Sowing Biodiversity

Cover Crops for Bees, Beneficial Insects, and Pest Management

Eric Lee-Mäder

Photo: notillveggioes.org

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Protecting the Life that Sustains Us

The Xerces Society is a nonprofit organization that protects wildlife through the conservation of invertebrates and their habitat.

Major Programs

- **Pollinator conservation and agricultural biodiversity**
- **Pesticide policy and regulation**
- **Endangered species**
- **Aquatic conservation**

Photos: Xerces; Joel Sartore

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Insects as Ecosystem Engineers

- First stage in decomposition and creation of soil organic matter
- Insect mineralization of soils may sequester carbon
- Mass scale soil churning: tons/acre/year
- Insects as a major food source for other wildlife (songbirds, fish, bears, etc.)

Photo: Magnus Robinson

Dorn, R. 2014. Ants as a powerful biotic agent of olivine and plagioclase dissolution. Geology. 42(9):771-774.

Nardi, J. 2007. Life in the Soil. University of Chicago Press. 195-196.

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Insect Pollinators

- 85% of terrestrial plant species require pollinators
- Bee pollinated crops = $200+ billion annually
- 4,000+ native bee species in North America

Photo: Eric Lee-Mäder

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.

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Insects and Pest Management

- Only ~2% of species are pests
- $4.5 - $12 billion annual value of natural pest suppression

Photo: John Flannery, Flickr-CC2.0

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)

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.

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Earth Without Animals

Part 1

Photo: Anne Stine, Xerces Society

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Honey Bees in Decline

50% decline in managed hives since 1950

Causes: Disease, parasites, pesticides

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

Photo: Scott Bauer, USDA-ARS

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Photos: John Anderson, Johanna James-Heinz

Bumble Bees and Monarchs

25% of Bumble Bee Species At-Risk of Extinction

- Among the most important wild pollinators of crops and native plants

Monarch Butterflies Decline 90% Since 1990s

- Loss of milkweed
- Disappearance rate similar to passenger pigeon

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

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Global Disappearance of Insects

New Research: Published October 2017

Between 1986 and 2016, insect biomass declined by 76% in German nature reserves

Hallmann, et al. 2017. More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PLoSOne.https://doi.org/10.1371/journal.pone.0185809.

Photo: Alex Wild

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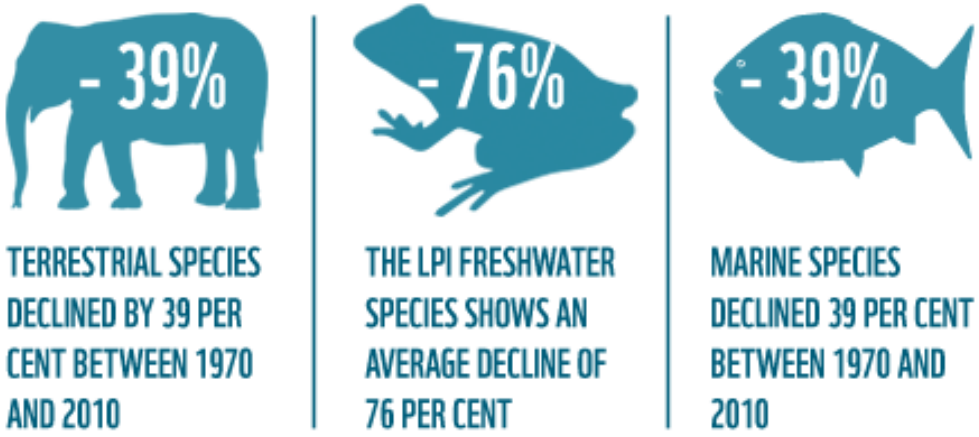
Living Planet Index - Meta Analysis

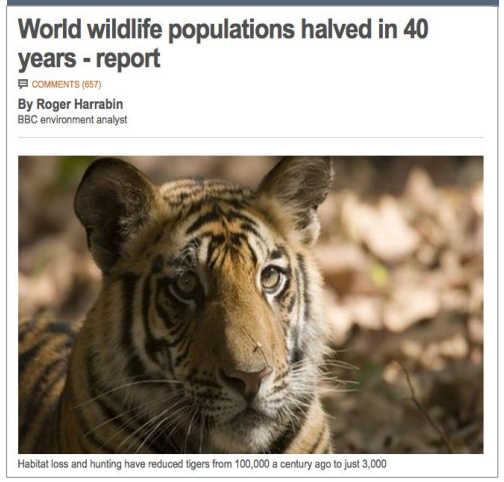
Earth Has Lost Half of its Wildlife in the Past 40 Years



Photos: WWF, BBC, Gory Sowie

Ecosystems are degrading at a rate unprecedented in human history

Largest global analysis of thousands of animal species (birds, mammals, fish, reptiles, etc.)



World wildlife populations halved in 40 years - report

COMMENTS (657)

By Roger Harrabin
BBC environment analyst

Habitat loss and hunting have reduced tigers from 100,000 a century ago to just 3,000

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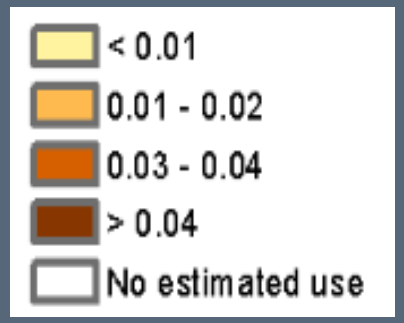
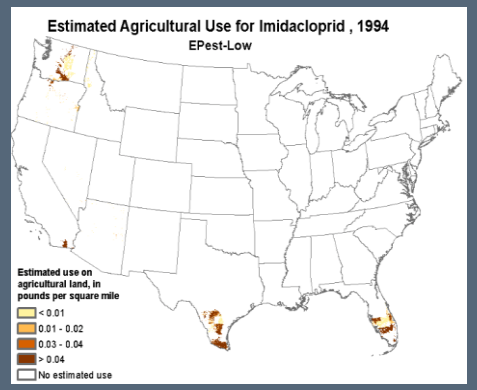
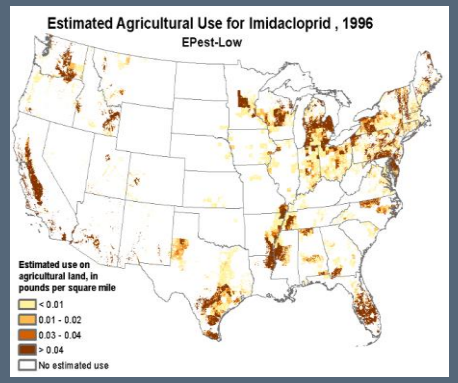
The Rise of New Insecticides

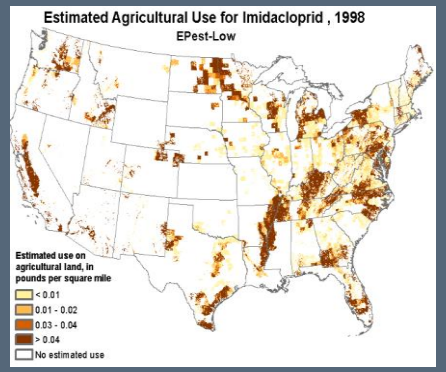
Neonicotinoid Insecticide Use 1994 to 2013

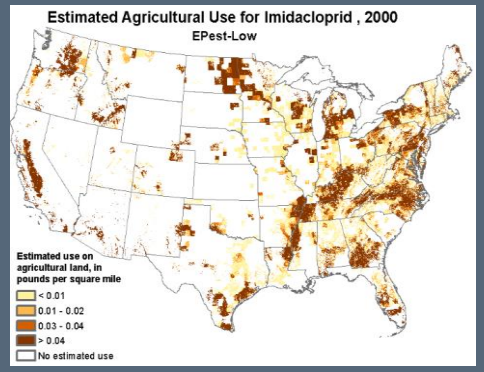
Estimated use on agricultural land in pounds per square mile over 10 years

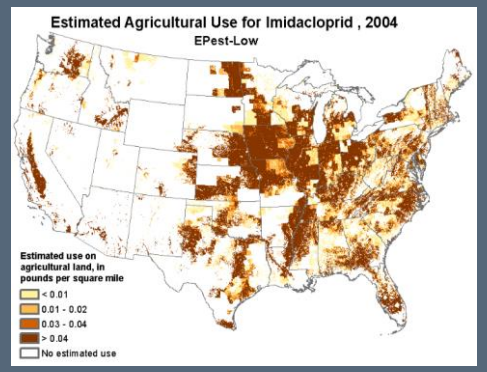


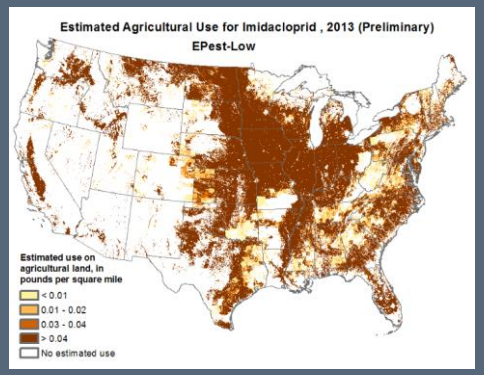












U.S> Geological Survey

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Unprecedented Habitat Loss in the U.S.

- 53 Million acres of grassland and prairie conversion since 2008
- Largest conversion of grassland to cropland since just before the Dust Bowl

Photos: Griggs Dakota

Gage, A.M., Olimb, S.K., Nelson, J. 2016. Plowprint: tracking cumulative cropland expansion to target grassland conservation. Great Plains Research 26: 107-116.

Harvey, C. 2016. North America's grasslands are slowly disappearing – and no one's's paying attention. The Washington Post. Nov. 29.

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Insects and Soil Health

Part 2

Photo: Tess Grasswitz

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Soil Insects

Native Prairie or Forest Soils

- 5000+ Insects, spiders, other arthropods per square meter
- May be active more than 10 feet deep
- Some species extremely long-lived

Photo: Tess Grasswitz

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Soil Insects

Ants

- Most abundant arthropod in most soils
- The most important soil engineers on earth (along with roots and worms)
- Ants move 30-tons of soil per acre/year in New England fields

Photo: Elizabeth Cash ASU

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Soil Insects

Predatory 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

Photo: Sarah Foltz-Jordan

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Soil Insects

Seed-Feeding Beetles

- Voracious consumers of lambsquarters, ragweed, pigweed, velvetleaf, foxtail, crabgrass, etc.
- Average of 74 to 208 seeds consumed in 48 hours depending on species

Photo: University of Minnesota Extension

Lundgren, J. 2005. Ground beetles as weed control agents: effects of farm management. American Entomologist. 224-226.

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Soil Insects

Dung Beetles

- “Rollers,” “dwellers, “tunnelers”
- Can reduce calf parasites by 75%
- Eliminate methane by up to 12%
- Eliminate e.coli

Photo: Marc Barrison

Fincher, G. T. 1975. Effects of dung beetle activity on number of nematode parasites acquired by grazing cattle. Journal of Parasitology 61: 759–762. (Available online at: https://doi.org/10.2307/3279480 (verified 3 Oct 2017).

Jones, M. S., S. Tadepalli, D. F. Bridges, V.C.H. Wu, and F. A. Drummond. 2015. Suppression of *Escherichia coli* O157:H7 by dung beetles (Coleoptera: Scarabaeidae) using the lowbush blueberry agroecosystem as a model system. PLoS ONE 10: e0120904.

Slade, E. M., T. Riutta, T. Roslin, and H. L. Tuomisto. 2016. The role of dung beetles in reducing greenhouse gas emissions from cattle farming. Scientific Reports 6: 18140. (Available online at: 10.1038/srep18140

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Soil Insects

Ground-Nesting Bees

- Roughly 70% of wild bees are ground-nesting species
- Nest can extend several feet deep, withstand flooding

Solitary lifecycle

Most wild bees live individually not in a social colony

Short Adult Lives

Ground-nesting bee larvae may live for almost a year under ground

Photos: Rollin Coville, Eric Lee-Mäder, Dennis Briggs

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Cover Crops and Insect Management

Part 3

Photo: T Martin

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Case Study:

Pollinators and Farm Habitat

- Diverse flowering habitat increases honey bee health
- Canada: Canola yields increase if 30% of farm is maintained as habitat
- California: Watermelon fully pollinated by wild bees when 30% of surrounding farmland is habitat

Photos: Toby Alexander, NRCS

Alaux C., Ducloz F., Crauser D., Le Conte Y. (2010)

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

Morandin, L., and M. Winston. 2006. Pollinators provide economic incentive to preserve natural land in agroecosystems. Agriculture, Ecosystems and Environment 116:289-292.

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Case Study:

Pollinators and Cover Crops

California Almonds

- Xerces and UC Berkeley: Wild bee increases in cover crops
- Designed for secondary benefits: SOM, water holding capacity

Photo: Jessa Kay Cruz

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Case Study:

Pest Suppression and Farm Habitat

If more than 20% of a farm is habitat, beneficial insect pest suppression is observed throughout crop fields

(Tscharntke e al. 2002).

Photo: Nancy Adamson

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Case Study:

Pest Suppression and Cover Crops

Flowering Cover Crops Suppress Pests

Flowering cover crops near soybeans increase wasp parasitism of stink bug eggs by 2 ½ times

Parasitic Wasps

Attack eggs of other insects; adults depend on flower nectar as food

Cover Crops for Beneficial Wasps

Buckwheat, phacelia, flowering brassicas

Photos: Eric Lee-Mäder, Russ Ottens, Jennifer Hopwood

Tillman *et al*., 2015. Trap cropping systems and a physical barrier for suppression of stink bugs (Hemiptera: Pentatomidae) in Cotton. J. Economic Entomology 108(5): 2324-2334.

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Case Study:

Weed Seed Predation and Cover Crops

Cover crops increase of insect consumption of weed seed by 73%

(Blubaugh et al. 2016. Cover crops increase foraging activity of omnivourous predators in seed patches and facilitate weed biological control. Agriculture, Ecosystems & Environment. Vol. 231. 264-270.

Photo: Eric Lee-Mäder

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Maximizing Insect Benefits

Part 4

Photo: Jessa Kay Cruz

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Extend The Bloom

Cocktail Mixes

- Multi-species blends likely maximize insect value
- Focus on forbs: clover, buckwheat, phacelia, vetch, brassicas

Photo: Eric Lee-Mäder

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Try Including Natives

Beneficial Insects Associated With Native Plants

Few true native cover crops are currently available; additional development needed

Lacy Phacelia

Cool season West Coast annual, prolific nectar producer

Partridge Pea

Warm-season Midwest native prairie legume, growth similar to vetch

Photos: Eric Lee-Mäder, Jessa Kay Cruz

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Reduce the Impact of Cover Crop Termination

- Wait for forbs to finish blooming if possible
- Roller crimper and grazing = less impact than cultivation
- Leave undisturbed “strips”

Photo: Cornell University

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Keep Part of the Farm in Permanent Cover

Beetle Banks

- Permanent native prairie grass strips
- Daytime and overwintering habitat for beetles

Photo: Grinnell Heritage Farm

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Keep Part of the Farm in Permanent Cover

Prairie Strips

- Multiple benefits to wildlife, living snow fences, sediment capture, wind protection for seedling capture

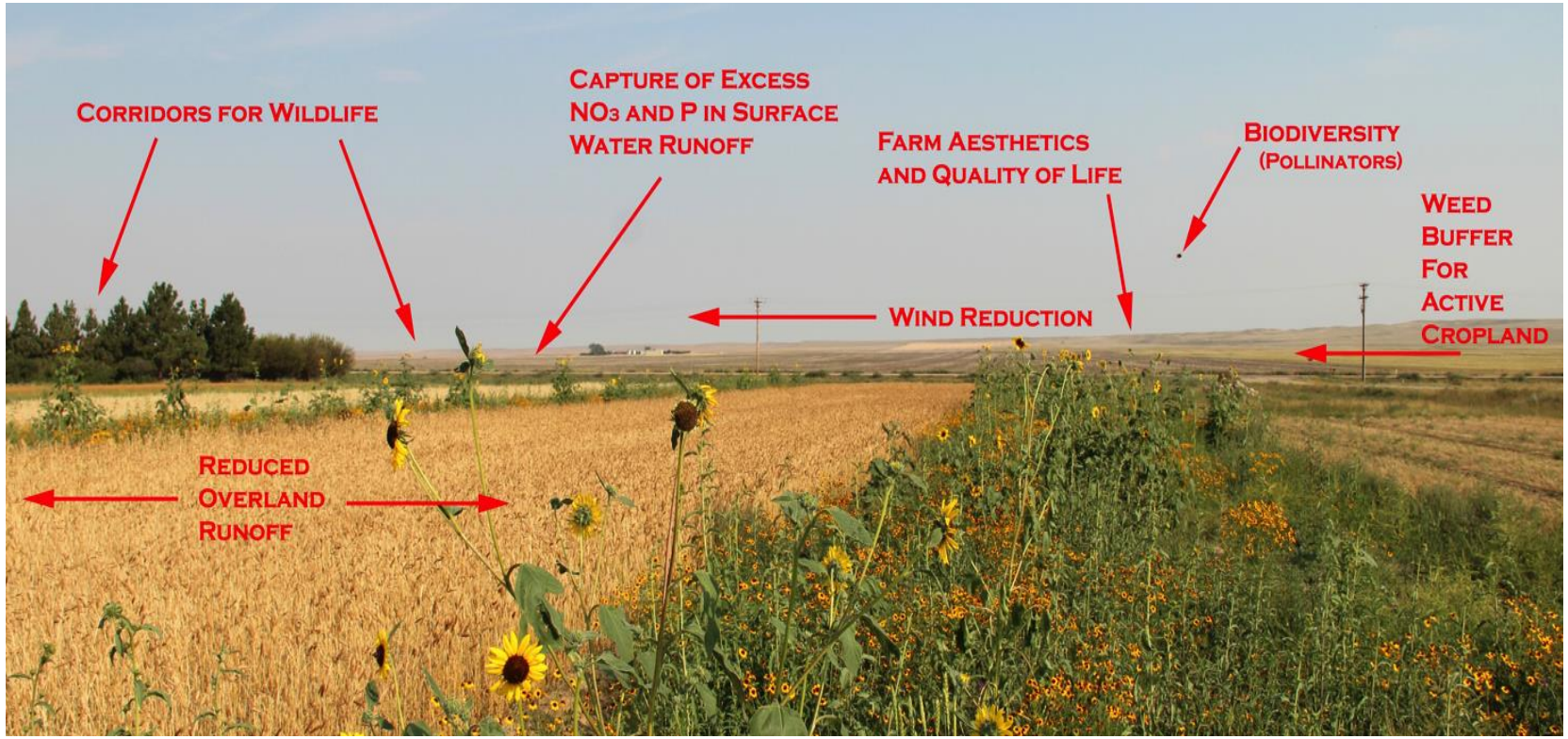

Photo: Jennifer Hopwood

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Keep Part of the Farm in Permanent Cover

Hedgerows

- Ancient practice, living fences
- Attract beneficial birds for a 33% reduction of some pests
- Pest management & pollination value offsets costs in 5 – 10 years

Photo: Jessa Kay Cruz

Kross, S. , T.R. Kelsey, C. McColl, J. Townsend. 2016. Field-scale habitat complexity enhances avian conservation and avian –mediated pest-control services in an intensive agricultural crop. Agriculture, Ecosystems & Environment. 225:140-149.

*Morandin, L., R. Long, and C. Kremen. 2014. Hedgerows enhance beneficial insects on adjacent tomato fields in an intensive agricultural landscape. Agriculture, Ecosystems, and Environment. 189: 164-170.

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Rethinking Treated Cash Crop Seed

- Contrary to IPM (prophylactic use)
- Highly toxic to bees and beneficials
- Persist for years
- Water soluble
- No yield increases for Midwest soybeans compared to IPM

Photo: Adam Varenhorst

Krupke *et al*., 2017. Assessing the value and pest management window provided by neonicotinoid seed treatments for management of soybean aphid (Aphis glycines Matsumura) in the Upper Midwestern United States. Pest Management Science.

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Rethinking Treated Cash Crop Seed

As Beneficial Insects Decline, Pest Increase

Pennsylvania: Loss of predatory beetles makes slug outbreaks worse

Predatory Beetles

Primary predators of slugs; susceptible to insecticides

Slugs

Not a pest of soybeans until recently; immune to neonicotinoids

Photos: Penn State University

Douglas et al. 2015. “Neonicotinoid Insecticide Travels through a Soil Food Chain, Disrupting Biological Control of Non-Target Pests and Decreasing Soya Bean Yield.” J Appl Ecol 52 (1): 250–60.

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Additional Resources

Part 5

Photo: Eric Lee-Mäder

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BENEFICIAL INSECTS FOR NATURAL PEST CONTROL:

Soil Scouting

PURPOSE

Beneficial insects like predatory ground beetles and spiders can provide important natural pest control in a farm or garden setting. This guide and worksheet is designed to help you assess the presence of predatory organisms that hunt and rest on soils. Using catch-and-release pitfall traps, you will be able to easily detect and count these soil-surface predators. Use this guide along with our flower and foliage scouting guides to gain a better understanding of the beneficial insect community on your farm.

WHAT YOU NEED	• Clipboard , worksheet copy, and pen/pencil • Small spade or trowel • Containers for pitfall traps (e.g., plastic drinking cups or large yogurt containers, ideally with lids) • Flags or stakes (to mark trap locations)
WHERE TO USE	Undisturbed habitats adjacent to crops (e.g. field borders, hedgerows, woodland edges) or within crops (e.g. cover crops, beetle banks, insectary strips). Scouted habitat areas should be located in full sun and protected from pesticide applications.
WHEN TO USE	Twice per year, July-September • Visits separated by at least 1 month • Deploy pitfall traps in early evening • Empty traps as soon as possible the next morning Warm conditions with daytime temperatures >60 °F (15.5 °C) Avoid sampling in rainy conditions that may flood traps

HOW TO SCOUT

You will be setting out catch-and-release pitfall traps (see photo, right) to observe and record soil-surface predators. The number of traps you will set out is dependent on the number of habitat areas you are interested in monitoring. We recommend one or two pitfall traps per habitat feature of interest, placed at least 50 ft. apart (further apart in larger habitat areas).

- **Select habitat area(s) you want to monitor.**
- **Deploy traps in late afternoon or early evening.** Dig an appropriate-sized hole in each location you wish to survey. Place container (lidded if possible) inside the hole so that its rim is level with the soil surface. (Using lid prevents dirt from spilling into bottom of the trap, and a dirt-free container makes trap evaluation easier the next morning.) Once the container is well-positioned, fill dirt in around the container and carefully remove the lid.
- **Use flags or stakes to mark trap locations.** Mark trap locations to ensure you can find traps again the next morning.
- **Revisit traps the following morning.** Use provided worksheet to record any predators in traps. Use photos at right for guidance on commonly caught predators.
- **Remove trap, or place lid on the trap (if reusing).** The stake/flagging should be left in place for the next survey date. Traps can be left in place, but must be covered to prevent further captures during the interim period. If farm practices (like mowing) prevent use of physical markers in some habitat areas, then a detailed description of trap locations is needed.

Acknowledgments: Guide created by Thelma Heidel-Baker, Sarah Foltz Jordan, Jarrod Fowler, and Eric Lee-Mader of The Xerces Society. All photos taken by Sarah Foltz Jordan.

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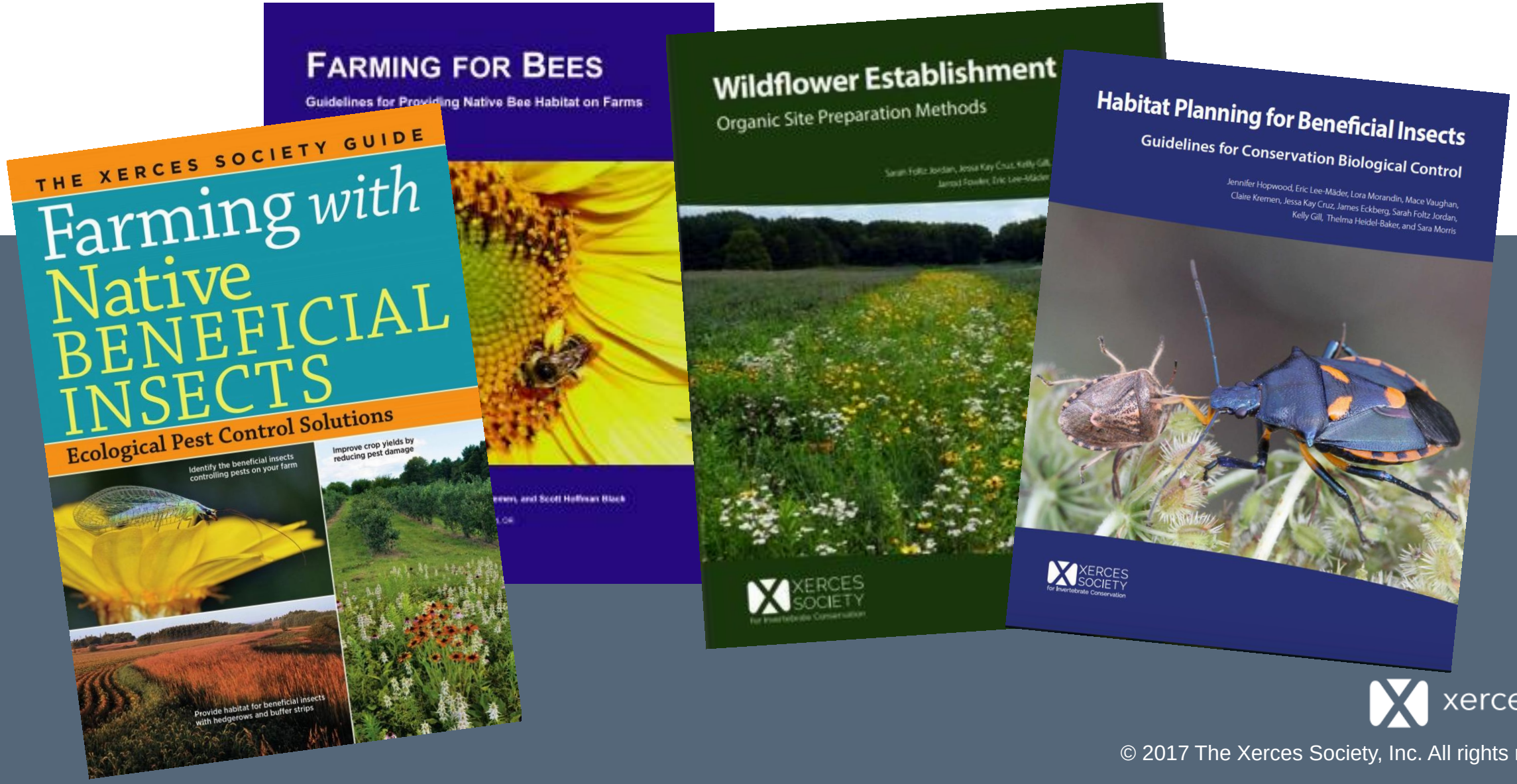

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Thank You

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