Honeybees, CCD, and the importance of wild bees for orchard pollination

Bryan N. Danforth, Mia Park, EJ Blitzer, Jason Gibbs, Laura Russo

Department of Entomology, Cornell University, Ithaca, NY 14853
Website: http://www.danforthlab.entomology.cornell.edu/
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USDA

Cornell University
Cooperative Extension

CORNELL

Outline

Honeybees and CCD

- Symptoms of “CCD”
- Historical perspectives on CCD
- Most likely causes of honey bee declines
- What we really know about honey bee declines

Native bees

- Native bee diversity and abundance in apple orchards
- Drivers of diversity/abundance
- Native bee pollinator effectiveness
- What you can do…
- What **we** can do **together**

Tuesday 13 March 2012

The Telegraph

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Study finds causes of Colony Collapse Disorder in bees

A major investigation into a deadly threat to the honeybee has identified two common infections working together as the cause. Ian Douglas reports

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powered by one spot

New suspect in bee colony collapse disorder [Life Lines]

(Posted on ScienceBlogs : Combined Feed at Wed, Jan 04, 2012 at 08:26PM)

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Mobile Phones and Dying Bees

By Holger Dambeck

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Survey: 36% of bee hives lost in U.S.

Updated 5/7/2008 2:57 PM | Comments 105 | Recommend 40

Enlarge By J. Pat Carter, AP

By Juliana Barbassa, Associated Press

SAN FRANCISCO — A survey of bee health released Tuesday revealed a grim picture, with 36.1% of the nation's commercially managed hives lost since last year.

Last year's survey commissioned by the Apiary Inspectors of America found losses of about 32%.

As beekeepers travel with their hives this spring to pollinate crops around the country, it's clear the insects are buckling under the weight of new diseases, pesticide drift and old enemies like the parasitic varroa mite,

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ROOM for DEBATE

September 2, 2009, 7:36 PM

Saving Bees: What We Know Now

By THE EDITORS

Colony collapse disorder (CCD)

Colony collapse disorder (CCD)

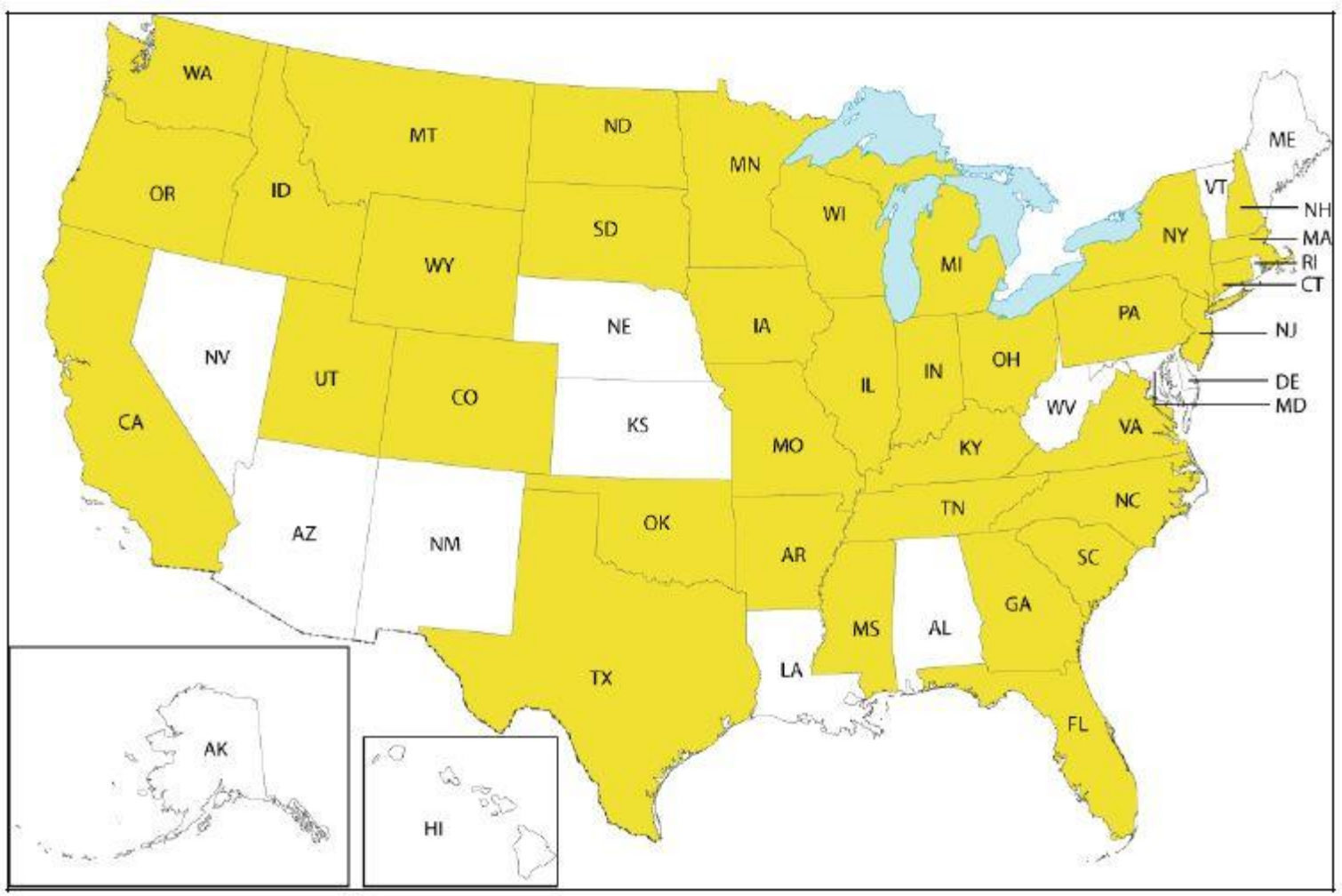
Symptoms:

Bee keepers would find colonies with no resident adult workers. Only the queen and young brood would be present.

All the adult worker bees appear to have dispersed or died.

Comb from abandoned hive
http://www.waldeneffect.org/

Colony collapse disorder (CCD)



States reporting CCD-like symptoms in 2007/2008
http://www.earthlyissues.com/

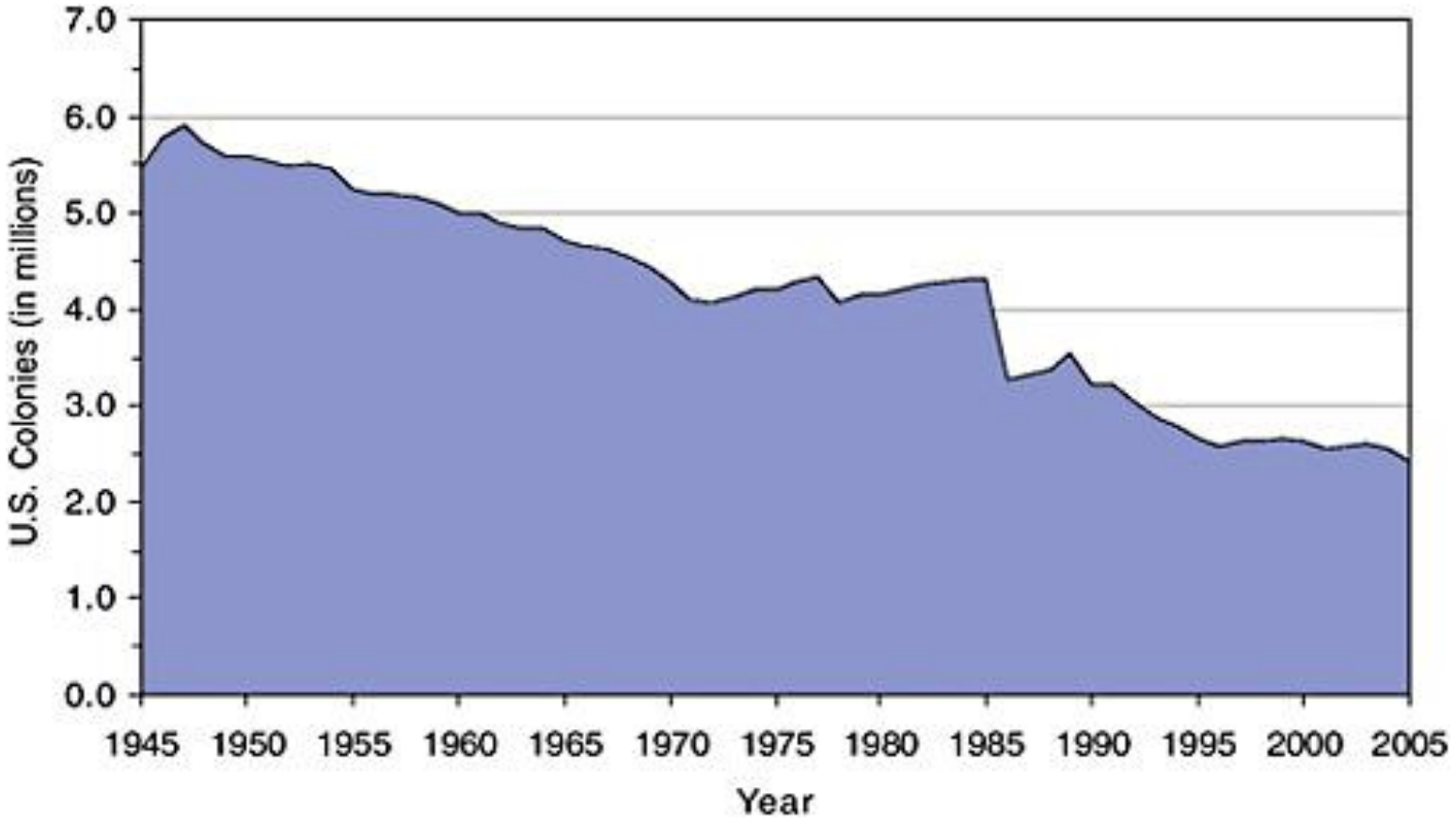
Colony collapse disorder (CCD)

Historical precedence: Reports of “spring dwindling” and “disappearing disease” go back over 1000 years.

950 (Ireland) – “great mortality of bees”
992 (Ireland) – “great mortality of bees”
1443 (Ireland) – “great mortality of bees”
1906 (Isle of Wight, UK) – all colonies died off
1903 (Cache Valley, UT) – “disappearing disease”
1995 (Pennsylvania) – 53% of colonies died

In 2007 colony losses ranged from 50% - 100%

Colony collapse disorder (CCD)



From: National Academy of Sciences (2005). *Status of Pollinators in North America*.

Colony collapse disorder (CCD)

The most likely cause(s):

- Pathogens and parasites
- Pesticides including insecticides, fungicides, and possibly inert ingredients
- Migratory beekeeping and long-distance transport of colonies, especially to almond orchards in the Central Valley of CA
- “Synergistic” (i.e., *sublethal*) effects

Pathogens and parasites

Microsporidia:

Nosema (*Nosema apis*) – 2005 arrived in US

Bacteria:

Foul brood (*Paenibacillus larvae*) -- 1906

Fungi:

Chalkbrood (*Ascosphaera apis*) – 1968

Parasites:

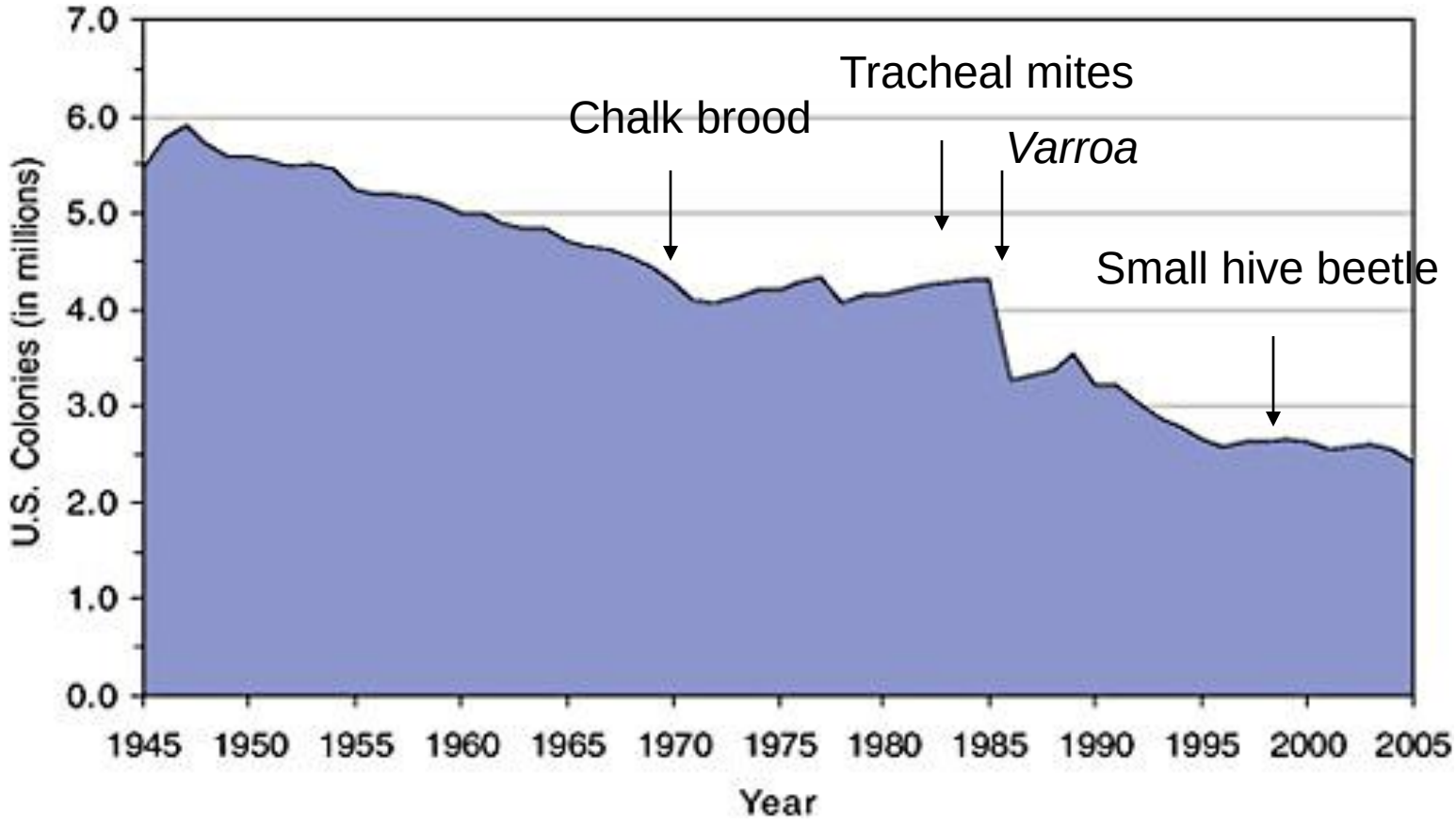
Varroa mites (*Varroa destructor*) -- 1987
Tracheal mites (*Acarapis woodi*) -- 1984
Small hive beetle (*Aethina tumida*) – 1998

Chalkbrood infected cells
http://www.egofelix.com/

Viruses: deformed wing virus, black queen cell virus, sacbrood virus, Kashmir bee virus, acute bee paralysis virus, chronic bee paralysis virus, and Israeli acute paralysis virus

http://www.caes.uga.edu/departments/ent/bees/index.html

Pathogens and parasites



From: National Academy of Sciences (2005). *Status of Pollinators in North America*.

Pathogens and parasites

Varroa mites (*Varroa destructor*)
Introduced into US in 1987; origin: southeast Asian species of honey bee (*Apis cerana*)

Pesticides

OPEN ACCESS Freely available online

PLoS one

High Levels of Miticides and Agrochemicals in North American Apiaries: Implications for Honey Bee Health

Christopher A. Mullin[1]*, Maryann Frazier[1], James L. Frazier[1], Sara Ashcraft[1], Roger Simonds[2], Dennis vanEngelsdorp[3], Jeffery S. Pettis[4]

1 Department of Entomology, The Pennsylvania State University, University Park, Pennsylvania, United States of America, 2 National Science Laboratory, United States Department of Agriculture - Agricultural Marketing Service, Gastonia, North Carolina, United States of America, 3 Pennsylvania Department of Agriculture, Harrisburg, Pennsylvania, United States of America, 4 Bee Research Laboratory, United States Department of Agriculture - Agricultural Research Service, Beltsville, Maryland, United States of America

121 different pesticides detected in pollen and wax samples taken from honey bee colonies in Pennsylvania, Florida, and California.

<u>Most common</u>:

- ❑ Acaricides (fluvalinate, coumaphos)
- ❑ Insecticides (aldicarb, carbaryl, chlorpyrifos, imidacloprid)
- ❑ Fungicides (chlorothalonil, boscalid, captan, myclobutanil)
- ❑ Herbicides (pendimethalin)

Pesticides – neonics?

50 YEARS WITH IMPACT

Journal of Applied Ecology

British Ecological Society

Journal of Applied Ecology 2013

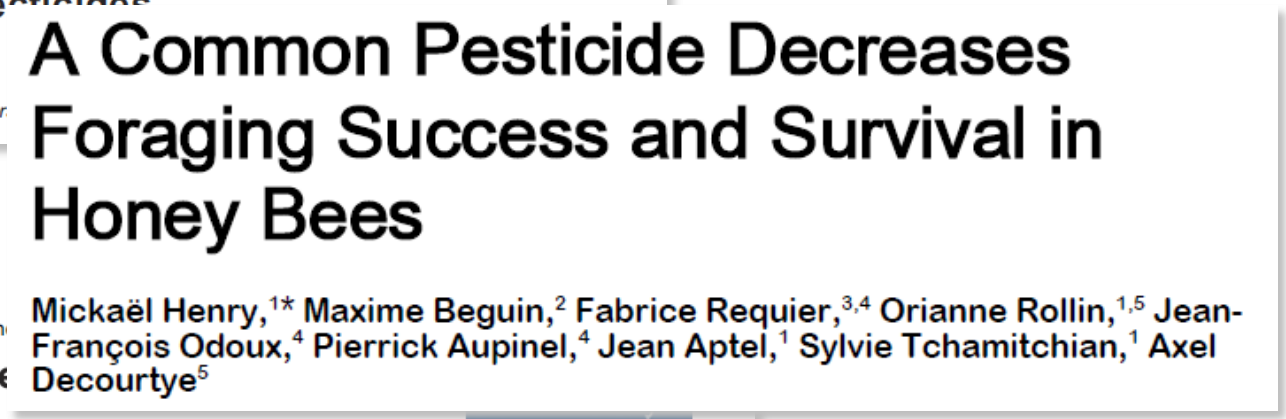
doi: 10.1111/1365-2664.12111

REVIEW

An overview of the environmental risks posed by neonicotinoid insecticides

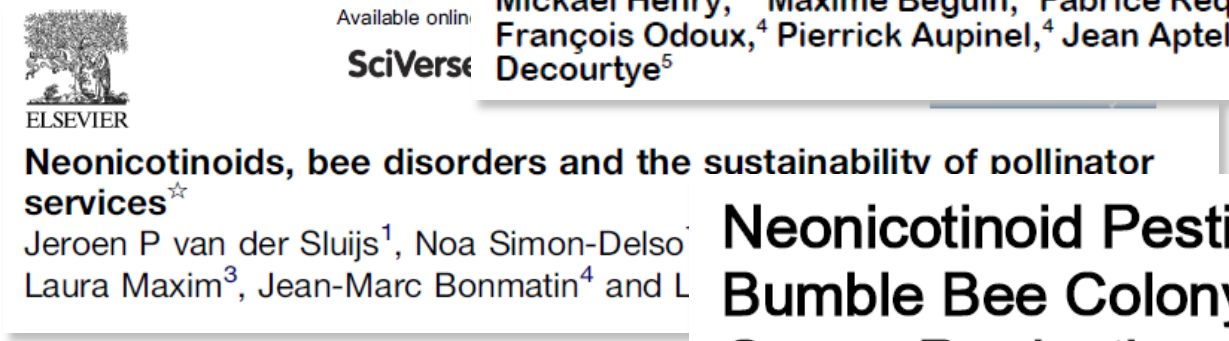
Dave Goulson

Biological and Environmental Sciences, Univer



A Common Pesticide Decreases Foraging Success and Survival in Honey Bees

Mickaël Henry,[1]* Maxime Beguin,[2] Fabrice Requier,[3,4] Orianne Rollin,[1,5] Jean-François Odoux,[4] Pierrick Aupinel,[4] Jean Aptel,[1] Sylvie Tchamitchian,[1] Axel Decourtye[5]



ELSEVIER

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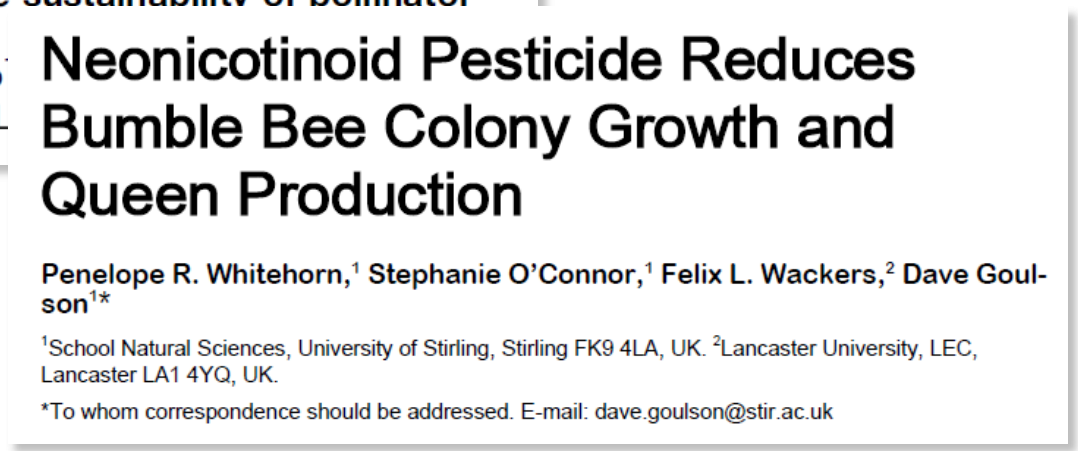
Neonicotinoids, bee disorders and the sustainability of pollinator services☆

Jeroen P van der Sluijs[1], Noa Simon-Delso

Laura Maxim[3], Jean-Marc Bonmatin[4] and L



Neonicotinoid Pesticide Reduces Bumble Bee Colony Growth and Queen Production

Penelope R. Whitehorn,[1] Stephanie O'Connor,[1] Felix L. Wackers,[2] Dave Goulson[1]*

[1]School Natural Sciences, University of Stirling, Stirling FK9 4LA, UK. [2]Lancaster University, LEC, Lancaster LA1 4YQ, UK.

*To whom correspondence should be addressed. E-mail: dave.goulson@stir.ac.uk

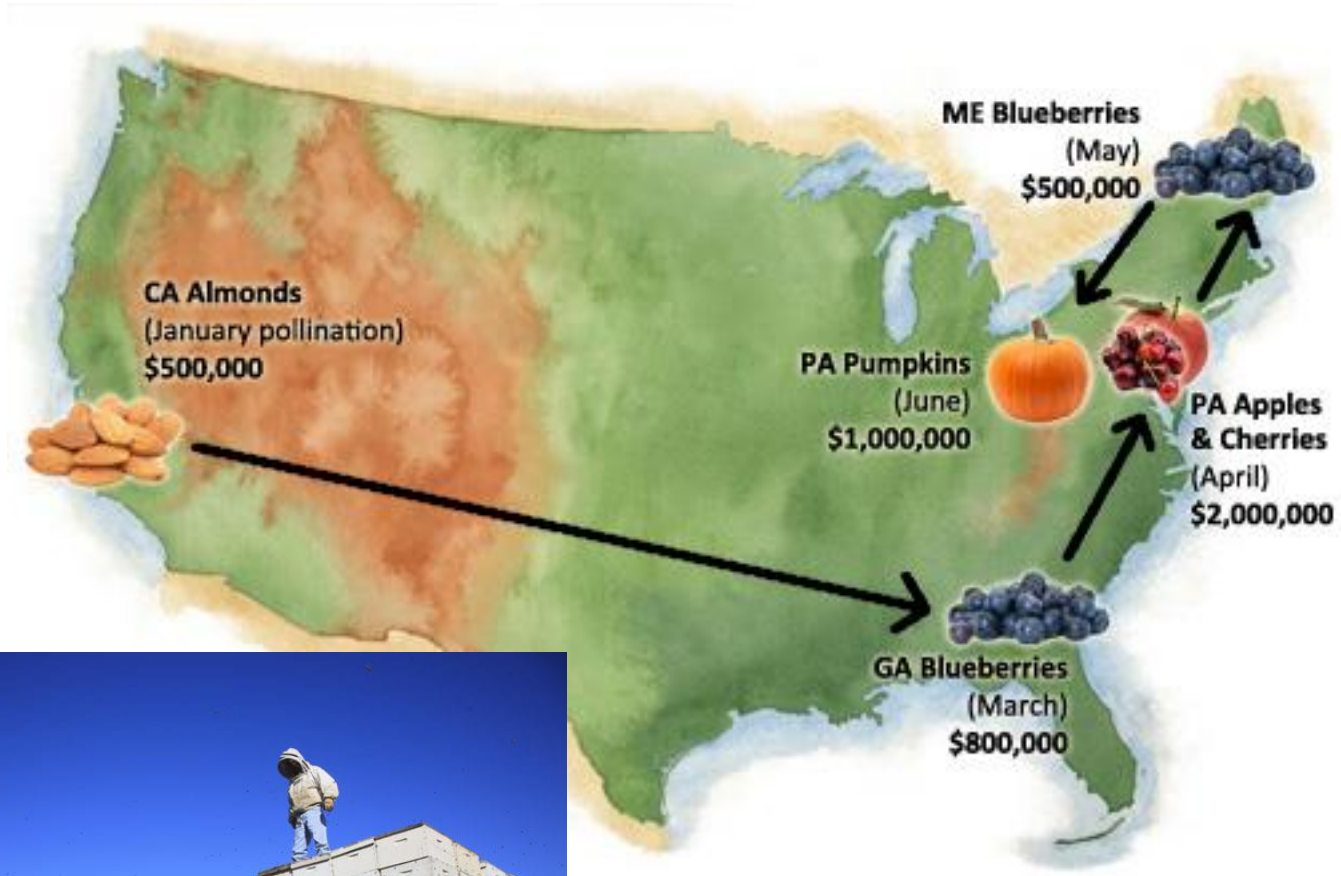
Pesticides -- neonics

Some potential problems with neonicotinoid pesticides:

- ❑ High toxicity (10,000 x more toxic than DDT)
- ❑ Water soluble so they can accumulate in ground and surface water
- ❑ Can be taken up by root systems of non-target plants
- ❑ Are expressed in all plant tissues
- ❑ Long term persistence (=years)
- ❑ Sublethal effects on pollinators include:
    1. Impaired foraging and navigation
    2. Impaired larval development
    3. Reduced colony growth

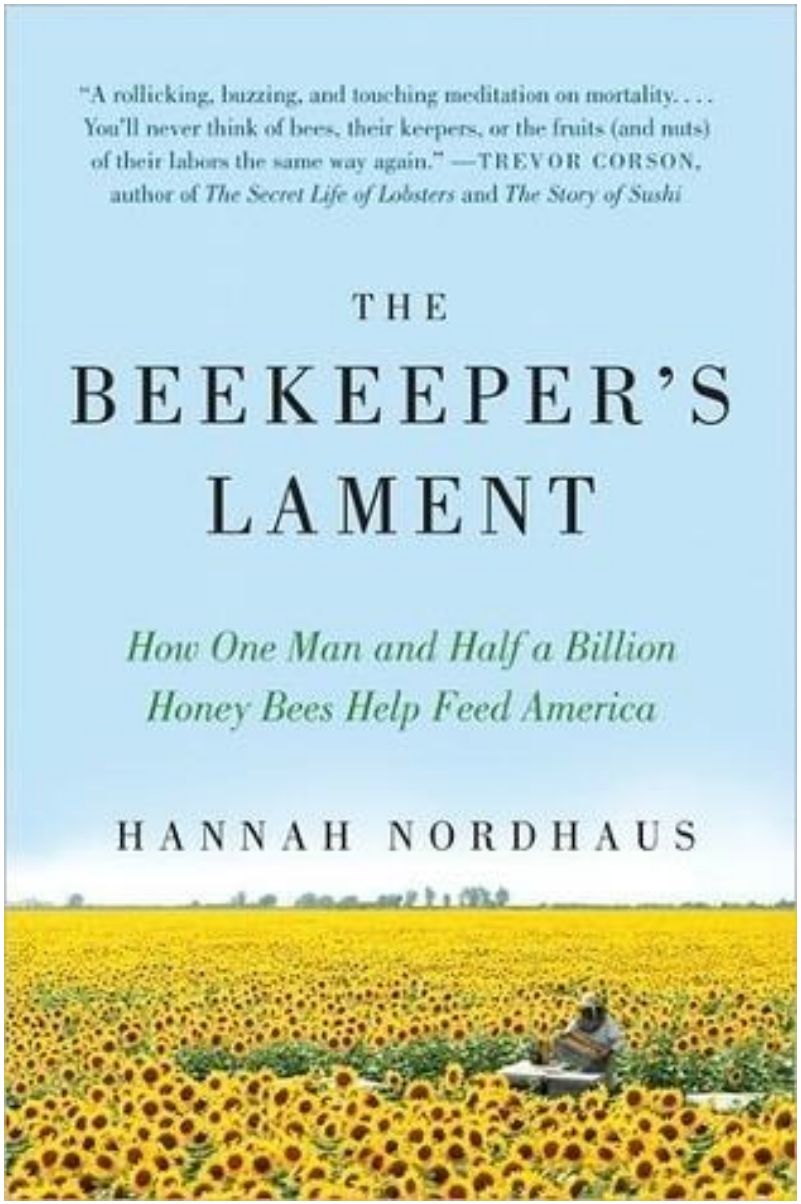
For more information: http://www.xerces.org/neonicotinoids-and-bees/

Migratory beekeeping



Estimate: 1/3 of all US bee hives are moved to CA in the early spring for almond pollination!

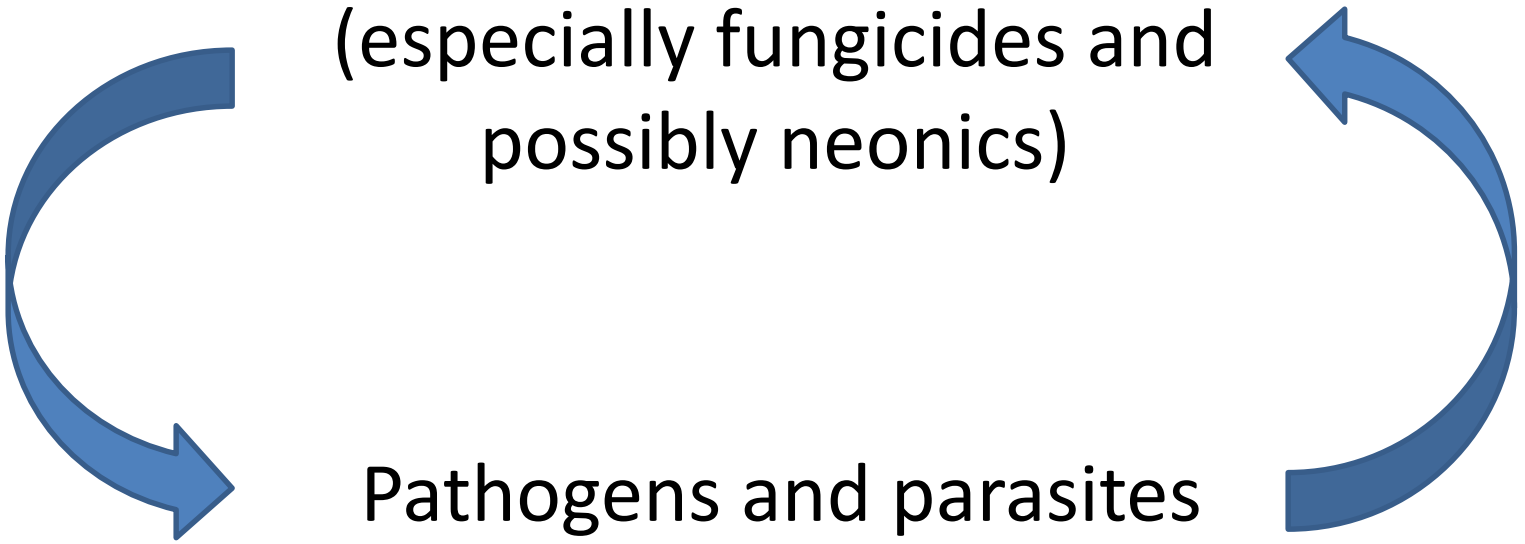
Migratory beekeeping



Winter reading?

The Beekeeper's Lament
Hannah Nordhaus
2010

“Synergistic” (=sublethal) effects



“Synergistic” (=sublethal) effects

OPEN ACCESS Freely available online

PLOS | ONE

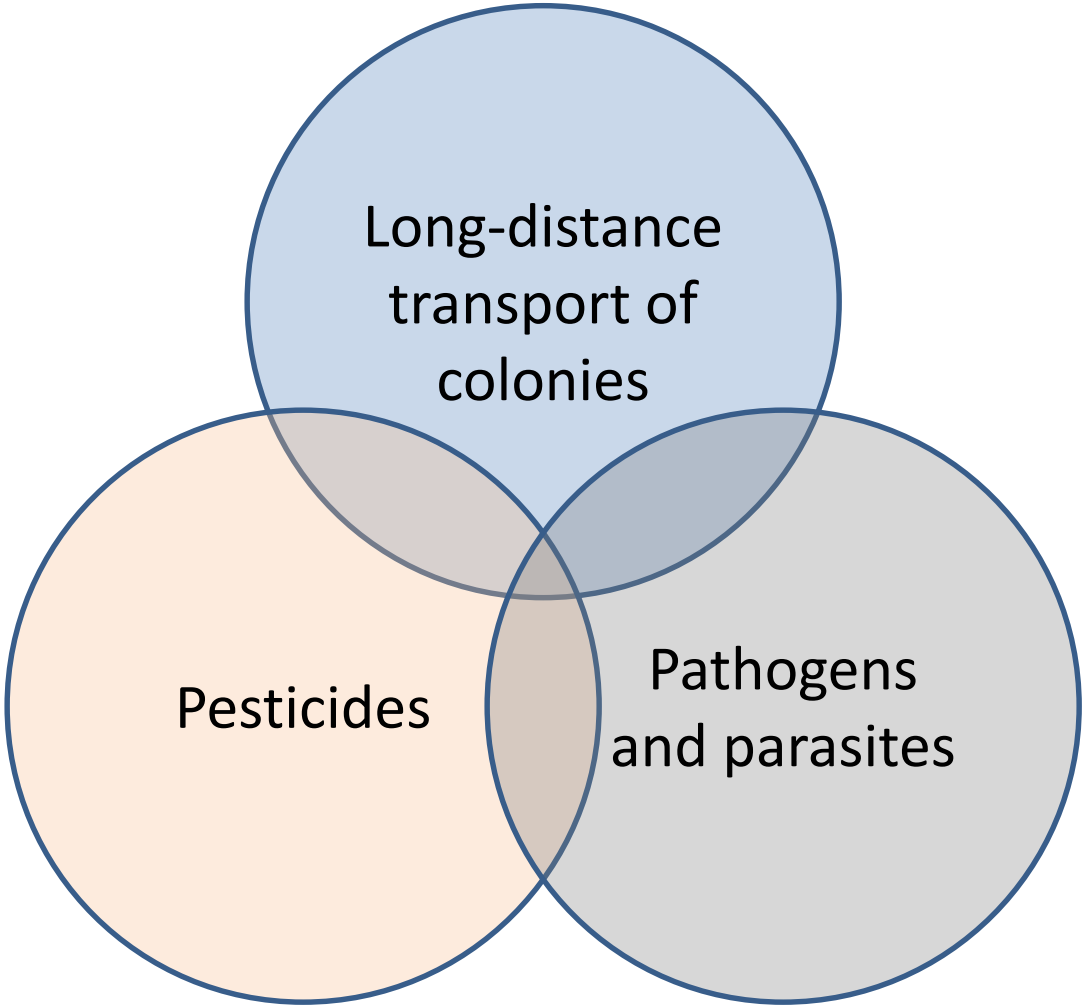
Crop Pollination Exposes Honey Bees to Pesticides Which Alters Their Susceptibility to the Gut Pathogen *Nosema ceranae*

Jeffery S. Pettis[1], Elinor M. Lichtenberg[2], Michael Andree[3], Jennie Stitzinger[2], Robyn Rose[4], Dennis vanEngelsdorp[2]*

1 Bee Research Laboratory, USDA-ARS, Beltsville, Maryland, United States of America, **2** Department of Entomology, University of Maryland, College Park, College Park, Maryland, United States of America, **3** Cooperative Extension Butte County, University of California, Oroville, California, United States of America, **4** USDA-APHIS, Riverdale, Maryland, United States of America

“While fungicides are typically seen as fairly safe for honey bees, we found an increased probability of Nosema infection in bees that consumed pollen with a higher fungicide load. Our results highlight a need for research on sub-lethal effects of fungicides and other chemicals that bees placed in an agricultural setting are exposed to.”

“Synergistic” (=sublethal) effects



A bad combination…. and none of these problems are going away

Native bees

Thank you!

Ithaca:
Barbara Reynolds
Brayton Foster
Dennis Hartley
Eric Shatt
Reenie Sandsted
Joanna Cornell
Susan Grisamore
Steve Cummins
Brian Caldwell
John Bokaer-Smith
Ian & Jackie Merwin

Wayne County:
Doug Mason
Steve Knapp
Gary & Stephanie Craft
Rob Perkins
Paul Wafler
Kendra Burnap
Ron DeBadts
Chris Hance
Lou Walker
Richard Endres
Brian Bartleson
Bob DeBadts
Ken Simpelaar

Geneva:
Brian Nicholson

Syracuse:
Walt Blackler

Watkins Glen:
Rick Reisinger

… plus Mike Biltonen and Jim Eve!

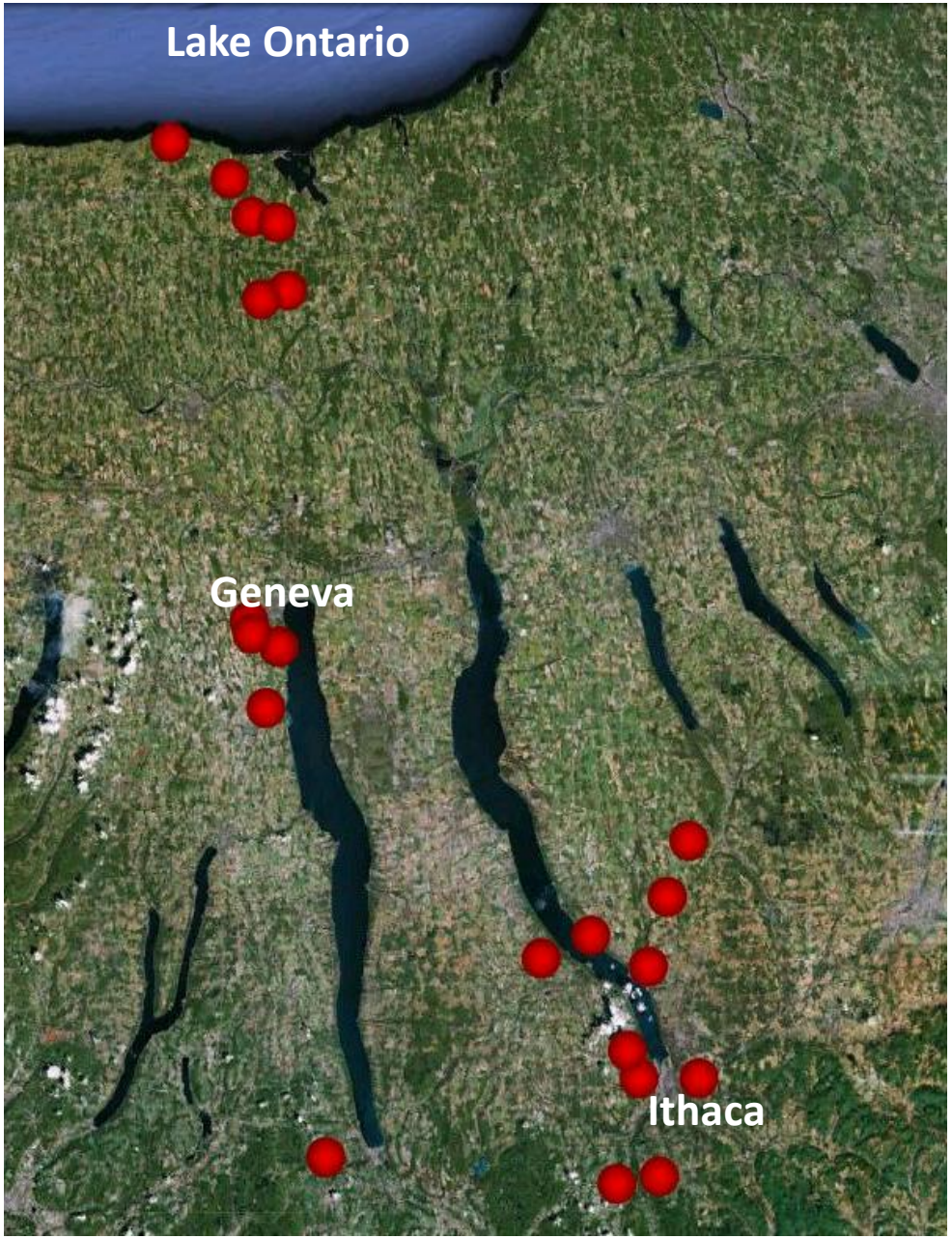
1. Native bee diversity and abundance

orchard surveys

- 2009-2014, 21 farms intensively surveyed
- honey and wild bees collected in 15min standardized transects

- local scale
  - farm size
  - management

- landscape scale
  - % natural area
  - % apple
  - % other agriculture

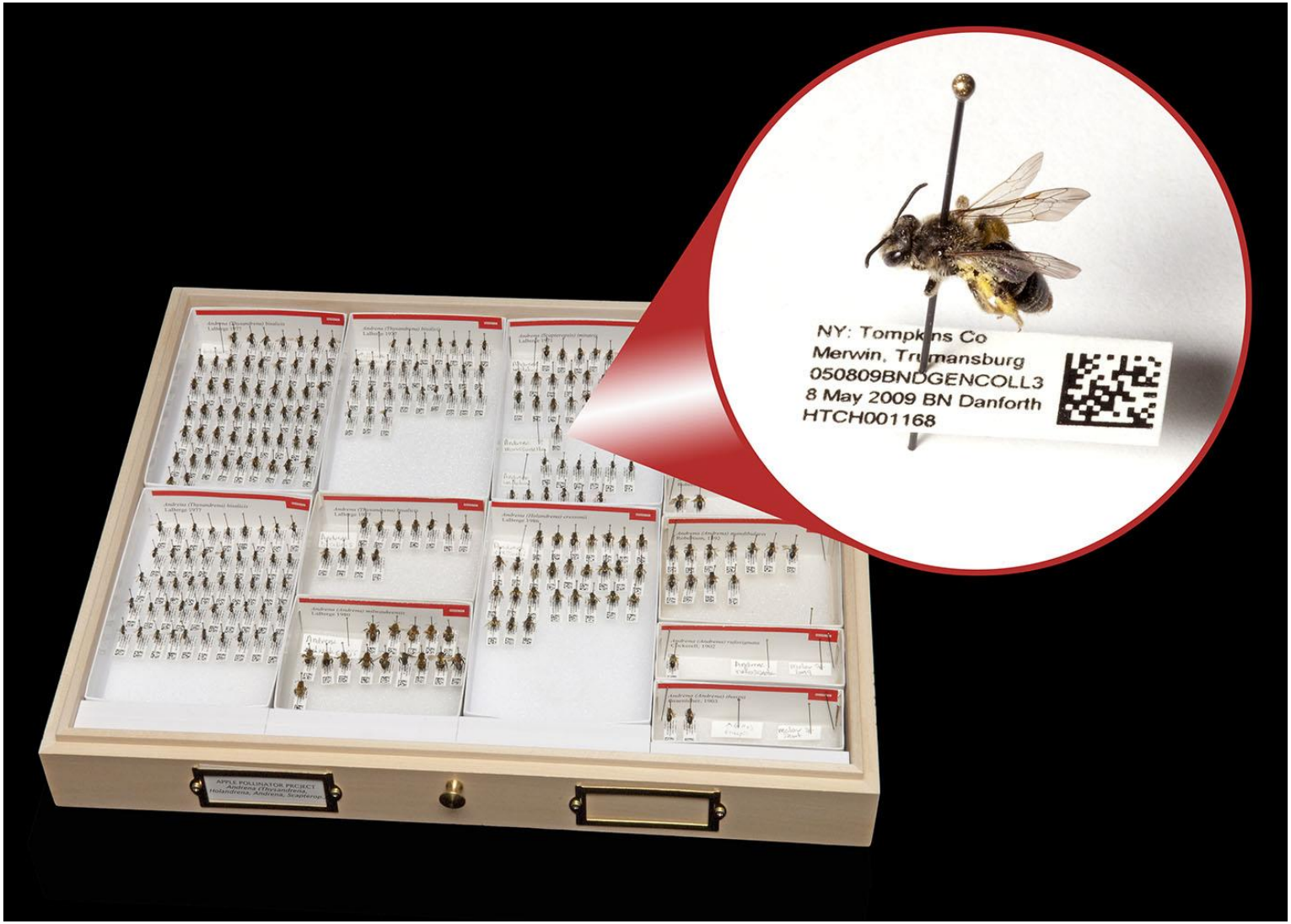


1. Native bee diversity and abundance

orchard surveys

- Collect (aerial netting)
  - 1. “General” collecting
  - 2. “Time trials”
- Label and barcode
- Identify to species
- Database (Biota)
- ~3000 specimens per year

1. Native bee diversity and abundance



CUIC as a resource for biodiversity studies

1. Native bee diversity and abundance

Results: Bee community

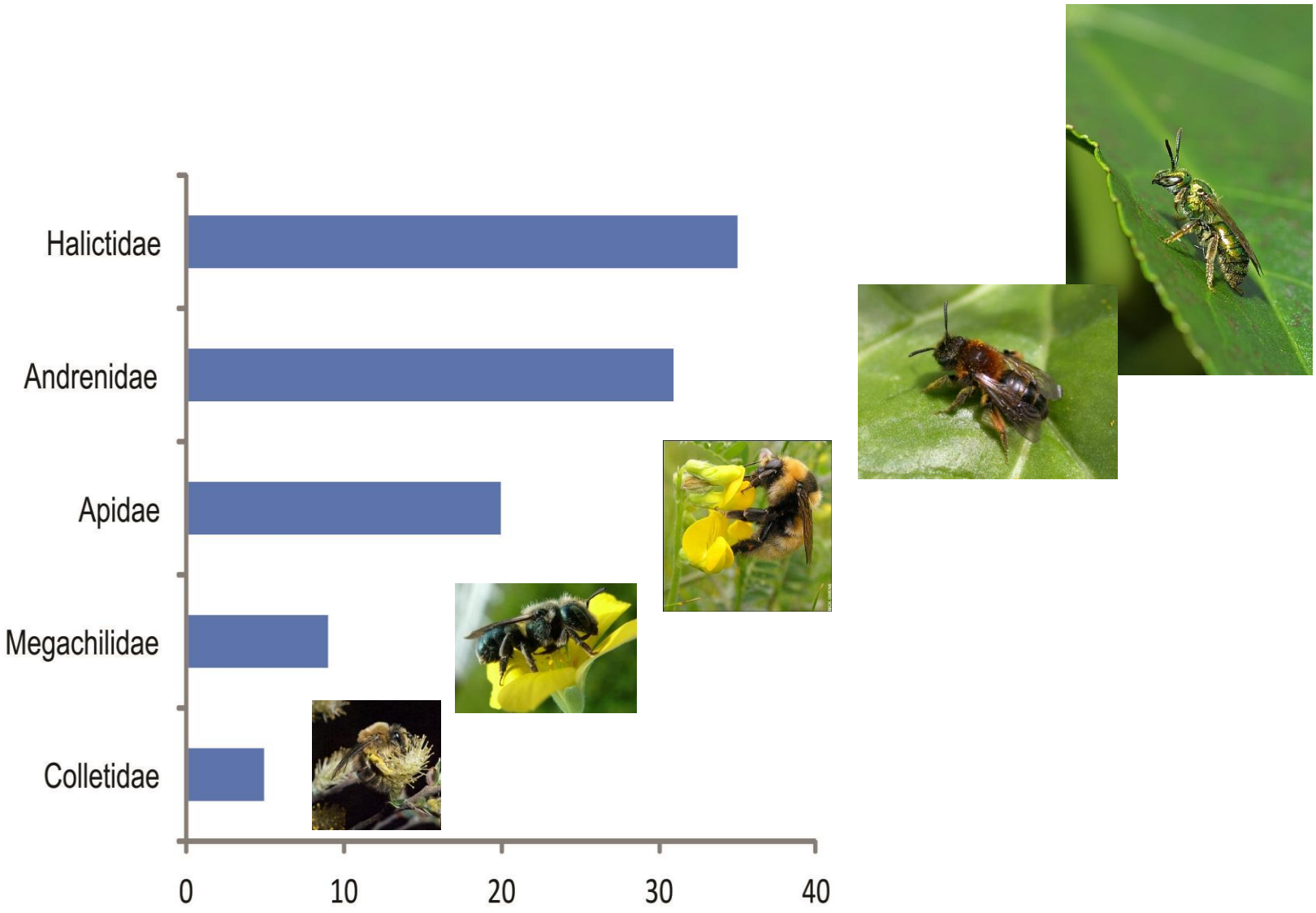
Total number species:

Please take a guess….

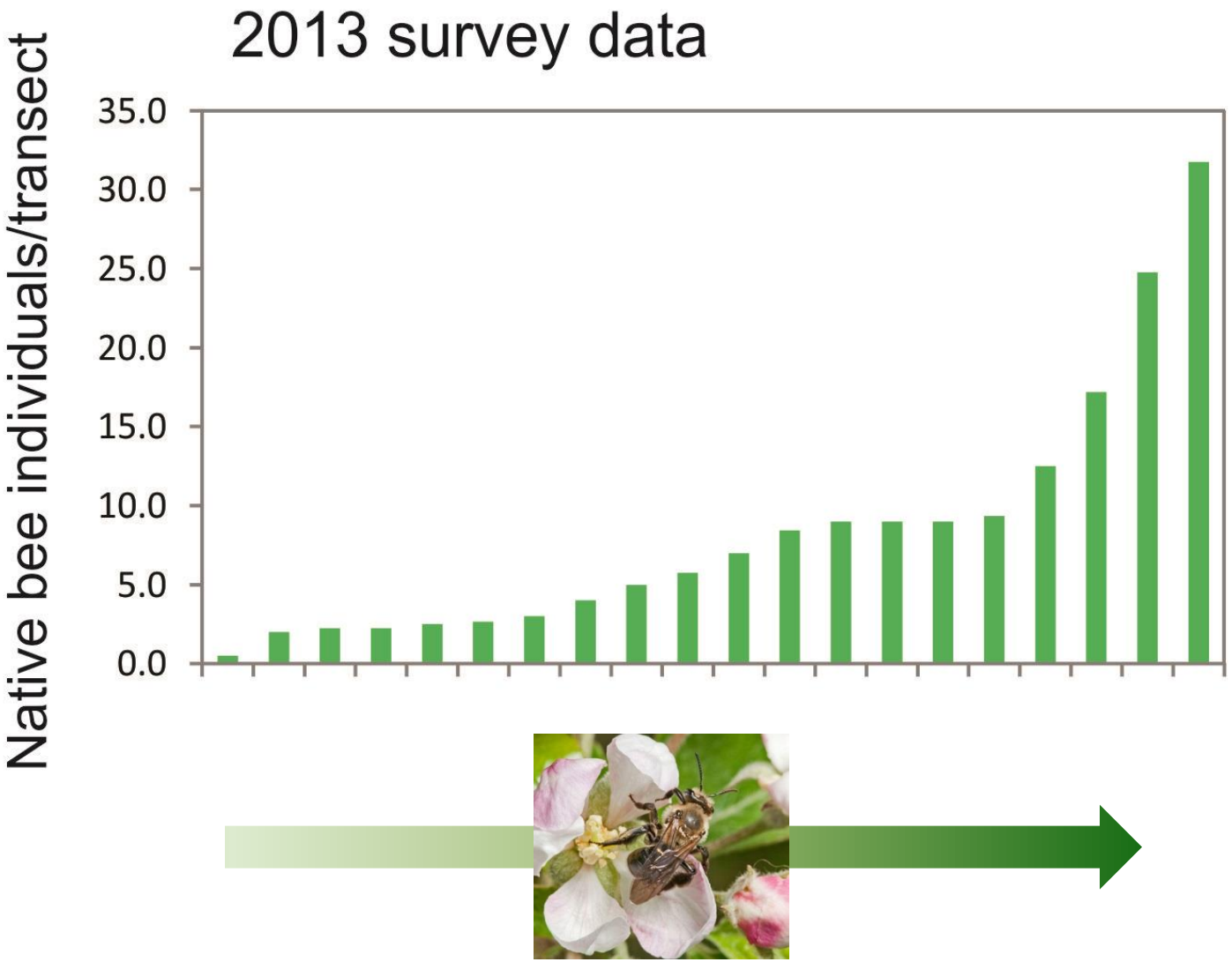
Results: Bee community

Total number species: **102**

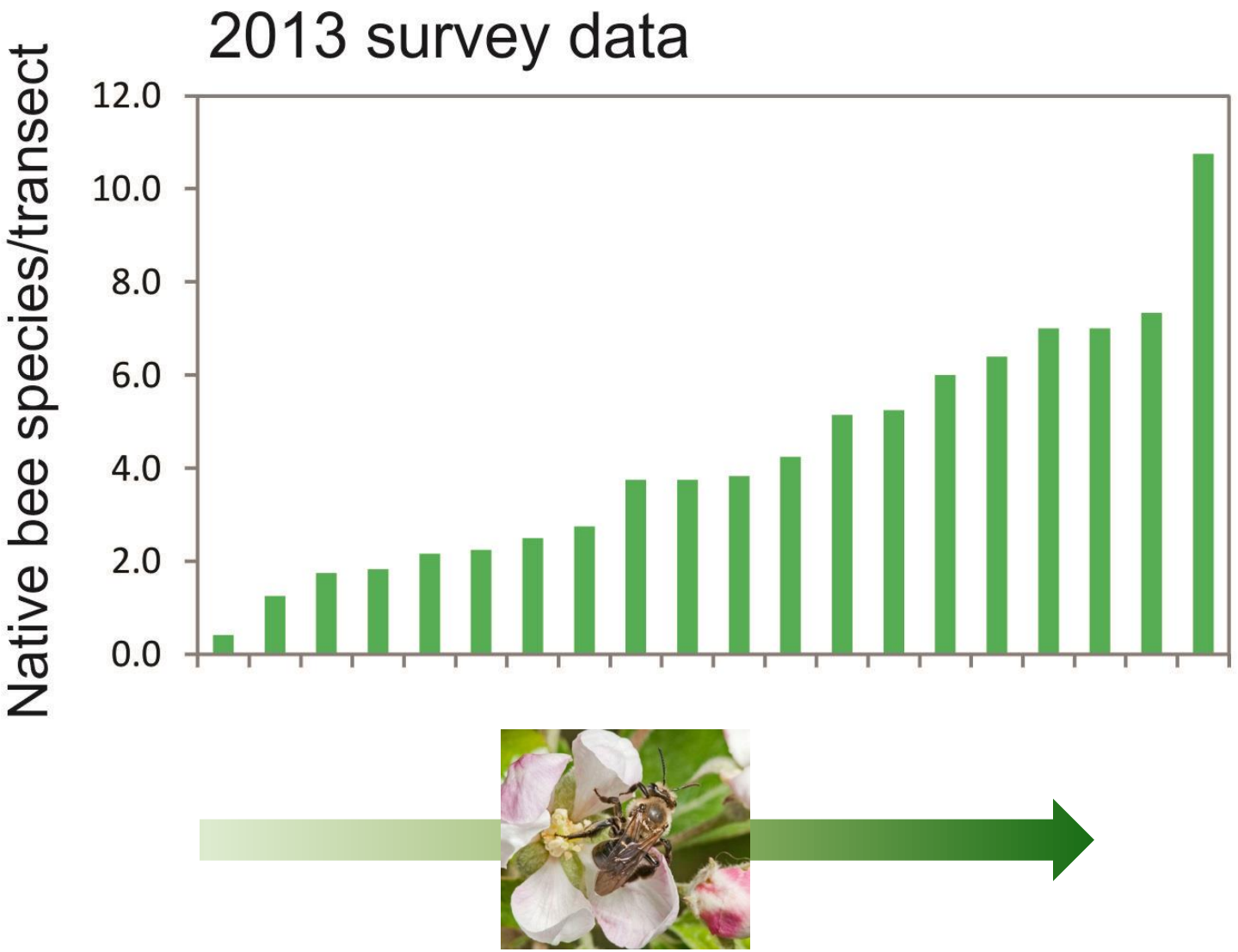
Results: Bee community



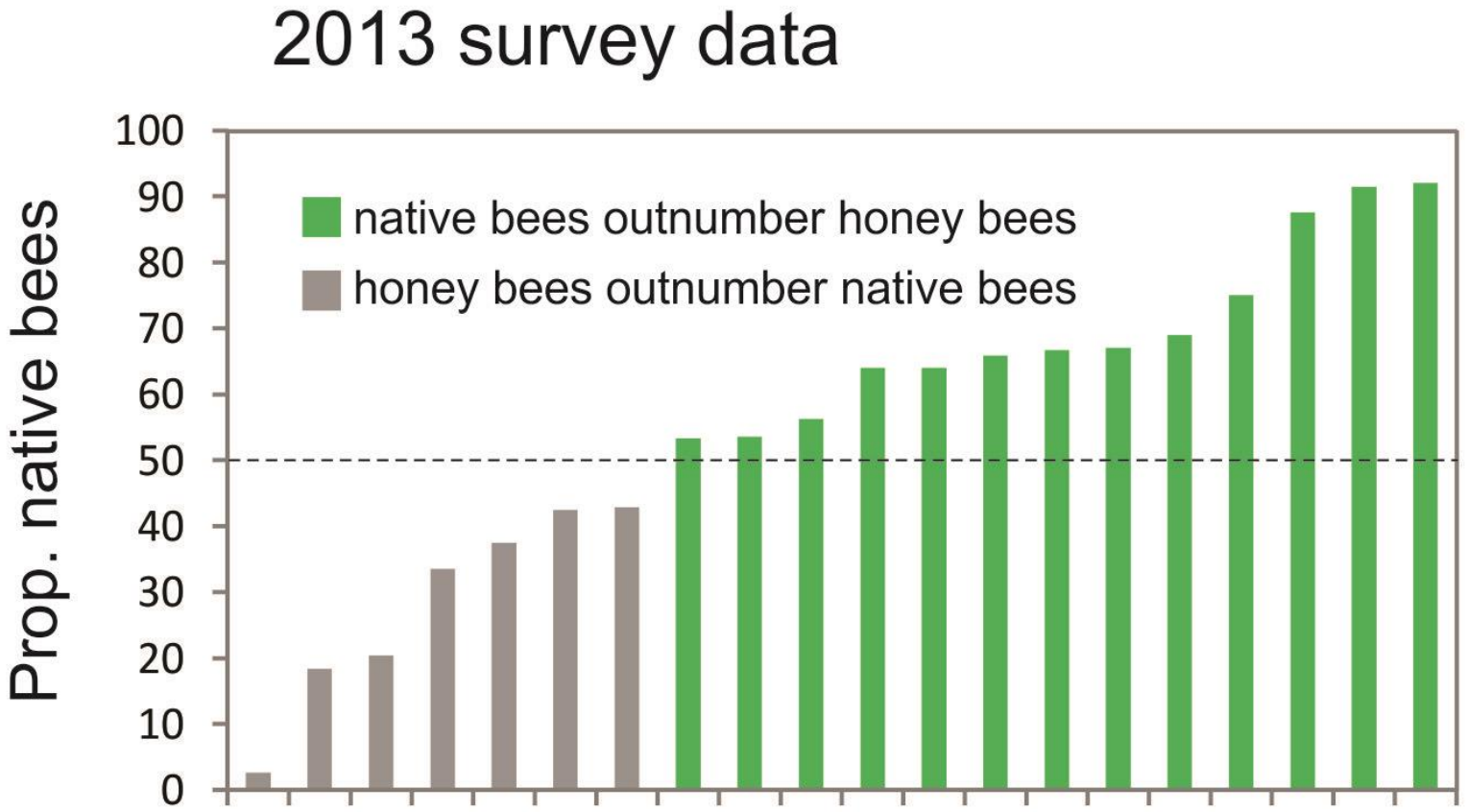
Results: Bee community



Results: Bee community



Results: Bee community



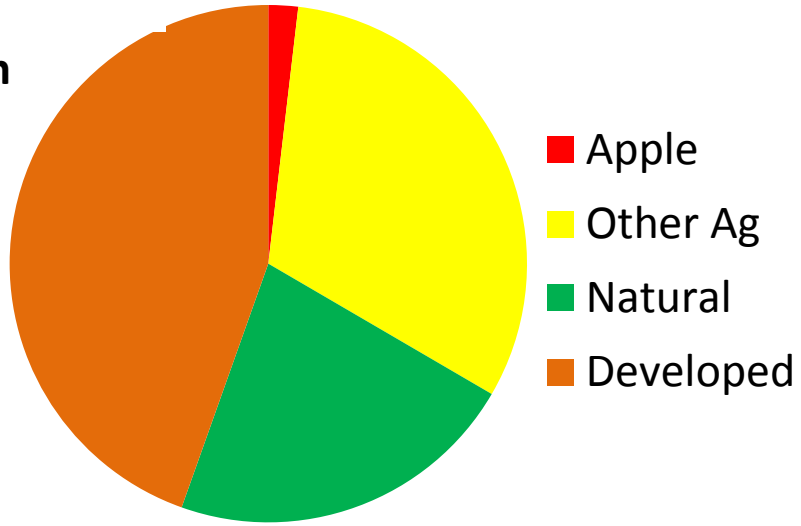
2. Drivers of bee abundance and diversity in apple orchards

Two factors appear to be important in determining native bee abundance and diversity:

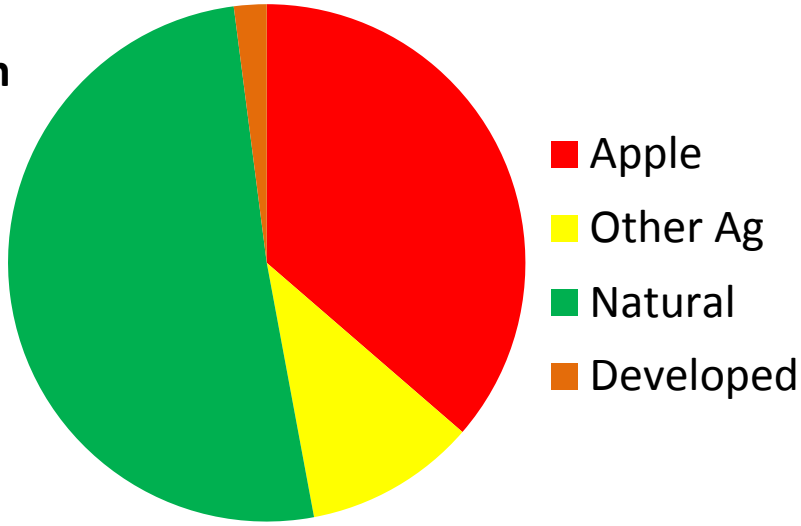
- Percentage of natural habitat surrounding orchards
- Level of pesticide (especially fungicide) use within orchards

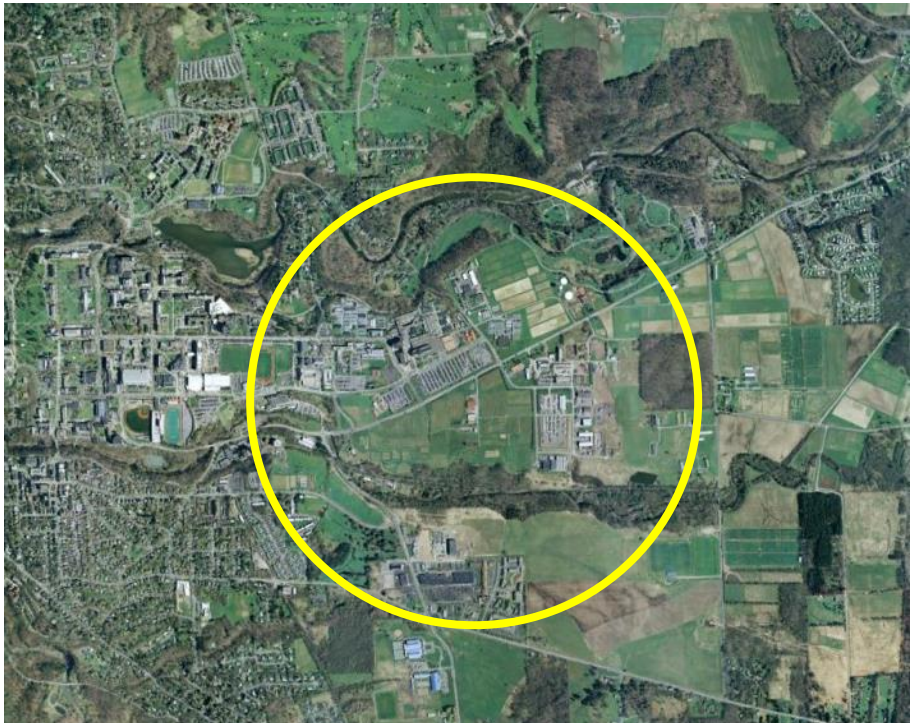
Methods: Bee community

1000m

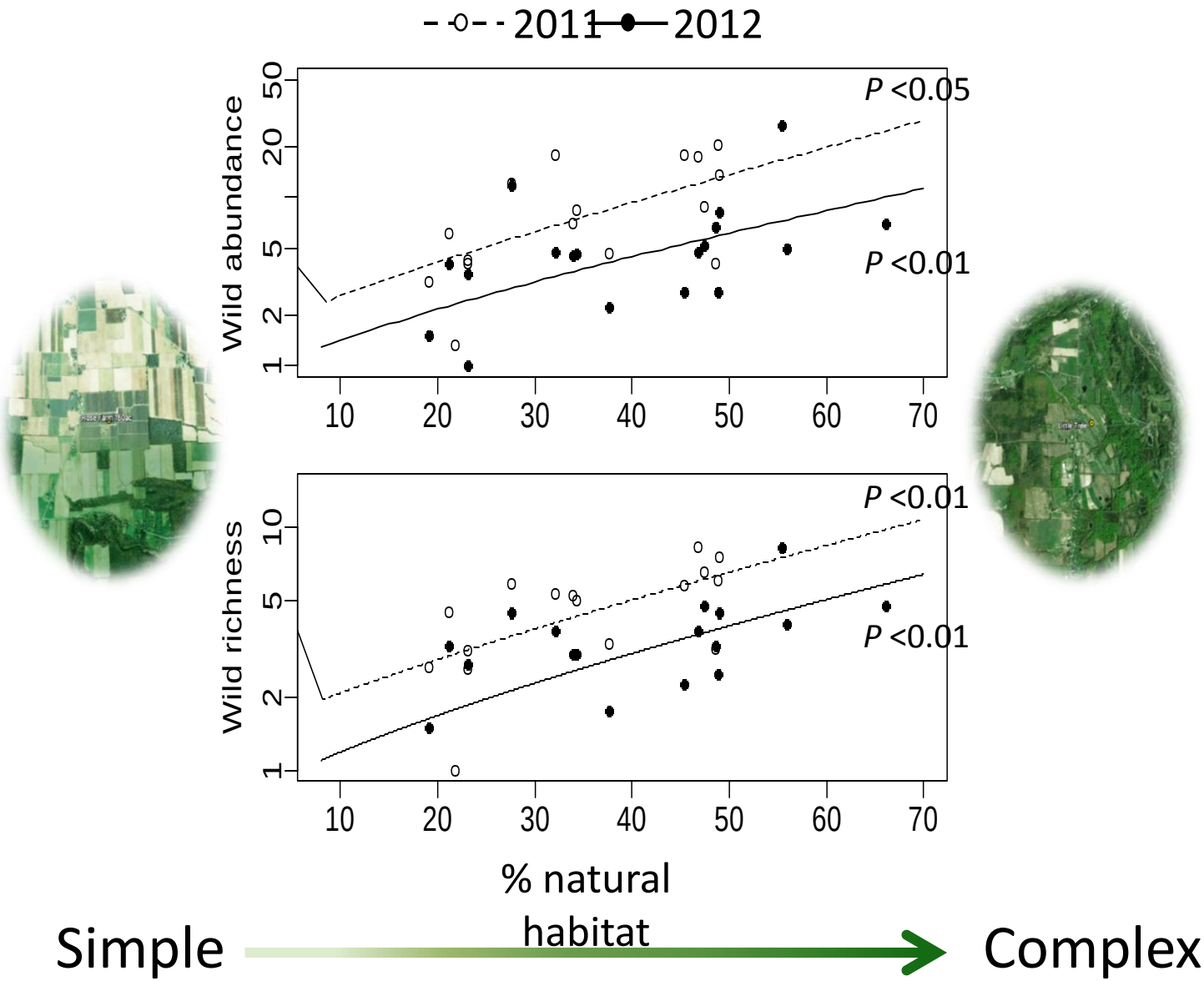


1000m

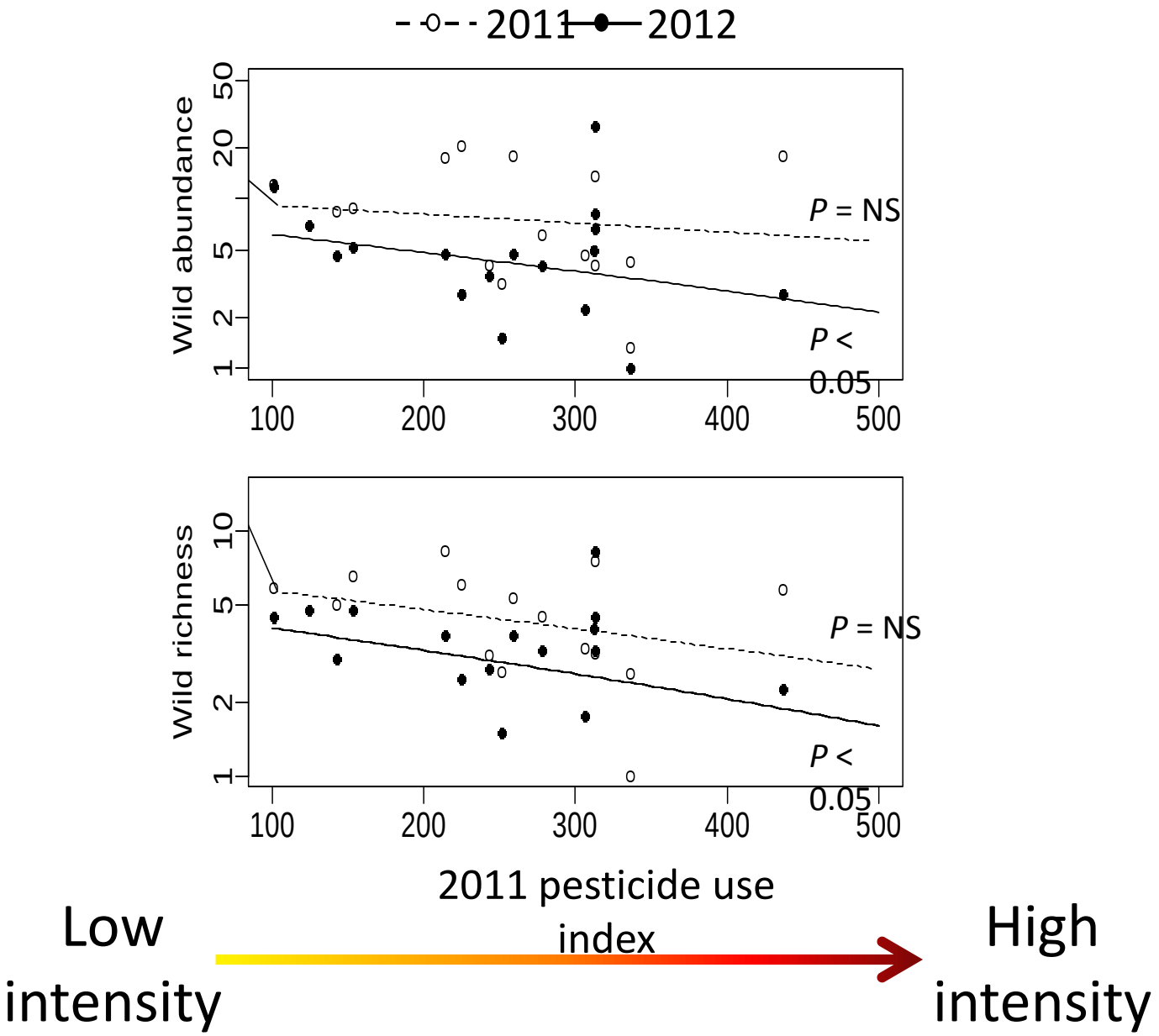




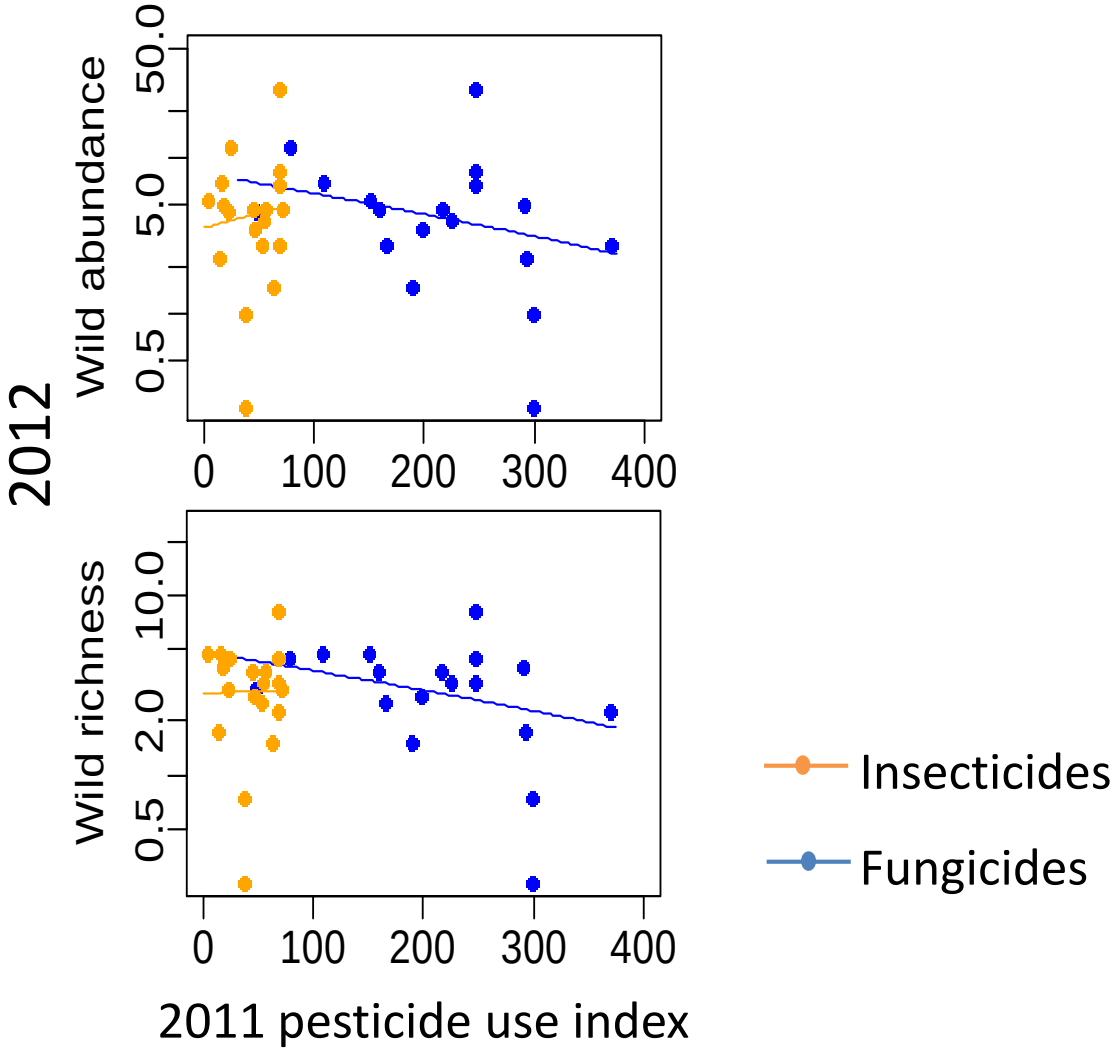
Results: % natural habitat



Results: pesticides



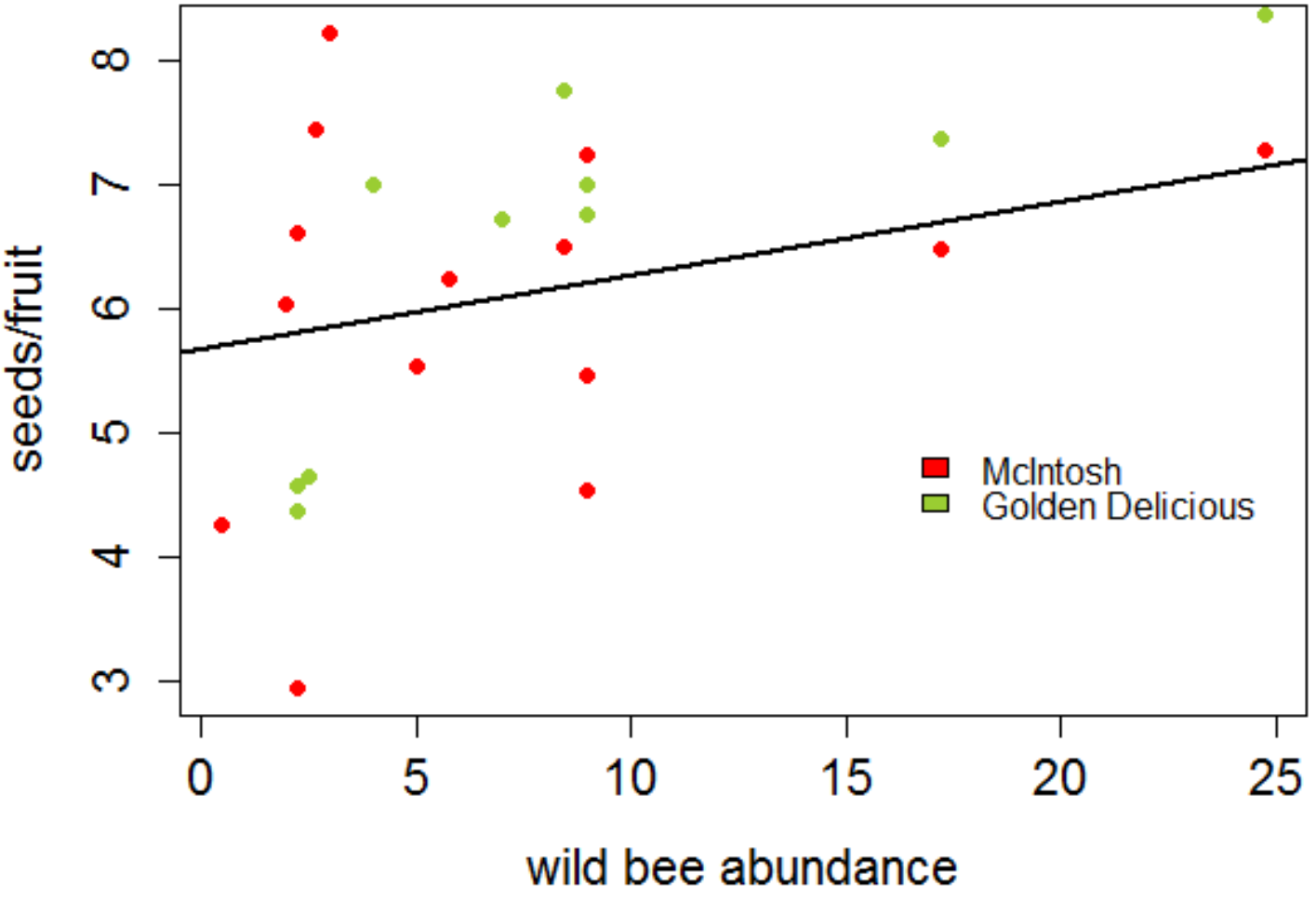
Results: fungicides vs. insecticides



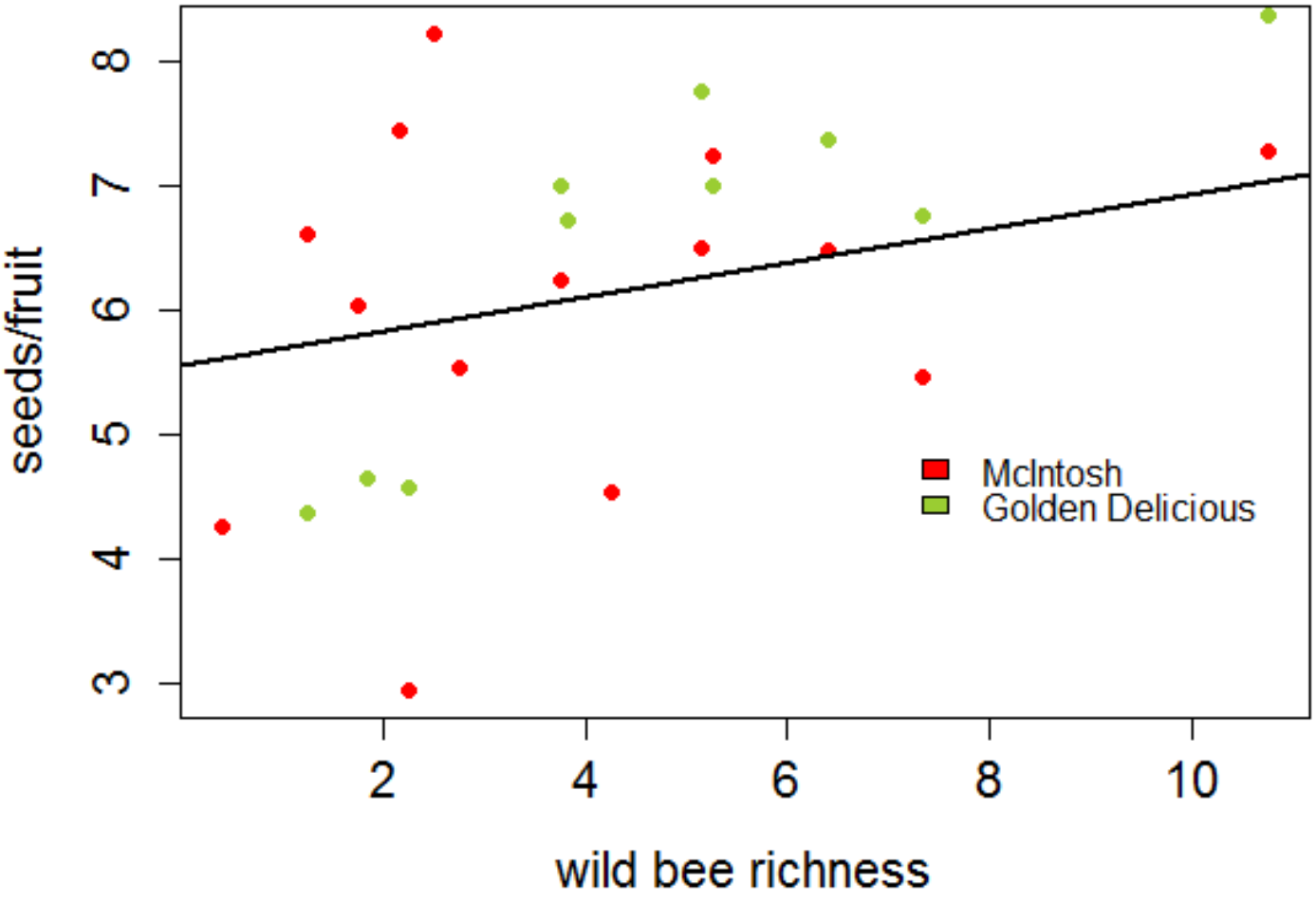
Fungicides, not insecticides, impact bee pollinators

Fungicides are having a much bigger impact on native bees than we realized.

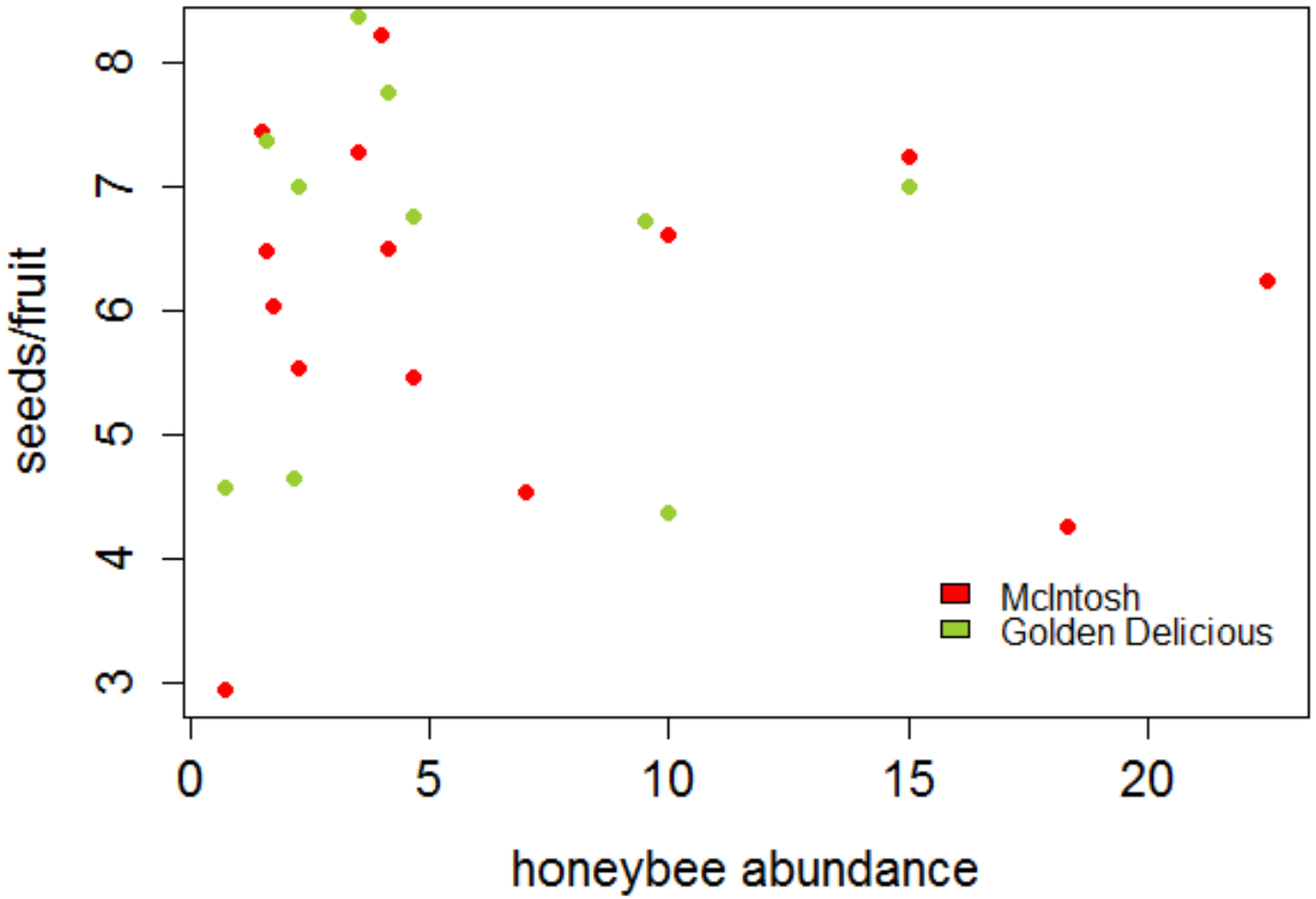
3. Impacts of native bees on fruit and seed set in apples



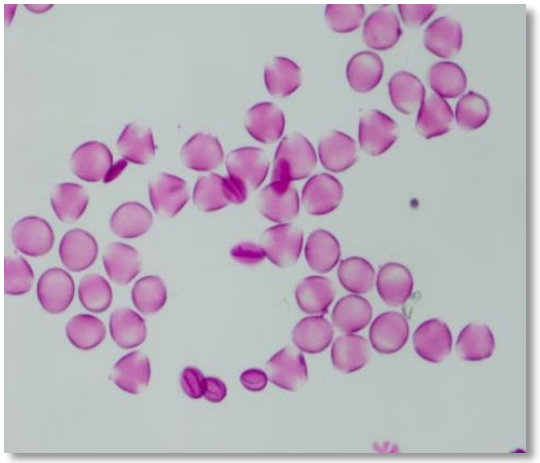
3. Impacts of native bees on fruit and seed set in apples



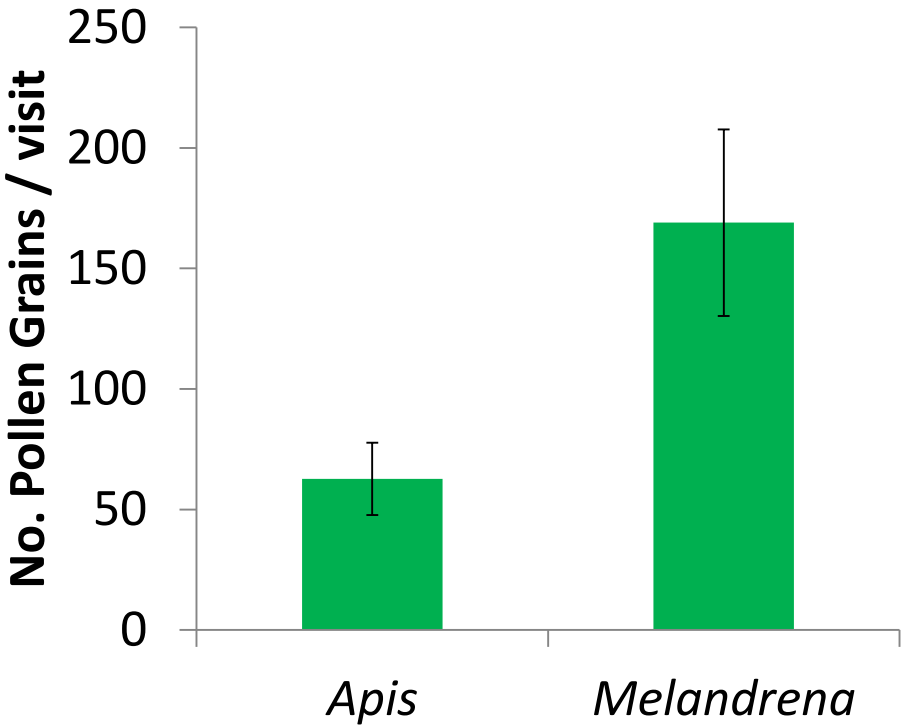
3. Impacts of native bees on fruit and seed set in apples



4. Native bee pollinator effectiveness



Apple pollen



Native bees deposit 2-4 times more pollen per visit than honey bees

Bottom line: native bees are having an impact on apple pollination in New York State

Studies in Pennsylvania, Wisconsin and Quebec are finding the same thing… native bees are important apple pollinators.

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Pollination services are mediated by bee functional diversity and landscape context

Kyle T. Martins [1,*], Andrew Gonzalez [1], Martin J. Lechowicz [1]

50 YEARS WITH IMPACT

Journal of Applied Ecology

British Ecological Society

Journal of Applied Ecology 2014

doi: 10.1111/1365-2664.12377

Species richness of wild bees, but not the use of managed honeybees, increases fruit set of a pollinator-dependent crop

Rachel E. Mallinger* and Claudio Gratton

Department of Entomology, University of Wisconsin Madison, 1552 University Ave, Madison, WI 53726, USA

What you can do to maintain native bee diversity and abundance

Provide nesting resources for native bees

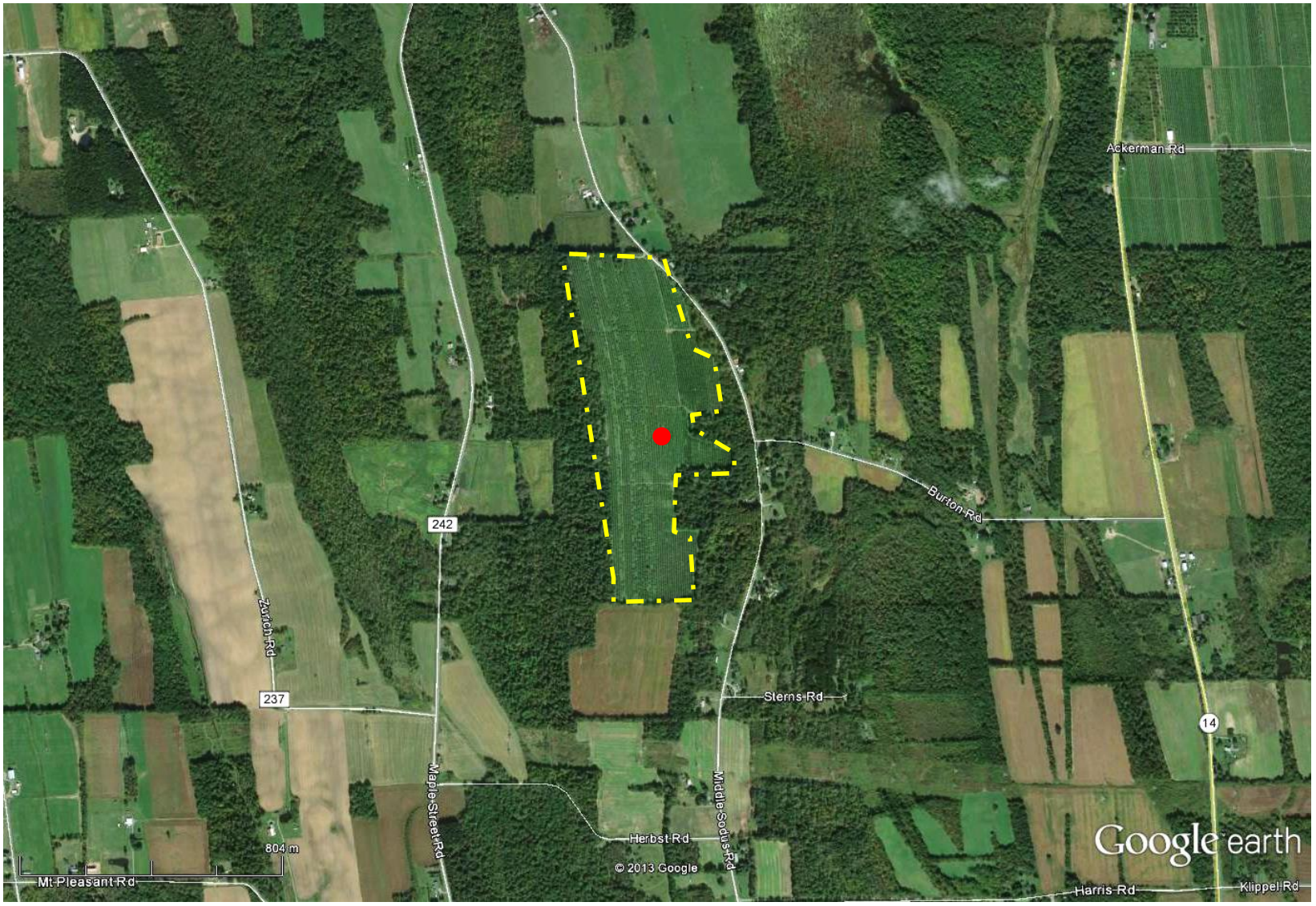
Pollinator Paradise
http://pollinatorparadise.com/Market/Pricelist.htm

Knox Cellars
http://www.knoxcellars.com/

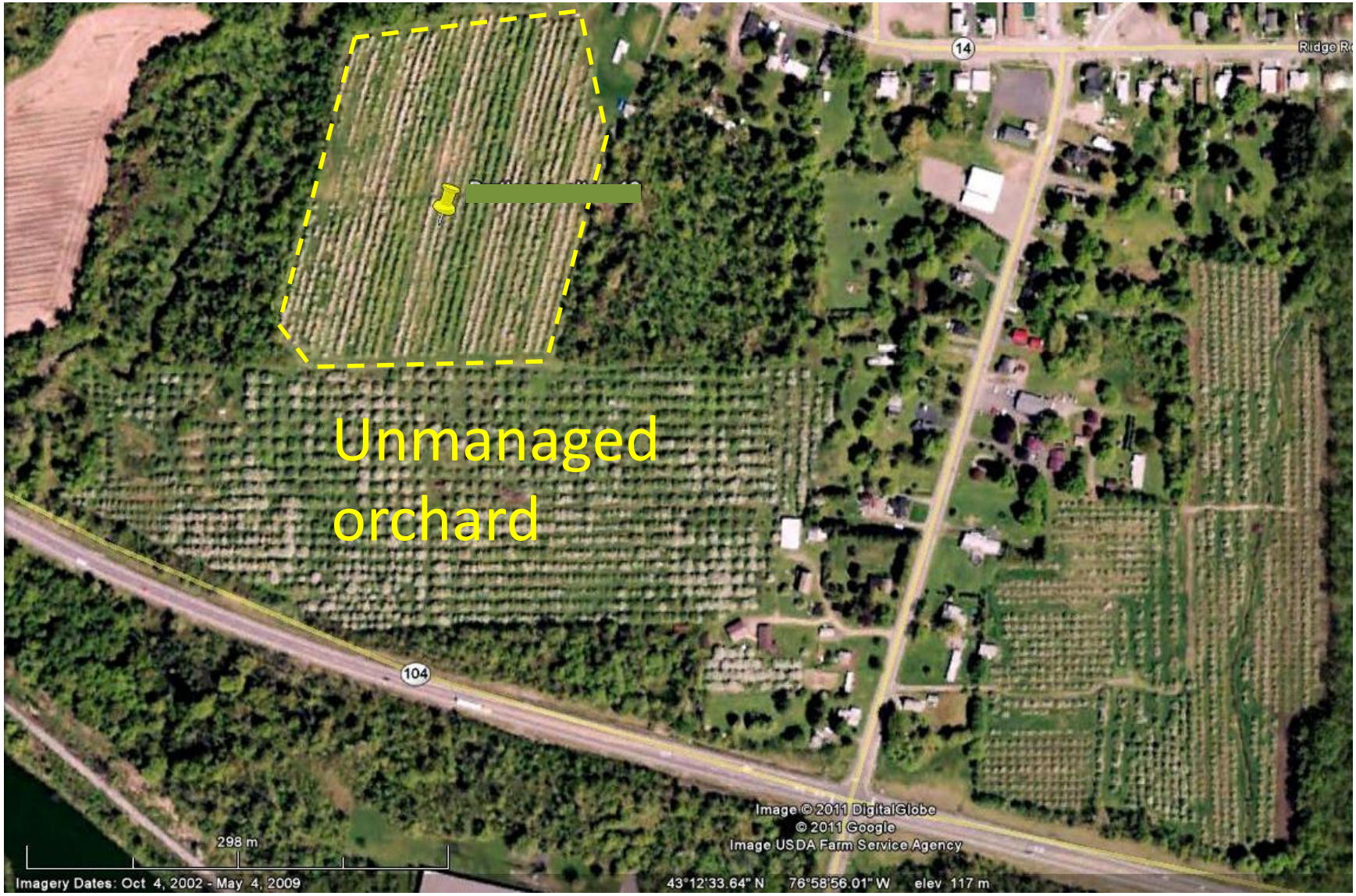
Some ideas:

- ❑ Disturb the soil (till) in unused portions of the orchard
- ❑ Leave abandoned wood and dead trees
- ❑ Leave stone walls intact (excellent sites for bumble bees)
- ❑ Install “trap” nests for mason bees (at left)

Maintain natural habitat in and around orchards



Leave unmanaged orchards intact



Minimize fungicide use (to the extent possible)

Fungicides may be having a more significant impact on native bees than we had previously realized.

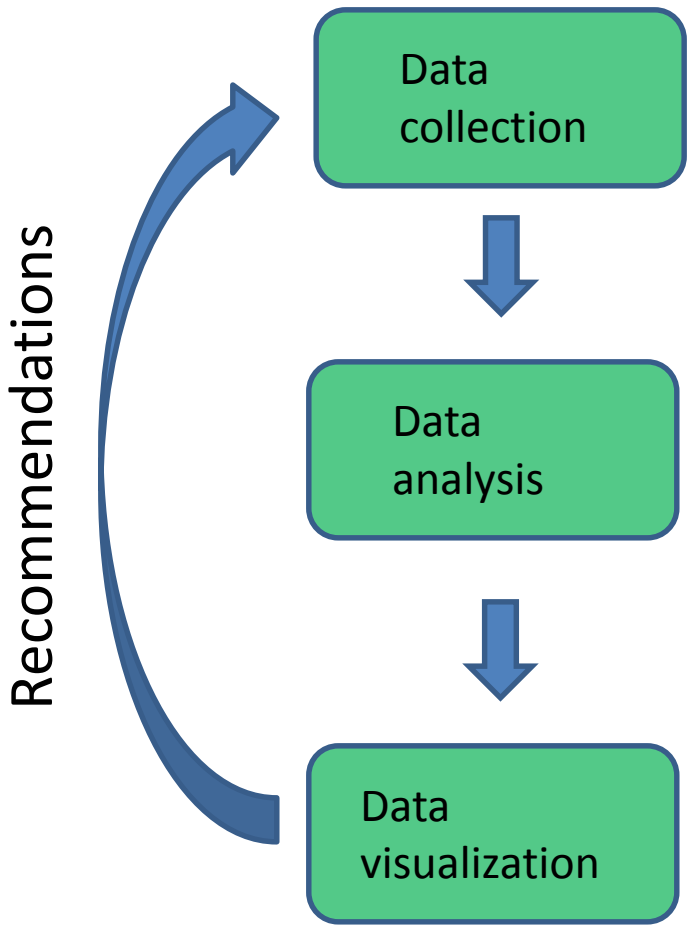
What we can do together to develop more effective pollinator management for NYS apple growers

THE NORTHEAST POLLINATOR PARTNERSHIP

"A partnership between scientists and apple growers that will lead to more informed orchard pollination, long-term monitoring of wild bee populations, and more sustainable pollinator management."

www.northeastpollinatorpartnership.org

THE NORTHEAST POLLINATOR PARTNERSHIP



Participants

Apple growers
Extension professionals
Scientists (i.e., my lab)

Scientists (i.e., my lab)
App designers (Ancient Wisdom Productions)

Apple growers
Extension professionals
The general public
K-12 classrooms
Scientists
Policy makers

www.northeastpollinatorpartnership.org

THE NORTHEAST POLLINATOR PARTNERSHIP

Data collection

?

What does “data collection” mean?

Data collection would be made via a smart-phone app:

- ❑ Number of wild bees and honey bees in a 5 minute interval
- ❑ Location (lat/long)
- ❑ Temperature
- ❑ Time of day
- ❑ Level of apple bloom

Wild bee

Honey bee

NY farm viability INSTITUTE

THE NORTHEAST POLLINATOR PARTNERSHIP

What **YOU** could do with the data:

- ❑ make more informed decisions about whether to purchase, rent, or borrow honey bees for apple pollination
- ❑ reduce the cost associated with honey bee rentals
- ❑ develop a more efficient method for achieving sufficient apple pollination

www.northeastpollinatorpartnership.org

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What **RESEARCHERS** could do with the data:

- ❑ detect declines in wild pollinators across the Northeast
- ❑ Understand the impact of climate change on apple flowering and pollination
- ❑ Understand more about what factors drive wild pollinator communities

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What **interested citizens and K-12 classrooms** can do with the data:

- ❑ learn more about pollination biology
- ❑ learn more about bees and bee biology
- ❑ learn more about conservation of wild pollinators
- ❑ learn more about the challenges of sustainable apple orchard management

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We need your input…

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Acknowledgements

Growers:
28 orchard owners in central NY

Collaborators:
Art Agnello (Cornell)
Ian Merwin (Cornell)
Susan Brown (Cornell)
Mike Biltonen (Apple Leaf)
Jim Eve (Eve Farm Services)
Brian Caldwell (Cornell)

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Cuyler Remick
Edward Hurme
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Andrew Debevec
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Sally Hartwick
Susan Villarreal
Keri San-Miguel
Nancy Adamson
Margarita Lopez-Uribe
Shannon Hedtke
Caleb Radens
Graham Montgomery
Michael Orr
Julia Brokaw
Kristina Chyn
Lori Moshman

Funding agencies:

USDA

Cornell University
Cooperative Extension

Cornell University
David R. Atkinson Center for a Sustainable Future

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Data collection

?

What does “data collection” mean?

Observational samples of the number of bees (distinguishing between honey bees and wild bees) over a 5 minute period

Data entry via an iPhone or iPad would allow us to capture the precise location (lat/long), time of day, temperature, and state of apple bloom.

Wild bee

Honey bee

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Summary

- Honey bees are in decline and CCD is a multifaceted problem
- We have detected **97 species** of native bees in apple orchards since 2009 – many of these appear to be effective apple pollinators
- Native bee abundance and diversity are impacted by both natural habitat and pesticide use
- Native bee diversity and abundance significantly impact seed set in apples, whereas honey bee abundance seems to have no detectable effect
- You can support your local native bees by providing suitable habitat, nesting resources, and reducing pesticide use (if possible)
- We need your input on the **Northeast Pollinator Partnership**

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The awesome power of “citizen science”

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In God we trust… all others must bring data.

Michael Bloomberg

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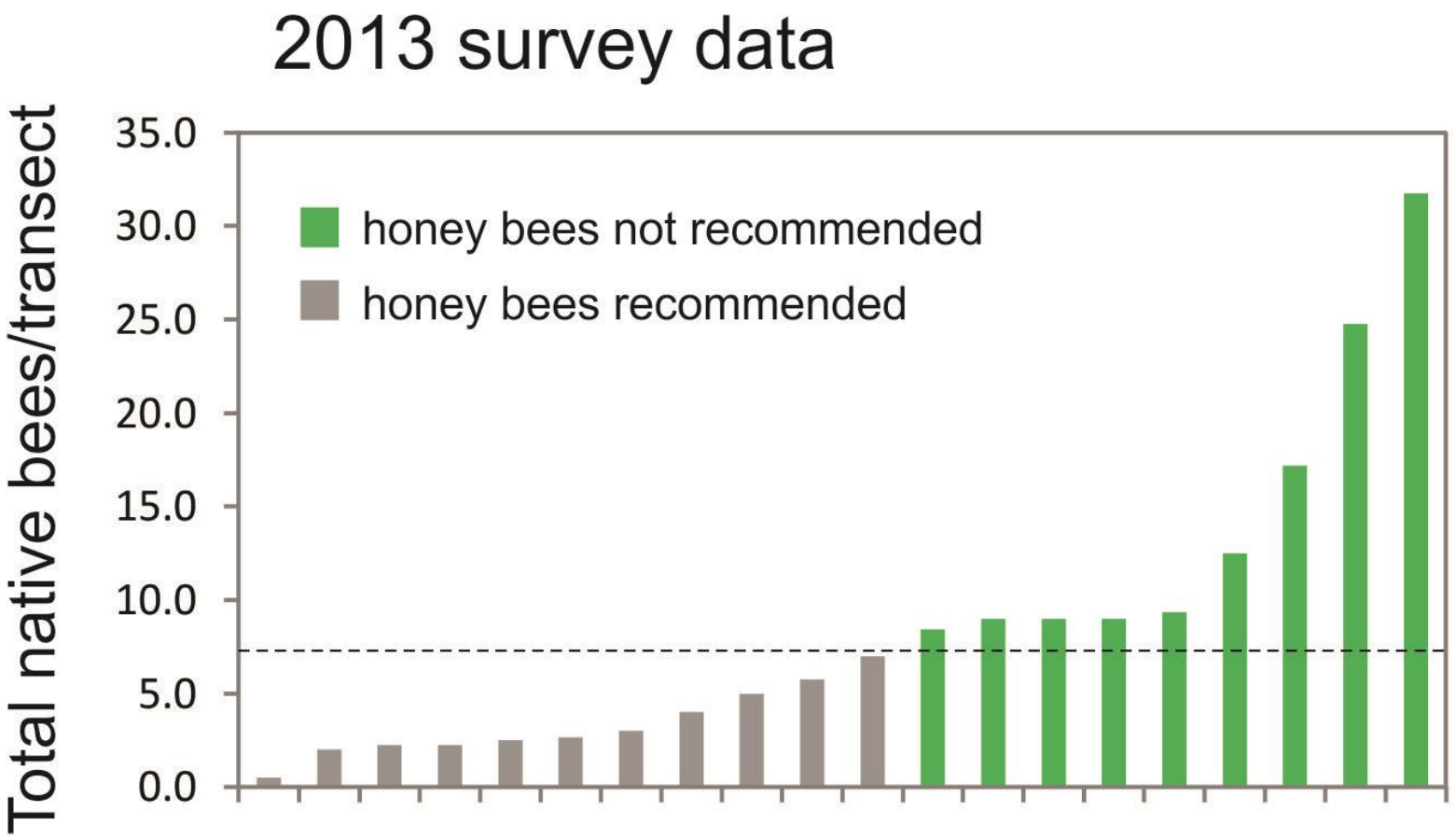
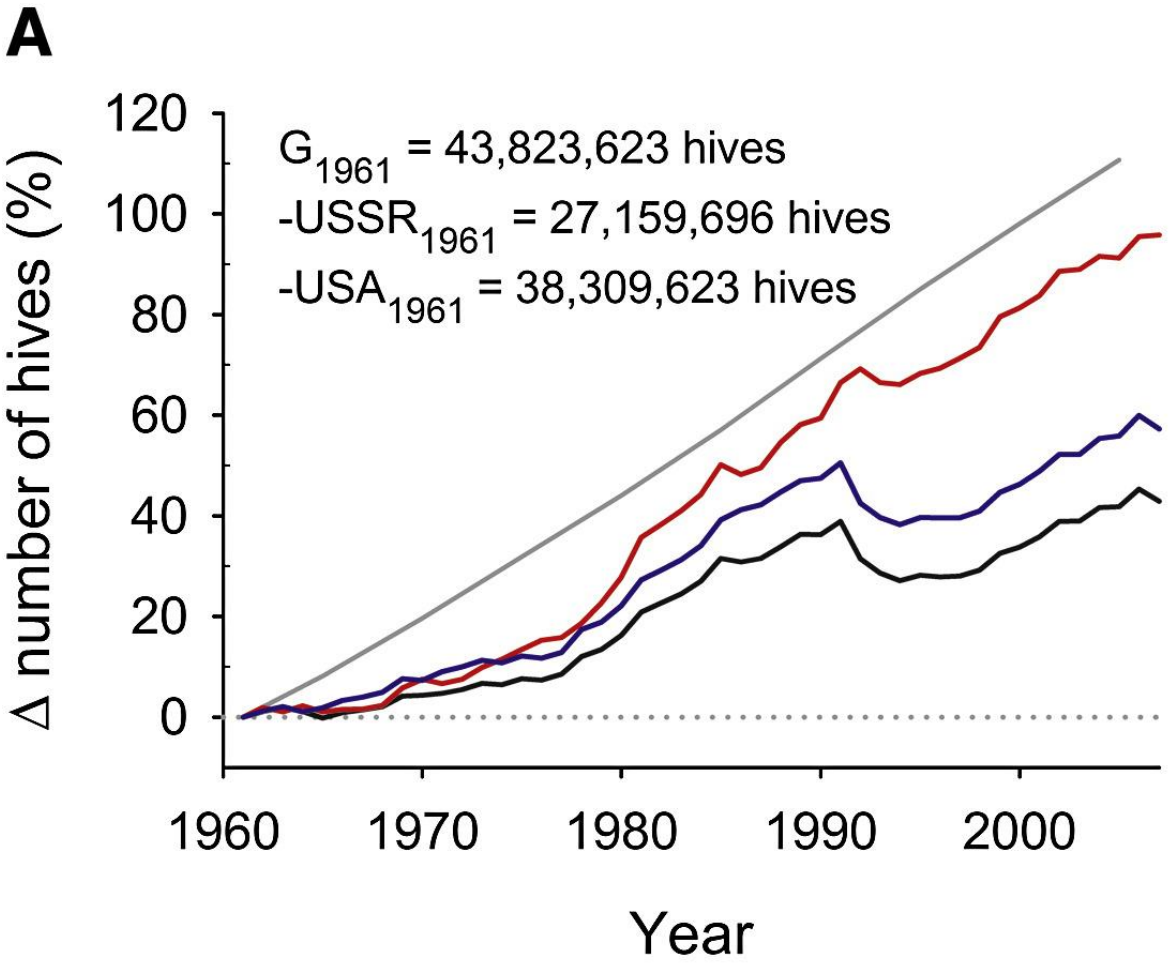


When demand outstrips supply…

"...our analysis of Food and Agriculture Organization (FAO) [11] data reveals that the global population of managed honey-bee hives has **increased ~45%** during the last half century and suggests that economic globalization, rather than biological factors, drives both the dynamics of the global managed honey-bee population and increasing demands for agricultural pollination services ."

Aizen & Harder
2009 Current
Biology

When demand outstrips supply…



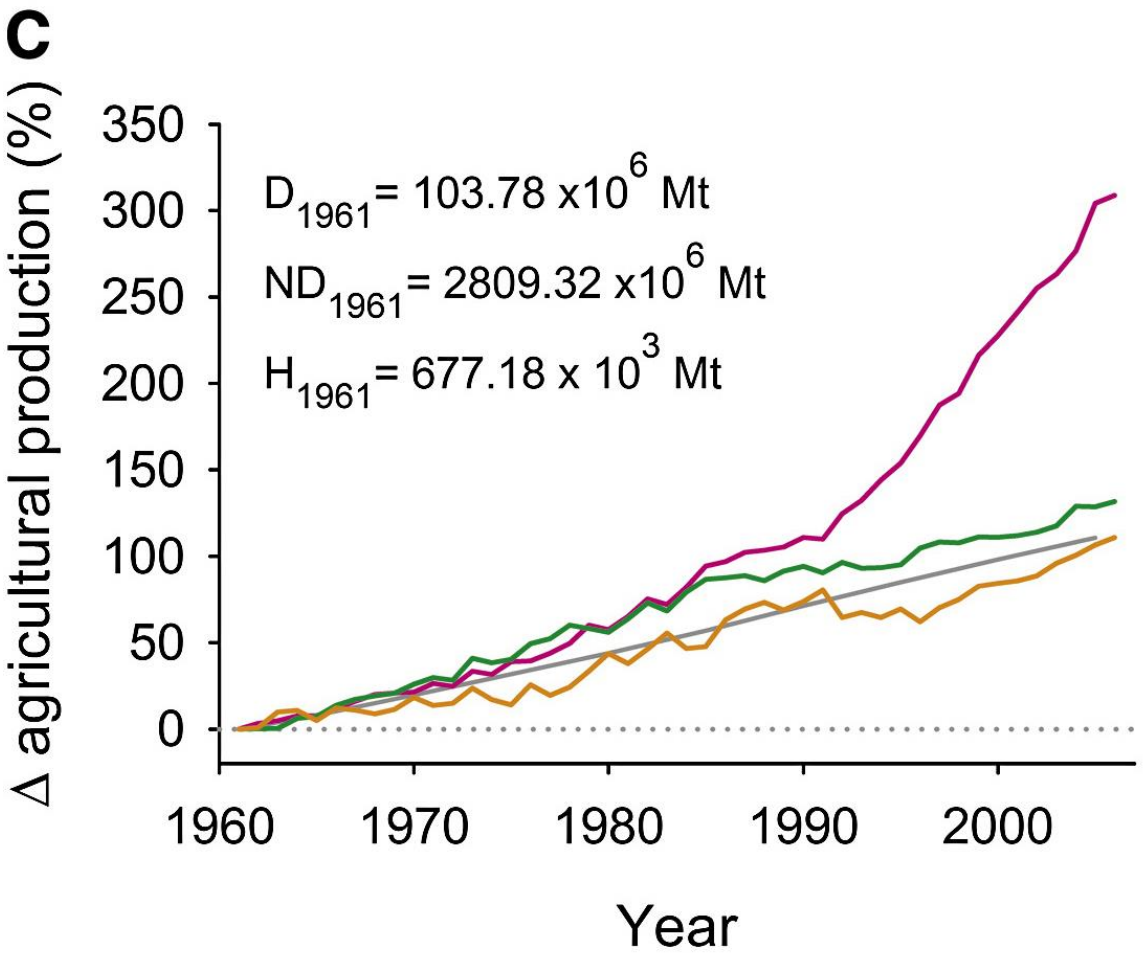
w/o USSR

w/o USA

global

Aizen & Harder 2009 Current Biology

When demand outstrips supply…



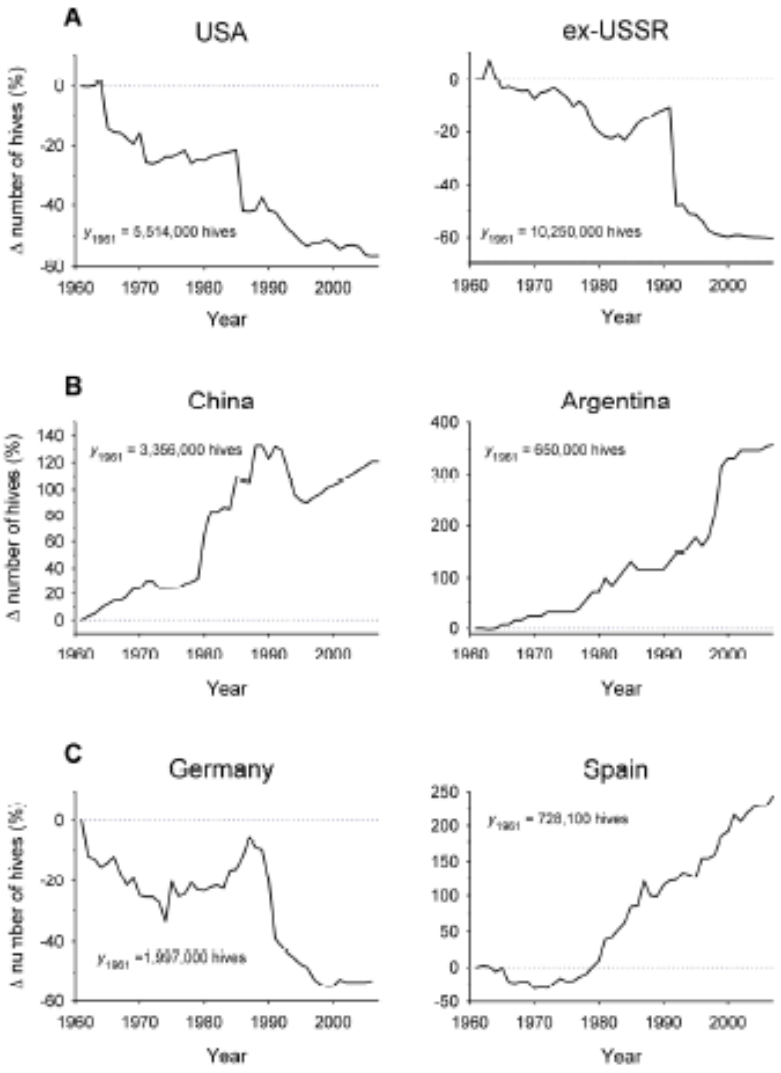
Crops dependent on insect pollination

Not dependent

Honey prod.

Aizen & Harder 2009 Current Biology

When demand outstrips supply…



Declines in the US, ex-Soviet Union, and Germany – but **growth** in China, South America, and Spain

Aizen & Harder 2009 Current Biology

Agricultural pesticides

Available online at www.sciencedirect.com

SciVerse ScienceDirect

Current Opinion in Environmental Sustainability

Neonicotinoids, bee disorders and the sustainability of pollinator services☆

Jeroen P van der Sluijs[1], Noa Simon-Delso[1], Dave Goulson[2], Laura Maxim[3], Jean-Marc Bonmatin[4] and Luc P Belzunces[5]

"At field realistic doses, neonicotinoids cause a wide range of adverse sublethal effects in honeybee and bumblebee colonies, affecting colony performance through impairment of foraging success, brood and larval development, memory and learning, damage to the central nervous system, susceptibility to diseases, hive hygiene etc…. The limited available data suggest that they are likely to exhibit similar toxicity to virtually all other wild insect pollinators."

Agricultural pesticides

50 YEARS WITH IMPACT

Journal of Applied Ecology

1913 2013 British Ecological Society — CELEBRATING 100 YEARS —

Journal of Applied Ecology 2013

doi: 10.1111/1365-2664.12111

REVIEW

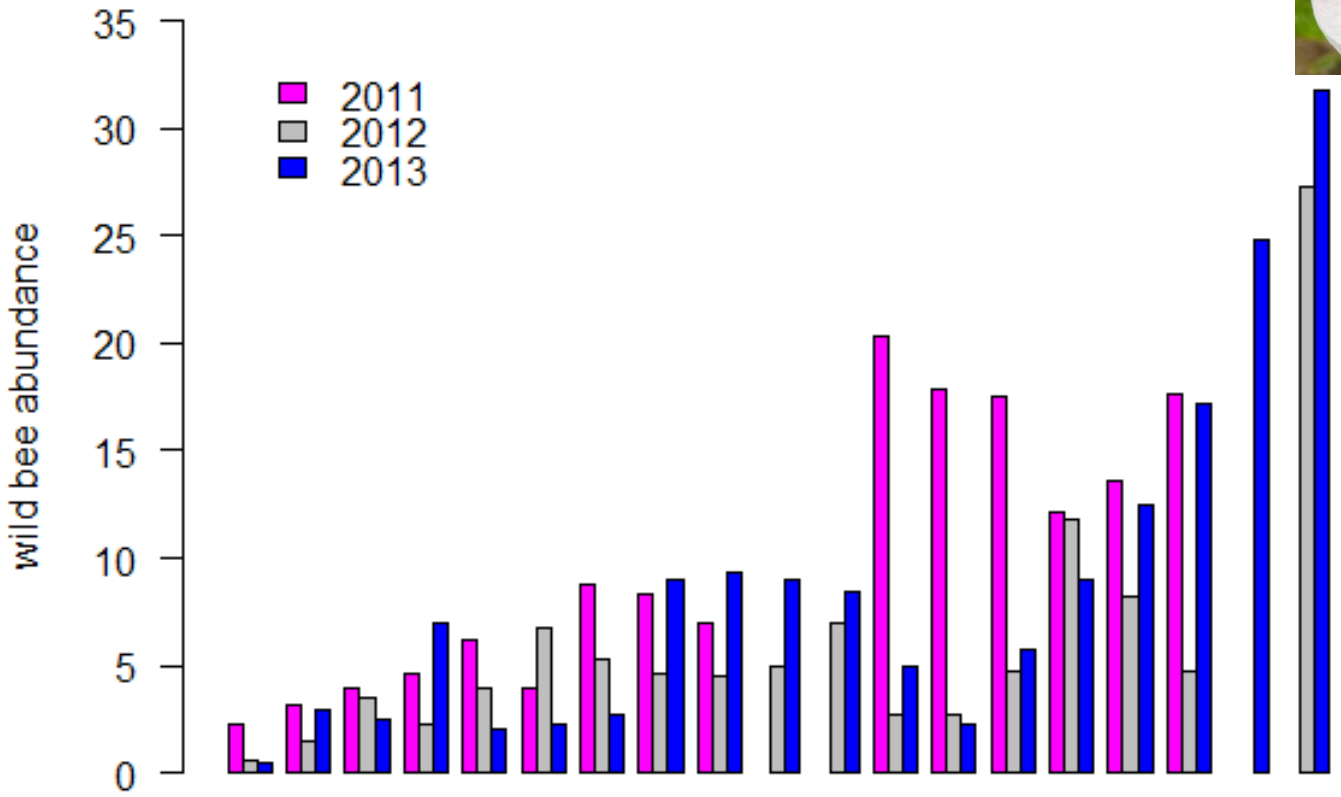
An overview of the environmental risks posed by neonicotinoid insecticides

Dave Goulson

Biological and Environmental Sciences, University of Stirling, Stirling, FK9 4LA, UK

"In summary, there is clear evidence that exposure of bees to field-realistic levels of neonicotinoids has significant sublethal impacts and that in the case of bumblebees, this has been demonstrated to have major impacts on colony success."

Results: Bee community



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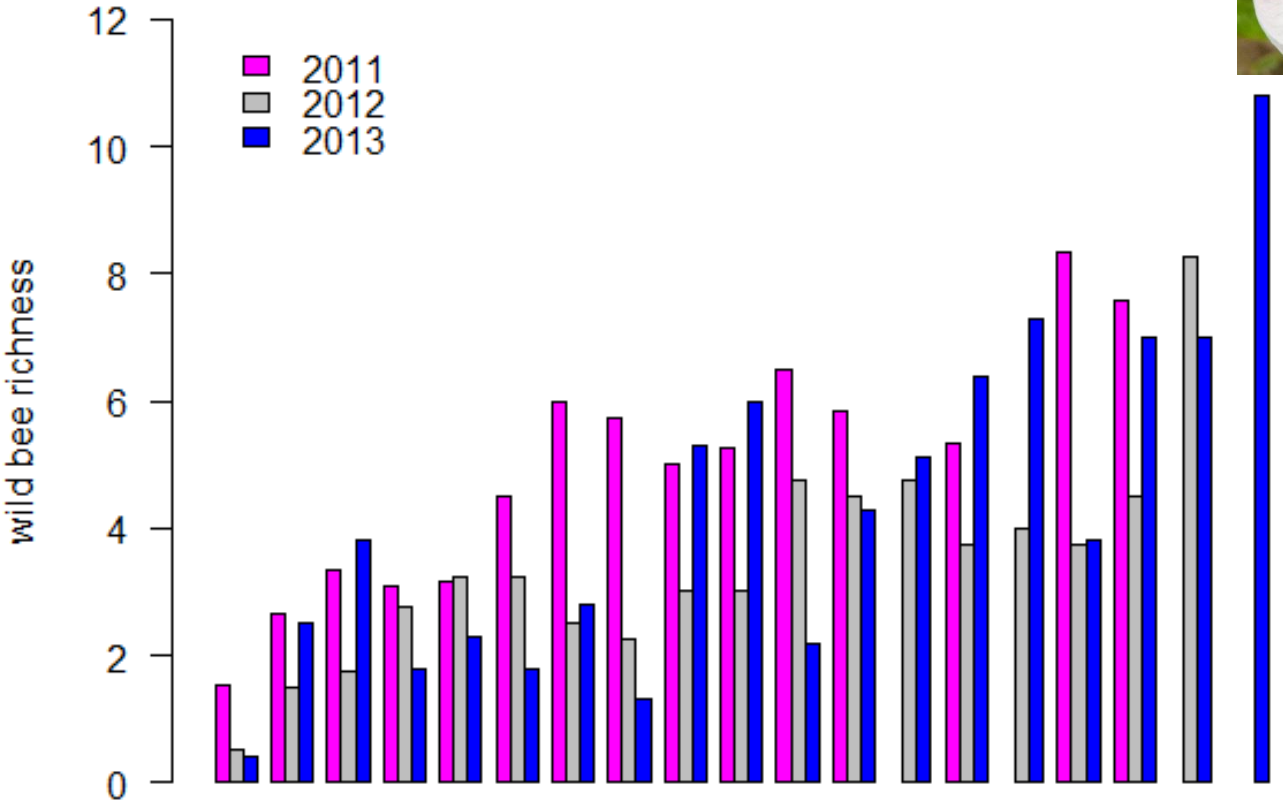
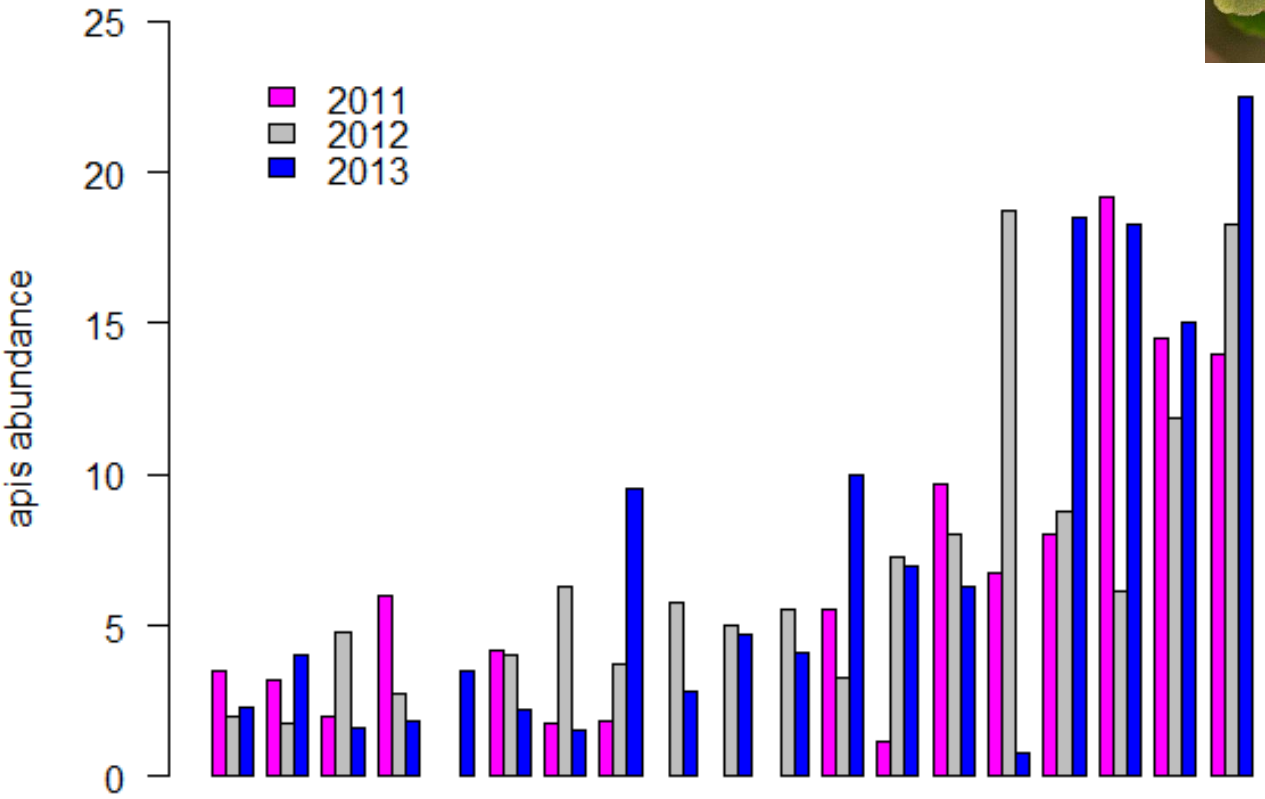


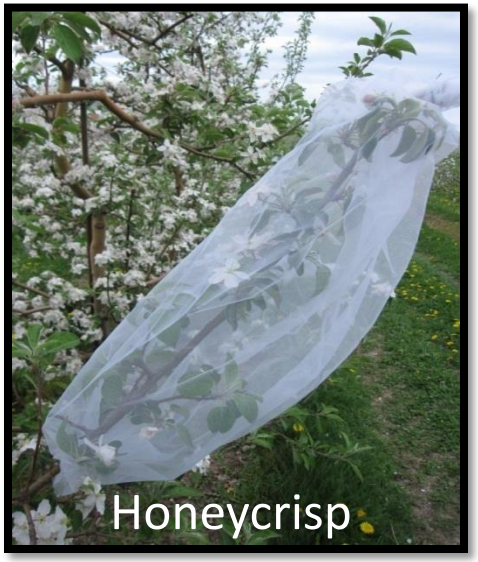
Results: Bee community

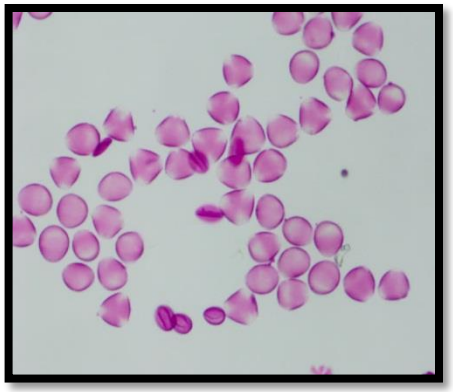


What we know for sure:

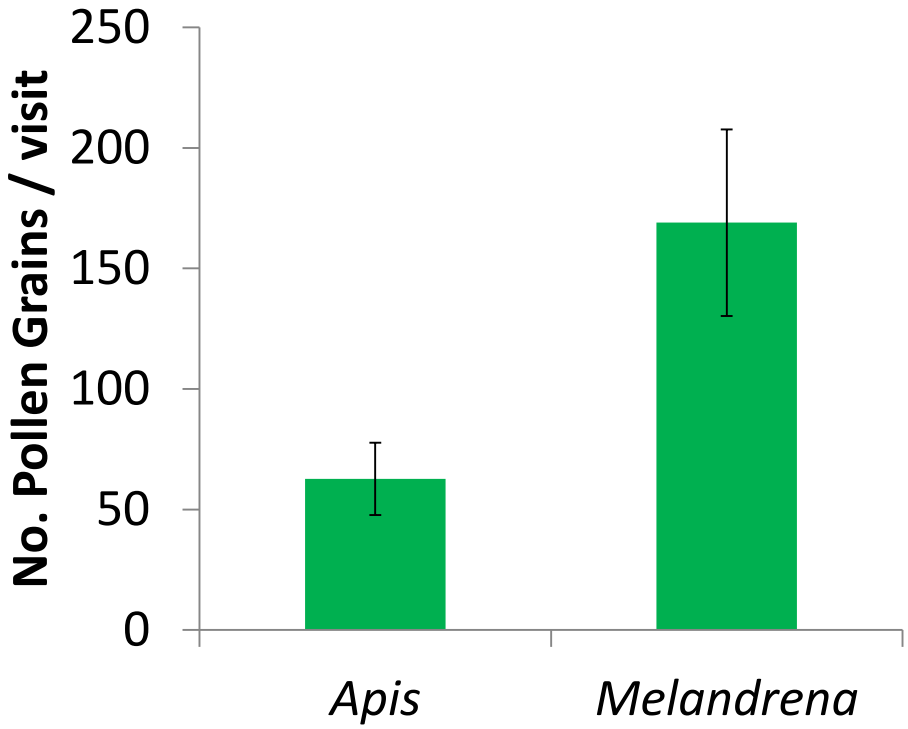
1. CCD-like diseases have been reported for over the past 1000 years in Europe and NA
2. Annual colony losses of honey bees in N. America are typically ~30% per year
3. The **combination** of multiple pathogens and parasites plus exposure to pesticides and stress due to long-distance transport are the most likely explanations for CCD-like symptoms
4. The implications of honey bee declines will vary tremendously from crop to crop
5. The pathogens and parasites that affect honey bees do not appear to be present in other (native) bees.

4. Native bee pollinator effectiveness





4. Native bee pollinator effectiveness



Native bees deposit 2-4 times more pollen per visit than honey bees