

On-Farm Habitat Restoration Using Transplants

Practical Farmers of Iowa
Jan 17-19, 2019

Jon Judson
Diversity Farms

Sarah Foltz Jordan
Xerces Society



Photo: Sarah Foltz Jordan



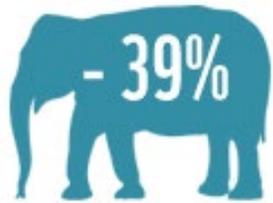
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Living Planet Index - Meta Analysis

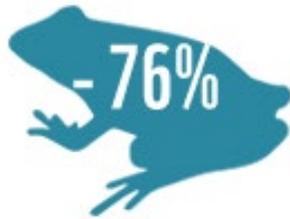
Earth has lost >50% of its wild animal populations in the past 40 years



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



TERRESTRIAL SPECIES DECLINED BY 39 PER CENT BETWEEN 1970 AND 2010



THE LPI FRESHWATER SPECIES SHOWS AN AVERAGE DECLINE OF 76 PER CENT



MARINE SPECIES DECLINED 39 PER CENT BETWEEN 1970 AND 2010

Ecosystems are degrading at a rate unprecedented in human history

World wildlife populations halved in 40 years - report

[COMMENTS \(857\)](#)

By Roger Harrabin
BBC environment analyst



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

Insect populations are plummeting, even in natural areas

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>.

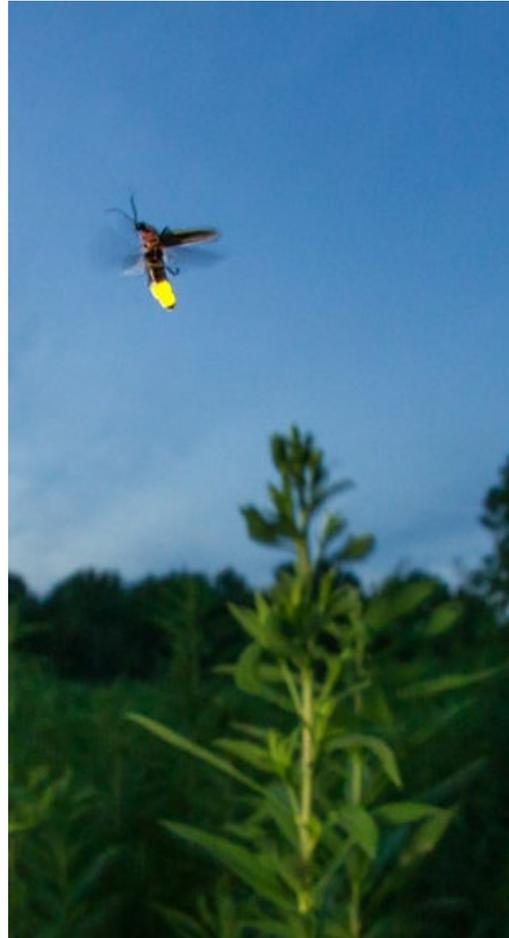


Photo: Alex Wild

The Washington Post

‘This is very alarming!’: Flying insects vanish from nature preserves

By Ben Guarino October 18



The white tent of a malaise trap in a nature reserve abutting farmland. (Verein Krefeld, entomologist)

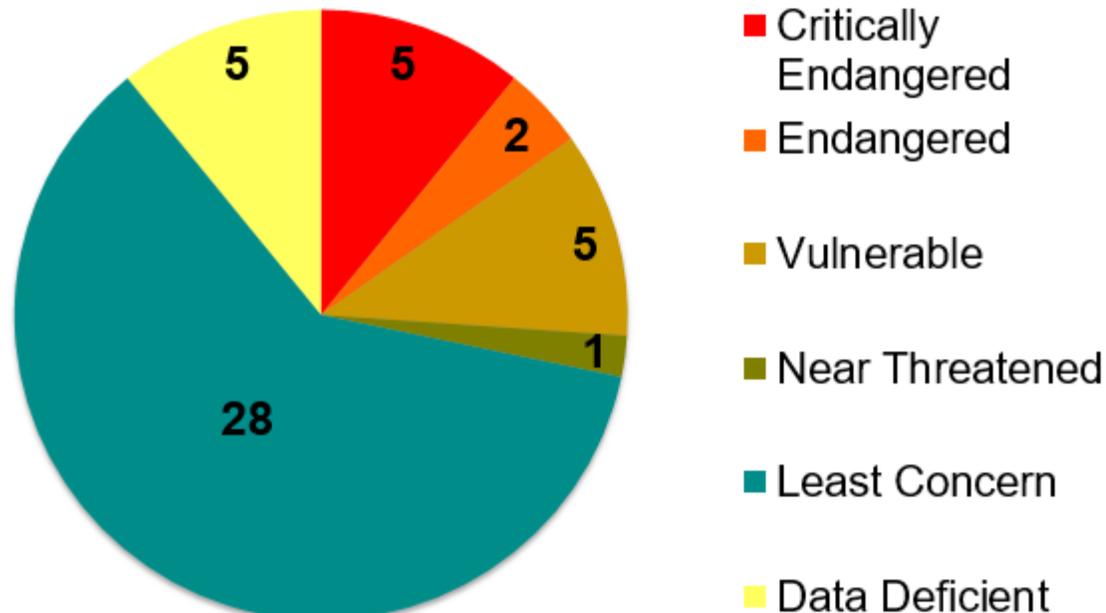
Not long ago, a lengthy drive on a hot day wouldn't be complete without scraping bug guts off a windshield. But splattered insects have gone the way of the Chevy Nova — you just don't see them on the road like you



Bumble Bees

25% of North American Bumble Bee Species At-Risk of Extinction

- Including 6+ species in the Upper Midwest
- Among the most important wild pollinators of crops and native plants



- Critically Endangered
- Endangered
- Vulnerable
- Near Threatened
- Least Concern
- Data Deficient

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

Photos: John Anderson, Johanna James-Heinz



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Butterflies are also in serious decline

- According to NatureServe, **at least 141 N. American butterfly species are considered at risk of extinction (18%)**
- Historically rare, specialist butterflies are at risk but we are also seeing **declines in many once wide ranging and common butterflies.**



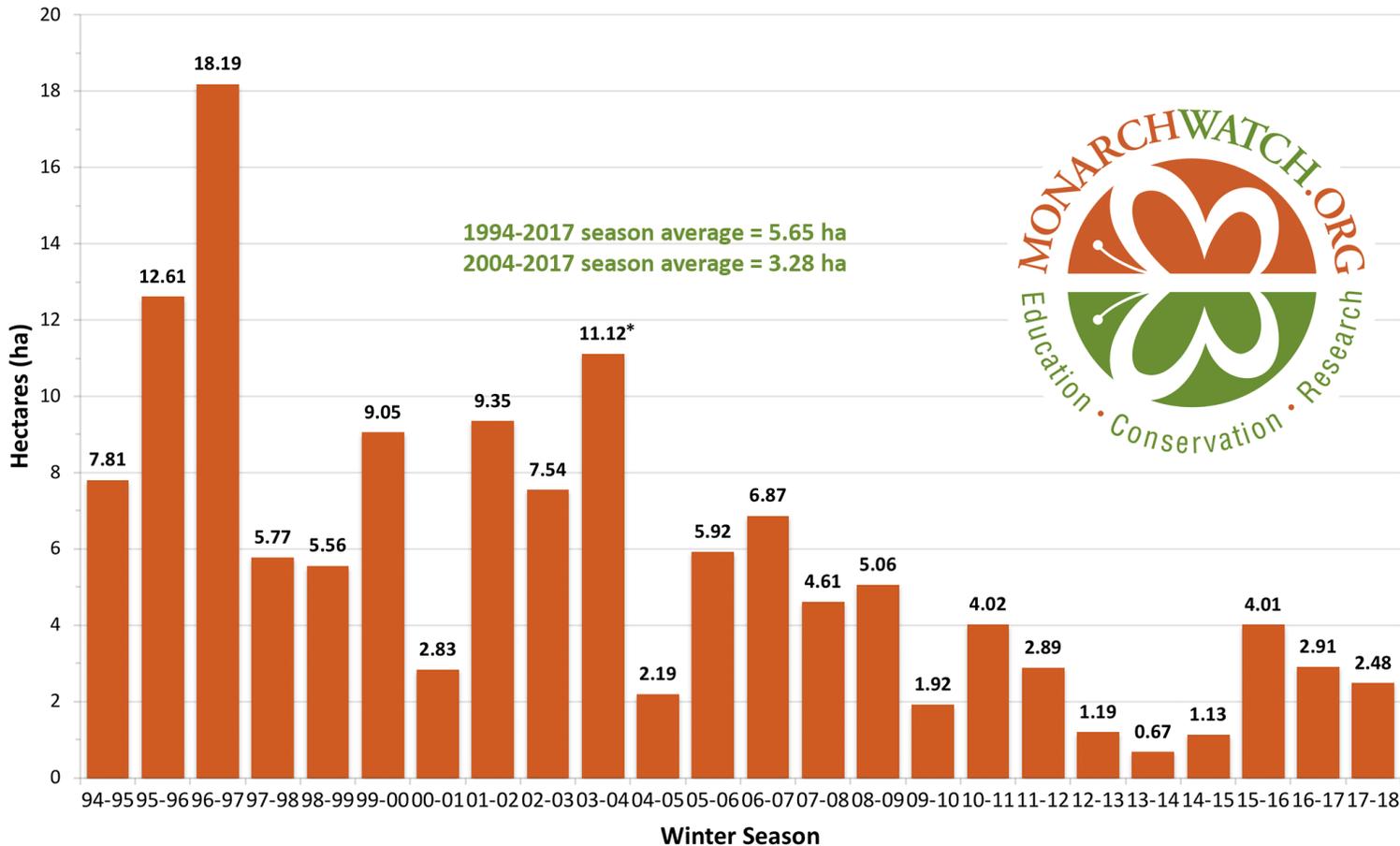
Photo: Cale Nordmeyer, MN Zoo

Monarch Status

Monarch Butterflies Decline >80% Since 1990s

1990s: **400 million** monarchs
 2016-17: ~60 million monarchs

Total Area Occupied by Monarch Colonies at Overwintering Sites in Mexico



Data for 1994-2003 collected by personnel of the Monarch Butterfly Biosphere Reserve (MBBR) of the National Commission of Natural Protected Areas (CONANP) in Mexico. Data for 2004-2017 collected by World Wildlife Fund Mexico in coordination with the Directorate of the MBBR.

* Represents colony sizes measured in November of 2003 before the colonies consolidated. Measures obtained in January 2004 indicated the population was much smaller, possibly 8-9 hectares. CT



What's at stake?

Pollinators are critical to our economy... and our diets!

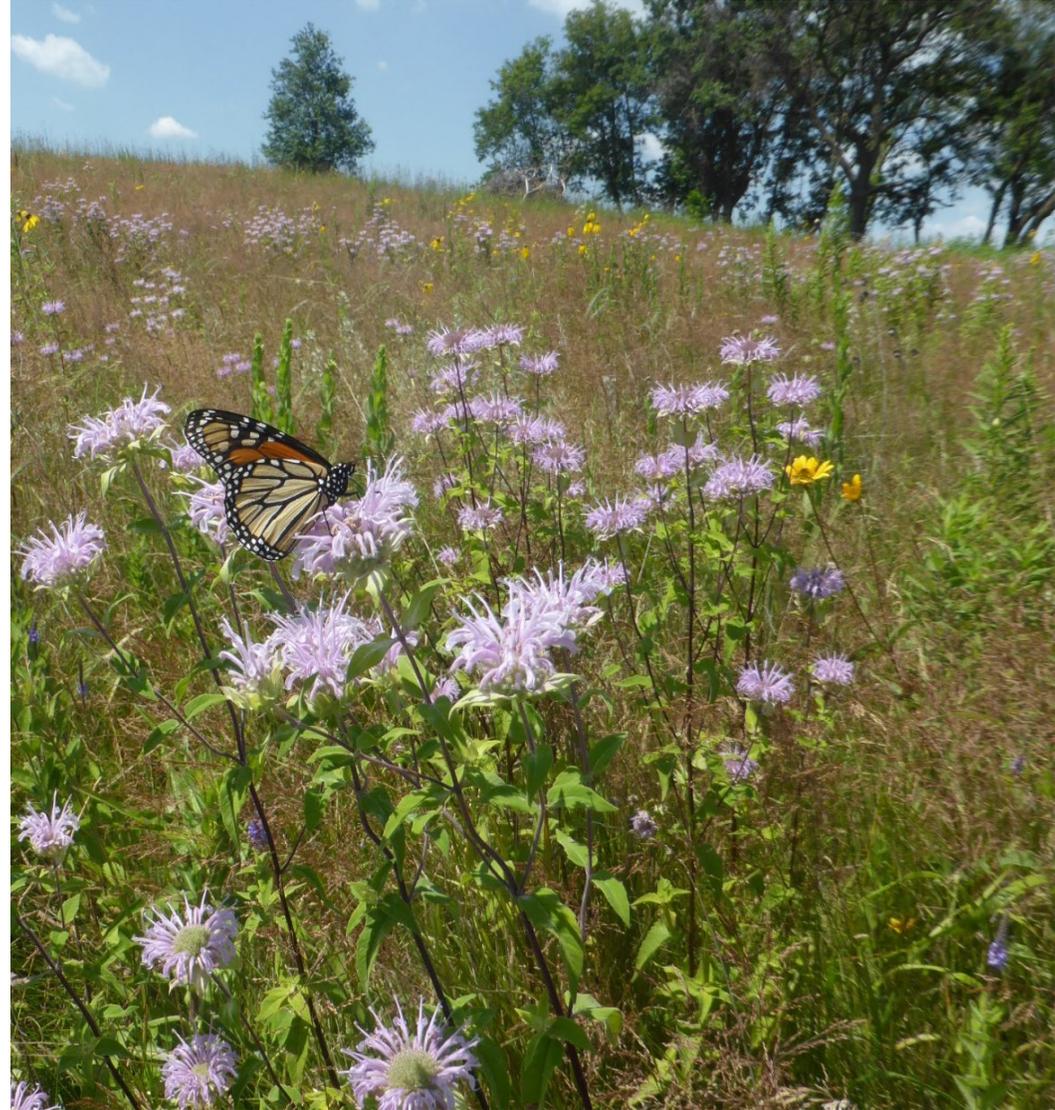
- 2/3 of crop plants (worldwide)
- 35% of crop production (worldwide)
- Many of our necessary vitamins and minerals come from insect-pollinated plants
- Over \$18 to \$27 billion value of crops in U.S. (\$217 billion worldwide)

Morse and Calderone 2000; Klein et al. 2007; Eilers et al. 2011



Pollinators are Critical to Ecosystem Health

- More than 85% (~240,000 spp.) of flowering plants require an animal, mostly insects, to move pollen
- Diversity and longevity of our wild plant communities depends on pollination



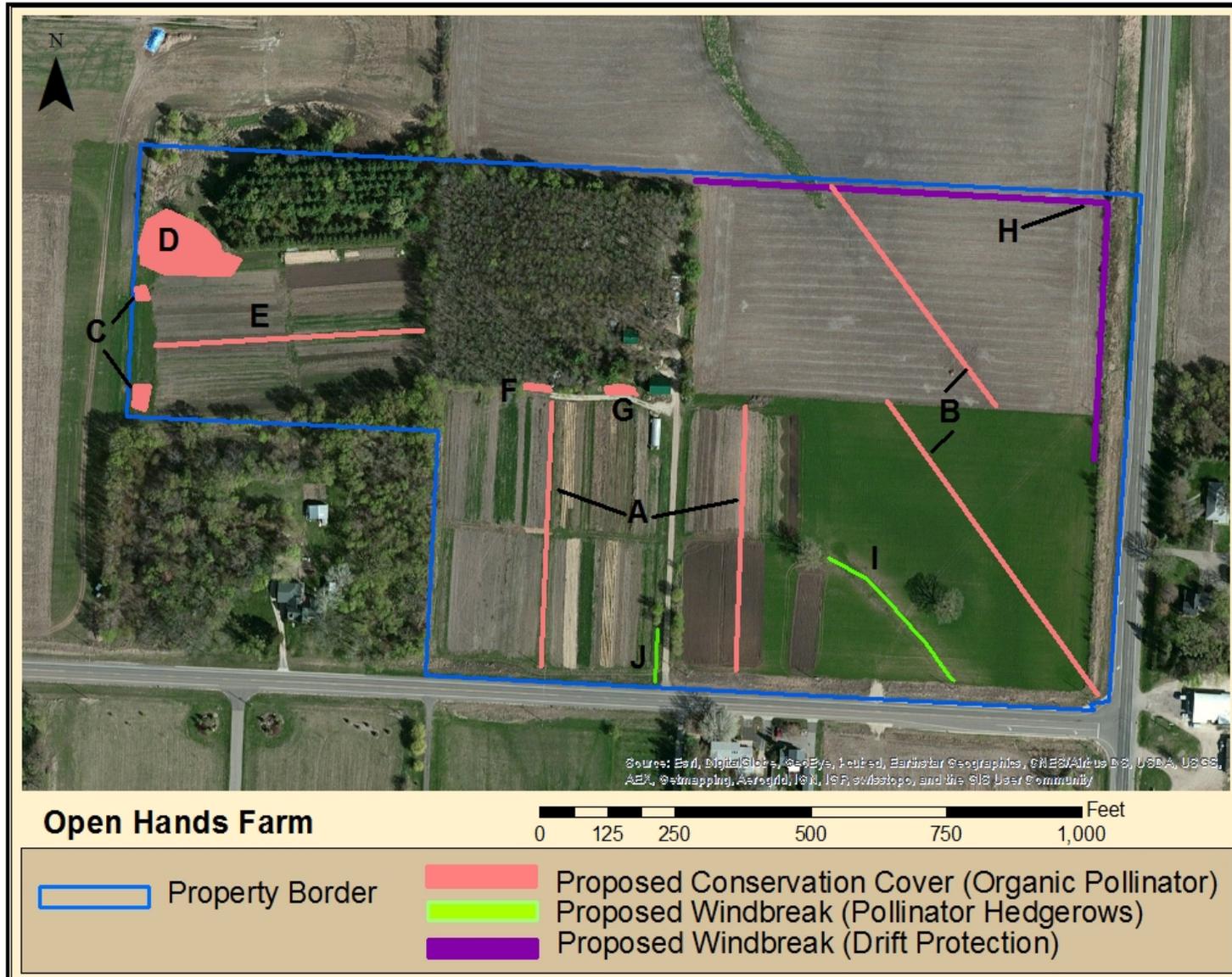
Ollerton et al. 2011. How many flowering plants are pollinated by animals? *Oikos* 120: 321-326.

Burkle, L.A., Marlin, J.C., and T.M. Knight. 2013. Plant-Pollinator Interactions over 120 Years: Loss of Species, Co-Occurrence, and Function. *Science* 339: 6127 pp. 1611-1615.

Native habitat is multifunctional



There are lots of habitat restoration options for farms



- Field Border Plantings;
Conversion of Fallow Areas
- Pollinator / Insectary Strips
- Beetle Banks
- Cover crops
- Flowering hedgerows
- Filter Strips, Contour Strips
- Understory Plantings
- Pasture Plantings
- Drift Protection (non-flowering hedgerows)

Farm Bill Programs, etc.

Native Habitat Restoration

Starting from Seed	Starting from Transplants
Low Cost	Can be low cost if you are set up to grow transplants yourself

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Less Control (design is limited to seed mix)	More Control & Design Opportunities (desired plants can be selected, clustered, evenly distributed, etc.)
Better for large areas	Better for small areas (1/10 acre = 4K plants)
Doesn't need irrigation	May require irrigation or water at time of transplant

Example: Open Hands Farm: ½ acre Native Habitat Restoration *From Seed*

Fall 2014



2015:
MOWING

Summer 2016



Example: Prairie Drifter Farm: 1000 ft. Native Habitat Strips *From Transplants*



- Native plants propagated in greenhouse
- Integrated into vegetable fields with same bed width as vegetables
- **Year 1: Irrigated & Cultivated like vegetable crop**
- **Year 2: cultivated once in spring; spot weeded in Sept.**
- **Year 3: spot weeded in Sept.**



Rapid Restoration!

- Dense & diverse wildflowers just ONE YEAR after planting
- Very little weed management needed



August 2017

Prairie Drifter Farm, Litchfield MN

Photos: Sarah Foltz Jordan

Example: Prairie Drifter Farm: Native Habitat Strips *From Transplants*



June 2017

Uproot Farm, Princeton, MN



July 2018

Photos: Sarah Foltz Jordan

Example: Grinnell Heritage Farm: Native “Beetle Banks” *From Transplants*



Ground beetles in numbers commonly found in Midwestern crop fields can remove:

Up to 4000 cutworms/acre/day

Up to 40 weed seeds/square ft/day

(Menalled and Landis 1997)

The combination of seeds and plugs

Example: Start with plugs, mulch and get them going well, add in seed later, after mulch has broken down. Sprinkle in purple prairie clover and black eyed susan, blue grama



Photo: Jon Judson

Example: Combining Seeds and Transplants: Del's Orchard

- Smother Crop Site Prep
- Planted native seed
- Included plugs of Lupin and New Jersey Tea



Invasive Weeds Summer



Buckwheat



Seeding Fall



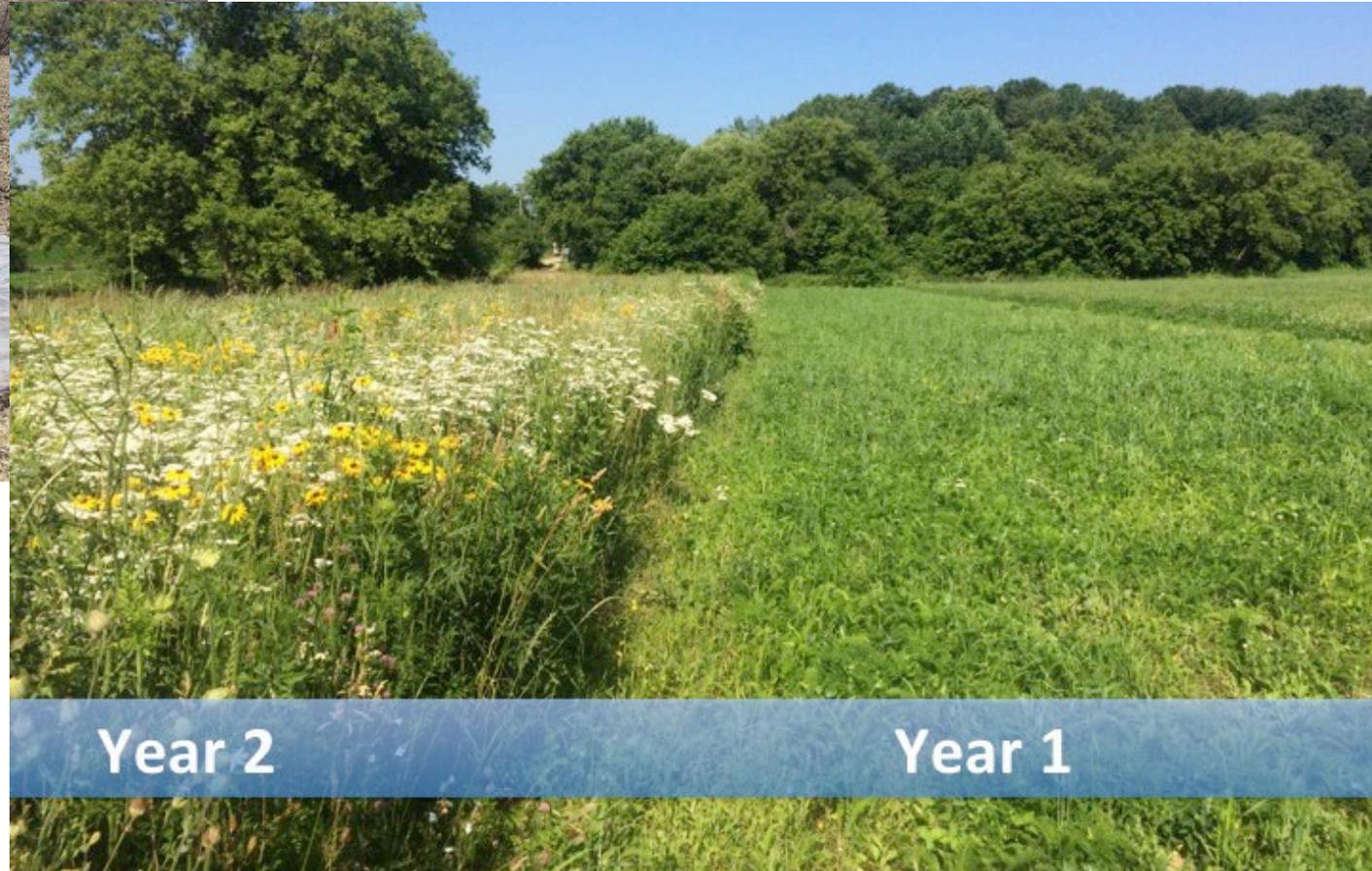
Summer 2017



Example: Combining Seeds and Transplants: Heidel Family Farm

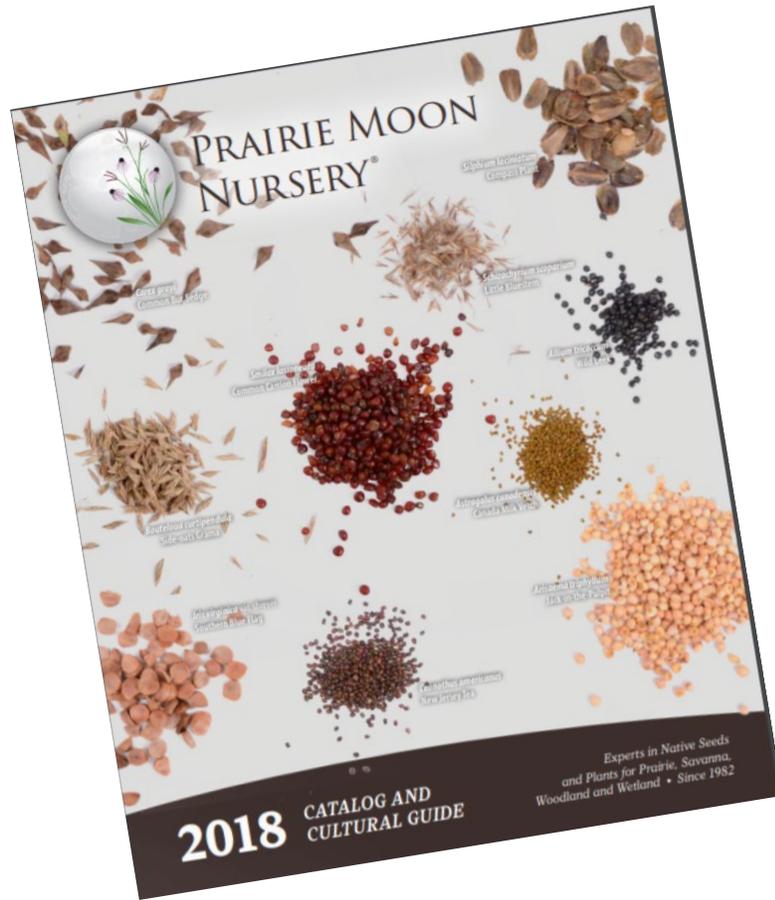
CAN OMIT THIS SLIDE IF TOO LONG

- Solarization Site Prep
- Planted native seed
- Included Liatris as a bare root plant
- Mowed around the Liatris when possible



Propagation Considerations: Germination

- Different species have different requirements to break dormancy
- Prairie Moon Cultural Catalog Germination Codes
- A is the easiest (no treatment)
- B needs hot water
- C needs cold-moist stratification for a few days to a few months
- H needs scarification
- Etc.



GERMINATION CODES AND INSTRUCTIONS

A **NO PRE-TREATMENT NECESSARY** other than cold, dry storage (also called dry cold stratification). Seed purchased from Prairie Moon has been stored under these conditions. Seed should germinate upon sowing in a warm location.

B **HOT WATER TREATMENT:** Bring water to a boil, remove from heat, pour over seeds, and soak at room temperature for 24 hours prior to planting.

C **STRATIFICATION NEEDED:** Seeds germinate after a period of cold, moist stratification. Approximate number of days needed is indicated in the parentheses, next to germination code C (e.g. C (60) = 60 days of cold, moist conditions needed). See indoor stratification recommendations, opposite page.

PLEASE NOTE: You do not need to stratify if you are fall planting or using a seed drill. Also, do not use this method if you are planting a seed mix and cannot keep the site moist.

Stratification Sand

We use fine sand as a medium to artificially stratify seed. We send one cup of sand which can be used to stratify up to 1/2 oz of seed (slightly more or less depending on seed size). We like this sand because, unlike other seed starting media, the uniform color and fine texture allows you to see your seed. *(includes shipping & handling)*

STRAT Seed Starting Medium \$7.00

D **SURFACE SOW:** Seeds are very small or need light to naturally break dormancy and germinate.

E **SEEDS NEED A WARM, MOIST PERIOD FOLLOWED BY A COLD, MOIST PERIOD.** Mix seeds with sterile medium, place mixture in a labeled, sealed plastic bag and store in warm (about 80°F) place for 60-90 days. Then place in refrigerator (33-38°F) for 60-90 days before sowing. Or, sow outdoors and allow one full year for germination.

F **SEEDS NEED A COLD, MOIST PERIOD FOLLOWED BY A WARM, MOIST PERIOD FOLLOWED BY A 2ND COLD, MOIST PERIOD.**

G **SEEDS GERMINATE MOST SUCCESSFULLY IN COOL SOIL.** Sow seeds in late fall (after hard frost) or early spring.



Starting Seeds
How to Grow Healthy, Productive Vegetables, Herbs, and Flowers from Seed
by Barbara Ellis

A succinct, compact manual containing all the basic information you need to successfully start plants from seed. Ellis covers the fundamentals of seed selection, soil preparation, proper light and moisture, helpful tools, creating a schedule, successful transplanting, troubleshooting tips, and a list of internet resources. This book is an excellent how-to guide for any gardener interested in saving money, experimenting with diversity, or avoiding chemicals. 121 pages.

START - \$9.00

H **SEEDS NEED SCARIFICATION:** For spring planting, Prairie Moon scarifies these seeds before shipping. Seeds for fall or frost planting are not scarified to prevent premature germination and winter kill.

I **LEGUME, RHIZOBIUM INOCULUM - INCLUDED**

Add inoculant to dampened seed and mix thoroughly at time of stratification (code C) or outdoor seeding. Inoculum aids in the fixation of atmospheric nitrogen and improves the long-term health of native plant communities.

INOCULUM FOR LEGUMES

We include genus-specific inoculum with legume seed free of charge. Additional inoculum can also be purchased. Choose from 79 different rhizobial inoculum strains on our website; search "inoculum".

INOCULSM Inoculates up to 2 oz seed \$1.50

J **DEHULLED** We remove the hulls from these legume seeds.

K **HEMIPARASITIC SPECIES** that needs a host plant. Good hosts for many parasitic species include low-growing grasses and sedges.

L **PLANT FRESH SEED OR KEEP MOIST.** Refrigerate until planting or starting other treatment.

M **BEST PLANTED OUTDOORS IN THE FALL.**

? **UNSURE:** Your input would be of interest to us.

Propagation Considerations:

Stratification

- Count backwards number of days required for stratification plus growing time.
 - e.g., C(30) requires 30 days of stratification, plus greenhouse growing time, before transplant will be ready to plant outdoors.
- Stratification Media: Moist Sand; Vermiculite; Moist Paper Towel (may depend on if you need to singulate seed after stratification)
- Scarification required for certain species
- Heat treatment required for some species
- Check on Seed Weekly
- Plant seeds when stratification time is up, or sooner if significant sprouting has occurred

OPTION 1 SAND (BEST FOR SOWING SEED IN ROWS)



1. GATHER SUPPLIES. PLACE A SMALL AMOUNT OF STRATIFYING MEDIUM INTO A BOWL. We are using ~1/3 cup fine stratification sand (see opposite page) with ~1/8 oz seed.

2. ADD WATER. 1 to 2 teaspoons is all we needed for this amount of sand.



3. MIX ONLY ENOUGH WATER TO ALLOW MEDIUM TO FORM INTO A BALL.



OPTION 2 PAPER TOWEL OR COFFEE FILTER



1. USING A CALENDAR AND OUR GERMINATION CODES, CALCULATE THE DATE TO START COLD, MOIST STRATIFICATION PRE-TREATMENT. Rinse or complete a short soak. Pour into a coffee filter, paper towel or fine screen to drain.



2. ARRANGE SEED IN A SINGLE LAYER AND ALLOW ALL EXCESS WATER TO DRAIN OFF.



3. FOLD SEED LOOSELY INTO THE COFFEE FILTER OR PAPER TOWEL TO ALLOW FOR WEEKLY SPOT CHECKS. The seed and paper should be damp but not wet.

Easy Wildflowers to Start With:

* no stratification needed

- Agastache spp. (hyssop)
- Asclepias incarnata (swamp milkweed) (*Germinate well but don't transplant well—sow directly)
- Aster novae-angliae and other spp. (New England aster and others) some*
- Coreopsis spp. (coreopsis)
- Dalea spp. (prairie clover)*
- Desmodium canadense (Canada tick trefoil)*
- Echinacea pallida (echinacea)*
- Eryngium yuccifolium (rattlesnake master)
- Eupatorium spp. (boneset, Joe Pye weed, etc)
- Helianthus spp. (native sunflowers)
- Helenium autumnale (sneezeweed)*
- Monarda spp. (bee balm, spotted bee balm)*
- Pycnanthemum spp. (mountain mint)*
- Penstemon spp. (penstemon) (damp off issues)
- Solidago speciosa (showy goldenrod and others)
- Silphium spp. (compass plant, cup plant, etc)
- Verbena spp. (vervain)
- Vernonia spp. (iron weed)



Easy Grasses/Sedges to Start With:

* no stratification needed

- *Andropogon gerardii* (big bluestem)*
- *Bouteloua curtipendula* (side-oats grama)*
- *Bouteloua hirsuta* (hairy grama) *
- *Bromus kalmii* (prairie brome)*
- *Carex brevior* (plains oval sedge)
- *Sporobolus* sp. (prairie dropseed and others)
- *Elymus* spp. (wild rye & bottlebrush grass)*
- *Schizachyrium scoparium* (little bluestem)*
- *Koeleria macrantha* (june grass)*
- *Panicum virgatum* (Switch grass)*
- *Sorghastrum nutans* (Indian grass) *
- *Stipa* sp. (porcupine grass) *



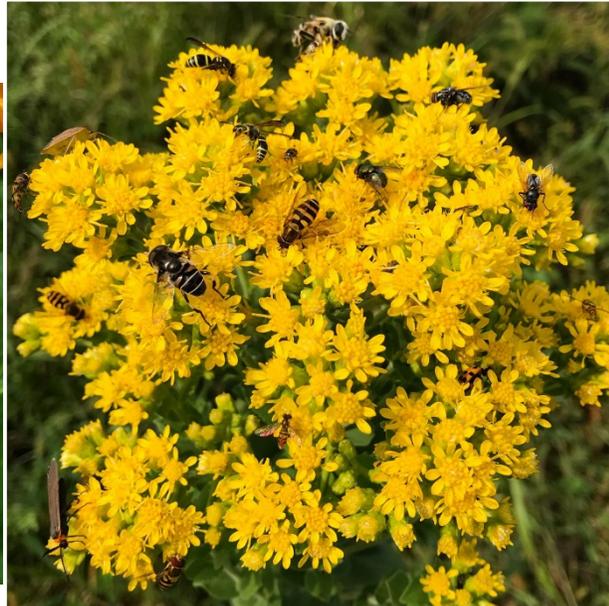
Photo: Xerces Society, Karin Jokela

Other Considerations for Species Selection

- **Soil Type:** Match the species habitat preferences to soil moisture conditions
- **Diversity!** Include representatives from as many plant families as possible
- Include species with **high pollinator value**
- Plan for **bloom succession** (pollinators need bloom all season long). Aggressive species as needed for resisting weed invasion
- **Locally adapted** species/ genotypes

NRCS	Nurseries / Seed Companies
Excessively drained	Dry
Somewhat excessively drained	Dry Mesic
Moderately well drained	Mesic
Well drained	Mesic
Somewhat poorly drained	Wet Mesic
Poorly drained	Wet Mesic
Very poorly drained	Wet

Photos: Sarah Foltz Jordan; Karin Jokela



Propagation Considerations: Seeding

- Potting Medium
 - Soil-less media ideal (light, well-drained, some fertility)
 - Example Recipe from Tallgrass Prairie Center:

Soil-less Mix Recipe

This recipe makes about 1 cubic yard of potting medium:

<i>Peat moss (4 cu. ft/bag)</i>	<i>2 bags (8 cu. ft)</i>
<i>Vermiculite (medium 4 cu. ft/bag)</i>	<i>1/2 bag (2 cu. ft)</i>
<i>Perlite (4 cu. ft/bag)</i>	<i>1/2 bag (2 cu. ft)</i>
<i>Sterile soil</i>	<i>two 5-gal buckets</i>
<i>Composted (sterile) manure</i>	<i>40-lb bag</i>
<i>Osmocote® Plus fertilizer 15-9-12 (180 days)</i>	<i>8 lb</i>



Photo: Jon Judson



Propagation Considerations: Seeding

Lots of Options

- Start in Open Flat (10 x 20) → transplant to individual cells
- Start in 128 → transplant to larger cells (leave in 128)



Photo: Karin Jokela



Photos: John Judson

Propagation Considerations: Seeding

- Sowing Depth
 - Small seeds are often surface sown; see “D” in Prairie Moon Cultural Catalog
- Legumes may benefit from inoculant



Black eyed Susan
(Rudbeckia hirta)
92,000 seeds/oz



Partridge pea
(Chamaecrista fasciculata)
2,700 seeds/oz

Even if you do everything right, germination is often poor and uneven....
and plant growth is slow. PLAN FOR THIS



Design Considerations: Site Selection

- Larger is better, but any size is better than none!
- Place plantings where pollination / pest control services are most needed
- Place plantings away from crop fields with pesticide use
- Minimize edges where weeds can encroach



Photo: Jon Judson

Perennial Insectary Strips

- Permanent mass wildflower plantings integrated into crop fields
- **Promote movement of pollinators and beneficial insects in the INTERIOR of the farm**



Outplanting your Transplants:

- Different species will be ready to outplant at different times (but can “hold” well in their containers until everything is ready)
- **Spring planting** – allows for growth and possible bloom before winter
- **Fall planting** – more consistent moisture
- Summer planting – ok if irrigation is possible
- Water thoroughly before bringing into the field
- Spacing: plant on 8 to 12 inch centers (or closer/farther depending on species)
- Water-wheel transplanter; by hand; etc.



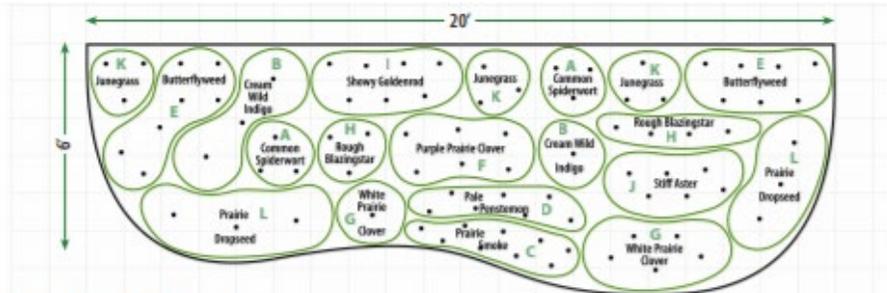
Outplanting your Transplants: Example: 1.5 days, 17K plants, 30 people!



Photo: Jon Judson

Planting Considerations: Design

- Clustering Species vs. Spreading Evenly
- Integrate plenty of native grasses (50:50 can really help with weedy grass invasion)



Dry Pollinator Garden

Common Name	Latin Name	No. of Plants	Height	Spacing	Flower Color
Early Bloomers					
A Common Spiderwort *	<i>Tradescantia ohiensis</i>	6	2'-4'	1'	Blue
B Cream Wild Indigo	<i>Baptisia bracteata</i>	4	1'-3'	1'-3'	Cream
C Prairie Smoke	<i>Geum triflorum</i>	9	6"	6"-1'	Pink
D Pale Penstemon *	<i>Penstemon pallidus</i>	7	1'	6"-1'	White
Mid Season Bloomers					
E Butterflyweed	<i>Asclepias tuberosa</i>	14	2'-3'	1'-18"	Orange
F Purple Prairie Clover	<i>Dalea purpurea</i>	6	1'-2'	1'	Purple
G White Prairie Clover	<i>Dalea candida</i>	6	1'-2'	1'	White
Late Season Bloomers					
H Rough or Meadow Blazingstar	<i>Liatriis aspera</i> or <i>Liatriis ligulistylis</i>	7	2'-5'	6"-1'	Purple
I Showy Goldenrod*	<i>Solidago speciosa</i>	7	1'-3'	1'-18"	Yellow
J Stiff Aster*	<i>Aster linariifolius</i>	6	1'-2'	1'	Purple
Grasses					
K Junegrass	<i>Koeleria macrantha</i>	9	2'-3'	1'-3'	—
L Prairie Dropseed	<i>Sporobolus heterolepis</i>	6	2'-3'	2'-3'	—

* Reseeds readily. Remove spent flowers before the plant goes to seed.



Diagram: Illinois NRCS; Photo: Karin Jokela

Weed Control at Planting Time



Straw Mulch



Biodegradable Weed Guard



Ongoing Weed Control



Cultivate edges



Mow edges



Controlled Burn

Crop-Related Concerns:



Photos: Xerces Society / Karin Jokela

Spread of Natives into Crops?

- Mostly not an issue; Tillage keeps most things in check
- Partridge pea (annual legume) can spread

Shading of Adjacent Crops? Flopping?

- Mostly not an issue, but if that's a concern, select shorter stature plants

Crop-Related Concerns:



Strips may capture snow drift, adding moisture to adjacent fields → slower drying, slower warming in spring

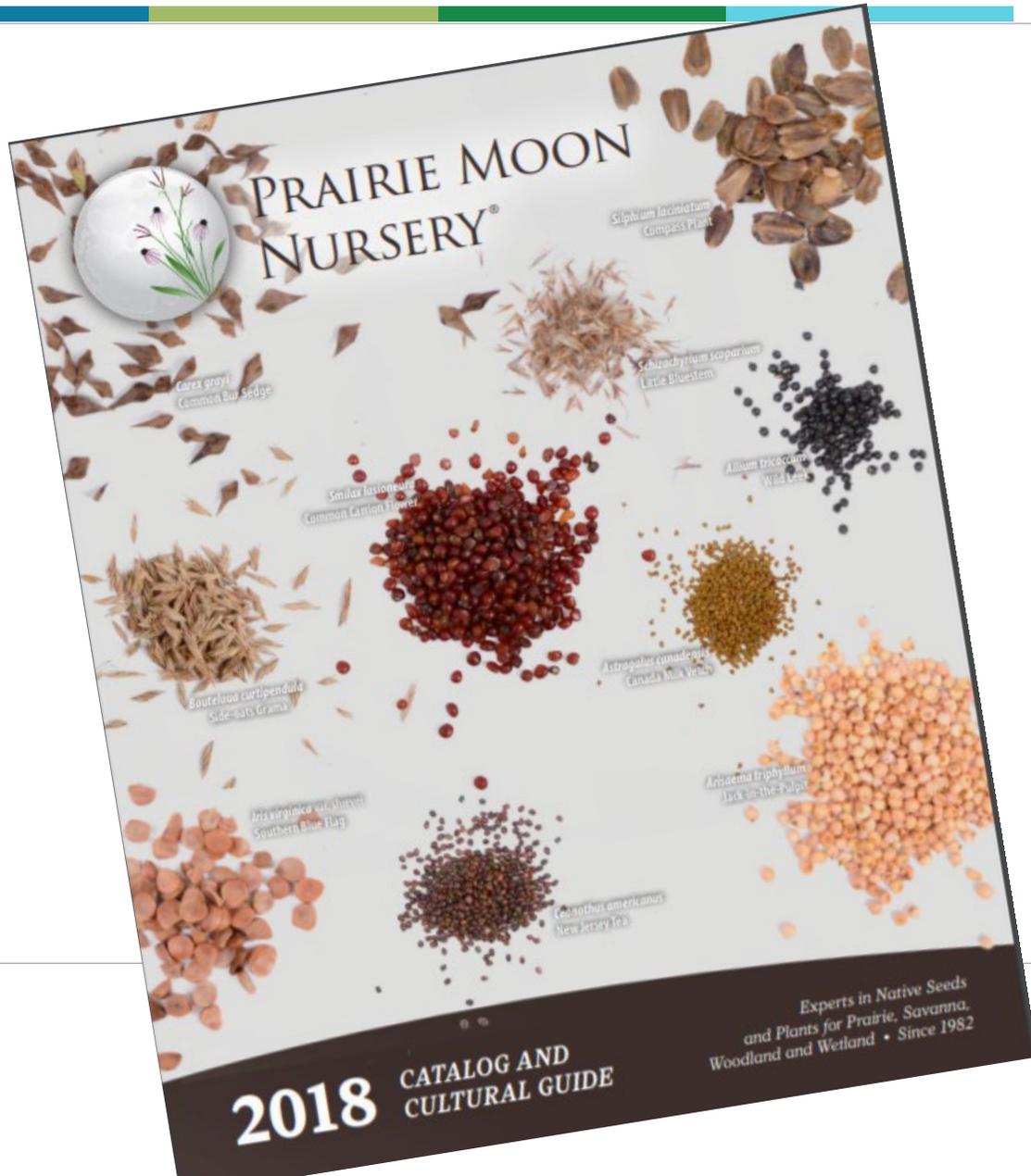
Additional Resources: Tallgrass Prairie Center Technical Guides

<https://tallgrassprairiecenter.org/technical-guides>

1. Seed collecting from tallgrass prairies
2. Drying, cleaning and storing prairie seed
3. Propagating native plants
4. Recognizing and appreciating tallgrass prairie remnants
5. Native seed source and quality
6. Designing seed mixes
7. Site preparation
8. Seeding
9. Initial post seeding and early reconstruction management
10. Evaluating stand establishment



Additional Resources: Prairie Moon Cultural Catalog



Additional Resources: Xerces Society: Harvesting & Using Your Own Seed

Collecting and Using Your Own Wildflower Seed

To Expand Pollinator Habitat on Farms

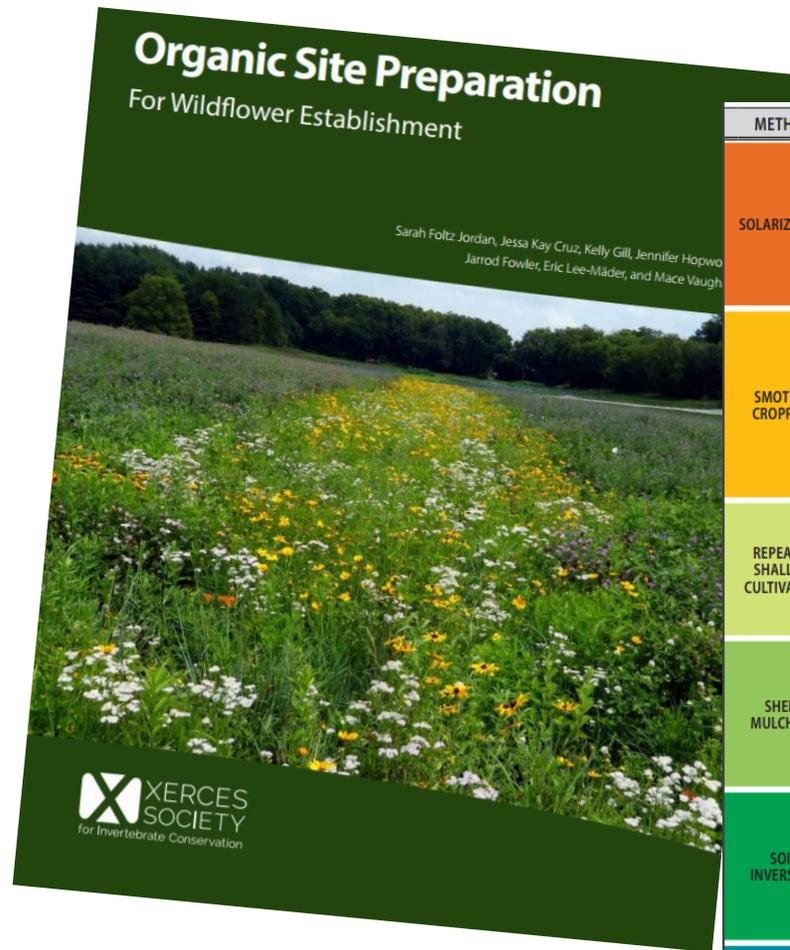
James Eckberg, Jennifer Hopwood, and Eric Lee-Mader



Native wildflowers are the backbone of pollinator habitat on the farm. Field borders, filter strips, pastures, hedgerows, and other places where wildflowers (and grasses) grow also provide us with natural pest control by sustaining predators of crop pests. Additionally, these plants help filter rainfall from fields, and protect soil from erosion. Despite the benefits that native wildflowers and grasses provide, the cost of seed can be daunting. Fortunately, if you have native plant areas already established, they can provide you with a readily available source for additional seed.

While harvesting seed from existing wildflowers around the farm may not yield large volumes, it can provide you with the raw material to gradually create more habitat on the farm. By collecting seed from plants already growing on your land, you are also increasing your efforts on species that are known to perform well on your soils. In this document we outline the basic steps of collecting native plant seed using readily available, non-specialized equipment. While our focus is primarily on wildflowers, many of these same techniques can be useful for collecting native grasses as well as seeds from trees and shrubs.

Additional Resources: Xerces Site Preparation / Weed Control



METHOD	WHEN TO USE	WHEN NOT TO USE
SOLARIZATION	<ul style="list-style-type: none"> ✓ Flat or gently sloping sites with low risk of erosion ✓ Sunny sites ✓ Small sites, ≤½ ac (see page 10 for solarization options for large sites) ✓ Cultivation equipment is unavailable ✓ Used clear UV-stable plastic is available or new is affordable ✓ Minimal maintenance of the site during summer is desired 	<ul style="list-style-type: none"> ✗ Steep slopes or areas with microtopography ✗ Shady or wet sites ✗ Large sites (>½ ac) ✗ Regions where average summer temperatures are low ✗ Clear UV-stable plastic is unavailable or unaffordable ✗ Sites where deer pressure is high, as deer can easily puncture plastic
SMOTHER CROPPING	<ul style="list-style-type: none"> ✓ Flat or gently sloping, sunny, and well-drained sites ✓ Cover crop rotations are already used or easily fit into existing operations ✓ Weed pressure is low to moderate ✓ Timelines can be strictly followed throughout entire site prep process ✓ Proper equipment is available and can be calibrated and operated specifically for cover-cropping ✓ Irrigation is available and can be used as needed ✓ Minimal maintenance of the site during summer is desired 	<ul style="list-style-type: none"> ✗ Steep slopes/sites with high erosion potential or poor drainage ✗ Cover crop rotations are not used or do not fit into farm plan ✗ Weed pressure is high (i.e., fallow fields) ✗ Timelines cannot be strictly followed (see text) ✗ Proper equipment for planting and termination are not available ✗ Irrigation is not available or easily accessed ✗ In designated wetlands or area with poorly drained soil ✗ Where planting non-native plants is prohibited or native plants may be threatened by the unintentional escape of non-native/cultivated species
REPEATED SHALLOW CULTIVATION	<ul style="list-style-type: none"> ✓ Flat or gently sloping, sunny or shady sites ✓ Transitioning crop fields or sites with low weed pressure ✓ Proper equipment is available and can be used for this purpose ✓ Irrigation is available ✓ Timelines can be strictly followed throughout entire site preparation process 	<ul style="list-style-type: none"> ✗ Steep slopes ✗ Where erosion is of concern ✗ Site is followed or weed pressure is medium to high ✗ Shallow tillage equipment is unavailable (see Appendix B) ✗ Irrigation is unavailable ✗ Designated wetlands or areas with poorly drained or fragile soil
SHEET MULCHING	<ul style="list-style-type: none"> ✓ Flat or gently sloping, sunny or shady, and humid sites ✓ Small sites, up to ~½ ac ✓ Cultivation is impractical (e.g., rocky conditions, weed pressure, etc.) ✓ Minimal maintenance of the site is desired ✓ Mulching materials are available or affordable ✓ Solarization is impractical (e.g., plastic unavailable/unaffordable, shady) 	<ul style="list-style-type: none"> ✗ Steep slopes or arid sites without irrigation ✗ Large sites (>½ ac) ✗ Arid or semi-arid climates without access to irrigation ✗ Site contains aggressive or persistent deep-rooted, perennial, rhizomatous or woody weeds ✗ Mulching materials are unavailable or unaffordable (see text)
SOIL INVERSION	<ul style="list-style-type: none"> ✓ Flat/gently sloping sites; sites where soil erosion is not a concern ✓ Large sites, >½ ac ✓ Sites with medium to high weed pressure or dense grass sod ✓ Effective on sunny or shady sites ✓ Moldboard plow is available or affordable and an experienced operator is available 	<ul style="list-style-type: none"> ✗ Steep slopes ✗ Erosion concerns are very high ✗ Moldboard plow is unavailable or unaffordable ✗ Abundant deep-rooted perennial weeds (less susceptible to method) ✗ Weed pressure is low and other methods can be used
ORGANIC HERBICIDE APPLICATIONS	<ul style="list-style-type: none"> ✓ Flat to sloping, sunny or shady sites ✓ Cultivation is impractical (e.g., rocky conditions or conservation concerns) ✓ Targeted weeds are annual broadleaf species (see text) ✓ Targeted weeds are at seedling stage 	<ul style="list-style-type: none"> ✗ Application equipment is unavailable or unaffordable ✗ Targeted weeds are monocots (grasses), succulents, or perennials ✗ Targeted weeds are taller than 6" ✗ Water pollution concerns are high
SOD REMOVAL	<ul style="list-style-type: none"> ✓ Sites composed of dense sod, regularly mowed for several years ✓ Small sites (<¼ ac) where sod removal is feasible 	<ul style="list-style-type: none"> ✗ Large sites where sod removal would be impractical

- Solarization
- Smother Cropping
- Repeat Cultivation
- Soil inversion
- Organic Herbicides
- Sheet Mulching
- Sod Removal
- Weed barriers
- Burning
- Livestock Rooting

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