





Strategies for pollen movement

1. Wind pollination

- Gymnosperms and some flowering plants (grasses, trees)
- Flowers are small, grouped together
- Not a very efficient method: too chancy and extremely wasteful



Strategies for pollen movement

- 2. Animal pollination
- Insects bees, wasps, flies, butterflies, moths, ants
- Birds hummingbirds, honey creeper
- Mammals bats, mice, monkeys
- Even some reptiles and amphibians



Animal pollination

Benefits to plant

- 1. Directed movement, allowing plants to make less pollen
- 2. Works in low-wind environments or wrong wind direction
- Can move genes longer distances
 Can work at low plant density
- 5. Potential for specialization

Costs to plant

- 1. Risk (if no animal available)
- 2. Resources required as an incentive to attract pollinators (nectar) and cues (flowers)
- 3. Susceptibility to exploitation

Rewards

Nectar: sugary fluid (15-45% carbohydrates) produced by nectar glands (nectaries) in flower; primarily simple sugars but contains trace amounts of amino acids, vitamins, phenolics,...

Pollen: high in proteins (~25%) & lipids, and trace amounts of minerals, vitamins,...



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

Economics of insect pollination
 \$15 billion per year to the US economy
 \$217 billion worldwide (Science Daily 2008)





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







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 that last one season, queens overwinter
- Most abundant native pollinators of both crops and wild flowers



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



















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...)





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

Since 1984, multiple introduction of invasive species:

- parasitic tracheal mite Acarapis woodi (identified 1984)
- parasitic mite Varroa destructor (identified 1987)
- Africanized honey bees (1991)
- small hive beetle Aethina tumida (identified 1996)
- Israeli Acute Paralysis Virus IAPV (identified 2007)
- gut parasite Nosema ceranae (identified 2007)

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USDA CCD 2012 Annual Progress Report
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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





Pollinator decline

Sign of nutritionally desperate bees?



Bees from apiaries near Ribeauvillé in France have acquired taste for processed sugars at local biogas plant that processes waste from Mars chocolate factory

Instead of mining local wildflowers for nectar, bees have been sucking up colorful sugar at factory!



Agricultural/residential practices

Nature Deficit Disorder

Monocultures

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



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

Pesticide exposure

Pesticides: insecticides, fungicides, and herbicides



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



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Examples	of Neonicotinoid Garde	n Products Used in the United States
Neonicotinoio	Garden & ornamental uses	Garden product trademark names
Imidacloprid	Seed dressing, soll drench, granules, hylocton, or spany to a wide ange of omamental plants trees, and turt.	Bayer Advances 3 to 1 med. Disease. Is Mills Control Bayer Advances 1 ben With The & Shrub Instruct & Field Bayer Advances 1 Min Worth The & Shrub Instruct & Field Bayer Advances 1 Mills Instead Control Divi The Coale Products Multi Instead Villar Horizon 2014 Statistics (Spring Horizon 2014) Statistics (Spring Horizon 2014) Statistics (Spring Horizon 2014)
Clothanidin	Seed treatment, foilar 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
Thiamethoxan	Soil drench, injection, granules, for foliar spray to a wide range of ornamental plants and turf.	Flagship Mexicle Dual Action Insect Killer Merician
Acetamiprid	Foliar spray for fruits, vegetables, proamental 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, 8 ornamental plants.	Green Light Tree & Shrub insect Control with Safari 2 G Safari Transict Nume not C Sustemic Turf Incerticide



Declined by 87% in last 20 years Potential causes: diseases and pathogens introduced in by commercially reared bumble bee colonies, habitat loss, pesticide

exposure, climate change



Extreme pollinator decline ...?

China's Sichuan Province, one of the largest apple-producing regions in the world...hand pollination!



Pollinator conservation and protection

- Provide variety of resources for seasonlong 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)





Pollinator conservation

Provide food

- Add flowering plants to landscape
- Provide a variety of pollen/nectar sources
- Provide season long forage (min. 3 per season)
- Tolerate non-invasive weeds!





Providing nesting sites

Retain or create bare soil for ground nesters:

• Keep some areas of bare ground

- Minimize untilled areas
- Clear away some plants from well drained slopes







Providing nesting sites Etain or create nest sites for bumblebees: Plant native bunch grasses Maximize "wild" areas Artificial nests are not effective

Reducing pest and pathogen transmission

- Avoid locating managed bees near conservation areas
- Diseases can be spread through pollen

Pollinator conservation and protection

- Use the lowest risk/lowest concentration
- Avoid dusts and micro-encapsulated products
- Avoid products with long residual
 (systemic)
- Time applications to avoid bees: spray in evening when bees not active



Examples of Neonicotinoid Garden Products Used in the United States			
Neonicotinoid	Garden & ornamental uses	Garden product trademark names	
Imidacloprid	Seed diresting, toll dirench, granules, Hjection, or spray to a wide range of ornamental plants trees, and turf.	Bayer Advanced 3-in treact: Desema, 8. MML Control Bayer Advanced 3-in thread: Shore and Control Bayer Advanced 5-Into The Advance and Control Bayer Advanced 7-Into Chrus A Vergetable Insect Control Bayer Advanced 7-Into Chrus A Vergetable Insect Control Bayer Advanced 7-Into Chrus A Vergetable Insect Control Part Sonra 2-N-1 Splannic Parts Control Advanced 7-Into Chrus Bayer Advanced The Chrus Chrus Killer Lance Barett Machine Monteny Once a Verair Insect Control I Onto Lang Bion Year-Long Time & Shrub Insect Control Dimolecular Units Control II Onto Baye Bion Year-Long Time & Shrub Insect Control Dimolecular Units Chrus Chrus Chrussel Dimolecular Data Chrus Chrussel	
Clothlanidin	Seed treatment, foilar spray or soil drench for turf, a variety of omamental trees, and flowers.	Bayer Advanced All-in-One Rose & Flower Care granules Green Light Grub Control with Arena	
Thiamethoxan	Soil drench, injection, granules, for foliar spray to a wide range of ormamental plants and turf.	Flagship Mexide Dual Action Insect Killer Mericlan	
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Dinotefuran	Soil drench or foliar spray to leafy & fruiting vegetables, turf, 8 ornamental plants.	Green Light Tree & Shrub Insect Control with Safari 2 G Safari Translet Zvlam 1950 Sustamin Turf Insecticida	





