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Pollinator Habitats: What Can Recent Science Tell Us?

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Connecticut Agricultural Experiment Station
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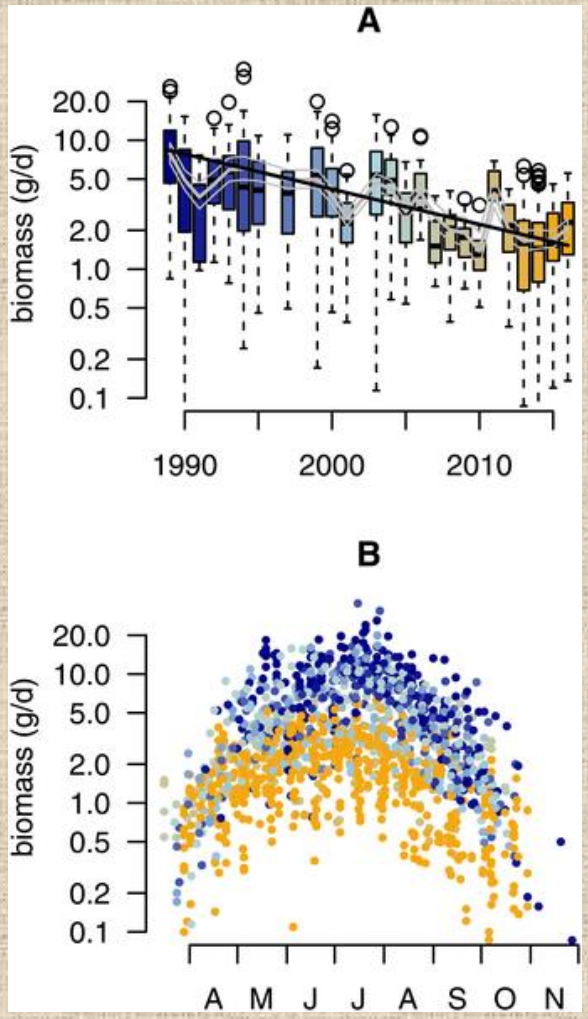
Context – “The Insect Apocalypse” – 75 % decline in insect biomass over 27 years in Germany

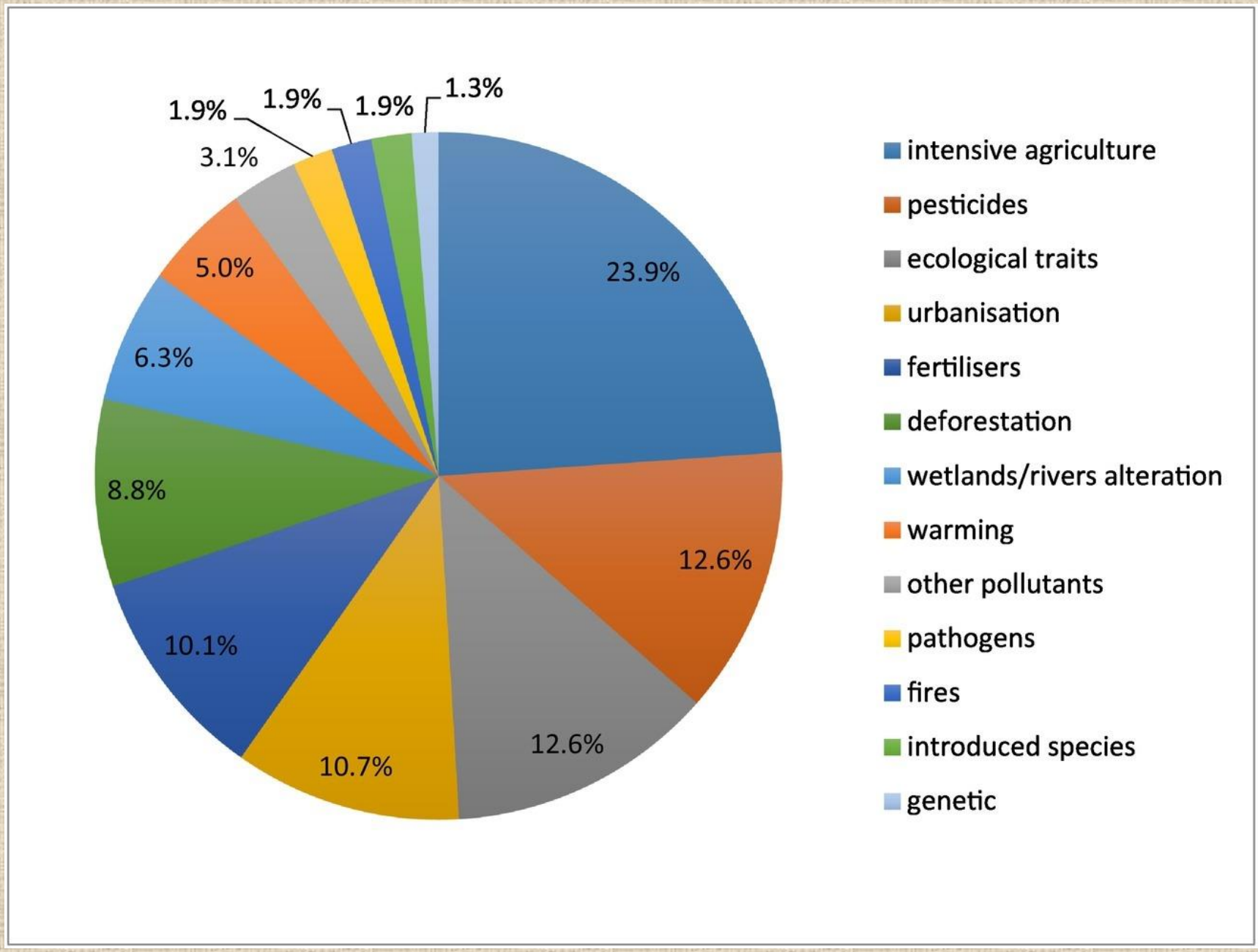


Hallmann CA, Sorg M, Jongejans E, Siepel H, Hofland N, et al. (2017) More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PLOS ONE 12(10): e0185809. https://doi.org/10.1371/journal.pone.0185809
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0185809

Worldwide decline of the entomofauna: A review of its drivers. Sanchez-Bayo &Wyckhuys. 2019.

Drivers of losses of species diversity and/or abundance of insects worldwide:

- Habitat loss and conversion to intensive agriculture and urbanization
- Pollution – mainly from pesticides and fertilizers
- Introduced pathogens and invasive species
- Climate change



Worldwide decline of the entomofauna: A review of its drivers.
Sanchez-Bayo & Wyckhuys. 2019.

Bee Diversity in Connecticut

- Bee species recorded in CT – 349 species
- 9 species are exotic, rest are native to US
- 1 species of honey bee (exotic, social)
- 16 species of bumble bees (native, social)
- 10 species of *Colletes* (cellophane bee, solitary)
- 20 species of *Osmia* (mason bees, solitary)
- 84 species of *Andrena* (digger bees, solitary)
- Over 91 species of sweat bees (*Halictus, Lasioglossum, Agapostemon, etc.*) most solitary, but some social
- Many other species, mostly solitary

Honey Bees – Live in hives, make nice hexagonal honey comb, store honey and pollen from one season to the next….
Native bees don’t do any of that.

Bumble Bees

Photo by Tracy Zarrillo

Bumble bee species are declining and being lost worldwide, due to:

- Spread of disease-causing organisms
  - From commercial bumble bees reared for agricultural pollination
  - From honey bee colonies infected with viruses
- Non-native commercial bumble bees for agricultural pollination escaping and displacing native species (not an issue here in the Northeast US)
- Loss of habitat
  - Flower-rich meadows, pasture, and early-successional habitat
  - Nesting areas, including holes made by other animals
- Widespread pesticide use, including insecticides, herbicides (removing flowering plants) and fungicides
- Climate change

Bumble bee species declining or increasing in Northeast

List from Bartomeus et al. 2013 (* = state listed species, ** = Federally listed species)

Bumble bee species declining in Northeast	First and most recent record in CT	Bumble bee species increasing in Northeast
Bombus affinis **	1904 - 1997	*Bombus bimaculatus*
Bombus ashtoni *	1905 - 1992	*Bombus citrinus*
Bombus auricomus	1905 - 1919	*Bombus griseocollis*
Bombus borealis	1932	*Bombus impatiens*
Bombus fernaldae	1911 - 2018	*Bombus perplexus*
Bombus fervidus	1904 - 2018	
Bombus pensylvanicus	1902 - 2006	**Stable bumble bee species**
Bombus ternarius	1914 - 2012	*Bombus sandersoni*
Bombus terricola *	1904 - 2018	
Bombus vagans	1904 - 2018	

Bumble Bee Life Cycle

In the early stages, the queen takes care of all nest duties

Nest Making (spring)

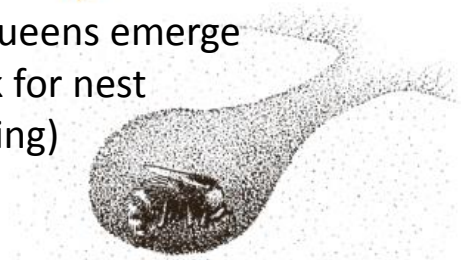
As the colony grows, the workers take over

Nest Development (summer)

At the end of the colony cycle, males and queens are produced

Queens and males (summer)

Mated queens emerge And look for nest Site (Spring)



Queen Hibernates (winter)

Queen Foraging (spring)

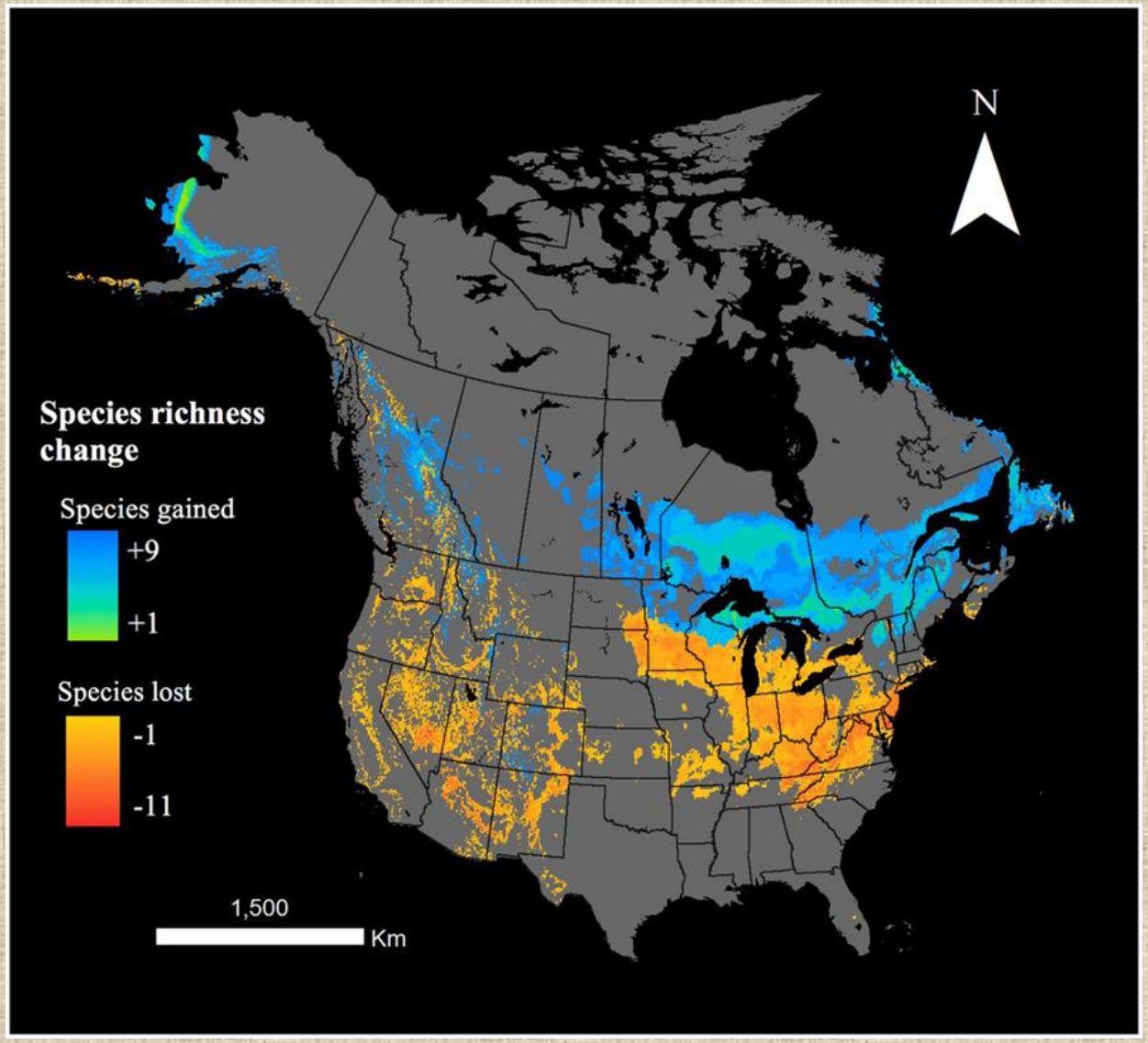
Managed bees (honey bees, commercial bumble bees, etc.) can increase disease susceptibility and/or transmission in wild bees

- Pathogens first found in honey bees, now found in bumble bees, some other bees (and even some wasps):
  - Deformed Wing Virus
  - Black Queen Cell Virus
  - Sacbrood Virus
  - Israeli Acute Paralysis Virus
  - *Nosema ceranae* (fungus)
  - Some, but not all, of these honey bee pathogens are known to replicate in bumble bees and affect bumble bee health
- Bumble bee pathogens – may have been spread by commercial bumble bee trade
  - *Nosema bombi* (fungus)
  - *Crithidia bombi* (protozoan)
  - *Apicystis bombi* (protozoan)
  - *Locustacarus buchneri* (bb-specific mite)

From Graystock et al 2015.

“Bumble bees crushed by climate change” – (Kerr et al. 2015 –*Science)*

- Study with 423,000 observations of 67 species of bumble bees in North America and Europe
- Compared historic range (before 1974) to new range (1999-2010).
- Found overall, bumble bee species retreated from their historic southern limit - often by hundreds of miles
- But, they did not significantly expand their ranges to the north
- Fastest known rate of dispersal for any bumble bee species is 10 km (6 miles) per year



Modeled gains and losses of bumble bee species based on changes in climate by 2070 (using projections of greenhouse gas concentrations from the reports of the International Panel on Climate Change)

Note this is projecting loss (or gain) of bumble bee species based **just** on climate change
(Not including habitat loss, disease spread, pesticides, etc.)

From Sirois-Delisle & Kerr. 2018. Climate change-driven losses among bumble bee species are poised to accelerate. Sci. Rep. 8: 14464.

Bumble bees more susceptible to pesticides than honey bees

- Honey bee queens never forage for their own food. The only time they leave the colony is for the mating flight. Then, they spend the rest of their lives protected by workers.
- Bumble bee queens forage in fall for both pollen and nectar, consume those resources over the winter, then forage again in spring. During nest incubation, a bb queen may consume her body weight in nectar each day
- Bumble bee colony survival, growth and reproduction also severely affected at much lower concentration of neonicotinoids than honey bee colonies

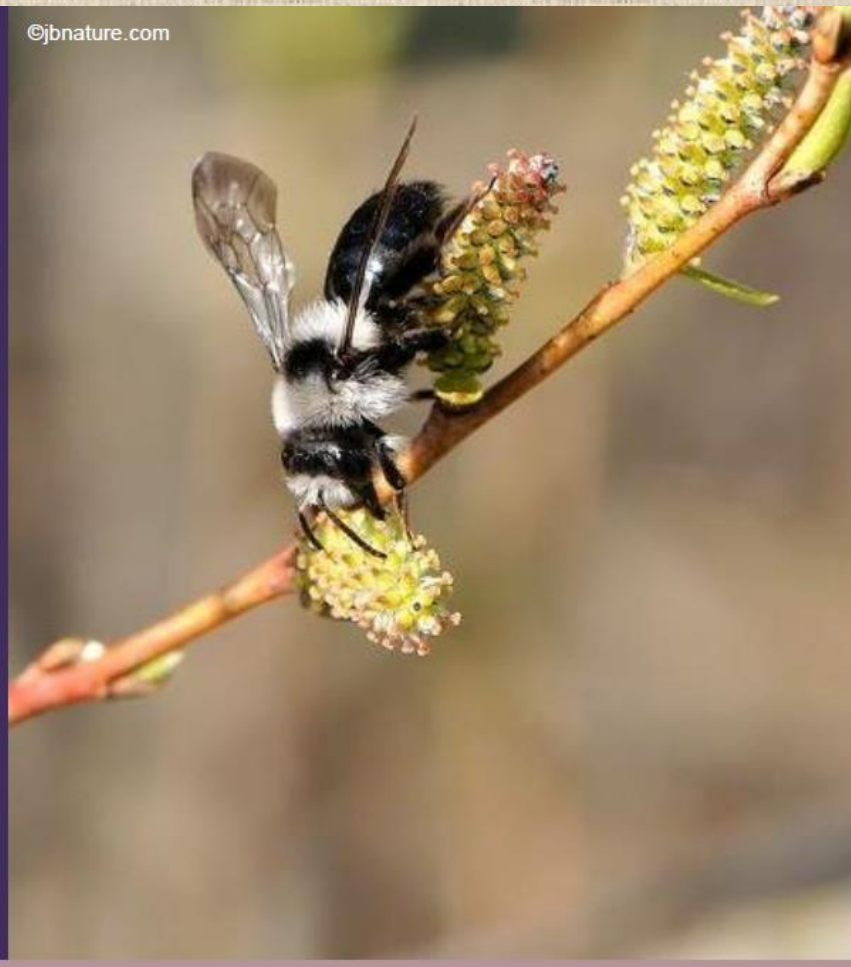
How much flower-rich habitat is enough for wild pollinators?

Answering a key policy question with incomplete knowledge

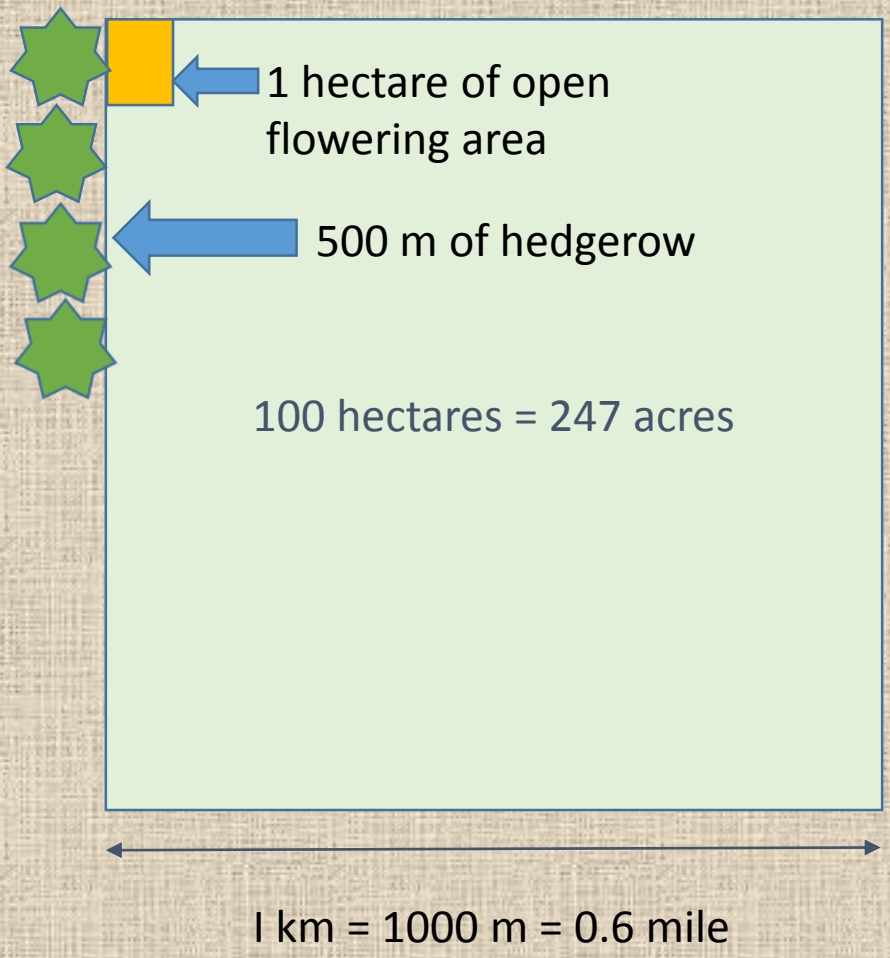
Lynn Dicks, University of East Anglia

Co-authors: Mathilde Baude, Stuart Roberts, James Phillips, Mike Green, Claire Carvell

7 December 2017, Copenhagen



Standard used for funding farmland habitat in UK pollinator habitat strategy



- 1-3 hectares per 100 hectares (or 1-3% of farmland) for flower-rich open land (meadows, flowering grasslands), AND
- 500 m – 2000 m of hedgerow (trees, shrubs) per 100 hectares of farmland

How effective are pollinator habitats in increasing bumble bee survival?

- Best study comes from these pollinator habitats in England (Carvell et al. 2017)
  - Measured survival of bumble bee family lineages over two years by genetic analysis for three bb species
  - Greatest positive effects were from the amount of each of these factors within 1000 m (0.6 mile) of nest
    - mixed semi-natural habitat,
    - flowers visited by spring queens
    - combination of flowers visited by queens in spring and workers in summer
  - Summer flowers alone did not increase family survival (but did in combination with spring flowers)
  - Nesting habitat alone did not increase family survival (but did increase the dispersal distance of queens – allowing them to move out into new suitable habitats)

Early season plants for queen bumble bees – from Massachusetts

- Rhododendron (*Rhododendron* spp.)
- American pussy willow (*Salix discolor*)
- Dogwood (*Cornus* spp.)
- American holly (*Ilex opaca*)
- Black cherry (*Prunus serotina*)
- Winterberry (*Ilex verticillata*)
- Black willow (*Salix nigra*)
- Beach plum (*Prunus maritima*)
- Beard tongue (*Penstemon* spp.)
- Southern arrowwood (*Viburnum dentatum*)
- Swamp rose (*Rosa palustris*)
- Lowbush blueberry (*Vaccinium angustifolium*)

From Couto, A.V. and A.L. Averill, A Review on Bees, Northeast Crops Edition

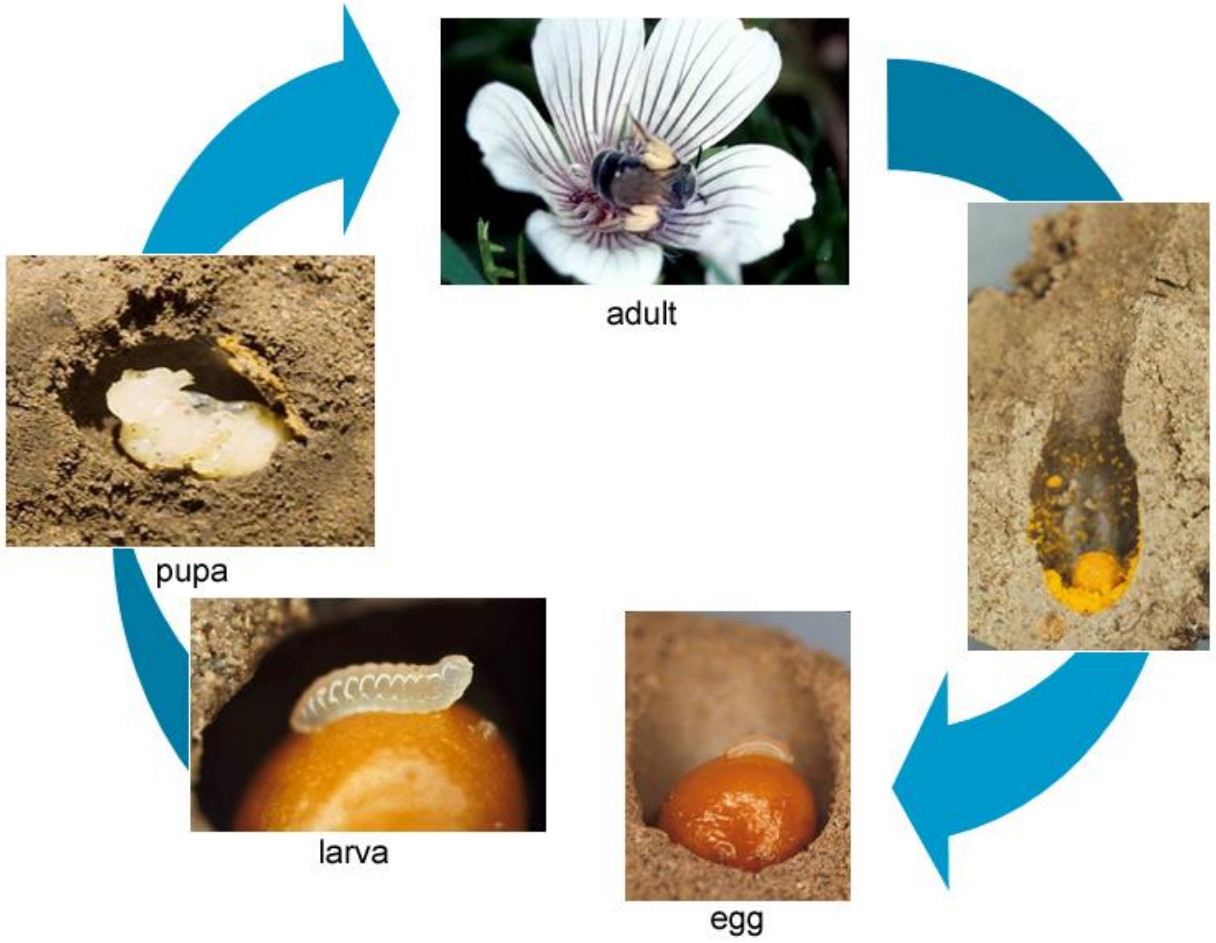
Pollen drives growth and reproduction in commercial colonies of common eastern bumble bee

- *Bombus impatiens* (common eastern bumble bee) colonies maintained a protein: lipid ratio in pollen averaging 4:1 over the season, regardless of whether the colony was in forest, on the edge of the forest, or in open (mixed agricultural) habitats
- However, the amount of pollen collected varied tremendously with habitat, with greatest pollen collection in the mixed agricultural habitat
- Colonies in the forest did not reproduce. Those in the mixed agricultural habitat produced 3 X as many reproductives (males and queens) as those on the forest edge (Vaudo et al. 2018)

What do bumble bees need?

- Sources of nectar – most critical early in the season when queens are establishing nests and incubating larvae, and late in season when new queens are bulking up for winter hibernation
- Sources of nutritious pollen – important throughout the season, in order to raise workers and then males and queens. Protein, sterols and other lipids are important.
- Nesting habitat – preferred habitat varies by species. Mostly underground. Some species nest in forests, others in open habitats
- Overwintering habitat for queens – little is known about this because overwintering queens have mostly been discovered by accident
- Protection from pesticides

Life Cycle of Solitary Bees

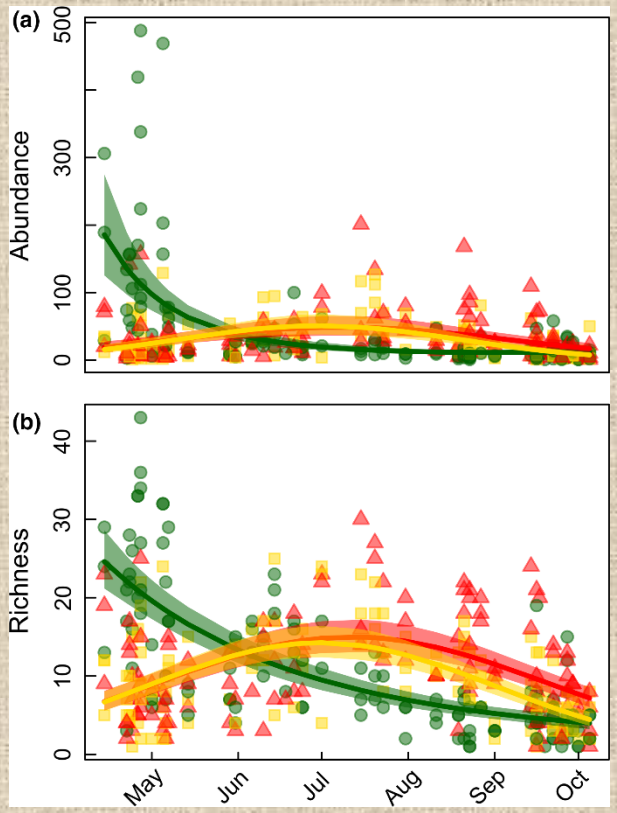


www.xerces.org/nativebees

What do solitary bees need?

- Pollen – Some species are specialists and collect pollen from a only particular genus, or a few genera. Other species are generalists and will collect pollen on a wide range of plants in bloom during the short time they are active. Some are generalists with strong preferences.
- Nectar – Source of energy, but can't store as honey. Less important for these bees than for honey bees
- Nesting sites – mostly ground nesting, need patches of undisturbed soil. Others nest in hollow stems, holes in wood, gravelly areas
- Short season of activity – 6 to 8 weeks. Spend the rest of the year in nest (larval development, pupation, in some species adult dormancy)

Forest bees are replaced in agricultural and urban landscapes by native species with different phenologies and life-history traits - Harrison et al. , 2017.



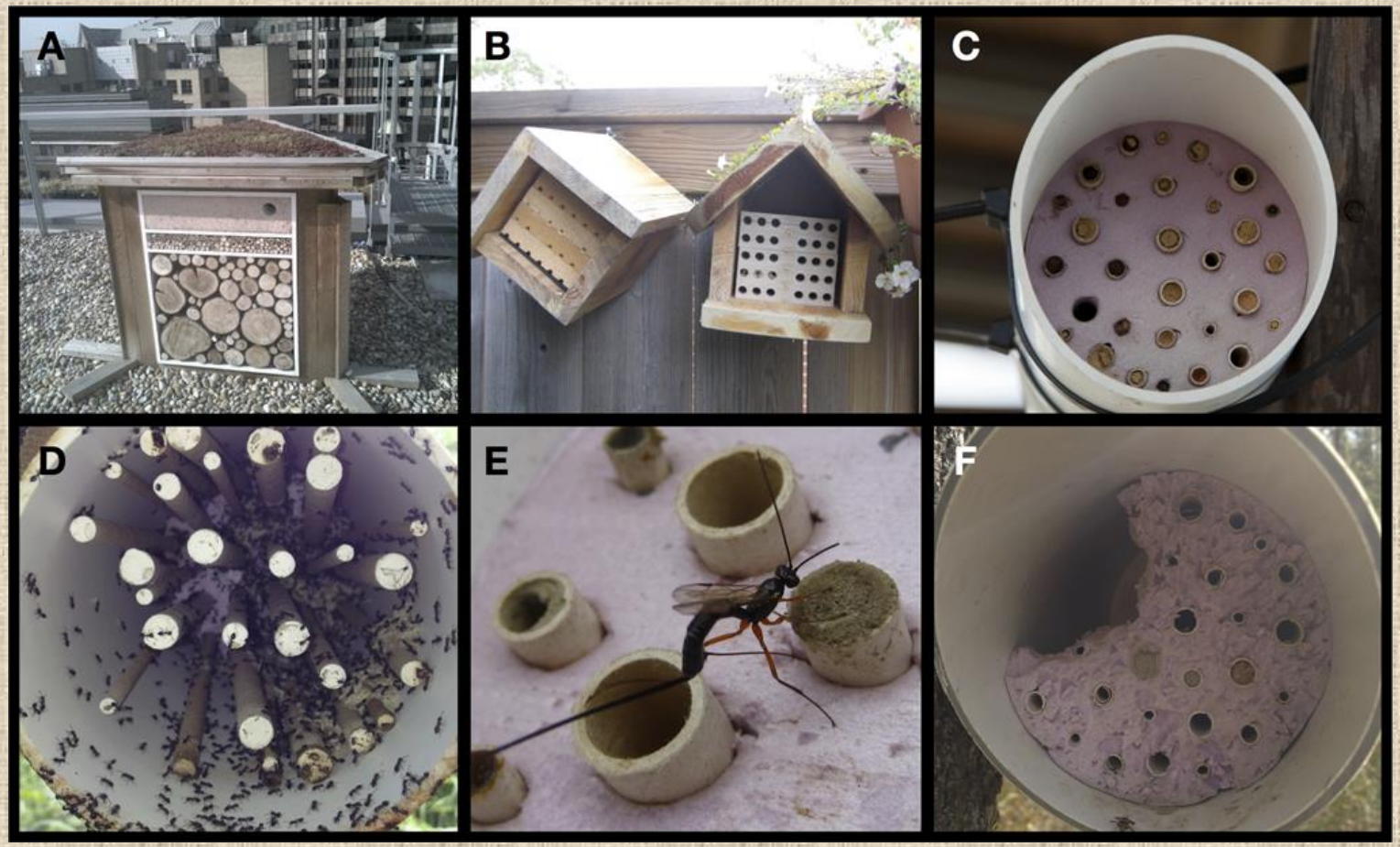
Forest bees (green) are as diverse and abundant as bees in agriculture (yellow) or urban areas (red). Forest bees are more often spring fliers, wood & cavity nesters, and solitary compared to ag and urban bees.

Global Change Biology, Volume: 24, Issue: 1, Pages: 287-296, First published: 04 October 2017, DOI: (10.1111/gcb.13921)

Some solitary bees are specialists – feeding their larvae only certain kinds of pollen

Squash bee female , *Peponapis pruinosa,* on male pumpkin flower

Bee hotels – Do they really benefit native bees? Not clear. Could be a focus for disease, parasites, or predators.



MacIvor & Packer. 2015. “Bee Hotels” as tools for native pollinator conservation: A premature verdict? PLoS ONE 10(3): e0122126. doi:10.1371/journal.pone.0122126

Solitary bees need pollen to feed their larvae and also to reproduce

- Pollen mixed with nectar are provided by the female to each egg she lays. Pollen provides the nutrients for larval development.
- Eggs of solitary bees are enormous compared to the size of the bee. Without adequate pollen feeding as an adult, a solitary bee will resorb her eggs without reproducing.
- Because the eggs are so large, a solitary female can produce only 1-2 eggs per day. Delay due to lack of pollen reduces total reproduction, because she lives only a few weeks as an adult.

Are wild bees other than bumble bees in decline?

- Statistical analysis of museum collections have indicated some species that may be in decline in the Northeast. Similar studies have shown loss of species diversity in Europe.
- We don’t have enough long-term data on abundance to know, really, for here in the Northeast.
- Many states – including Connecticut! – are working on checklists of species and comparing currently collected species with historical records

Citizen Science: How you can contribute

- Best way is to work with existing Citizen Science platforms, such as:
- www.Bumblebeewatch.org
- www.inaturalist.org

https://www.inaturalist.org

Apps | Hourly Weather Fore | Google Scholar | The Connecticut Agri | New Haven, CT 10-D | Suggested Sites | Files - Dropbox | Find every public cha | New Tab | CAES: Entomology | spinetoram | Bee vs. Wasp Nest Id

iNaturalist | Explore | Community | More

How It Works

1 Record your observations

2 Share with fellow naturalists

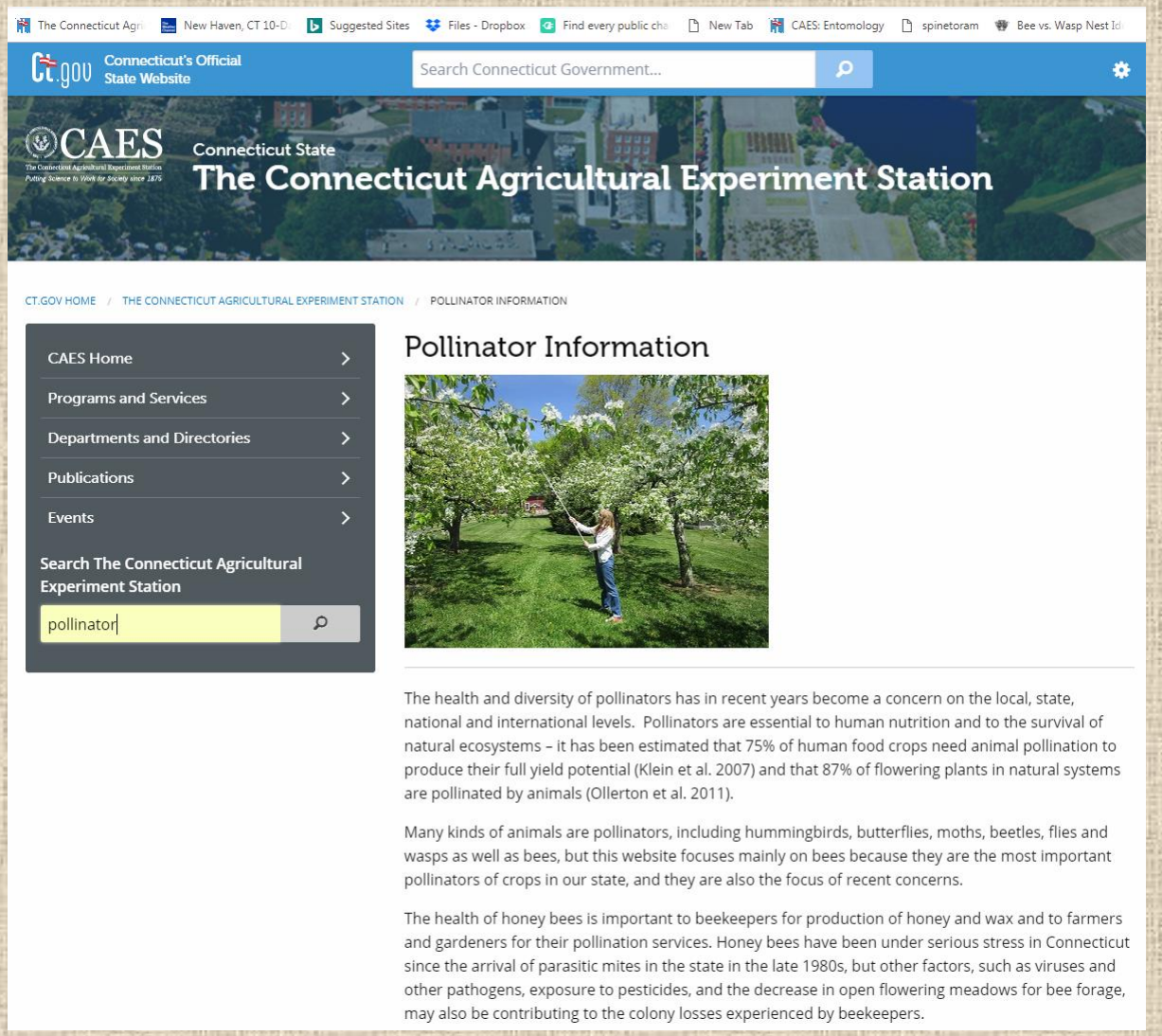
3 Discuss your findings

Advantages of joining an existing platform for bee monitoring

- Collecting photos rather than specimens. People are reluctant to kill bees. Specimens take considerable time to process, pin, label, identify, and enter into databases.
- Expert identification through crowd-sourcing real time. World-renowned bee experts identify bees from photos in i-naturalist.
- Data availability to experts. The experts make these ids because they can make discoveries (range extensions, new records of rare bees of concern…) without having to physically collect and process the bees themselves.

More information on the CAES website
www.ct.gov/caes/pollinators

Or go to the website and put "pollinator" in the search box



Tracy Zarrillo

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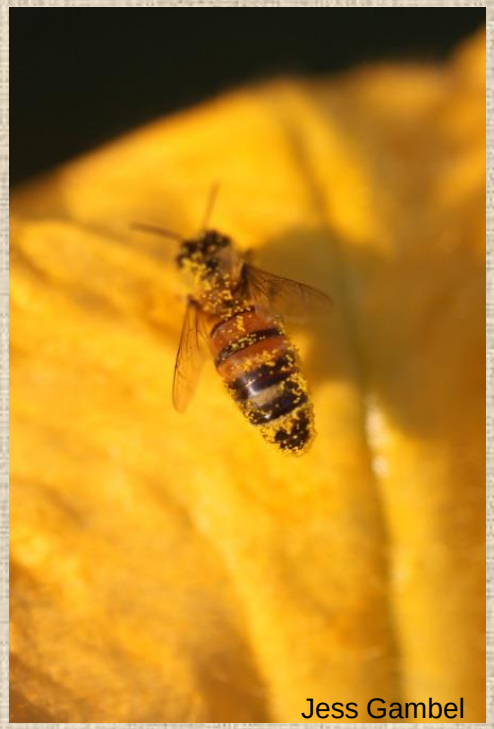

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