Ensuring pollinator health and resilience in natural areas:

A syntheses of the pollinator management symposium at the 17th annual NAA meeting.

Natural Areas Association, US Forest Service, Pollinator Partnership

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How do we manage for pollinators in natural areas?

- When natural areas are managed, restored, or otherwise used our goals as land managers remain the same; to protect, promote, and even enhance these resource-rich landscapes.
- Pollinators are directly responsible for the reproduction of between 67% to 96% of flowering plants globally

2017 annual meeting of the Natural Areas Association

- A special pollinator symposium was held, curated by William Carromero of the US FS and Lisa Smith of the Natural Areas Association.

- New research, management and restoration practices, and BMPs for pollinators in specific landscape scenarios were presented.

Session Topics

- Ungulate grazing and pollinators
- Alpine forest management, assessment of pollinators
- Restoring prairies
- Guidance for bee pasture on natural lands
- Monarch butterfly management
- Rangeland management

- A forthcoming synthesis paper will appear in the NAJ
- For those not present at the annual meeting here is a light synthesis of the Pollinator Symposium

BIOLOGICAL DIVERSITY OF POLLINATORS IN A HIGH ELEVATION SPRUCE FOREST, presented by Seth Davis

1) What is the wild bee fauna present in high elevation spruce forest of Colorado?

2) Does composition of the wild bee community vary during the growing season?

3) Is bee diversity related to forest structure or composition?

4) Is there a spatial structure underlying the distribution of bee diversity at the site scale?

BIOLOGICAL DIVERSITY OF POLLINATORS IN A HIGH ELEVATION SPRUCE FOREST, presented by Seth Davis

What is the wild bee fauna present in high elevation spruce forest of Colorado?

- -Approximately 45 species/morphospecies identified
- -Community predominated by several *Bombus* spp. and an unidentified *Osmia* sp.

How does the wild bee community composition vary throughout the growing season?

- \- Observable community shift across growing season, with evidence for 'shoulder season' and 'high season' differences

Is bee species diversity correlated with forest structure or composition?

- \- Structure: fewer and less diverse bees captured in areas with high basal area.
- \- Structure: highest diversity when basal area less than $7.5 m^2/ha$
- \- Composition: weak positive correlations between understory (forb/grass) richness and bee richness/diversity at fine spatial scales

Is there a spatial structure underlying the distribution of bee diversity at the site scale?

- \- Diversity index exhibits clumped pattern (20-40 m); clumps spaced ~400 m

Ungulate grazing and pollinators, presented by Mary Rowland

- Elk, cattle, and pollinators may have dietary overlap, but what does this network look like?
- The interaction between native pollinators and large herbivores is not well-studied
- Grazing effects can vary greatly by taxa, space, and time
- Both groups provide key ecosystem services

Ungulate grazing and pollinators, presented by Mary Rowland

Findings

- Realized effects of large mammal herbivory on bees will depend on not only location and timing but also:
  - Animal dietary preferences
  - Relative abundance of other flowers and forage
- Ungulate space use driven by many factors that differ across the biological year: e.g., elk respond to human disturbance, cattle, and phenology
- Scale of habitat selection by elk will ultimately influence local effects on floral resources
- Get the full story in this webinar series

Restoration and management of prairie habitats to support pollinating insects, presented by Thomas Kaye

- Restoring prairies has been a priority and our understanding of this practice has improved recently
- Specific use of restoration techniques for pollinators is a logical next step
- A restoration ecologist’s tool kit includes a series of standard components, this study provides more context for pollinator promotion

Restoration and management of prairie habitats to support pollinating insects, presented by Thomas Kaye

- Restoration practices and literature relevant to conducting restoration in support of pollinators provides us with the following key points that may be considered BMPs at this point in time:
  - 1. include a diversity of plant species;
  - 2. ensure the availability of substrates for nesting; and
  - 3. promote connectivity and adjacent habitats.

Thomas will be presenting in the next NAA webinar

BMPs for Western Monarch Management and Rangeland Management, presented by Scott Hoffman Black

- Two BMP guides for land managers in the west have been developed by the Xerces Society, with a release date of Spring 2018
- Managing Western Monarchs provides BMPs and conservation guidance for the unique needs of the Western Monarch butterfly migration
- BMPs for rangelands provides management and guidance in all scenarios encountered on range lands in the west (grazing, restoration seedings, burns, road and right-of-way management).

- Check out their presentation in this webinar series

Competition and interactions between managed honey bees and native bees in North America, presented by Vicki Wojcik

- An examination of resource competition between managed honey bees and wild bees
- There are many opinions, but what does the research tell us and can we support management decisions?

- The topic of our next webinar.

Competition and interactions between managed honey bees and native bees in North America

Victoria Wojcik, Lora Morandin, Laurie Davies Adams, Kelly Rourke, Beatriz Moisset
Pollinator Partnership

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The management challenge: *maintaining honey bee productivity and sustaining native bees*

- Native bees within the United States:
  - 4000+ species
  - Spatiotemporal patterns of occurrence
  - Key pollinators of wildland flowering plants
  - Some managed for pollination: *Bombus impatiens, Bombus terrestris, Bombus huntii, Osmia lignaria, Megachile rotundata, Nomia melanderi*
  - Status of most unknown, trends in population declines noted;
  - Some species listed (*Bombus affinis*)






Beekeepers like pasturing bees on natural landscapes

- Abundant, diverse food.
- Little or no chemical inputs.
- Few alternatives.
- Overcrowding on pasture lands.

Honey bees on natural lands

- Forest lands
- Park Service lands
- State public lands
- Land trusts
- Utility corridors
- Industrial lands

Policy and Practice

- Site-specific contracts/agreements
- Mandates to allow access to public lands (CA regulation)

- Beekeepers being denied access:
  - Non-renewal of contracts/agreements
  - Disruption of access
  - Pasture without access agreement

- When the answer is 'no':
  - Won't promote/allow non-native species
  - Precautionary approach
  - Suggestion that there is evidence for honey bees causing harm through competition
- Access without permission does occur.

Finding a balance

- Maintaining and improving honey bee health, while not causing detrimental effects to vulnerable native bee populations is crucial for biodiversity preservation and the future of sustainable food production.

- Actions based on evidence is ideal.

Examining Evidence of Competition: A difficult task

- Difficult to conduct a realistic, controlled study.
- Diversity of native bees suggests diversity of responses.
- Many studies extrapolate impacts of competition from patterns in occurrence data.
- *Foraging data do not universally correlate with survival and productivity.* (Thomson 2004; Goulson and Sparrow 2009)

Research Review Goals

1. Assemble experimental papers on honey bee and native bee competition;

2. Present outcomes of studies categorically;

3. Provide evidence-based recommendations for management if there is sufficient data;

4. Highlight gaps in knowledge.

Interference and Exploitative Competition in Bees

- Interference = directly preventing access to floral resources (physical contact)
- Exploitative = depleting floral resources
- Examples of both in bee interactions, but exploitative more common.

A competitive advantage?

- Managed agricultural species can have a competitive advantage.
  - protection from humans against diseases and weather
  - access to high-value locations with abundant resources

Photo credit: UGA CAES

Where is the highest likelihood of competition?

Two theories:

- **oligolectic** or **mesolectic** bees (the majority of native solitary bees).
  - narrow niche space, less able to shift to feed on other plants

- generalist, **polylectic** feeders, like bumble bees
  - most resource overlap with honey bees
  - *Bombus* with medium tongue length

Literature Search and Evaluation

- Database, Google, works cited review, and peer solicitation.
- 78 published papers using our search criteria
  - 13 prior reviews of bee competition
- Screening for either manipulative experiments or paired field observations
  - 19 research papers (13 directed experiments, 6 paired landscape observations)

Coding the results

- Inconclusive – statistical power was low and definitive conclusions limited or absent.
- No competition – no evidence of reduced reproduction or floral visits to either honey or wild bees.
- Exploitative competition – honey bee favored; wild bees on flowers decrease in the presence of honey bees and/or negative reproductive impacts to wild bees.
- Exploitative competition – wild bee favored; the occurrence of honey bees at flowers decreases in the presence of wild bees and/or negative reproductive impacts to honey bees.

Results of studies

- 10 indicating no response or inconclusive
    - One of these examined reproductive outputs
- 9 indicating exploitative competition with negative outcome for native bees
    - 5 of these studies examined reproductive outputs
- Limited studies overall; limited studies from US – only 4, 2 show competition.
    - Only costal chaparral and *Bombus occidentalis* assessed in natural lands within the US.
- Evidence for competition within native range of honey bees indicates nativity is not a factor, life history is.

Findings - Bombus

No response with HB		Negative response to HB	
Schaffer et al. 1983*	*Bombus* sp.	Thomson 2004	*Bombus occidentalis*
Thomson 2006	*Bombus caliginosus* *Bombus vosesenskii* *Bombus edwardsi* *Bombus californicus* *Bombus occidentalis*	Rogers et al. 2013	*Bombus impatiens*
Forup and Memmott 2005	*Bombus lucorum* *Bombus terrestris*	Goulson and Sparrow 2009	*Bombus pascuorum* *Bombus lucorum* *Bombus lapidarius* *Bombus terrestris*
Walther-Hellwig et al. 2006	*Bombus terrestris* *Bombus lucorum* *Bombus crypptarum* *Bombus soroeensis* *Bombus parcuorum* *Bombus sylvarum* *Bombus mascorum*	Elbgami et al. 2014	*Bombus terrestris audax*
Torne-Noguera et al. 2016*	*Bombus terrestris*	Herbertsson et al. 2016	*Bombus* spp.
		Lindstrom et al. 2016*	*Bombus* spp.

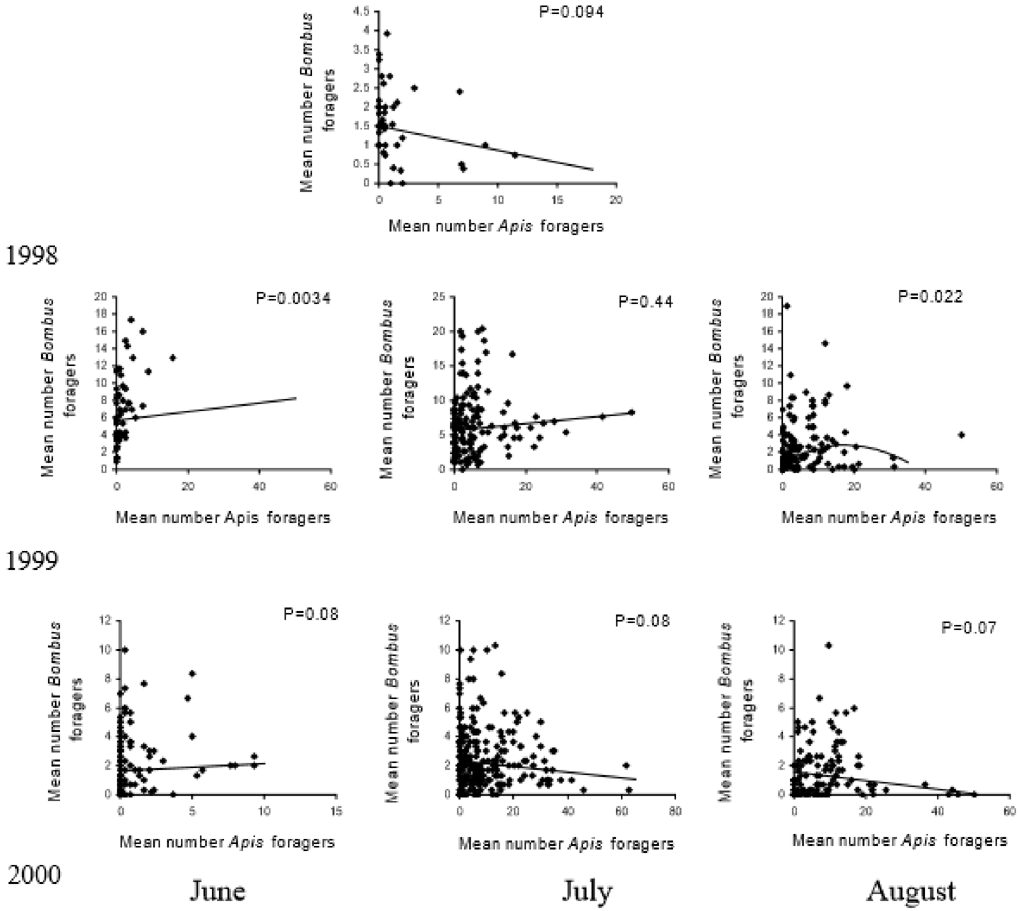
* Study examined both Bombus and other native bees

Findings – other native

No response with HB		Negative response with HB	
Schaffer et al. 1983*	*Xylocopa* sp.	Paini and Roberts 2006	*Hylaeus alcyoneus*
Sugden and Pyke 1991	*Exoneura asimillima*	Gross 2001	*Leioproctus* sp. *Lasioglossum* sp.
Goulson et al. 2002	native bee community	Hudewenz and Klein 2013	*Osmia bicornis*
Steffan-Dewenter and Tscharntke 2000	native bee community	Lindstrom et al. 2016*	native solitary community
Hudewenz and Klein 2013	*Andrena fuscipes* *Colletes succinctus* *Epeolus cruciger* *Sphecodes reticulantus* (clepto parasite)		
Shavit et al. 2013	native bee community		
Torne-Noguera et al. 2016*	native bee community		

* Study examined both Bombus and other native bees

No competition – Thomson 2006



Correlations between numbers of *Apis* foragers and numbers of *Bombus* foragers highly variable, significant negative relationship in only one of the seven months observed.

No competition – Shavit et al. 2013

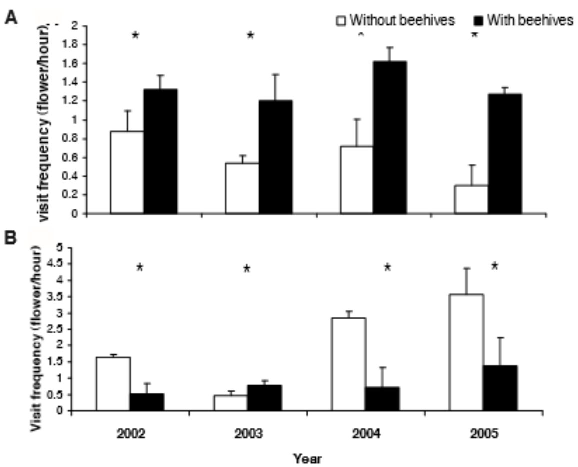
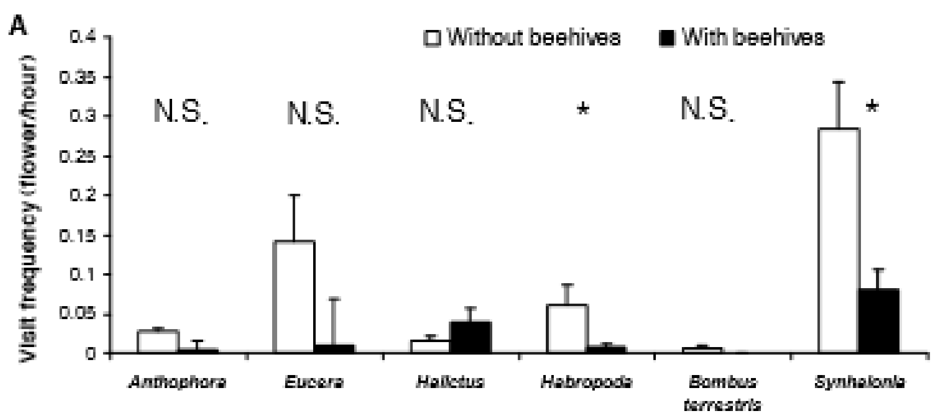


Fig. 2. Average visitation frequencies (per flower per hour) to flowers of all focal plants by honeybees (A) and native bees (B) in the presence of honeybee hives and in their absence during all study years. The vertical bar indicates one SE, and *, a significant difference (Wilcoxon signed rank tests, $p < 0.05$). 2002: N = 30; 2003: N = 54; 2004: N = 41, 2005: N = 66.



- Introduction of honeybee hives decreased average visitation frequency of native bees, however, examination of the effects on specific native bees on each of the focal flowering plants reveals an ambiguous picture.

No competition – Goulson et al. 2001

Table 2. Results of analysis of variance and Pearson product-moment correlations for hand search data on richness (no. species), diversity and abundance (number of individuals) of flower-visiting insects according to the presence or absence of bumblebees and honeybees, abundance of bumblebees and honeybees, and according to habitat type.

Explanatory factor	Species Richness	Diversity	Abundance
Bumblebee presence	$F_{1,57} = 0.021$, $p = 0.89$	$F_{1,57} = 0.783$, $p = 0.38$	$F_{1,57} = 0.000$, $p = 0.99$
Bumblebee abundance	$r = -0.145$, $p = 0.24$	$r = -0.169$, $p = 0.17$	$r = -0.114$, $p = 0.36$
Honeybee presence	$F_{1,57} = 0.047$, $p = 0.83$	$F_{1,57} = 2.22$, $p = 0.14$	$F_{1,65} = 0.016$, $p = 0.90$
Honeybee abundance	$r = -0.051$, $p = 0.68$	$r = 0.118$, $p = 0.34$	$r = 0.309$, $p = 0.011$
Habitat	$F_{2,57} = 2.85$, $p = 0.07$	$F_{2,64} = 4.44$, $p = 0.016$	$F_{2,64} = 0.12$, $p = 0.88$

Table 4. Results of analyses of richness (no. species), diversity and abundance (number of individuals) of native bees according to the presence or absence of bumblebees and honeybees, abundance of bumblebees and honeybees, and according to habitat type.

Explanatory factor	Species Richness	Diversity	Abundance
Bumblebee presence	$U = 520$, $p = 0.79$	$F_{1,58} = 0.132$, $p = 0.72$	$F_{1,58} = 0.16$, $p = 0.69$
Bumblebee abundance	$Rho = -0.027$, $p = 0.83$	$r = -0.048$, $p = 0.70$	$R = -0.176$, $p = 0.16$
Honeybee presence	$U = 142$, $p = 0.17$	$F_{1,58} = 0.090$, $p = 0.77$	$F_{1,58} = 21.3$, $p < 0.001$
Honeybee abundance	$Rho = 0.054$, $p = 0.67$	$r = 0.092$, $p = 0.46$	$R = 0.135$, $p = 0.28$
Habitat	$\chi^2_2 = 5.27$, $p = 0.72$	$F_{2,58} = 0.891$, $p = 0.42$	$F_{2,58} = 0.099$, $p = 0.91$

- Considerable niche overlap between honeybees, bumblebees and native. Sites where bumblebees were established had similar species richness, diversity and abundance of native flower-visiting insects compared to sites where bumblebees were absent. In contrast, native bees were over three times more abundant at the few sites where honeybees were absent, compared to those where they were present.

No competition – Forup and Memmott 2005

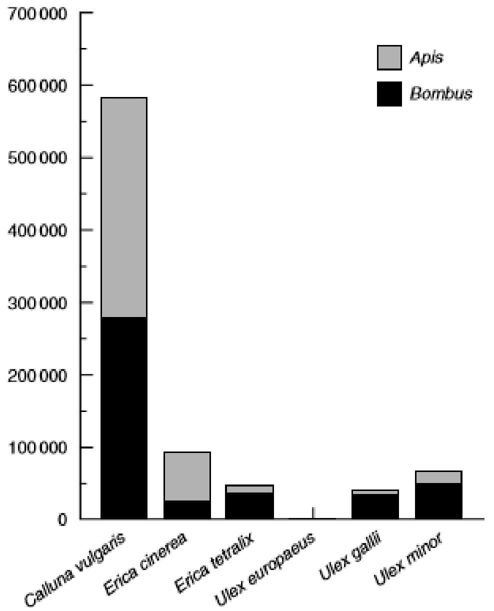
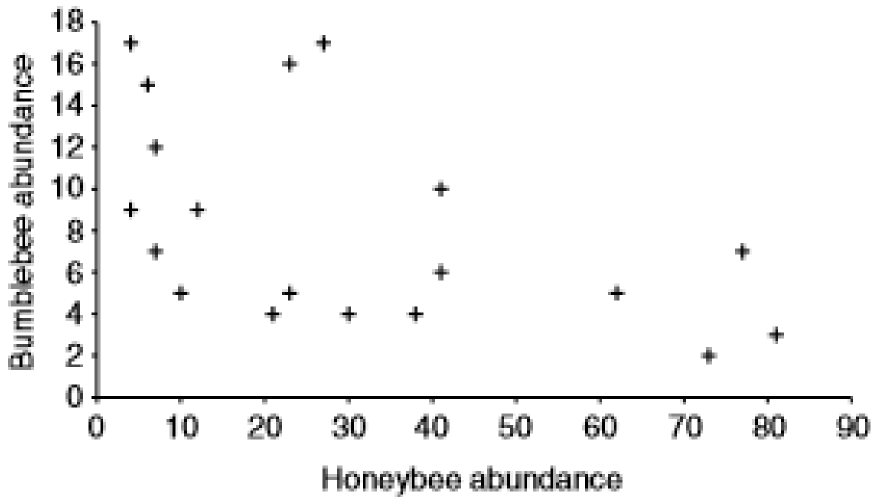
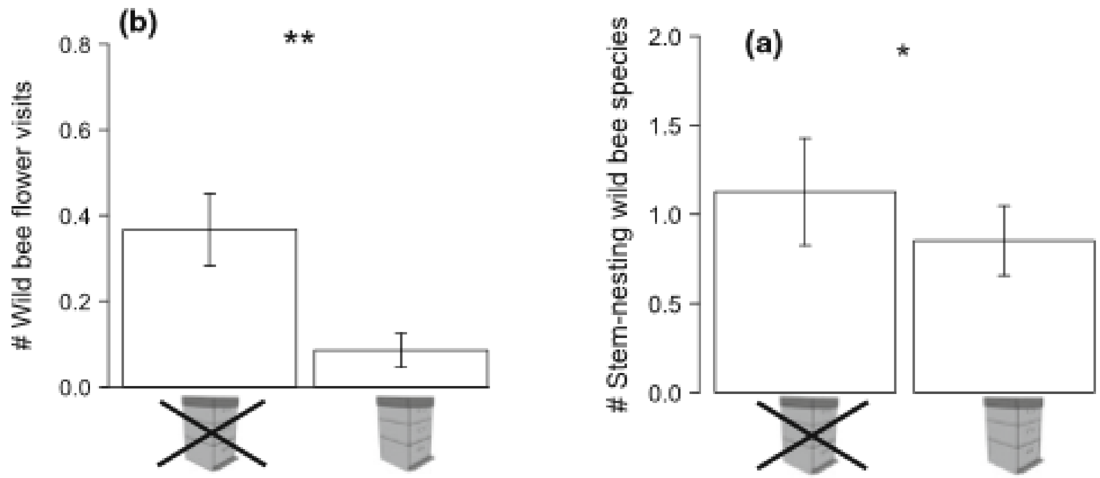


Fig. 7. The quantity of pollen obtained from the coats of bumblebees and honeybees sampled on eight occasions in 2001.



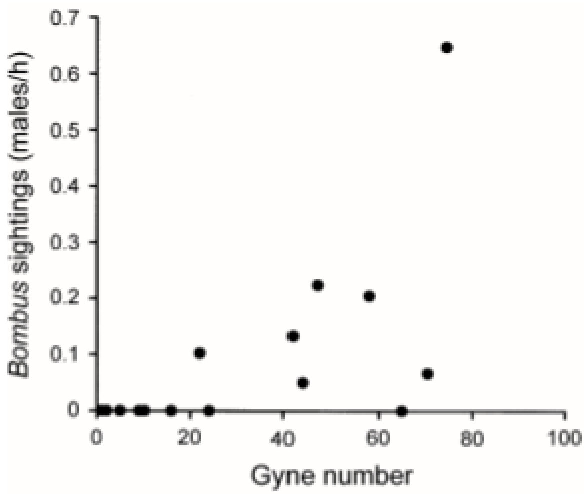
- Niche overlap, but not much clear indication that presence of honey bees drives declines in bumble bees. Likely a more complex trend than can be seen with presence/absence data.

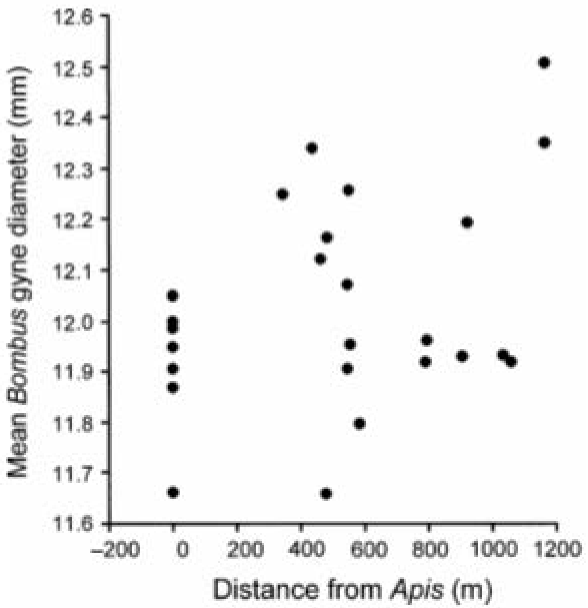
No competition – Hudewenz and Klein 2015



- Wild bees visit fewer flowers when honey bees are present. Fewer stem-nesting bee species with honey bees present. The reproductive success, measured as number of nests, was not affected by distance to honey-bee hives or their presence but by availability and characteristics of nesting resources.

Competition - Thomson 2004





- *B. occidentalis* colonies located near experimentally introduced *Apis* hives had lower mean rates of forager return and a lower ratio of foraging trips for pollen relative to nectar. Both male and female reproductive success of *B. occidentalis* were also reduced with greater proximity to introduced *Apis* hives.

Competition - Rogers et al. 2013

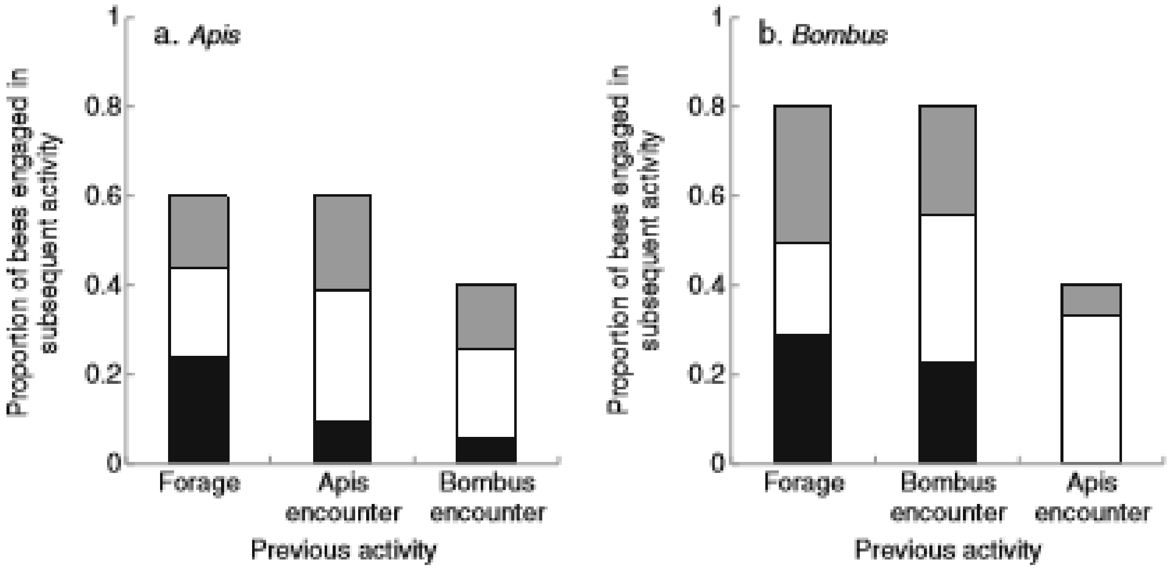


Figure 2. Proportion of **(a)** *Apis* and **(b)** *Bombus* that continued foraging (*black*), left the "plant" (*white*), or inspected "flowers" (*gray*) following either a foraging event or an encounter with a con- or heterospecific bee. Proportions represent trial averages, and thus do not sum to 1.

- *B. impatiens* that encountered *A. mellifera* discontinued foraging at the observed plant, but exhibited only a slight decrease in foraging following an intraspecific encounter.

Competition - Goulson and Sparrow 2013

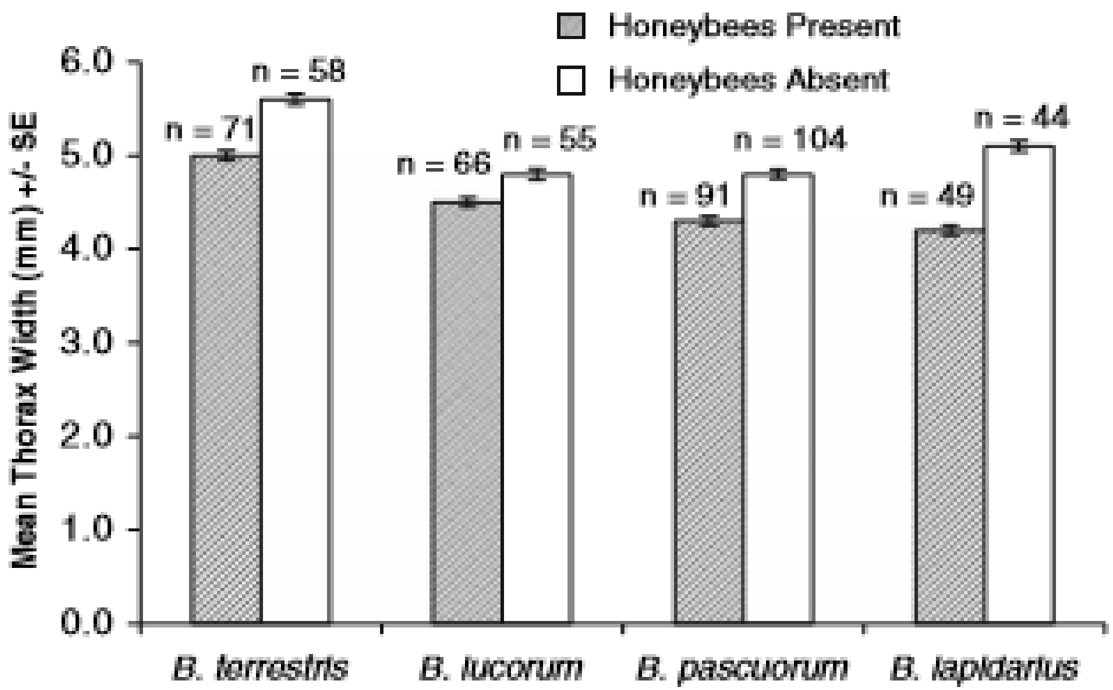
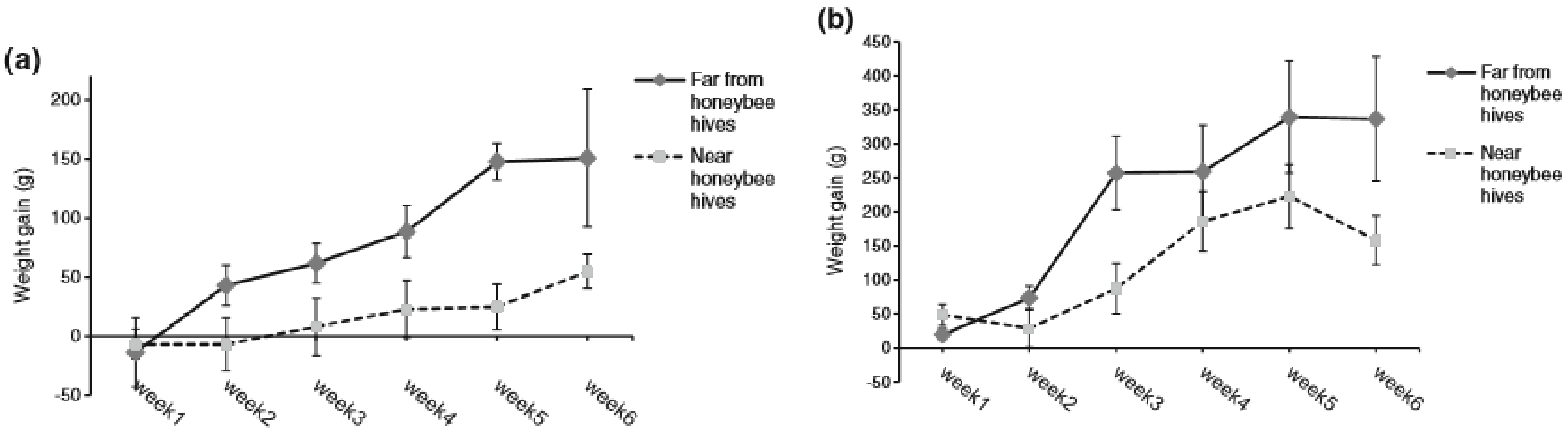


Fig. 1 Mean thorax widths (±SE) of workers of four bumblebee species in sites with and without honeybees

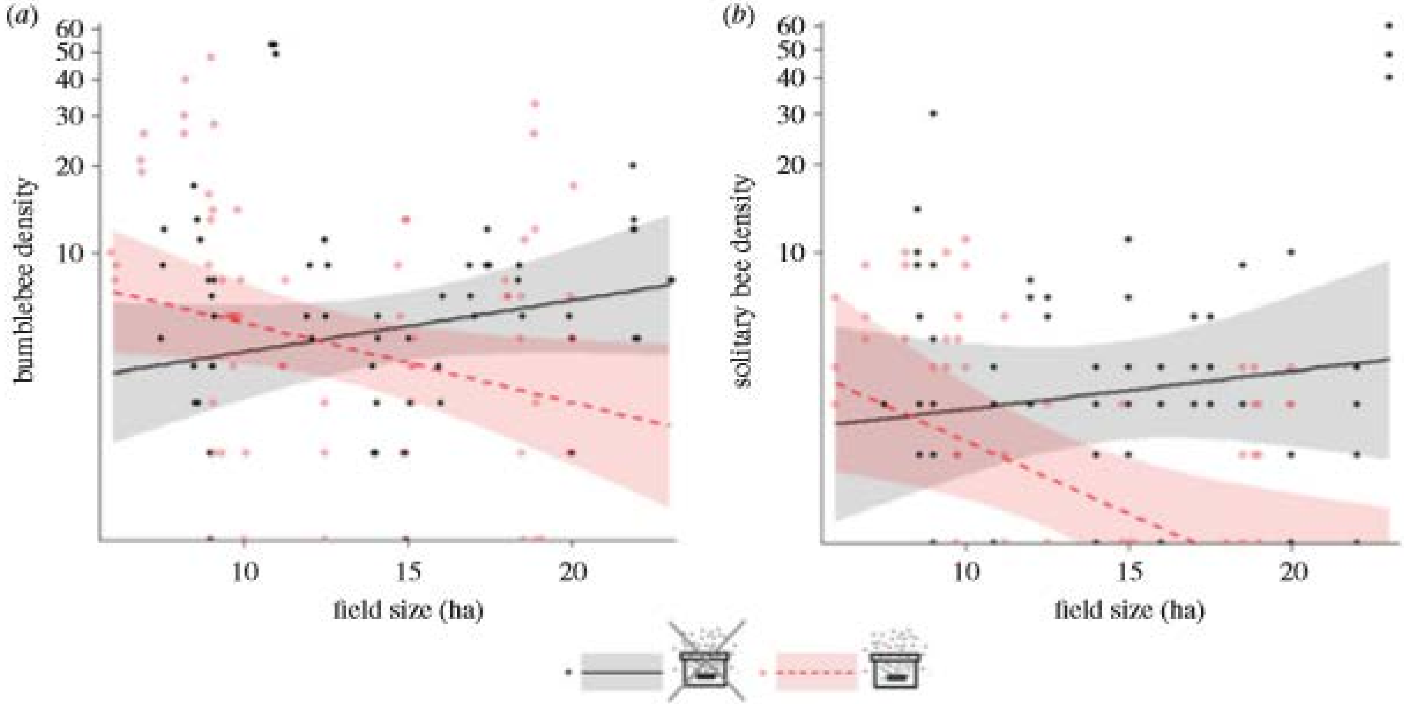
- Workers of *Bombus pascuorum*, *B. lucorum*, *B. lapidarius* and *B. terrestris* were significantly smaller in areas with honeybees.

Competition - Elbgami et al. 2014



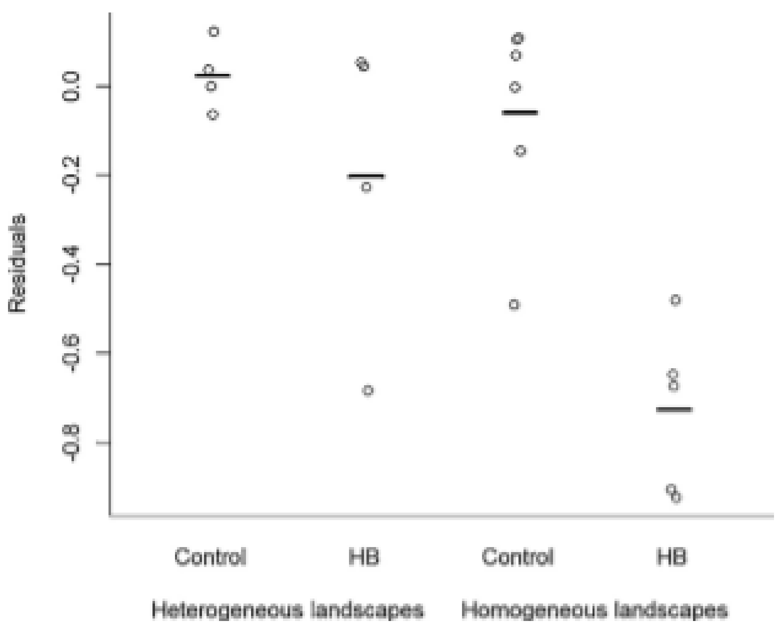
- Bumble bee colonies located at a site near an honey bee apiary gained less weight, and produced fewer and smaller queens, in both years than colonies at a site far from an apiary.

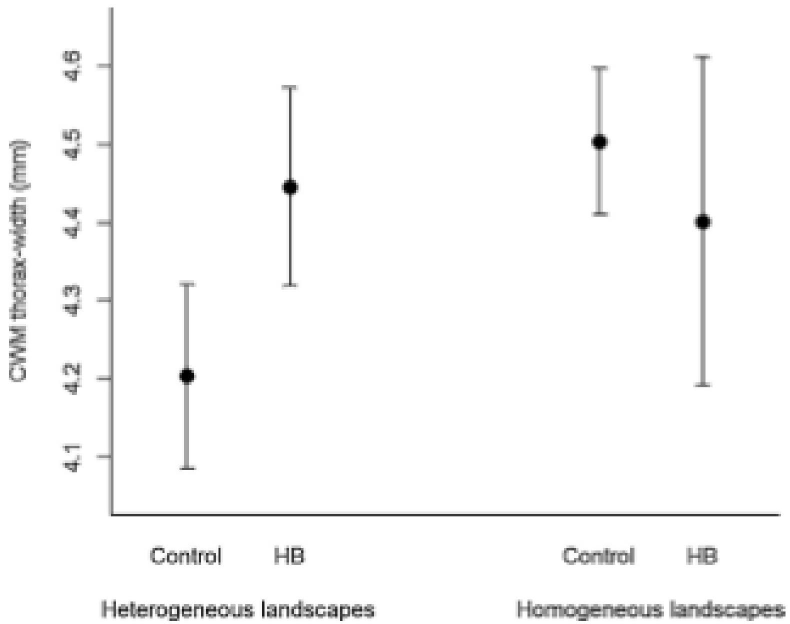
Competition - Lindstrom et al. 2016



- The addition of honey bees depresses the densities of wild bumblebees and solitary bees, even in a mass flowering resource (oil-seed rape). The effect is independent of landscape complexity.

Competition - Herbertsson et al. 2016





- Adding honey bees suppressed bumble bee densities in field borders and road vergers in homogenous landscapes whereas no such effect was detected in heterogeneous landscapes.

Competition - Gross 2001

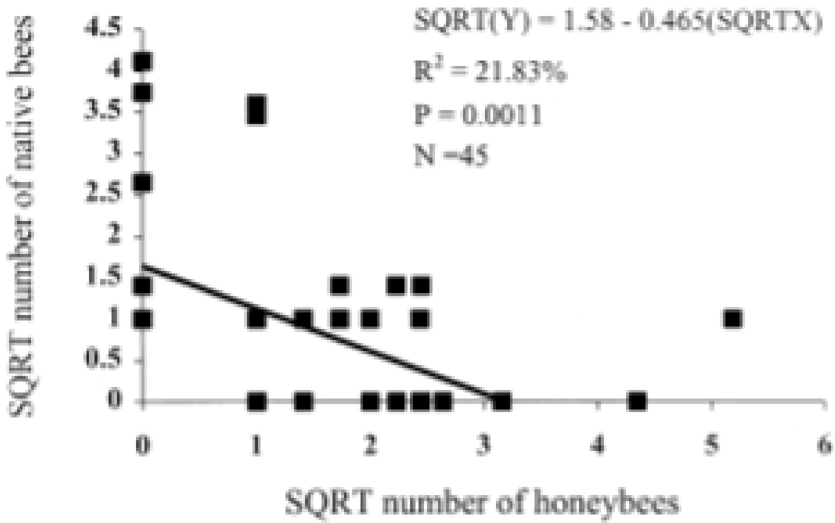


Fig. 2. The relationship between the square-root (number of honey-bees) and the square-root (number of native bees).

- Visitation data also revealed that native bee presence is negatively correlated with the presence of honey bees. At one of the study sites, honey bees were very abundant, but very few native bees were ever recorded over the 3 years.

Competition - Paini and Roberts 2006

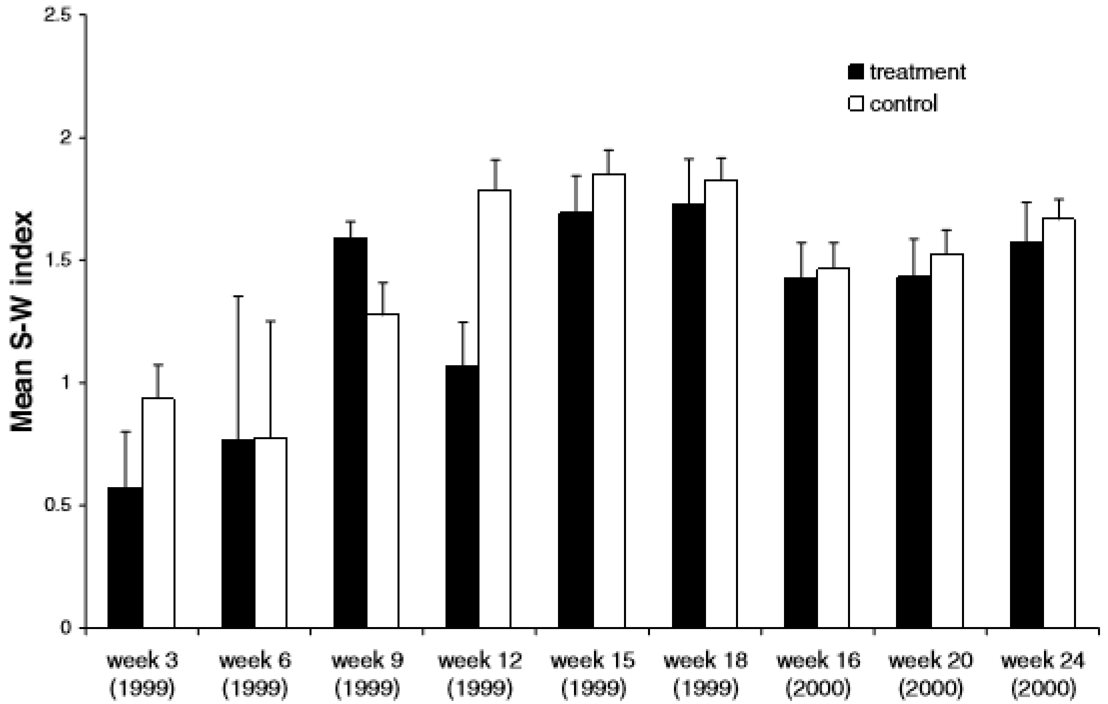


Fig. 3. Mean Shannon–Weiner index for flowering plant diversity from control and treatment sites (+SE). Week 12 '1999 was not significant after sequential Bonferroni adjustment.

- The number of nests produced by *Hylaeus* was 23% less at the treatment site than control sites.

Competition - Hudewenz and Klein 2015

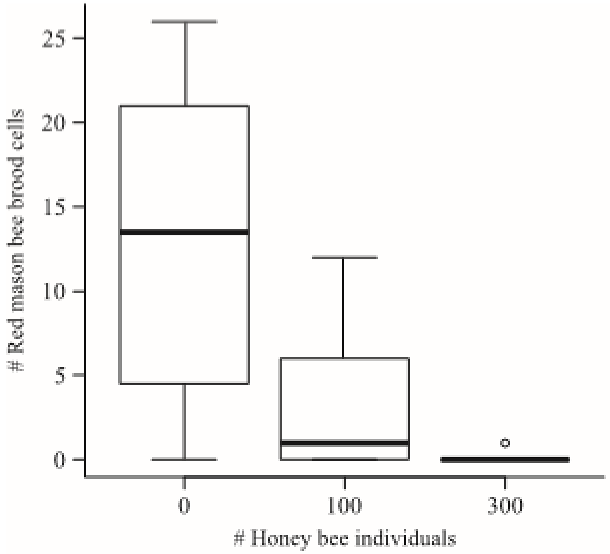
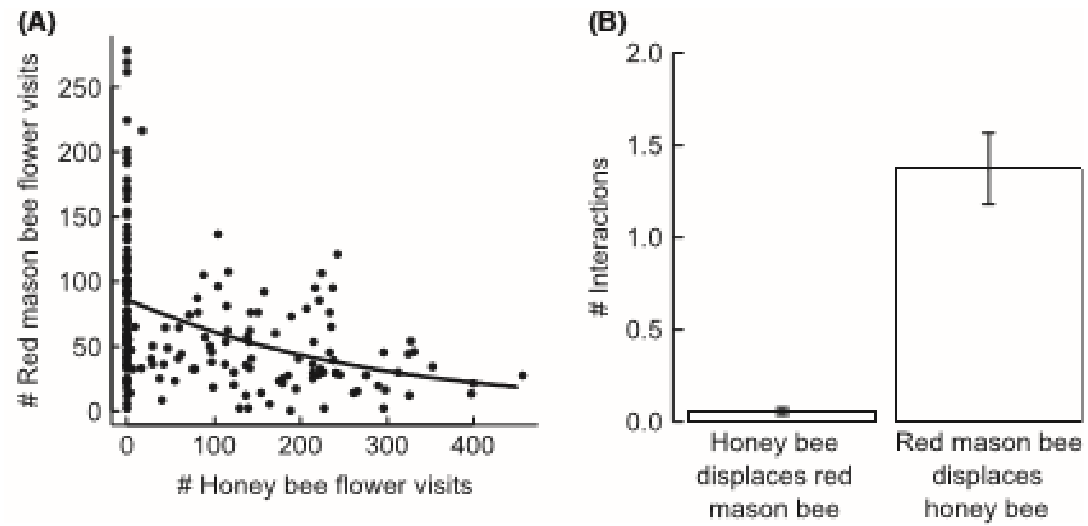


Figure 3. Number of red mason bee brood cells ($n = 24$, df $= 21$, GLMM, $P < 0.001$) in cages without honey bees, with 100 and with 300 honey bee individuals.



- Red mason (*Osmia bicornis*) bees visited fewer flowers when honey bees were present. Niche breadth of red mason bees decreased with increasing honey bee density while resource overlaps remained constant. The reproduction of red mason bees decreased in cages with honey bees.

Summary of outcomes

- Indication that seasonal bumble bee growth and reproduction can be negatively impacted by the presence of honey bee colonies in natural and semi-natural areas (6 of 11 studies). There was no study with a long enough time frame to assess population-level outcomes.
- Some, but limited, evidence that other bees display similar reproductive responses. (4 of 11 studies)
- Many null results. (10 of 19 studies)
- No instance where native bees exploited or excluded honey bees.

Non-competitive interactions

- Honey bees altering flora community, multiple possible outcomes.
- Pathogen, virus, and parasite spillover.
  - Transmission goes both ways, but wild bees cannot be treated.

Recommendations

- Difficult to make a universal statement (evidence is 50/50).
- Cautioned placement of honey bees in areas where bumble bees are keystone and known to be vulnerable.
- Seasonal selection to minimize potential impacts.
- Avoid promotion of honey bee pasturing on natural landscapes that are home to bumble bee species at risk.
- More research to fill gaps in understanding.

Gaps in understanding competition

- Are floral resources limited?
  - Degree of interspecific competition between natives?
- Calculation of carrying capacity for natural lands. (see Cane and Tepedino 2016: Hive Unit Monthly (HUM) = 33,000 native bee progeny (*Megachile rotundata)*)
- Nutritional supports provided.
- Reproductive output on full range of native species. (less than 20 have been examined)

Gaps in understanding competition

- None of the studies have looked at population-level trends through time (most one year or less in duration).
- Individuals can survive, grow, and thrive. We do not know the population-level impact of reduced growth and reproduction of individuals or colonies at this time.

Thank you

- Questions, comments?

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