Neonicotinoids

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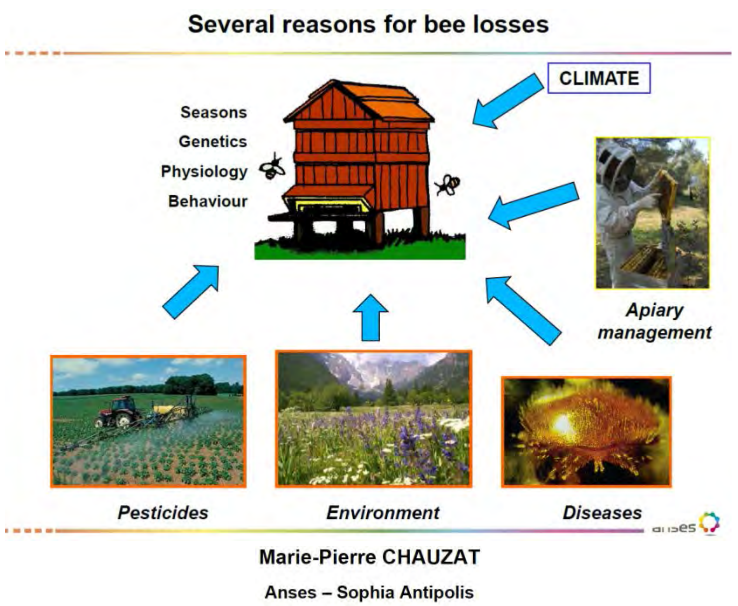
My premise

- I am not here to defend or indict pesticides
- I will try to outline the latest research findings
- I am not a bee or CCD expert by any means
- My head is still spinning from all the reading I have done



A little neonic history

* Neonicotinoids are "insecticides" and of course they can and will kill bees, other pollinators, beneficials and aquatic invertebrates
* Came onto the market when EPA began to look for alternatives to organophosphates and carbamates
* Imidacloprid came first in 1994 and was originally conditionally registered for ornamental & turf uses
* The rest soon followed after EPA instituted a Reduced Risk (RR) and OP Alternative (OPA) accelerated registration process
  * Thiamethoxam – 2000
  * Acetamiprid – 2002
  * Clothianidin – 2003
  * Dinotefuran – 2004
* Thiacloprid was conditionally registered in 2003 outside of the RR/OPA program

More history

* Neonicotinoids were favored for their
  * low mammalian toxicity
  * lack of mammalian CNS effects, and
  * lack of carcinogenic (cancer) effects
* Use rates are very low (ml vs pts/Ac)
* EPA knew all along that they had some negatives:
  * Very water soluble (good & bad)
  * very leachable (groundwater concerns)
  * fairly persistent in woody plants and soils

Neonic history

* EPA decided right from the beginning to manage the negatives with very specific label language
* Ground water warnings, reduced rates, pollinator warnings, etc.
* EPA scientists agreed that using neonics as labeled would be a better alternative to the continued use of OPs and carbamates because they:
  * are much higher in mammalian toxicity, data on carcinogencity is equivocal and nervous system effects are definite

Neonic users

* NNE agricultural production relies on neonics for yield and quality
  * Potatoes
  * Apples
  * Vegetables
  * Small Fruits
  * Nurseries
  * Sod Farms
* Turf and Ornamental managers rely on them, and
* Homeowners rely on them too

What if…

* neonicotinoids are banned…
* Other pesticides will fill the vacuum
* Pyrethroids, OPs, Carbamates, Spinosad, Phorate, Chlorantraniliprole, Indoxacarb, Spinetoram, etc.
  * Most of these are as or more toxic to bees than neonics
  * Some of these are also systemics
* What if bee declines continue?
* We need to look at the whole universe of exposures
  * insecticides, fungicides, herbicides
  * surfactants and other adjuvants
  * tank mixes and synergistic effects

Future of neonicitinoids

* EPA is opening the re-registration docket on all the neonicotinoids
* EPA - "some uncertainties have been identified since their initial registration"
  * Environmental fate and
  * Effects on pollinators
* Concerns about persistence and bioaccumulation
  * Higher levels in guttation water
  * Higher levels expressed in soil injected woody plants
  * Higher levels expressed in ornamental plants

Schedule for Review of Neonicotinoid Pesticides

The dockets for all the neonicotinoid pesticides have been opened. Our goal is to review the pesticides in this class in the same timeframe so we can ensure consistency across the class.

Chemical Name and Docket Number	Initiation	Data Generation	Completion
Imidacloprid EPA-HQ-OPP-2008-0844	Dec. 2008	2010-2015	2016-2017
Clothianidin EPA-HQ-OPP-2100-0865	Dec. 2011	2013-2016	2017-2018
Thiamethoxam EPA-HQ-OPP-2011-0581	Dec. 2011	2013-2016	2017-2018
Dinotefuran EPA-HQ-OPP-2011-0920	Dec. 2011	2013-2016	2017-2018
Acetamiprid EPA-HQ-OPP-2012-0329	Dec. 2012	2014-2017	2018-2019
Thiacloprid EPA-HQ-OPP-2012-0218	Dec. 2012	2014-2017	2018-2019

The Facts About Systemic Insecticides – Richard Cowles - CAES

* CCD has not diminished in countries where neonicotinoid insecticide use was curtailed[6],
* CCD is not found in Australia, where neonicotinoid insecticides are used, but where Varroa mite (a parasite and vector of bee viruses) is also not found[6],
* 96% of colonies with CCD have been found to harbor a complex of viruses, for which Israeli Acute Paralysis Virus is most strongly implicated[7];

6 Ratnieks, FLW and N. L. Carreck. 2010. Science 327: 152 - 153.
7 Cox-Foster, D. L., et al. 2007. Science 318: 283 - 287.

EU Commission Decision

* Restricts the use of 3 neonicotinoids (clothianidin, imidacloprid and thiamethoxam) for seed treatment, soil application (granules) and foliar treatment on bee attractive plants and cereals.
* In addition, the remaining authorized uses are available only to professionals.
* Exceptions are limited treating bee-attractive crops in greenhouses and in open-air fields only after flowering.
* The restrictions began on **December 1, 2013.**
* As soon as new information is available, and at the latest within 2 years, the Commission will **review the conditions of approval of the 3 neonicotinoids** to take into account relevant scientific and technical developments.


EUROPA > European Commission > DG Health and Consumers > Overview > Animal Health and Welfare

Live Animals Semen, Ova & Embryos Products of Animal Origin Animal Diseases Identification Animal Welfare Zootechnics Strategy (2007-2013)

Bees/Neonicotinoids

Bees & Pesticides: Commission goes ahead with plan to better protect bees

The European Commission will in the coming weeks adopt a proposal to restrict the use of **3 pesticides belonging to the neonicotinoid family (clothianidin, imidacloprid and thiametoxam)** for a period of 2 years. An Appeal Committee vote on 29 April 2013 returned an inconclusive opinion where: 15 Member States supported the proposal, 4 abstained and 8 voted against. Since no qualified majority was reached, procedurally, the responsibility on deciding whether to adopt the proposal now lies with the Commission.

The Commission's action is a response to the European Food Safety Authority's (EFSA) scientific report which identified **"high acute risks"** for bees as regards exposure to dust in several crops such as maize, cereals and sunflower, to residue in pollen and nectar in crops like oilseed rape and sunflower and to guttation in maize.

Previously the proposal failed to reach qualified majority at the expert's meeting of the Standing Committee on the Food Chain and Animal Health on 15 March.

In absence of an agreement between Member States, it is for the Commission to decide on the adoption of the proposed restriction.

Main elements of the Commission's proposal to Member States:

- The proposal restricts the use of 3 neonicotinoids (clothianidin, imidacloprid and thiametoxam) for seed treatment, soil application (granules) and foliar treatment on bee attractive plants and cereals.
- In addition, the remaining authorised uses are available only to professionals.
- Exceptions will be limited to the possibility to treat bee-attractive crops in greenhouses, in open-air fields only after flowering.
- The restrictions will apply from **1 December 2013**.
- As soon as new information is available, and at the latest within 2 years, the Commission will **review the conditions of approval of the 3 neonicotinoids** to take into account relevant scientific and technical developments.

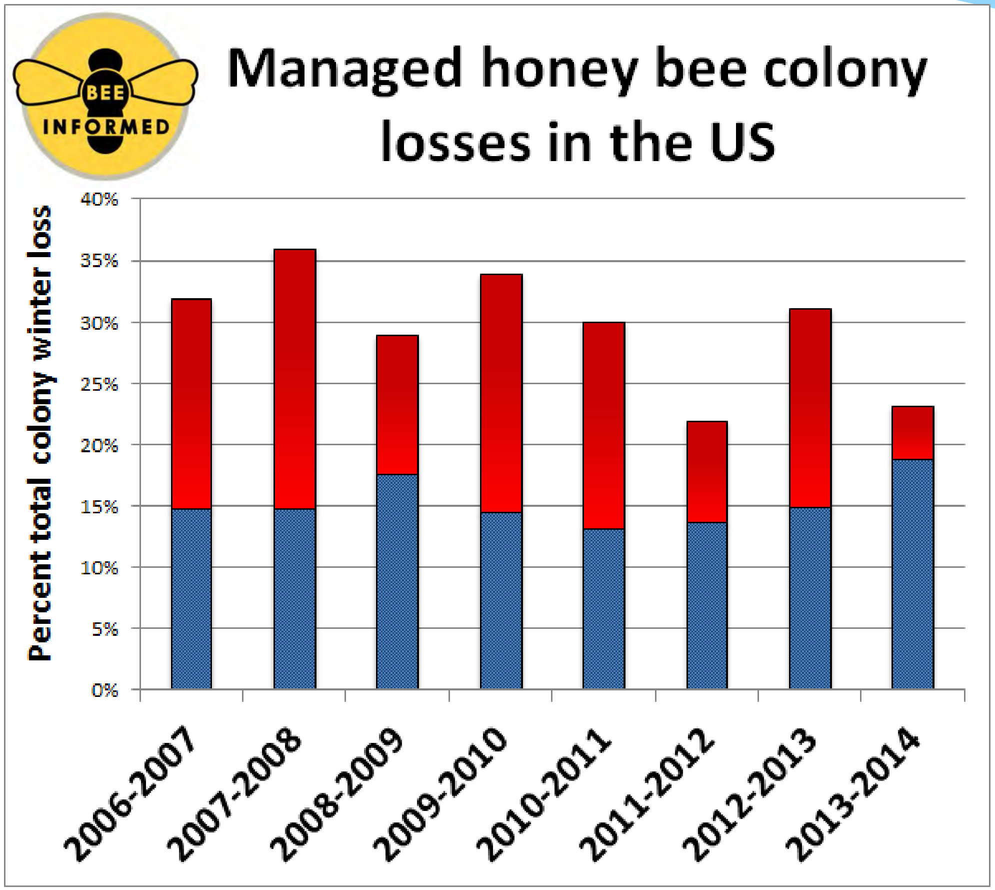
Related information: EFSA page on Bee Health

Topics: Introduction, Bee health, EU reference laboratory for bee health, Veterinary Medicines, Residues in honey, Pollination and biodiversity, Pesticides, Research, Practical information for bee keepers, Neonicotinoids

http://ec.europa.eu/food/animal/liveanimals/bees/neonicotinoids_en.htm

European honeybee winter losses down – before restrictions begin

US winter loss survey results over 8 years

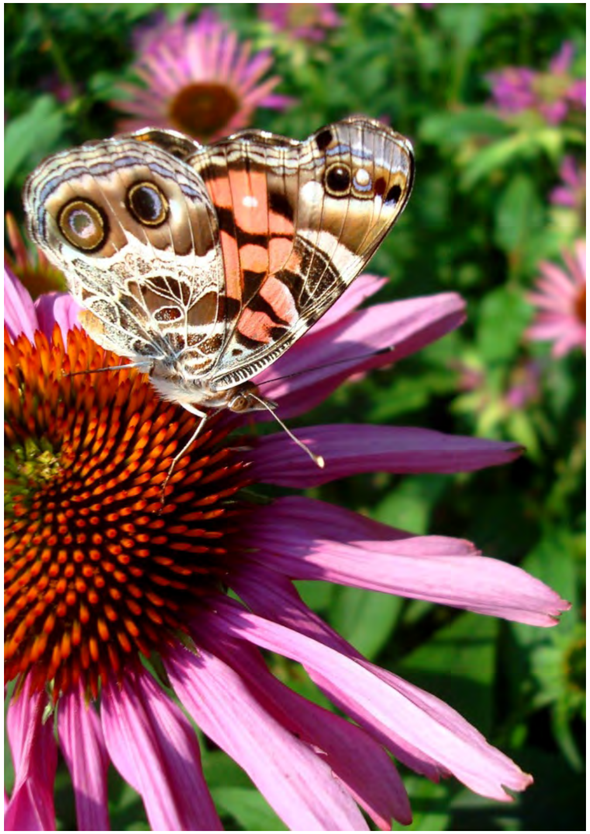


http://beeinformed.org/

Summary of the total overwinter colony (red bars). The acceptable range (blue bars) is the average percentage of acceptable loss declared survey participants

National Stakeholders Conference Key Findings 2012

* Parasites and disease are major factors
* Increased genetic diversity is needed
* Poor nutrition has a major impact on bee and colony longevity
* Need to improve collaboration and information sharing
* Additional research is needed to determine the pesticide risks



National Stakeholders Conference Key Findings 2012

* Undernourished or malnourished bees appear to be more susceptible to pathogens, parasites, and other stressors, including pesticides and other environmental contaminants
    * Research is needed on forage, pollen quality, artificial and natural food sources, and food processing and storage in the hive
* Federal and state partners should consider actions affecting land management to maximize bee forage quantity and quality

National Stakeholders Conference Key Findings 2012

- Pathogens and parasites have major negative impacts on colonies. The management of the parasitic Varroa mite and viruses needs special attention
  - Honey bees have a limited capacity to metabolize toxins, including beekeeper-applied varroacides, and some toxins can accumulate in beeswax combs.
  - Some varroacides can tie up bees' detoxification capabilities and render them less able to deal with other varroacides and pesticides used on crops.

Varroa destructor
Anderson & Trueman, 2000

National Stakeholders Conference Key Findings 2012

* We need informed and coordinated communication between growers and beekeepers and effective collaboration between stakeholders

* Need accurate and timely bee kill incident reporting, monitoring, and enforcement

National Stakeholders Conference Key Findings 2012

* Breeding should emphasize traits such as hygienic behavior that confer improved resistance to Varroa mites and diseases (such as American Foulbrood).

Managed Pollinator Coordinated Agriculture Program Update Highlights 2013

* Varroa mite is vector of Israeli Acute Paralysis Virus which is a potentially serious problem

* Sentinel apiary study –
  * Bee mortality increases as Ag land % increases
  * On average 6.2 pesticides per hive found in bee pollen
  * 130 different pesticide residues found but no trend associated with bee mortality
  * High levels of varroa = high levels of IAPV = low populations of adult bees and brood

Managed Pollinator Coordinated Agriculture Program Update Highlights 2013

* High degree of cross-infection of viruses between honey bees and native bumble bees
* Possible bee susceptibility to interactions (synergism) between agricultural insecticides and fungicides
* Some of those fungicides include, chlorothalonil, boscalid, captan and myclobutanil

CAP report 2013

* **What about pyrethroids as major bee toxicants?**
  * Pyrethroids bioaccumulate in wax and bees due to their high fat solubility in contrast to neonicotinoids
  * 92% of wax samples contained pyrethroids versus 2 with imidacloprid and 4 with thiacloprid, with the average pyrethroid residue content > 64,000 times higher than the total neonicotinoid
  * Pyrethroid prevalence and persistence in the hive likely has more consequences for colony survival than the water-soluble neonicotinoids

CAP report 2013

- The only other major insecticide detected in hive samples with high toxicity was the organophosphate chlorpyrifos
  - This OP degrades more rapidly and is less persistent than pyrethroids
- However, higher residues of the less toxic neonicotinoids acetamiprid and thiacloprid or of pyrethroids in pollens with even higher amounts of fungicides may have considerable impact on bee health via their synergistic combinations.
- Pyrethroids disable foraging of bees at levels of 9 ng permethrin per bee (90 ppb) and 2.5 ng deltamethrin per bee, which is of a potency similar to that of imidacloprid

CAP report – sub-lethal levels of pesticides 2013

* The answers are only beginning to emerge, but current research has revealed some results
* For honey bees low levels of pesticides have been shown to reduce associative learning of individual bees in laboratory studies
* These changes in learning and behavior can potentially alter normal colony level func-tions
* Some studies have shown reduced queen production

CAP report – sub-lethal levels of pesticides 2013

* Honey bee larvae reared in cells contaminated with the miticides fluvalinate or coumaphos show a reduced developmental rate and delayed adult emergence along with reduced adult longevity
* Fungicides have long been known to synergize with some insecticides in laboratory toxicity bioassays
* What happens when 3 or 4 or 5 different pesticide mixtures are in-gested by honey bee larvae or adults for substantial periods of time?

Pesticide Residues & Bees – A Risk Assessment 2014

* The large number and frequency of pesticide residues found in pollen and nectar of crop plants pose a clear risk to bees
* Based solely on contact exposure, some 18 compounds (mostly pyrethroids and neonicotinoids) pose a threat to worker bees where ≥50% of bees die, but
  * only five insecticides, namely thiamethoxam, phosmet, imidacloprid, chlorpyrifos and clothianidin, and
  * four insecticide-fungicide mixtures pose risks with probabilities above 5%
    * fungicides include propiconazole, myclobutanil & penconazole

Sanchez-Bayo, et. al. PLOS One 9(4): e94482

% Risk to honey bee workers from contact exposure

Use[1]	Chemical	Honey bee				
		Topical LD50 (μg bee^{-1})	Risk (%)		TD50 (days)	
			Average	Max	Average	Max
I	thiamethoxam	0.02	29.58	3.66	1	0.2
I	phosmet	0.62	14.56	23.89	2	0.04
I	chlorpyrifos	0.07	12.92	10.33	2	0.1
I	imidacloprid (total)	0.06	10.34	16.00	3	0.1
I+F	cyhalothrin+propiconazole	0.003[2]	8.79	5.90	0.4	0.1
I+F	cyhalothrin+myclobutanil	0.004[2]	7.86	5.52	0.6	0.1
I+F	cyhalothrin+penconazole	0.011[2]	7.23	3.68	2	0.3
I	clothianidin	0.04	5.28	0.99	4	1
I+F	thiacloprid+propiconazole	0.065[2]	4.21	7.43	1	0.1
A	acrinathrin (total)	0.17	3.44	1.21	1	0.2
I	deltamethrin	0.02	3.27	2.26	1	0.3
I-A	cypermethrin	0.03	2.40	1.75	2	1
I	carbaryl	0.84	2.32	0.95	14	1
I	bifenthrin	0.01	1.97	1.14	7	1
I	esfenvalerate	0.03	1.96	2.99	8	0.4
I	fenthion	0.22	1.89	0.57	5	1
I	dinotefuran	0.05	1.84	2.18	1	0.3

Sanchez-Bayo, et. al. PLOS One 9(4): e94482

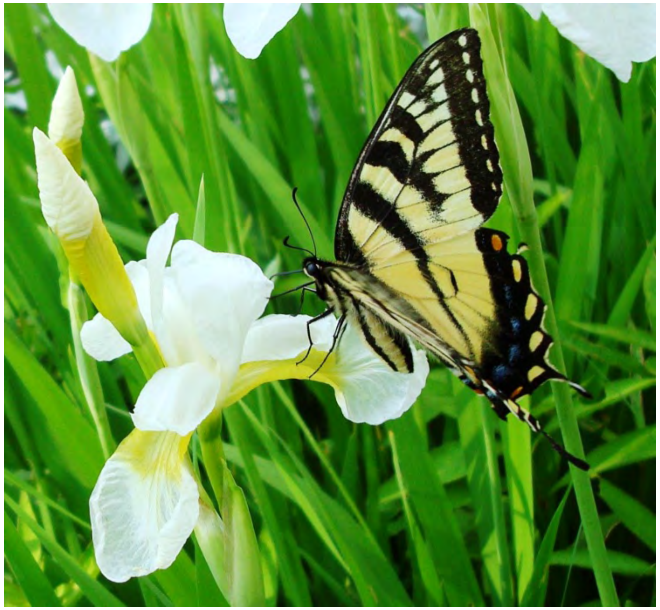
Bumble bees 2 – 3 x more sensitive

% Risk to bumble bee workers from contact exposure

Bumble bee				
Topical LD50 (µg bee⁻¹)	Risk (%)		TD50 (days)	
	Average	Max	Average	Max
0.09	10.32	8.26	3	0.1
0.02	31.77	49.15	1	0.02
0.01[2]	2.56	1.71	1.4	0.3
0.02[2]	2.28	1.60	2.1	0.4
0.04[2]	2.10	1.07	5	1.0
0.02	13.26	2.49	2	0.4
0.28	0.29	0.20	11	3

Pesticide Residues & Bees – A Risk Assessment

* Thiamethoxam, imidacloprid, and clothianidin pose the highest risk to worker bees and larvae when feeding on contaminated honey or nectar, but
* only thiamethoxam is of great concern when they feed on contaminated pollen, honey or nectar
* In addition, risks of systemic neonicotinoids are probably underestimated because of their time-cumulative toxicity, synergistic effects with ergosterol inhibiting fungicides, and additive effects in combination with pyrethroids.
* Further research on the combined effects of such mixtures is needed to fully understand the reasons behind the collapse of honey bee and bumble bee colonies.



Sanchez-Bayo, et. al. PLOS One 9(4): e94482

% Risk to honey bees from ingestion of pollen and/or nectar

1Exposure period of 5 days.
2Exposure period of 10 days.
3Exposure period of 30 days.

Chemical	Oral LD50 (µg bee^{-1})	Risk (%)					
		Worker larvae[1]		Nurses[2]		Nectar forager[3]	
		Average	Max	Average	Max	Average	Max
thiamethoxam	0.005	2.77	0.23	4.80	0.59	200.18	3.86
gamma-HCH (lindane)	0.05	0.62	4.02	0.01	0.01	200.40	313.09
imidacloprid (total)	0.013	1.19	0.64	1.57	2.43	23.33	5.93
clothianidin	0.004	1.02	0.23	1.91	0.36	22.04	3.25
cypermethrin	0.06	0.13	0.10	0.04	0.03	4.00	6.77
coumaphos (total)	4.61	0.11	0.03	0.06	0.04	2.62	4.37
dinotefuran	0.02	0.10	0.06	0.13	0.16	1.50	2.37
quinalphos	0.07	0.00	0.00			1.29	0.69
methiocarb	0.47	0.00	0.00	0.00	0.00	1.08	0.28
chlorpyrifos	0.24	0.04	0.01	0.13	0.10	0.86	0.30
carbaryl	0.15	0.41	0.03	0.42	0.17	0.54	0.82

Sanchez-Bayo, et. al. PLOS One 9(4): e94482

% Risk to bumble bees from ingestion of pollen and/or nectar

Chemical	Oral LD50 (μg bee^{-1})	Risk (%)					
		Worker larvae[1]		Nurses[2]		Nectar forager[3]	
		Average	Max	Average	Max	Average	Max
imidacloprid (total)	0.03	2.93	1.57	3.86	5.98	57.39	14.58
heptenophos	0.53	0.00	0.00			28.98	10.42
chlorpyrifos	0.23	0.23	0.07	0.65	0.52	4.44	1.57
quinalphos	0.18	0.00	0.00			2.51	1.34
beta-cyfluthrin	0.12	0.22	0.05	0.02	0.06	0.90	1.28
dimethoate	0.82	0.01	0.00	0.00	0.00	0.41	0.25
lambda-cyhalothrin	0.18	0.02	0.00	0.08	0.03	0.19	0.10
carbaryl	3.88	0.08	0.01	0.08	0.03	0.10	0.16
cyhalothrin+propiconazole	0.01[4]	0.12	0.03	0.11	0.13	0.19	0.10
cyhalothrin+myclobutanil	0.02[4]	0.11	0.03	0.07	0.12	0.19	0.10
cyhalothrin+penconazole	0.04[4]	0.10	0.02	0.03	0.08	0.19	0.10
acetamiprid+propiconazole	0.21[4]	0.02	0.02	0.00	0.02	0.07	0.00

What about organic approved pesticides?

Toxicity of Common Organic-Approved Pesticides to Pollinators

PESTICIDE	NON-TOXIC	LOW TOXICITY	HIGHLY TOXIC
Insecticides/Repellants/Pest Barriers			
Bacillus thuringiensis (Bt)	■		
Beauveria bassiana			■
Cydia pomonella granulosis	■		
Diatomaceous Earth			■
Garlic	■		
Insecticidal Soap			■
Kaolin Clay	■		
Neem		■	
Horticultural Oil			■
Pyrethrins			■
Rotenone			■
Sabadilla			■
Spinosad			■
Herbicides/Plant Growth Regulators/Adjuvants			
Adjuvants		■	
Corn Gluten	■		
Gibberellic Acid	■		
Horticultural Vinegar		■	
Fungicides			
Copper		■	
Copper Sulfate			■
Lime Sulfur	■		
Sulfur			■

Soaps and Oils, only when directly sprayed upon the pollinator

Eric Mader – The Xerces Society for Invertebrate Conservation

Consequences of neonicotinoid use

* The deaths of individual pollinators may not lead to a proportionate decrease in the overall numbers of that pollinator species
* In the case of rare species, extra mortality caused by insecticides could lead to a threshold below which the species declines to extinction
* There is a weak evidence base to illustrate the presence and magnitude of these effects in the field
* Models of honeybee and bumblebee colony dynamics, as well as population-level models of all pollinators, are important tools needed to explore these effects

Godfray, et. al. Proceedings of The Royal Society B 2014 281, 20140558

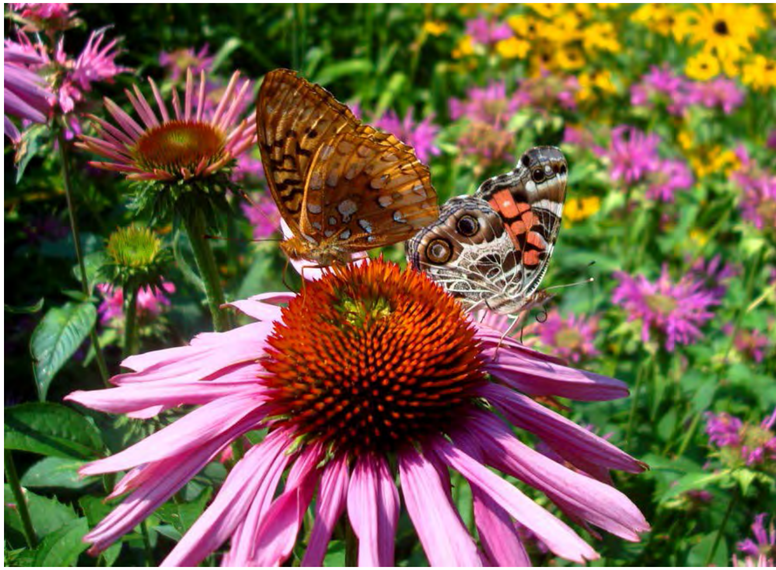
Consequences of neonicotinoid use

* There is evidence that some crops do not always receive sufficient pollination, and
* further limited evidence that this has increased in recent decades;
  * but the information available does not allow us to determine whether or not this has been influenced by the increased use of neonicotinoids
* Whether pollination deficits in wild plants have increased is not known

Godfray, et. al. Proceedings of The Royal Society B 2014 281, 20140558

Consequences of neonicotinoid use

- Declines in the populations of many insect species in general and pollinators in particular have been observed
  - although the decline in bees predate by some decades the introduction of neonicotinoid insecticides, and
  - there is some evidence of a recent abatement in the rate of decline for some groups
- Habitat alteration is widely considered to be the most important factor responsible
- The evidence available does not allow us to say whether neonicotinoid use has had an effect on these trends since their introduction



Godfray, et. al. Proceedings of The Royal Society B 2014 281, 20140558

Consequences of neonicotinoid use

* There have been marked increases in overwintering mortality of managed honeybee populations in recent decades
* It has been suggested that insecticides (particularly neonicotinoids) may be wholly or partly responsible
* The weak evidence base cannot at present resolve this question
* Honeybee declines began before the wide use of neonicotinoids and there is poor geographical correlation between neonicotinoid use and honeybee decline

Godfray, et. al. Proceedings of The Royal Society B 2014 281, 20140558

Consequences of neonicotinoid use

* Two studies using different structured methodologies have explored the question of a neonicotinoid cause
  * Cresswell et al used 'Hill's epidemiological "causality criteria"' and concluded the evidence base did not currently support a role for dietary neonicotinoids in honeybee decline but that conclusion is provisional
  * Staveley et al used "causal analysis" methodology and concluded neonicotinoids were 'unlikely' to be the sole cause of honeybee decline but could be a contributing factor

Godfray, et. al. Proceedings of The Royal Society B 2014 281, 20140558

Consequences of neonicotinoid use

* If neonicotinoid use is restricted:
  * farmers may switch to other pest-management strategies that may have effects on pollinator populations that could overall be more or less damaging than neonicotinoids, or
  * they may choose not to grow the crops concerned, which will reduce exposure of pollinators to neonicotinoids but also reduce the total flowers available to pollinators

Godfray, et. al. Proceedings of The Royal Society B 2014 281, 20140558

Consequences of neonicotinoid use

- To understand the consequences of changing neonicotinoid use it is important to consider:
  - pollinator colony-level and population processes,
  - the likely effect on pollination ecosystem services,
  - as well as how farmers might change their agronomic practices in response to restrictions on neonicotinoid use
- While all these areas are currently being researched there is at present a limited evidence base to guide policy-makers

Godfray, et. al. Proceedings of The Royal Society B 2014 281, 20140558

Questions?

* That's all folks!