USA)	visitation rates	seed set	Plant Reproduction	-	y	Number Only	100+ hives
Competition	Batra 1999	A. mellifera*	many	North America (USA)	visitation rates	visitation rates	Abundance/Visitation	0	n	Number Only	50 - 99 hives
Plant Communities	Beavon & Kelly 2012	A. mellifera*, Bombus spp.*	many	New Zealand	visitation rates, presence/absence	fruit set	Plant Reproduction	-	n	No Managed Hives	No Managed Hives / N/A

Category	Reference	Managed bee species (* indicates exotic range)	Native bee species	Location	Managed bee metric (independent variable)	Native bee/plant metric (dependent variable)	Native bee/plant metric category	Reported Overall effect	Control (y/n)	Managed Hive Information	Size Category
Plant communities	Bruckman & Campbell 2014	A. mellifera*	many	North America (USA)	visitation rates, foraging behavior (pollen deposition)	seed set	Plant Reproduction	+/0	y	No Managed Hives	No Managed Hives / N/A
Plant Communities	Carbonari et al. 2009	A. mellifera*	none	South America (Brazil)	foraging behavior (frequency of nectar robbing)	floral abortion	Plant Reproduction	-	n	Number Only	<10 hives
Competition	Carneiro & Martins 2012	A. mellifera scutellata*	many	South America (Brazil)	visitation rates	visitation rates	Abundance/Visitation	-	n	No Managed Hives	No Managed Hives / N/A
Plant communities	Chamberlain & Schlising 2008	A. mellifera*	many	North America (USA)	visitation rates	seed set	Plant Reproduction	+	n	No Managed Hives	No Managed Hives / N/A
Competition	Connor & Neumeier 1995	A. mellifera*	many	North America (USA)	visitation rates	visitation rates	Abundance/Visitation	-	n	No Managed Hives	No Managed Hives / N/A
Plant communities	Dick 2001	A. mellifera scutellata*	many	South America (Brazil)	visitation rates	seed set	Plant Reproduction	+	n	No Managed Hives	No Managed Hives / N/A
Competition	Dohzono et al. 2008_1	B. terrestris*	Bombus ardens, Bombus hypocrita	Asia (Japan)	presence/ absence	visitation rates	Abundance/Visitation	-	y	No Managed Hives	No Managed Hives / N/A
Plant Communities	Dohzono et al. 2008_2	B. terrestris*	Bombus ardens, Bombus hypocrita	Asia (Japan)	presence/absence	fruit set	Plant Reproduction	-	y	No Managed Hives	No Managed Hives / N/A
Pathogens	Dolezal et al. 2016	Apis mellifera*	many	North America (USA)	pathogen prevalence, viral load	pathogen prevalence	Pathogen Extent/Severity	-/0	n	Number/Size Unknown	?/?*

Category	Reference	Managed bee species (* indicates exotic range)	Native bee species	Location	Managed bee metric (independent variable)	Native bee/plant metric (dependent variable)	Native bee/plant metric category	Reported Overall effect	Control (y/n)	Managed Hive Information	Size Category
Competition	Esterio et al. 2013	B. terrestris*	B. dahlbomii	South America (Chile)	visitation rates, foraging behavior (number of pollen grains carried & deposited)	visitation rates	Abundance/Visitation	0	n	No Managed Hives	No Managed Hives / N/A
Plant communities	Faria & Araujo 2015	A. mellifera*	Augochloropsis spp.	South America (Brazil)	pollinator effectiveness (fruit set per visit)	fruit set	Plant Reproduction	+	y	No Managed Hives	No Managed Hives / N/A
Pathogens	Forsgren et al. 2015	A. mellifera*	Apis cerana	Asia (Vietnam & China)	pathogen prevalence	pathogen prevalence	Pathogen Extent/Severity	0	y	Number/Size Unknown	?/?*
Competition	Franco et al. 2009	A. mellifera*	Bombus atratus	South America (Brazil)	foraging behavior (plant use, diet breadth)	foraging behavior (plant use, diet breadth)	Foraging Behavior - Plant Use/Preference	-/0	n	No Managed Hives	No Managed Hives / N/A
Pathogens	Gilliam et al. 1994	A. mellifera*	Xylocopa californica arizonensis	North America (USA)	none	pathogen occurrence	Pathogen Extent/Severity	-	n	No Managed Hives	No Managed Hives / N/A
Plant communities	Gilpin et al. 2014	A. mellifera*	many	Australia	visitation rates, foraging behavior (inter & intra-plant movements, pollen diversity on body)	relative plant distribution	Plant Abundance/Distribution	+	n	No Managed Hives	No Managed Hives / N/A
Competition	Ginsberg 1983	A. mellifera*	many	North America (USA)	foraging behavior (plant preferences & foraging period)	foraging behavior (plant preferences & foraging period)	Foraging Behavior - Plant Use/Preference	-/0	n	No Managed Hives	No Managed Hives / N/A

Category	Reference	Managed bee species (* indicates exotic range)	Native bee species	Location	Managed bee metric (independent variable)	Native bee/plant metric (dependent variable)	Native bee/plant metric category	Reported Overall effect	Control (y/n)	Managed Hive Information	Size Category
Plant communities	Goulson & Rotheray 2012	A. mellifera*, B. terrestris*	many	Tasmania	visitation rates	population size	Plant Abundance/Distribution	-/0	n	No Managed Hives	No Managed Hives / N/A
Plant Communities	Goulson & Derwent 2004	A. mellifera*	many	Australia	abundance, visitation rates, presence/absence	fruit set	Plant Reproduction	-	y	No Managed Hives	No Managed Hives / N/A
Competition	Goulson et al. 2002	A. mellifera*, Bombus terrestris*	many	Australia	presence/ absence	abundance	Abundance/Visitation	-/0	n	No Managed Hives	No Managed Hives / N/A
Competition	Gross & Mackay 1998_1	A. mellifera*	many	Australia	visitation rates	visitation rates	Abundance/Visitation	-	n	Number Only	10-49 hives
Plant Communities	Gross & Mackay 1998_2	A. mellifera*	many	Australia	visitation rates	fruit set	Plant Reproduction	-	n	Number Only	10-49 hives
Competition	Gross 2001_1	A. mellifera*	many	Australia	abundance, visitation rates	abundance	Abundance/Visitation	-	n	No Managed Hives	No Managed Hives / N/A
Plant communities	Gross 2001_2	A. mellifera*	many	Australia	abundance, visitation rates, foraging behavior (handling time)	pollen limitation	Plant Reproduction	+	n	No Managed Hives	No Managed Hives / N/A

Category	Reference	Managed bee species (* indicates exotic range)	Native bee species	Location	Managed bee metric (independent variable)	Native bee/plant metric (dependent variable)	Native bee/plant metric category	Reported Overall effect	Control (y/n)	Managed Hive Information	Size Category
Plant Communities	Gross et al. 2010	A. mellifera*	many	Australia	visitation rates, abundance, presence/absence, foraging behavior (foraging time, number of probes per flower head, etc.)	abundance	Plant Abundance/Distribution	-	y	No Managed Hives	No Managed Hives / N/A
Plant communities	Hanna et al. 2013	A. mellifera*	many	Hawaii	visitation rates, presence/absence	fruit set	Plant Reproduction	+	n	No Managed Hives	No Managed Hives / N/A
Competition	Hingston & McQuilan 1998	B. terrestris*	many	Australia	foraging behavior (diet breadth)	foraging behavior (diet breadth)	Foraging Behavior - Plant Use/Preference	-	n	No Managed Hives	No Managed Hives / N/A
Competition	Hingston & McQuilan 1999	B. terrestris*	Chalicodoma spp.	Australia	presence/ absence	visitation rates	Abundance/Visitation	-	y	No Managed Hives	No Managed Hives / N/A
Pathogens	Hoffmann et al. 2008	A. mellifera*	B. impatiens	North America (USA)	parasite host preference & host shifting	parasite host preference & host shifting	Pathogens - Other	-	n	No Managed Hives	No Managed Hives / N/A
Competition	Horskins & Turner 1999	A. mellifera*	many	Australia	foraging behavior (temporal foraging patterns, stigma contact, nectar vs. pollen collecting trips)	foraging behavior (temporal foraging patterns, stigma contact, nectar vs. pollen collecting trips)	Foraging Behavior - Resource Collection	0	n	No Managed Hives	No Managed Hives / N/A

Category	Reference	Managed bee species (* indicates exotic range)	Native bee species	Location	Managed bee metric (independent variable)	Native bee/plant metric (dependent variable)	Native bee/plant metric category	Reported Overall effect	Control (y/n)	Managed Hive Information	Size Category
Competition	Inari et al. 2005	B. terrestris*	B. ardens	Asia (Japan)	abundance, distance from greenhouse	abundance	Abundance/Visitation	-	n	Number Only	100+ hives
Competition	Ings et al. 2006	B. terrestris dalmatinus*	B. terrestris audax	Europe (UK)	foraging behavior, visitation rates, production of new queens & males	foraging behavior	Foraging Behavior - Resource Collection	-	n	Number and Size	<10 hives
Competition	Inoue et al. 2010	B. terrestris*	Bombus ignitus	Asia (Japan)	foraging behavior (foraging load, foraging efficiency)	foraging behavior (foraging load, foraging efficiency)	Foraging Behavior - Resource Collection	-	n	Number and Size	<10 hives
Competition	Ishii et al. 2008	B. terrestris*	B. diversus tersatus, B. pseudobaicalensis, B. hypocrita sapporoensis	Asia (Japan)	habitat occupancy, foraging behavior (floral preferences)	habitat occupancy	Abundance/Visitation	-	n	No Managed Hives	No Managed Hives / N/A
Plant communities	Junker et al. 2010	A. mellifera*	Hylaeus spp.	Hawaii	presence/absence, visitation rates, foraging behavior (foraging trip duration, stigma contacts, resource collection)	fruit set	Plant Reproduction	+	n	No Managed Hives	No Managed Hives / N/A

Category	Reference	Managed bee species (* indicates exotic range)	Native bee species	Location	Managed bee metric (independent variable)	Native bee/plant metric (dependent variable)	Native bee/plant metric category	Reported Overall effect	Control (y/n)	Managed Hive Information	Size Category
Competition	Kato & Kawakita 2004	A. mellifera*	many	New Caledonia	foraging behavior (plant use)	foraging behavior (plant use)	Foraging Behavior - Plant Use/Preference	-	n	No Managed Hives	No Managed Hives / N/A
Competition	Kato et al. 1999	A. mellifera*	many	Bonin Islands	relative abundance	relative abundance	Abundance/Visitation	-	n	Number Only	<10 hives
Plant Communities	Kenta et al. 2007	Bombus terrestris*	Bombus spp.	Asia (Japan)	presence/absence	fruit set	Plant Reproduction	-	y	Number and Size	<10 hives
Pathogens	Kojima et al. 2011	A. mellifera*	A. cerana	Asia (Japan)	infection frequency	infection frequency	Pathogen Extent/Severity	-/0	n	Number/Size Unknown	?/?*
Pathogens	Levitt et al. 2013	A. mellifera*	many	North America (USA)	pathogen presence	pathogen presence	Pathogen Extent/Severity	-	n	Number/Size Unknown	?/?*
Pathogens	Li et al. 2011	A. mellifera*	Bombus huntii	North America (USA)	none	pathogen infectivity	Pathogen Extent/Severity	-	n	No Managed Hives	No Managed Hives / N/A
Plant Communities	Liu et al. 2006	A. mellifera*	many	North America (USA)	visitation rates	fruit set	Plant Reproduction	-	n	No Managed Hives	No Managed Hives / N/A
Plant Communities	Liu et al. 2013	A. mellifera*	many	Asia (China)	visitation rates	fruit set	Plant Reproduction	-	n	No Managed Hives	No Managed Hives / N/A
Plant communities	Lomov et al. 2010	A. mellifera*	many	Australia	presence/absence, visitation rates, foraging behavior (contact with stigma & anthers)	fruit set	Plant Reproduction	0	n	No Managed Hives	No Managed Hives / N/A
Plant communities	Madjidian et al. 2008	Bombus ruderatus*	Bombus dahlbomii	South America (Argentina)	visitation rates, foraging behavior (time spent per flower, pollen deposition)	seed set	Plant Reproduction	+	y	No Managed Hives	No Managed Hives / N/A

Category	Reference	Managed bee species (* indicates exotic range)	Native bee species	Location	Managed bee metric (independent variable)	Native bee/plant metric (dependent variable)	Native bee/plant metric category	Reported Overall effect	Control (y/n)	Managed Hive Information	Size Category
Pathogens	Maharramov et al. 2013	B. terrestris*, B. ruderatus*, A. mellifera*	B. dahlbomii	South America (Argentina)	genetic description of parasite	genetic description of parasite	Pathogens - Other	-	n	No Managed Hives	No Managed Hives / N/A
Competition	Morales et al. 2013	Bombus ruderatus*, B. terrestris*	B. dahlbomii	South America (Chile)	temporal trends in regional abundance, geographic distribution	temporal trends in regional abundance	Abundance/Visitation	-	n	No Managed Hives	No Managed Hives / N/A
Competition	Nagamitsu et al. 2007a	B. terrestris*	B. ardens, B. hypocrita	Asia (Japan)	presence/ absence	queen body mass, colony mass	Reproduction and Survival	0	y	Number and Size	<10 hives
Competition	Nagamitsu et al. 2007b	B. terrestris*	B. hypocrita, B. ardens, B. diversus	Asia (Japan)	abundance	abundance	Abundance/Visitation	0	n	No Managed Hives	No Managed Hives / N/A
Competition	Nagamitsu et al. 2010	B. terrestris*	B. ardens, B. hypocrita	Asia (Japan)	presence/ absence	abundance	Abundance/Visitation	-	y	No Managed Hives	No Managed Hives / N/A
Competition	Nakamura 2014	B. terrestris*	B. pseudobaicalensis, B. hypocrita sapporoensis	Asia (Japan)	visitation rates, foraging behavior (pollen type & diversity on body)	visitation rates	Abundance/Visitation	-/0	n	No Managed Hives	No Managed Hives / N/A
Competition	Nishikawa & Shimamura 2015	B. terrestris*	B. hypocrita, Bombus deuteronymus	Asia (Japan)	visitation rates	visitation rates	Abundance/Visitation	0	n	No Managed Hives	No Managed Hives / N/A
Competition	Paini & Roberts 2005	A. mellifera*	Hylaeus alcyoneus	Australia	presence/ absence	fecundity (number of nests, number of eggs per nest, progeny mass)	Reproduction and Survival	-	y	Number Only	100+ hives

Category	Reference	Managed bee species (* indicates exotic range)	Native bee species	Location	Managed bee metric (independent variable)	Native bee/plant metric (dependent variable)	Native bee/plant metric category	Reported Overall effect	Control (y/n)	Managed Hive Information	Size Category
Competition	Paini et al. 2005	A. mellifera*	Megachile spp.	Australia	presence/ absence	reproductive success	Reproduction and Survival	0	y	Number Only	<10 hives
Competition	Pedro & Camargo 1991	A. mellifera*	many	South America (Brazil)	relative abundance, foraging behavior (floral preference)	relative abundance	Abundance/Visitation	0	n	No Managed Hives	No Managed Hives / N/A
Pathogens	Peng et al. 2011	A. mellifera*	B. huntii	North America (USA)	none	pathogen infectivity	Pathogen Extent/Severity	-	n	No Managed Hives	No Managed Hives / N/A
Competition	Pick & Schlindwein 2011	A. mellifera*	Melitoma segmentaria, Melitoma osmioides, Melitomella murihir, Lithurgus huberi	South America (Brazil)	foraging behavior (floral preferences)	foraging behavior (floral preference)	Foraging Behavior - Plant Use/Preference	0	n	No Managed Hives	No Managed Hives / N/A
Competition	Pinkus-Rendon et al. 2005	A. mellifera*	Peponapis limitaris, Partamona bilineata	North America (Mexico)	visitation rates, foraging behavior (plant use)	visitation rates	Abundance/Visitation	-	n	Number/Size Unknown	?/?*
Competition	Pleasants 1981	A. mellifera*	Bombus spp.	North America (USA)	presence/ absence	abundance	Abundance/Visitation	-	y	No Managed Hives	No Managed Hives / N/A

Category	Reference	Managed bee species (* indicates exotic range)	Native bee species	Location	Managed bee metric (independent variable)	Native bee/plant metric (dependent variable)	Native bee/plant metric category	Reported Overall effect	Control (y/n)	Managed Hive Information	Size Category
Pathogens	Plischuk & Lange 2009	Bombus terrestris*	Bombus atratus, Bombus morio, Bombus bellicosus, Bombus opifex, Bombus. tucumanus	South America (Argentina)	pathogen prevalence	pathogen prevalence	Pathogen Extent/Severity	0	n	No Managed Hives	No Managed Hives / N/A
Plant communities	Richardson et al. 2016	A. mellifera*	many	North America (USA)	visitation rates, foraging behavior (number of floral visits per plant, plant preferences)	numbers of seed capsules, intact seeds, & total seeds	Plant Reproduction	+	n	No Managed Hives	No Managed Hives / N/A
Competition	Rogers et al. 2013	A. mellifera*	Bombus impatiens	North America (USA)	response to intra & interspecific physical encounters at flowers	response to intra & interspecific physical encounters at flowers	Direct Competition	-	y	Number and Size	<10 hives
Competition	Roubik & Villanueva-Gutierrez 2009	A. mellifera*	many	North America (Mexico)	presence/ absence, foraging behaviors (plant use)	abundance	Abundance/Visitation	0	n	No Managed Hives	No Managed Hives / N/A
Competition	Roubik & Wolda 2001	A. mellifera*	many	North America (Panama)	presence/ absence, abundance	abundance	Abundance/Visitation	0	n	No Managed Hives	No Managed Hives / N/A

Category	Reference	Managed bee species (* indicates exotic range)	Native bee species	Location	Managed bee metric (independent variable)	Native bee/plant metric (dependent variable)	Native bee/plant metric category	Reported Overall effect	Control (y/n)	Managed Hive Information	Size Category
Competition	Roubik 1978	A. mellifera*	many	South America (French Guiana)	presence/ absence	visitation rates	Abundance/Visitation	-/0	y	Number and Size	<10 hives
Competition	Roubik 1980	A. mellifera*	Melipona spp., Trigona spp.	South America (French Guiana)	visitation rates to feeders	visitation rates	Abundance/Visitation	-/0	n	Size Only	?/?*
Competition	Roubik 1983	A. mellifera*	Melipona favosa, Melipona fulva	South America (French Guiana)	presence/ absence, number of hives, amounts of brood, honey, & pollen in hive	amounts of brood, honey, & pollen in nest	Reproduction and Survival	0	y	Number and Size	10-49 hives
Competition	Roubik et al. 1986	A. mellifera*	many	North America (Panama)	rate of forager return, foraging behavior (type, quantity, & quality of pollen& nectar gathered)	rate of forager return	Foraging Behavior - Resource Collection	-/0	y	Number and Size	10-49 hives
Plant communities	Sanguinetti & Singer 2014	A. mellifera*, B. terrestris*, B. ruderatus*	many	South America (Argentina)	visitation rates, pollinator behavior (time per flower, number of flowers visited)	fruit set	Plant Reproduction	+	n	No Managed Hives	No Managed Hives / N/A
Competition	Schaffer et al 1983	A. mellifera*	many	North America (USA)	presence/ absence	visitation rates	Abundance/Visitation	-	y	Number and Size	<10 hives

Category	Reference	Managed bee species (* indicates exotic range)	Native bee species	Location	Managed bee metric (independent variable)	Native bee/plant metric (dependent variable)	Native bee/plant metric category	Reported Overall effect	Control (y/n)	Managed Hive Information	Size Category
Competition	Schaffer et al. 1979	A. mellifera*	Bombus sonorous, Xylocopa arizonensis	North America (USA)	visitation rates, foraging behavior (resource collection)	visitation rates	Abundance/Visitation	-	n	No Managed Hives	No Managed Hives / N/A
Plant Communities	Simpson et al. 2005	A. mellifera*	many	Australia	presence/absence, visitation rates, foraging behavior (flower tripping)	seed set	Plant Reproduction	-	y	No Managed Hives	No Managed Hives / N/A
Pathogens	Singh et al. 2010	A. mellifera*	many	North America (USA)	pathogen presence	pathogen presence	Pathogen Extent/Severity	-	y	Number Only	<10 hives
Competition	Smith-Ramirez et al. 2014	A. mellifera*, B. terrestris*	many	South America (Chile)	visitation rates	visitation rates	Abundance/Visitation	-	n	No Managed Hives	No Managed Hives / N/A
Plant Communities	Stout et al. 2002	A. mellifera*, B. terrestris*	many	Tasmania	visitation rates	seed set	Plant Reproduction	-	n	No Managed Hives	No Managed Hives / N/A
Competition	Sugden & Pyke 1991	A. mellifera*	Exoneura asimillima	Australia	presence/absence	colony survival, developmental stage & sex ratios, relative frequency of founder vs. established colonies	Reproduction and Survival	-	y	Number Only	10-49 hives

Category	Reference	Managed bee species (* indicates exotic range)	Native bee species	Location	Managed bee metric (independent variable)	Native bee/plant metric (dependent variable)	Native bee/plant metric category	Reported Overall effect	Control (y/n)	Managed Hive Information	Size Category
Plant communities	Sun et al. 2013a	A. mellifera*, B. terrestris*	many	Asia (China)	visitation rates, foraging behavior (resource collection, number of flower visits per foraging bout, pollen removal & deposition)	fruit set	Plant Reproduction	+	y	Number/Size Unknown	?/?*
Pathogens	Szabo et al. 2012	B. terrestris*	Bombus affinis, Bombus terricola, Bombus pensylvanic-us	North America	density of vegetable greenhouses	bee geographic range (historic/ current)	Pathogens - Other	-/0	n	No Managed Hives	No Managed Hives / N/A
Competition	Tepedino et al. 2007	A. mellifera*	many	North America (USA)	visitation rates, distance from hive	visitation rates	Abundance/Visitation	0	y	Number/Size Unknown	?/?*
Competition	Thomson 2004	A. mellifera*	B. occidentalis	North America (USA)	distance from hive	foraging behavior (pollen vs. nectar collection, forager return rates)	Foraging Behavior - Resource Collection	-	y	Number and Size	<10 hives
Competition	Thomson 2006	A. mellifera*	Bombus spp.	North America (USA)	foraging behavior (plant use), visitation rates, distance from hive	foraging behavior (plant use)	Foraging Behavior - Plant Use/Preference	-/0	y	Number and Size	<10 hives

Category	Reference	Managed bee species (* indicates exotic range)	Native bee species	Location	Managed bee metric (independent variable)	Native bee/plant metric (dependent variable)	Native bee/plant metric category	Reported Overall effect	Control (y/n)	Managed Hive Information	Size Category
Competition	Thomson 2016	A. mellifera*	Bombus spp.	North America (USA)	density	densities	Abundance/Visitation	-	n	No Managed Hives	No Managed Hives / N/A
Competition	Wilms & Weichers 1997	A. mellifera*	Melipona bicolor, Melipona quadrifasciata	South America (Brazil)	foraging behavior (types & amount of pollen & nectar collected)	foraging behavior (type/quantity or quality of pollen & nectar gathered)	Foraging Behavior - Resource Collection	-	n	Number Only	<10 hives
Plant communities	Xia et al. 2007	A. mellifera*, Apis cerana	Bombus richardsi, Bombus. atrocinctus	Asia (China)	presence/absence, abundance, visitation rate, foraging behaviors (intra- & inter-plant movement)	outcrossing rates	Plant Genetics	+	y	Number/Size Unknown	?/?*

Table A-2. Studies excluded from this summary

Category	Reference	Managed bee species	Native bee species	Location	Managed bee metric (independent variable)	Native bee metric (dependent variable)	Reported effect	Rationale for Exclusion
Competition	Abe et al. 2011	*Apis mellifera**	*Xylocopa Ogasawarensis* & endemic small bees	Asia (Japan)	honey bee presence/ absence and/or abundance	distribution	0	Not directly addressing competition between non-native and native bees, included only in Plant Communities for this summary rather than Competition as well (included in both categories by Mallinger et al., 2017).

Category	Reference	Managed bee species	Native bee species	Location	Managed bee metric (independent variable)	Native bee metric (dependent variable)	Reported effect	Rationale for Exclusion
Plant Communities	Aslan et al. 2016	*A. mellifera**	many	North America (USA)	visitation rates	none	+/0	No specific outcome measured
Competition	Balfour et al. 2013	*A.mellifera*	*Bombus terrestris/ lucorum*, *Bombus pascuorum*, *Bombus lapidarius*	Europe (UK)	visitation rates, foraging behavior (handling times, number of floral probes)	visitation rates, foraging behavior (handling time, number of floral probes)	0	Managed bee species native to study area
Competition	Balfour et al. 2015	*A.mellifera*	*Bombus* spp.	Europe (UK)	visitation rates, foraging behavior (search time, extraction time, etc.)	visitation rates, foraging behavior (search time, extraction time, etc.)	0	Managed bee species native to study area
Pathogens	Cameron et al. 2016	*Bombus* spp.	*Bombus* spp.	North America (USA)	before/after pathogen introduction from commercial colonies	pathogen prevalence, pathogen genetic variation	-	Managed bee species native to study area
Competition	Cane & Tepedino 2017	*A. mellifera**	many (average-sized solitary bees)	North America (USA)	amount of pollen collected per colony	amount of pollen needed to produce one offspring	-	Not reporting experimental impact of non-native bees, theoretical impact based on amount of resources honey bees use
Plant Communities	Cayuela et al. 2011	*A. mellifera*	none	Europe (Spain)	distance from apiary	fruit set	+/0	Managed bee species native to study area
Pathogens	Colla et al. 2006	Bombus impatiens	*Bombus* spp.	North America (Canada)	distance to commercial greenhouses	pathogen prevalence	-	Managed bee species native to study area
Plant Communities	Descamps et al. 2015	*A. mellifera*	many	Europe (France)	visitation rates	none	+	Managed bee species native to study area
Competition	Dupont et al. 2004	*A. mellifera**	*Anthophora alluaudi*, *Eucera gracilipes*	Canary Islands	abundance	visitation rates	-	Study location

Category	Reference	Managed bee species	Native bee species	Location	Managed bee metric (independent variable)	Native bee metric (dependent variable)	Reported effect	Rationale for Exclusion
Plant Communities	Dupont et al. 2004	*A. mellifera**	many	Canary Islands	abundance	seed set & viability	0	Study location
Competition	El Shafie et al. 2002	*Apis florea**	*A. mellifera sudanensis*	Africa (Sudan)	foraging behavior (types of pollen collected), visitation rates	foraging behavior (type of pollen collected), visitation rates	0	A. florea not a commonly used managed bee species
Competition	Elbgami et al. 2014	*A. mellifera**	*B. terrestris*	Europe (UK)	distance from apiary	individual bee weight & reproductive success	-	Managed bee species native to study area
Plant Communities	Esterio et al. 2013	*B. terrestris**	many	South America (Chile)	visitation rates, foraging behavior (pollen collection, pollen deposition)	none	0	No specific outcome measured
Plant Communities	Faria & Araujo 2016	*A. mellifera**	many	South America (Brazil)	visitation rates	none	+	No specific outcome measured
Competition	Forup & Memmot 2005	*A. mellifera*	*Bombus* spp.	Europe (UK)	abundance, foraging behavior (diet breadth)	abundance, diversity, foraging behavior (diet breadth)	-/0	Managed bee species native to study area
Pathogens	Fu¨ rst et al. 2014	*A. mellifera*	*Bombus* spp.	Europe (UK)	pathogen prevalence	pathogen susceptibility/ infectivity, pathogen prevalence	-	Managed bee species native to study area
Pathogens	Genersch et al. 2006	*A. mellifera*	*B. terrestris*, *Bombus pascuorum*	Europe (Germany)	presence	pathogen occurrence	-	Managed bee species native to study area
Competition	Goras et al. 2016	*A. mellifera*	many	Europe (Greece)	hive density	visitation rates, foraging behavior (visit duration)	0	Managed bee species native to study area

Category	Reference	Managed bee species	Native bee species	Location	Managed bee metric (independent variable)	Native bee metric (dependent variable)	Reported effect	Rationale for Exclusion
Competition	Goulson & Sparrow 2009	*A. mellifera*	*B. pascuorum, B. lucorum, B. lapidarius, B. terrestris*	Europe (UK)	presence/ absence	thorax width	-	Managed bee species native to study area
Pathogens	Graystock et al. 2013	*A. mellifera*	*Bombus* spp.	Europe (UK)	none	pathogen prevalence & infectivity	-	Managed bee species native to study area
Pathogens	Graystock et al. 2014	*Bombus* spp., *A. mellifera*	*Bombus* spp.	Europe (UK)	presence/ absence, distance from apiary	pathogen/ parasite prevalence & richness	-	Managed bee species native to study area
Competition	Herbertsson et al 2016	*A. mellifera*	*Bombus* spp.	Europe (Sweden)	presence/ absence	density	-/0	Managed bee species native to study area
Plant Communities	Hermansen et al. 2014	*A. mellifera**	many	Australia	visitation rates, foraging behavior (pollen load diversity, pollen removal & deposition)	none	+	No specific outcome measured
Plant Communities	Hingston 2005	*B. terrestris**	none	Australia	visitation rates, foraging behavior (floral preferences)	none	0	No specific outcome measured
Competition	Holmes 1964	*A. mellifera**	*Bombus* spp.	North America (USA)	visitation rates	visitation rates	-	Could not locate study
Plant Communities	Horskins & Turner 1999	*A. mellifera**	many	Australia	foraging behavior (temporal foraging patterns, stigma contact, nectar vs. pollen collection, pollen load diversity)	none	+	No specific outcome measured
Competition	Hudewenz & Klein 2013	*A. mellifera*	many	Europe (Germany)	distance to hive, presence/ absence	visitation rates, number of nests	-	Managed bee species native to study area

Category	Reference	Managed bee species	Native bee species	Location	Managed bee metric (independent variable)	Native bee metric (dependent variable)	Reported effect	Rationale for Exclusion
Competition	Hudewenz & Klein 2015	*A. mellifera*	*Osmia bicornis*	Europe (Germany)	abundance	number of nests & brood cells	-	Managed bee species native to study area
Competition	Inoue & Yokoyama 2010	*B. terrestris**	*B. hypocrita sapporoensis*, *Bombus schrencki albidopleuralis*, *Bombus pseudobaicalensis*, *Bombus diversus tersatus*	Asia (Japan)	foraging behavior (diet breadth), reproductive capacity, temporal changes in abundance	temporal changes in abundance, foraging behavior (diet breadth)	-	Not reporting experimental impact of non-native bees
Plant Communities	Kaiser-Bunbury & Muller 2009	*A. mellifera**	many	Mauritius	visitation rates	fruit set, seed set, fruit size & weight	+	Study location
Plant Communities	Kaiser-Bunbury et al. 2011	*A. mellifera**	many	Seychelles	visitation rates	plant reproductive success, fruit set	-/0	Study location
Competition	Kajobe 2007	*A. mellifera*	*Meliponula bocandei*, *Meliponula nebulata*	Africa (Uganda)	foraging behavior (diversity of pollen collected)	foraging behavior (diversity of pollen collected)	-/0	Managed bee species native to study area
Pathogens	Koch & Strange 2012	*Bombus* spp.	*Bombus occidentalis*, *Bombus moderatus*	North America (USA)	none	bee distribution & relative abundance, pathogen prevalence	0	Managed bee species native to study area
Competition	Kuhn et al. 2006	*A. mellifera*	*Megachile lapponica*	Europe (Germany)	density	visitation rates, foraging behavior (duration of foraging flights), brood cell construction	0	Managed bee species native to study area
Competition	Lindstrom et al. 2016	*A. mellifera*	many	Europe (Sweden)	presence/ absence, density	density	-	Managed bee species native to study area

Category	Reference	Managed bee species	Native bee species	Location	Managed bee metric (independent variable)	Native bee metric (dependent variable)	Reported effect	Rationale for Exclusion
Competition	Lye et al. 2011	*B. terrestris**	many	Scotland	presence/ absence	visitation rates	0	Study location
Competition	Martins 2004	*A. mellifera*	many	Africa (Kenya)	visitation rates, foraging behavior (temporal foraging patterns, plant use)	visitation rates, foraging behavior (temporal foraging patterns, plant use)	-	Managed bee species native to study area
Plant Communities	McGregor et al. 1959	*A. mellifera**	many	North America (USA)	visitation rates, foraging behavior	none	+/0	No specific outcome measured
Pathogens	McMahon et al. 2015	*A. mellifera*	*Bombus* spp.	Europe (UK)	abundance (estimated), pathogen prevalence, pathogen load	pathogen prevalence, pathogen load	-	Managed bee species native to study area
Competition	Menezes et al. 2007	A. mellifera*	Scaptotrigona spp.	South America (Brazil)	presence/ absence	visitation rates, foraging behavior (floral preference)	-	Could not find/access English version
Plant Communities	Miller et al. 2015	*A. mellifera**	*Hylaeus* spp.	Hawaii	visitation rates, foraging behavior (pollen quantity, type & diversity on body)	none	-	No specific outcome measured
Plant Communities	Montalva et al. 2011	*B. terrestris**, *B. ruderatus**	*B. dahlbomii*, *Bombus funebris*	South America (Chile)	distribution, foraging behavior (floral association)	distribution	-	Not reporting experimental impact of non-native bees, theoretical impact based on data (location, date, associated plant information) from specimens already collected or from entomological collections
Plant Communities	Morandin & Kremen 2013	*A. mellifera**	many	North America (USA)	abundance, foraging behavior (floral preference)	none	+/0	No specific outcome measured
Pathogens	Murray et al. 2013	*B. terrestris*	*Bombus* spp.	Europe (Ireland)	pathogen prevalence	pathogen prevalence	-	Managed bee species native to study area

Category	Reference	Managed bee species	Native bee species	Location	Managed bee metric (independent variable)	Native bee metric (dependent variable)	Reported effect	Rationale for Exclusion
Competition	Neumayer 2006	*A. mellifera*	many	Europe (Austria)	distance from hive, presence/ absence	visitation rates/ local abundance	-	Managed bee species native to study area
Competition	Nielsen et al. 2012	*A. mellifera*	many	Europe	visitation rates	visitation rates	-/0/+	Managed bee species native to study area
Pathogens	Niwa et al. 2004	B. terrestris*	Bombus hypocrita, Bombus diversus	Asia (Japan)	pathogen prevalence	pathogen infectivity	-	Could not find/access English version
Plant Communities	Ott et al. 2016	*A. mellifera**	*Bombus vosnesenskii*, *Xylocopa* spp.	North America (USA)	visitation rates, foraging behavior (handling time, contact with pollen/ stigma, nectar intake), body size	none	0	No specific outcome measured
Pathogens	Otterstater et al. 2008	*B. impatiens*	*Bombus* spp.	North America (Canada)	presence/ absence, distance from greenhouse	pathogen prevalence	-	Managed bee species native to study area
Pathogens	Plischuk et al. 2009	*A. mellifera**1	*B. atratus*, *B. morio*, *B. bellicosus*	South America (Argentina)	none	pathogen presence	-/0	Not reporting experimental impact of non-native bees, theoretical impact based on pathogen presence in 3 different bumblebee species.
Pathogens	Ravoet et al. 2014	*A. mellifera*	*Osmia* spp., *Andrena* spp., *Heriades truncorum*	Europe (Belgium)	pathogen presence	pathogen presence	-	Managed bee species native to study area
Competition	Semida & Elbanna 2006	*A. mellifera*	many	Africa (Egypt)	visitation rates	visitation rates	-/0	Managed bee species native to study area
Competition	Shavit et al. 2009	*A. mellifera*	many	Asia (Israel)	presence/ absence	foraging behavior (temporal foraging patterns, plant use), visitation rates	-/0	Managed bee species native to study area

Category	Reference	Managed bee species	Native bee species	Location	Managed bee metric (independent variable)	Native bee metric (dependent variable)	Reported effect	Rationale for Exclusion
Competition	Steffan-Dewenter & Tscharntke 2000	*A. mellifera*	many	Europe (Germany)	density, visitation rates	abundance, diversity, number of nests, number of brood cells, visitation rates	0	Managed bee species native to study area
Plant Communities	Sun et al. 2013b	*A. mellifera**	many	Asia (China)	presence/absence, visitation rate, foraging behavior (number of capitula visited per plant, pollen load diversity)	seed set	+/0	Not addressing impact of non-native bees directly, study focuses on the impact of increasing invasion of a non-native plant species on pollination services for two native plant species.
Plant Communities	Taylor & Whelan 1988	*A. mellifera**	many	Australia	visitation rate, foraging behavior (nectar vs. pollen collection, pollen deposition, pollen type & diversity)	none	-	No specific outcome measured
Competition	Torne-Noguera et al. 2016	*A. mellifera*	many	Europe (Spain)	distance to apiary, visitation rate	visitation rate, wild bee biomass	-	Managed bee species native to study area
Competition	Walther-Hellwig et al. 2006	*A. mellifera*	*Bombus* spp.	Europe (Germany)	density	visitation rates/ local abundance	-/0	Managed bee species native to study area
Pathogens	Whitehorn et al. 2013	*B. terrestris*, *B. terrestris audax*	*B. pascuorum*, *Bombus pratorum*, *Bombus lapidarius*	Europe (UK)	presence/ absence	pathogen prevalence & abundance	0	Managed bee species native to study area
Plant Communities	Woods et al. 2012	*A. mellifera**	many	North America (USA)	visitation rate, foraging behavior	none	-	No specific outcome measured

Appendix B – Explanation of Study Categorization and Reported Effect Ratings

Excerpts from Mallinger et al. (2017), p. 4-5:

“We searched for and synthesized papers that fell into three broad topical areas by which managed bees can affect wild bees: 1) competition for shared resources; 2) changes in plant community composition, specifically an increase in exotic plants and a subsequent decline in native plants, which is both a conservation concern in itself and has the potential to negatively affect native wild bees, and 3) the transmission of shared pathogens.”

“We additionally scored each article for whether the authors reported negative, positive, mixed, or no effects of managed bees. Consistent across all three topical areas, scores are from the perspective of native wild bees or native plants, where a negative score means that some measure of their performance decreases with managed bees, and a positive score means that performance improves with managed bees. Specifically, for competitive effects of managed bees on wild bees, “negative” (-) means that managed bees compete with wild bees and/or increased intra- or interspecific competition among wild bees, “no effect” (0) means that managed bees did not compete with wild bees and/or had no competitive effect on wild bees, and "mixed effects" means that responses varied across different wild bee species or different measures of competition. While we did not specifically search for studies examining mutualism or commensalism, a “positive” effect (+) in this area would include studies examining potential competitive effects but finding positive relationships between managed and wild bees (e.g., a positive correlation between abundances or visitation rates of managed and wild bees).

For the effects of managed bees on plant communities, “negative” (-) means that managed bees had a negative effect on native plants (e.g., decreased plant abundance) and/or a positive effect on exotic plants (e.g., increased plant abundance), “positive” (+) means that managed bees had a positive effect on native plants and/or a negative effect on exotic plants, “no effect” (0) means that managed bees had no effect on plant communities, and “mixed effects” means that responses varied by plant species or across different plant variables measured. Increases in native plants and/or decreases in exotic plants was considered to be a positive response because restoring native plant communities, a common bee conservation goal, is often associated with increases in native wild bees.

For evaluating the potential effects of managed bees on wild bees via pathogens, “negative” (-) means that managed bees increased pathogen occurrence in wild bees or that managed bee pathogens had a negative effect on wild bees including on fitness, abundance, diversity, etc., “no effect” (0) means that managed bees had no effect on the occurrence of pathogens in wild bees, or that managed bee pathogens had no effect on wild bees, and “mixed effects” means that effects varied across wild bee species, pathogens, or response variables examined. As it is unlikely that managed bees could have a positive effect on wild bees in this area (e.g., decrease pathogen occurrence), and pathogens by definition do not have a positive effect on their host, there were no positive effects found in this category.”

Appendix C - Definitions of Subcategories, All Outcomes by Reported Effect

Competition Subcategories

Abundance/Visitation – measures of how many bees of a given species are present / how often bees of a given species are visiting plants
Direct Competition – physical interactions between bee species at flowers
Foraging Behavior - Plant Use/Preference – measures of which, how many, or the diversity of plant species bees are using
Foraging Behavior - Pollinator Efficiency/Effectiveness – measures of how successfully bee species transfer pollen from one plant to another of the same species
Foraging Behavior - Resource Collection – measures of amounts of resources collected or frequency of resource collection by bee species
Foraging Behavior - Time/Duration – measures of how long bee species visit flowers or spend foraging
Population Level Measures – measures of broader information on a bee species such as range/distribution or diversity of species present
Reproduction and Survival – measures related to reproduction of a bee species such as number of nests and young or size of young

Pathogens Subcategories

Pathogen Extent/Severity – measures of how widespread a bee pathogen is / the severity of a pathogen's effects on bee species
Pathogens – Other – catch-all subcategory for other specific outcomes that cannot be easily grouped

Plant Communities Subcategories

Plant Abundance/Distribution – measures of how many plants of a given species are present / distribution of a given plant species
Plant Genetics – measures related to genetic exchange between plants of the same species
Plant Reproduction – measures related to how successfully a plant species is reproducing such as seed set or fruit set

Table C-1. Outcome Measurements by Reported Effect

Competition					
Native Bee/Plant Outcome Subcategory	**Native Bee/Plant Outcome**	**-**	**0**	**+**	**Total**
Abundance/Visitation	abundance	6 (67%)	3 (33%)		9 (100%)
	densities	1 (100%)			1 (100%)
	habitat occupancy	1 (100%)			1 (100%)
	relative abundance	1 (50%)	1 (50%)		2 (100%)
	temporal trends in regional abundance	1 (100%)			1 (100%)
	visitation rates	15 (65%)	8 (35%)		23 (100%)
	Abundance/Visitation Total	**25 (68%)**	**12 (32%)**		**37 (100%)**
Direct Competition	response to intra & interspecific physical encounters at flowers	1 (100%)			1 (100%)
	foraging behavior (diet breadth)	1 (100%)			1 (100%)

Foraging Behavior - Plant Use/Preference	foraging behavior (floral preference)	1 (25%)	3 (75%)		4 (100%)
	foraging behavior (floral preferences, nectar removal)		1 (100%)		1 (100%)
	foraging behavior (plant preferences & foraging period)	1 (50%)	1 (50%)		2 (100%)
	foraging behavior (plant use, diet breadth)	1 (50%)	1 (50%)		2 (100%)
	foraging behavior (plant use)	2 (67%)	1 (33%)		3 (100%)
	foraging behavior (pollen type & diversity)		2 (100%)		2 (100%)
	Foraging Behavior - Plant Use/Preference Total	**6 (40%)**	**9 (60%)**		**15 (100%)**
Foraging Behavior - Pollinator Efficiency/Effectiveness	foraging behavior (number of pollen grains carried & deposited)		1 (100%)		1 (100%)
Foraging Behavior - Resource Collection	foraging behavior	1 (100%)			1 (100%)
	foraging behavior (foraging load, foraging efficiency)	1 (100%)			1 (100%)
	foraging behavior (pollen vs. nectar collection, forager return rates)	1 (100%)			1 (100%)
	foraging behavior (resource collection)	1 (100%)			1 (100%)
	foraging behavior (temporal foraging patterns, stigma contact, nectar vs. pollen collecting trips)		1 (100%)		1 (100%)
	foraging behavior (type/quantity or quality of pollen & nectar gathered)	1 (50%)	1 (50%)		2 (100%)
	rate of forager return	1 (50%)	1 (50%)		2 (100%)
	Foraging Behavior - Resource Collection Total	**6 (67%)**	**3 (33%)**		**9 (100%)**
Foraging Behavior - Time/Duration	foraging behavior (duration of floral visits)	1 (100%)			1 (100%)
	foraging behavior (foraging time)	1 (100%)			1 (100%)
	Foraging Behavior - Time/Duration Total	**2 (100%)**			**2 (100%)**
Population Level Measures	diversity	1 (50%)	1 (50%)		2 (100%)
	geographic distribution	1 (100%)			1 (100%)
	Population Level Measures Total	**2 (67%)**	**1 (33%)**		**3 (100%)**
Reproduction and Survival	amounts of brood, honey, & pollen in nest		1 (100%)		1 (100%)
	body size	1 (50%)	1 (50%)		2 (100%)
	colony survival, developmental stage & sex ratios, relative frequency of founder vs. established colonies	1 (100%)			1 (100%)
	fecundity (number of nests, number of eggs per nest, progeny mass)	1 (100%)			1 (100%)

		-	0	+	Total
	production of new queens & males	1 (100%)			1 (100%)
	queen body mass, colony mass		1 (100%)		1 (100%)
	reproductive success	1 (50%)	1 (50%)		2 (100%)
	Reproduction and Survival Total	**5 (56%)**	**4 (44%)**		**9 (100%)**
Competition Total		**47 (61%)**	**30 (39%)**		**77 (100%)**

Pathogens					
Native Bee/Plant Outcome Subcategory	**Native Bee/Plant Outcome**	**-**	**0**	**+**	**Total**
Pathogen Extent/Severity	infection frequency	1 (50%)	1 (50%)		2 (100%)
	parasite presence/ absence	1 (100%)			1 (100%)
	pathogen infectivity	2 (100%)			2 (100%)
	pathogen load		1 (100%)		1 (100%)
	pathogen occurrence	1 (100%)			1 (100%)
	pathogen presence	2 (100%)			2 (100%)
	pathogen prevalence	1 (33%)	2 (67%)		3 (100%)
	Pathogen Extent/Severity Total	**8 (67%)**	**4 (33%)**		**12 (100%)**
Pathogens - Other	bee defense behavior	1 (100%)			1 (100%)
	bee geographic range (historic/ current)	1 (50%)	1 (50%)		2 (100%)
	genetic description of parasite	1 (100%)			1 (100%)
	lethality to bees		1 (100%)		1 (100%)
	parasite host preference & host shifting	1 (100%)			1 (100%)
	Pathogens - Other Total	**4 (67%)**	**2 (33%)**		**6 (100%)**
Pathogens Total		12 (67%)	6 (33%)		18 (100%)

Plant Communities					
Native Bee/Plant Outcome Subcategory	**Native Bee/Plant Outcome**	**-**	**0**	**+**	**Total**
Plant Abundance/Distribution	abundance	1 (100%)			1 (100%)
	population size	1 (100%)			1 (100%)
	relative plant distribution			1 (100%)	1 (100%)
	Plant Abundance/Distribution Total	**2 (67%)**		**1 (33%)**	**3 (100%)**
Plant Genetics	gene flow			1 (100%)	1 (100%)
	genetic diversity			1 (100%)	1 (100%)
	outcrossing rates			1 (100%)	1 (100%)
	Plant Genetics Total			**3 (100%)**	**3 (100%)**
Plant Reproduction	floral abortion	1 (100%)			1 (100%)
	fruit quality	1 (100%)			1 (100%)
	fruit set	9 (53%)	1 (6%)	7 (41%)	17 (100%)
	fruit size	1 (100%)			1 (100%)
	germination success	1 (100%)			1 (100%)
	number of ovules fertilized per flower	1 (100%)			1 (100%)

	numbers of seed capsules, intact seeds, & total seeds			1 (100%)	1 (100%)
	pollen limitation			1 (100%)	1 (100%)
	seed set	9 (50%)	3 (17%)	6 (33%)	18 (100%)
	Plant Reproduction Total	**23 (55%)**	**4 (10%)**	**15 (36%)**	**42 (100%)**
Plant Communities Total		**25 (52%)**	**4 (8%)**	**19 (40%)**	**48 (100%)**
Grand Total		**84 (59%)**	**40 (28%)**	**19 (13%)**	**143 (100%)**

Appendix D – Honey Bee Apiary Permits on the Colorado Plateau (Active Spring 2018 – 2020)

Agency	State	Forest/District Office	Ranger District/Field Office	Permit date issued	Permit Expiration Date	Permit period allowed	Number of sites/hives	Total Hives
Forest Service	AZ	Tonto	Mesa	6/25/2013	4/22/2018	5 years (2013-2018)	2 sites, 120 hives total	120
Forest Service	AZ	Tonto	Globe, Mesa	5/15/2017	6/30/2018	1 year	6 sites x 20 hives	120
Forest Service	UT	Manti-La Sal	Ferron (2 sites) & Sanpete (1 site)	7/1/2019	12/31/2019	Doesn't specify, but based on expiration date seems to be year of 2019	3 sites x 20 hives	60
Forest Service	AZ	Tonto	Mesa	3/27/2019	3/16/2020	1 year	2 sites x 40 hives	80
Forest Service	AZ	Tonto	Mesa	5/2/2019	5/9/2020	1 year	1 site w 16 hives max	16
Forest Service	AZ	Kaibab	Williams	6/29/2015	12/31/2020	5 years (2015-2020)	6 colonies	6
Forest Service	AZ	Apache-Sitgreaves	Alpine	8/21/2019	12/31/2021	3 years	4 sites x 112 hives	448
Forest Service	UT	Uinta-Wasatch-Cache	Ogden and Logan	4/7/2014	12/31/2023	10 years (2014-2023)	8 sites x unspecified # of bees	Unknown
Forest Service	UT	Uinta-Wasatch-Cache	Heber (3 sites) & Evanston (1 site)	5/20/2015	12/31/2024	10 years (2015-2024)	4 sites x 96 hives	384

Bureau of Land Management	AZ	Phoenix	Hassayampa	9/19/2016	9/19/2019	3 years, renewable (2016-2019)	9 sites x up to 100 hives per site	900
Bureau of Land Management	CO	Southwest	Uncompahgre	5/8/2018	12/31/2020	3 years, renewable (2018-2020)	2 sites x 56 hives per site	112
Bureau of Land Management	AZ	Phoenix	Hassayampa	7/6/2018	7/6/2021	3 years, renewable (2018-2021)	5 sites x up to 100 hives per site	500
Bureau of Land Management	AZ	Phoenix	Hassayampa	9/5/2019	9/5/2021	3 years, renewable (2019-2021)	8 sites x up to 100 hives per site	800
Bureau of Land Management	AZ	Phoenix	Hassayampa	10/2/2018	10/1/2021	3 years, renewable (2018-2021)	3 sites x up to 100 hives per site	300
Bureau of Land Management	UT	West Desert	Fillmore	3/13/2019	12/31/2021	3 years, renewable (2019-2021)	1 site of 2.73 acres, unknown # of hives	Unknown

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