Pollinators: who are they, what is their status, and what can we do to protect them?

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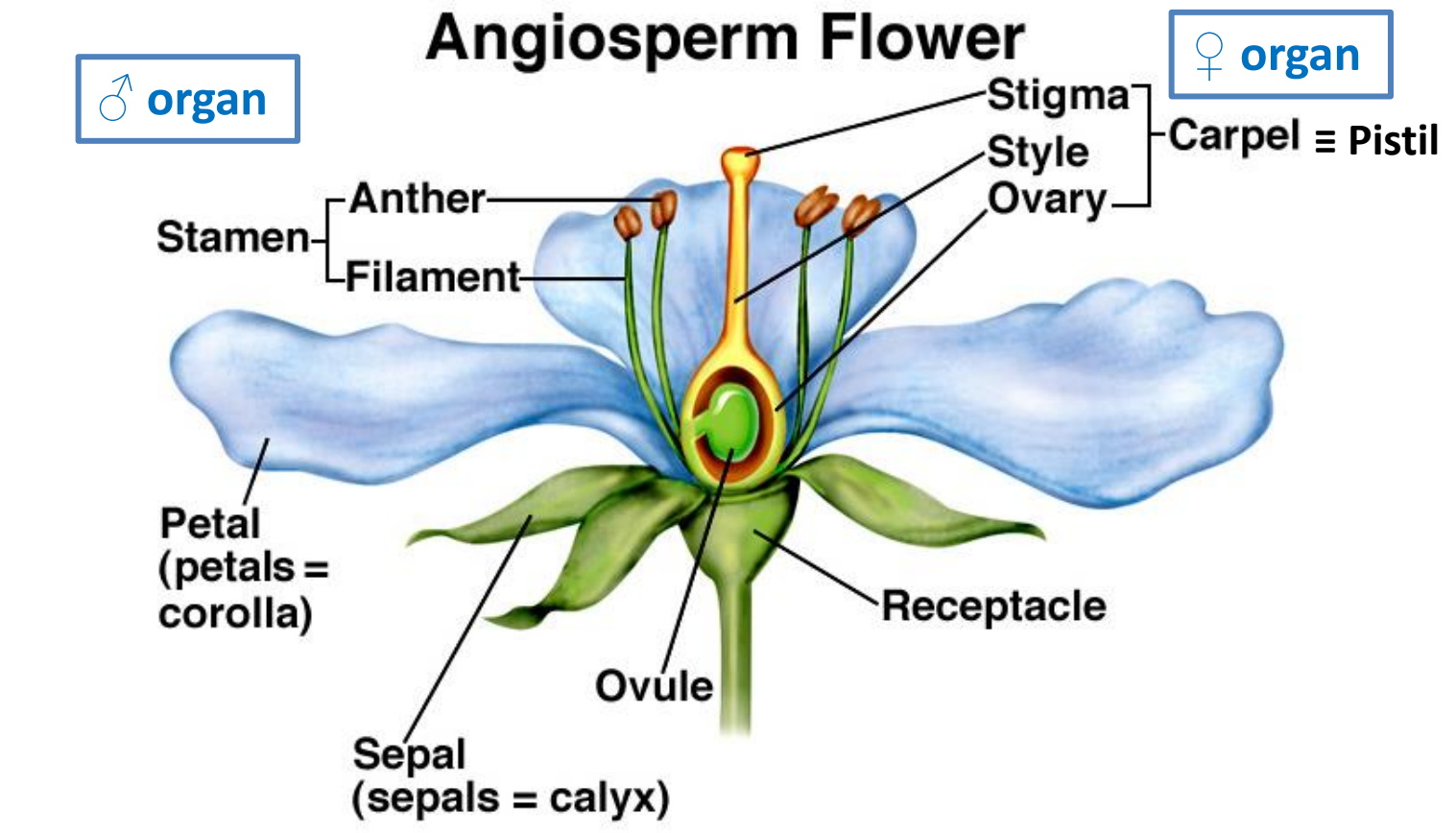
Pollination definition

In flowering plants, transfer of pollen grains from anther (male part) to stigma (female part); must be pollen of same species



Why is pollination important?

1. **Ecological**

~80% of flowering plants rely on animals for gene transfer (seed and pollen). Fruits and seeds comprise ~25% of diets of birds and mammals; so lack pollination means scarce resources

2. **Agricultural**

Insects pollinate ~2/3 of world's crops
account for 1/3 of food we eat

3. **Economics of insect pollination**

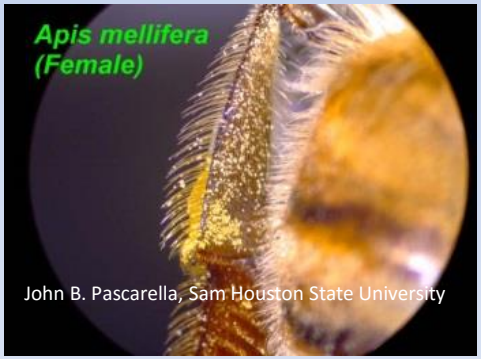
~$15 billion per year to the US economy
$217 billion worldwide (Science Daily 2008)

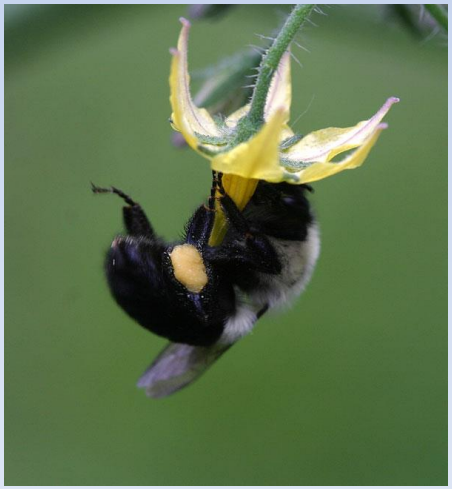
Major insect pollinators

> 70% flowering plants (~250,000 spp.) require an insect to move pollen

Most important insect pollinators: Bees

1. Feed on nectar and pollen
2. Pollen collecting structures (scopa, corbicula)
3. Display floral constancy





Bees: distinguishing characteristics

Bees	vs.	Wasps
Robust		Slender
Hairy		Smooth
Flat rear legs		Slender legs
Feed on nectar and pollen		Predators

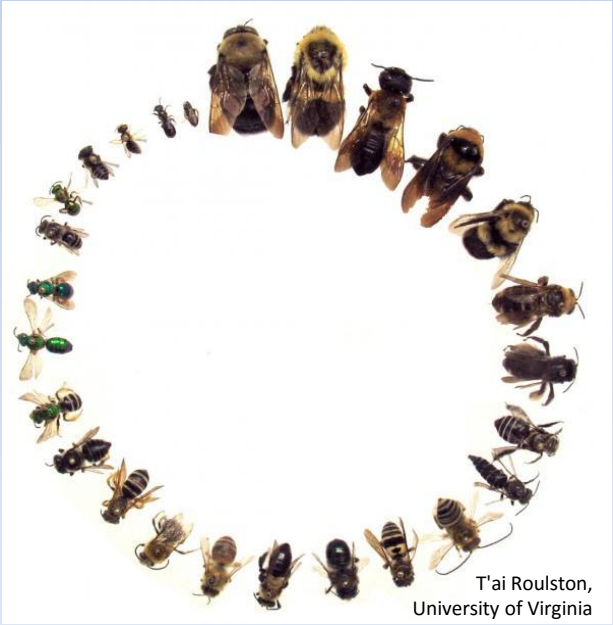
Why are bees important?

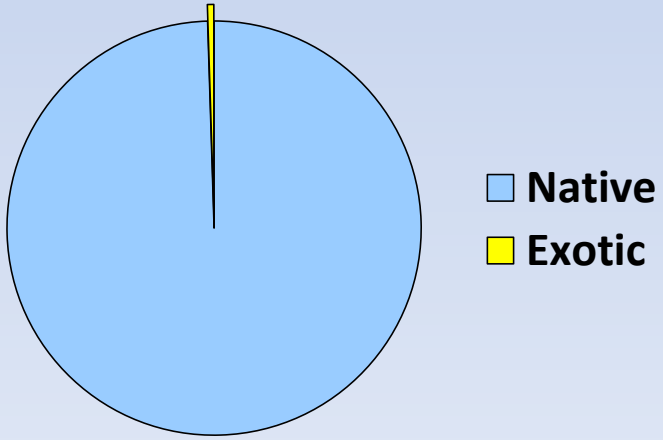
Whole foods and Xerces Society "Share the Buzz" campaign (2013)

Bees

- At least 25,000 known species of bees (more than birds and mammals combined!)
- Social vs. solitary, 90% being solitary
- ~4,500 solitary spp. in North America
- Wisconsin: ~400 spp.

Smallest North American bee (*Perdita minima*) on largest female carpenter bee

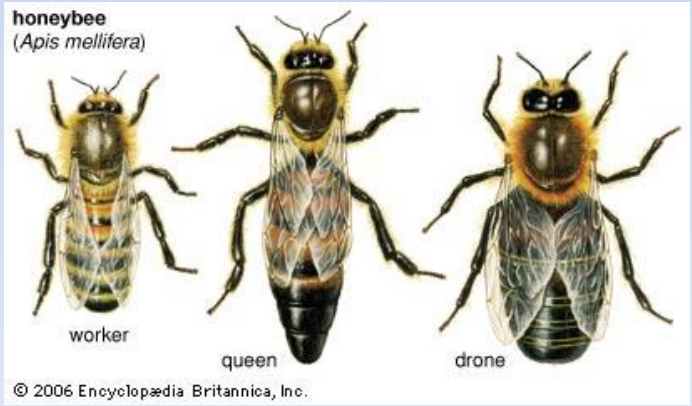




The honeybee

Apis mellifera: the “honey-bearing bee”

Honeybees account for 84% of all insect pollination



- 7 species of honeybees
- Western honeybee, *Apis mellifera* only species in North America
- Non-native, introduced in 1600s
- Social colonies founded by single queen
- Colonies are perennial
- Hive with typically 30 to 50,000 workers

Bumblebees

All bumble species in genus *Bombus,* meaning “booming”

- 250 known species (probably most discovered)
- 49 species in U.S. (18 species in WI)
- Social colonies
- Most abundant native pollinators of both crops and wild flowers

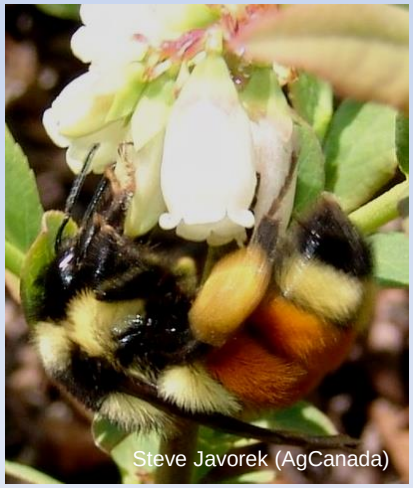
Bumblebees

- Social colonies founded by a single queen
- Nest in abandoned rodent burrows or under lodged grasses
- Colonies last only one season
- Only queen overwinters
- Nest may contain 100-300 workers
- Nests up to 12” diam and may have several entrances

Goulson, 2010 *Bumblebees. Behavior, ecology, and conservation*

Bumblebee and crop pollination

- Active in cool and wet weather
- Buzz pollination makes them better pollinator of tomatoes, blueberry, cranberry, melons, cucumber, etc…
- Until 1980s, tomato pollination in glasshouses done by hand



Solitary bees

Polyester bee (Colletes sp)

Leafcutter bee (*Megachile* sp.)

Photos: James Cane; Steve Javorek (Ag Canada); Edward S. Ross

Solitary bees


Metallic sweat bee (*Agapostemon* sp.)


Yellow-faced bee (*Hylaeus* sp.)


Mason bee (*Osmia* sp.)

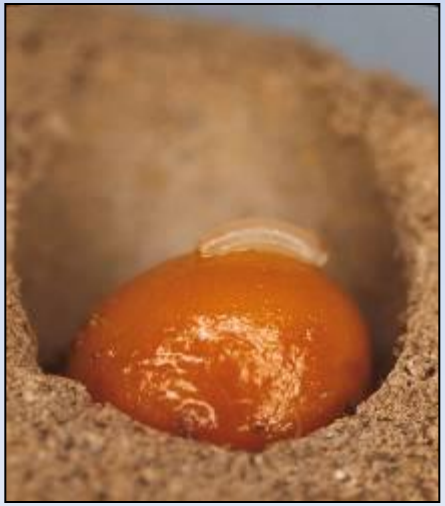

Sweat bee (*Halictus* sp.)

Photos: Bruce Newhouse; Edward S. Ross; Mace Vaughan; USDA-ARS/Jack Dykinga

Solitary bees

Life Cycle of a Solitary Bee

Mining bee (*Andrena* sp.): a year in its underground nest as egg, larva, and pupa before emerging to spend a few weeks as an adult.

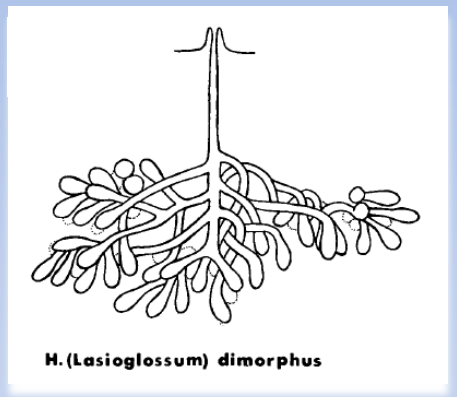


Photos: Dennis Briggs

Ground-nesting solitary bees

~70% of native bee species nest underground

- Resemble ant-nests from above ground
- Nests may be as deep as 3’



Photos: Eric Mader, Matthew Shepherd, Dennis Briggs

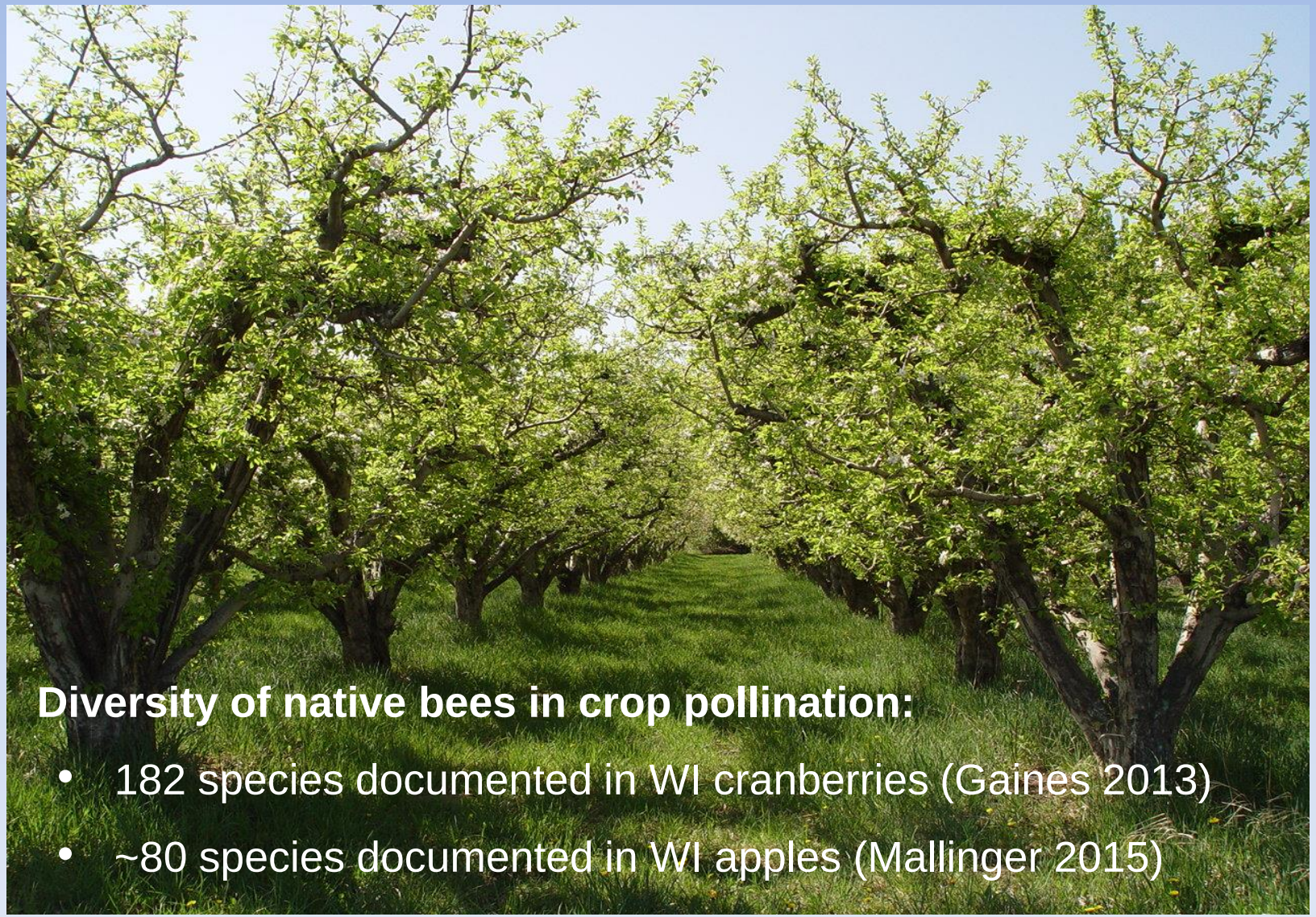
Cavity-nesting solitary bees

~30% of native species nest in cavities

- Nest in hollow plant stems, old beetle borer holes, man-made cavities
- Artificially managed for some crops

Photos: Edward Ross, Darrin O'Brien, Matthew Shepherd

Native bee diversity in agriculture



Diversity of native bees in crop pollination:

- 182 species documented in WI cranberries (Gaines 2013)
- ~80 species documented in WI apples (Mallinger 2015)

Pollinator decline

Politico: Bees bring new buzz to Capitol Hill

Pollinator decline

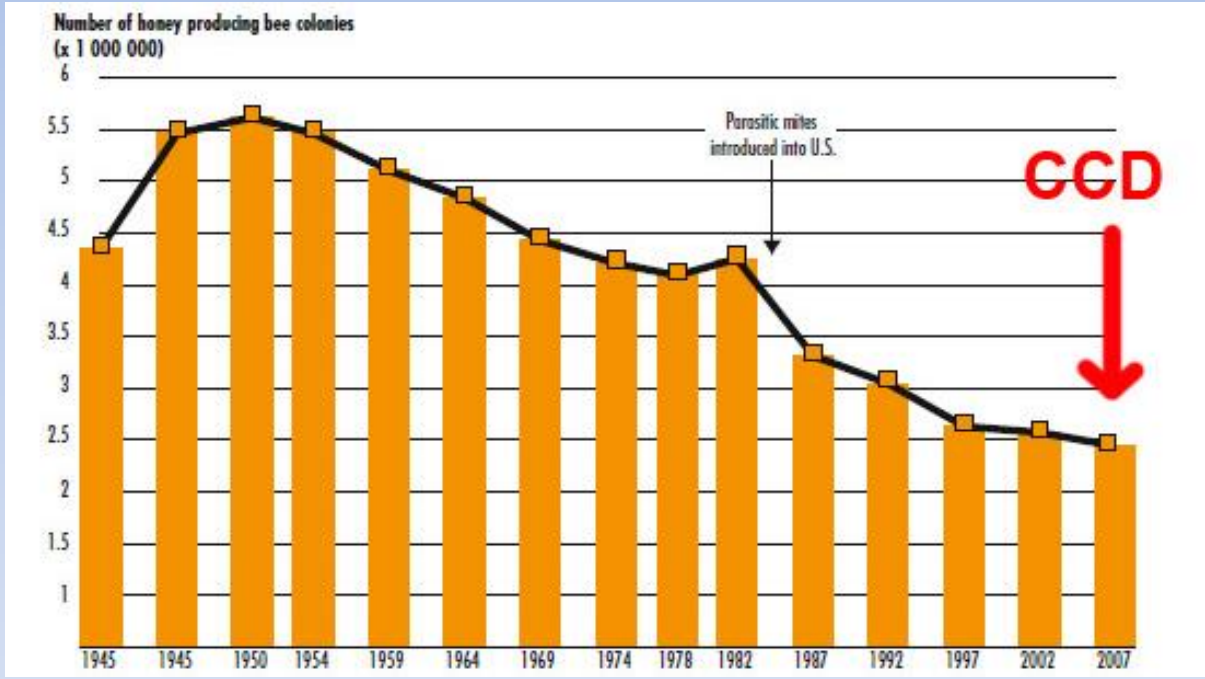
Colony collapse disorder: Honeybees

In 2006, U.S. beekeepers reported losses of 30-90% of hives

Main symptoms: very low or no worker bees, queen is alive, with larvae present, and no dead bodies inside or in front of hive (thus hard to study potential causes…)

Honeybees

Currently, estimated 2.62 million colonies of honeybees in USA



Pollinator decline

Factors associated with honeybee declines:

- Arthropod pests and pathogens
- Poor nutrition
- Bee management practices
- Agricultural practices and pesticides
- *Habitat fragmentation*

Not a single factor, but a combination of factors

Pests and pathogens

Parasitic mite: *Varroa destructor*

- Single most detrimental pest of honeybees
- Introduced from Eastern Asia and identified in U.S. hives in 1987
- Blood sucking parasites that also transmit viruses to bees
- Cause significant colony losses each year

Poor nutrition

Monoculture, i.e. almond and other commercial crops provide no diversity of food

Agricultural/residential practices

Nature Deficit Disorder

- Monocultures
- Lack of cover crops (natural fertilizers)
- Herbicides to kill off weeds (dandelion, clover, etc…)

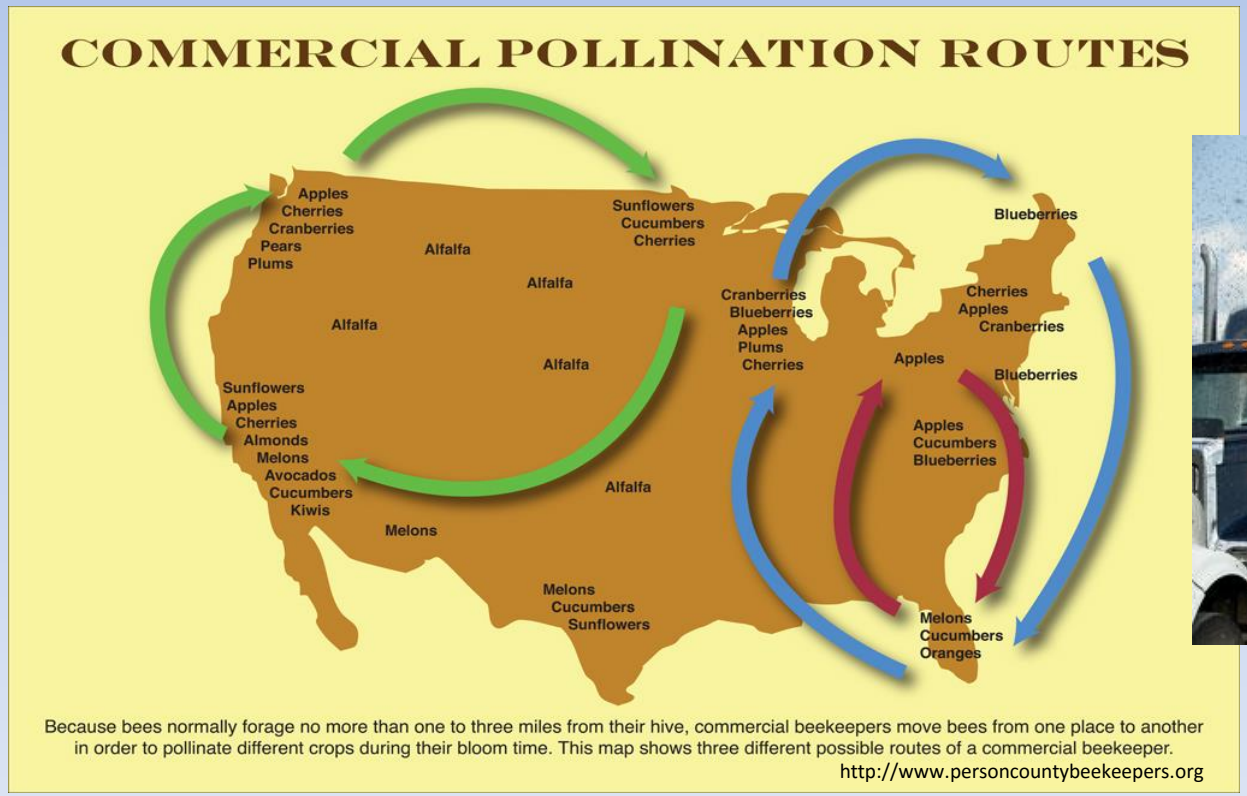

http://bif.rs/wp-content/uploads/2013/05/monokultura.jpg


http://environmentalgeography.wordpress.com

In 2001, 11% of pesticides were used on lawns and 5% greenhouse gases produced by mowing our lawns

Bee management practices

Not uncommon for beekeeper to travel 37,000-40,000 miles per year to pollinate 4 or more different crop



Rucker et al 2001

Pesticide exposure

Pesticides: insecticides, fungicides, and herbicides (and adjuvants)

Pesticide exposure

How do pesticides affect pollinators

- Lethal effects: acutely toxic to bees and result in death
- Sublethal effects: do not kill bees but affect performance that inhibit tasks such as olfactory learning, foraging, reproduction, longevity,…thus affecting colony health
- Synergistic effects: toxic effects when in combination with other pesticides

Pesticide exposure

List of pesticides found in pollen on honeybees returning to hive

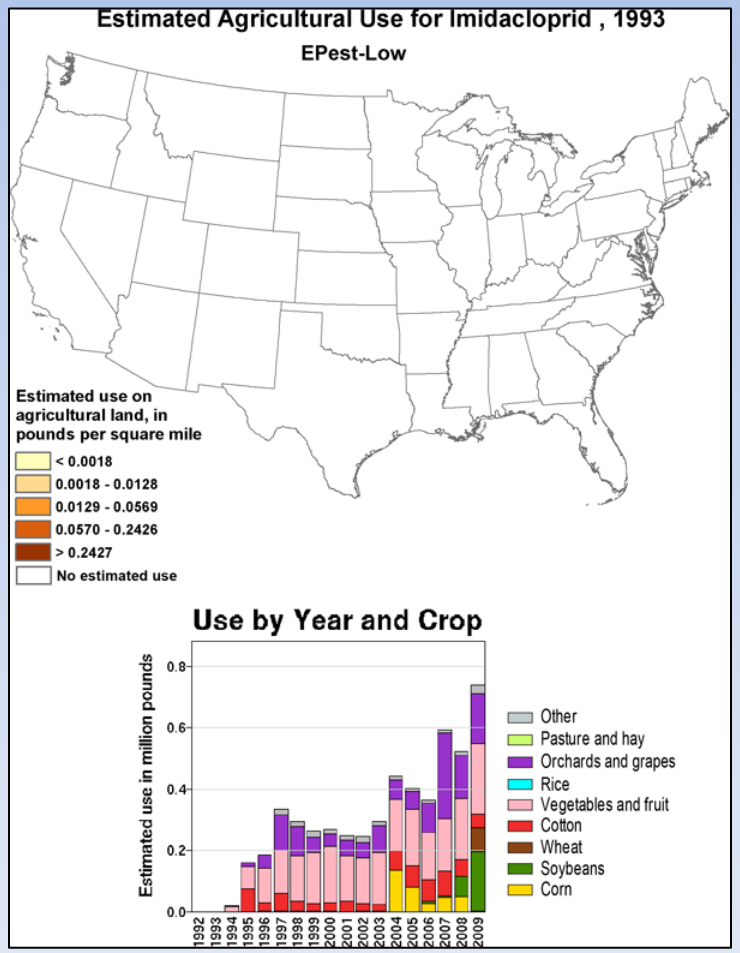
Fungicides
Herbicides
Insecticides

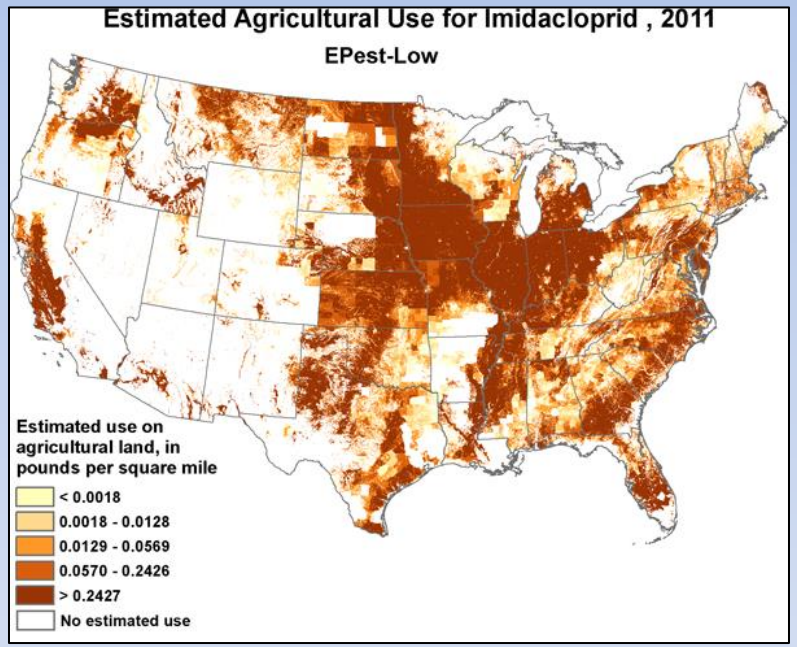
Pesticide	Insecticide family	LD_{50} (ppm)[a]	Crops in which detected[c]	Detections	Quantity detected, mean±se (max) (ppb)	Relative risk (95% CI)
Fungicides						
Azoxystrobin		>1,562.5 [64]	Cr, Cu, Wa	10	60.3±25.6 (332)	0.75 (0.56, 1.02)
Captan		>78.13 [65]	Ap, Cr, Cu, Wa	9	976.9±734.4 (13,800)	0.59 (0.42, 0.81)†
Chlorothalonil		>1,414.06 [66]	Ap, Bl, Cr, Cu, Pu, Wa	17	4,491.2±2,130.7 (29,000)	2.31 (1.35, 3.94)†
Cyprodinil		>6,125 [67]	Ap	3	996.9±707.5 (12,700)	0.31 (0.15, 0.65)†
Difenoconazole		>781.25 [68]	Ap	3	171.4±119.4 (2,110)	0.31 (0.15, 0.65)†
Fenbuconazole		>2,282.65 [69]	Ap, Cr, Cu	10	227.3±89.2 (1,420)	0.33 (0.23, 0.48)†
Pyraclostrobin		573.44 [70]	Cr, Pu	4	2,787.1±1,890.1 (27,000)	2.85 (2.16, 3.75)†
Quintozene (PCNB)		>0.78 [71]	Cr	2	0.3±0.3 (4.7)	0.97 (0.59, 1.61)
THPI	Captan metabolite		Cr, Cu	3	832.1±531.8 (9,470)	0.42 (0.21, 0.82)†
Herbicides						
Carfentrazone ethyl		>217.97 [72]	Cr	1	0.1±0.08 (1.6)	1.05 (0.54, 2.05)
Pendimethalin		>388.28 [73]	Ap, Cr, Pu	5	5.1±3.7 (69.5)	1.47 (1.08, 1.99)†
Insecticides						
2,4 Dimethylphenyl formamide (DMPF)*	Amitraz (formamidine) metabolite		Bl, Cu, Pu, Wa	10	171.5±117.0 (2,060)	2.13 (1.56, 2.92)†
Acetamiprid	Neonicotinoid	55.47 [60]	Ap	3	59.1±32.2 (401)	0.31 (0.15, 0.65)†
Bifenthrin	Pyrethroid	0.11 [74]	Pu, Wa	3	6.6±3.8 (53.1)	2.08 (1.53, 2.83)†
Carbaryl	Carbamate	8.59 [75]	Ap, Cu, Wa	6	57.8±30.0 (403)	0.42 (0.27, 0.66)†
Chlorpyrifos	Organophosphate	0.86 [16]	Ap, Cr, Cu, Pu	7	3.1±1.1 (15.5)	0.89 (0.64, 1.23)
Coumaphos*	Organophosphate	35.94 [16]	Bl, Cr, Cu	6	2.2±1.0 (17.5)	0.62 (0.43, 0.91)†
Cyfluthrin	Pyrethroid	<0.31 [76]	Cr, Wa	2	0.6±0.4 (5.4)	1.31 (0.85, 2.02)
Cyhalothrin	Pyrethroid	0.30 [77]	Ap, Pu, Wa	7	14.6±7.9 (131)	0.94 (0.69, 1.29)
Cypermethrin	Pyrethroid	0.18–4.38 [78]	Cr	1	0.4±0.4 (6.9)	1.05 (0.54, 2.05)
Deltamethrin	Pyrethroid	0.39 [79]	Cr	1	4.5±4.5 (85.3)	1.05 (0.54, 2.04)
Diazinon	Organophosphate	1.72 [80]	Ap, Cr	3	1.4±1.0 (19.8)	0.56 (0.32, 0.97)†
Endosulfan I	Cyclodiene	54.69 [16]	Ap, Cr, Cu, Pu, Wa	8	1.5±0.7 (12.9)	1.60 (1.20, 2.14)†
Endosulfan II	Cyclodiene	54.69 [16]	Ap, Cr, Cu, Pu	6	0.8±0.3 (5.3)	1.41 (1.04, 1.91)†
Endosulfan sulfate	Endosulfan metabolite		Cr, Cu	4	0.3±0.2 (2.1)	0.79 (0.52, 1.19)
Esfenvalerate	Pyrethroid	0.13 [81]	Ap, Cr, Cu	7	16.9±12.0 (216)	0.51 (0.35, 0.75)†
Fluvalinate*	Pyrethroid	1.56 [82]	Bl, Cr, Cu, Pu, Wa	16	42.4±29.7 (570)	2.43 (1.49, 3.96)†
Heptachlor epoxide	Heptachlor[b] (cyclodiene) metabolite		Cr	1	0.6±0.6 (12)	1.05 (0.54, 2.04)
Imidacloprid	Neonicotinoid	0.23 [83]	Ap	3	2.8±2.0 (36.5)	0.31 (0.15, 0.65)†
Indoxacarb	Oxadiazine	1.41 [84]	Ap	2	0.5±0.5 (9)	0.28 (0.11, 0.73)†
Methidathion	Organophosphate	1.85 [85]	Cr	1	1.6±1.6 (31)	1.05 (0.54, 2.04)
Methomyl	Carbamate	<3.91 [86]	Wa	1	13.6±13.6 (259)	1.54 (0.91, 2.61)
Phosmet	Organophosphate	8.83 [85]	Ap, Cr, Cu	5	798.7±772.4 (14,700)	0.36 (0.21, 0.61)†
Pyrethrins	Pyrethroid	0.16 [16]	Cr	1	5.1±5.1 (97.4)	1.05 (0.54, 2.05)
Thiacloprid	Neonicotinoid	114.06 [60]	Ap	2	1.1±0.8 (12.4)	0.35 (0.15, 0.82)†
Control diets						
BRL	NA	NA	NA	NA	NA	0.58 (0.23, 1.48)
MegaBee	NA	NA	NA	NA	NA	0.74 (0.33, 1.67)

Pettis et al 2013 PlosOne 8: 1-9

Pesticide exposure

- Imidacloprid (Admire) registered in 1994
- 1st neonic registered





US Geological Survey
http://www.usgs.gov/

Pesticides in your garden

Examples of Neonicotinoid Garden Products Used in the United States

Neonicotinoid	Garden & ornamental uses	Garden product trademark names
Imidacloprid	Seed dressing, soil drench, granules, injection, or spray to a wide range of ornamental plants, trees, and turf.	Bayer Advanced 3-in-1 Insect, Disease, & Mite Control Bayer Advanced 12 Month Tree & Shrub Insect Control Bayer Advanced 12 Month Tree & Shrub Protect & Feed Bayer Advanced Fruit, Citrus & Vegetable Insect Control Bayer Advanced All-in-One Rose & Flower Care concentrate DIY Tree Care Products Multi-Insect Killer Ferti-lome 2-N-1 Systemic Hi-Yield Systemic Insect Spray Hunter Knockout Ready-To-Use Grub Killer Lesco Bandit Marathon Merit Monterey Once a Year Insect Control II Ortho Bug B Gon Year-Long Tree & Shrub Insect Control Ortho MAX Tree & Shrub Insect Control Surrender Brand GrubZ Out
Clothianidin	Seed treatment, foliar spray or soil drench for turf, a variety of ornamental trees, and flowers.	Bayer Advanced All-in-One Rose & Flower Care granules Green Light Grub Control with Arena
Thiamethoxam	Soil drench, injection, granules, or foliar spray to a wide range of ornamental plants and turf.	Flagship Maxide Dual Action Insect Killer Meridian
Acetamiprid	Foliar spray for fruits, vegetables, ornamental plants, and flowers.	Ortho Flower, Fruit and Vegetable Insect Killer Ortho Rose and Flower Insect Killer
Dinotefuran	Soil drench or foliar spray to leafy & fruiting vegetables, turf, & ornamental plants.	Green Light Tree & Shrub Insect Control with Safari 2 G Safari Transect Zylam 20SG Systemic Turf Insecticide

Pollinator habitat

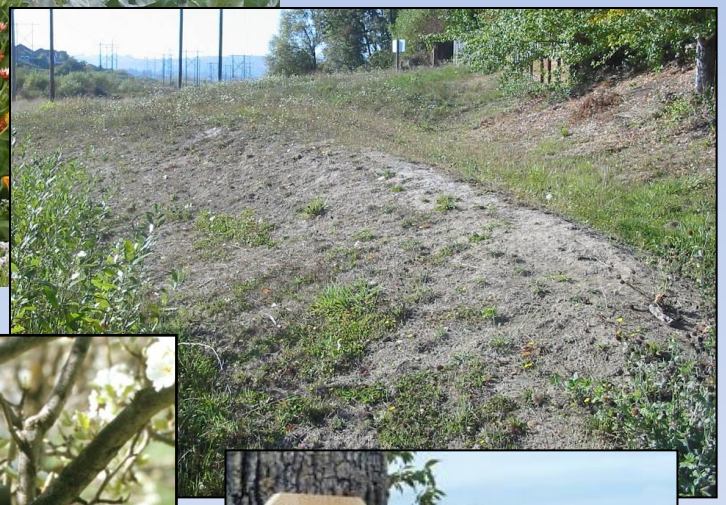
- Loss of suitable habitat
- Fragmentation into smaller isolated habitat patches

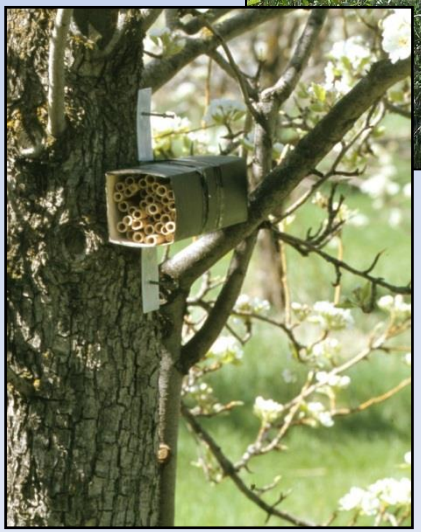
Rusty patched bumble bee
Bombus affinis

Yellow banded bumble bee
Bombus terricola

Pollinator conservation and protection

- Provide variety of resources for season-long forage
- Provide habitat for ground-nesting and cavity nesters
- Protect pollinators from pesticide exposure (lowest risk, lowest concentration, avoid dusts and long residual products, spray at night)





Plants for Wisconsin

Native flowers

- Lupine
- Spiderwort
- Penstemon
- Milkweed
- Beebalm
- Joe Pye weed
- Blazing star
- Goldenrod
- Asters
- Prairie clover
- Purple cone flower
- Leadplant
- Cup plant

The Xerces Society

Photos: Eric Mader

Plants for Wisconsin

Woody plants

- Redbud
- Apple
- Plum
- Basswood
- Wild rose
- Pussy willow
- Hawthorn
- Ninebark
- Raspberry
- Blueberry

Thank you!

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