

Biodiversity and Ecosystem Services

Discussion 1

10 February 2017

Colony Collapse Disorder

- Phenomenon where workers stop returning from foraging visits.
- Eventually hive disappears, leaving only the brood.
- Has been documented since antiquity.



Colony Collapse Disorder

- Most feral European honeybee colonies went extinct between 1970-2005.
- CCD refers to dramatic increase in domestic hive loss first documented in North America in 2006.



Pollinator Loss

Goulson *et al.* 2016

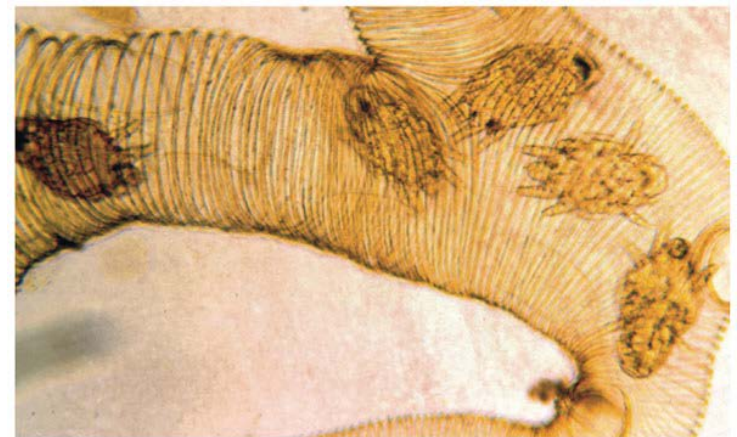
- What do YOU think is driving pollinator loss?
- Group 1: Habitat loss
- Group 2: Parasites & Disease
- Group 3: Pesticides
- Group 4: Agriculture

Returning to this...

- If there are limited resources for implementing solutions, which would you prioritize?
- How does this relate to observations we saw in the papers?

Proximate Causes

- There are numerous possible culprits:
 - Poor nutrition or malnutrition;
 - Pathogens;
 - *Varroa* mites
 - *Nosema* fungus
 - Invertebrate Iridescent virus (IIV)
 - Numerous other positive strand RNA viruses including Deformed wing virus (DWV) and Israel acute paralysis virus (IAPV)
 - Environmental change-related stresses;
 - Pesticides;
 - Domestication and loss of propolis.



This is a honey bee trachea with tracheal mites, *Acarapis woodi*. The Honeybee Act of 1922 prevented importation of European bees and kept the United States free of tracheal mites for decades. Photograph: USDA, Lilia De Guzman.

- Bromenshenk, J.J. *et al.* 2010. Iridovirus and microsporidian linked to honey bee colony decline. PLoS ONE 5(10): e13181.
- Potts, S.G. *et al.* 2010. Global pollinator declines: trends, impacts and drivers. TREE 25(6): 345-353.
- Watanabe, M.E. 2008. Colony collapse disorder: many suspects, no smoking gun. Bioscience 58(5): 384-388.

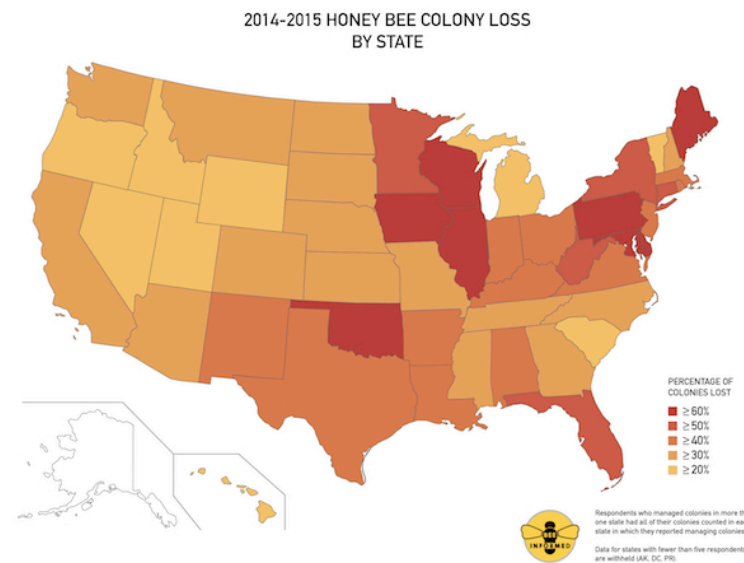
Most important factors?

- There are numerous possible culprits:
 - Poor nutrition or malnutrition;
 - Pathogens;
 - *Varroa* mites
 - *Nosema* fungus
 - Invertebrate Iridescent virus (IIV)
 - Numerous other positive strand RNA viruses including Deformed wing virus (DWV) and Israel acute paralysis virus (IAPV)
 - Environmental change-related stresses;
 - Pesticides;
 - Domestication and loss of propolis.



What are some of the consequences of CCD?

- Widespread effect.
- Migratory beekeeping deemed essential (?) for many crops.
- Responsible for ~1/3 of U.S. crops.
- Value exceeds \$15 billion annually (USA).



CCD and Biodiversity

Winfree *et al.* 2007

- What are ecosystem services?
- How might preserving biodiversity enhance pollination services?
- The details of the paper.
- What lessons might we learn from this?
 - How might this be applied to agricultural practices in California?

Ecosystem Services

- Crop pollination is an example where we depend on functioning ecosystems for services (generally defined economically).
- We currently depend largely on *Apis mellifera*.



Ecosystem Services

- But of course flowering plants existed in the New World well before European honeybees arrived.
- North America has a diverse suite of native pollinators.
- Many are threatened by land use changes, pesticides, introduced diseases, competition from introduced bees.



Ecosystem Services

- Can managing agro-ecosystems to maintain native bee diversity provide a buffer of insurance against losing European honeybees?

Ecology Letters, (2007) 10: 1105–1113

doi: 10.1111/j.1461-0248.2007.01110.x

LETTER

Native bees provide insurance against ongoing honey bee losses

Winfree *et al.* 2007

- Do native bees provide pollination services in commercial watermelon fields in comparison to honey bees?
- Could native bees sufficiently pollinate watermelon fields on their own?
- Is this related to land use cover?

The study

- 23 watermelon farms in New Jersey and Pennsylvania.
 - Watermelon requires high pollination rates to set fruit.
- Embedded in temperate forest matrix.



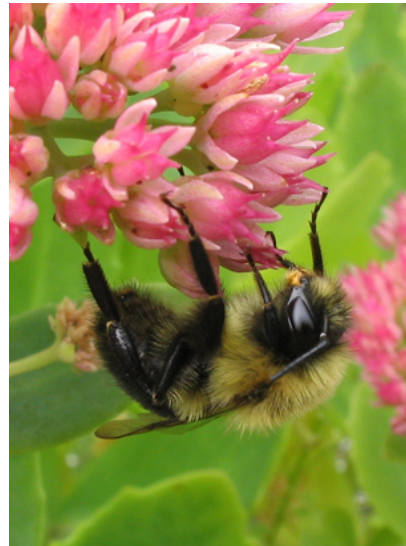
The study

- Data collection:
 - Measured pollinator visitation rate to flowers (45 second intervals at 40 points per 50m transect).
 - Identified pollinator to five groups:
 - Honeybee
 - Native bees: bumblebees, large bees, green bees, small bees
 - Three times per day



The study

- Data collection:
 - Per visit pollen deposition.
 - Following observation, bagged flowers, removed stigmas, counted adhered pollen grains.
 - Tallied this *for each bee species observed*.



The model

- Built a simulation model based on the data collected:
 - Flower visitation rate for each bee species at each farm.
 - Per-visit pollen deposition for each bee species.
 - Incorporated measures of variance.

The model

- Monte Carlo model samples data from this information in order to build a simulated dataset for some specified community of pollinators.
 - E.g. honeybees alone, bumblebees alone, only native bees, all bees, etc.
- Using these simulations, they asked whether pollination would be sufficient from these different sets (>1400 pollen grains/flower).

Results

- Visitation rate was not correlated with pollination success in honeybees.
- Was highly correlated in native bees.
- Are they better pollinators?

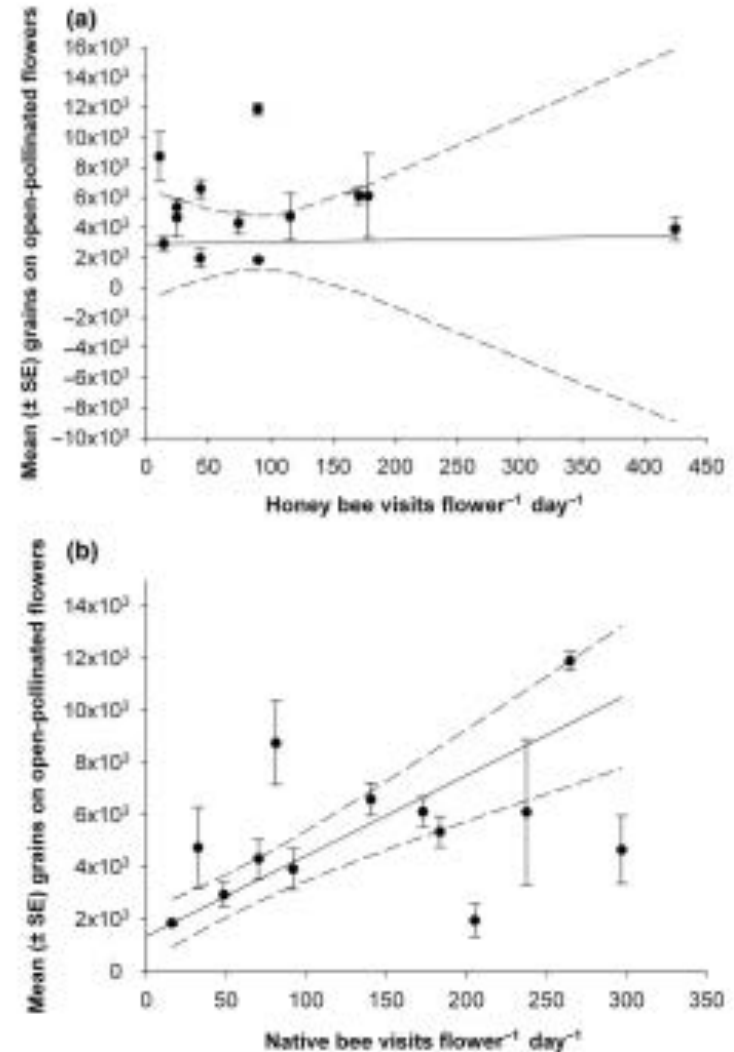


Figure 1 Inverse variance weighted linear regressions of day-long pollen deposition on open-pollinated watermelon flowers as a function of bee visitation rate. Points show the mean (\pm SE) pollen grains per flower. Dashed lines are 95% CI for the regressions. (a) There is no relationship between honey bee visitation rate and pollen deposition. (b) Native bee visitation rate is positively related to pollen deposition.

Results

- The majority of flowers are pollinated by native bees.
- Native bees alone provided sufficient pollination at 91% of farms.
- Honeybees alone provided sufficient pollination at 78% of farms.

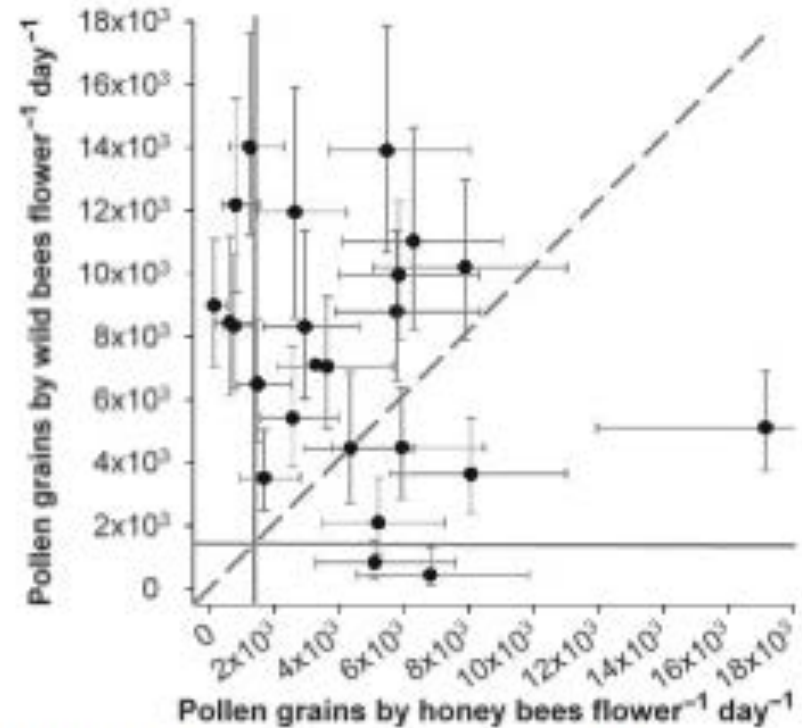


Figure 3 Simulation estimates for median (\pm 10%/90% quantiles) pollen grains per flower per day delivered by honey bees vs. native bees. Each data point represents a farm. Points above the dashed line received most of their pollination from native bees. Pollination is sufficient when the median flower receives > 1400 pollen grains, as indicated by the grey shaded lines. Native bees alone provide sufficient pollination at 91% of farms (points above the horizontal grey line), and honey bees at 78% of farms (points to the right of the vertical grey line). Total pollination is more than adequate at all farms.

Results

- Most farms could be pollinated fully by one of the native bee species groups.

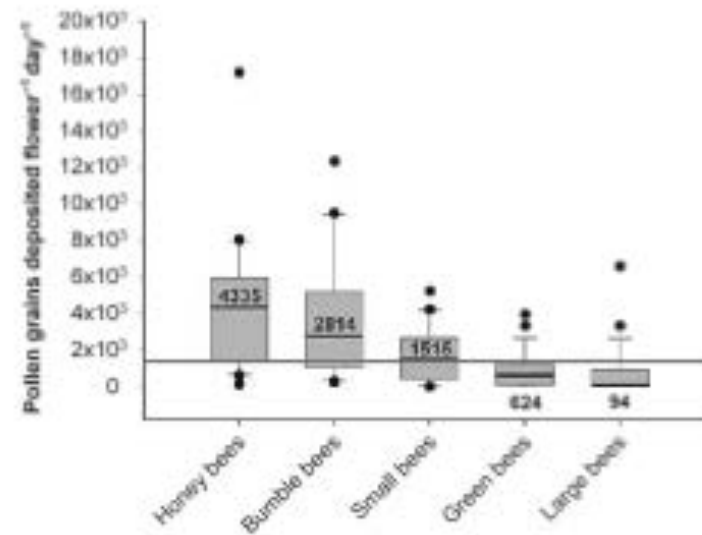


Figure 4 Simulation estimates for median number of pollen grains deposited per flower per day by each of the bee species groups. Black lines and numbers represent medians, boxes represent the interquartile range and whiskers represent 10%/90% quantiles. When the median flower receives 1400 pollen grains, as indicated by the grey shaded line, pollination is sufficient. Bumble bees alone pollinate the crop fully at 70% of farms, small bees alone at 57% of farms and green bees alone at 22% of farms.

Results

- Successful pollination did not depend on landscape.

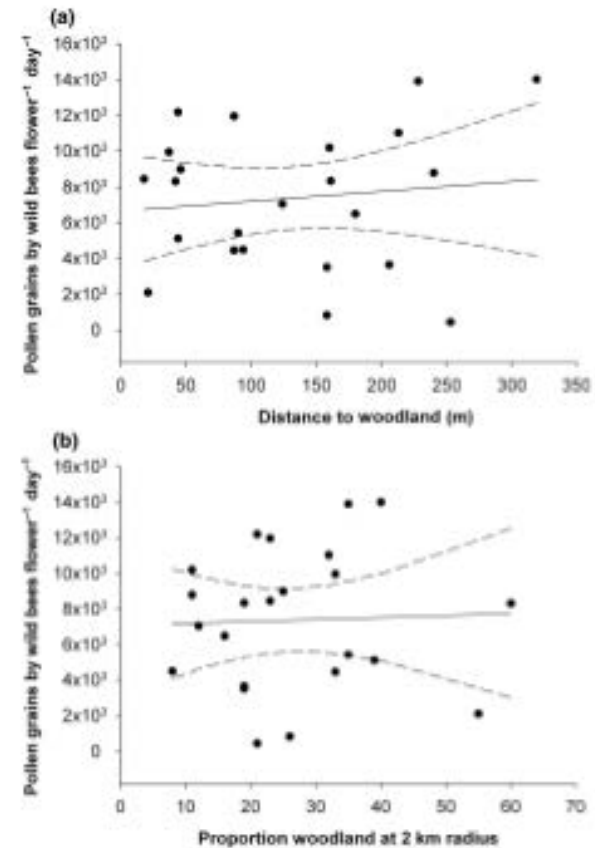


Figure 5 Single linear regressions (\pm 95% CI) showing the lack of relationship between native bee pollination and land use. Each point represents one farm. Simulation estimates for median pollen grains per flower per day delivered to watermelon by all native bee species combined, and (a) distance to nearest woodland fragment ($r^2 = 0.01$, d.f. = 22, $P = 0.59$) and (b) proportion woodland cover in the surrounding landscape at a 2 km radius ($r^2 = 0.00$, d.f. = 22, $P = 0.86$).

Conclusions

- Maintenance of bee diversity can buffer loss of honeybees.
- Why is the diversity maintained in this scenario?
- Why are the pollinators successful?

Possible discussion questions

- How did this compare to results from other areas? Especially California?
- How is this situation different from California?
- What could be done in California to address this problem if honeybee losses continue?