

Farming for Bees


Conservation of Native Pollinators



Presented by Eric Mader
The Xerces Society for Invertebrate Conservation

Photo: Edward S. Ross

What is the Xerces Society?




THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION

Since 1971, the Society has worked to protect wildlife through the conservation of invertebrates and their habitat.

Major Programs:

- Endangered species
- Aquatic invertebrates
- Pollinator conservation



*** Xerces blue butterfly (*Glaucopsyche xerces*), the first U.S. butterfly to go extinct due to human activities**

Photo: Edward S. Ross

What is the Xerces Society?



Advocacy, Education, Restoration, and Applied Research

Photos: Paul Jepson, Matthew Shepherd, Heidi Ballard

What is the Xerces Society?

The Xerces Society: A Nationwide Pollinator Training and Education Service

Collaborating with scientists, government agencies, cooperative extension, conservation groups and farmers

- Training and outreach
- Technical publications
- Applied research
- Direct technical support to growers
- Develop new conservation tools
- Information for policymakers and media
- Document at-risk pollinators
- Technical support to the USDA-NRCS



Photo: Eric Mader

Xerces Pollinator Program Technical Expertise

Xerces Society Staff Background

Graduate level training in ecology, entomology, horticulture, and teaching




Professional experience in farming, wildlife conservation, ecological research, commercial beekeeping, crop scouting, and native seed production.

Photo: Eric Mader

Short Course Outline

Overview:

1. The importance of pollinators
2. Bee biology
3. Bee-friendly farming
4. Developing new pollinator habitat
5. Bee conservation and Farm Bill programs
6. Additional resources


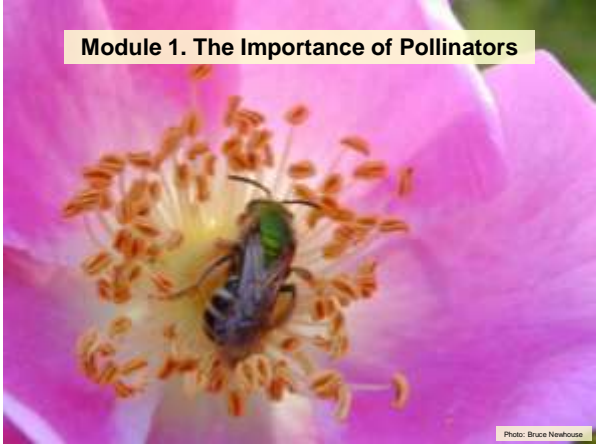
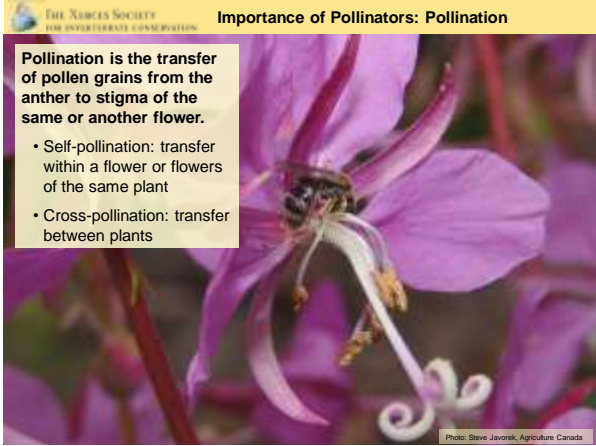


Photo: Bruce Newhouse



Module 1. The Importance of Pollinators

Photo: Bruce Newhouse

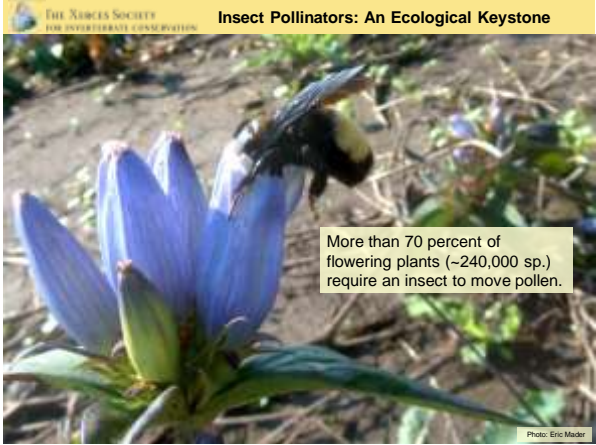


Importance of Pollinators: Pollination

Pollination is the transfer of pollen grains from the anther to stigma of the same or another flower.

- Self-pollination: transfer within a flower or flowers of the same plant
- Cross-pollination: transfer between plants

Photo: Steve Javorek, Agriculture Canada



Insect Pollinators: An Ecological Keystone

More than 70 percent of flowering plants (~240,000 sp.) require an insect to move pollen.

Photo: Eric Mader



Bugs Drive the System

Wildlife conservation

- Fruits and seeds are a major part of the diet of about 25% of birds, and many mammals
- Pollinators are food for wildlife

USDA/NRCS

Robert Parks

USDA/NRCS

Photo: Karen Ward, NPS



Main Groups of Pollinators

Photos: Mace Vaughan, Bob Hammond, David Inouye, Bruce Newhouse



Bees: The Most Important Pollinators

- Bees actively collect and transport pollen
- Bees exhibit flower constancy
- Bees regularly forage in area around nest

Photo: Edward S. Ross

Pollination and Human Nutrition

Pollinators provide an ecosystem service that enables plants to produce fruits and seeds.

- 35% of crop production, worldwide
- Over \$18 to \$27 billion value of crops in U.S. (\$217 billion worldwide)
- One in three mouthfuls of food and drink we consume



Morse RA, Calderone NW. 2000. The value of honey bees as pollinators of U.S. crops in 2000. Bee Culture 128:1-15.
Klein et al. 2007. Importance of pollinators in changing landscapes for world crops. Proc. R. Soc. B 274: 303-313.

Photo: USDA-ARS/Peggy Greb

Annual Values of Insect Pollinated Crops

- Alfalfa (seed and forage) = Over \$7 billion
- Apple = Over \$1.5 billion
- Almond = Over \$1.1 billion
- Berries = Over \$2.5 billion
- Canola, soybean, cotton = ???

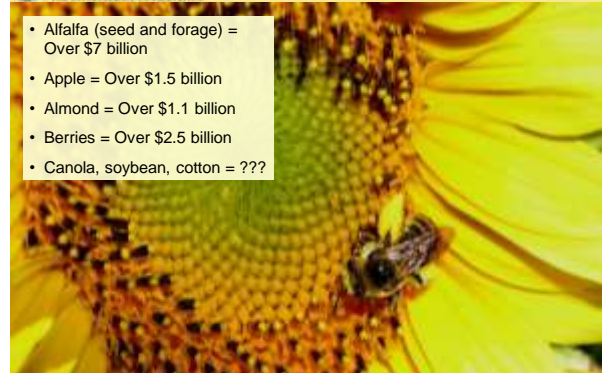


Photo: Sarah Greenleaf

Honey Bees: Essential Non-Native Livestock

- Most crop pollination is done by the European honey bee.
- This leaves us reliant on a single pollinator, one that is experiencing many problems.



Photo: USDA-ARS/Scott Bauer

Crop Pollination: Honey Bees in Decline

Fewer honey bees available

- 50% decline in managed hives since 1950
- Doubling of cropland requiring bee pollination
- 70-100% decline in feral colonies

Causes: Disease, pests, honey prices, and...



National Research Council. 2007. Status of Pollinators in North America. National Academies Press, 326 pp.

Photo: USDA-ARS/Scott Bauer

Honey Bees: Colony Collapse Disorder

Colony Collapse Disorder

In 2006-7, about 25% of beekeeping operations in the U.S. lost an average of 45% of hives.



vanEngelstrop, D., R. Underwood, D. Carron, J. Hayes Jr. 2007. An Estimate of Managed Colony Losses in the Winter of 2006-2007. A Report Commissioned by the Apiary Inspectors of America. Am. Bee Journal 147: 559-603.

Photo: Eric Mader

Possible Causes of Colony Collapse Disorder

Colony Collapse Disorder

- Disease/pathogen?
 - Israeli Acute Paralysis Virus?
 - New strain of *Nosema*?
- Pests?
- Poor diet?
- Insecticides?
- Stress?


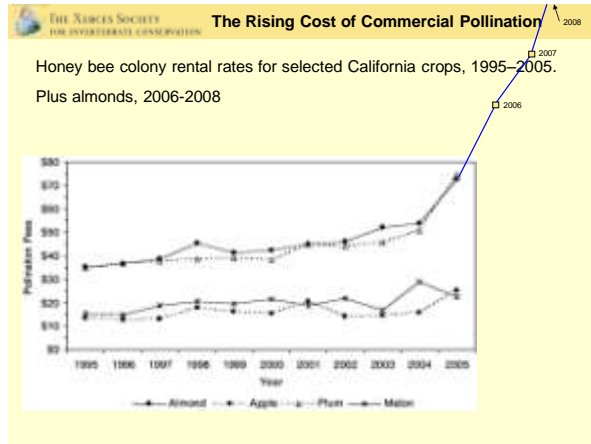
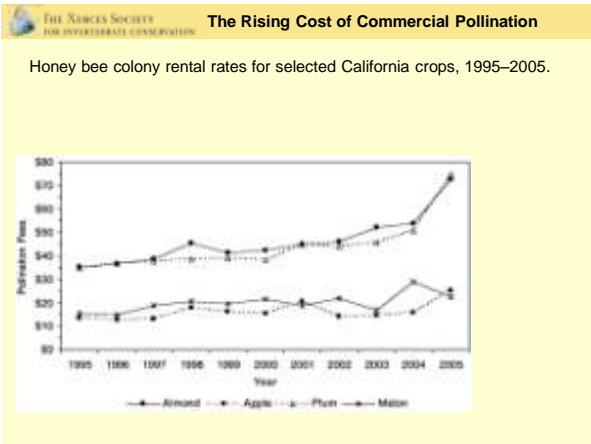


Photo: USDA-ARS/Scott Bauer



The Xerces Society FOR INVERTEBRATE CONSERVATION **Crop Pollination: Important to Diversify**

Fewer honey bees available

- Important to diversify pollinators for production agriculture
- Important to strengthen habitat and pesticide protection for all bees (honey and native)

Photo: Bob Hammond, CSU Coop Ext.

The Xerces Society FOR INVERTEBRATE CONSERVATION **Native Bee Diversity**

North America: 4,000+ species

Photo: Edward S. Ross

The Xerces Society FOR INVERTEBRATE CONSERVATION **The Economic Value of Native Bees**

Hundreds of species of native bees contribute significantly to crop pollination.

- \$3 billion/year

Losley, J. and M. Vaughan. 2006. The Economic Value of Ecological Services Provided by Insects. *BioScience*, 56 (4).

Photo: USDA/ARS/Scott Bezar & Estelita Maldon.

The Xerces Society FOR INVERTEBRATE CONSERVATION **Value of Native bees**

Native bees are very efficient:

- Active earlier and later in the day
- Collect both pollen and nectar
- Buzz pollination
- Keep honey bees moving
- No rental fees

Native bees can supplement honey bees if they are hard to acquire.

Photo: Mace Vaughan

Native Bee Diversity in Agriculture

Contribution of native bees to crop pollination:

- 80+ bee species recorded visiting berry crops in New England
- 100+ species documented in WI cranberries
- 100+ species visiting apples in NY and PA
- 50+ species visiting tomato, sunflower, or watermelon in California

Photo: USDA-ARS

Native Bee Diversity in Agriculture

Example: Blue orchard bee

- 250 to 750 females/acre compared to 1 to 2.5 hives of honey bees
- Make contact with anther and stigma on almost every visit
- Active at low light levels and low temperatures
 - 33+ hours foraging in 5 days
 - 15+ hours by honey bees

Bosch, J. and W. Kemp. 2007. How to Manage the Blue Orchard Bee as an Orchard Pollinator. Sustainable Agriculture Network, Beltsville, MD. 89 pp.

Photo: Eric Mader

Buzz Pollination by Native Bees

Example: Cherry tomatoes

When native bees were present, the production of Sungold cherry tomatoes almost tripled.

Greenleaf, S. S. and C. Kremen. 2006. Wild bee species increase tomato production and respond differently to surrounding land use in Northern California. Biological Conservation 133:81-87.

Photos: Buzpep, Maca Vaughan

Pollination of Complex Flowers

Native bees and alfalfa

- Honey bees learn to bypass the pollination mechanism
- Most seed production by leafcutter and alkali bees
- Wild bees trip over 80% of alfalfa flowers visited; leafcutter bees and alkali bees trip only 25%

Brunet, J. and C. M. Stewart. 2010. Impact of Bee Species and Plant Density on Alfalfa Pollination and Potential for Gene Flow. Psyche

Photo: Eric Mader

Native Bees Keep Honey Bees Moving

Hybrid sunflower production:

When native bees were present, the seed set in hybrid sunflower fields more than doubled.

Greenleaf, S. and C. Kremen. 2006. Wild bees enhance honey bees' pollination of hybrid sunflower. Proceedings of the National Academy of Sciences. 103:1371-1385-15.

Photo: Sarah Greenleaf

Other Important Bees in Decline

Native bees also in decline:

Four sister species of bumble bees

Evans, E. R., Thorp, S., Jepsen, and S. Hoffman-Black. 2009. Status Review of Three Formerly Common Species of Bumble Bee in the Subgenus *Bombus*. Xerces Society.

Cameron et al. 2011. Patterns of widespread decline in North American bumble bees. PNAS.


Colla and Packer. 2008. Evidence for decline in Eastern North American bumble bees (Hymenoptera: Apidae), with special focus on *Bombus affinis* Cresson. Biodivers Conserv.

© Leaf Richardson, © Pat Schroeder, © Jan Knudson, © Pat Michaels



Declining Native Bees

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HISTORIC RANGE OF BOMBUS AFFINIS



Historic range in yellow. U.S. Department of the Interior, Bureau of Land Management.

Rusty Patched Bumble Bee

- *Bombus affinis* was one of most common bumble bees in the Eastern U.S.
- Now gone from most of its historic range
- Most likely reason is disease and pathogens introduced in by commercially reared bumble bee colonies


Images: The Xerces Society

The rusty patched bumble bee was once common in the eastern United States and the upper Midwest. They can still occasionally be found in isolated patches, but *B. affinis* has disappeared from most of its former range in recent years. Your efforts to search for this bee will help document their current range. The Xerces Society and scientists studying declining bumble bees will use this information to promote conservation of remaining *B. affinis* populations.



Declining Native Bees

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HISTORIC RANGE OF BOMBUS TERRICOLA



Historic range in yellow. U.S. Department of the Interior, Bureau of Land Management.

Yellow Banded Bumble Bee

- *Bombus terricola* was one of most common bumble bees in the Eastern U.S.
- Now gone from most of its historic range
- Most likely reason is disease and pathogens introduced in by commercially reared bumble bee colonies

Images: The Xerces Society

The yellowbanded bumble bee was once commonly found throughout much of eastern North America. They can still be found occasionally in isolated patches, but *B. terricola* has disappeared from most of its former range in recent years. Your efforts to search for this bee will help document their current range. The Xerces Society and scientists studying bumble bee decline will use this information to promote conservation of remaining yellowbanded bumble bee populations.

Bumble Bee Citizen Monitoring Project

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© Joan Knudson © Amber Florer © Jack DeLong

Please participate in the Xerces Society Citizen monitoring project!

1. Take a pocket identification guide for the species that occurs in the region where you live
2. Look for bumble bees in the spring, summer and fall
3. If you spot a target species, email a photo to bumblebees@xerces.org


For more information, visit: www.xerces.org/bumble-bee-citizen-monitoring/

Pollination and Crop Security

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Even as bees decline, crop acreage requiring bee pollination grows.

- From 1961 to 2006 percent of global cropland requiring bee pollination rose from 18.2% to 34.9% (300% increase in total acreage)¹
- 5,000 to 10,000 new acres of Wisconsin cranberries over the next decade
- 150,000 new acres of California almonds anticipated



1. Aizen MA, LA Garibaldi, GA Cunningham, AM Klein. 2008. Long-term global trends in crop yield and production reveal no current pollination shortage but increasing pollinator dependency.

What Happens to Us When Bees Decline?

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Photo: Business Week Magazine



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Order Hymenoptera: Bees, Wasps, Ants

Hymenoptera: Membranous Wings

- Two pairs of wings
- Haplodiploidy sex-determination
- Complete metamorphosis

Common Characteristics:

- Skinny waists
- Ovipositor
- Long antennae

Rare Characteristics:

- Social behavior (mostly ants)
- Honey production (extremely rare)

Photos: USDA ARS, Jim Cane, Kim Cabrera, ERS Hodges MMA

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Bees: Distinguishing Characteristics

Characteristics of Bees:

- Branched hairs** (indicated by red arrows pointing to a magnified inset of hairs)
- Long tongues** (indicated by red arrows pointing to the mouthparts)
- Two pairs of attached wings** (indicated by red arrows pointing to the wings)
- Pollen-carrying hairs (scopa) (on abdomen or hind legs)** (indicated by red arrows pointing to the scopa on the abdomen and hind leg)

Photos: Ralph Hoenzthal, Mace Vaughan, Steve Buchmann

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Identifying Male and Female Bees

Males

- Smaller than females
- Longer antenna
- Sometimes colored eyes
- No stinger
- Often white or yellow facial hair

Females

- Larger than males
- Black eyes (usually)
- Scopa (pollen-carrying hairs on abdomen or rear legs)

Photo: Mace Vaughan

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Identifying Bees vs Flies

Flies

- One pair of wings
- Short, stout antenna
- Huge round eyes that “meet” in the middle
- No pollen-carrying structures
- Hair usually sparse (except bee mimics)
- Short, sponge-like mouthparts

Bees

- Two pairs of wings (connected)
- Long antenna
- Skinny, constricted waists
- Pollen-carrying structures
- Usually hairy (except cuckoo bees)
- Long tongues

Photos: Mace Vaughan, Eric Medler

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Identifying Bees vs Wasps

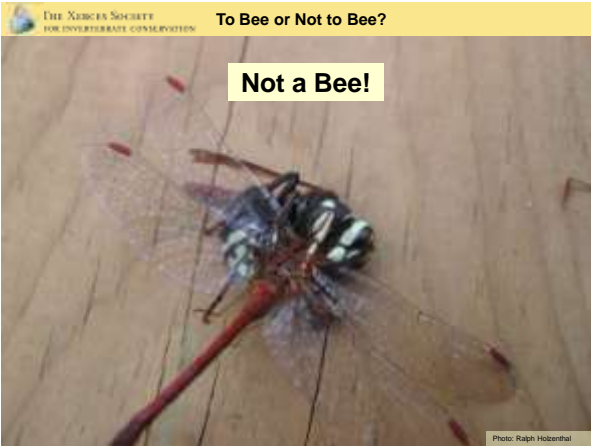
Wasps

- No pollen-carrying structures
- Body hairs usually sparse and non-branched (shiny hairs)

Bees

- Pollen-carrying structures
- Usually hairy (except cuckoo bees)
- Branched hairs (not shiny)

Photos: Darin Evans, Mace Vaughan





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Overall body shape:

Slender → Moderate → Robust

Body size:

Small (4 - 8mm) → Medium (9 - 14mm) → Large (15 - 25mm)

Photos: Edward S. Ross, Betty Betros, Jennifer Hopwood

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Honey Bees (*Apis mellifera*)**

Characteristics:

- Medium size and build
- Black and orange-brown coloration
- Only species with hairs on eyes
- Pollen basket on hind leg

Hairy eyes

Pollen basket (corbicula)

Photo: Betty Betros, USDA/ARS

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Characteristics:

- Large size, very hairy, robust bodies
- Black and yellow (and orange, brown)
- Pollen basket on hind legs (corbicula)

Pollen basket

Photo: MJ Haffield, Bruce Newhouse, Eric Mader

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Long-Horned Bees (*Melisoides*, *Eucera*, and *Svaestra* spp.)**

Characteristics:

- Medium to large size, robust build
- Long antenna
- Some with pale stripes
- Dense hind leg scopa hairs (chaps)
- Often associated with sunflowers

Melisoides

Svaestra

Scopa

Photo: Jennifer Hopwood, Mack Vaughan (Xerces), Bob Hammond (CSU coop Ext.)

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Carpenter Bees (*Xylocopa* and *Ceratina* spp.)**

Large Carpenter Bees (*Xylocopa* spp.)

Characteristics:

- Large size
- Yellow or black hair on thorax
- Shiny abdomen
- Scopa on hind legs

Small Carpenter Bees (*Ceratina* spp.)

Characteristics:

- Small, slender size
- Dark metallic blue or green color
- Shiny, hairless abdomen
- Scopa on hind leg

Smooth abdomen

Photo: Gene Barckman, © NRCS, Rollin Cowie

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Mining / Plasterer Bees (*Colletes* and *Andrena* spp.)



- Characteristics:**
- Small size, drab color
 - Hairy hind legs and thorax (“hairy armpits”)
 - Facial depressions (*Andrena* only)
 - Pale stripes on abdomen
 - Many species emerge in Spring



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Small Dark Bees (*Halictus*, *Lasioglossum*, *Hylaeus*)



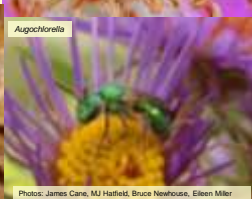
- Characteristics:**
- Small size, drab colors (black, brown, dull green or blue)
 - Short hairs, some with pale stripes
 - Very common
 - Some attracted to perspiration



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Green Sweat Bees (*Agapostemon* and *Augochlora* spp.)

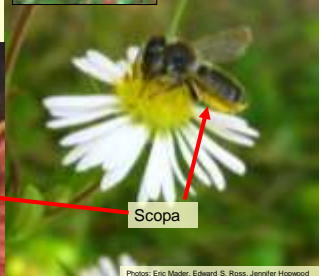
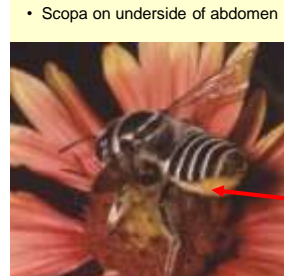
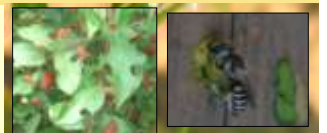
- Characteristics:**
- Small size, less hairy
 - Bright metallic green
 - Some with pale stripes
 - Common, generalist visitors
 - Some attracted to sweat



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Leafcutter Bees (*Megachile* spp.)

- Characteristics:**
- Small to large size
 - Wide bodies and heads
 - Dark, typically with pale stripes
 - Scopa on underside of abdomen



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Mason Bees (*Osmia* spp.)

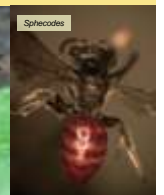


- Characteristics:**
- Small to large size, robust build
 - Usually metallic blue or green
 - Wide bodies and heads
 - Scopa on underside of abdomen
 - Fly in spring and early summer



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Cuckoo Bees: Nest Parasites



- Characteristics:**
- Slender, wasp-like
 - Small to medium size
 - Bodies not hairy, no scopa
 - Coloration highly variable
 - May have spiky projections



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Three Broad Groups of Native Bees

Bumble Bees (social)

Ground-Nesting Bees (solitary)

Wood-Nesting Bees (solitary)

Photos: Matthew Shepherd, Eric Mader, Elaine Elmore

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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

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Ground-Nesting Solitary Bees

Roughly 70% of native bee species nest underground.

- Resemble ant-nests from above ground
- Nest chambers are lined with waxy glandular secretions, and can sometimes even resist flooding

Photos: Eric Mader, Rollin Couvle, Dennis Briggs

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Wood-Nesting Bees

Roughly 30% of native species nest in hollow plant stems, or old beetle borer holes

- Nest tunnel partitions constructed of mud, leaf pieces, or sawdust
- Artificially managed for some crops
- Conserve snags, brush piles

Photo: Edward Ross

Photo: Matthew Shepherd

Photo: Mike Carter

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Wood-Nesting Bees

Hollow stem example:

Cross-section of silk cocoons →

Pollen mass **Egg** **Mud wall**

Larva **Pupa** **Adult**

Silk cocoons with dormant bees inside **Mud cap closure**

Photos: USA-ARS, Eric Mader

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Wood-Nesting Bees

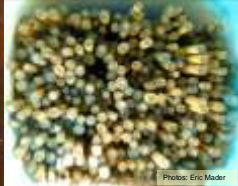
Nest cells separated with mud or leaf partitions

Photo: Eric Mader

THE XEROS SOCIETY FOR INVERTEBRATE CONSERVATION **Wood-Nesting Bees**

Managed tunnel nesting bees:

- Mason bees (blue orchard bee)
- Alfalfa leafcutter bee



Photos: Eric Mader

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- 45 species in U.S.
- Social colonies founded by a single queen
- Colonies last only one season
- Nest may contain 100-300 workers
- Nests in abandoned rodent burrows or under lodged grasses
- Conserve brush piles, un-mowed areas

Photos: Ruffin Coville, Elaine Evans

THE XEROS SOCIETY FOR INVERTEBRATE CONSERVATION **Life Cycle of a Bumble Bee Colony**

Fall: Mated queens seek overwintering sites

Winter: Hibernating queen

Spring: Nest establishment and egg laying

Fall: New queens leave the nest and mate

Fall: Old queen dies

Summer: Colony peak

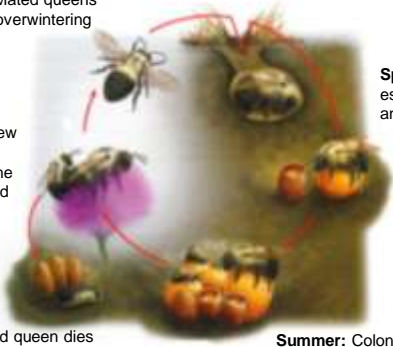


Illustration: David Wysocki

THE XEROS SOCIETY FOR INVERTEBRATE CONSERVATION **Bumble Bees: Excellent Crop Pollinators**

- Pollinators of red clover, tomato
- More efficient than honey bees for blueberry, cranberry, melons, etc.
- Active in cool and wet weather



Photos: Eric Mader (Xeros Society), Steve Javorek (AgCanada)

Module 3: Pollinator-Friendly Farm Practices



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Managing Insecticides

Pesticides cause significant damage to pollinator insect populations

- Use active ingredients with least impact on bees
- Consider formulation
- Select safe thinning agents
- Label guidelines only apply to honey bees
- Don't spray on plants in bloom
- Spray at night and when dry

Photo: The Xerces Society

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Managing Insecticides: Control Drift

Control drift and avoid over application

- Calibrate equipment annually
- Select proper nozzle type
- Avoid temperature inversions and windy conditions
- Establish buffer strips

Photos: USDA-ARS

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Neonicotinoid Insecticides

Neonicotinoid Insecticides:

- Increasingly used on crops and ornamental plants
- Systemic mode of action
- Sprays, soil drenches, granules, seed coatings, chemigation
- Residues in pollen and nectar
- Can persist over time in plants and soil

Photo: Regina Hirsch

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Neonicotinoid Insecticides

Neonicotinoid Toxicity to Bees

- Large doses are toxic to honey bees
- Small doses reduce foraging ability, flight activity, and learning
- Also detrimental to bumble bees, solitary bees, and other beneficial insects
- Breakdown chemicals can be even more dangerous than original product

Photo: Karl Foord

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION


Neonicotinoid Insecticides

Reducing Harm from Neonicotinoids

- Avoid application before or during bloom
- Avoid repeat annual use in perennial blooming species

Photo: Eric Madzi

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Managing Insecticides: Organic Approved**



Organic-approved pesticides aren't always safe for bees.


- Pyrethrins = Dangerous for Bees!
- Spinosad = Dangerous for Bees!
- *Beauveria bassiana* = Dangerous!
- Rotenone = Dangerous for Bees!

Okay when not directly applied to bees (i.e. non-blooming crops or at night):

- Insecticidal soap
- Horticultural oil
- Neem

Photo: NRCS/Toby Alexander

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Managing Insecticides: Alternative Options**



Safer pest management options:

- Bt
- Insect repellents (e.g. garlic or citrus oils)
- Kaolin clay barriers (Surround)
- Pheromone traps
- Mating disruptors

Photo: David Biddinger (Penn State University)

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Managing Insecticides: Alternative Options**

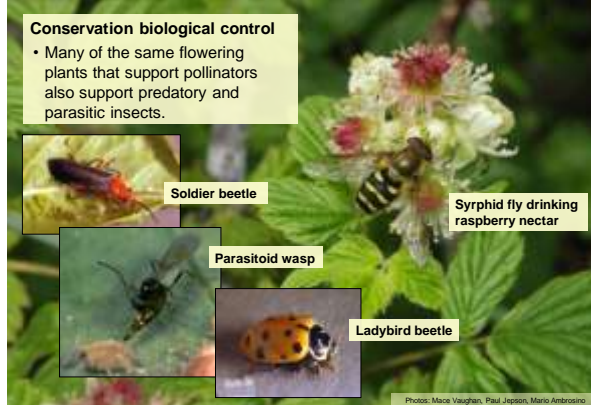


Alternatives to pesticides:

- Floating row covers
- Fruit bagging
- Crop rotation and diversity
- Resistant varieties
- Sanitation

Photo: NRCS/Toby Alexander

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Managing Pesticides: Conservation Biocontrol**



Conservation biological control

- Many of the same flowering plants that support pollinators also support predatory and parasitic insects.

Soldier beetle

Syrphid fly drinking raspberry nectar

Parasitoid wasp

Ladybird beetle

Photos: Mace Vaughan, Paul Jepson, Mario Ambrosio

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Integrated Pest Management

- Establish economic thresholds
- Scout crops before spraying
- Use the least toxic control option
- NRCS 595: Pest Management

Photo: Matthew Shepherd

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Bee-Friendly Farming: Protect Ground Nests**



Protect ground nests:

- Reduce Tillage
- Avoid soil fumigants
- Minimize plastic mulch

Photo: USDA-ARS

Bee-Friendly Farming: Protect Ground Nests

Example: No-till squash

No-till farms in Virginia hosted three times more native bees than did conventional farms




Shuler, et al. 2005. Farming Practices Influence Wild Pollinator Populations on Squash and Pumpkin. *Journal of Economic Entomology*, 98(3):790-795

Photos: Jim Cava

Bee-Friendly Farming: A Midwest Case Study

Midwest Native Seed Producer

- Highly industrialized
- 2000 Acres across two counties
- \$25,000/year honey bee rentals
- Goal: Reduce pollination costs and increase crop pollination






Photos: Eric Mader

Bee-Friendly Farming: A Midwest Case Study

Step 1: Reduce pesticide use

- Implemented IPM program
- Established economic thresholds
- Weekly crop scouting






Photos: Eric Mader

Bee-Friendly Farming: A Midwest Case Study

Step 2: Reduce tillage to protect ground nesting bees

- Scouting of nest sites
- Selective herbicides
- Hooded sprayers
- Flame-weeders






Photos: USDA-ARS, Eric Mader

Bee-Friendly Farming: A Midwest Case Study

Step 3: Conserve bumble bee nest habitat

- Reduced mowing around farms
- Created buffer strips between fields





Photos: Matthew Shepherd, Eric Mader

Bee-Friendly Farming: A Midwest Case Study

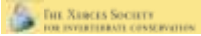
Step 4: Provide nests for tunnel-nesting bees

- Native resident bee populations
- Managed alfalfa leafcutter bees (*Megachile rotundata*)
- Also attracted beneficial predatory wasps





Photos: Eric Mader



Bee-Friendly Farming: A Midwest Case Study

Midwest Case Study Results

- Honey bee rentals reduced by more than one-half
- Improved pollination; increased yields
- More targeted pesticide use
- Greater biodiversity (birds, butterflies, amphibians)





THE XERUS SOCIETY FOR INVERTEBRATE CONSERVATION

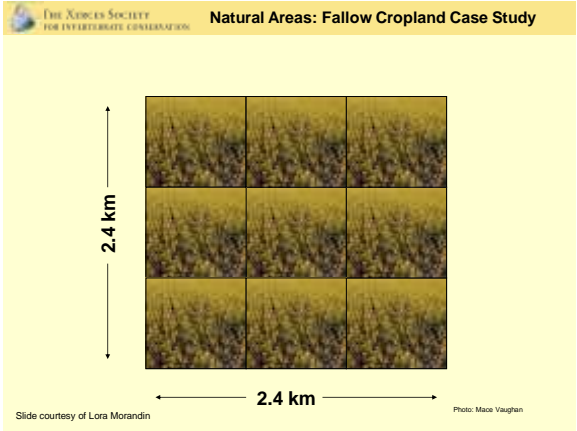
Why Develop New Pollinator Habitat?

Bees need food sources before and after crop bloom

- Example: flight periods of native bees in relation to blueberry bloom.

TAXA	APRIL	MAY	JUNE	JULY	AUG	SEP	OCT
Plaster Bees (<i>Colletes inaequalis, validis</i>)							
Mining Bees (<i>Andrena</i> spp.)							
Green Sweat Bees (<i>Augochlora pura</i>)							
Green Sweat Bees (<i>Augochlorella striata</i>)							
Sweat Bees (<i>Halictus</i> spp.)							
Sweat Bees (<i>Lasiosgossium</i> spp.)							
Mason Bees (<i>Osmia</i> spp.)							
Bumble Bees (<i>Bombus</i> spp.)							

© Data from Steve Javorek, Agriculture Canada
Agriculture and Agri-Food Canada Agriculture et Agroalimentaire Canada



Natural Areas: Fallow Cropland Case Study

Slide courtesy of Lora Morandin

Natural Areas: Adjacent Wildlands Case Study

Example: Watermelon in California

If more than 30% of the area within 1.2 km of a field is natural habitat, growers can achieve full pollination of watermelons by native bees in the Central Valley.

Krohn, C. et al. 2004. The area requirements of an ecosystem service: crop pollination by native bee communities in California. Ecology Letters 7:1109-1119. Photo: Marc Vaughan

Natural Areas: Adjacent Wildlands Case Study

Photo: Google Earth

Natural Areas: Adjacent Wildlands Case Study

Pollen Deposition on Agricultural Lands

Dr. Glenn Hansen, Biology and Evolutionary Biology, Princeton University

Designing New Pollinator Habitat: The Basics

The 5 Critical Design Considerations

1. Early Successional Habitat
2. Connectivity
3. Distance to Crops
4. Bloom Time Succession
5. Floral Abundance

Photo: Eric Mader (1), Photo: Matthew Shepherd (2), Photo: Toby Alexander (3), Photo: Eric Mader (4), Photo: Kirk Henderson (5)

General Design Considerations

Design Considerations 1.

Early Successional Habitat: Bees are not forest insects

Photo: Eric Mader

General Design Considerations

Design Considerations 2.
 Connectivity: Hedgerows, roadsides, riparian plantings can connect fragment habitats



Photo: Matthew Shepherd

General Design Considerations

Design Considerations 3.
 Distance to crops: Small bees may fly less than 500 ft., bumble bees up to 1 mile



Photo: Toby Alexander (VT NRCS)

General Design Considerations

Design Considerations 4.
 • Bloom Time Succession: Include at least 3 species in bloom for each season (spring, summer, and fall)



Photo: Eric Mader

General Design Considerations

Design Considerations 5.
 Floral Abundance: Aim for at least 45% forbs or flowering shrubs



Photo: Kirk Henderson (IA, RVM)

Secondary Design Considerations

Additional Design Considerations for Optimal Effect

1. Floral Diversity
2. Native Plants
3. Floral Clusters
4. Nest Sites

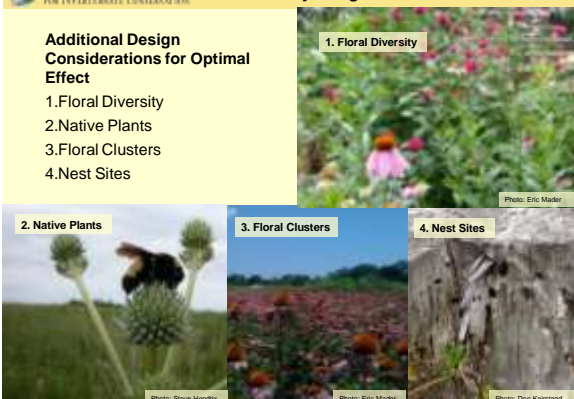


Photo: Eric Mader
Photo: Steve Hendrix
Photo: Eric Mader
Photo: Don Keirstead

Secondary Design Considerations

Additional Design Considerations 1.
 Floral Diversity: Bee diversity maximized when 15 to 25 flower species are present.



Photo: Eric Mader

Secondary Design Considerations

Additional Design Considerations 2.
 Native Plants: Locally native plants support more abundant and species-rich bee communities.



Photo: Steve Hendrix

Secondary Design Considerations

Additional Design Considerations 3.
 Floral Clusters: For small areas of habitat, clump single species together for best results (increases visibility to pollinators, increases foraging efficiency).



Photos: Toby Alexander, Eric Mader

Secondary Design Considerations

Additional Design Considerations 4.
 Nest Sites: Warm-season bunch grasses, Stumps and snags, brush piles, naturally occurring bare ground, artificial nest blocks

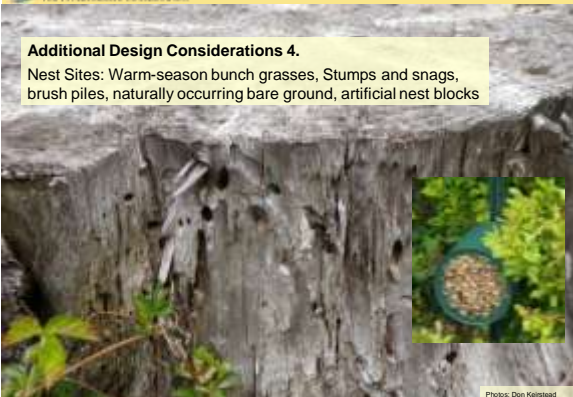


Photo: Don Kelmwald

Plant Selection: How Do You Know?

But...what to plant!?
 (Acres of *Rudbeckia* and not a bee in site!?)



Photo: Eric Mader

Plant Selection Criteria

- Use only plants with documented value to pollinators (trust your informational source!)
- Avoid species with weed-potential (ex: goldenrod near cranberries)
- No alternate pest/disease host plants (ex: rosaceous plants near tree fruit)




Photo: Mace Vaughan

Plant Selection: Best Bets for North Carolina

Native wildflowers:

- Baptisia
- Spiderwort
- Penstemon
- Milkweed
- Blue lobelia
- Partridge Pea
- Hyssop
- Beebalm
- Joe Pye Weed
- Mountain Mint
- Boneset
- Blazingstar
- Sneezeweed
- Goldenrod
- Asters





Photo: Eric Mader

THE XEROPHYTE SOCIETY FOR INVERTEBRATE CONSERVATION

Native Milkweeds (*Asclepias* spp.)

- High quality nectar source for pollinators
- Obligate host plants for monarch caterpillars
- Top species for attracting beneficial insects (lady beetles, parasitic wasps, pirate bugs, syrphid flies) in western US vineyards

James, D.G. 2010. Attraction of beneficial insects to flowering endemic perennial plants in the Yakima Valley. Integrated Agriculture Research and Extension Center, Washington State University. Unpublished raw data.



Photos: Rod Gilbert & Eric Estrada

THE XEROPHYTE SOCIETY FOR INVERTEBRATE CONSERVATION

Plant Selection: Best Bets for North Carolina

Non-native bee plants

- Red clover (esp. mammoth red)
- White clover (esp. Ladino)
- Alfalfa
- Buckwheat
- Basil
- Borage
- Hairy vetch
- Catmint
- Cosmos
- Annual sunflower
- Oregano
- Russian sage
- Siberian squill

Photos: Mace Vaughan, Eric Mosler

THE XEROPHYTE SOCIETY FOR INVERTEBRATE CONSERVATION

Plant Selection: Best Bets for North Carolina

Woody plants:

- Buttonbush
- Pussy willow
- Plum
- Apple
- Redbud
- Hawthorn
- Blueberry
- Basswood
- Raspberry
- Wild rose
- New Jersey Tea




Photo: Mace Vaughan

THE XEROPHYTE SOCIETY FOR INVERTEBRATE CONSERVATION

Establishing New Habitat: Keys to Success

The 6 Critical Elements of Establishing New Habitat:

1. Remove **ALL** perennial weeds prior to planting
2. Do not disturb dormant weed seed
3. Make a clean seed bed/planting area
4. Use appropriate planting technology for the site
5. Plant perennial seed in the fall
6. Manage annual and biennial weeds for two years after planting



Photo: Paul Jepson, OSU IPHC

THE XEROPHYTE SOCIETY FOR INVERTEBRATE CONSERVATION

Remove ALL Perennial Weeds Prior to Planting

For Conventional Farms:

- Close mow of planting site followed by Glyphosate treatments (4 to 8 week intervals) for a full growing season
- Round-up ready soybeans




Photo: Matthew Shepherd

THE XEROPHYTE SOCIETY FOR INVERTEBRATE CONSERVATION

Remove ALL Perennial Weeds Prior to Planting

For Organic Farms:

- Repeat shallow cultivation (4 to 6 week intervals), or shallow cultivation followed by a smother crop (at least 1 year on previously cropped land)
 - Buckwheat
 - Sudan grass
- Solarization (clear plastic): At least 1 year on previously cropped land
- Horticultural vinegar (expensive)



Photo: Matthew Shepherd

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Create a Clean Seed Bed**

Seed Bed Preparation:

- Burn or rake off debris, or very light disk or harrow to smooth surface
- Do not to bring more weed seeds to the surface!

Not ready for planting!

Ready for planting!

Photos: Don Keirstead

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Appropriate Planting Technology**

Native Seed Drills:

- Multiple seed sizes
- Plant directly in stubble (no till)
- Tye, Truax, Great Plains (common manufacturers)

Brillion Drop Seeders:

- Made for sowing turf and pasture grasses, also alfalfa and clover
- Works with native seed (change seed box agitators)
- Requires smooth, cultivated seed bed (not like this photo!)

Photos: Jessa Guisse

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Appropriate Planting Technology**

Hand Seeding, Seed Broadcasters and Walk Behind Lawn Seeders:

- Small areas
- Mix seed with sand for even distribution
- Requires clean, exposed seed bed
- Seed broadcasters for ATVs, tractors, trucks

Photos: Jessa Guisse, Don Keirstead

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Appropriate Planting Technology**

Transplants:

- Supplemental irrigation
- Animal guards
- Mechanical transplanters
 - Tree planters
 - Vegetable transplanters

Photos: Mace Vaughan, Matthew Shepherd

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Establishing New Habitat: Planting**

Post Seeding:

- Roll with cultipacker, lawn roller
- Mow perennial seeded areas first and second year, before annual and biennial weeds produce seed
- Grass-selective herbicides

Post Transplanting:

- Irrigate as necessary for first two years

Photos: Mace Vaughan, Jessa Guisse

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **The Finished Product!**

The Finished Product!

Photo: Jessa Guisse

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION Case Study: Native Plant Field Border

Oregon Cherry Orchard (Columbia Gorge)

Photos: Mike Oring, Marc Vaughan (Xerces Society)

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION Case Study: California Rangeland Planting

California Cattle Ranch

April 2010

May 2010

August 2011

Photos: Claudia Street (Glenn County RCD)

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION Case Study: Native Plant Field Border

New Hampshire Blueberry Farm

Pre-Planting: 2009

Post-Planting: 2011

Photos: Don Karentz

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION Case Study: Native Plant Hedgerow

California Central Valley Farm

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION Case Study: Endangered Butterflies

Wisconsin State Acres for Wildlife Enhancement CRP Program (Karner blue butterfly)

Fall 2008

Summer 2010

Photos: Eric Mader (Xerces Society)

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION Case Study: Native Plant Field Border

Oregon Pear and Hay Farm (Medford Area)

Pre-Planting: Fall 2010

Post-Planting: Summer 2011

Photos: Eric Mader (Xerces Society)

Case Study: Native Plant Field Border

Massachusetts Cranberry Farm

Post-Planting: Summer 2011

Hydroseeding Native Wildflowers: Fall 2010

Photos: Plymouth County NRCS

Case Study: Native Shrub Hedgerow

California Central Valley Farm

June 2007 (Looking East)

November 2010 (Looking West)

Developing New Nest Habitat: Ground Nests

A lack of nest sites is a constraint on bee populations in many areas.

Photo: Bob Hammond, CQ Coop Ext

Developing New Nest Habitat: Ground Nests

Ground-nesting bees need:

- Access to bare, sandy soil
- Areas without tillage, mulch, or landscape fabric

Photo: Matthew Shepherd

Recognize Habitat: Ground-Nesting Bees

Sabin Elementary School: Portland, Oregon

Photos: Mace Vaughan (Xerces Society)

Developing New Nest Habitat: Bumble Bees

Bumble bees build nests in:

- Cavities such as old rodent holes
- Overgrown areas
- Under brush piles
- Under bunch grasses
- Artificial nests are ineffective

Conserve un-mowed areas

Photos: Mace Vaughan, Matthew Shepherd, Bonnie Cantharis

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Recognize Habitat: Wood-Nesting Bees**

Wood-nesting bees use:

- Snags, stumps, and brush piles
- Hollow or pithy plant stems (e.g. cane fruit)
- Artificial nests?

Photos: Eric Mader, Katharina Ullman

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Developing New Nest Habitat: Tunnel Nests**

Photos: Eric Mader, Jeff Adams, Matthew Shephard, Mace Vaughan

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Developing New Nest Habitat: Tunnel Nests**

Retain or create tunnels:

- Place in bright, indirect sunlight
- Bees benefit from large landmarks
- Irregular length and diameter tunnels are best
- Irregular surfaces

Photos: Eric Mader, Mace Vaughan, Katharina Ullman

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Long-Term Tunnel Nest Management**

Sanitation is CRITICAL:

- Parasites (wasps, mites)
- Diseases (chalkbrood)
- Woodpeckers
- Phase out nests EVERY TWO OR THREE YEARS
- Place old nests in an emergence container

Photos: Eric Mader, Pavel Klimov

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Managing Habitat: Considerations**

Adapt practices to avoid causing undue harm.

- Special species
- Tree encroachment
- Herbicides
- Fire
- Grazing

Photo: Whitney Cranshaw (Colorado State University)

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION **Managing Habitat: Specialist Species**

Butterflies need:

- Caterpillar hostplants
- Safe place to pupate
- Overwintering sites
- Mineral salts/puddles

Photo: Dana Ross

Managing Habitat: Tree Encroachment

At sites where trees or shrubs are encroaching, they should be removed as soon as possible, before they grow larger and reproduce.



Photo: Toby Alexander

Managing Habitat: Herbicides

When applied with care, herbicides can be a useful habitat management tool. However, they can also dramatically change plant communities and decrease the usability of habitat for pollinators.



Photo: USDA-NRCS

Managing Habitat: Fire or Mowing

Burning or mowing of prairies and meadows with populations of pollinator insects could extirpate the pollinators if not done carefully.



Photo: USDA-NRCS/Jeff Stranga

Managing Habitat: Grazing

Studies show that the abundance of pollinators is in direct proportion to intensity of grazing by cattle, sheep or goats. Very carefully timed grazing with cattle can reduce grass competition, but wait even a day too long and the wildflowers are eaten.



Photo: Debra Jappan

Long-Term Habitat Management: Limit Disturbance

Mowing, grazing, burning are best at infrequent intervals

- Disturbance to no more than 1/3 of habitat area each year
- Time management for when most effective against target, or during dormant season
- Early successional habitat is ideal; too much disturbance favors grasses over forbs




Photo: USDA-ARS, Auburn, California

Module 5: USDA Conservation Programs



Photo: USDA-ARS

Background of 2008 Farm Bill

THE XERES SOCIETY FOR INVERTEBRATE CONSERVATION

- **December 2006:** National Academy of Sciences Report
- **December 2006:** First cases of CCD discovered
- **Spring 2007:** Initial pollinator conservation legislation introduced




Photo: Edward S. Ross

2008 Farm Bill: Pollinator Habitat Provisions

THE XERES SOCIETY FOR INVERTEBRATE CONSERVATION

- Makes pollinators a priority for every USDA land manager and conservationist
- Identifies pollinator habitat as a priority for EQIP
- Requires that pollinators are considered in the review of Practice Standards
- Encourages the inclusion of pollinators in all USDA conservation programs



Photo: Mace Vaughan (Xerxes Society)

Farm Bill Implementation: Practices for Pollinators

THE XERES SOCIETY FOR INVERTEBRATE CONSERVATION

Core Programs
EQIP, WHIP, CSP

Tech Note 78
Using Farm Bill Programs for Pollinator Conservation

Practices for Pollinators

- Tree/Shrub Establishment
- Conservation Cover
- Hedgerow Planting
- Field Border
- Restoration and Management of Rare or Declining Habitats
- Range Planting
- Upland Wildlife Habitat Management
- Pest Management
- Early Successional Habitat Development/ Management



Farm Bill Implementation

THE XERES SOCIETY FOR INVERTEBRATE CONSERVATION

Example of Wisconsin Environmental Quality Incentives Program:

- Incentive payment for installed conservation practices:
- Field Border (Pollinator Seed Mix: \$350/acre)
- Tree/Shrub Establishment (Pollinator Shrubs: \$425/acre)

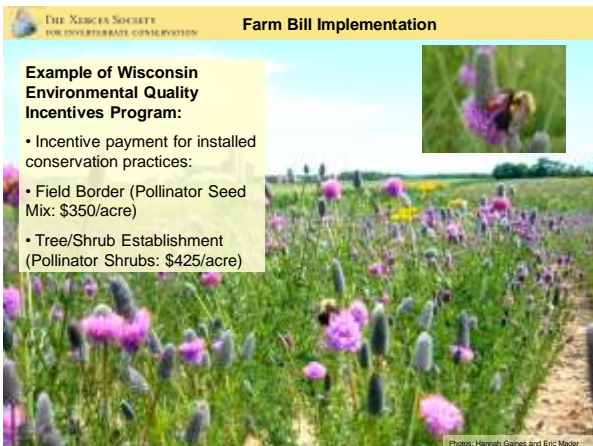


Photo: Heatham Garner and Eric Mader

Incentive Programs Available to Support Growers

THE XERES SOCIETY FOR INVERTEBRATE CONSERVATION

USDA POLLINATOR HABITAT PLANTING Michigan CRP - SAFE CP-3EE Pollinator
Natural Resources Conservation Service, July 2008

Example of CRP-SAFE: Michigan Case Study

- Targets western fruit growing region
- Bee-friendly wildflowers
- 2,500 acre enrollment
- Annual rental payments
- Sign-up incentive payment
- 90% establishment assistance
- 2 acre minimum per farm
- Maintenance agreement

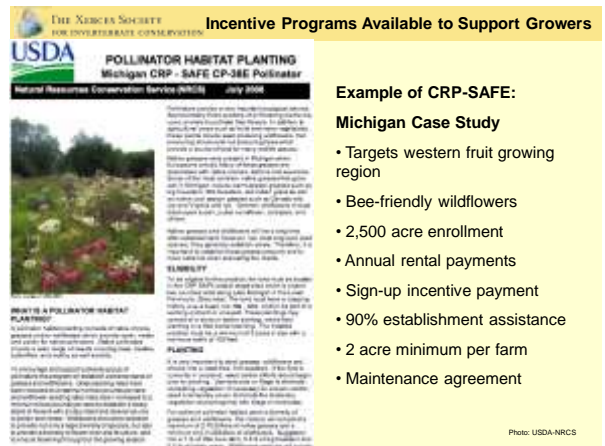


Photo: USDA-NRCS

Field Border Practice Standard (386): Can include a diverse mix of native and low cost non-native plants



Photo: Eric Mader

Hedgerows Practice Standard (422):

- Plant a succession of flowering shrubs
- Design for multiple benefits



Photo: Katharine Ultrann (Xerces Society)

Filter Strip Practice Standard (393): Use pollinator plants to control run-off, over septic drain fields, in ditches



Photo: Moad Vaughan, Xerces Society

Cover Crop Practice Standard (340): Can include diverse flowering forbs such as clover, mustard, buckwheat, phacelia, oilseed radish



Photo: NRCS/Toby Alexander

Conservation Cover Practice Standard (327):

- Permanent vegetation on highly erodible sites



Photo: Eric Mader (Xerces Society)

Pest Management Practice Standard (595):

- Protecting pollinators from pesticides
- Establishing habitat for other beneficial insects



Photos: David Biddinger (Penn State University), Moad Vaughan (Xerces Society), and Steve Fog

THE XEROPHYTE SOCIETY FOR INVERTEBRATE CONSERVATION

Farm Bill Implementation: CRP

Current CRP Pollinator Initiative

- 10% of acreage in parcels of pollinator-friendly shrubs, forbs, legumes, or
- At least 1 acre for CRP acreage less than 10 acres
- Pollinator parcels must be at least 20 feet wide
- Parcels must have a minimum of species with at least 3 blooming species for each growing season
- No more than 25% grasses in pollinator parcels





Photo: Eric Mader

THE XEROPHYTE SOCIETY FOR INVERTEBRATE CONSERVATION

NRCS Farm Planning Example 1.

Diversified Organic Farm

- 24 Acres
- Fruits and vegetables
- Conventional farm neighbors
- Potential resources concerns
 - Pollinators
 - Pest management
 - Protection from neighbor's pesticides
 - Weed control in fallow ground



THE XEROPHYTE SOCIETY FOR INVERTEBRATE CONSERVATION

NRCS Farm Planning Example 1.

Proposed Practices

Field Border (386)

- Diverse native forb plantings

Hedgerow (422)

- Diverse flowering native shrubs

Cover Crop (340)

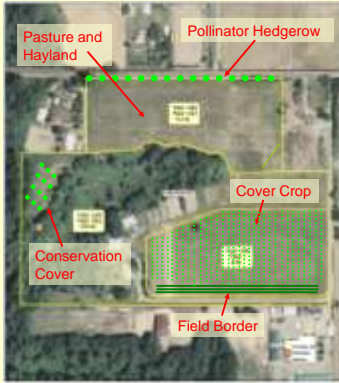
- Phacelia tanacetifolia, crimson clover, buckwheat

Pasture and Hayland (512)

- Grazing plan to encourage forb diversity and abundance

Conservation Cover (327)

- Mixture of low cost native and non-native forbs




THE XEROPHYTE SOCIETY FOR INVERTEBRATE CONSERVATION

NRCS Farm Planning Example 2.

Mixed Berry Farm

- Blueberries
- Blackberries
- Various annual crops in surrounding fields
- Potential resources concerns
 - Lack of pollinator habitat
 - Drift, dust, noise from adjacent fields?



THE XEROPHYTE SOCIETY FOR INVERTEBRATE CONSERVATION

NRCS Farm Planning Example 2.

Proposed Practices

Hedgerow (422)


- Outer evergreen hedgerow to reduce chemical drift from neighbors
- Inner native shrub hedgerow selected to compliment crop bloom time and avoid pest host plants

Conservation Cover (327)

- Steep ditches on South and West sides inter-seed with low-cost pollinator plants

Pest Management 595

- Establish IPM program to reduce pollinator mortality from pesticides





Further Information: USDA-NRCS

USDA-Natural Resources Conservation Service

- State and regional Technical Notes
- *Farming for Pollinators* brochure
- Agroforestry Notes
- PLANTS Database
- NRCS Plant Material Centers

Further Information: the Xerces Society

- Xerces Society publications
- www.xerces.org

Further Information: Publications

Published in February 2011

"*Attracting Native Pollinators* belongs on the bookshelf of everyone who values the future of the natural world."

- Douglas W. Tallamy, researcher and author of *Bringing Nature Home*

"Precise, elegant and thoughtful, the recommendations offered by the Xerces Society will become essential to advancing a healthy and diverse food production system."

- Gary Nabhan, author of *The Forgotten Pollinators* and *Renewing America's Food Traditions*

www.xerces.org/store

Further Information: NCAT/ATTRA

National Sustainable Agriculture Information Service (formerly ATTRA) of the National Center for Appropriate Technology

- Alternative pollinator online publication
- New edition March 2010

<http://attra.ncat.org/attra-pub/nativebee.html>

Further Information: USDA-SARE

Sustainable Agriculture Research and Extension

New Managing Alternative Pollinators Handbook

- Bumble bee, mason bee, and leafcutter bee management methods
- Native bee conservation
- Now available!

www.sare.org or www.xerces.org/store

Further Information: Resource Center

Pollinator Conservation Resource Center

Region-specific Information from Xerces, Cooperative Extension, USDA-NRCS, NGO, and other sources, including:

- Regional plant lists
- National plant lists
- Conservation guides
- Nest construction guides
- Links to identification guides
- Pesticide guidelines
- Native plant nursery directory

www.xerces.org/pollinator-resource-center



Xerces Society Resources

Conservation Seed Store

www.xerces.org/pollinator-seed

Additional Native Seed Mixes Coming Soon!



What's Old is What's New?

WILD BEES ARE GOOD POLLINATORS

Years ago wild bees did most of the pollinating. But intensive cropping, clearing up of fence rows, and uncontrolled burning have destroyed their homes and greatly reduced their number. Wild bees are the most efficient pollinators, especially for alfalfa.

You can increase the number of wild bees on your farm by protecting the following kinds of land from grazing and burning:

Drainage ditch banks	Pool areas
Fence rows	Shelterbelts and windbreaks
Field borders	Strawstacks
Odd areas	Wood lots



UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service, Upper Mississippi Region, Milwaukee, Wis.

PA-126 Issued June 1959

What's Old is What's New?

In 1938, Dr. Patch predicted that by the year 2000

...the President of the United States would issue a proclamation claiming that land areas at regular intervals throughout the U.S. would be maintained as "Insect Gardens," under the direction of government entomologists. These would be planted with milkweed, hawthorn, and other plants that could sustain populations of butterflies and bees. She predicted that some time in the future, "Entomologists will be as much or more concerned with the conservation and preservation of beneficial insect life as they are now with the destruction of injurious insects."



**Dr. Edith Patch (1916)
President, Entomological Society of America**

Photo: The Friends of Edith Patch (www.edithpatch.org)

Take Home Message

Remember:

Plant flowers...

...as native as possible.

Reduce pesticide use.

www.xerces.org



Photo: Mace Vaughan

Special Thank You!

- Southern SARE!
- USDA-NRCS-ENTSC!
- North Carolina NRCS!
- Short Course Participants!








Photo: Mace Vaughan

Thanks

Many excellent scientists,
conservationists, and farmers

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- Dudley Foundation
- Bullitt Foundation
- Disney Wildlife Conservation Fund
- Richard and Rhoda Goldman Foundation
- Panta Rhea Foundation
- Gaia Fund
- Bill Healy Foundation
- Bradshaw-Knight Foundation
- Wildwood Foundation
- Organic Valley



Photo: Mace Vaughan