Conservation Biological Control

Habitat Management to Encourage Beneficial Insects and Control Pests

Eric Lee-Mäder, Pollinator Conservation Program Co-Director
The Xerces Society for Invertebrate Conservation

Photo: Debbie Roos

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
- Pesticides (policy and regulation)
- Pollinator conservation
- Reduced-risk pest management

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

What is the Xerces Society?

The Xerces Society Agricultural Biodiversity Program

- Research partnerships on pollinators and beneficial insects
- Habitat restoration on farms

Staff Biologists

- Located in CA, OR, TX, MN, NE, NJ, NC
- Xerces / NRCS partner biologists

Staff Backgrounds

- Farming, wildlife conservation, pest management, beekeeping, native seed production

Photo: Eric Mader

The Conservation Biocontrol Concept

Photo: Jennifer Hopwood

The Conservation Biocontrol Concept

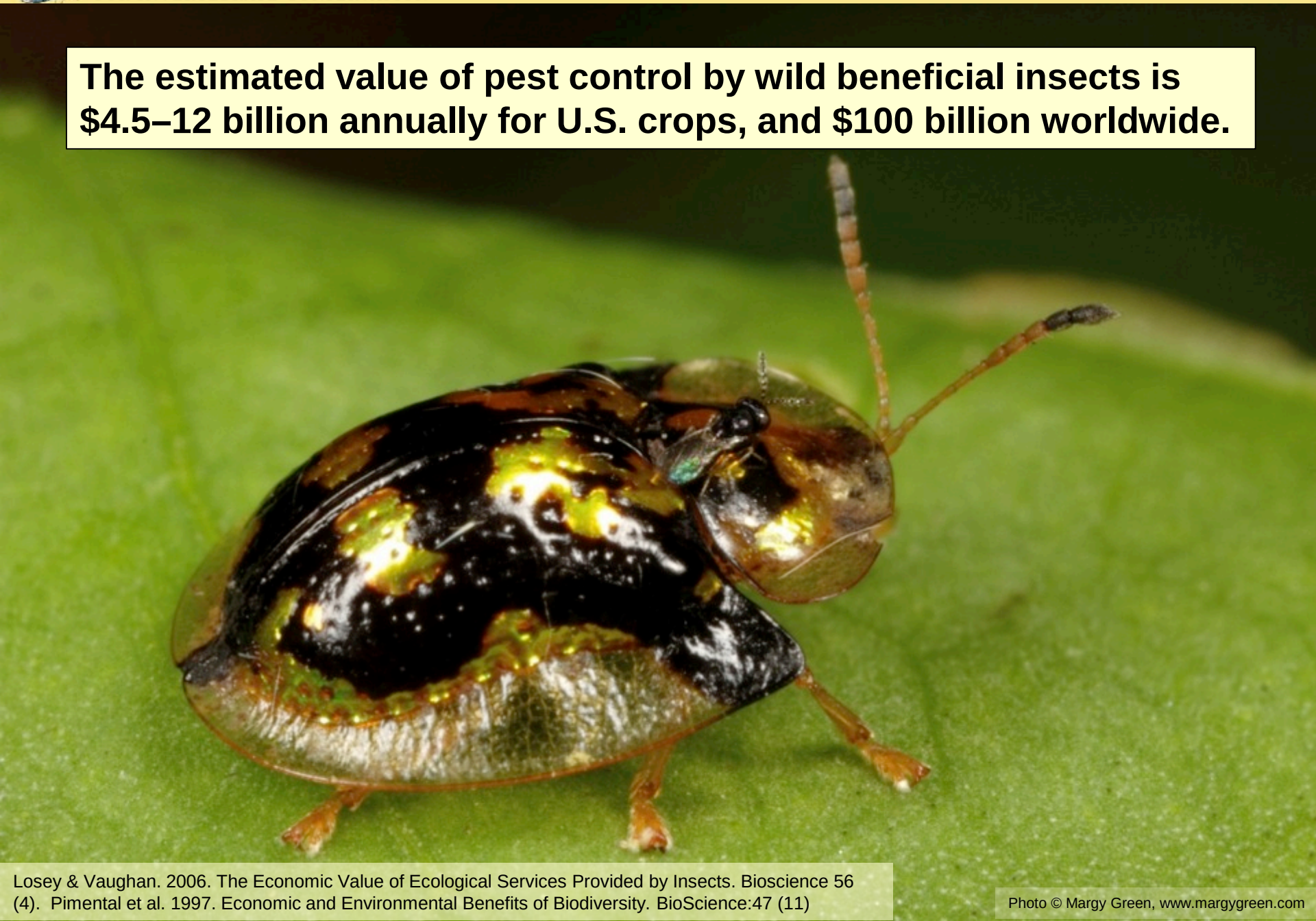
"The greatest single factor in preventing insects from overwhelming the rest of the world is the internecine warfare which they carry out among themselves" **- Dr. Robert Metcalf.**

Assassin bug eating stink bug on raspberry

Photo: Nancy Adamson

The Conservation Biocontrol Concept

The estimated value of pest control by wild beneficial insects is $4.5–12 billion annually for U.S. crops, and $100 billion worldwide.



Losey & Vaughan. 2006. The Economic Value of Ecological Services Provided by Insects. Bioscience 56 (4). Pimental et al. 1997. Economic and Environmental Benefits of Biodiversity. BioScience:47 (11)

The Conservation Biocontrol Concept

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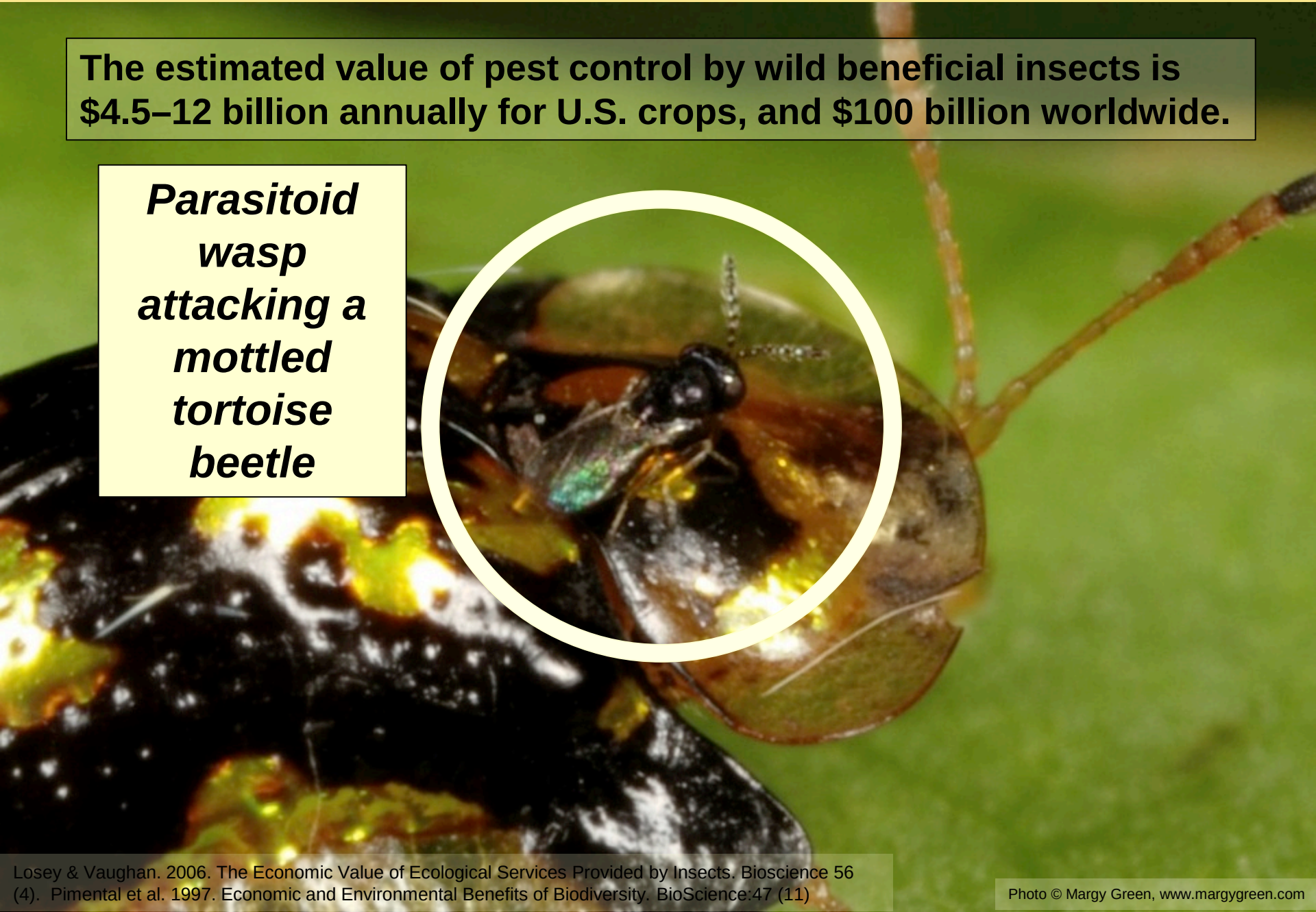
Parasitoid wasp attacking a mottled tortoise beetle



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The Conservation Biocontrol Concept

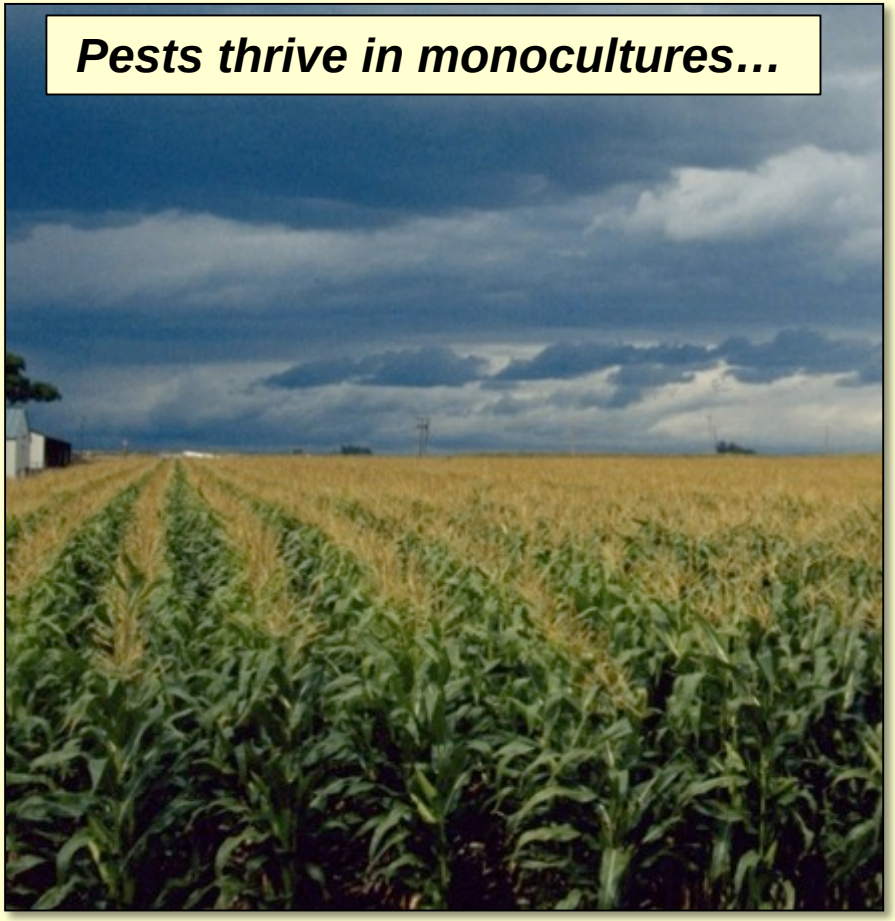
The Conservation Biocontrol Concept

The amount of natural habitat on a farm directly influences beneficial insect abundance.

Photo: Eric Mader

Habitat is the Key Ingredient

Bianchi et al 2011: Landscape complexity enhances natural beneficial insect populations in 74% of cases



Bianchi, F. J. J. A., C. J. H. Booij, and T. Tscharntke. 2011. Sustainable pest regulation in agricultural landscapes: a review on landscape composition, biodiversity and natural pest control. *Proc. R. Soc. B* 273: 1715-1727.

Photos: Matthew Roth and Lynn

The Conservation Biocontrol Concept

The Value of Habitat for Pest Control

Research demonstrates that if more than 20% of a farm is diverse habitat, pest control by beneficial insects is observed throughout fields

Assassin bug eating stink bug pest

Syrphid fly

(Tscharntke e al. 2002).

Photos: Mace Vaughan, Nancy Adamson

The Conservation Biocontrol Concept

Natural Habitat Provides:

Alternate food sources (pollen & nectar; alternate prey)

Shelter (over-wintering and egg-laying)

Photos: Paula Kleintjes-Neff

The Conservation Biocontrol Concept

Habitat: Alternate Food

- Many insects eat pollen or nectar when prey are not available
- Some switch diets depending on their life stage.

Photos: Mace Vaughan, Alex Wild, Ed Ross

The Conservation Biocontrol Concept

Habitat: Alternate Food

- Habitat can harbor alternate prey when crop pests are absent

Lady beetle larvae on milkweed

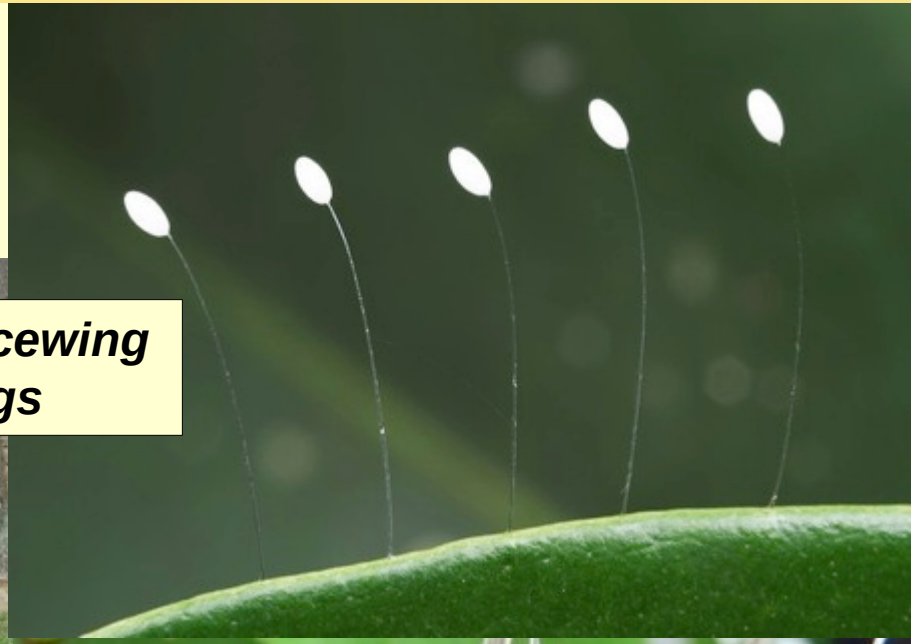
Eating oleander aphids (not a crop pest)

Photos: Alex Wild

The Conservation Biocontrol Concept

Habitat: Shelter

- Over-wintering & egg-laying



Lacewing eggs

Nesting Isodontia wasp (grasshopper hunter)

Photos: insecte.org; Alex

Common Beneficial Insect Groups

Photo: Elise Fog

Common Beneficial Insect Groups

Insect Predators: Ground beetles, lady beetles, assassin bugs, syrphid flies, lacewings, etc.

Insect Parasitoids: Solitary wasps, tachinid flies

Others (non-insects): Spiders, predatory mites, parasitic nematodes

Lacewing larva eating aphids

Photo: Alex Wild

Common Beneficial Insect Groups

Most Predators are Generalists

- They may attack any smaller prey
- They reduce pest populations, even if not always below damaging levels.
- Some predaceous throughout their life; (others only as larvae)

Spined soldier bug attacking caterpillar

Common Beneficial Insect Groups

Predators: Syrphid Flies

- Adults feed on pollen and nectar
- A single larvae will eat hundreds of aphids a week

Photos: Mace Vaughan; Mario Ambrosino

Common Beneficial Insect Groups

Predators: Lady Beetles

- Individuals may consume as many as 5,000 aphids in their lifetime
- Predatory during all life stages
- Adults also feed on pollen and nectar

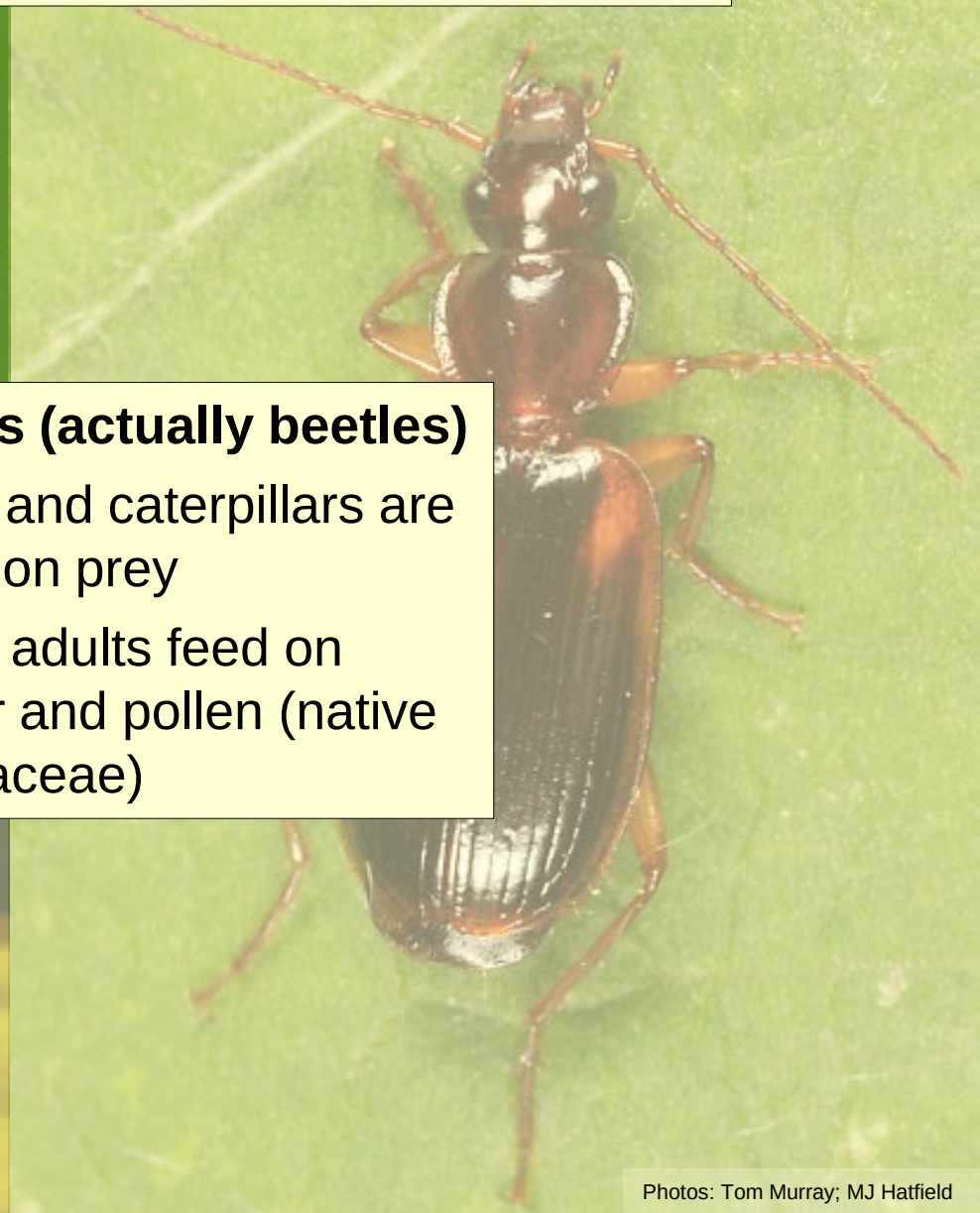
Photo: SABeebe (bugguide.net); Alex Wild

Common Beneficial Insect Groups

Predators: Ground Beetles, Soldier Beetles, Fireflies

Photos: Tom Murray; MJ Hatfield

Predators: Ground Beetles, Soldier Beetles, Fireflies

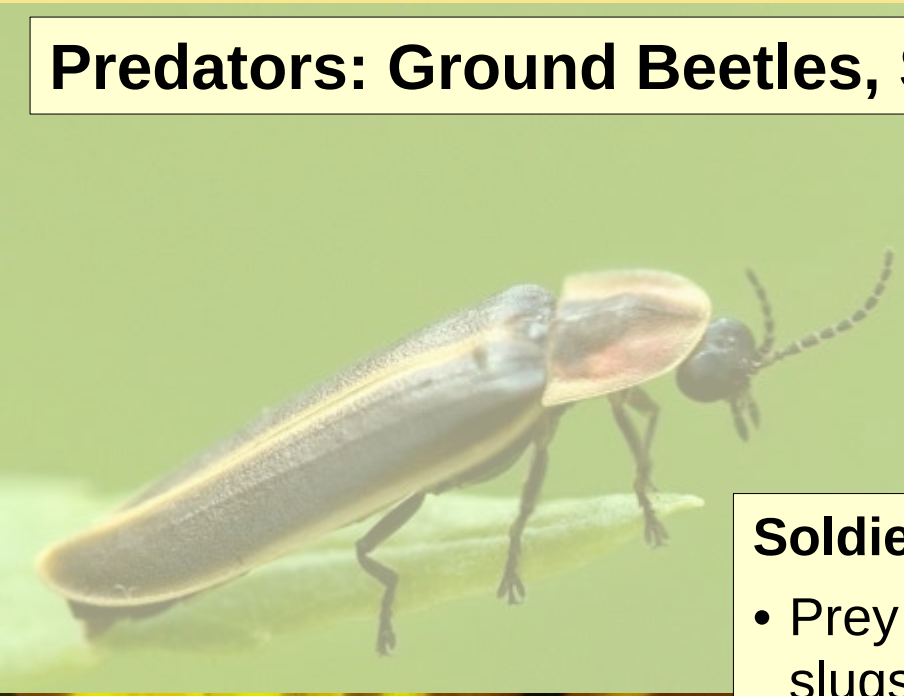


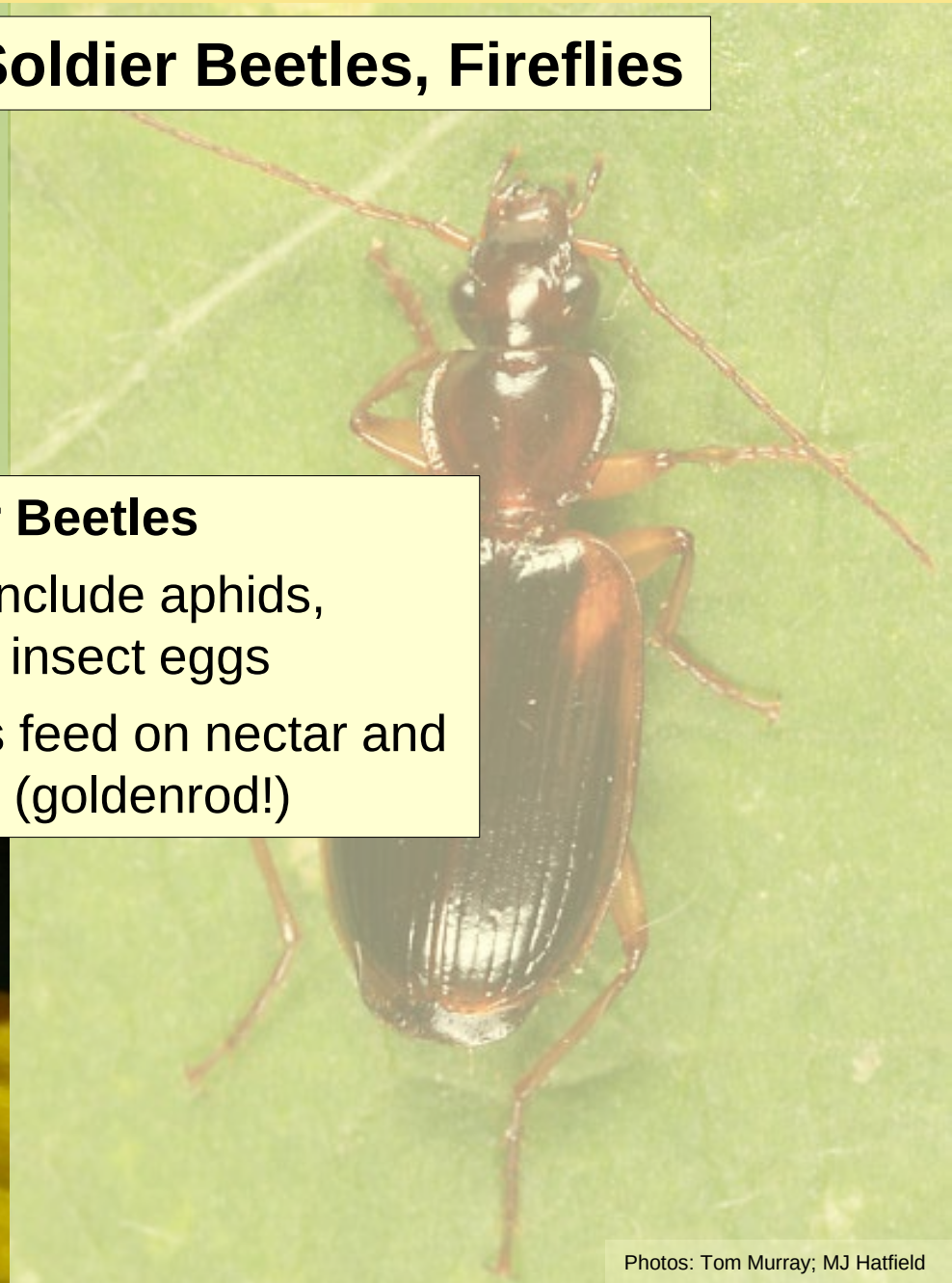
Fireflies (actually beetles)

- Slugs and caterpillars are common prey
- Some adults feed on nectar and pollen (native Asteraceae)

Photos: Tom Murray; MJ Hatfield

Predators: Ground Beetles, Soldier Beetles, Fireflies



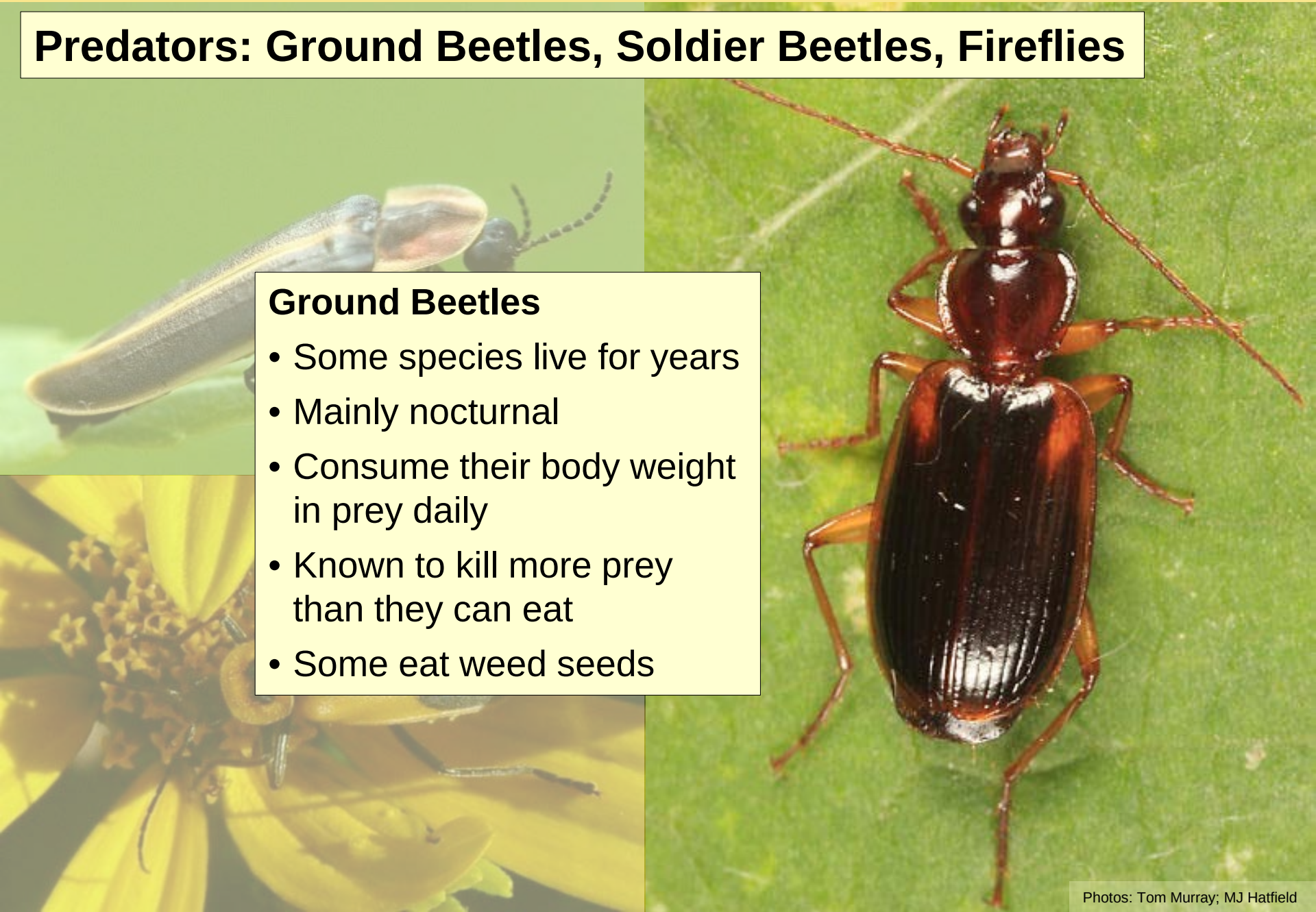


Soldier Beetles

- Prey include aphids, slugs, insect eggs
- Adults feed on nectar and pollen (goldenrod!)

Photos: Tom Murray; MJ Hatfield

Predators: Ground Beetles, Soldier Beetles, Fireflies



Ground Beetles

- Some species live for years
- Mainly nocturnal
- Consume their body weight in prey daily
- Known to kill more prey than they can eat
- Some eat weed seeds

Photos: Tom Murray; MJ Hatfield

Common Beneficial Insect Groups

Predators: True Bugs

- Assassin Bugs
- Ambush Bugs
- Wheel Bugs
- Damsel Bugs
- Minute Pirate Pugs
- Big-Eye Bugs
- Predatory Stink Bugs

Photos: Alex Wild; David James

Common Beneficial Insect Groups

Predators: True Bugs

Assassin Bugs

- Large insects (some over 1 inch in length)
- Generalist predators of caterpillars, beetles, leafhoppers, and more
- Grasping (‘raptorial’) front legs for catching prey

Photos: Alex Wild; David James

Common Beneficial Insect Groups

Predators: True Bugs

Ambush Bugs

- Generalist predators – ambush style of hunting
- May drink nectar when prey are scare
- Masters of camouflage
- Capture prey 10 times their size

Photos: Alex Wild; David James

Common Beneficial Insect Groups

Predators: True Bugs

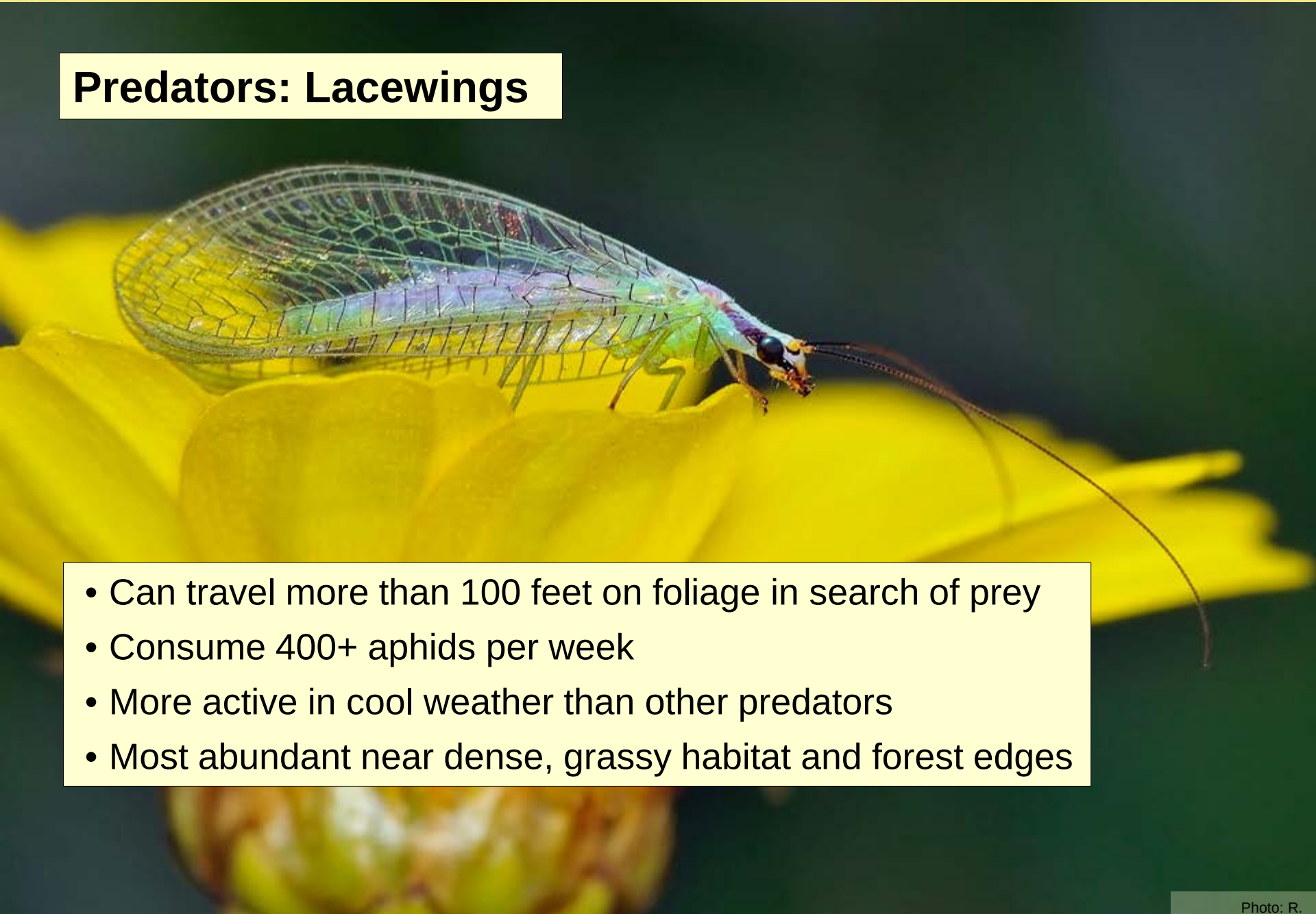
Minute Pirate Bugs

- Less than ¼ inch in length
- Prey upon thrips, mites, scale, aphids, small caterpillars
- Excellent at seeking out low density populations of prey
- Common in orchards

Photos: Alex Wild; David James

Common Beneficial Insect Groups

Predators: Lacewings



- Can travel more than 100 feet on foliage in search of prey
- Consume 400+ aphids per week
- More active in cool weather than other predators
- Most abundant near dense, grassy habitat and forest edges

Photo: R.

Common Beneficial Insect Groups

Predators: Mantids (not so beneficial)

- Mostly non-native (best not to release them)
- Not very effective for pest control; prey upon everything including hummingbirds, frogs, each other

Photo: Mace Vaughan (Xerces Society)

Common Beneficial Insect Groups

Parasitoids: Lay eggs on prey

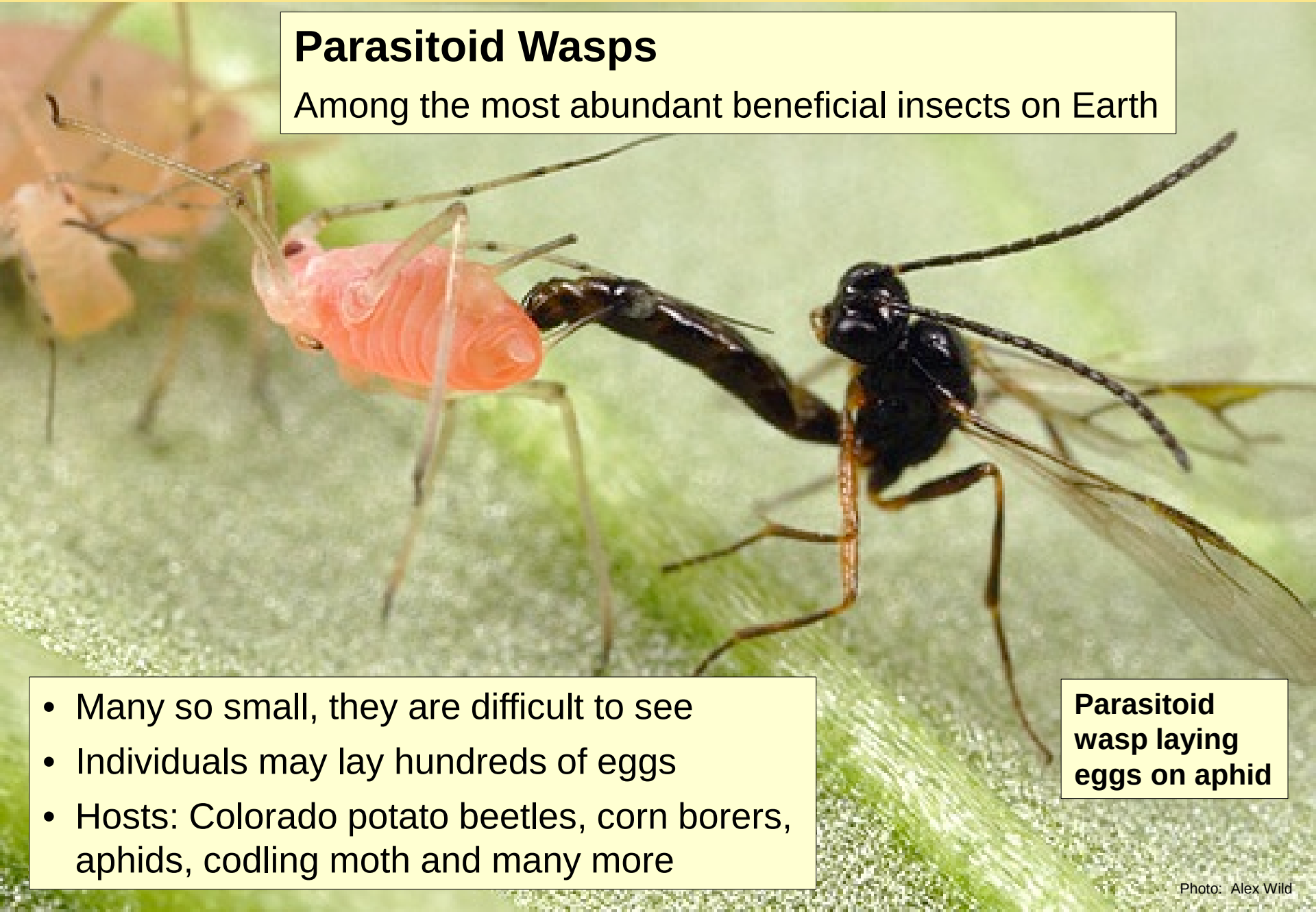
- Various wasps and flies
- Eggs laid on a specific host
- Larvae feed on host, eventually killing it (e.g. the movie, *Alien*)
- Small, but highly effective pest control

Photos: Matthew Roth and Alex Wild

Common Beneficial Insect Groups

Parasitoid Wasps

Among the most abundant beneficial insects on Earth

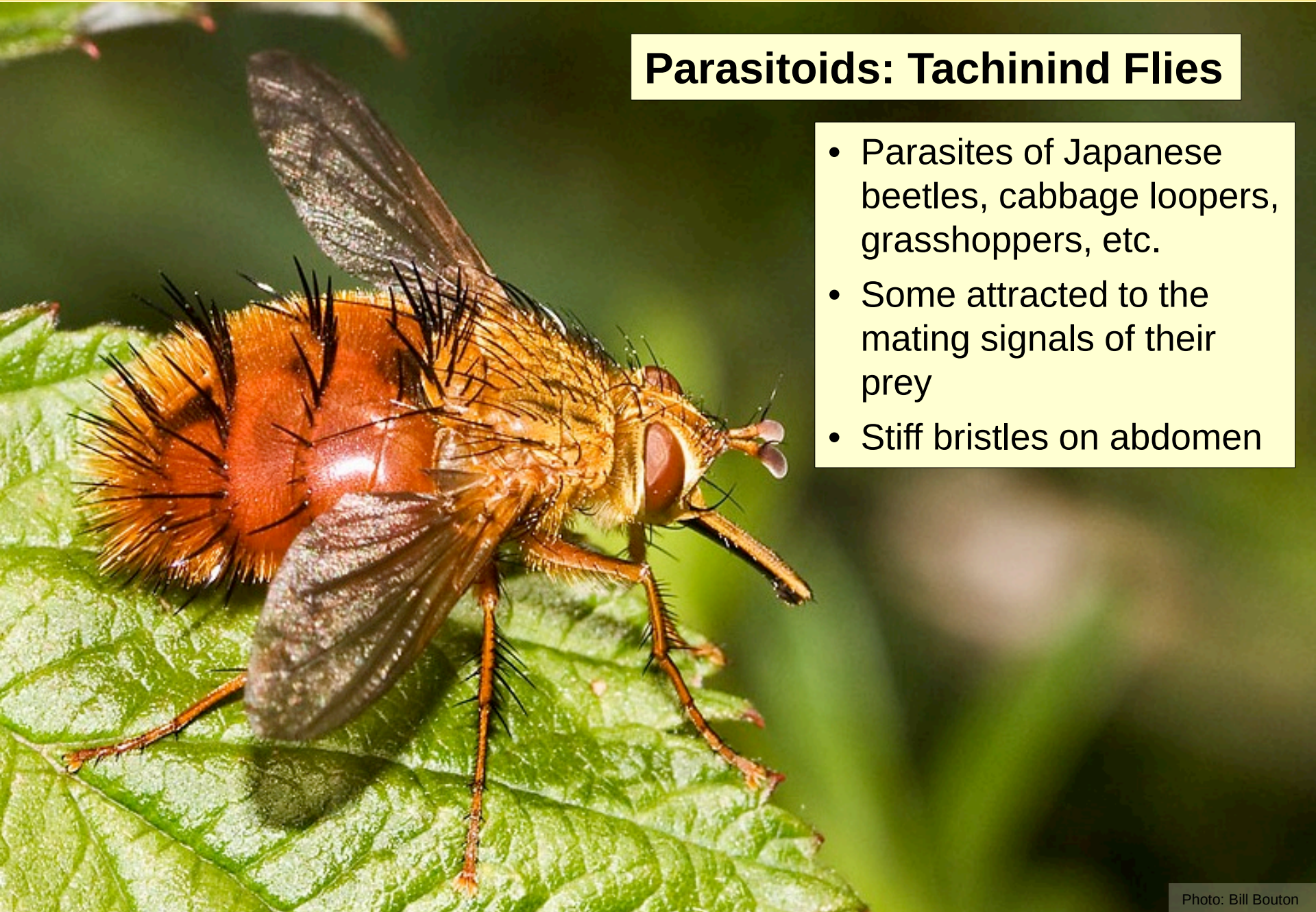


- Many so small, they are difficult to see
- Individuals may lay hundreds of eggs
- Hosts: Colorado potato beetles, corn borers, aphids, codling moth and many more

Parasitoid wasp laying eggs on aphid

Photo: Alex Wild

Common Beneficial Insect Groups



Parasitoids: Tachinind Flies

- Parasites of Japanese beetles, cabbage loopers, grasshoppers, etc.
- Some attracted to the mating signals of their prey
- Stiff bristles on abdomen

Photo: Bill Bouton

Common Beneficial Insect Groups

Non-Insect Beneficial Groups

Spiders

- Orb weavers, wolf spiders, jumping spiders

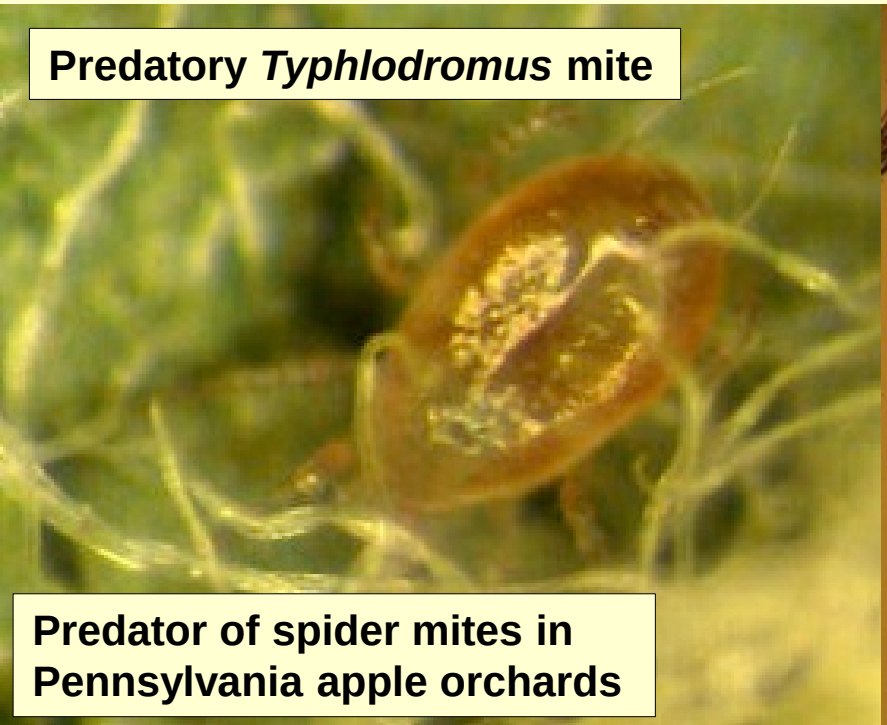
Predatory Mites

- Prey: spider mites, thrips, scale, etc.

Nematodes

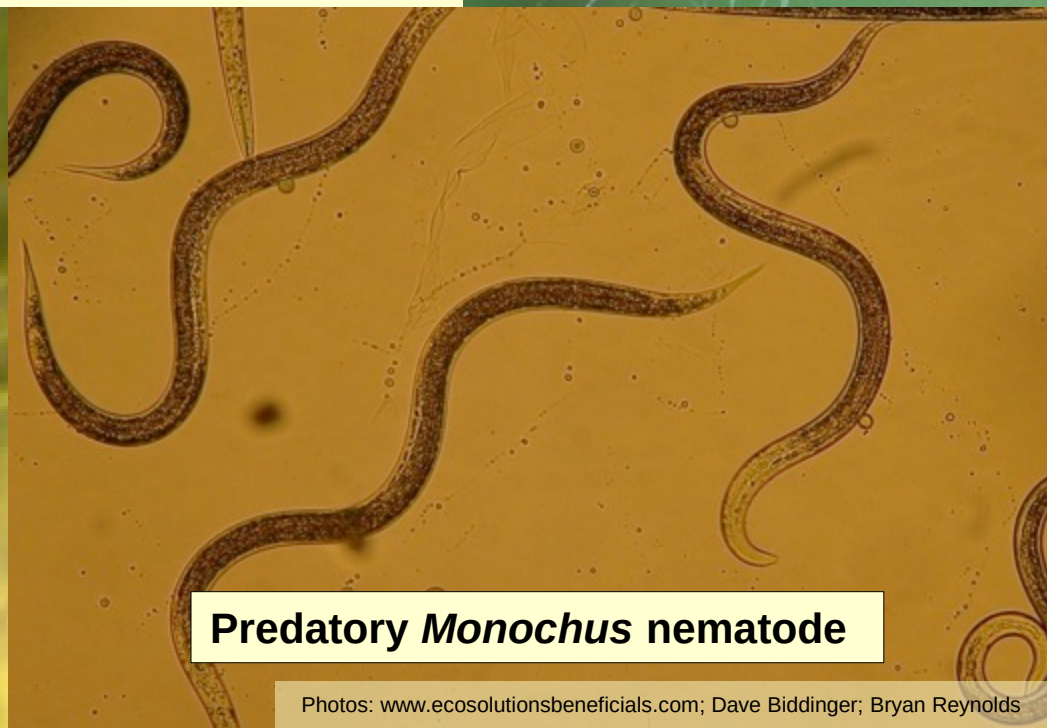
- Parasites of insects and pest nematodes

Orb weaver spider



Predatory *Typhlodromus* mite

Predator of spider mites in Pennsylvania apple orchards



Predatory *Monochus* nematode

Photos: www.ecosolutionsbeneficials.com; Dave Biddinger; Bryan Reynolds

Farm Planning for Conservation Biocontrol

Xerces habitat planting, California almond orchard

Photo: Jessa

Farm Planning for Conservation Biocontrol

Where can you add habitat to the farm?

Farm Planning for Conservation Biocontrol

Where can you add habitat to the farm?

Work from the outside in.

Farm Planning for Conservation Biocontrol

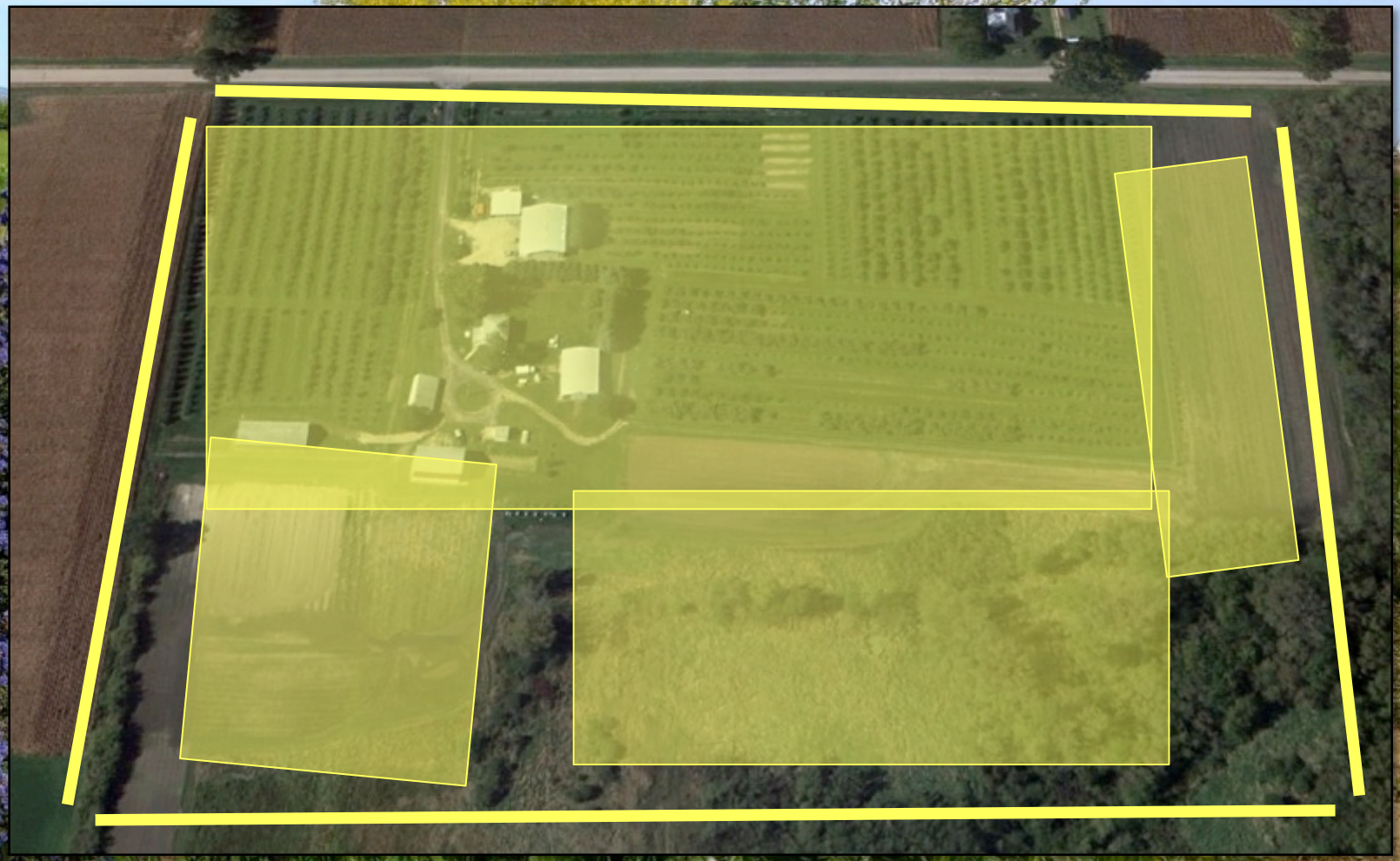
- **Hedgerows and windbreaks on the property lines**

Farm Planning for Conservation Biocontrol

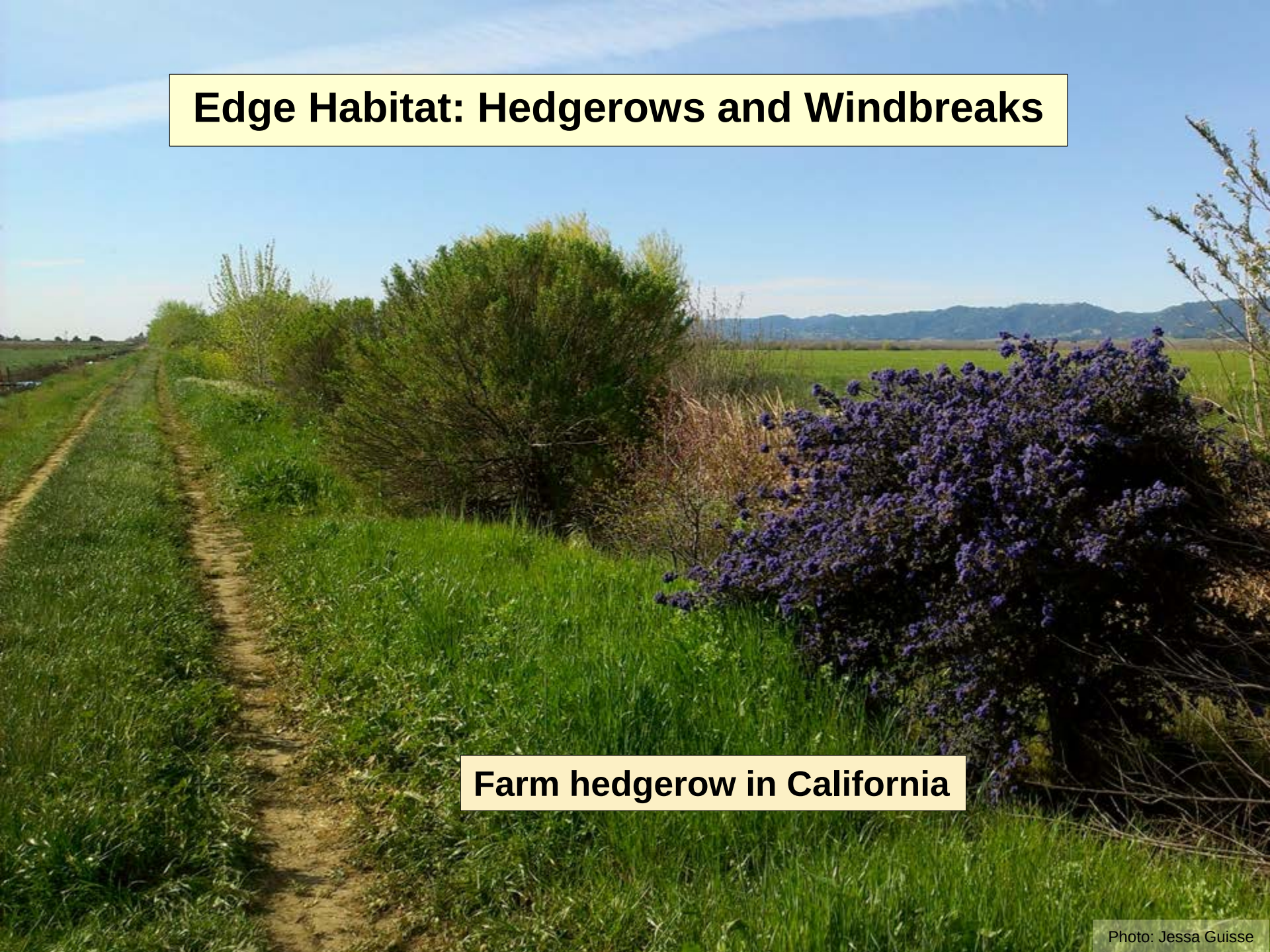
- **Hedgerows and windbreaks on the property lines**
- **Buffer areas and field borders throughout the farm**

Farm Planning for Conservation Biocontrol

- Hedgerows and windbreaks on the property lines
- Buffer areas and field borders throughout the farm
- Cover crops, orchard ground covers, and grazing plants



Edge Habitat: Hedgerows and Windbreaks



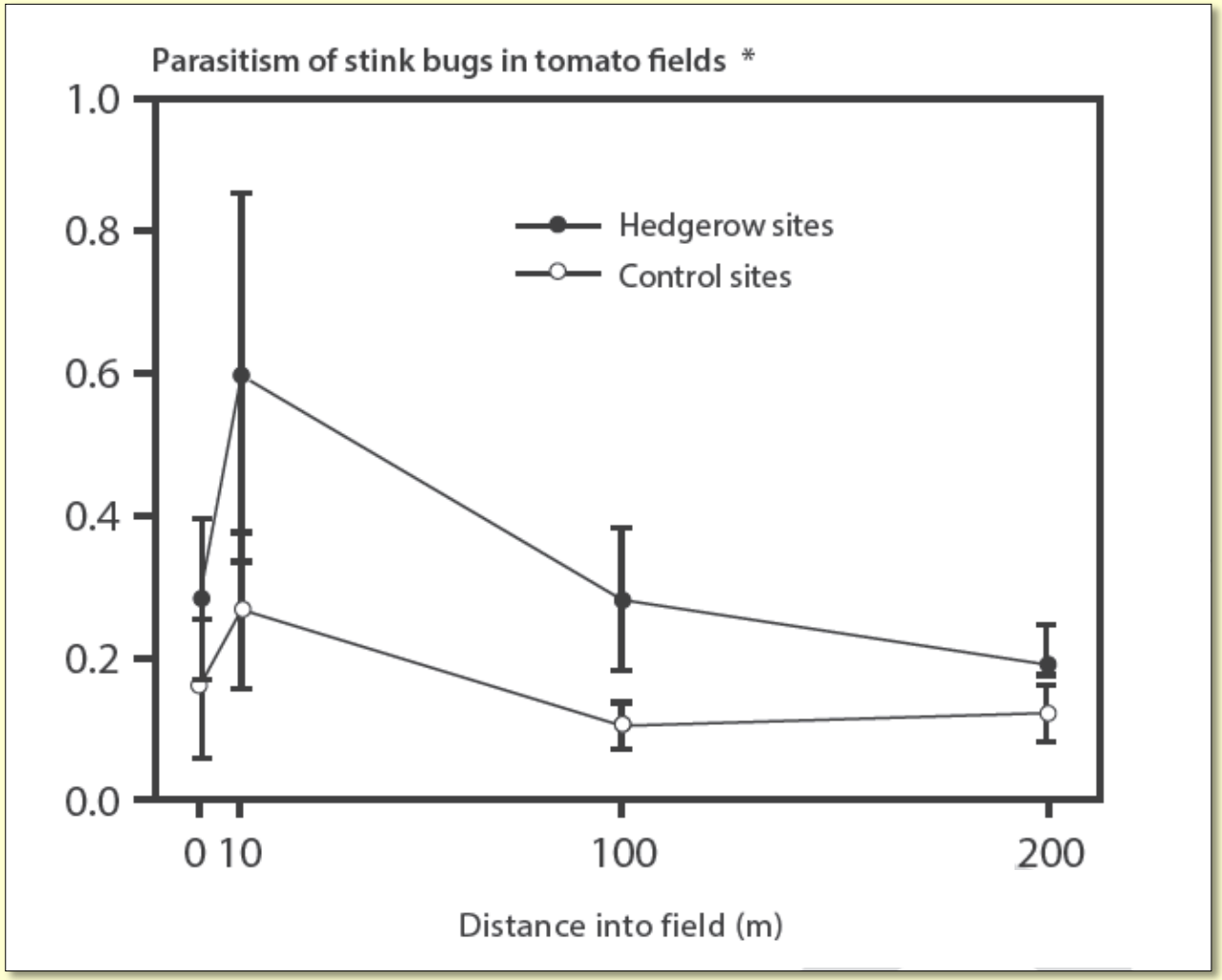
Farm hedgerow in California

Photo: Jessa Guisse

Hedgerows Enhance Pest Control

A 6-Year UC Berkeley / Xerces Society CIG-Funded Case Study

- More stink bug eggs parasitized (by wasps) in fields with nearby native plant hedgerows (than in fields without)
- Vertical axis is proportion of parasitized egg masses observed at distances from the field edge



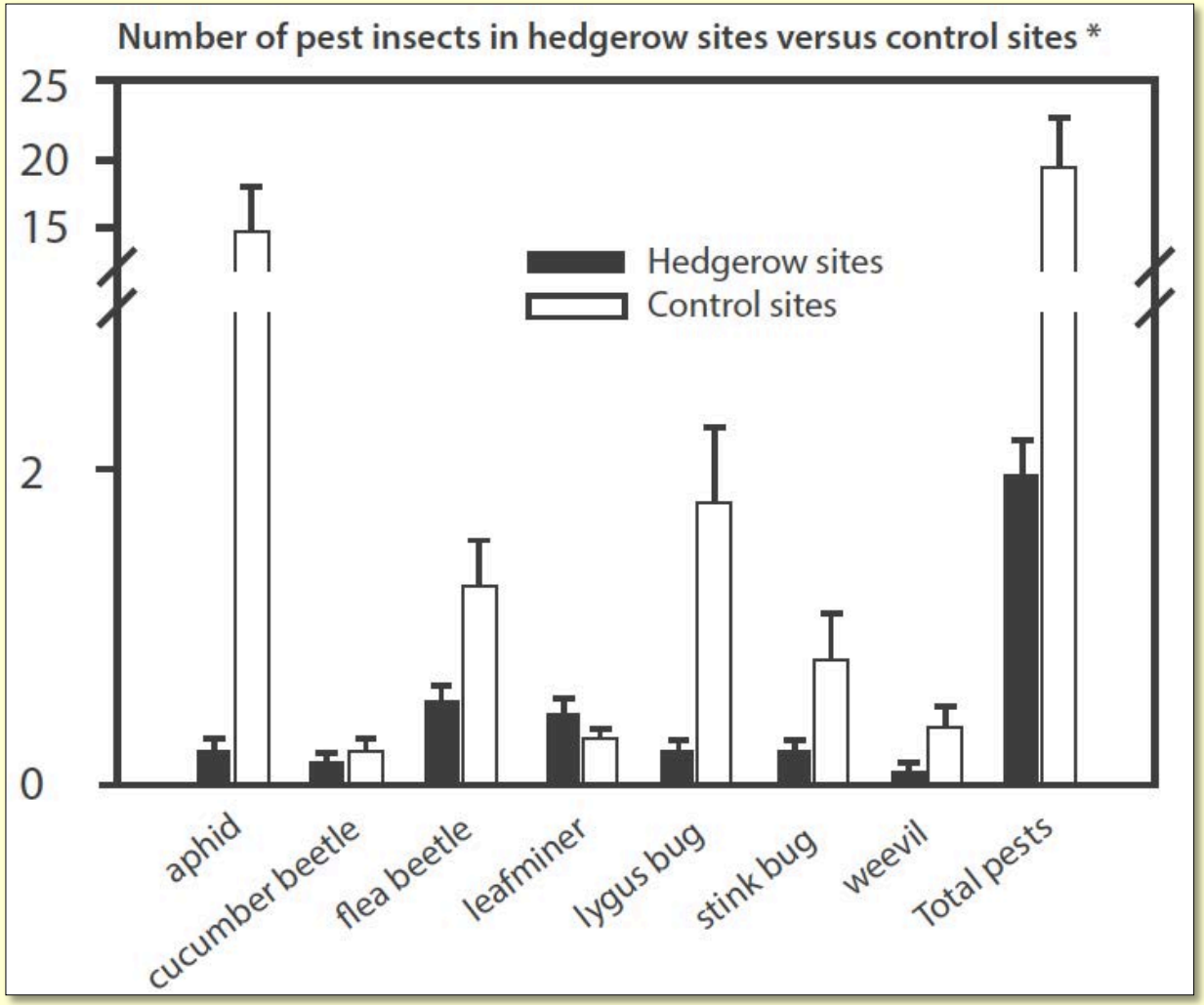
*Morandin et. al in press

Graph: Lora Morandin

Hedgerows Do Not Increase Pest Populations

A 6-Year UC Berkeley / Xerces Society CIG-Funded Case Study

- Sweep net samples of insect activity
- Native plant hedgerows versus weedy field edges
- Fewer pests (except leafminers) at the hedgerow sites



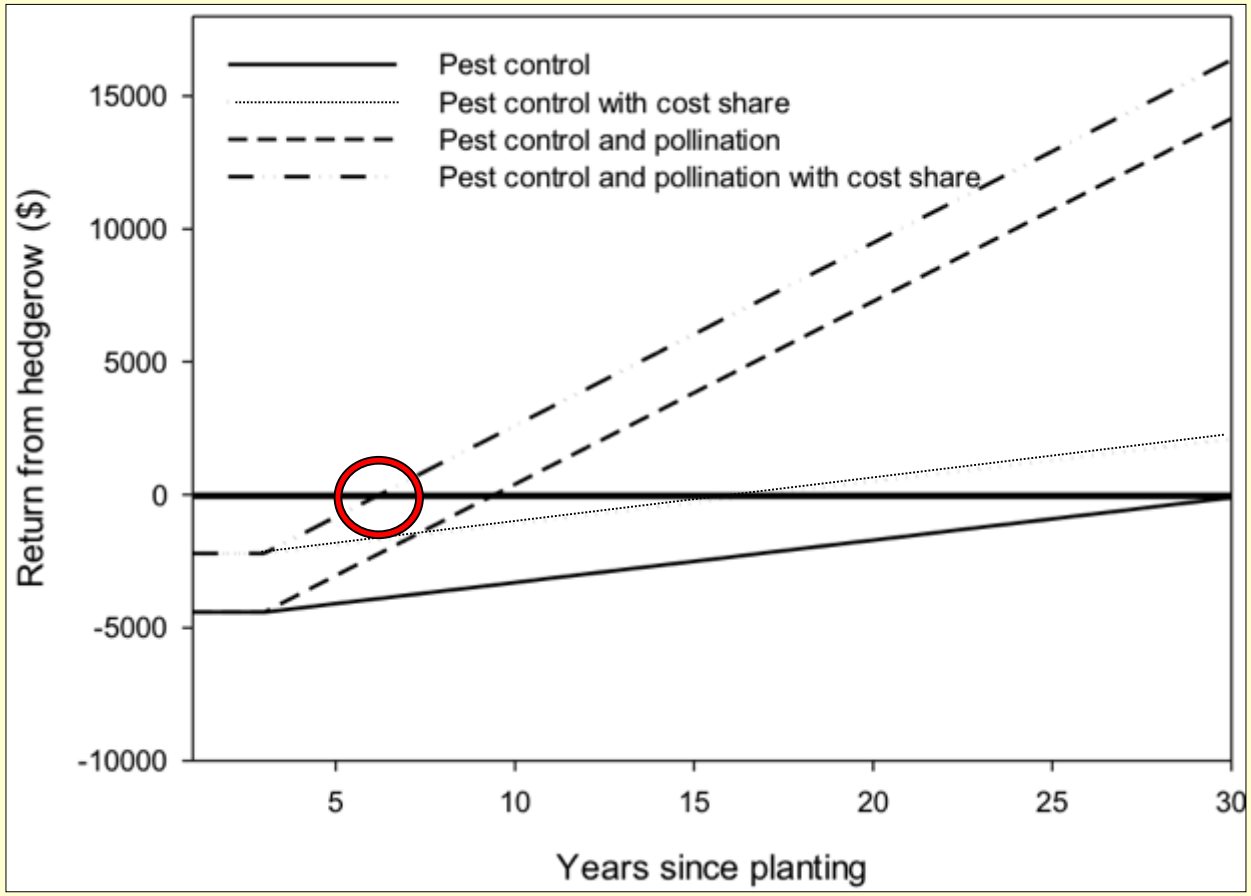
*Morandin et. al in press

Graph: Lora Morandin

Hedgerows Pay for Themselves

A 6-Year UC Berkeley / Xerces Society CIG-Funded Case Study

- The value of increased pollination and pest control pays for the initial investment within 10 years.
- Or within 5 years with NRCS assistance.



*Morandin et. al in press

Graph: Lora Morandin

Edge Habitat: Hedgerows and Windbreaks

Example: Xerces/Muir Glen Hedgerow, California

One-mile in length, supporting organic field crop production

Photos: Jessa Guisse

Edge Habitat: Hedgerows and Windbreaks

Edge Habitat: Hedgerows and Windbreaks

Xerces/Muir Glen Hedgerow, California


California Fuschia


Silver Lupine


California Gumplant


Elderberry

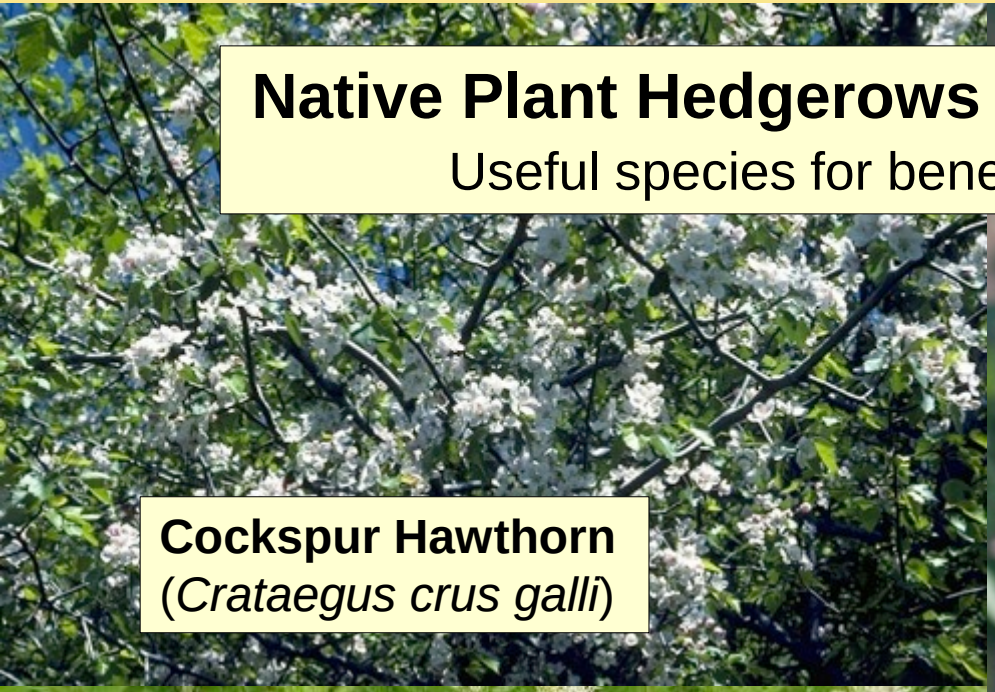

Showy Milkweed

Purple Salvia

Photos: Jessa Guisse

Native Plant Hedgerows and Windbreaks

Useful species for beneficial insects

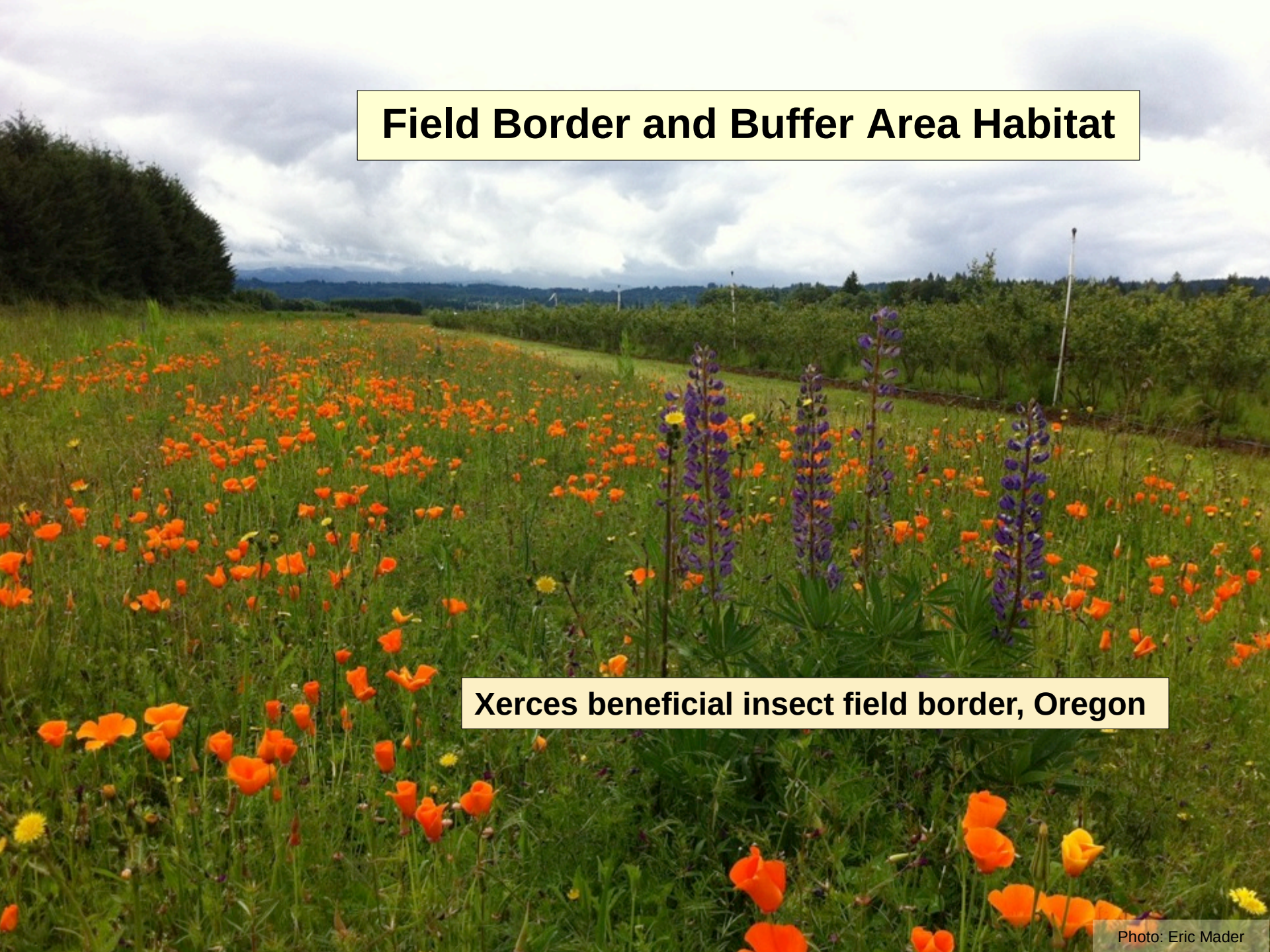


Cockspur Hawthorn
(*Crataegus crus galli*)

New Jersey Tea
(*Ceanothus americanus*)

False Indigo Bush
(*Amorpha fruiticosa*)

Field Border and Buffer Area Habitat



Xerces beneficial insect field border, Oregon

Photo: Eric Mader

Native Plant Field Borders and Pest Management

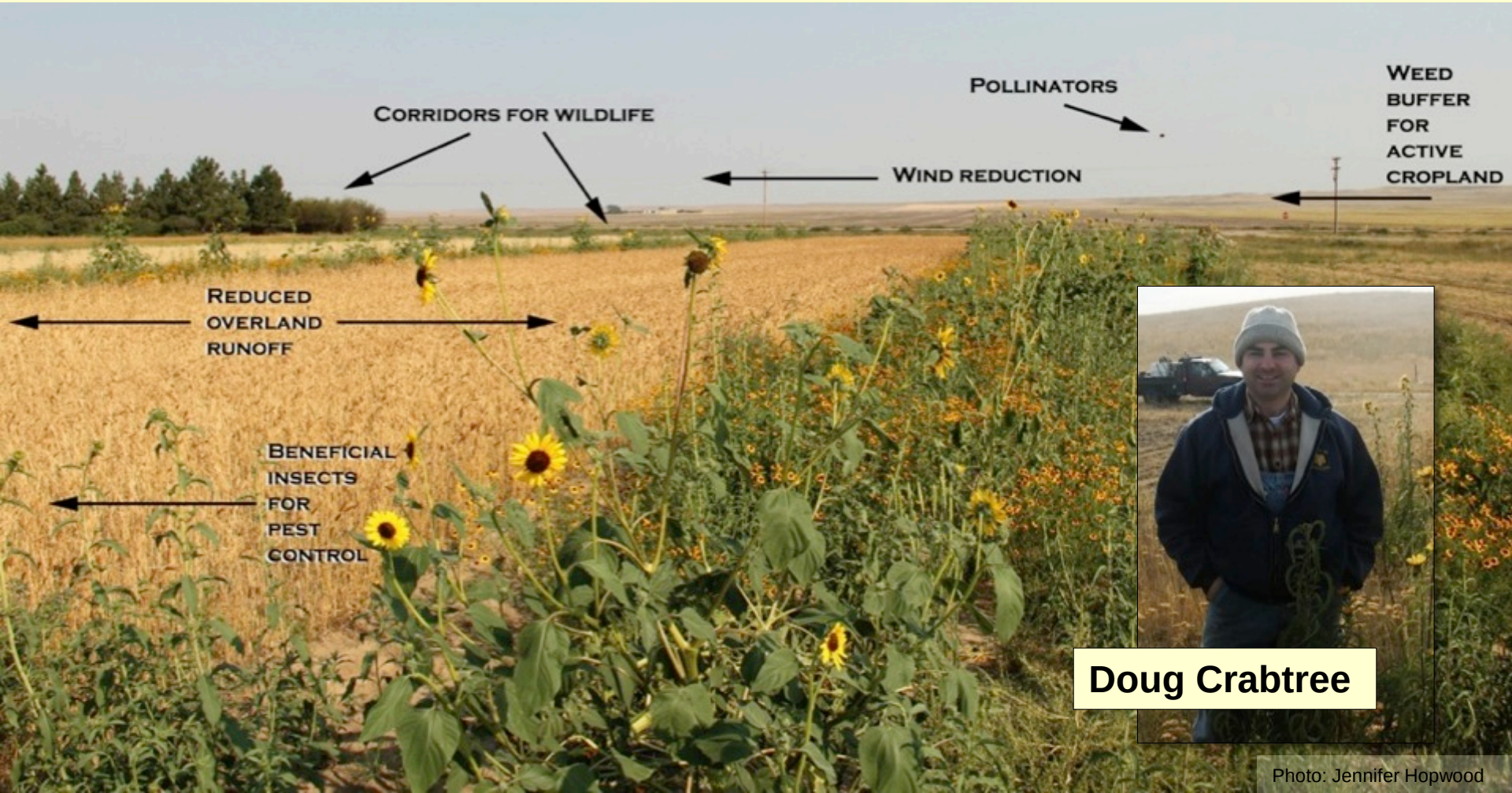
- Emerging Research: Sand wasp predation of brown marmorated stinkbugs
- Mountain mint (*Pycnanthemum* spp.) and spotted bee balm (*Monarda punctata*) as nectar plants for wasps

Research by Dave Biddinger, Penn State University; Photos: Alex Suricia, Jennifer Hopwood, Scott Seigfried

Field Border and Buffer Area Habitat

Example: Vilicus Farm, Montana

- 1500 Acres (organic small grains, pulses, oilseed crops)
- Native plant field borders throughout
- 20+ species of native forbs and grasses (replacing crested wheatgrass)



Field Border and Buffer Area Habitat

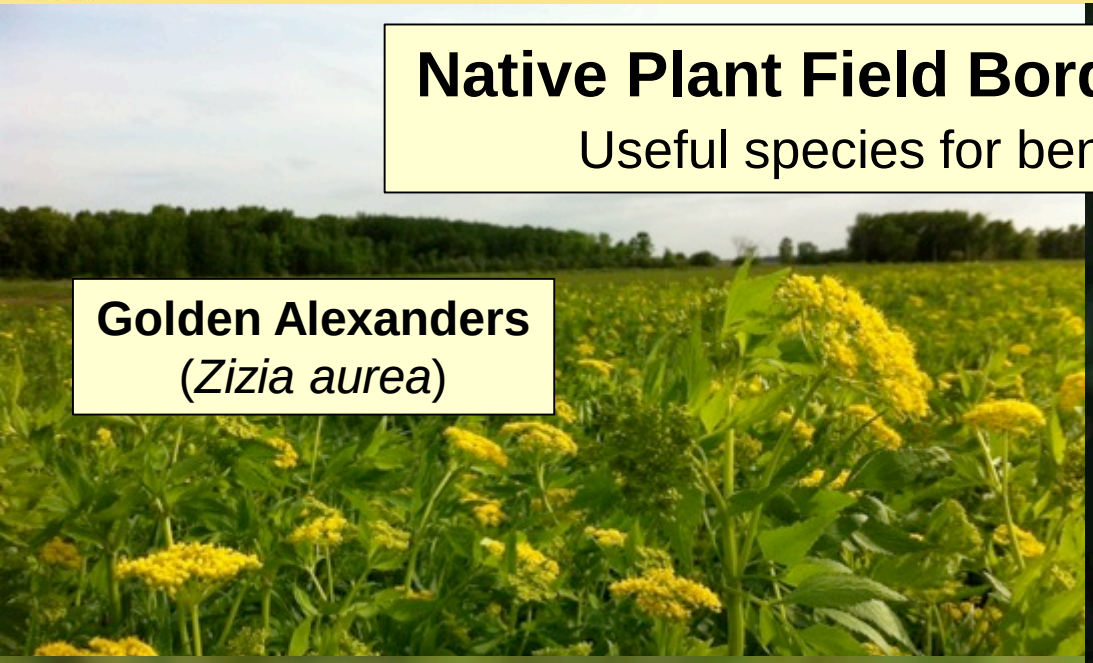
Example: Sturm Berry Farm, Oregon

- Border areas planted with more than a dozen native wildflower species
- Does not use insecticides – Even for spotted wing *Drosophila*

Photos: Eric Mader

Native Plant Field Borders and Buffers

Useful species for beneficial insects



Golden Alexanders
(*Zizia aurea*)

Milkweeds
(*Asclepias spp.*)

Bluejoint Grass
(*Calamagrostis canadensis*)

Photos: Gene Barickman, Eric Mader, Andy

Pasture and Permanent Ground Cover Habitat

Prairie smoke (*Geum triflorum*) in a grass pasture, Minnesota

Photo: Eric Mader

Example: Klickitat Canyon Vineyard, Washington

- Native grass & wildflower understory; no insecticide use
- No measurable leafhopper damage (due to enhanced natural pest control)

Photos: Eric Mader and Robin Dobson

Pasture and Permanent Ground Cover Habitat

Beetle Banks

- Raised bed of perennial bunch grasses
- Cover for predatory ground beetles
- Central location, extending length of field

Example: Beetle bank installation field trials, Oregon

OSU Oregon State University

Pasture and Permanent Ground Cover Habitat

Example: Grinnell Heritage Farm Beetle Bank, Iowa

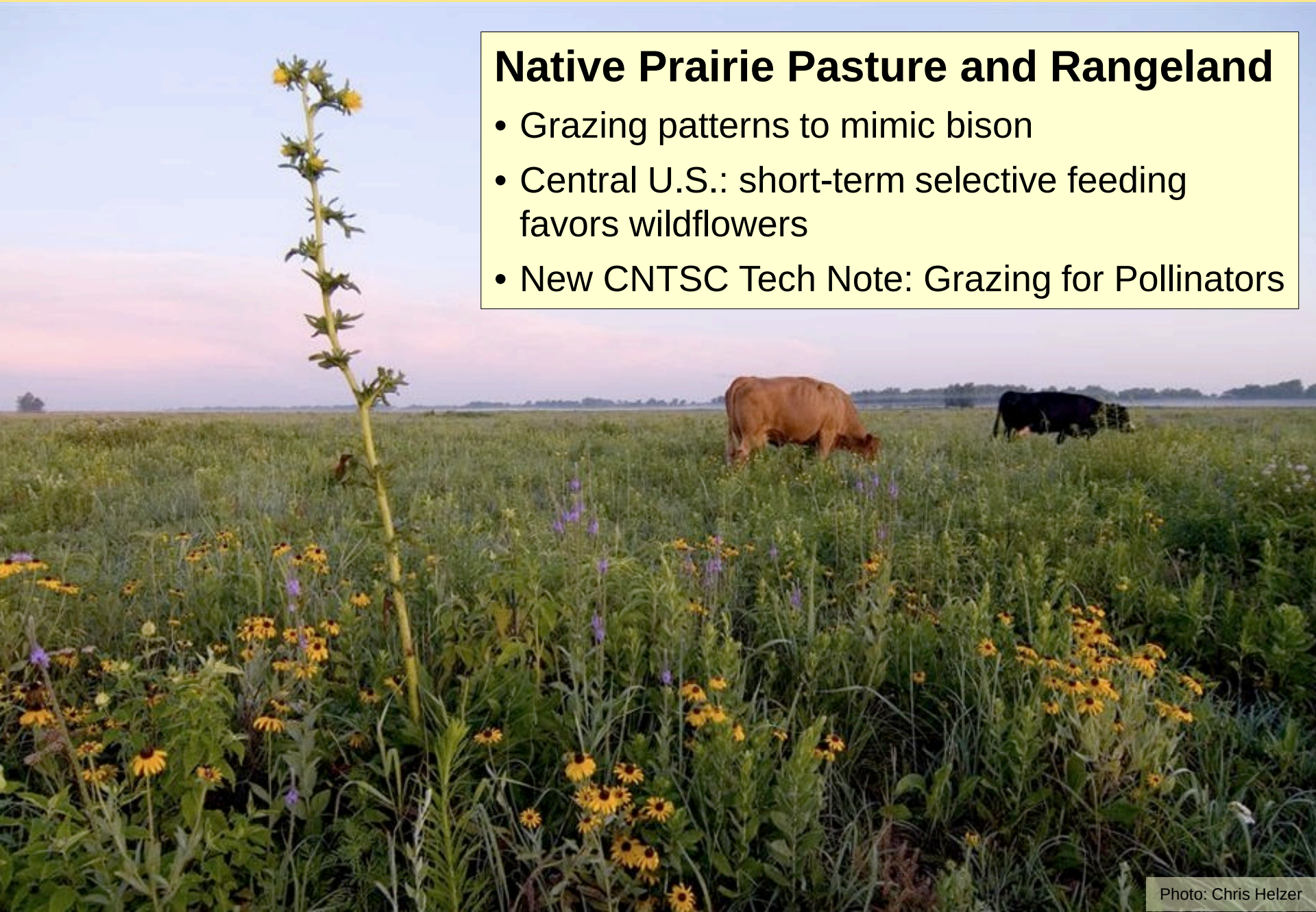
Permanent native grass strips intercropped with vegetables

Pasimachus ground beetle

Firefly beetle

Photo: Grinnell Heritage Farm; Bugwood

Pasture and Permanent Ground Cover Habitat



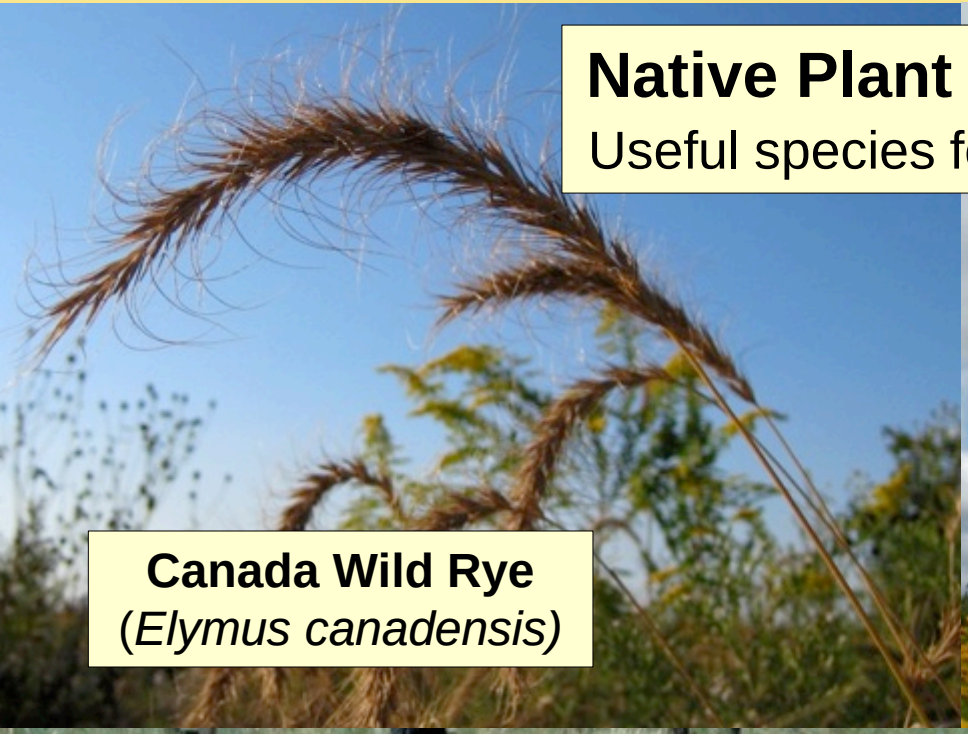
Native Prairie Pasture and Rangeland

- Grazing patterns to mimic bison
- Central U.S.: short-term selective feeding favors wildflowers
- New CNTSC Tech Note: Grazing for Pollinators

Photo: Chris Helzer

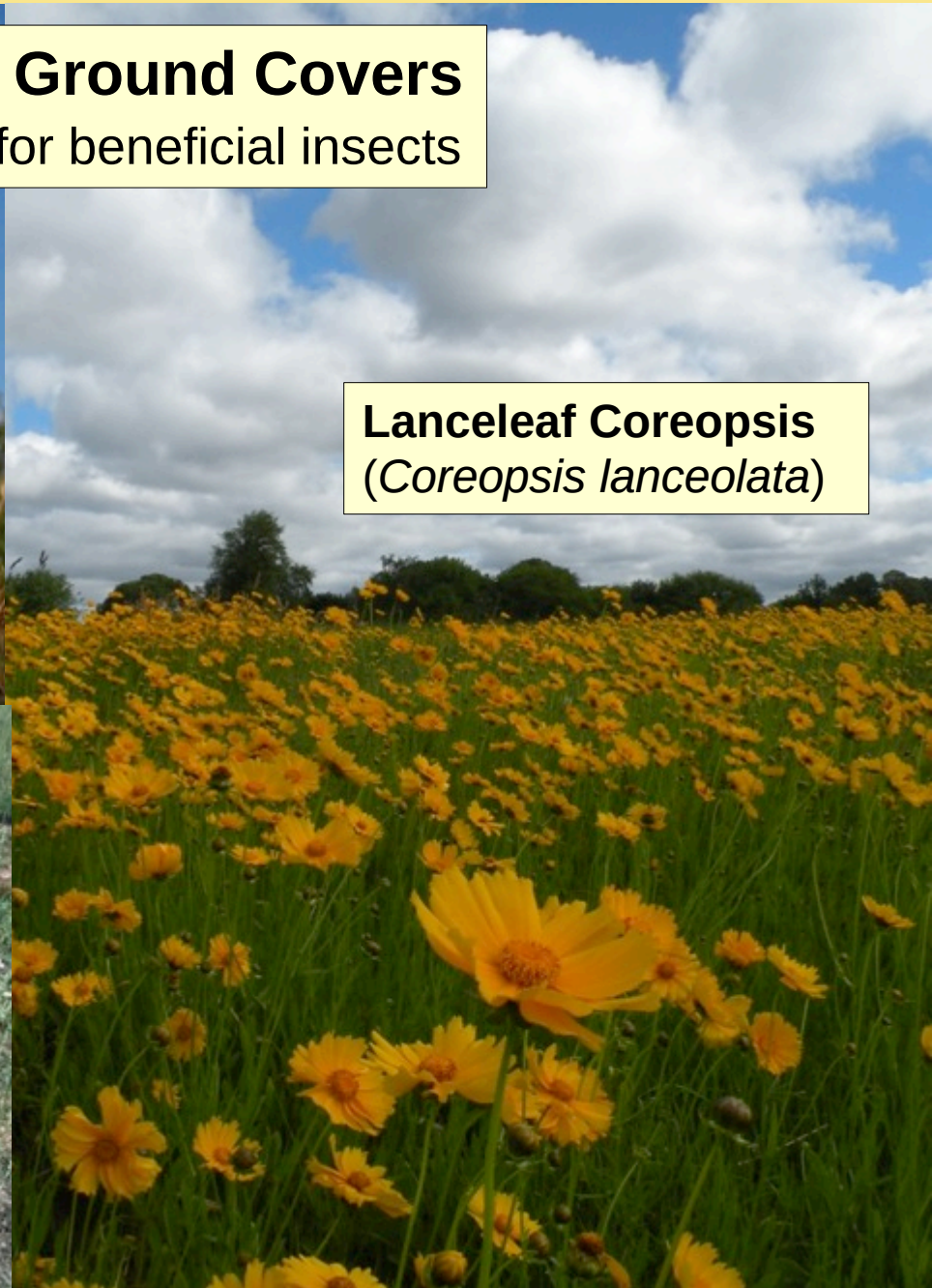
Native Plant Ground Covers

Useful species for beneficial insects



Canada Wild Rye
(*Elymus canadensis*)

Prairie Junegrass
(*Koeleria macrantha*)



Lanceleaf Coreopsis
(*Coreopsis lanceolata*)

Cover Crop and Insectary Strip Habitat

Crimson clover inter-cropping with vegetables, North Carolina

Photo: Debbie Roos

Flowering Cover Crops Enhance Pest Control

- Mississippi: flowering cover crops near soybeans (buckwheat for nectar) increased wasp parasitism of stink bug eggs by 2 ½ times.

Telenomus wasp parasitizing stink bug eggs

Glynn Tillman, USDA ARS. 2013. Crop Protection & Management Research Lab, Tifton, GA, Manuscript in progress.

Photos: Russ Ottens; Jennifer

Cover Crop and Insectary Strip Habitat

Insectary Strips

- Temporary mass wildflower plantings between row crops

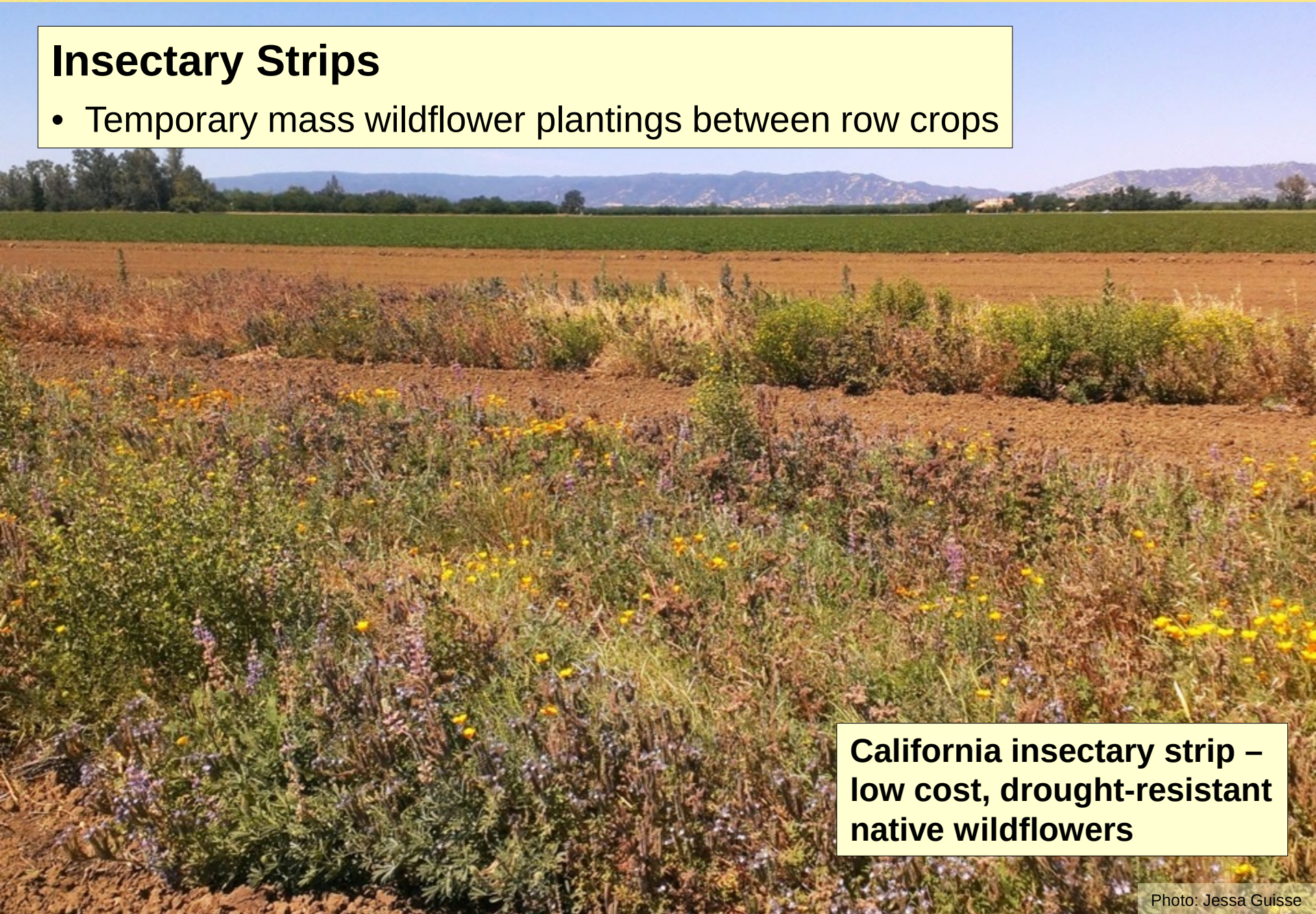
California insectary strip – low cost, drought-resistant native wildflowers

Photo: Jessa Guisse

Cover Crop and Insectary Strip Habitat

Insectary Strips

- Temporary mass wildflower plantings between row crops



California insectary strip – low cost, drought-resistant native wildflowers

Photo: Jessa Guisse

Cover Crop and Insectary Strip Habitat

Example: Burleigh County, North Dakota - Cover Crop Trials

Multi-species cool-season cover crop mix

Diverse cover crop mix inter-seeded with sunflower

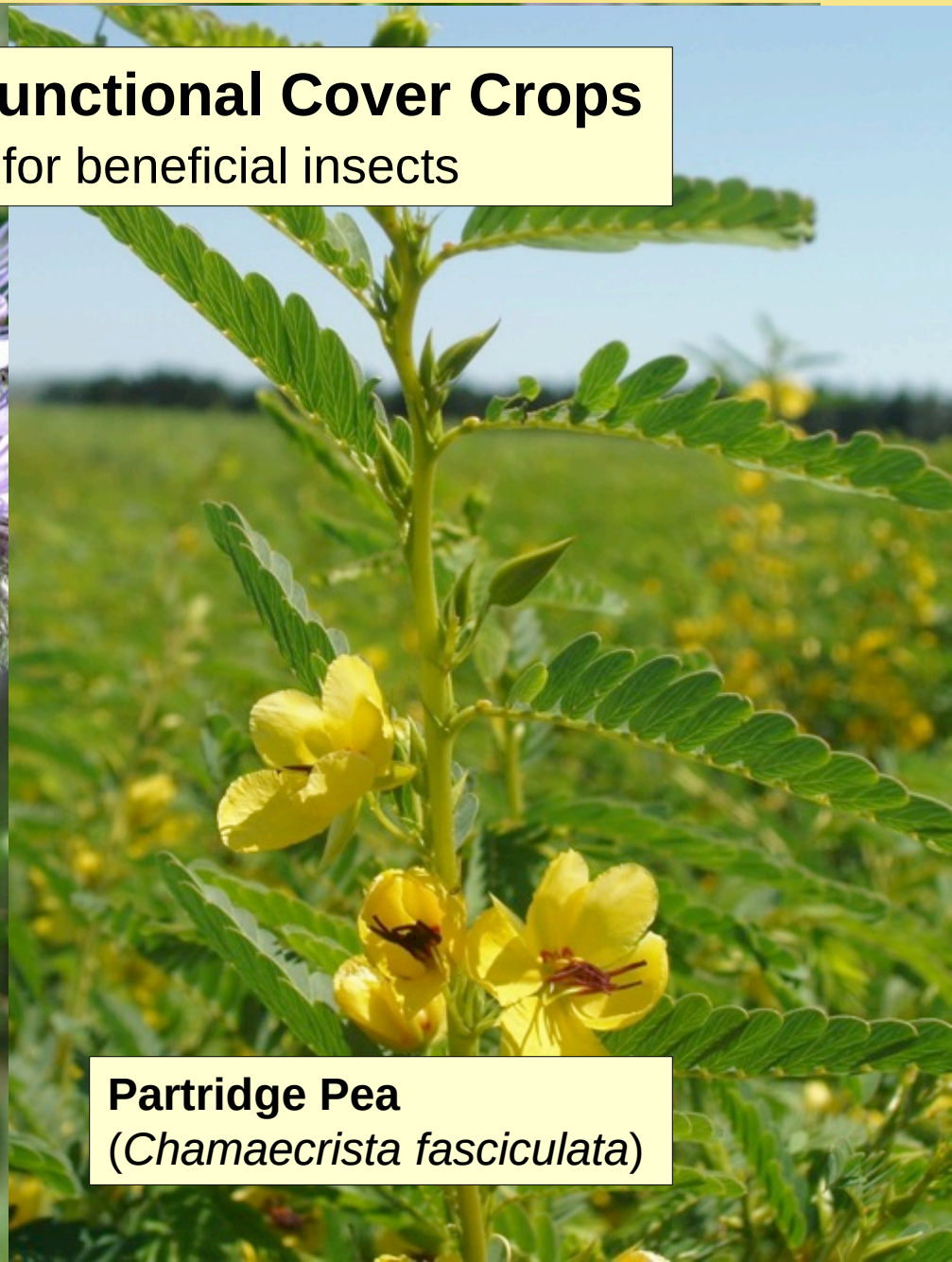
Jay Fuhrer
District Conservationist

Photos: Eric Mader and Robin Dobson

Native Plants as Functional Cover Crops

Useful species for beneficial insects

Lacy Phacelia
(*Phacelia tanacetifolia*)



Partridge Pea
(*Chamaecrista fasciculata*)

A Few Words About Restoration

Photo: Eric Mader

The Native Plant Restoration Process

The Habitat Restoration Basics

- Transplants for hedgerows and windbreaks
- Direct seeding wildflowers and grasses over larger areas
- Removal of all weeds (and dormant weed seed!) prior to planting is critical

Photos: Don Keirstead, Gwendolyn Ellen, Eric Mader

The Native Plant Restoration Process

Cultivating to create a seed bed (spring)

Solarization plastic (summer)

Example: Headwaters Farm field border, Oregon

- Summer solarization (high tunnel plastic with the edges buried)
- Broadcast seeding in the fall

Removing the plastic (fall)

Broadcast seeding (fall)

Photos: Eric Mader

The Native Plant Restoration Process

Photos: Eric Mader

The Native Plant Restoration Process

Photos: Eric Mader

The Native Plant Restoration Process

October 2013: Plastic removed; broadcast seeded

Photos: Eric Mader

The Native Plant Restoration Process

May 2014: Initial Wildflower Germination

Photos: Eric Mader

The Native Plant Restoration Process

July 2014: Full Wildflower Establishment

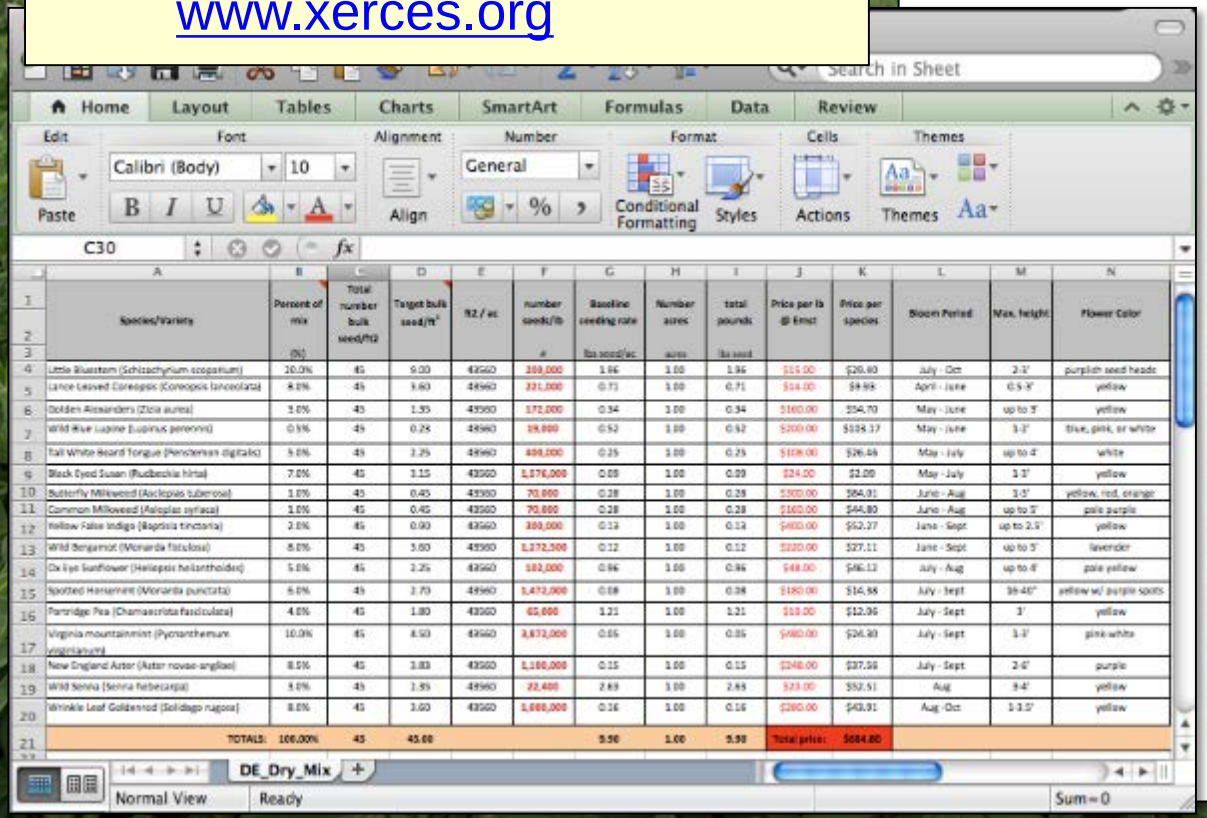
Photos: Eric Mader

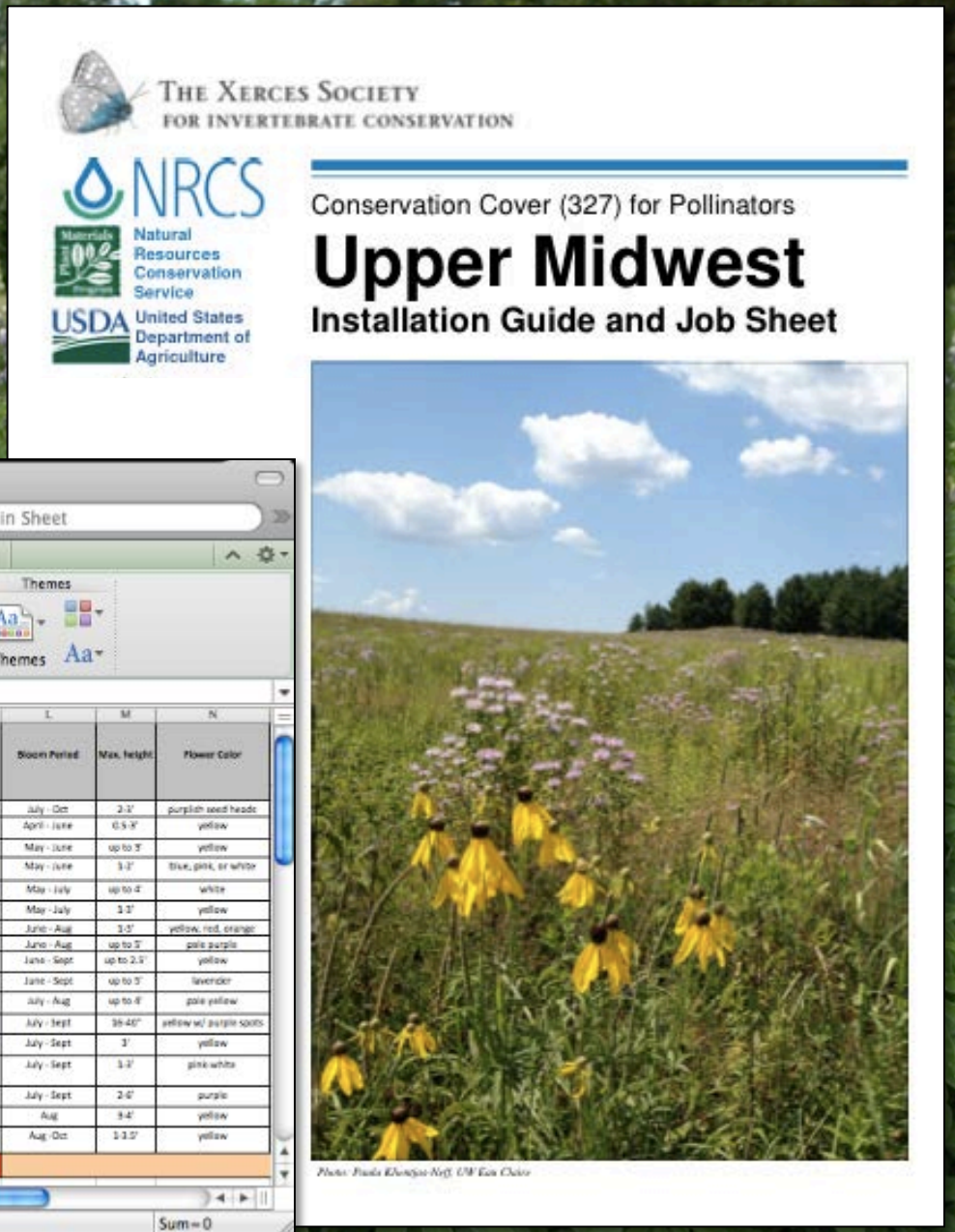
The Native Plant Restoration Process

Xerces Habitat Installation Guides and Seed Mix Calculators

Wildflower meadow and hedgerow installation guidelines for multiple regions of the U.S.

www.xerces.org





Additional Resources

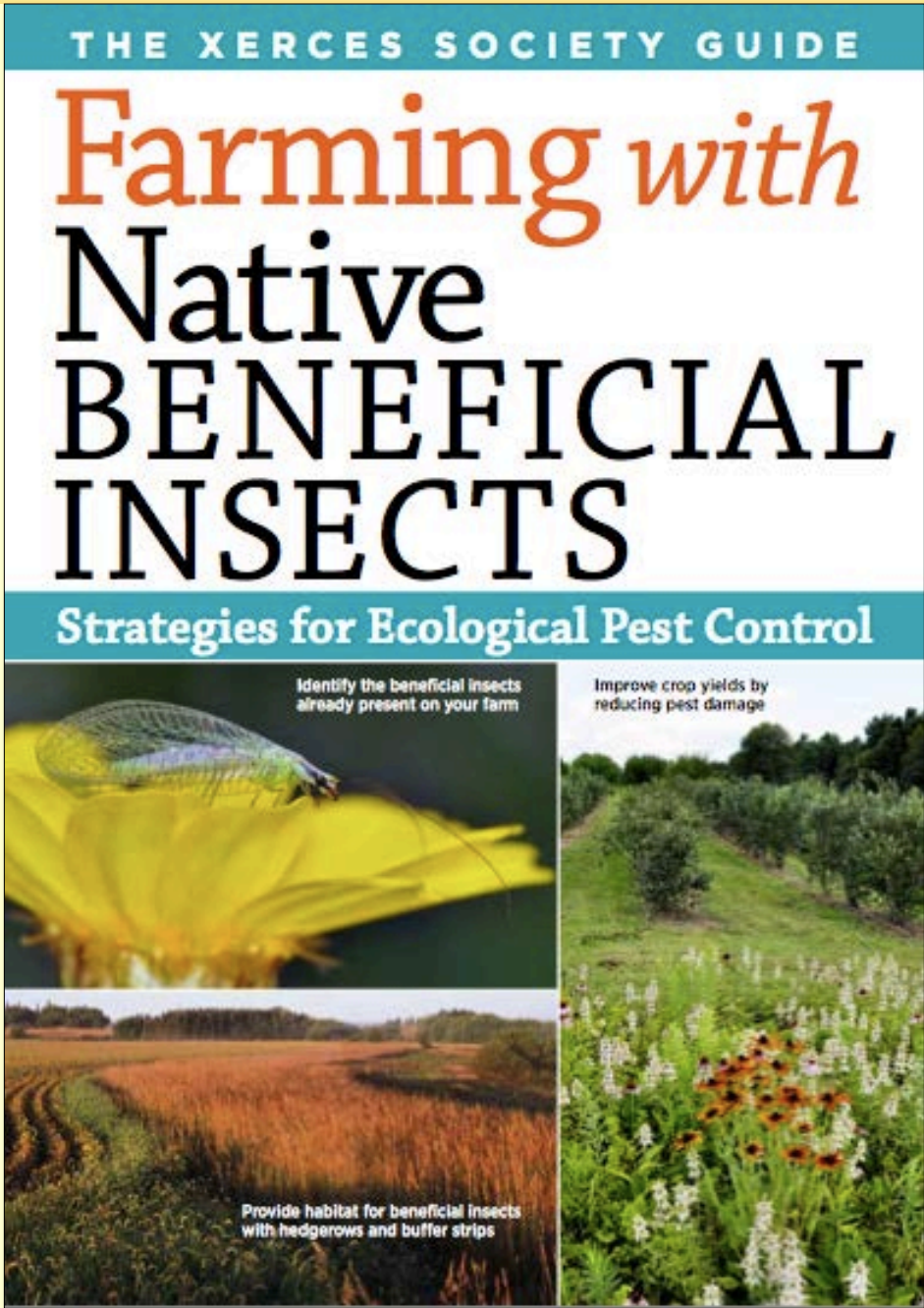
Convergent lady beetle winter aggregation

Photo: David James

Additional Resources

NEW ECOLOGICAL PEST MANAGEMENT BOOK

- Installation guidelines for hedgerows, beetle banks, native plant field borders, insectary strips, cover cropping, and more
- Pesticide risk mitigation guidance
- Based upon Xerces Society & UC Berkeley CIG-funded project
- Real world case studies from across the U.S.



Additional Resources

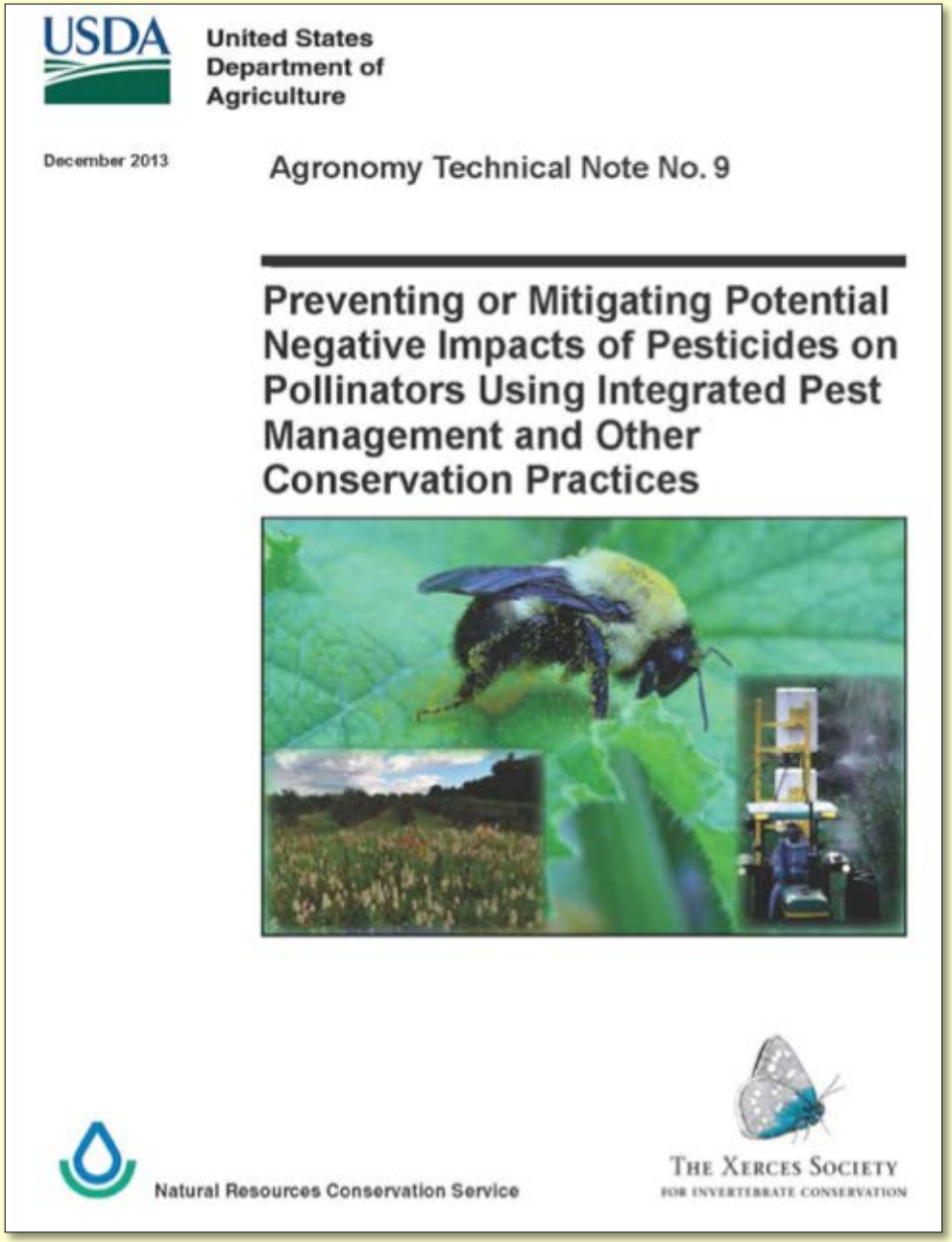
New USDA-NRCS Technical Guide

- Integrating conservation biocontrol into NRCS conservation practice standards
- Available soon

Additional Resources

Agronomy Tech Note No. 9 Pesticide Risk Mitigation

- Identifying potential risks to pollinators and beneficial insects
- Mitigating those risks with outside support and consultation from local IPM experts
- Risk mitigation through conservation practices (windbreaks, buffer systems, etc.)



Additional Resources

Xerces Conservation Biocontrol Short Course

- Coming soon to Western and Midwestern states; other regions pending
- Basic beneficial insect ecology, habitat design, restoration, and management
- Pesticide risk mitigation (e.g. buffer construction, sprayer technology, etc.)

25 Years of SARE
NORTH CENTRAL
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Sustainable Agriculture
Research & Education

Additional Resources

Xerces Society – Habitat Restoration Consulting

- Custom conservation plans and habitat restoration nationwide

Thank You NRCS!

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