A spatiotemporal survey of viruses in honey and native bees in Northern California

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7/26/2019


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alamy

Benefits of bees

World: Pollinators fully required for 85% of flowering plants reproduction and 35% of crop production

USA: Honey bee > $15 billion/year worth of crop production

USA: Value of honey production > ~$320 million/year

Intergovernmental Platform on Biodiversity and Ecosystem Services 2016
Calderone, 2012; Hatfield et al 2018

Benefits of bees

Commercial Bumblebees

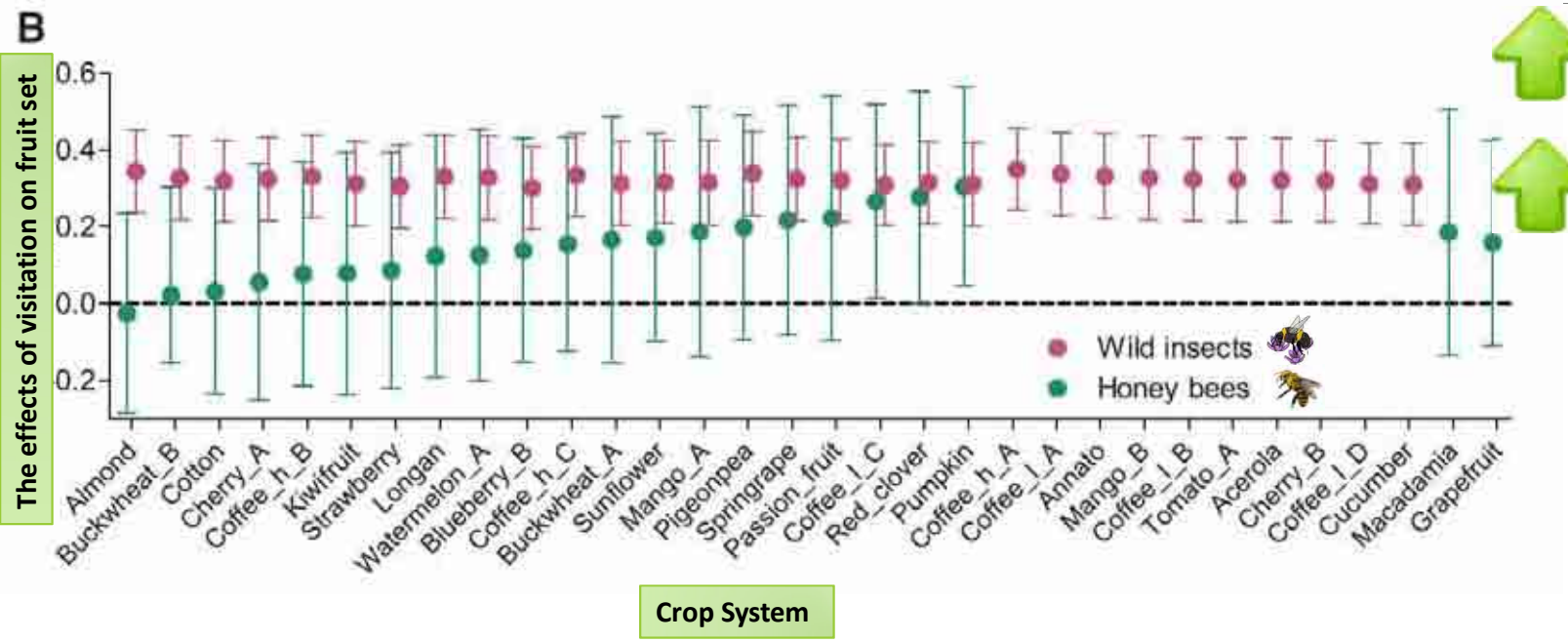
- Pollinate crops that require buzz pollination such as raspberries, peppers, and tomatoes.

Native bees > $3 billion/year worth of crop production for US

- Free pollination services
- More efficient than honey bees (individually) on many crops.

(VanEngelsdorp and Meixner, 2010); Garibaldi et al, 2013; Calderone, 2012).

Benefits: Increased efficiency



Wild insect visitation

Fruit set

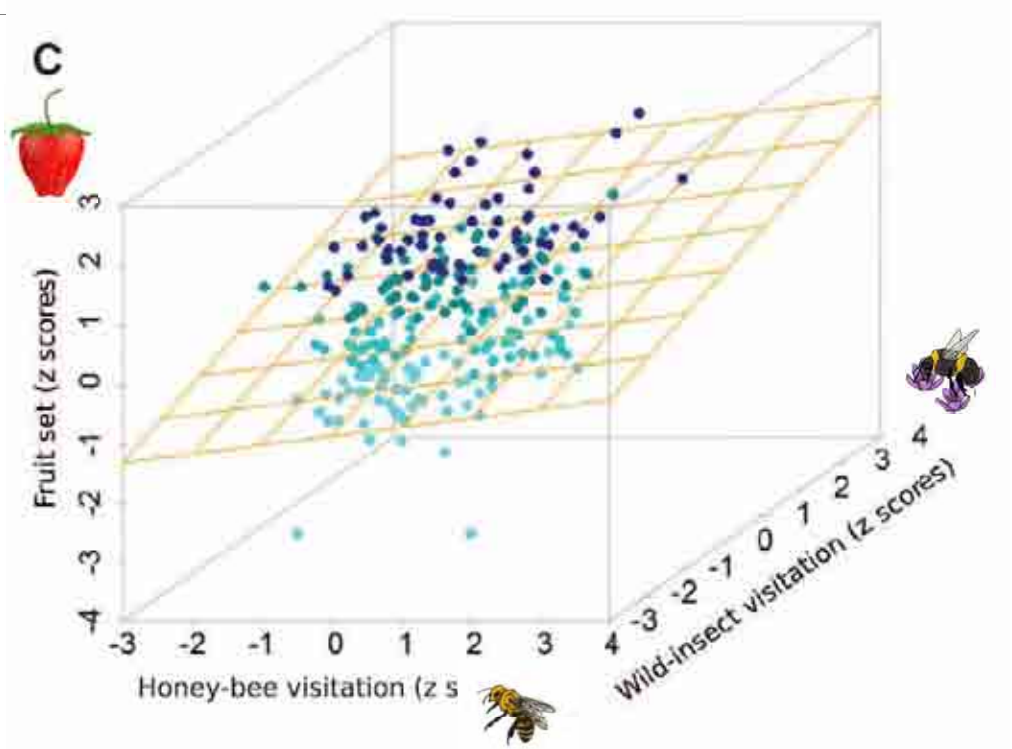
Having increased wild insect visitation increased fruit set in all systems

fruit set = proportion of flowers that turn into fruit

Garibaldi et al 2013

Benefits: Increased efficiency

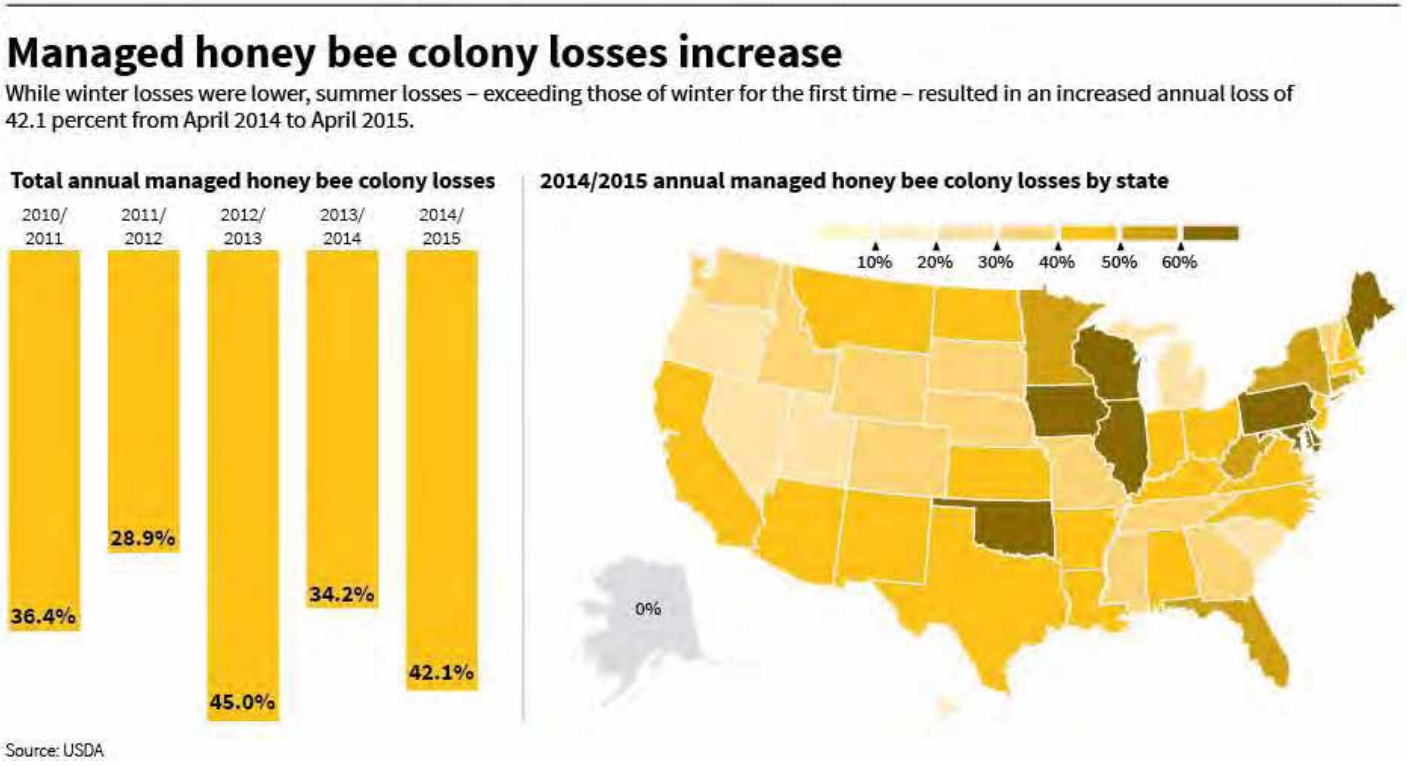
Highest fruit set =



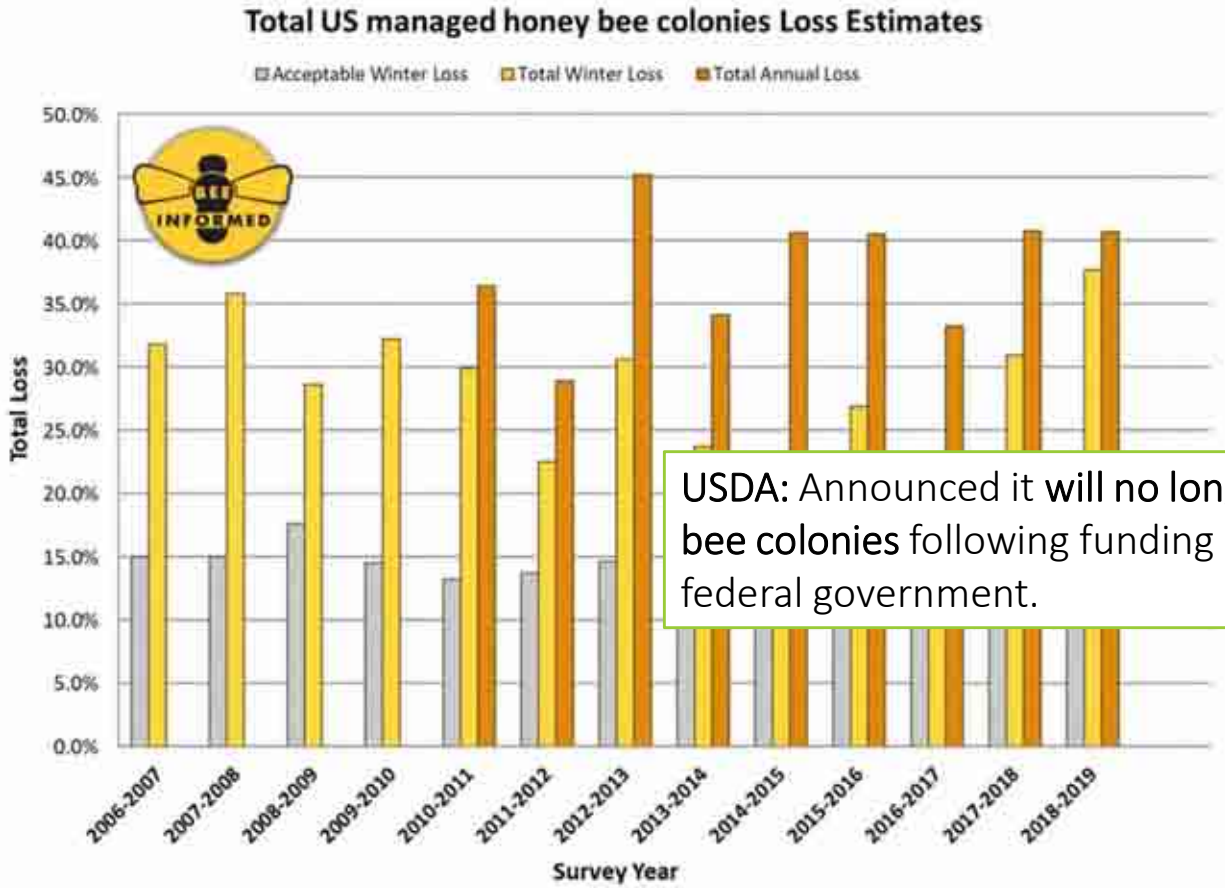
fruit set = proportion of flowers that turn into fruit

Garibaldi et al 2013

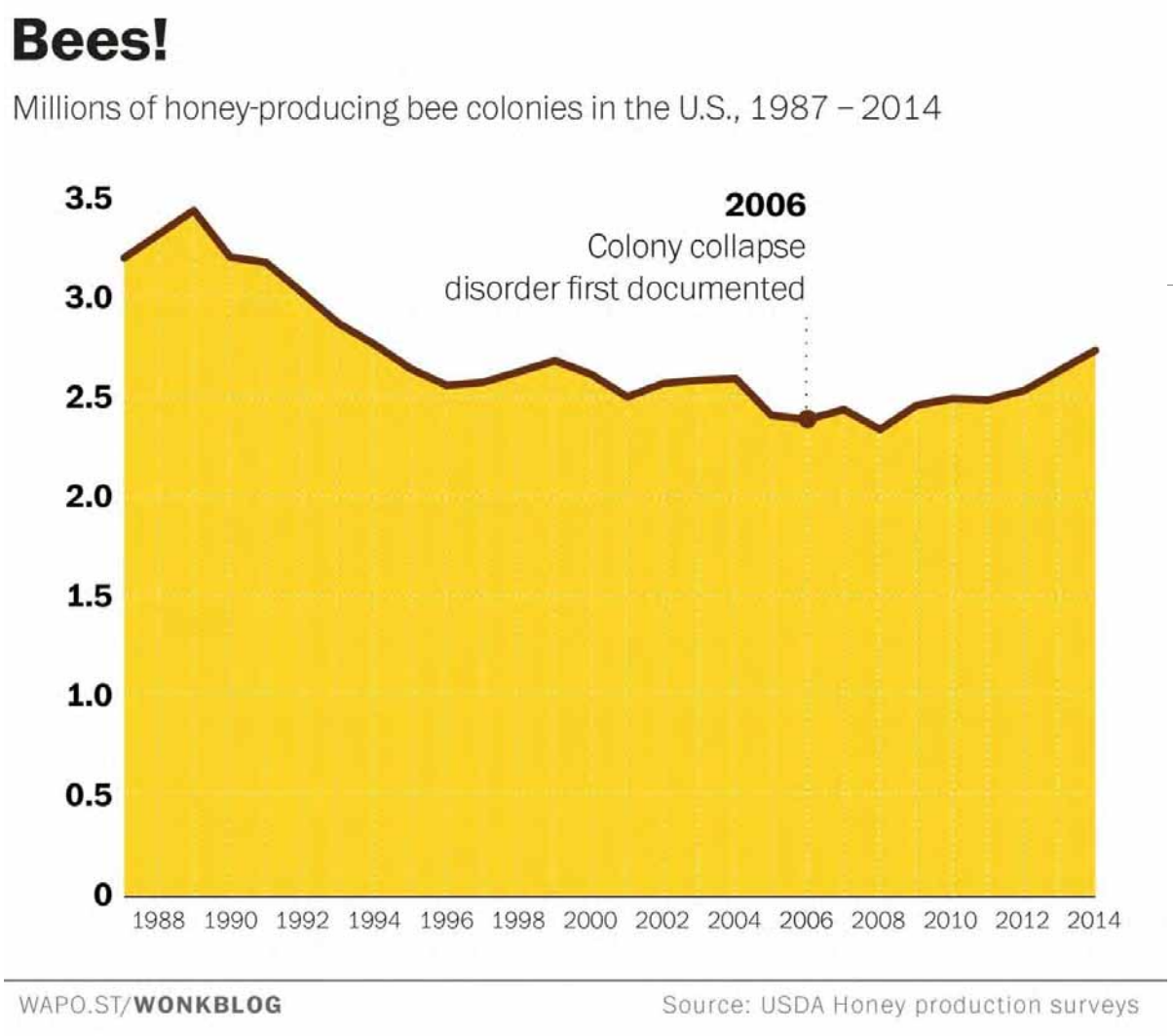
Declines – Honey bees



During the 2018-2019 winter an estimated **37.7%** of managed honey bee colonies in the United States **were lost** (Fig. 1). This loss represents an increase of 7 percentage points compared to last year (30.7%). This year's estimate is the **highest level of winter losses reported since the survey began in 2006-2007**.



USDA: Announced it **will no longer collect data on bee colonies** following funding cuts from the federal government.



Declines?

World:
In the past 50 years honeybee hives have **increased** in number by **45%**

However, the fraction of crops that depend on some amount of animal pollination have risen by **300%** in the same time.

(Aizen and Harder, 2009).

Declines – Wild bees

IPBES 2016: Globally 40% of pollinator species at risk of **extinction** in coming years

IUCN Red list: 11% of all bumblebee species worldwide are listed as **threatened**

Eastern North America: bumblebees have also declined in diversity and abundance from 1971- 2006

US: In the mid-west, 1/2 of the native bumblebee species have declined during the mid-twentieth century

Williams and Osborne, 2009; (Colla and Packer, 2008); (Grixti et al., 2009)

Declines – Wild bees

Bombus affinis:

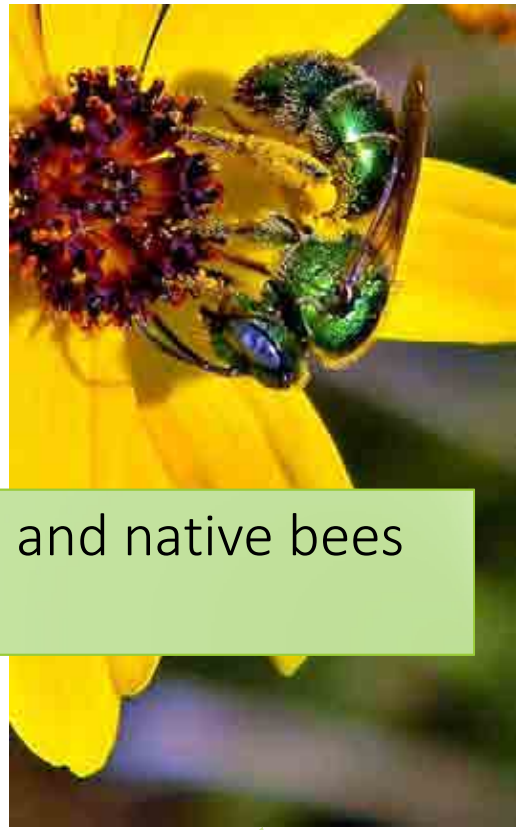
- Decreased by 90 percent in abundance and distribution since the late 1990s, according to the U.S. Fish and Wildlife Service
- 2017: listed as endangered

The IUCN: ¼ of the 47 species of native U.S. and Canadian bumble bees face a risk of extinction.

Declines - Why is this happening?

Climate change	Habitat fragmentation	Stress
Pesticides	Poor diet	Disease



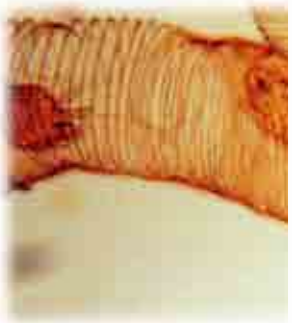
Big Question: Are ecological interactions between managed and native bees responsible for some of the declines?

Interactions

Common honey bee parasites/pathogens

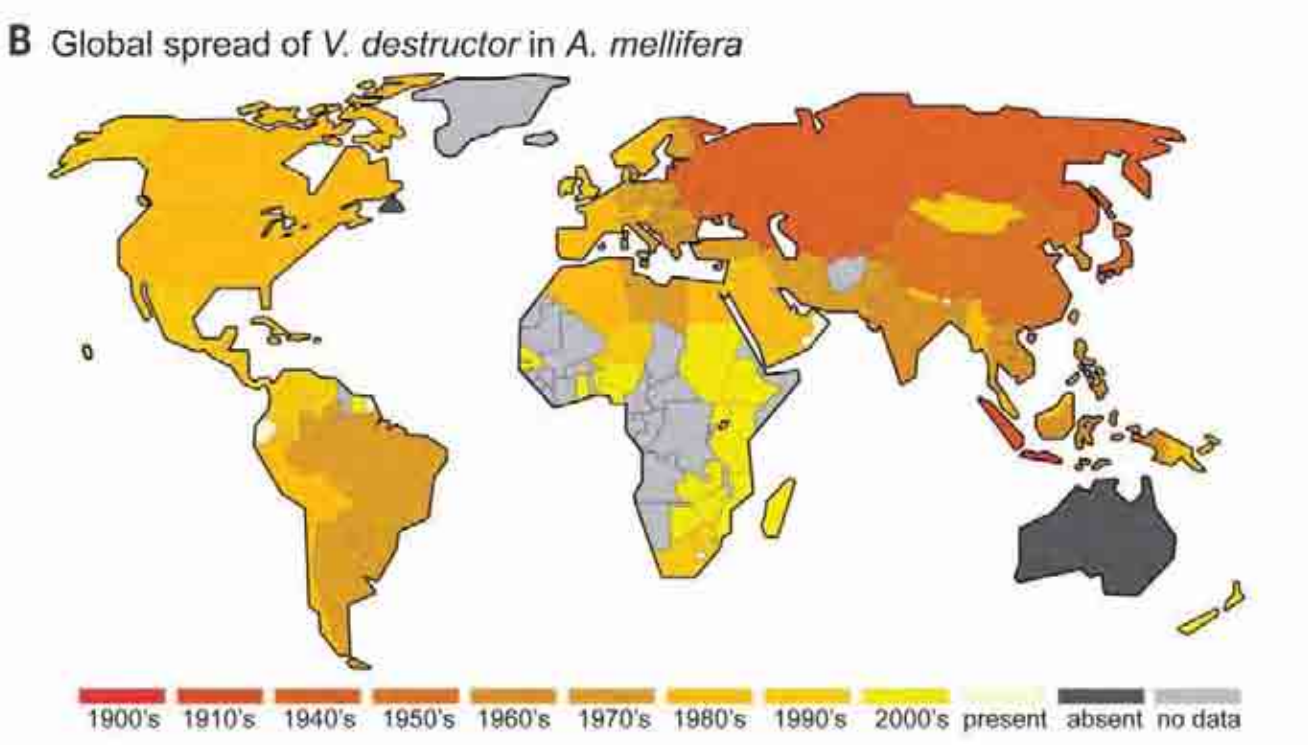
Disease transmission

Varroa destructor



Acarapis

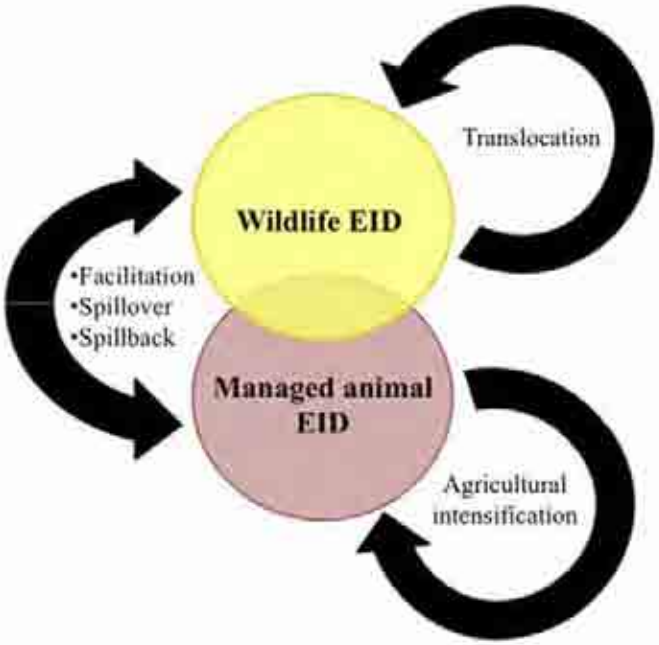
Spillover event – *Varroa jacobsoni* on *Apis cerana* (East Asia)



Graystock et al 2016

Where are these diseases coming from?

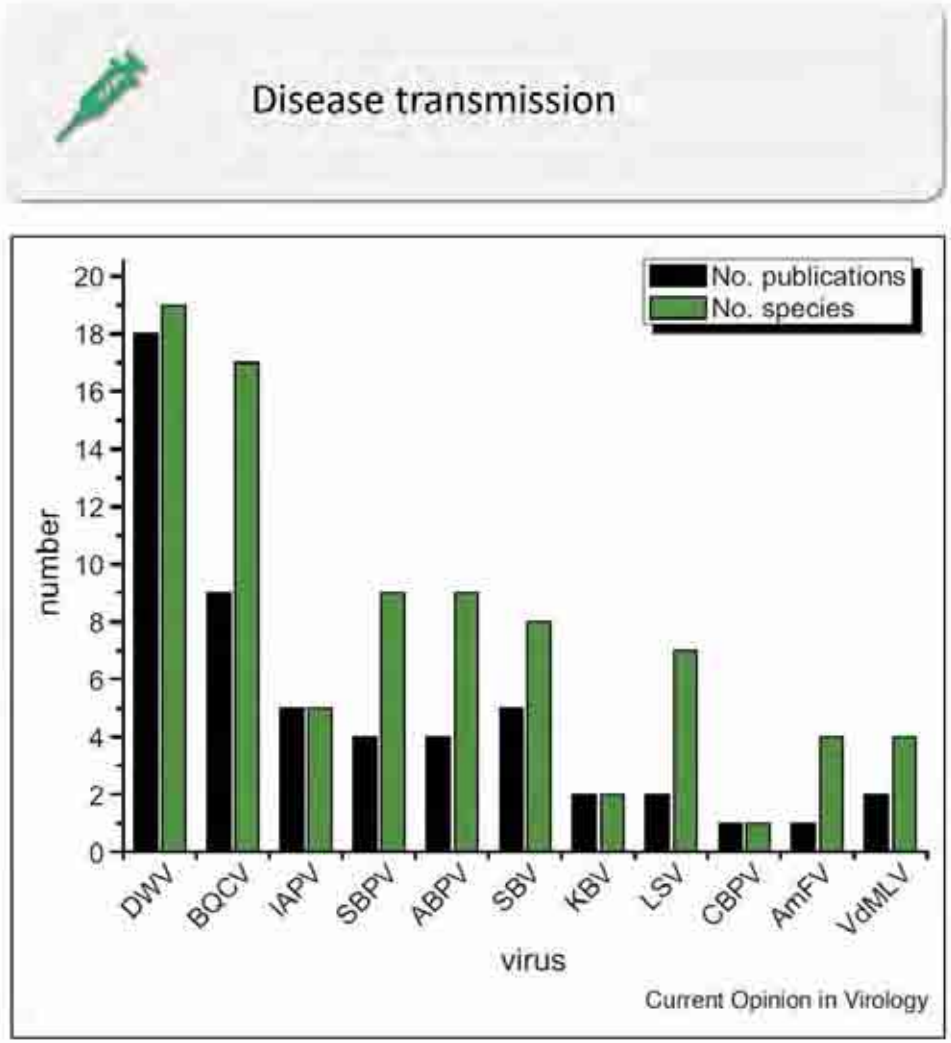
- **Spillover event** = When a disease enters a new host population
- In vertebrates, spillover of disease from livestock to wildlife is the **main source** of new infectious diseases for wildlife
  - Bovine tuberculosis, paratuberculosis
- By allowing managed bees to mix with wild, there is the **potential for disease emergence via sharing contaminated floral resources and facilitated by changes in host susceptibility** (Goulson et al., 2008).



Graystock et al 2016; Goulson et al., 2008

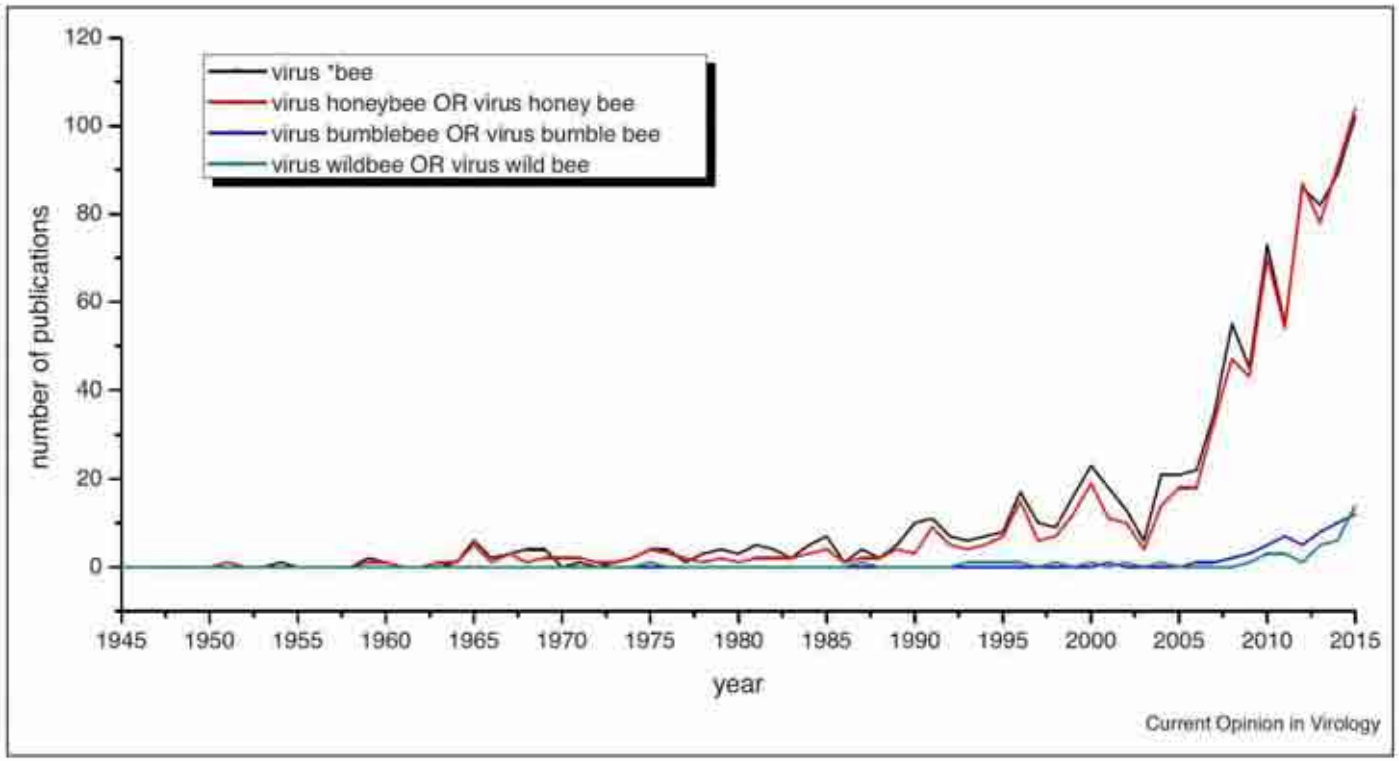
Parasite spillover

- There is a heavy focus on viruses
  - Can mutate rapidly
  - Get into new hosts easily
  - Highest likelihood of spillover
- How many species are honey bee viruses being found in?
  - Important implications in epidemiology + evolution + eradication of the pathogen



Tehel et al, 2016

Open questions



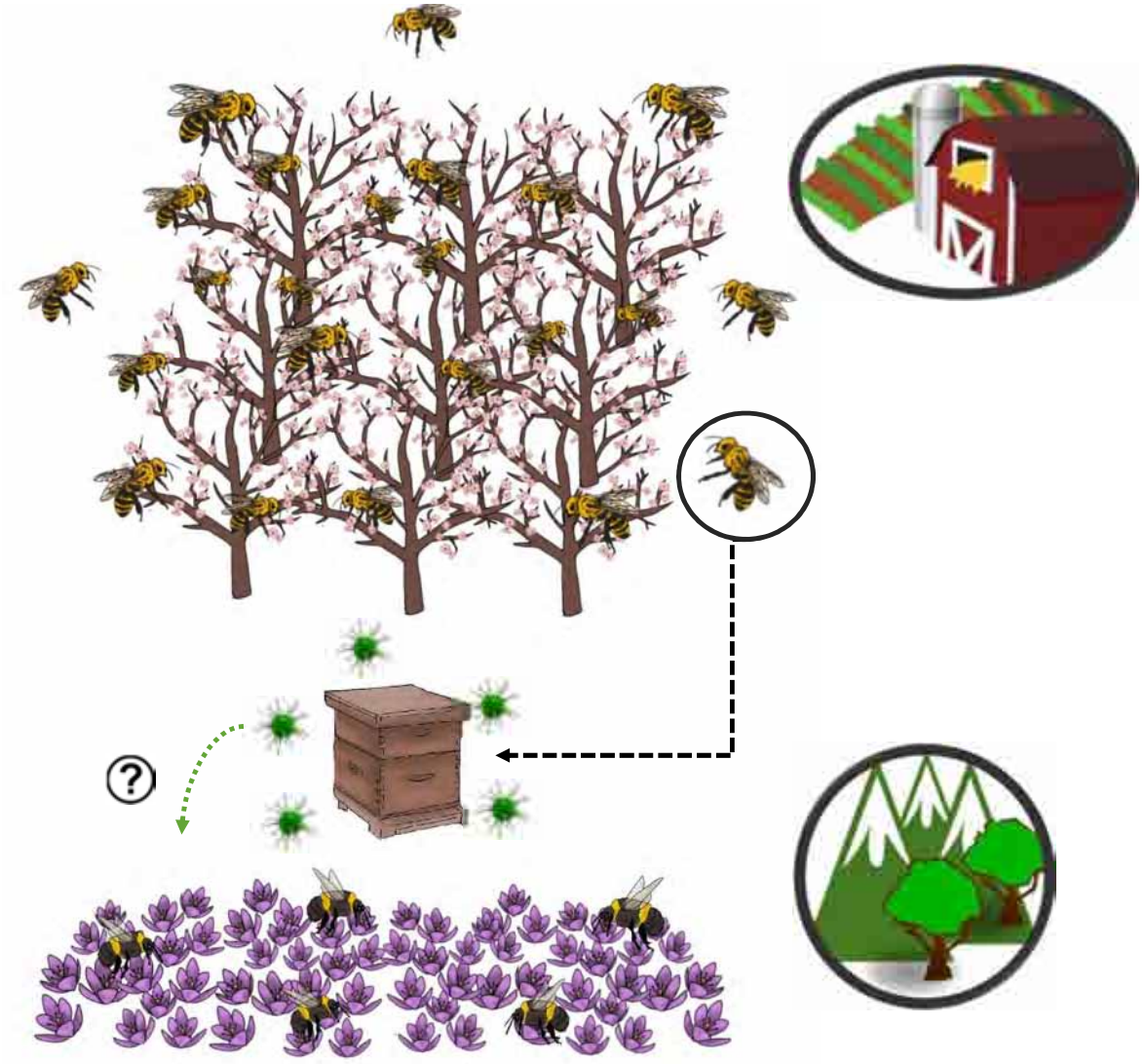
Study of honey bee viruses getting increasing attention

But relatively little work done on bumblebee or wild bee viruses

Tehel et al, 2016

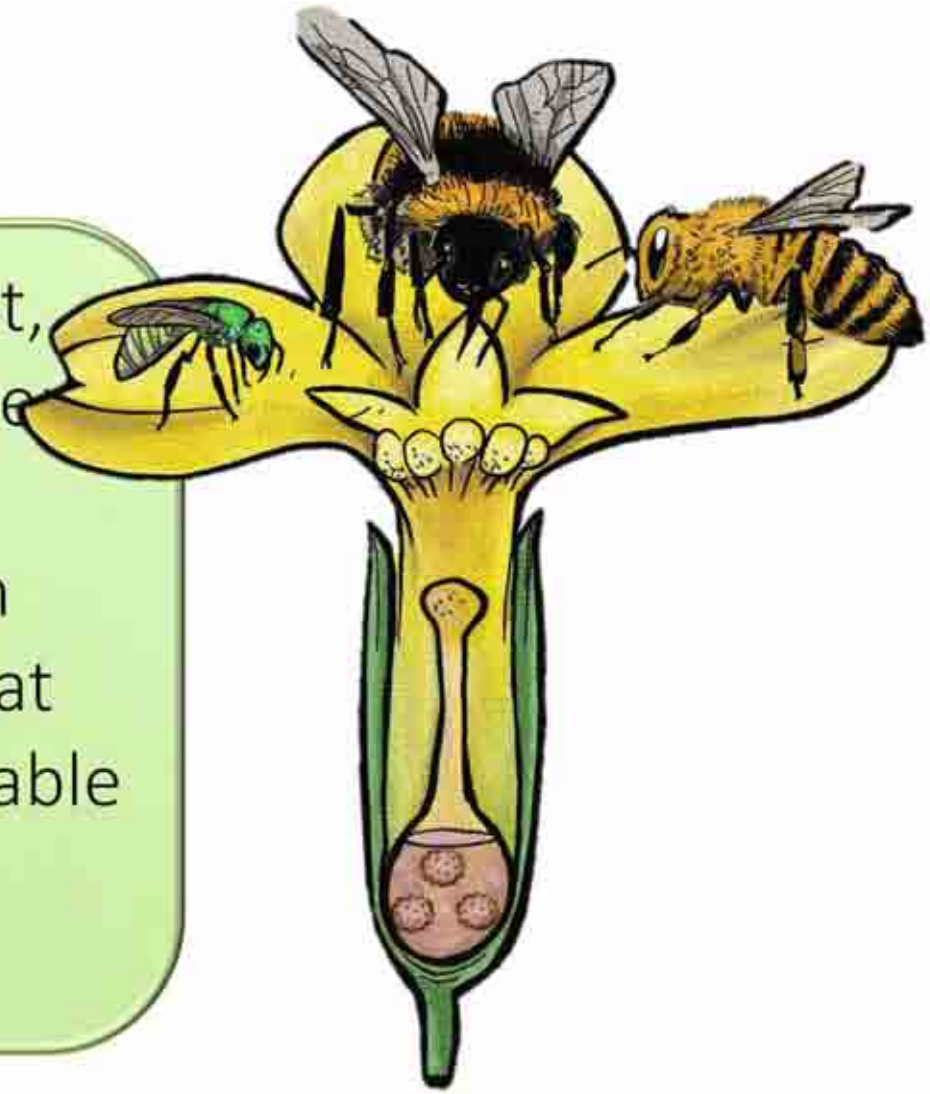
My Research Interests

- What are the patterns of virus infections in honey/wild bees through time?
- Does the **mass importations** of honey bees into California impact bee's viral community?
- Are these patterns recapitulated in **wild bees**?
  - Evidence of spillover?
  - Look across a range of **sites** (urban, crop, nature)
- What are the impacts of these viruses on native bee **populations**?
  - Are some species more **tolerant/resistant** than others?
- Are there correlations between honeybee presence or density, and viral patterns in wild bees?
  - How does increased floral resources impact these patterns?



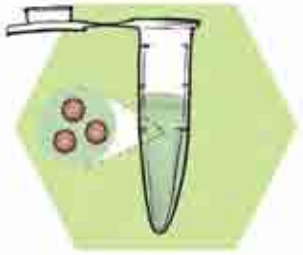
Hypotheses

Viruses will spike in honeybees first, then spillover into bumblebees, the solitary bees. I predict that the highest prevalence will be found in areas with the least forage, and that viruses will not be found at detectable levels in bees isolated from honeybees.

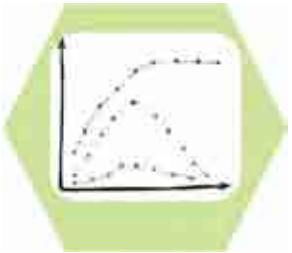


Methods

Catch bees at sites that vary in human impact
+ honey bee density every 2 weeks



RNA extract
Reverse transcriptase + PCR
Deformed wing virus (DWV), Black queen cell virus (BQCV), Sacbrood virus (SBV)
Repeat for negative strand = active replication



Viral prevalence (proportion of bees with active infection/total) graphed over time at each site

My sites:

Cattle Ranch
- 400+ commercial hives

Wildflower farm
- 8 backyard hives

Alpine wildflower meadows
- No honey bees
- 400+ commercial bees
- ~15 backyard hives

So far…

- Collected bees every other week starting from April 9th until July 15th
- Total # of bees collected: 995
- Approximate # of genera: 13

Next steps:

- ❑ Identify bee species
- ❑ Identify viruses + evidence of active replication
- ❑ Graph viral prevalence for DWV, BQCV, SBV at each site
- ❑ Collect from agricultural + urban sites
- ❑ Model rates of spillover

Conclusions

- Californian agriculture requires the importation of billions of managed bees, and hosts a huge **diversity** of native bees, but we know little about their direct interactions.
- Evidence is emerging to show that managed bee pathogens are being found in **new** wild species, but with **unknown** impacts to their populations.
- Diseases can be **transmitted** through an ecosystem in a variety of ways.
  - How they travel impacts the management strategies
- Need additional research to bolster species **tolerance** to disease.
- A lot of **open questions**, with a need for long term studies.

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Robert Paxton (https://www.youtube.com/watch?v=8Z1hN1zbfFg)

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