Pollinators & CCD: What's The Scoop and the Risk?

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outline for today

- Pollinators – who are they ?
- Factors that affect pollinators
- Honey bee health
- Native bee health

who are the pollinators of fruit, nut and vegetable crops in Maine ?

- primarily bees: 260 species & counting
  - wild: since the glaciers receded, 12,000 years
    - sand bees (27%), sweat bees (38%), yellow faced bees (16%), bumble bees (6%), leaf cutting bees (8%)
  - honey bees – in the U.S. since 1624…Maine's "State Insect"…75,000 honey bees brought in for pollination of blueberry crop, second most # bees brought to pollinate single crop
  - commercial bumble bees – the impatient bumble since early 1990s


All but 7 species are native
Introduced: Honey bee, Giant resin bee
Wool carder bee
Anthidium manicatum, from Europe

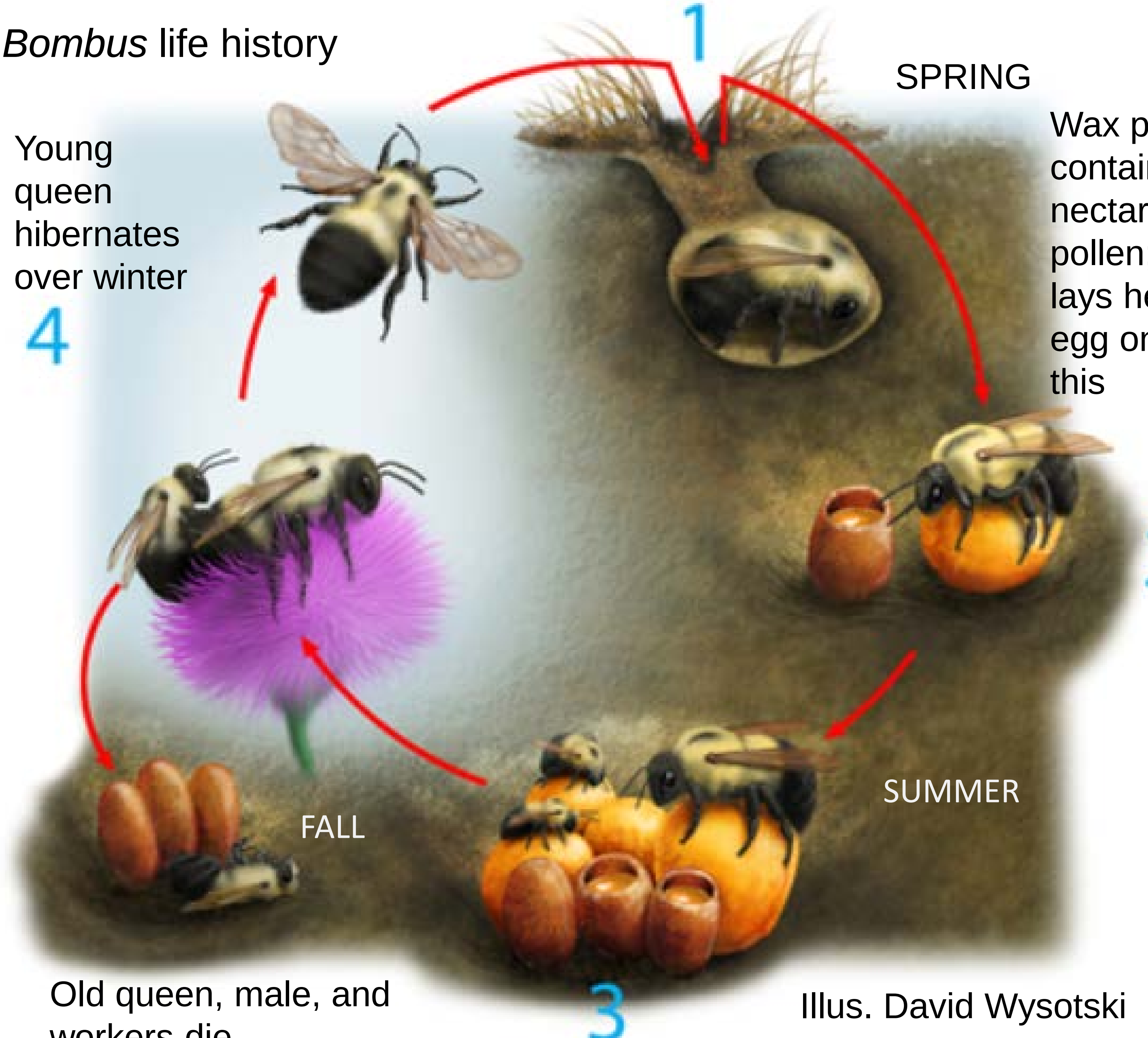
bee diversity

- Worldwide – 20,000 species
- U.S. – 2,500 species
- Arizona – 700 species
- New England – 550 species
- Maine – 260 species and counting (about 7 exotics)

Biology of Bees

- Life cycles ?
- Food Resources ?
- Nesting?

Bombus life history



Illus. David Wysotski

NESTS

Bombus might seek out an abandoned rodent nest

Smell of mouse urine – “Ahh -- there’s no place like home!”

The workers construct honey pots of wax and pollen in which to store nectar for the rearing of their sisters

NEST HABITATS

LARGE DEAD TREES

Keep some large dead trees and logs in the woodlot or edge of the field. Megachilids might occupy old galleries created by borer beetles

NEST HABITATS

STEMS

HOLLOW OR PITHY

Hylaeus, others –
might hollow the pith out prior to laying first egg

e.g., red-berried elder, *Sambucus racemosa,* honeysuckle, raspberry, herbaceous plants too -- goldenrod, etc.

Nest habitats for leaf cutter bees

bundle of perennial stem sections

wooden nest block -- holes of several diameters, 6-7 inches long

Dead wood with spruce beetle exit holes – leave a tree where it died

PATCHES OF BARE GROUND

Tumili – the excavated soil from the nest.

A single hole might be shared by multiple bees, perhaps all sisters?

BERM – Bare earth, free of dense vegetation

what are the factors that affect bee performance and abundance ?

- weather
- diseases
- nest sites
- lack of forage b/a bloom
  - suitable landscapes in Maine ?
- competing flowers w bloom
- **pesticide exposure**

how are the bees doing?

CCD: colony collapse disorder

mysterious disorder: *swift dwindling of colony, no corpses recovered near hive, subsequent rejection of equipment by bees*

- First described in 2006 (US and Europe)
- Migratory beekeeping operations
- 1 million hives lost in 2006
- Fewer in 2007 – 2013
- BUT hive loss rate still high
- Other pollinators in decline…

  Is it related to CCD?

so what is going on and how serious is it?

- SEVEN years later…still not understood

- colony losses
  - losses of 10-15% in a year were considered normal two decades ago; NOW averages 20-40% (in 2012: 33.4%)

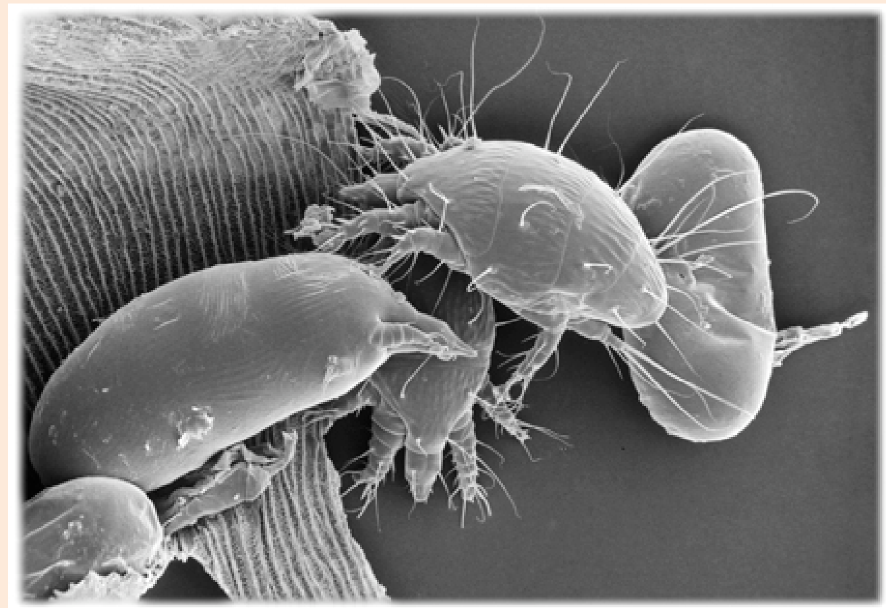
- increasingly difficult to raise honey bees for profit…beekeepers declining

coincidence or linked to global bee trade?

potential causes ?

- parasitic mites (2 predominant species)
  - tracheal mite, *Acarapis woodi* (adult, introduced 1984)
    - occlude tracheae
    - feed on haemolymph
    - winter mortality
  - *Varroa* mite, *Varroa destructor*– jumped from another species of *Apis* (pupa / adult, introduced 1987)
    - feed on haemolymph
    - compromises immune system
    - transmit several pathogenic viruses

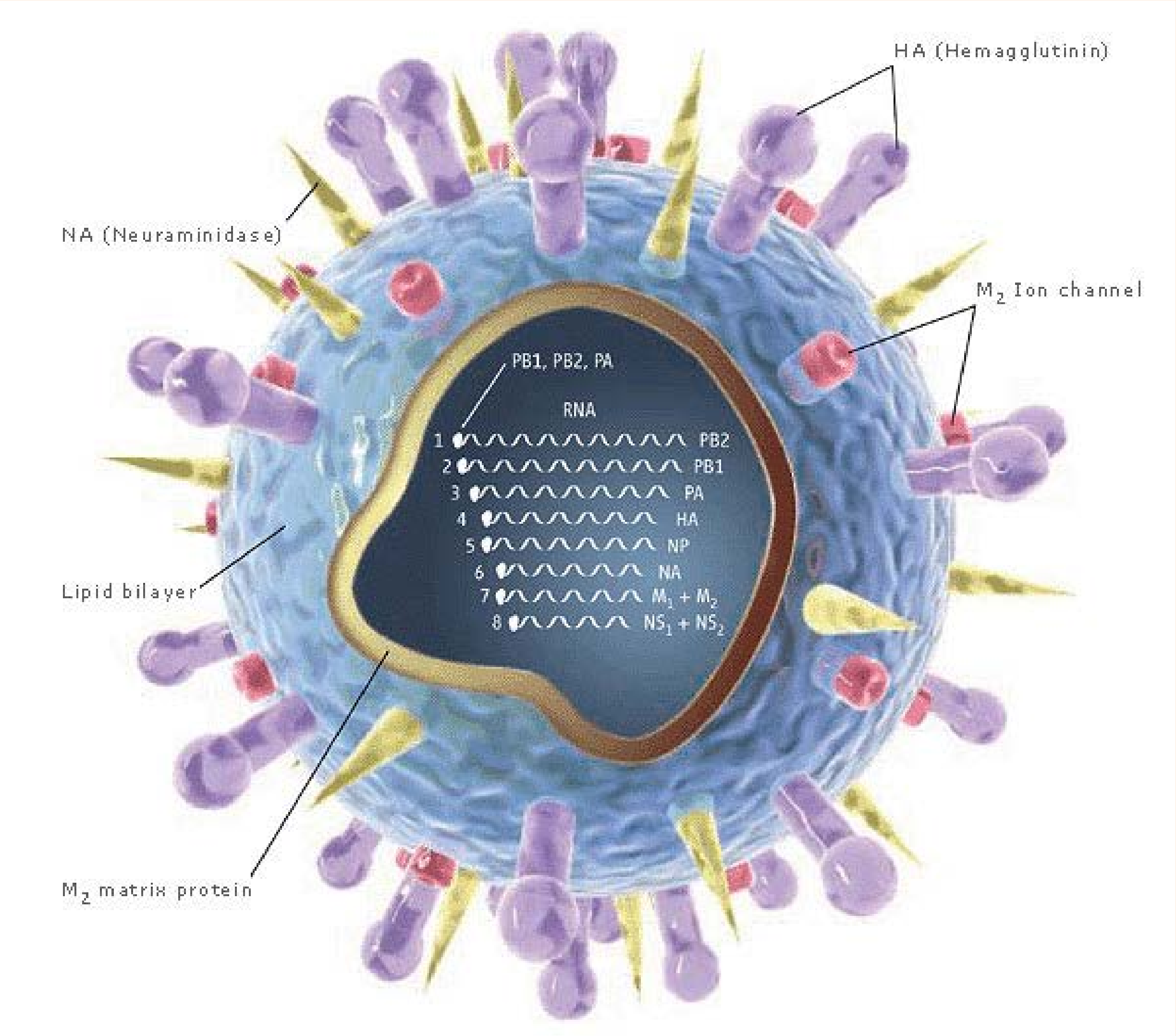
tracheal mite



Varroa mite

Viruses (>18, single stranded RNA viruses)

Deformed Wing, Sacbrood, Black Queen Cell, Israeli Acute Paralysis, Kashmir…etc.



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more potential causes?

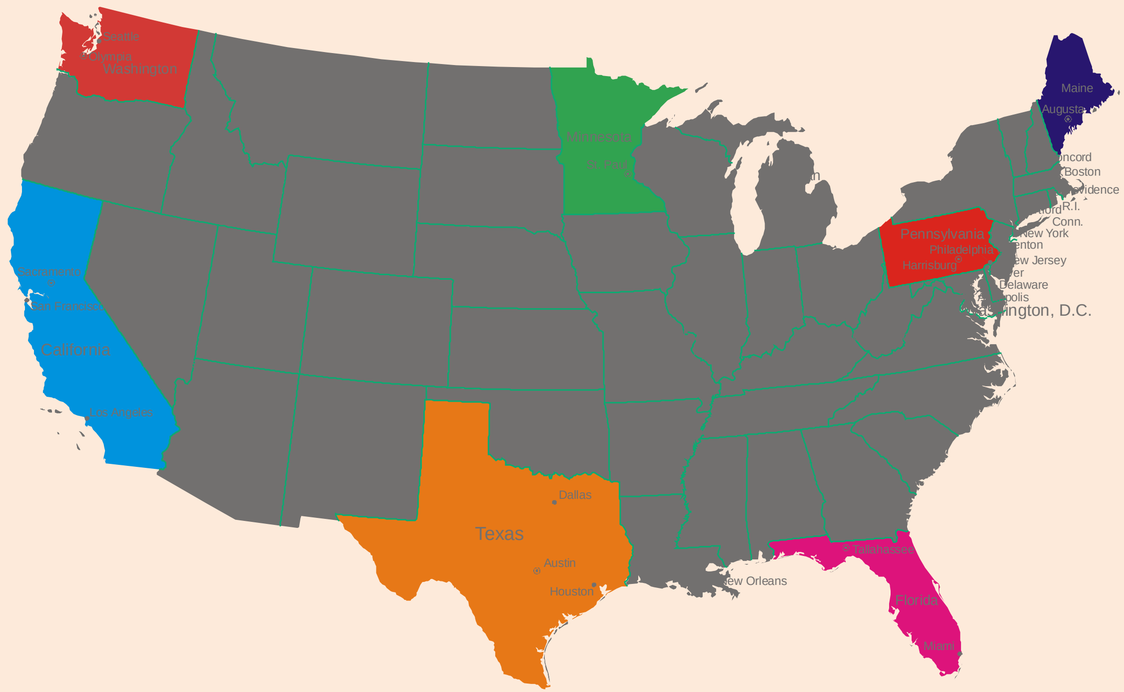
- bacteria (two common species)
- fungi
  - chalkbrood
  - *Nosema* (2 species, 1990s?)
- small hive beetle (2005)
- pesticides (ca. 100)
  - up to 38 per colony
- migratory stress
- nutrition
- genetic diversity

the hypothesis:
Multiple Stressor

- diseases
- macro-parasites
- insecticides
- other factors overlaid


Managed Pollinator CAP
Coordinated Agricultural Project
A National Research and Extension Initiative
to Reverse Pollinator Decline

stationary hive project (2009-2013)



goal:

identify factors and their interactions with colony losses in stationary honey bee colonies across the United States…not sole focus on CCD…

experimental design

- apiaries in 7 states
- 30 colonies / apiary
- first season of each trial…colonies from new packages
- new equipment for each colony when possible
- new wax–coated rigid plastic foundation (Pierco™)
- queen source: Koehnen's queens (Ordbend, California)
- 2 complete trials: 2009 and 2011 and 1 partial trial: 2010

management & maintenance

- feed sugar syrup and protein supplement (MegaBee patties)
- no disease/pest treatments
- management is typical to each region

apiary setup

a) 2009 (Italian queens)

CA, X FL, ME, MN, PA, TX, WA

b) 2010 (Italian queens)

CA, ME2

c) 2011 (Carniolan queens)

CA, FL, ME, MN, PA, TX, WA

standardized data collection

I. weather (daily max & min temp and precip)
II. landscape composition (2 mi radius habitat)
III. pesticide contamination (pollen, wax)
   1. trapped pollen on 5 colonies every month
IV. colony productivity and survival
   1. frames of adult bees and sealed brood (Martin 1998)
   2. queen presence/absence, egg laying and brood pattern quality
   3. supercedure (marked queens)
VI. infestation
   1. *Varroa* mites – mites per 280 adult bees
   2. dissections - tracheal mite
   3. small hive beetle (SHB) adults and larvae
   4. *Nosema* (spp. ID, spore counts, markers)
   5. chalk brood symptoms
   6. bacterial pathogen symptoms
   7. viral symptoms and molecular markers: DWV, IAPV, SBV, BQCV

pesticide analysis

- samples from 5 trapped hives pooled monthly
- modifed QuEChERS procedure (Krupke et al. 2012) used to extract compounds from 5 g pollen samples (conducted by Dr. Brian Eitzer)

- LC/MS analysis used to identify compounds and estimate concentrations (1 ppb resolution) (conducted by Dr. Brian Eitzer)

pesticide contaminants – pollen and wax

2009, 2010, 2011* trials

* trial 3 not complete, currently compiling 2012 data

MN, August 2009

TX, November 2009

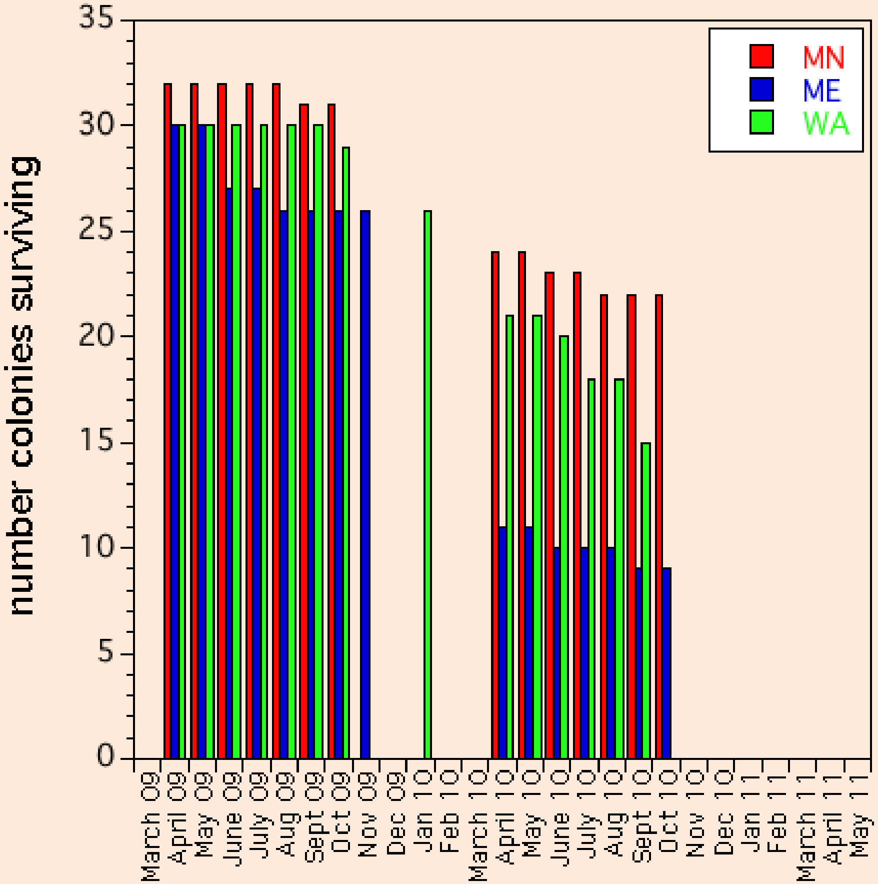
ME April 2010

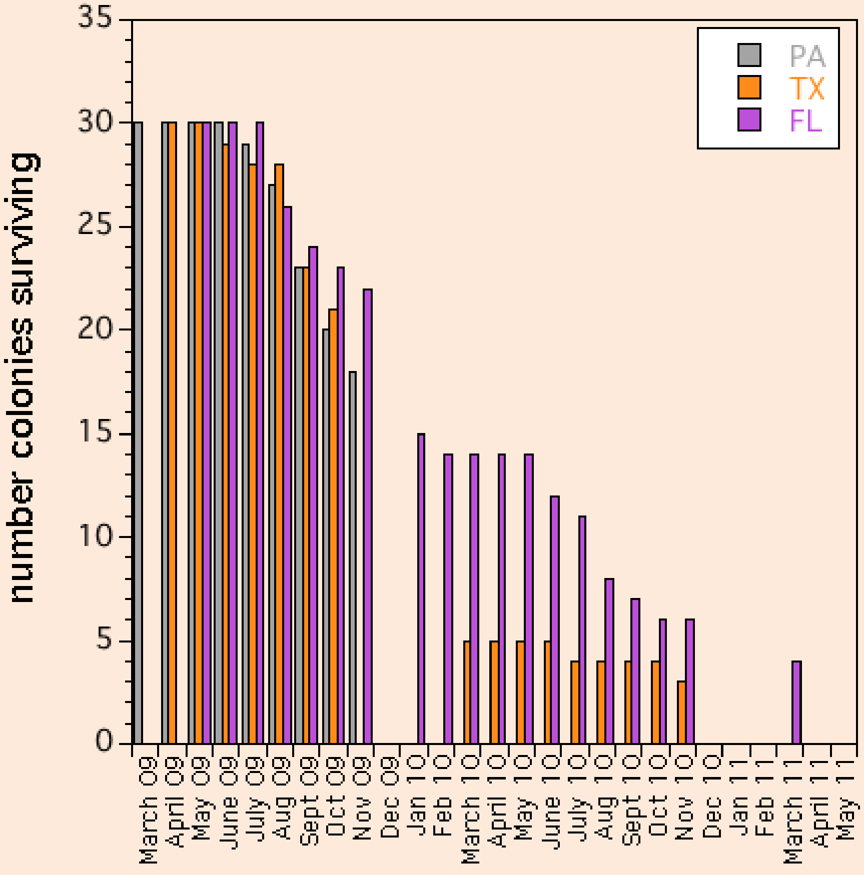
ME, July 2011

any differences among apiaries?

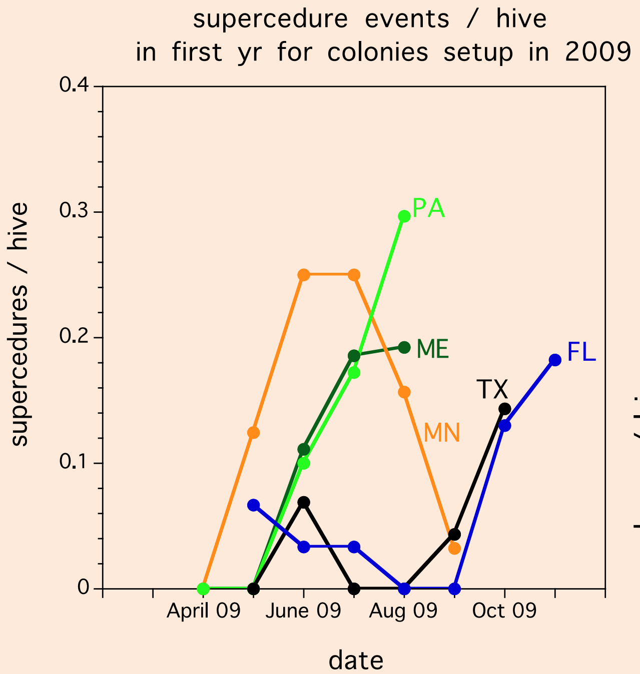
Apiary site	Colony loss rate year one	Colony loss rate year two†	Colony loss rate year three¥
setup 2009	P=0.013*, χ^2 = 14.466, (df=5)	P<0.0001, χ^2 = 60.747, (df=5)	P<0.0001, χ^2 = 52.766, (df=5)
MN	3.1 a$^{\Delta}$	31.1 a$^{\Delta}$	100.0 a
WA	3.3 a	50.0 ab	100.0 ab
ME	13.3 ab	70.0 bc	100.0 b
FL	26.7 b	80.0 cd	87.5 bc
TX	30.0 b	90.0 de	97.0 c
PA	40.0 b	100.0 e	100.0 c
setup 2010	P=0.634*, χ^2 = 0.226, (df=1)	P=0.137, χ^2 = 2.211, (df=1)	P=0.985, χ^2 = 1.723, (df=1)
CA	25.0 a	84.4 a	100.0 a
ME	20.0 a	100.0 a	100.0 a

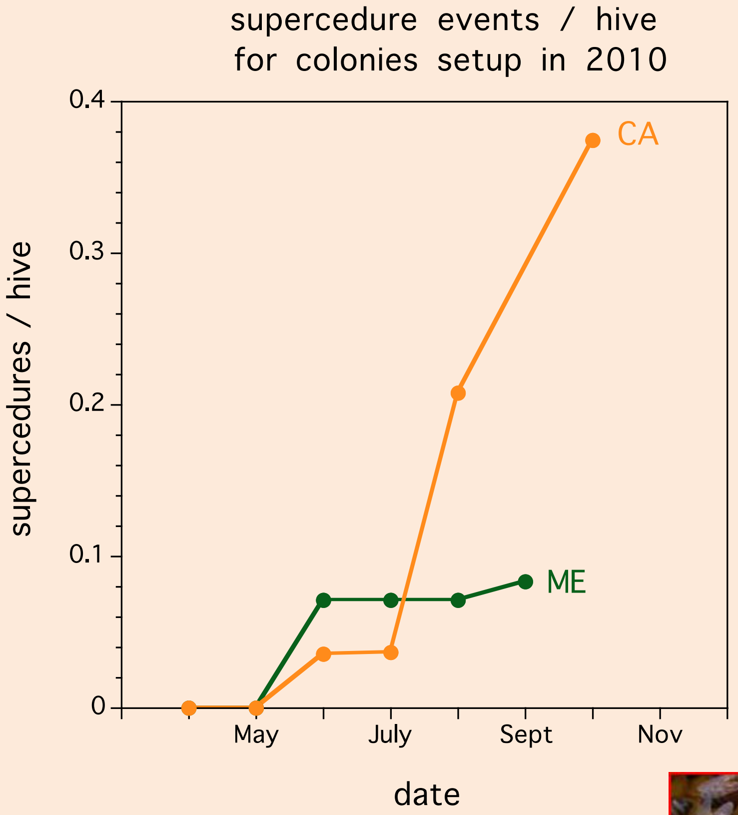
2009 apiaries

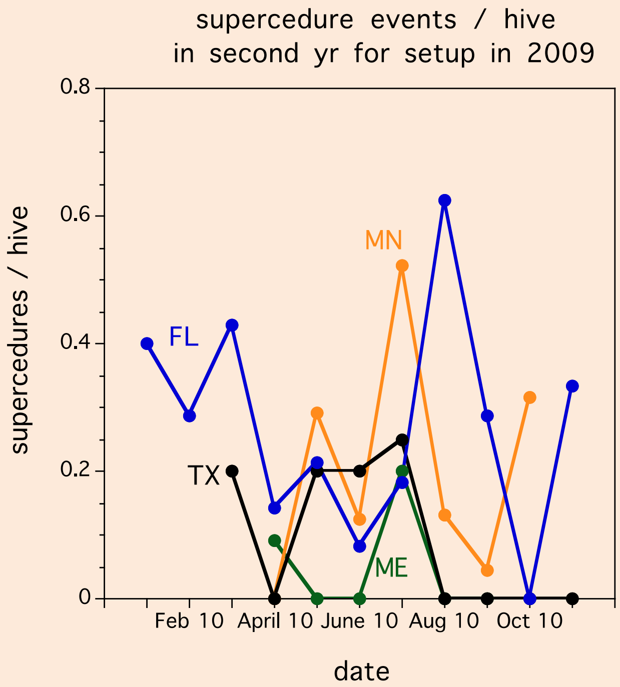




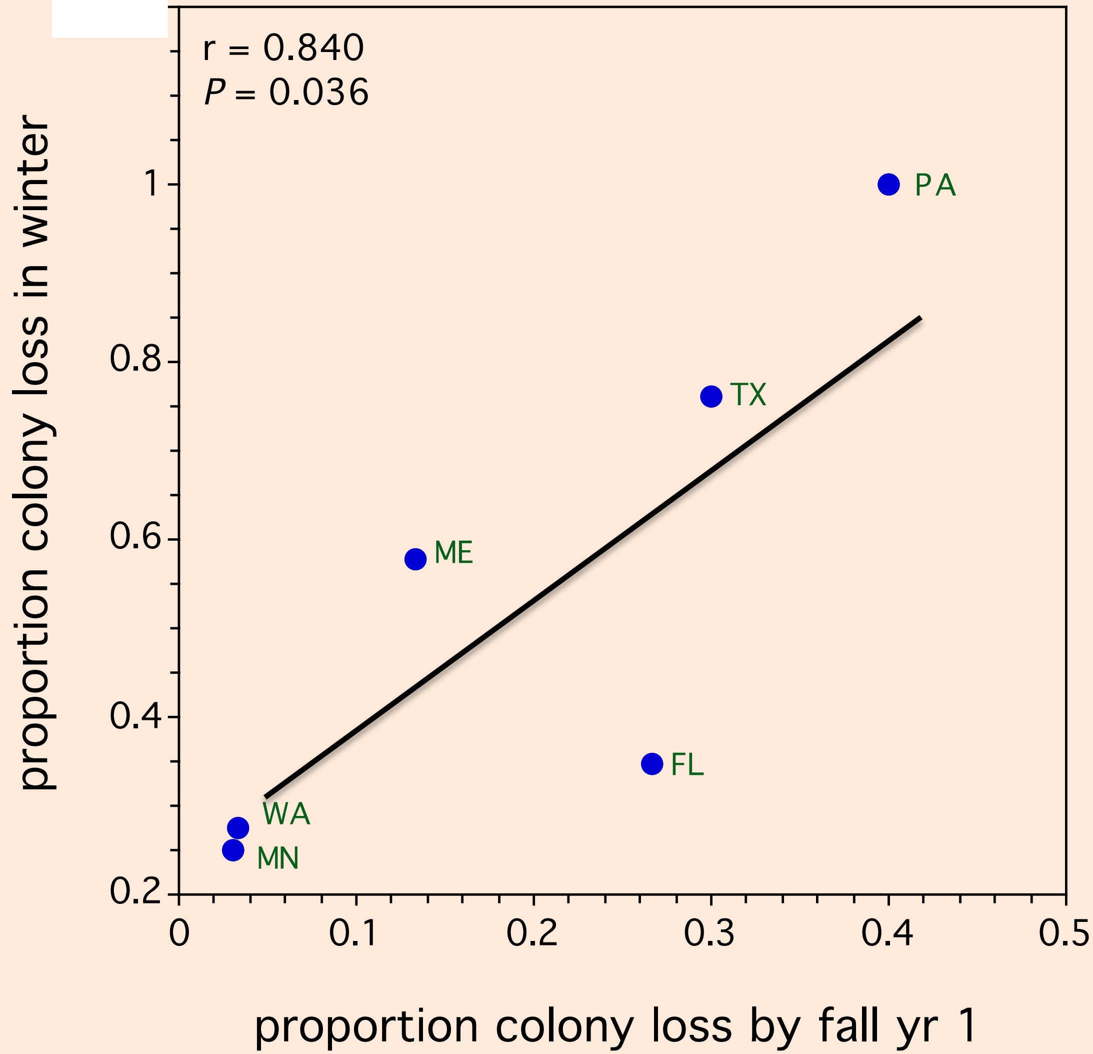
queen supercedure rates



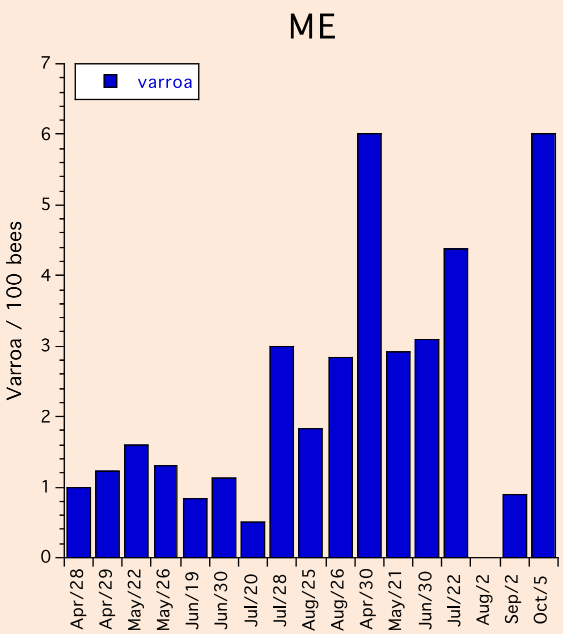


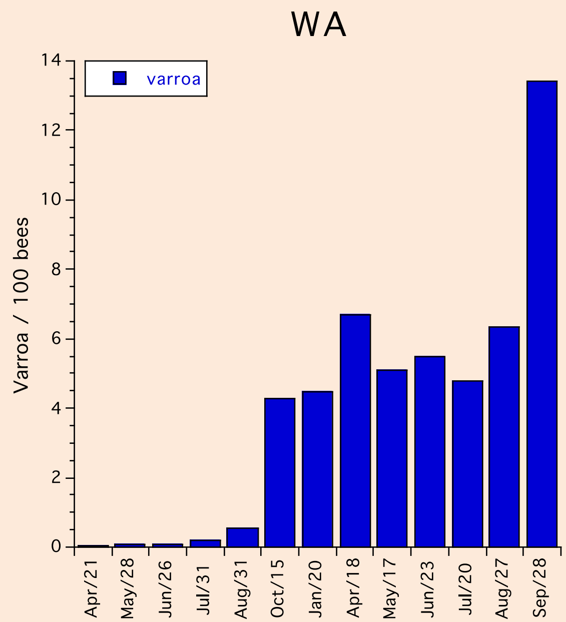


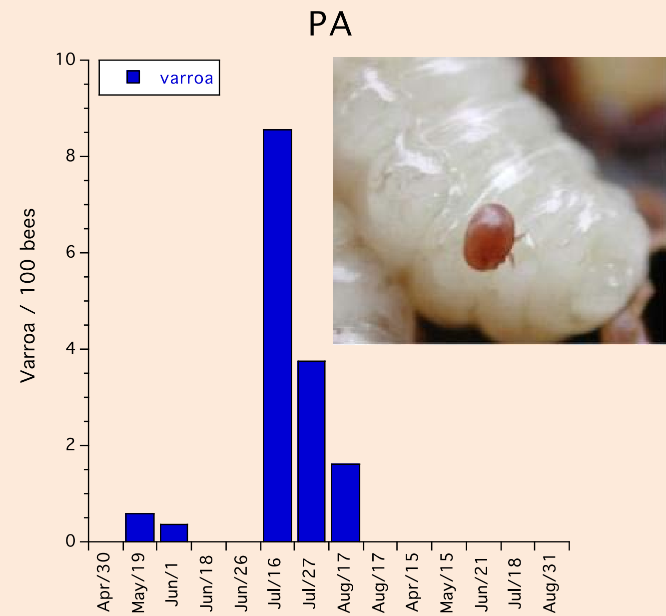
carryover effects in colony loss?
biotic factors affecting colony loss

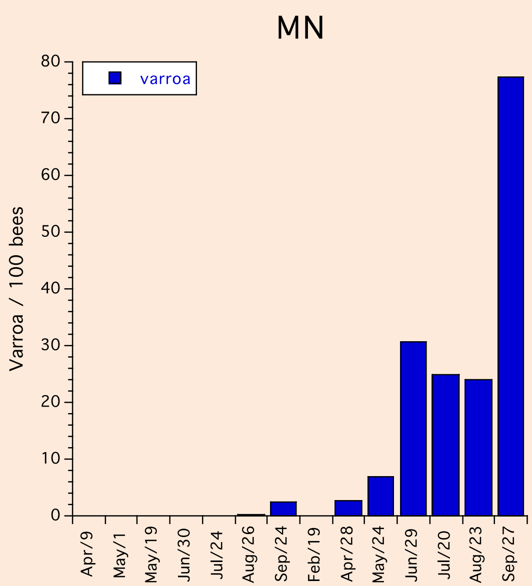


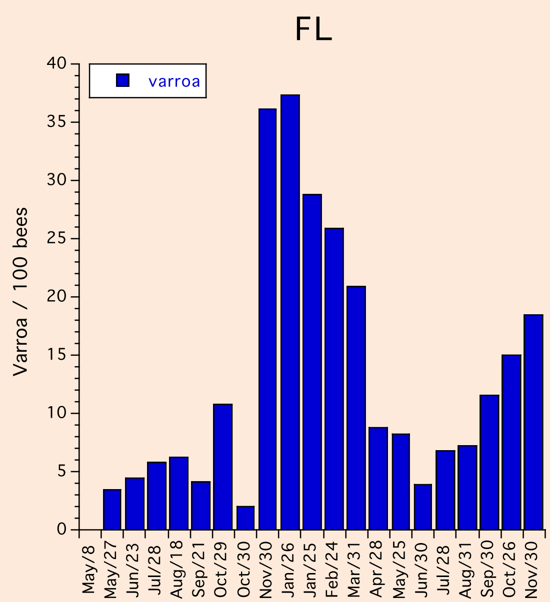
Varroa mite

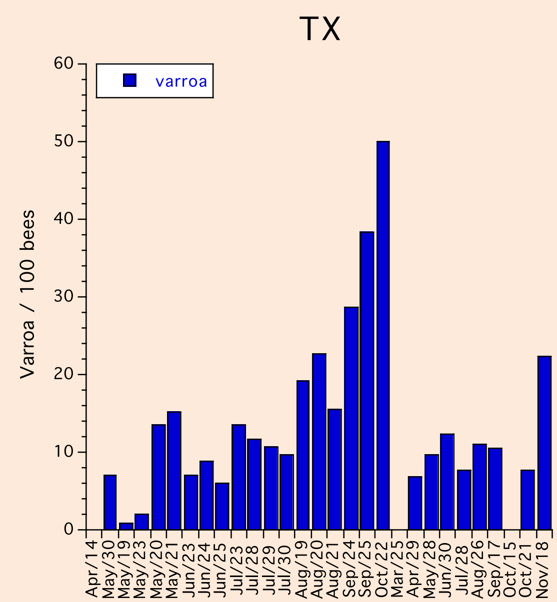

ME
varroa
Varroa / 100 bees
0
1
2
3
4
5
6
7
Apr/28
Apr/29
May/22
May/26
Jun/19
Jun/30
Jul/20
Jul/28
Aug/25
Aug/26
Apr/30
May/21
Jun/30
Jul/22
Aug/2
Sep/2
Oct/5


WA
varroa
Varroa / 100 bees
0
2
4
6
8
10
12
14
Apr/21
May/28
Jun/26
Jul/31
Aug/31
Oct/15
Jan/20
Apr/18
May/17
Jun/23
Jul/20
Aug/27
Sep/28

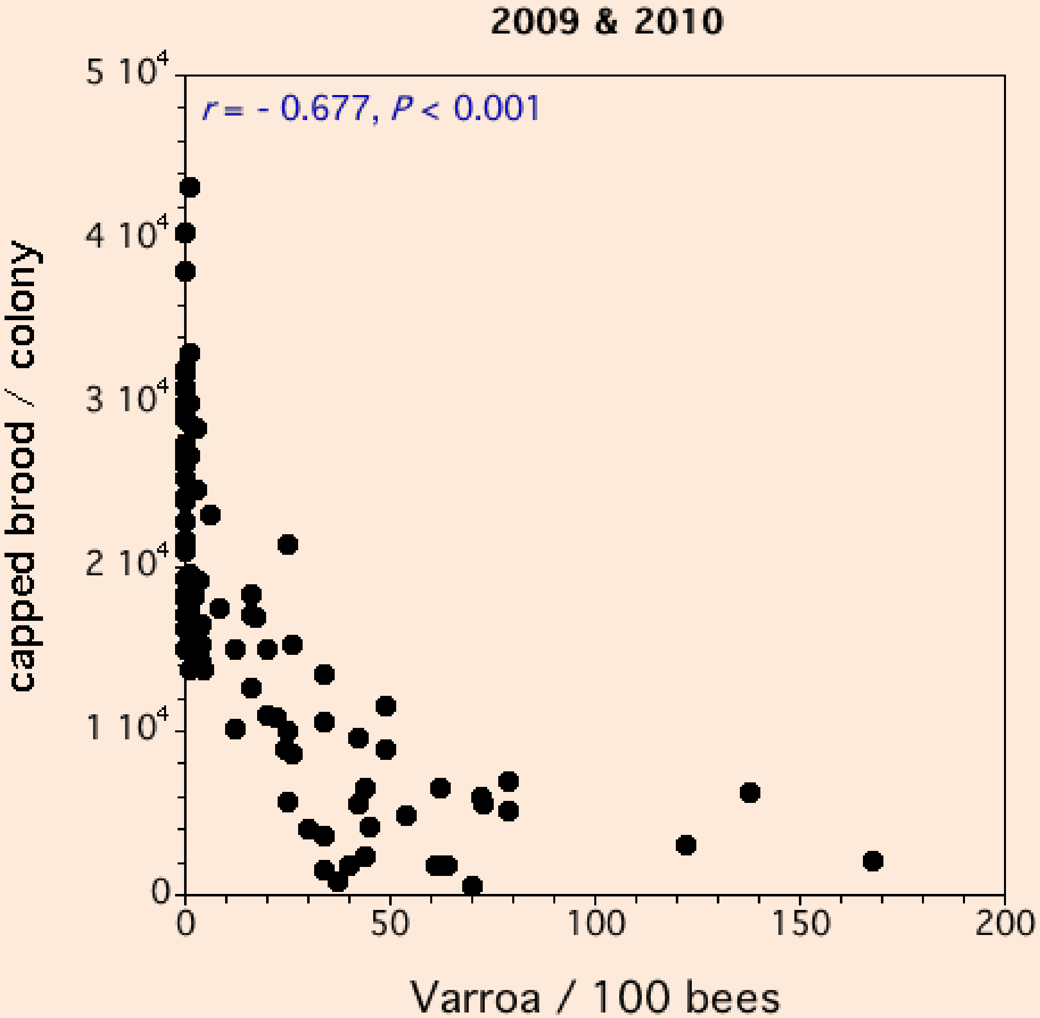

PA
varroa
Varroa / 100 bees
0
2
4
6
8
10
Apr/30
May/19
Jun/1
Jun/18
Jun/26
Jul/16
Jul/27
Aug/17
Aug/17
Apr/15
May/15
Jun/21
Jul/18
Aug/31


MN
varroa
Varroa / 100 bees
0
10
20
30
40
50
60
70
80
Apr/9
May/1
May/19
Jun/30
Jul/24
Aug/26
Sep/24
Feb/19
Apr/28
May/24
Jun/29
Jul/20
Aug/23
Sep/27

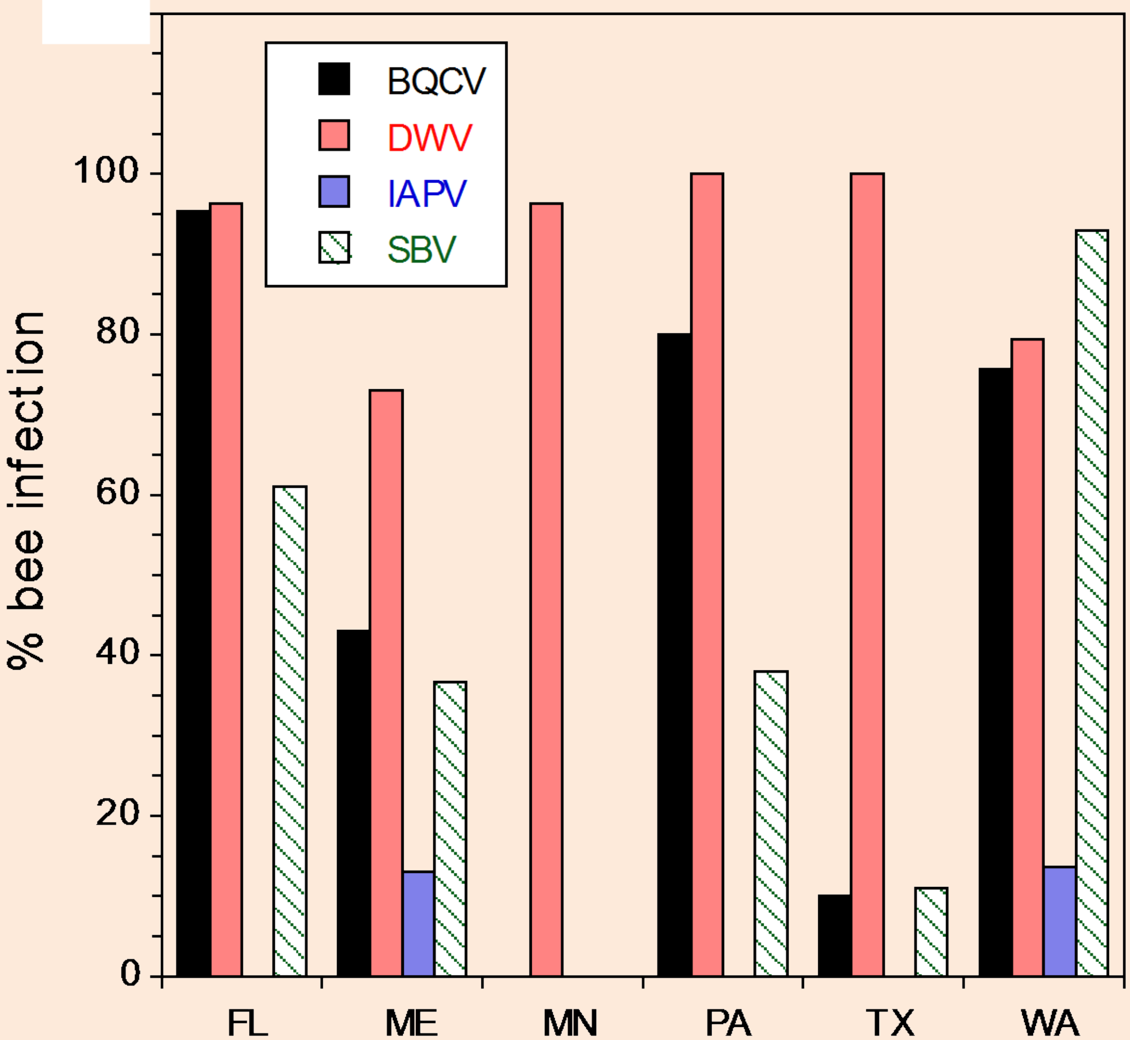

FL
varroa
Varroa / 100 bees
0
5
10
15
20
25
30
35
40
May/8
May/27
Jun/23
Jul/28
Aug/18
Sep/21
Oct/29
Oct/30
Nov/30
Jan/26
Jan/25
Feb/24
Mar/31
Apr/28
May/25
Jun/30
Jul/28
Aug/31
Sep/30
Oct/26
Nov/30

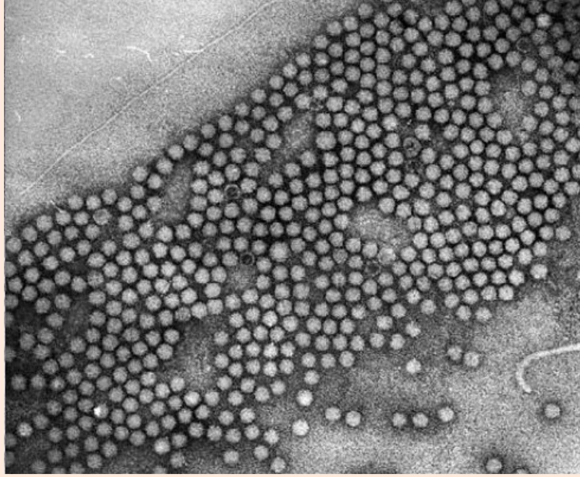

TX
varroa
Varroa / 100 bees
0
10
20
30
40
50
60
Apr/14
May/30
May/19
May/23
May/20
May/21
Jun/23
Jun/24
Jun/25
Jul/23
Jul/28
Jul/29
Jul/30
Aug/19
Aug/20
Aug/21
Sep/24
Sep/25
Oct/22
Mar/25
Apr/29
May/28
Jun/30
Jul/28
Aug/26
Sep/17
Oct/15
Oct/21
Nov/18

colony brood population density vs *Varroa*

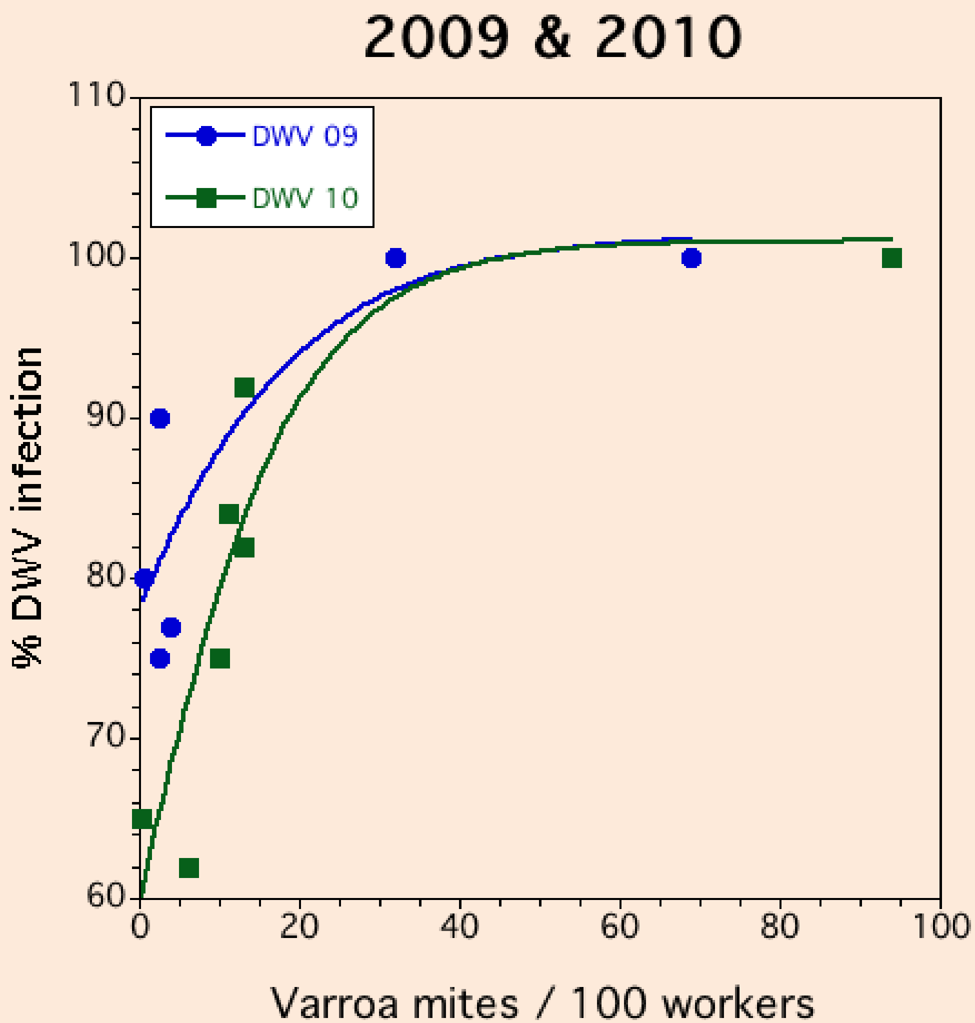


virus infections

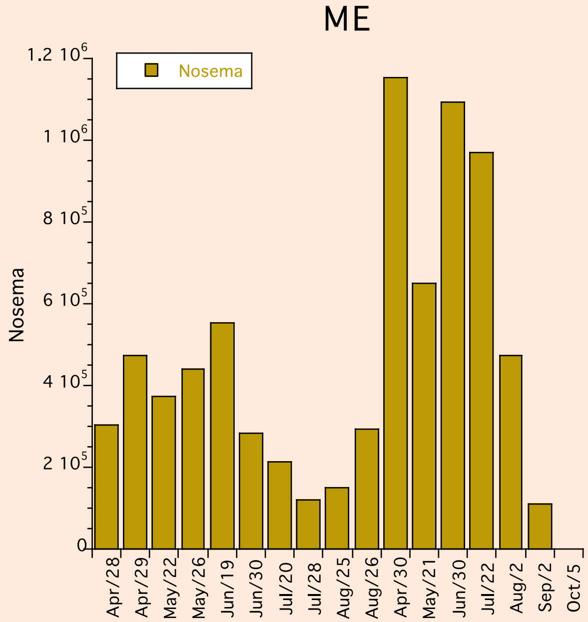


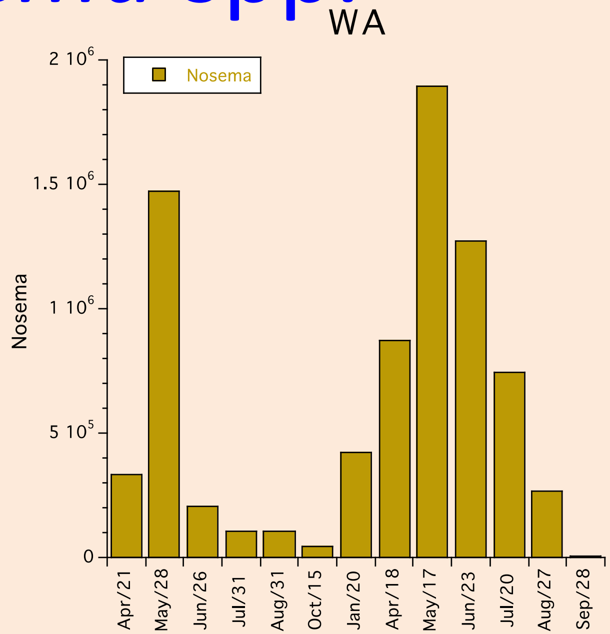


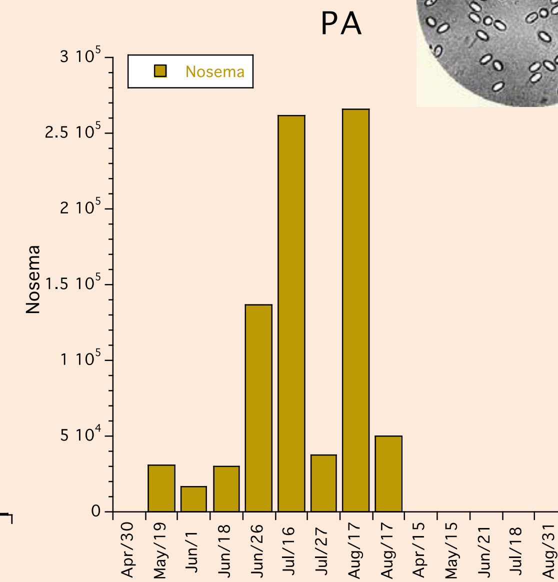
dynamics of main effects

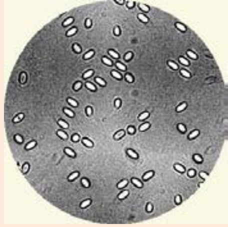


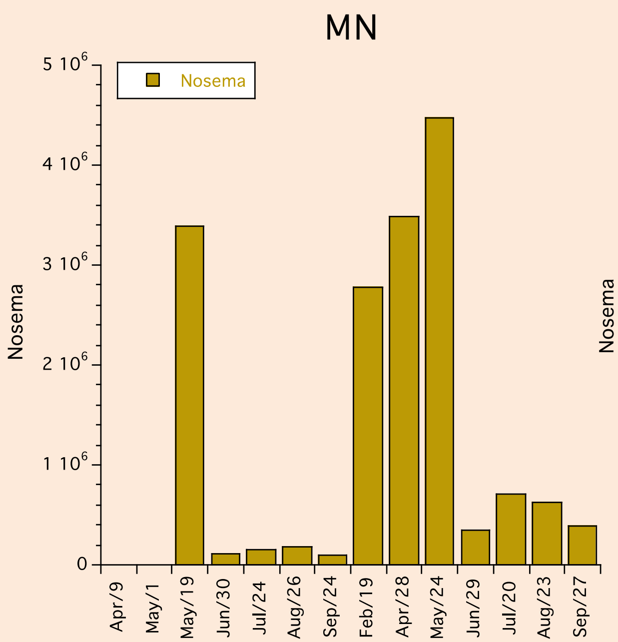
Nosema spp.

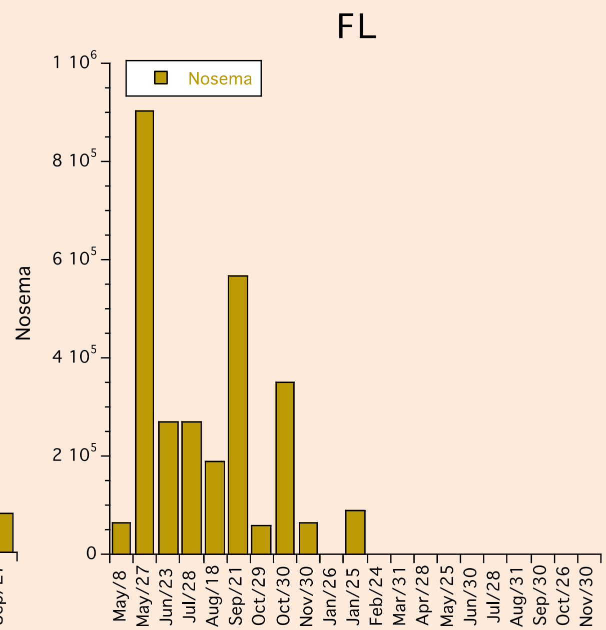

ME
Nosema
1.2 10^6
1 10^6
8 10^5
6 10^5
4 10^5
2 10^5
0
Nosema
Apr/28 Apr/29 May/22 May/26 Jun/19 Jun/30 Jul/20 Jul/28 Aug/25 Aug/26 Apr/30 May/21 Jun/30 Jul/22 Aug/2 Sep/2 Oct/5

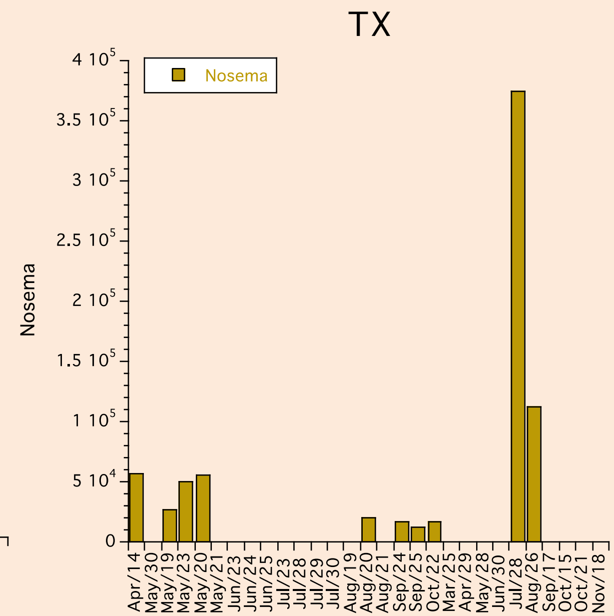

WA
Nosema
2 10^6
1.5 10^6
1 10^6
5 10^5
0
Nosema
Apr/21 May/28 Jun/26 Jul/31 Aug/31 Oct/15 Jan/20 Apr/18 May/17 Jun/23 Jul/20 Aug/27 Sep/28


PA
Nosema
3 10^5
2.5 10^5
2 10^5
1.5 10^5
1 10^5
5 10^4
0
Nosema
Apr/30 May/19 Jun/1 Jun/18 Jun/26 Jul/16 Jul/27 Aug/17 Aug/17 Apr/15 May/15 Jun/21 Jul/18 Aug/31

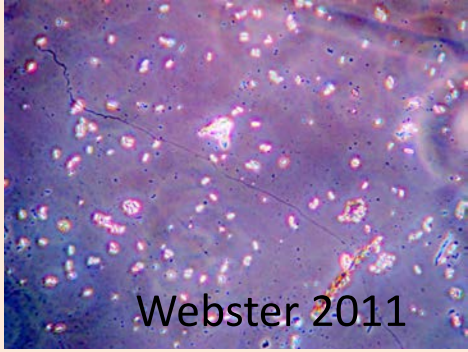


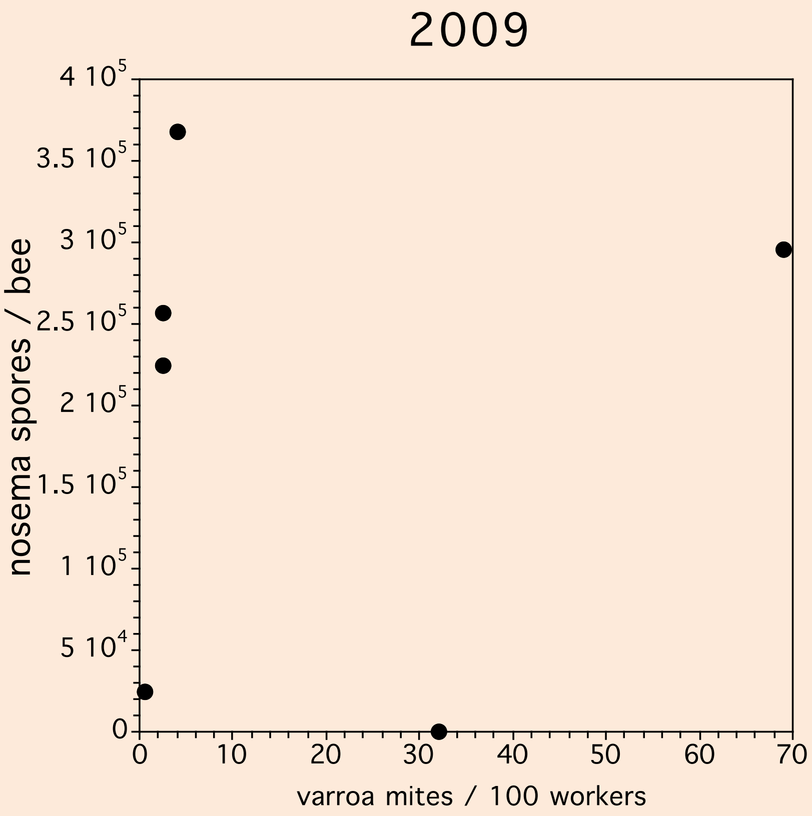

MN
Nosema
5 10^6
4 10^6
3 10^6
2 10^6
1 10^6
0
Nosema
Apr/9 May/1 May/19 Jun/30 Jul/24 Aug/26 Sep/24 Feb/19 Apr/28 May/24 Jun/29 Jul/20 Aug/23 Sep/27

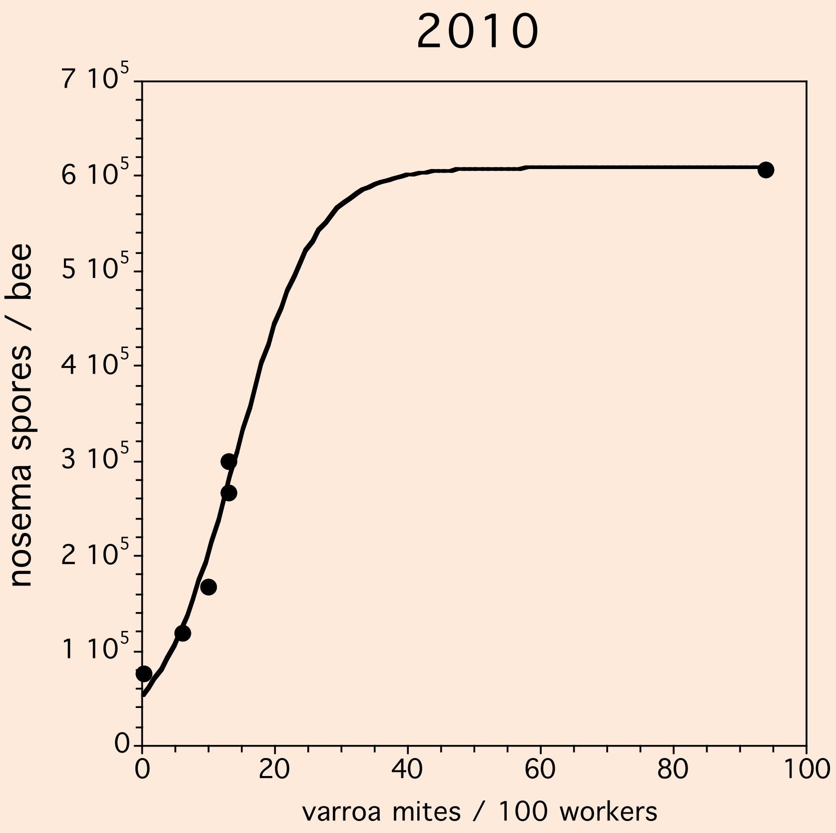

FL
Nosema
1 10^6
8 10^5
6 10^5
4 10^5
2 10^5
0
Nosema
May/8 May/27 Jun/23 Jul/28 Aug/18 Sep/21 Oct/29 Oct/30 Nov/30 Jan/26 Jan/25 Feb/24 Mar/31 Apr/28 May/25 Jun/30 Jul/28 Aug/31 Sep/30 Oct/26 Nov/30


TX
Nosema
4 10^5
3.5 10^5
3 10^5
2.5 10^5
2 10^5
1.5 10^5
1 10^5
5 10^4
0
Nosema
Apr/14 May/30 May/19 May/23 May/20 May/21 Jun/23 Jun/24 Jun/25 Jul/23 Jul/28 Jul/29 Jul/30 Aug/19 Aug/20 Aug/21 Sep/24 Sep/25 Oct/22 Mar/25 Apr/29 May/28 Jun/30 Jul/28 Aug/26 Sep/17 Oct/15 Oct/21 Nov/18

Varroa vs Nosema



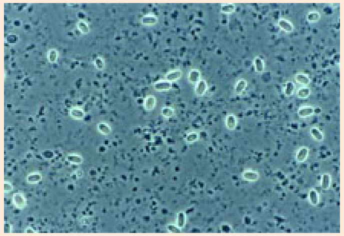


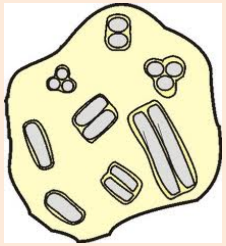


spring 2009 – spring 2011 colony losses (all sites)

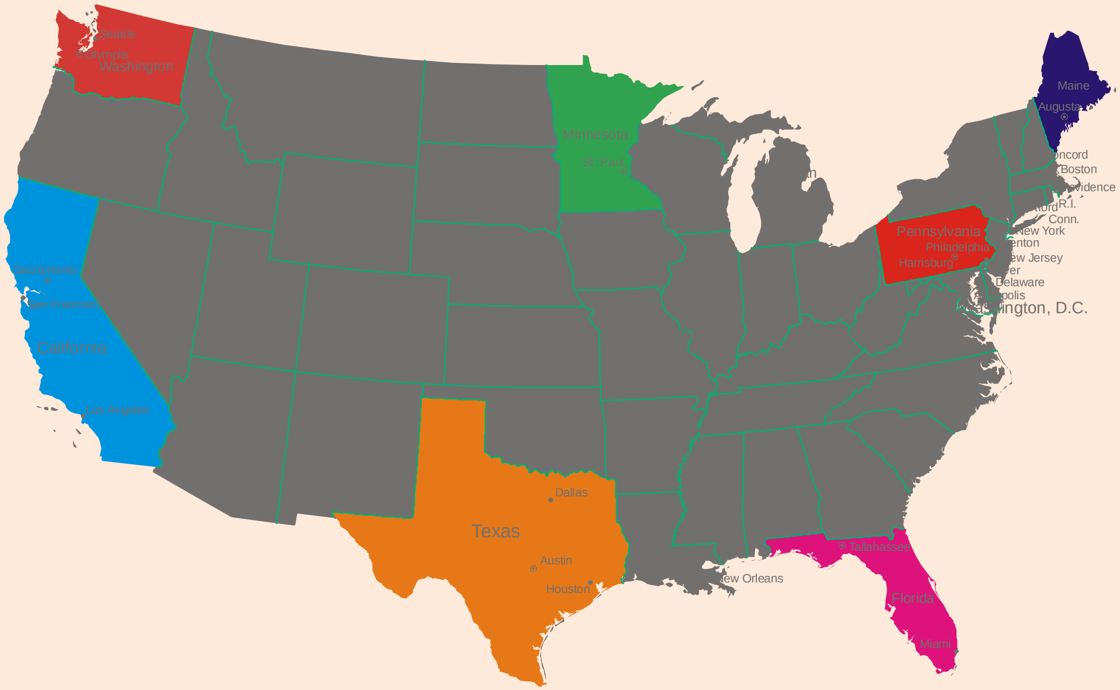
- 2009 - 2011 colony loss — relative risk

Apiary site	P < 0.0001	
Varroa	P < 0.0001	3.8
Varroa x site	P < 0.0001	
Nosema	P < 0.007	2.1
Nosema x site	P = 0.021	
IAPV	P = 0.054	1.3



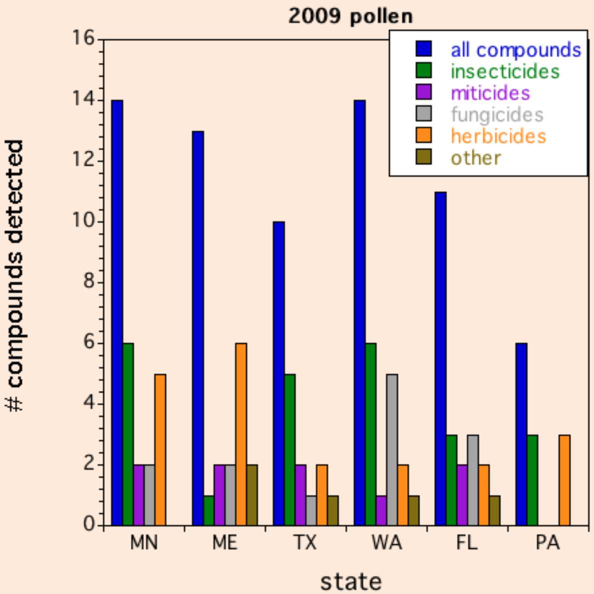


Apiary Site Effects ??

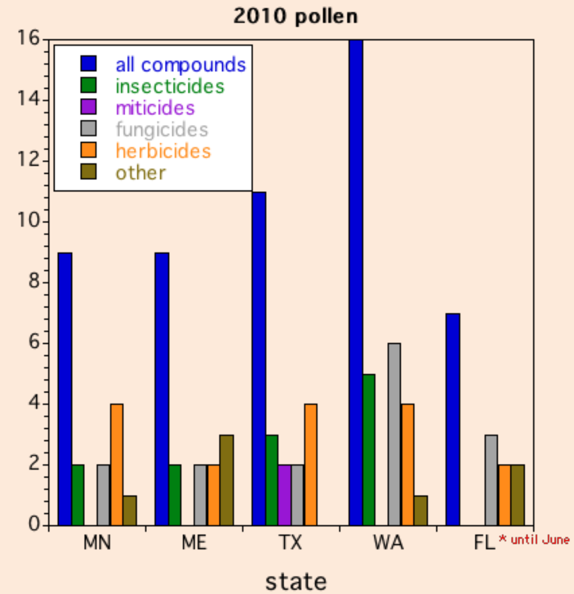


number of pesticides detected

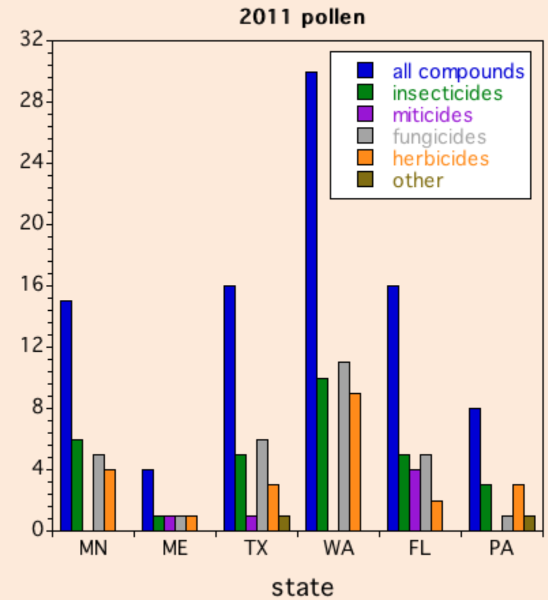
P = 0.022



P = 0.034



P = 0.010



correlations between years within states

2009 and 2010:

cmpds *ns*

classes: fungicides, *r* = 0.952, *P* = 0.028

2010 and 2011:

cmpds *ns*

classes: fungicides, *r* = 0.842, *P* = 0.074†

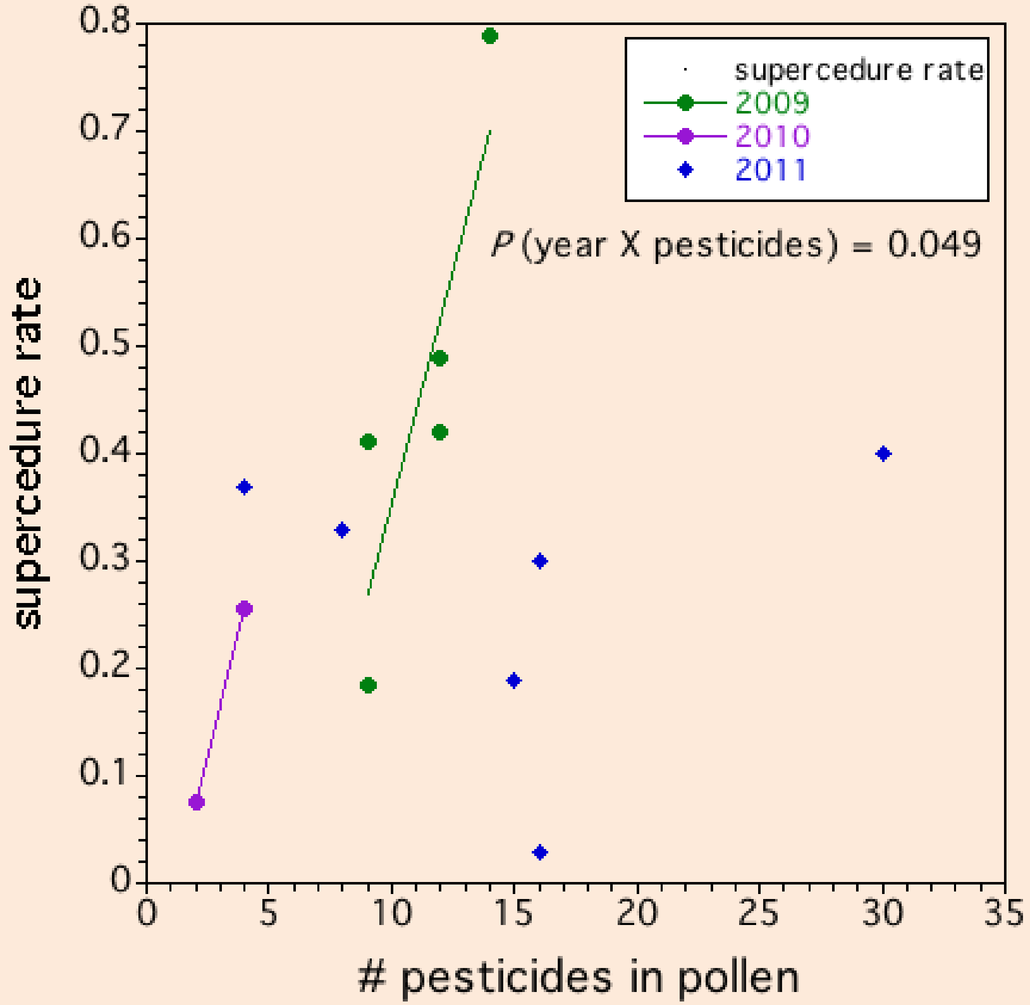
most common pesticides (most detections)

2009: atrazine, coumaphos, pendimethalin

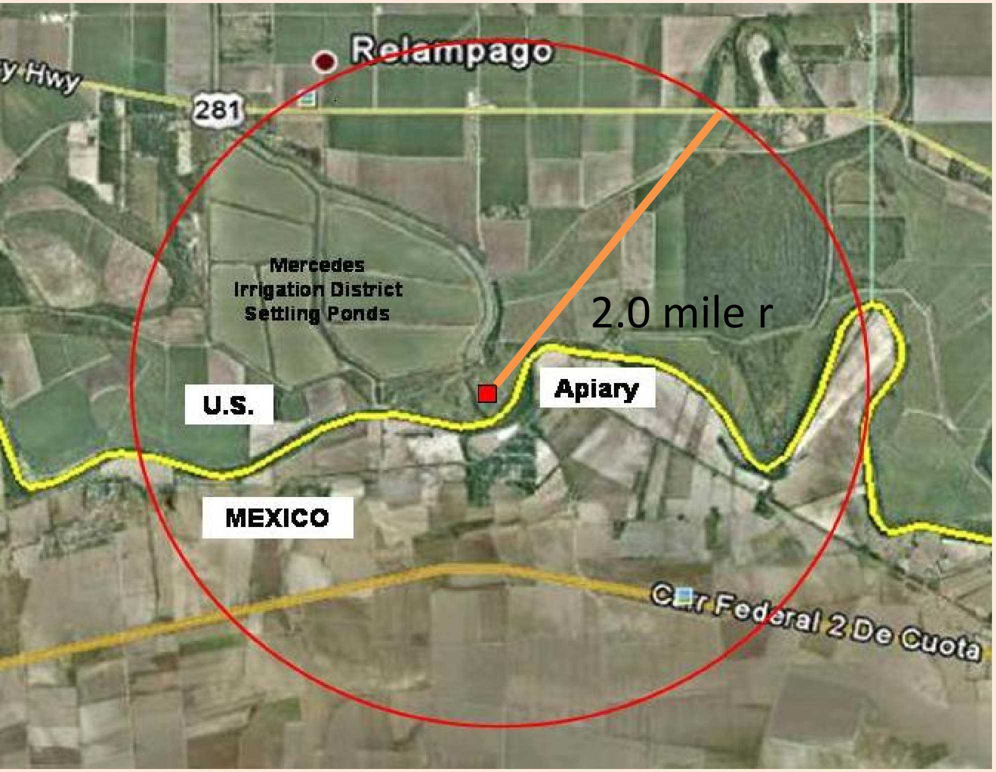
2010: atrazine, carbendazim, carbaryl

2011: atrazine, propiconazole, axoxystrobin

number of pesticides in trapped pollen during first season



apiary landscapes



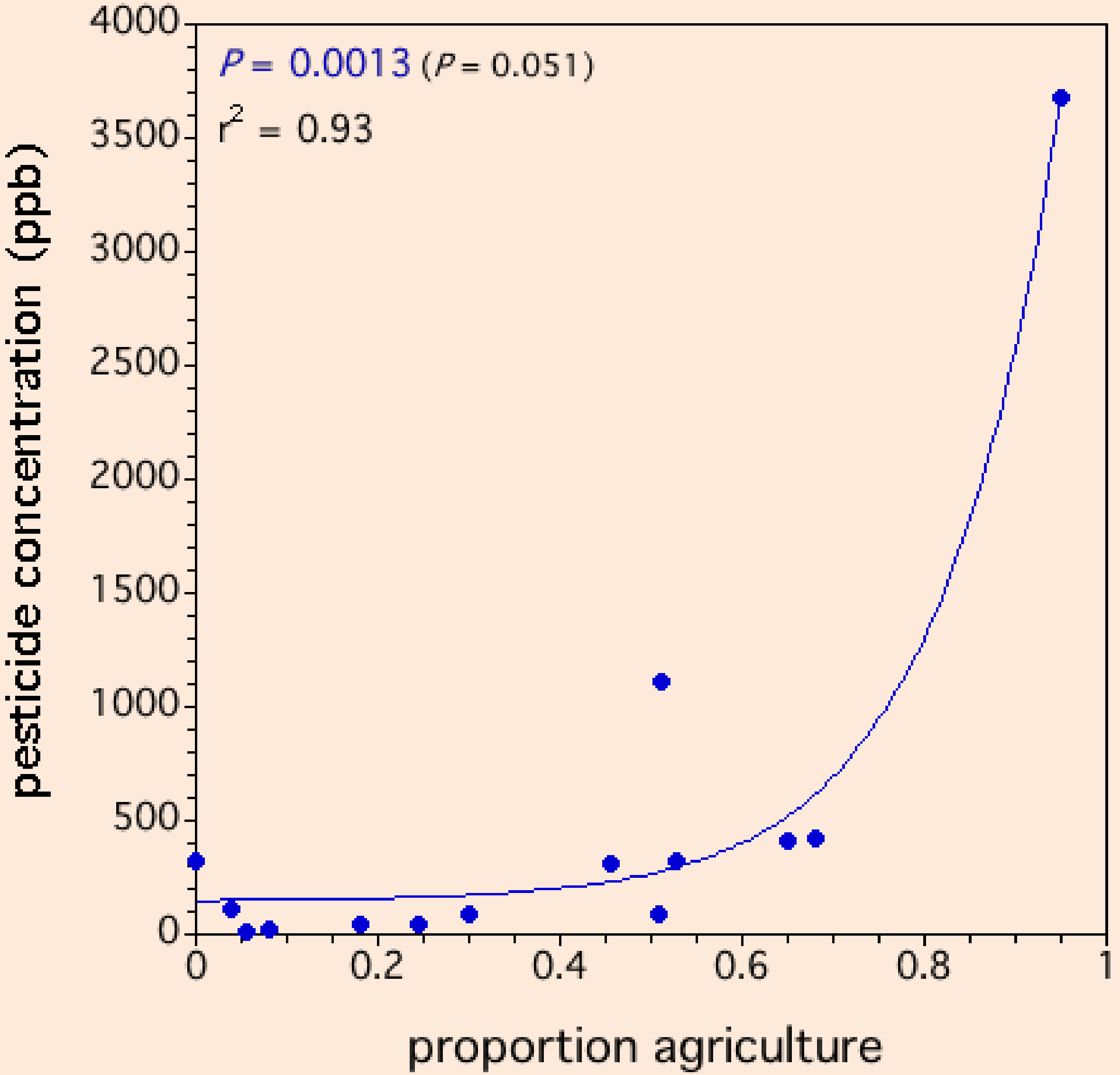
Texas apiary site

Florida land cover

Land Cover Description	Acres	Percent
Coniferous Pine	14.6	0.47%
Emergent Aquatic Veg	8.9	0.29%
Field Crops	543.3	17.62%
Forest Regeneration	83.9	2.72%
Freshwater Marshes	201	6.52%
Horse Farm	99	3.21%
Improved Pastures	1166.6	37.83%
Institutional	6.1	0.20%
Lakes	9.4	0.30%
Mixed Crops	216.5	7.02%
Mixed Scrub-shrub Wetland	25.3	0.82%
Mixed Upland Nonforested	1.4	0.05%
Mixed Wetland Hardwoods	15.6	0.51%
Reservoirs	0.4	0.01%
Residentual. Low desity	18.4	0.60%
Residentual. Med. desity	51.5	1.67%
Streams and Waterways	3.3	0.11%
Unimproved Pastures	2.7	0.09%
Upland hardwood Forest	9.3	0.30%
Upland Mixed Coniferous/Hardwood	457	14.82%
Wet Prairies	12.8	0.42%
Wetland Forested Mixed	15.3	0.50%
Woodland Pastures	121.9	3.95%

classes for analysis:

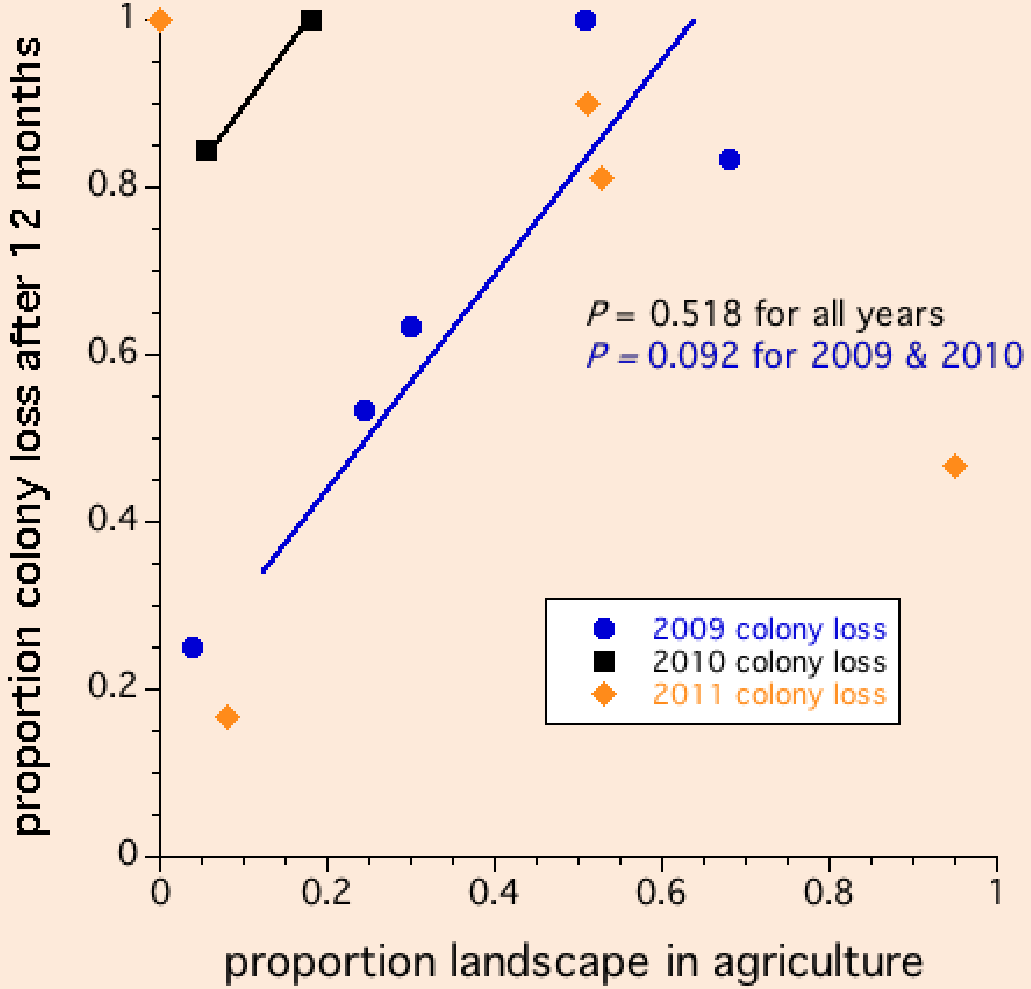
- forest
- old field scrub/shrub
- pasture
- wetlands
- urban / suburban
- agricultural



year ns

year X proportion ns

effect of intensive agriculture?



conclusions from pollen analyses

- # fungicides correlated between yrs
- miticide trend in concentrations 2009-2010
- # pesticides vs supercedure rate, 2009 & 2010 only
- agriculture vs colony losses, 2009 & 2010 only (P=0.092)
- agriculture explains variation in concentration

where to…from here?

- tease apart interactions between potential causal factors.

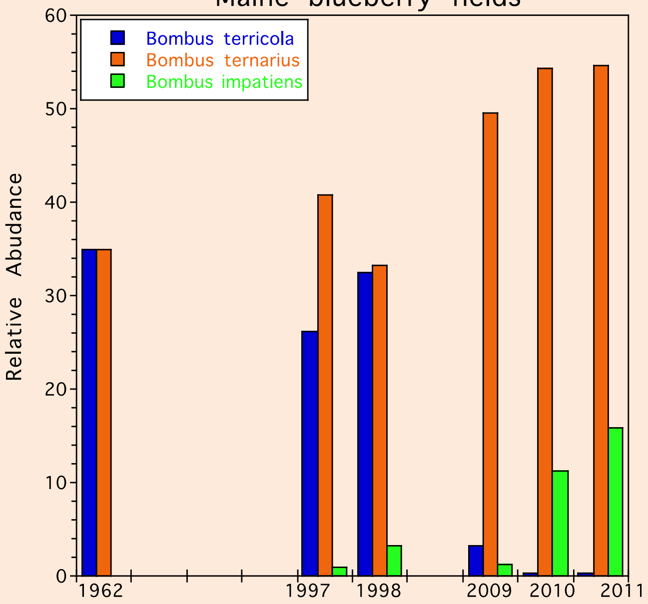
- additional factors

- ZOMBIE BEES?

  (2012)

what about the other bees… are they in decline?

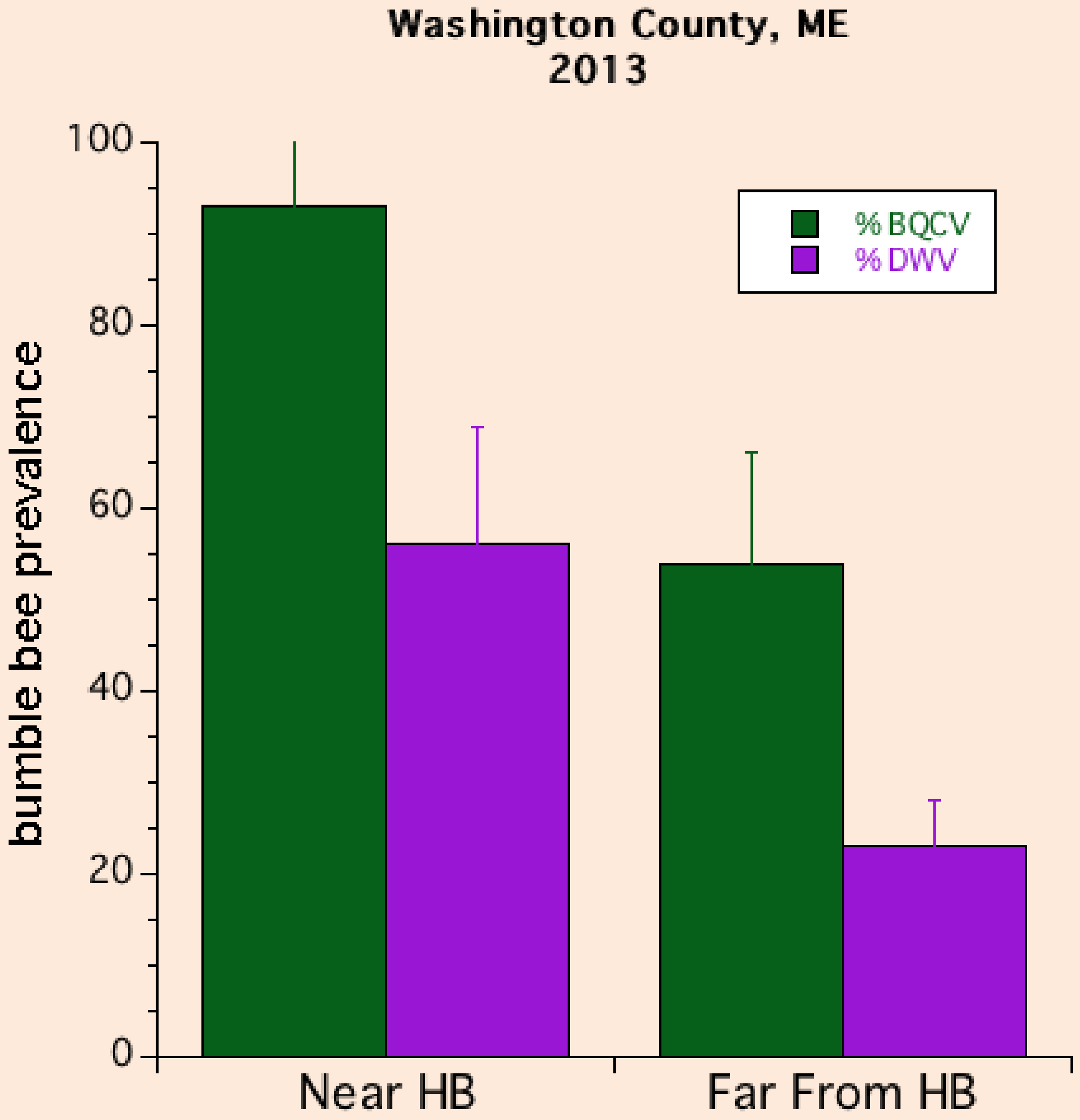
- native or wild bees

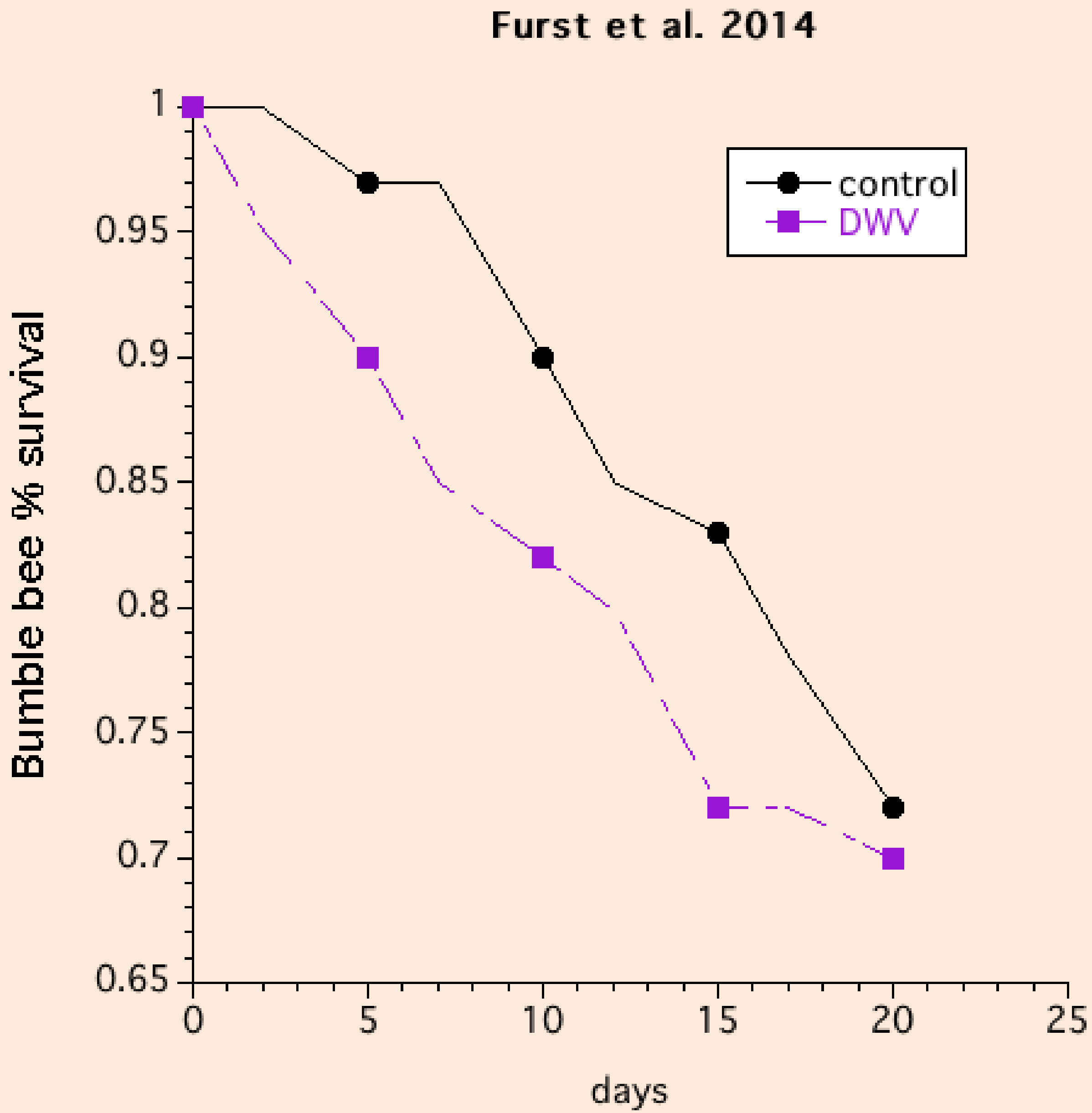


spillover of pathogens from honey bees to native bees?

Table 5. Percentage of virus-positive *Bombus* sampled from flowers in the vicinity of Stationary Apiaries in Maine, Minnesota, and Washington. Samples were taken in July/August 2010. DWV = Deformed wing virus and BQCV = Black queen shared *Bombus* cell virus.

Apiary and Species		**Single infection**	**Single infection**	**Dual infection**
	n	DWV	BQCV	DWV + BQCV
MAINE				
Bombus ternarius	26	73.1	38.5	30.7
Bombus vagans	5	80.0	40.0	20.0
Bombus spp.	8	87.5	62.5	62.5
Mean		**79.4**	**43.6**	**35.9**
MINNESOTA				
Bombus bimaculatus	5	20.0	40.0	20.0
Bombus impatiens	7	85.7	85.7	71.4
Bombus vagans	5	80.0	100	80.0
Mean		**64.7**	**76.5**	**58.8**
WASHINGTON				
Bombus mixtus	11	81.8	90.9	72.7
Bombus spp.	18	72.2	94.4	72.2
Mean		**75.9**	**93.1**	**72.5**


Washington County, ME
2013
bumble bee prevalence
100
80
60
40
20
0
% BQCV
% DWV
Near HB
Far From HB



Furst et al. 2014
Bumble bee % survival
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0
5
10
15
20
25
days
control
DWV

major take home points

- Pollinators ?
- Factors that can put them at risk ?
- CCD ?
- Native Pollinators ?