Bee health in the USA and the debate about Neonicotinoids

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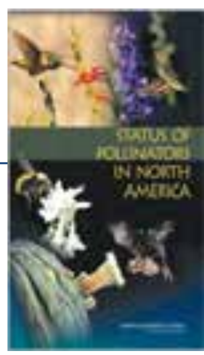
Bee Health

- Multiple federal reports have identified pollinator declines.



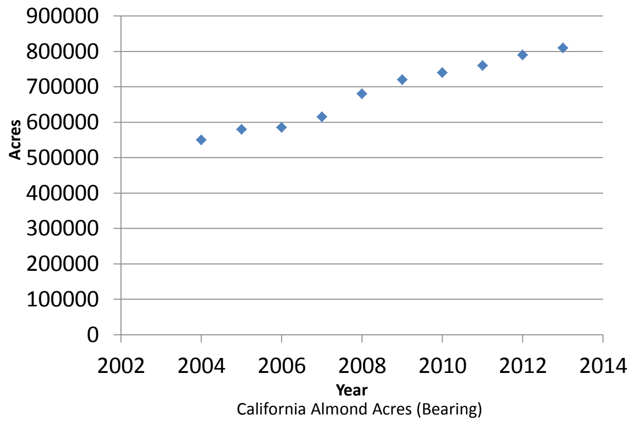
http://www.nap.edu/openbook.php?record_id=11761

http://www.nap.edu/openbook.php?record_id=11761

https://www.fas.org/sgp/crs/misc/R42855.pdf

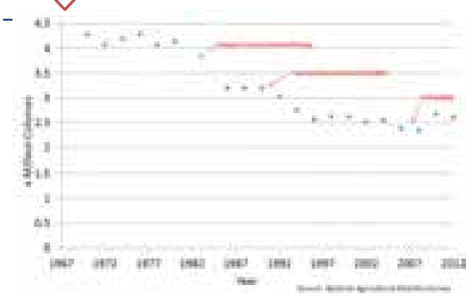
Bee Health

- Demand for managed pollinators has continued to increase across multiple crops requiring pollination services.
- Currently, roughly 800,000 acres are planted in almonds requiring roughly 1.6 million honey bee colonies.



Bee Health

- National Agricultural Statistics Survey (NASS) data indicate declines in managed honey bee colonies; peak of approximately 6 million colonies in 1947 to roughly 2.6 million in 2012 (USDA 2008).
- Change in survey methodology in mid-1990s
- Varroa mite introduction (1988) followed by decline in managed colony numbers.
- Numbers have leveled off since 1996.



Bee Health

- Reports of pollinator declines are not limited to North America


Parallel Declines in Pollinators and Insect-Pollinated Plants in Britain and the Netherlands

http://www.sciencemag.org/content/313/5785/351.full.pdf

http://www.sciencemag.org/content/313/5785/286.1.full.pdf

http://www.pollinator.org/PDFs/OPERAReport.pdf

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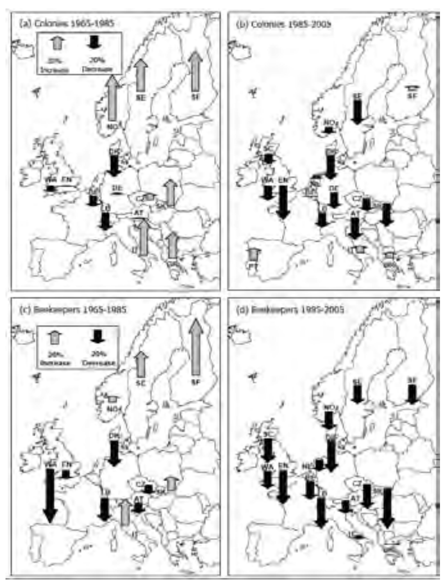
Bee Health

- Numbers of honey bee colonies (graph b) and the number of beekeepers (graph d) have declined in Europe from 1985 to 2005.



Source: Potts *et al*. 2010; J of Apicultural Research

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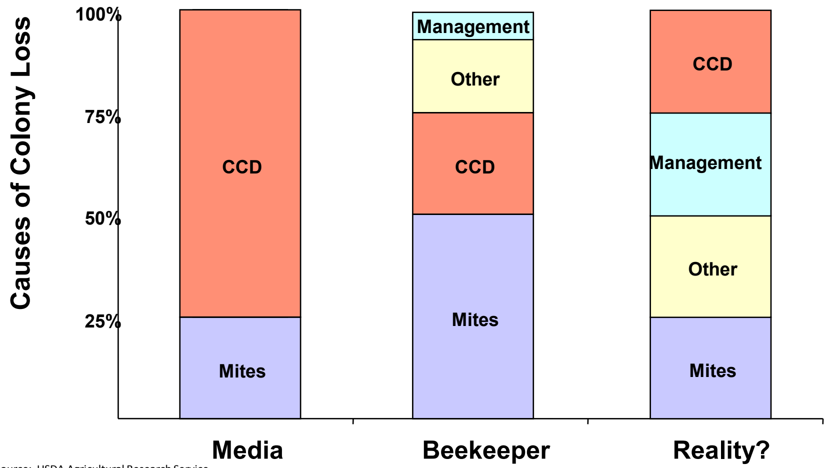
Bee Health

- Opinions regarding the "causes" of managed pollinator declines



Source: USDA Agricultural Research Service

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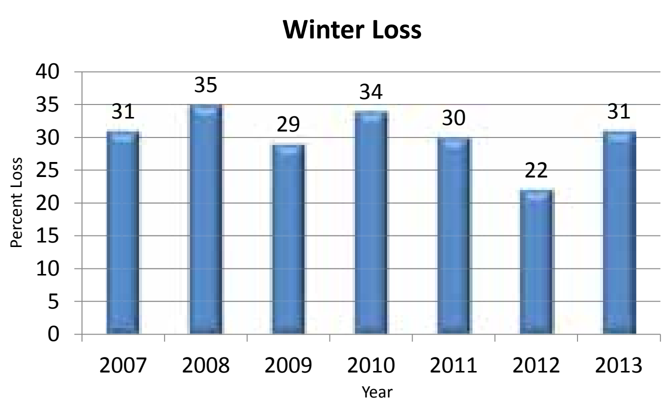
Bee Health: USDA Winter Loss Survey

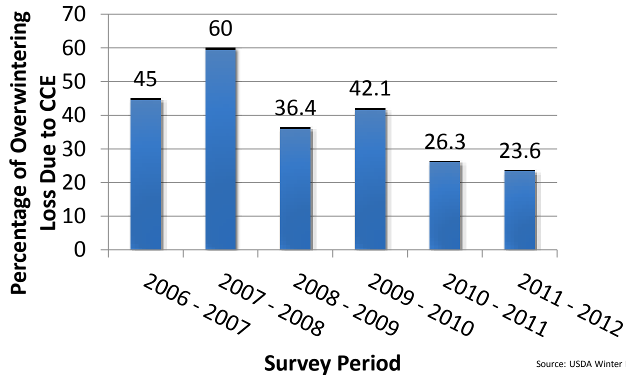
- Over-wintering losses have averaged roughly 31%



Based on USDA Winter Loss Survey Data; CCD Annual Report

Bee Health

- Contribution of CCD to total winter losses has declined in recent years.
- Most recent data for 2012 – 2013 indicate that CCD may account for ~60% of winter loss.

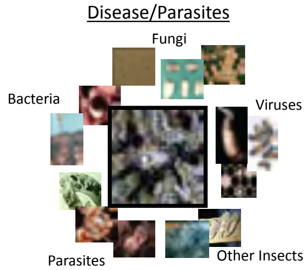


Source: USDA Winter Loss Survey Data

Bee Health

•USDA has identified multiple factors; no single factor identified as “cause”.

Disease/Parasites



Agricultural Practices

Urbanization

Bee Management Practices

Source: USDA Agricultural Research Service

Pesticides

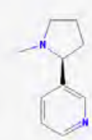
Nutrition

Bee Health

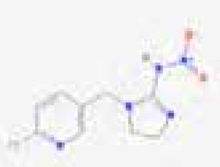
- Bee Informed Partnership Bee Technical Teams
- Varroa mites
  - Average varroa mite loads above triggers for treatment
  - Data suggest the colonies should be treated a minimum of 4/year
  - Untreated, varroa mites can reduce adult bee longevity by 50%
  - Mites vector multiple viruses (deformed wing virus, black queen cell virus, Israeli acute paralysis virus, chronic paralysis virus)
  - Mites represent a new route of viral transmission (inoculation) that has increased the virulence of viruses.
- Nosema
  - *N. ceranae* and *N. apis* can reduce longevity of adult bees.

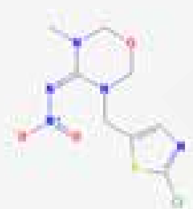
Neonicotinoid Insecticides

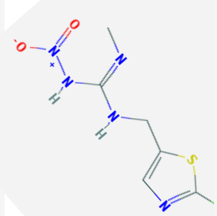
- Class of chemicals modeled after nicotine

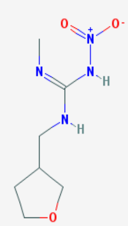

nicotine

- Mode of action as agonist at nicotinic acetylcholine receptors


imidacloprid


thiamethoxam


clothianidin


dinotefuran

Neonicotinoid Insecticides

Two subclasses:

- Cyano-substituted: thiacloprid, acetamiprid
- Nitroguanidine substituted: imidacloprid; thiamethoxam; clothianidin; dinotefuran
  - Low application rates.
  - Numerous use sites – ag and non-ag.; commercial and residential.
  - High percentage of acreage treated (clothianidin, imidacloprid and thiamethoxam are among the top ten compounds applied to all agricultural acreage).
  - All incorporate bee warning statements on labels.
  - The majority of research and public interest has been focused on nitroguanidine subclass.

Neonicotinoid Insecticides

Imidacloprid:

- Registered in 1994

Thiamethoxam

- Registered in 2000

Clothianidin

- Registered in 2003

Dinotefuran

- Registered in 2003

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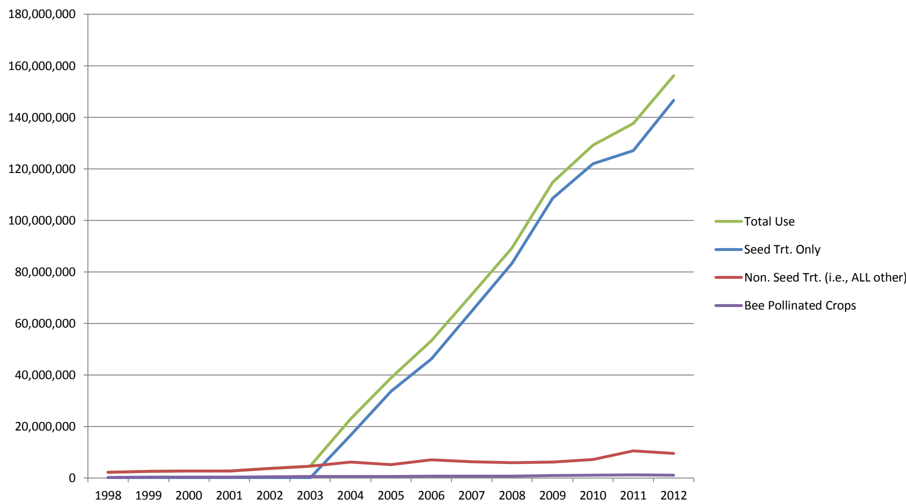
Neonicotinoid Insecticides

- Total U.S. Neonic. Treated Acreage over Time



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Neonicotinoid Insecticides

Field Dissipation Pathways

Environmental Fate Data	Imidacloprid	Clothianidin	Thiamethoxam	Dinotefuran
Solubility (mg/L)	580	327	4100	39830
Vapor Pressure (torr)	1.00E-07	2.90E-13	5.00E-11	1.30E-08
Henrys Constant (atm-m^3/mole)	5.80E-11	2.90E-16	4.60E-15	8.60E-14
Aerobic Soil Metabolism Half-life (90th UCL days)	188-to-341 (520)	148-to-1155 (744)	101-to- 294 (480)	16-to-100 (68)
Soil Organic Carbon Partition Coefficient (L/g-OC)	178	160	70	30
Field Dissipation Half-life (days)	107 to >365	257 to 1386	1 to 111	19 to 65
Toxic Degradation Products	5, hydroxy, olefin	None	clothianidin	MNG
Probable Dissipation Pathways				
Persistence Potential-(Accumulation in Soil)	Yes	Yes	Yes	No
Mobility Potential (Runoff/Leaching/Plant Uptake)	Yes	Yes	Yes	**Yes**
Volatilization Potential	No	No	No	No

Neonicotinoid Insecticides

Imidacloprid: Persistent Highly mobile Non-volatile Multiple active degradates (5-hydroxy, olefin)	**Clothianidin** • Persistent • Mobile to highly mobile • Non-volatile
Thiamethoxam Persistent Mobile Non-volatile Degrades to clothianidin	**Dinotefuran** • Moderately persistent • Mobile • Non-volatile • Single potentially active degradate (MNG: N-methyl-N′-nitro-guanidine)

Neonicotinoid Insecticides

Hazard Profile for Aquatic and Terrestrial Invertebrates

Chemical	Aquatic (µg a.i./L)		Terrestrial (µg a.i./bee)	
	Acute	Chronic	Acute contact	Acute oral
Acetamiprid	21	2.1	<13	>10
Clothianidin	22	1.1	0.044	0.0037
Dinotefuran	790	>95,000	0.024	0.0076
Imidacloprid	37	0.6	0.078	0.0039
Thiacloprid	31	1.1	38	17
Thiamethoxam	35	17	0.024	0.005

Neonicotinoid Insecticides

Hazard Profile for Terrestrial and Aquatic Vertebrates

Chemical	Acute (mg a.i./kg-bw or mg a.i./L)			Chronic (NOAEC; ppm)		
	Birds (LD_{50})	Mammals (LD_{50})	Fish (LC_{50})	Birds	Mammals	Fish
Acetamiprid	5.7	146	>100	<60	160	19
Clothianidin	423	389	>102	205	150	9.7
Dinotefuran	>2000	2000	>99	2150	3000	>6.4
Imidacloprid	31	424	>83	36	250	1.2
Thiacloprid	>2000	396	20	28	50	0.60
Thiamethoxam	575	1563	>100	300	200	9.7

Neonicotinoid Insecticides

Hazard Profile for Aquatic and Terrestrial Plants

Chemical	Aquatic (EC_{50}; mg a.i./L)		Terrestrial (EC_{25}; lb a.i./A)	
	Vascular	Non-vascular	Seedling emergence	Vegetative vigor
Acetamiprid	>1	>1	0.16	0.0056
Clothianidin	>121	64	>0.19*	>0.19*
Dinotefuran	>110	>98	>0.5*	>0.5*
Imidacloprid	>97	>10	>0.5*	>0.5*
Thiacloprid	>95	45	>0.5*	>0.5*
Thiamethoxam	>90	>97	NA	NA

*≥ maximum use rate

Neonicotinoid Insecticides

Other Effects Data Available for Honey Bees

- Field data submitted by registrants
  - Residue studies have been submitted on a variety of crops
    - California DPR and PMRA are requiring data
  - Semi-field and field studies have also been submitted
- Scientific literature: investigations of sublethal effects
  - Behavioral (*e.g.*, foraging)
  - Olfactory (*e.g.*, proboscis extension reflex; PER)
  - Immunosuppression
  - Queen performance
    - Pheromone
  - Nutrition (*e.g.*, hypopharyngeal gland development)

Neonicotinoid Insecticides

Summary of Previous Risk Conclusions for the Neonicotinoids

- Main concern is risk to insects in terrestrial and aquatic habitats
  - Cyano-substituted neonics are less toxic to bees (acute)
- In some cases, neonics "may" pose a risk to mammals and birds
  - Passerine birds may be more sensitive than standard test species
- In general, these chemicals do not pose a risk to fish or plants
  - Acetamiprid is an exception
- Some of these chemicals have degradates of concern

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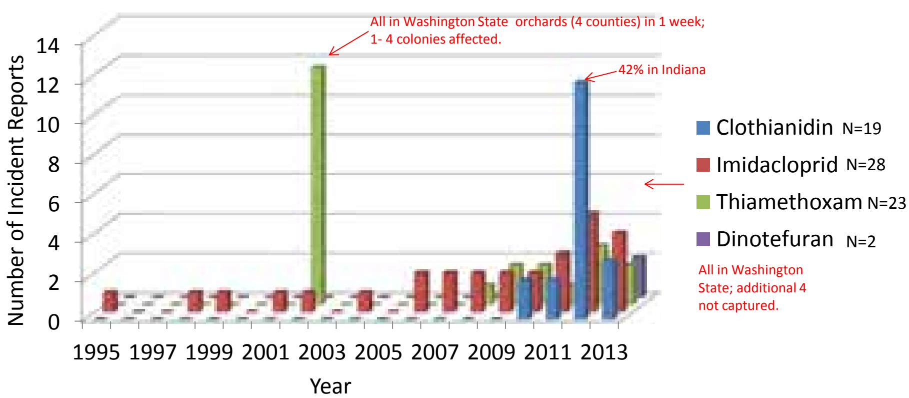
Neonicotinoid Insecticides

- OPP relies upon incident data as a line of evidence in evaluating potential effects of pesticides.
  - EPA has enhanced ways in which pollinator losses can be reported to the Agency.
  - National Pesticide Information Center (http://npic.orst.edu/).
  - EPA's beekill@epa.gov; direct phone links
- Some beekeepers believe strongly that neonicotinoids are associated with bee kills and particularly with reduced overwintering success.
- OPP has received relatively few incident reports.
  - Beekeeper reluctance
  - Limited state resources
- Available incident reports do not support hypothesis that exposure to neonicotinoids is leading to large scale losses of bee colonies in the U. S..
  - Uncertainty regarding potential chronic effects; however, incident data are not effective measures of chronic effects.
- Absence of incident reports cannot be construed as the absence of incidents.

Neonicotinoid Insecticides

•Other than spike in thiamethoxam incidents in 2002, incident reports in the U.S. have been relatively infrequent until recently.
•Spikes in incident reports associated with particular states.



Neonicotinoid Insecticides

- •In Canada, most incidents associated with planting of treated seed (clothianidin primarily)
- •Most (>95%) of the incidents occurred in southern Ontario
- •In 2012, between 4550 – 5890 colonies affected and in 2013 preliminary results indicate >3336 colonies affected.
- •Forage force of the colonies affected.

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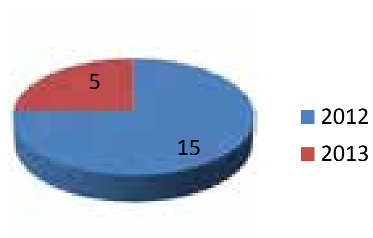
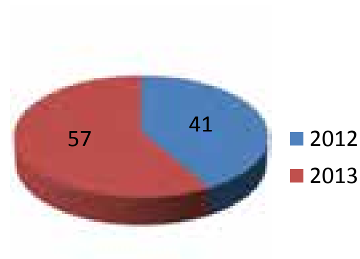
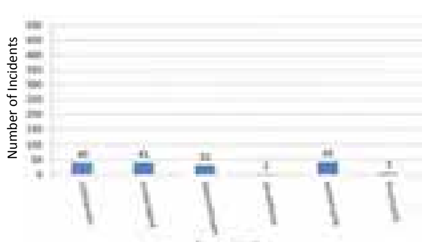


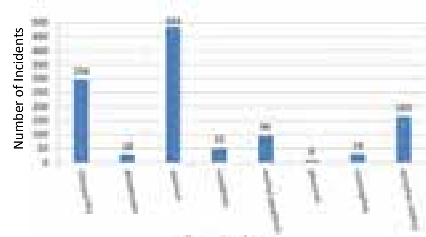
Canada

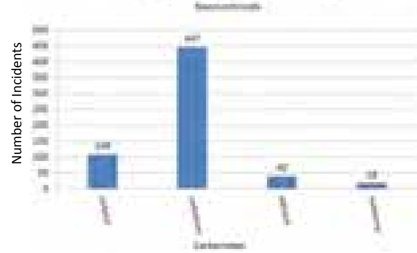


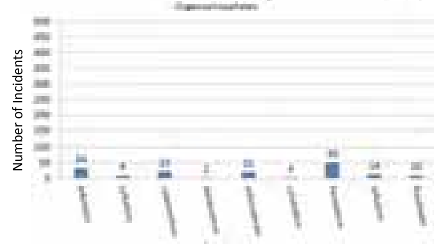
Neonicotinoid Insecticides

- •Relative to other chemical classes, number of reported incidents for neonicotinoids is low; however, other compounds have been in use longer.
- •Spectrum of affected taxa is lower for neonicotinoids.









Neonicotinoid Insecticides

- Pettis *et al*. 2012. Fungal spore counts increase with chronic exposure to imidacloprid.
- Pettis *et al*. 2013. Fungal spore counts increase with chronic exposure to fungicides.
- Krupke *et al*. 2012. Clothianidin dust from abraded seed coat/talc..
- Taparro *et al*. 2012. Clothianidin, imidacloprid, thiamethoxam dust from abraded seed coat/talc
- Whitehorn *et al*. 2012. Imidacloprid exposure to bumble bees; effects on queen production.
- Henry *et al*. 2012. Thiamethoxam and homing success; simulated colony-level effect
- Lu *et al*. 2012. Imidacloprid and CCD-like effects
- Stoner and Eitzer 2012. Imidacloprid and Thiamethoxam residues in pollen/nectar of squash

Neonicotinoid Insecticides

Registration Review Schedule

Compound	Docket Opened	Data Generation	Completion
Imidacloprid	Dec. 2008	2010 – 2015	2016 – 2017
Clothianidin	Dec. 2011	2013 – 2016	2017 – 2018
Thiamethoxam	Dec. 2011	2013 – 2016	2017 – 2018
Dinotefuran	Dec. 2011	2013 – 2016	2017 – 2018
Acetamiprid	Dec. 2012	2014 – 2017	2018 – 2019
Thiacloprid	Dec. 2012	2014 – 2017	2018 – 2019

- All but imidacloprid were originally scheduled to open between FY 13 and FY 15. In 2009, all the neonics were moved up. Nitro-guanidines were then further seperated from the cyano – substituted.
- Collaborating with California DPR and Health Canada's PMRA on imidacloprid, clothianidin, thiamethoxam and dinotefuran.
- All compounds being approached in light of the new risk assessment process.
  - Data approach between agencies is not identical, but supplement each other.

Neonicotinoid Insecticides

Registration Review

- Data in-house includes acute studies, and field data.
- Data on pollinators required under Registration Review include:
  - Residues in Pollen and Nectar
  - Larval Toxicity Test
  - Chronic Toxicity Study
  - Pollinator Field Study
- Partner with CDPR and PMRA on the science.
  - CDPR has required monitoring data on residues
  - CDPR data on larval toxicity
  - PMRA has required residue data
- Data due 2015.
- Will seek information to characterize potential exposure from drift.

Neonicotinoid Insecticides

- Pesticides and neonicotinoids in particular have **NOT** been identified as a cause of declines in pollinator health in general nor to CCD in particular.
- OPP will use the state of the science in requesting and evaluating data on the neonicotinoid compounds through Registration Review.
  - DCIs will focus on remaining uncertainties
  - Field studies intended to reflect actual use conditions
- OPP is coordinating and collaborating with State and Federal partners in study design and study interpretation.
- OPP is using its federal advisory committee (PPDC) to develop and explore mitigation and management options that go beyond the label.

Neonicotinoid Insecticides

- Pollinator protection language that has been applied to the neonicotinoid insecticides.
- Pesticide labels on these products will continue to retain more restrictive language.

Neonicotinoid Insecticides

- Actions to reduce potential exposure via dust drift (fugitive dust)
  - EPA is working to ensure appropriate sticking agents used to reduce potential abraded seed coat dust.
  - To reduce potential drift of abraded seed coat dust, equipment manufactures in collaboration with registrants and seed treaters are working domestically and international to develop international standards aimed at reducing dust from treated seed.
  - EPA has identified this route of exposure in the Registration Review of several of the neonicotinoids and has requested information would enable the Agency to characterize exposure and potential reduction technologies.

Engaging Stakeholders

- EPA as well as other federal agencies have MOUs with the Pollinator Partnership
  - Recognizes value of outreach, education and research toward understanding and mitigating factors associated with pollinator declines.
- EPA providing technical input to Corn Dust Research Consortium attempting to address uncertainties associated with dust-off.

Corn Dust Research Consortium (CDRC)

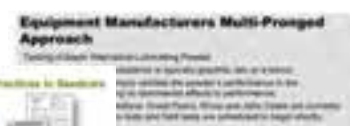
Preliminary Report

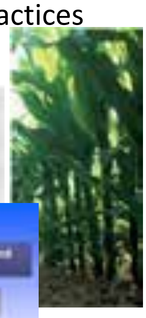
- Initial Findings for 2013
- Provisional Recommendations
- Timetable

http://www.pollinator.org/PDFs/CDRCfinalreport2013.pdf

Engaging Stakeholders

- Summit highlighting stewardship efforts
  - Seed treatment stewardship guide
  - Alternatives to currently used lubricant in seeding equipment
  - Improvements in formulation technologies and Best Practices for seed treatments and grower education
  - Education and outreach





Summary of Bee Health and Neonicotinoid Insecticides

- Multiple factors associated with declines in pollinator health.
- Pesticides are one factor; not a cause.
- Residues of neonicotinoids have been associated with some bee kill incidents. In general, these incidents have been regionally specific and have resulted in knock-back of colony strength.
- Varroa mite and the viruses vectored by the mite reduce longevity of bees.
  - Resistance development by mites requires more integrated approach.
- EPA collaborating with other regulatory authorities to evaluate the potential risks from neonicotinoids using a science-based foundation.
- EPA is collaborating with broad range of stakeholders to develop and implement tools for reducing exposure of bees to pesticides.
  - Alternative forage areas, equipment modification, fluency agents, increased communication/education, improved label language

Bee health in the USA and the debate about Neonicotinoids

Questions?