Maintaining Diverse Stands

of Wildflowers Planted for Pollinators

Ongoing Management of Pollinator Habitat

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XERCES SOCIETY
for Invertebrate Conservation

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The Xerces Society for Invertebrate Conservation

www.xerces.org

The Xerces® Society for Invertebrate Conservation is a nonprofit organization that protects wildlife through the conservation of invertebrates and their habitat. Established in 1971, the Society is at the forefront of invertebrate protection, harnessing the knowledge of scientists and the enthusiasm of citizens to implement conservation programs worldwide. The Society uses advocacy, education, and applied research to promote invertebrate conservation.

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Photographs & Artwork

Cover: Native pollinator planting featuring *Gilia*, *Phacelia*, *Clarkia*, and *Grindelia*, in a California almond orchard.

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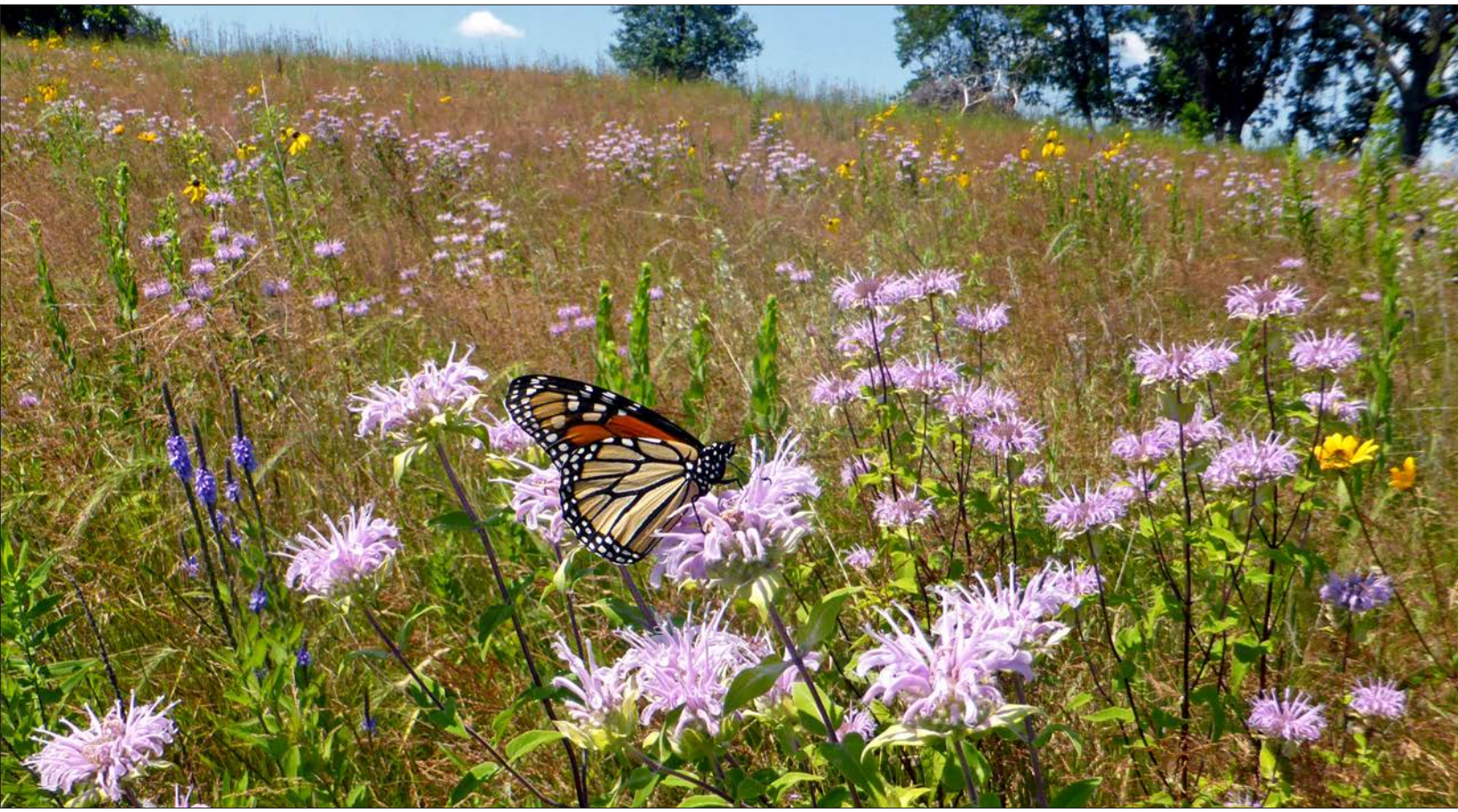
Contents

Importance of Long-term Management 1

Land managers, including farmers, are increasingly integrating pollinator habitat into farms to support pollinators and the crop pollination services they provide. These habitats, which typically consist of wildflower-rich field-borders, often require some level of ongoing management to maintain high flower diversity and abundance for foraging pollinators. Poor establishment, poor seed quality, effects of succession (e.g., woody plants begin to shade out wildflowers), overly vigorous native flowers, and invasion of weedy species can all degrade the plant community, requiring management action to improve the habitat for pollinators. When coupled with active monitoring, ongoing habitat management is an efficient use of time and resources capable of detecting and preventing problems before they degrade plant communities and adversely affect the pollinator value of the habitat.

This guide is intended to facilitate management of wildflower habitat in the years after initial establishment. First we discuss the characteristics that impact the pollinator value of planted wildflower habitat, and then we review the key steps in the management process. Next, we summarize the management tools most likely to sustain wildflower populations, which in turn support bees and other pollinators, and finally we provide diagnostic tools to help select appropriate management techniques for an array of potential habitat conditions. The management techniques described here are best suited to pollinator habitats in agricultural environments that range in size from 0.5–5 acres; they can be applied in other contexts but additional factors, such as sensitive or rare species and regulatory requirements, should be considered in natural habitats that are not covered in this document.

Figure 1.1: It's important to include wildflowers with overlapping bloom times from spring through fall in pollinator plantings in order to support diverse pollinators. For example, in the upper Midwest, an array of wildflowers provides nectar for migratory monarch butterflies (*Danaus plexippus*).



2 *Characteristics of Functional Pollinator Habitat*

Before determining whether wildflower habitat requires management, it is helpful to know the conditions that best support pollinators. Functional pollinator habitat has multiple species of wildflowers that start blooming in early spring and continue through fall (exact timing depends on the region; see Regional Differences Table). Periods of bloom should overlap rather than leaving time periods when nothing is in bloom, also known as gaps in bloom. We generally define a gap in bloom as a two week period when there is less than 10% cover of blooming wildflower species. Different pollinators rely on different plant species; therefore in order to support a robust pollinator community, wildflower habitat should contain a wide variety of native species present.

The key features that indicate pollinator habitat can support diverse, abundant populations of wild bees are:

- A diversity of desirable, pollinator-attractive plant species, with no single species dominant.
- Species that bloom in overlapping succession all season long (spring, summer, fall), with at least three species, ideally many more, blooming at any given time.
- Dominant plants are wildflowers (some weeds may be present, but they are not outcompeting wildflowers).
- Desired plant species persist over time.
- If unwanted weedy species are present, they are non-invasive and unlikely to compete with desirable species.

Overlapping Bloom

Many pollinators are only active during a portion of the growing season, while some forage throughout the entire growing season. During their flight periods, pollinators require a steady supply of pollen and nectar. A diverse community of pollinators is therefore best supported by wildflower habitat that contains numerous species with overlapping bloom periods. This is because gaps between bloom periods could force resident pollinators to abandon a site. We define a gap in bloom as a period of time when wildflower bloom is sparse or nonexistent (less than 10% cover of blooming wildflower species) for a two week period. Determining a gap in bloom can vary regionally. For example, wildflowers begin blooming as early as February in California, while bloom begins later in the spring—in March in the South/South Central states and around April/early May in the Midwest and East Coast. Some bloom expectations are consistent across regions: bloom should last until late October (under normal rainfall), when most of the pollinators have ceased activity in all regions.

It can be helpful to set specific goals for the planting, and refer back to them to ensure it is fulfilling its intended function. An example goal would be: wildflowers provide bloom throughout the growing season and weedy species cover is low (< 25%), with no problematic species present. It is also recommended to use the initial seed list to create a Pollinator Habitat Installation Plan, which can later be used as a point of reference when monitoring and evaluating the habitat (see an example Pollinator Habitat Installation Plan on p. 4). Ideally native species seeded into the site were well-adapted for the local site and weather conditions, and therefore expected to thrive. If so, then ask the following questions:

- Are all species planted present?
- Do wildflowers or weedy species dominate?
- Is a diversity of species present in each season?
- Are any problematic weed species present?

If answers to these questions indicate that wildflowers are not diverse and dominant in the habitat site, then management activities are likely necessary. The best way to determine the answers, though, is through routine monitoring of the wildflower habitat.

POLLINATOR HABITAT INSTALLATION PLAN

STEP 1—Habitat Installation Record

1. **Photocopy or print a copy** of this form in advance (www.xerces.org/habitat-assessment-guides);
2. **Record all of the species** initially seeded into the site and any desirable native species remaining after site preparation BEFORE the first monitoring (i.e., during or immediately after planting); AND
3. **Save a copy** of your Plan to work from during each monitoring.

SITE NAME: ______________________ **INSTALLATION DATE:** ______________

KEY SITE DETAILS that may impact wildflower establishment (e.g., weed pressure/species of concern, site history, soil characteristics, etc.):

____

____

STEP 2—Site Preparation & Habitat Installation

Site preparation is **one of the most important** and often inadequately addressed components for project success. It is also a process that may require more than one season of effort to reduce competition from invasive, noxious, or undesirable plants prior to planting. *In particular, site preparation should focus on the removal of perennial weeds* (there are more options to address annual or biennial weeds after planting). For more information on recommended site preparation methods, see *Wildflower Establishment: Organic Site Preparation Methods* or other habitat installation guides available at: www.xerces.org/pollinator-habitat-installation-guides.

1. Site Preparation Method(s):
- ☐ Solarization
- ☐ Soil inversion
- ☐ Smother cropping
- ☐ Organic herbicide applications
- ☐ Repeated shallow cultivation
- ☐ Sod removal
- ☐ Sheet mulching

2. Planting Method:
- ☐ Broadcasting
- ☐ Drop-seeding
- ☐ Native seed drill
- ☐ Transplants

3. Site Maintenance During Establishment
- ☐ Mowing
  - __ *Mowing for diversity:*
    - __ Seasonal mowing
    - __ Rotational mowing
  - __ *Mowing for weed control:*
    - __ Spot-mowing
- ☐ Hand-weeding
- ☐ Grass-selective herbicide
- ☐ Conservation haying
- ☐ Prescribed fire
- ☐ Spot-spraying
- ☐ Weed removal around site edges
- ☐ Irrigation
- ☐ Grazing

STEP 3—Plant Selection

Individual species should be chosen to provide **consistent and abundant** floral resources throughout the year. In order to achieve this goal, **at least three species from each blooming period (early, mid, and late season), should be included. The best time for planting most species is in the late fall.** NOTE: *Transplants may be preferred when seed is not available, weed pressure is high, or when a particular species is difficult to establish by seed. Plugs are usually the most cost-effective container size for transplants.*

DESIRABLE SPECIES			IDENTIFYING CHARACTERISTICS			
E	#	Common or scientific name	Description (variety or subspecies, color, etc.)	Life Cycle & Abundance	Bloom Time	Form
☐				Annual / Perennial — A C R ☆	☐ Early ☐ Mid ☐ Late	☐ Forb ☐ Grass ☐ Woody
☐				Annual / Perennial — A C R ☆	☐ Early ☐ Mid ☐ Late	☐ Forb ☐ Grass ☐ Woody
☐				Annual / Perennial — A C R ☆	☐ Early ☐ Mid ☐ Late	☐ Forb ☐ Grass ☐ Woody
☐				Annual / Perennial — A C R ☆	☐ Early ☐ Mid ☐ Late	☐ Forb ☐ Grass ☐ Woody
☐				Annual / Perennial — A C R ☆	☐ Early ☐ Mid ☐ Late	☐ Forb ☐ Grass ☐ Woody
☐				Annual / Perennial — A C R ☆	☐ Early ☐ Mid ☐ Late	☐ Forb ☐ Grass ☐ Woody
☐				Annual / Perennial — A C R ☆	☐ Early ☐ Mid ☐ Late	☐ Forb ☐ Grass ☐ Woody
☐				Annual / Perennial — A C R ☆	☐ Early ☐ Mid ☐ Late	☐ Forb ☐ Grass ☐ Woody
☐				Annual / Perennial — A C R ☆	☐ Early ☐ Mid ☐ Late	☐ Forb ☐ Grass ☐ Woody

KEY: **E** ✓ any Established desirable species that was *not* installed or part of the seed mix | **Abundance (expected):** **A** (Abundant), **C** (Common), **R** (Rare), ☆ (Early successional/low performance) | **Bloom time:** **Early** (spring), **Mid** (summer), **Late** (late summer/fall) | **Form:** **Forb** (wildflower), **Grass** (native), **Woody** (tree or shrub)

Figure 2.2: *Example* Pollinator Habitat Installation Plan

Example

POLLINATOR HABITAT INSTALLATION PLAN

STEP 1—Habitat Installation Record

1. **Photocopy or print a copy** of this form in advance (www.xerces.org/habitat-assessment-guides);
2. **Record all of the species** initially seeded into the site and any desirable native species remaining after site preparation BEFORE the first monitoring (i.e., during or immediately after planting); AND
3. **Save a copy** of your Plan to work from during each monitoring.

SITE NAME: oregon Meadow **INSTALLATION DATE:** October 1, 2012

KEY SITE DETAILS that may impact wildflower establishment (e.g., weed pressure/species of concern, site history, soil characteristics, etc.):

Bindweed, plaintain, sorrel, and harding grass were removed from the site during using solarization, but will likely require additional management over time.

STEP 2—Site Preparation & Habitat Installation

Site preparation is **one of the most important** and often inadequately addressed components for project success. It is also a process that may require more than one season of effort to reduce competition from invasive, noxious, or undesirable plants prior to planting. *In particular, site preparation should focus on the removal of perennial weeds* (there are more options to address annual or biennial weeds after planting). For more information on recommended site preparation methods, see *Wildflower Establishment: Organic Site Preparation Methods* or other habitat installation guides available at: www.xerces.org/pollinator-habitat-installation-guides.

1. Site Preparation Method(s): ☑ Solarization; ☐ Soil inversion; ☐ Smother cropping; ☐ Organic herbicide applications; ☐ Repeated shallow cultivation; ☐ Sod removal; ☐ Sheet mulching

2. Planting Method: ☑ Broadcasting; ☐ Drop-seeding; ☐ Native seed drill; ☐ Transplants

3. Site Maintenance During Establishment: ☐ Mowing — *Mowing for diversity:* — Seasonal mowing — Rotational mowing; *Mowing for weed control:* — Spot-mowing; ☑ Hand-weeding; ☐ Grass-selective herbicide; ☐ Conservation haying; ☐ Prescribed fire; ☑ Spot-spraying; ☑ Weed removal around site edges; ☐ Irrigation; ☐ Grazing

STEP 3—Plant Selection

Individual species should be chosen to provide **consistent and abundant** floral resources throughout the year. In order to achieve this goal, **at least three species from each blooming period (early, mid, and late season), should be included. The best time for planting most species is in the late fall.** NOTE: *Transplants may be preferred when seed is not available, weed pressure is high, or when a particular species is difficult to establish by seed. Plugs are usually the most cost-effective container size for transplants.*

DESIRABLE SPECIES			IDENTIFYING CHARACTERISTICS											
E	#	Common or scientific name	Description (variety or subspecies, color, etc.)	Life Cycle & Abundance			Bloom Time			Form		
	1.	California poppy (Eschscholzia californica)	4 petals, carrot-like leaves	(Annual) Perennial	(A) C R ★		Early ☑	Mid ☑	Late ☑	Forb ☑	Grass ☐	Woody ☐
	2.	Globe gilia (Gilia capitata)	Purple, "ball"-like	Annual Perennial	A (C) R ★		Early ☑	Mid ☐	Late ☐	Forb ☑	Grass ☐	Woody ☐
	3.	Farewell-to-spring (Clarkia amoena)	Pink, looks like a poppy	(Annual) Perennial	(A) C R ★		Early ☐	Mid ☑	Late ☐	Forb ☑	Grass ☐	Woody ☐
	4.	western yarrow (Achillea millefolium)	white, feathery leaves	Annual (Perennial)	A (C) R ★		Early ☐	Mid ☑	Late ☑	Forb ☑	Grass ☐	Woody ☐
	5.	Bigleaf lupine (Lupinus polyphyllus)	Purple, legume, palmate leaves	Annual (Perennial)	A (C) R ★		Early ☐	Mid ☑	Late ☐	Forb ☑	Grass ☐	Woody ☐
	6.	oregon sunshine (Eriophyllum lanatum)	Yellow, daisy-like	Annual (Perennial)	A (C) R ★		Early ☐	Mid ☑	Late ☐	Forb ☑	Grass ☐	Woody ☐
	7.	Douglas aster (Symphyotrichum subspicatum)	Purple, daisy-like	Annual (Perennial)	A (C) R ★		Early ☐	Mid ☐	Late ☑	Forb ☑	Grass ☐	Woody ☐
	8.	western goldentop (Euthamia occidentalis)	Yellow, small flowers	Annual (Perennial)	(A) (C) R ★		Early ☐	Mid ☐	Late ☑	Forb ☑	Grass ☐	Woody ☐
✓	9.	Roemer's fescue (Festuca roemeri)	Cool season bunchgrass	Annual (Perennial)	A C (R) ★		Early ☐	Mid ☑	Late ☑	Forb ☐	Grass ☑	Woody ☐

KEY — **E**: ✓ any Established desirable species that was ***not*** installed or part of the seed mix; **Abundance (expected):** **A** (Abundant), **C** (Common), **R** (Rare), ★ (Early successional/low performance); **Bloom time:** **Early** (spring), **Mid** (summer), **Late** (late summer/fall); **Form:** **Forb** (wildflower), **Grass** (native), **Woody** (tree or shrub)

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Management Process 3

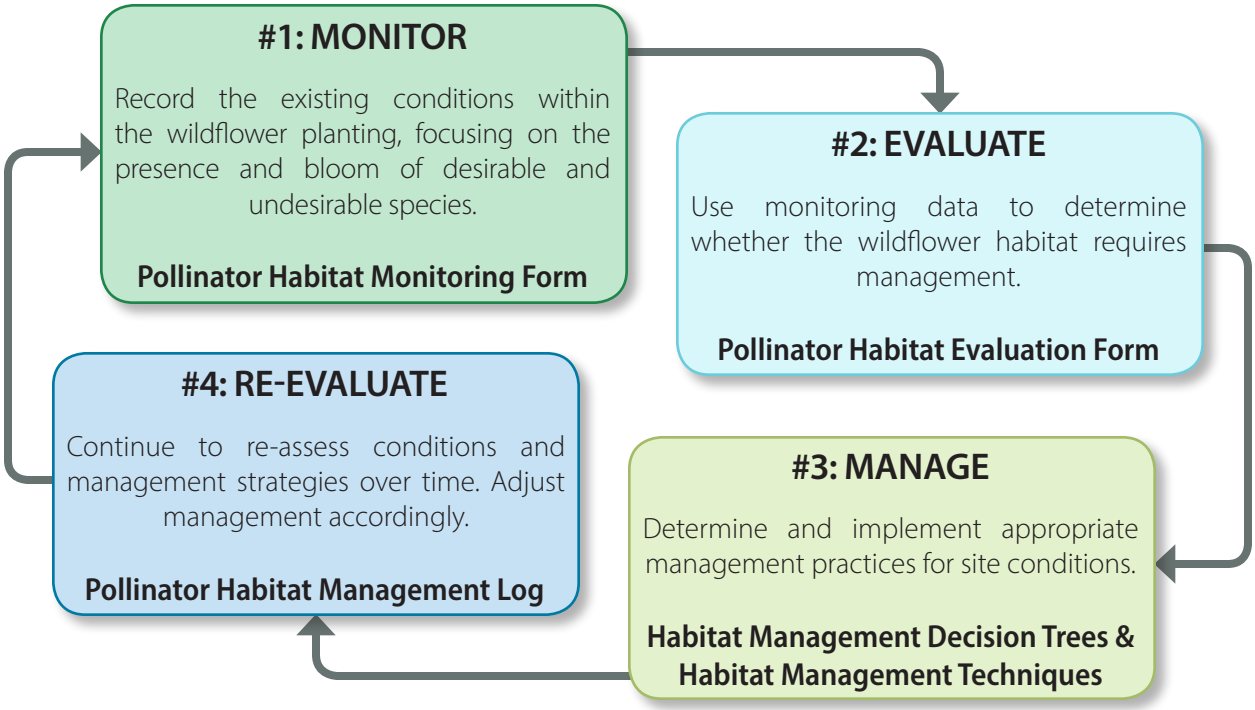
In order to achieve the best management outcomes for the long term health of wildflower habitat and the pollinators that habitat supports, we recommend taking an active management approach. Active management involves early identification of potential problems before they become major issues. For example, early detection and management of an incipient invasive weed is much easier than trying to control a large scale invasion. Active management can also help reduce costs, as re-starting a project is often more expensive than maintaining existing habitat. An active approach requires a low-level but consistent time commitment, in which the land manager or land owner regularly evaluates, prescribes, and implements management activities to maintain their wildflower plantings.

Monitoring

It is important to routinely check wildflower habitat to ensure that the species planted are still present and providing abundant blooms. Monitoring at different times throughout the growing season is particularly important because it allows observation of conditions across different seasons and the detection of trends that can't be observed without repeat monitoring. For example, monitoring allows land managers to identify gaps in bloom and plan management actions to fill that gap (e.g., interseeding in subsequent years).

We recommend monitoring every 2–4 weeks from spring through fall. The timing and intensity of monitoring varies by region (for more information, see the Regional Differences Table p.46). Many perennial species may not flower in the first year post-planting, while most annual species are early-successional species that disappear over time. Knowing which species should be present (consult the initial seed mix) can help with evaluation of whether the wildflower habitat is performing as expected. Over time, monitoring frequency can decrease, so long as it is still possible to ensure that the habitat maintains its desired condition. We do recommend increasing monitoring intensity in the years following severe or unusual weather to ensure the community has not shifted towards undesirable conditions.

Figure 3.1: Procedure for Monitoring and Managing Habitat

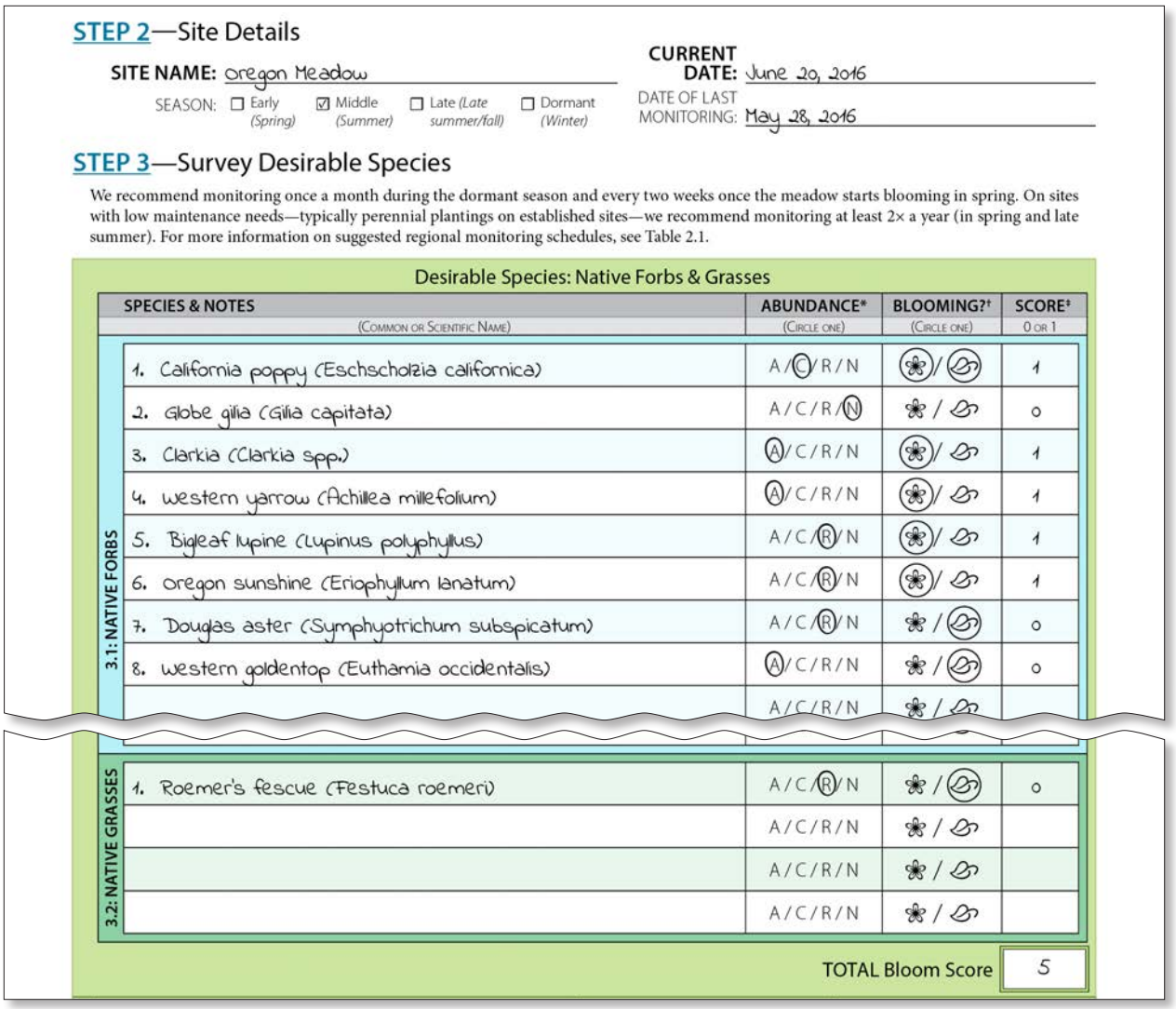


A few simple metrics can provide information on the status of the wildflower habitat and whether it is providing sufficient floral resources for pollinators throughout the year. These metrics include:

1. **Presence**—whether a specific species occupies a site, and at what density. We assign 4 categories that also denote the abundance of the species: Absent, Rare, Common, Abundant.
2. **Plant diversity**—the number of both planted (desired) and unwanted (weedy) species present.

Tracking each wildflower species over time can help to identify species that could potentially dominate the site or those in danger of disappearing. One easy way to do this is to use your original planting mix to keep track of the species planted within the site. It is also a good idea to note the presence and cover of unwanted weedy species to help determine when management is necessary. Use the Pollinator Habitat Monitoring Form (p. 7–8) to record all species present. The plant diversity data can help identify whether a variety and balance of species are providing pollen and nectar to bees, and will eventually assist in the selection of specific management actions that can maintain conditions that foster wildflower diversity.

Figure 3.2: *Example* Pollinator Habitat Monitoring Form



STEP 2—Site Details

SITE NAME: Oregon Meadow

CURRENT DATE: June 20, 2016

SEASON: ☐ Early (Spring) ☑ Middle (Summer) ☐ Late (Late summer/fall) ☐ Dormant (Winter)

DATE OF LAST MONITORING: May 28, 2016

STEP 3—Survey Desirable Species

We recommend monitoring once a month during the dormant season and every two weeks once the meadow starts blooming in spring. On sites with low maintenance needs—typically perennial plantings on established sites—we recommend monitoring at least 2× a year (in spring and late summer). For more information on suggested regional monitoring schedules, see Table 2.1.

Desirable Species: Native Forbs & Grasses

	SPECIES & NOTES (Common or Scientific Name)	ABUNDANCE* (Circle one)	BLOOMING?† (Circle one)	SCORE‡ 0 or 1
3.1: NATIVE FORBS	1. California poppy (Eschscholzia californica)	A/(C)/R/N	(🌸)/(🌿)	1
	2. Globe gilia (Gilia capitata)	A/C/R/(N)	🌸/🌿	0
	3. Clarkia (Clarkia spp.)	(A)/C/R/N	(🌸)/🌿	1
	4. western yarrow (Achillea millefolium)	(A)/C/R/N	(🌸)/🌿	1
	5. Bigleaf lupine (Lupinus polyphyllus)	A/C/(R)/N	(🌸)/🌿	1
	6. oregon sunshine (Eriophyllum lanatum)	A/C/(R)/N	(🌸)/🌿	1
	7. Douglas aster (Symphyotrichum subspicatum)	A/C/(R)/N	🌸/(🌿)	0
	8. western goldentop (Euthamia occidentalis)	(A)/C/R/N	🌸/(🌿)	0
		A/C/R/N	🌸/🌿	
3.2: NATIVE GRASSES	1. Roemer's fescue (Festuca roemeri)	A/C/(R)/N	🌸/(🌿)	0
		A/C/R/N	🌸/🌿	
		A/C/R/N	🌸/🌿	
		A/C/R/N	🌸/🌿	

TOTAL Bloom Score: 5

POLLINATOR HABITAT MONITORING FORM

STEP 1—Monitoring Record

1. **Photocopy or print a copy** of this form in advance (www.xerces.org/habitat-assessment-guides);
2. **Record all of the species** initially seeded into the site on your Pollinator Habitat Installation Plan BEFORE first monitoring (i.e., during or immediately after planting); AND
3. **Bring a copy** of your Pollinator Habitat Installation Plan to refer to during each monitoring.

STEP 2—Site Details

SITE NAME: _____ **CURRENT DATE:** _____

SEASON: ☐ Early *(Spring)* ☐ Middle *(Summer)* ☐ Late *(Late summer/fall)* ☐ Dormant *(Winter)*

DATE OF LAST MONITORING: _____

STEP 3—Survey Desirable Species

We recommend monitoring once a month during the dormant season and every two weeks once the meadow starts blooming in spring. On sites with low maintenance needs—typically perennial plantings on established sites—we recommend monitoring at least 2× a year (in spring and late summer). For more information on suggested regional monitoring schedules, see Table 2.1.

Desirable Species: Native Wildflowers & Grasses

SPECIES & NOTES (COMMON OR SCIENTIFIC NAME)	ABUNDANCE* (CIRCLE ONE)	BLOOMING?† (CIRCLE ONE)	SCORE‡ 0 OR 1
3.1: NATIVE WILDFLOWERS			
	A / C / R / N	❀ / 🌿	
	A / C / R / N	❀ / 🌿	
	A / C / R / N	❀ / 🌿	
	A / C / R / N	❀ / 🌿	
	A / C / R / N	❀ / 🌿	
	A / C / R / N	❀ / 🌿	
	A / C / R / N	❀ / 🌿	
	A / C / R / N	❀ / 🌿	
	A / C / R / N	❀ / 🌿	
	A / C / R / N	❀ / 🌿	
	A / C / R / N	❀ / 🌿	
	A / C / R / N	❀ / 🌿	
3.2: NATIVE GRASSES			
	A / C / R / N	❀ / 🌿	
	A / C / R / N	❀ / 🌿	
	A / C / R / N	❀ / 🌿	
	A / C / R / N	❀ / 🌿	
TOTAL Bloom Score			

KEY	ABUNDANCE*							BLOOMING?†				SCORE‡			
	A	Abundant	**C**	Common	**R**	Rare	**N**	Not present	❀	Blooming	🌿	Vegetative	**1**	❀ + A *or* C *or* R	**0**	🌿 *or* N

STEP 4—Survey Unwanted Species

Unwanted Species: Native Forbs & Grasses

	SPECIES & NOTES (Common or Scientific Name)	ABUNDANCE* (Circle one)	BLOOMING?† (Circle one)	⚠
4.2: TREES/SHRUBS		A / C / R / N	❀ / 〰	
		A / C / R / N	❀ / 〰	
		A / C / R / N	❀ / 〰	
		A / C / R / N	❀ / 〰	
4.1: WEEDY FORBS		A / C / R / N	❀ / 〰	
		A / C / R / N	❀ / 〰	
		A / C / R / N	❀ / 〰	
		A / C / R / N	❀ / 〰	
4.3: WEEDY GRASSES		A / C / R / N	❀ / 〰	
		A / C / R / N	❀ / 〰	
		A / C / R / N	❀ / 〰	
		A / C / R / N	❀ / 〰	

KEY	ABUNDANCE*							BLOOMING?†				⚠ (Highly Problematic)	
	A	Abundant	C	Common	R	Rare	N	Not present	❀	Blooming	〰	Vegetative	✘	Mark if species is highly problematic

Notes:

* **Abundance:** Is the species Abundant (present in high numbers), Common (present and fairly abundant), Rare (present but in low numbers), or Not present?

† **Blooming:** Is the species CURRENTLY Blooming (❀) or Vegetative (〰)?

‡ **Score:** The Bloom Score of a DESIRABLE species is calculated based on its abundance and whether it is blooming:

0 = Any species that is 〰 (CURRENTLY vegetative) or Not present

1 = Any species that is ❀ (CURRENTLY blooming) AND Abundant, Common, or Rare

⚠ **Highly Problematic Weed:** The presence or status of an UNWANTED species that requires immediate management action.

STEP 5—Calculate Species Diversity & Abundance

Tracking the levels of the desirable and unwanted species on a site over time will help to decide when management is necessary.

Desirable Species Total

	STEP	A	C	R	TOTAL
1	**Tally present species by abundance** *(Calculate total number of species)*				
2	**Count the number of species that are currently not present** *(Compare with Pollinator Habitat Installation Plan)*				
3	**Calculate TOTAL Bloom Score (Step 3)** *(If the TOTAL Bloom Score is ≤2, record this date as a* **Gap in Bloom** *on the Pollinator Habitat Evaluation Form)* ☛				

Unwanted Species Total

	STEP	A	C	R	TOTAL
1	**Tally present species by abundance** *(Calculate total number of species)*				
2	**Count the number of species that are currently not present** *(Compare with previous Monitoring Forms)*				
3	**Calculate TOTAL Highly Problematic Weeds** *(Highly Problematic species require immediate action—track actions taken on the Pollinator Habitat Management Log)* ☛				

STEP 6—Repeat Monitoring

Regular monitoring is important during the establishment phase (years 1 – 5). Consistent data, collected every 2–4 weeks from spring through fall during the key establishment years (which varies regionally; see regional variation Table 2.1), provides the best foundation for formulating management decisions. After the establishment time period, monitoring intervals can be increased. We do recommend periodic intensive monitoring every third year to ensure the habitat maintains desired conditions. Monitoring in years following severe or unusual weather can also help detect novel conditions that respond to the changing environment.

⭳ Print additional copies of this form and other habitat monitoring tools at: www.xerces.org/habitat-assessment-guides/

Figure 3.2: *Example* Pollinator Habitat Monitoring Form *continued*

STEP 4—Survey Unwanted Species

Unwanted Species: Native Forbs & Grasses

	SPECIES & NOTES (Common or Scientific Name)	ABUNDANCE* (Circle one)	BLOOMING?† (Circle one)	⚠
4.2: TREES/SHRUBS	1. Himalayan blackberry (Rubus armeniacus)	A/C/(R)/N	(🌸)/🍃	✗
		A/C/R/N	🌸/🍃	
		A/C/R/N	🌸/🍃	
		A/C/R/N	🌸/🍃	
4.1: WEEDY FORBS	1. Bindweed (Convolvulus arvensis)	A/(C)/R/N	(🌸)/🍃	✗
	2. English plaintain (Plantago lanceolata)	A/C/(R)/N	🌸/🍃	
		A/C/R/N	🌸/🍃	
		A/C/R/N	🌸/🍃	
4.3: WEEDY GRASSES	1. Giant foxtail (Setaria faberi)	A/C/(R)/N	🌸/(🍃)	
	2. Wild oat (Avena fatua)	A/(C)/R/N	🌸/(🍃)	✗
		A/C/R/N	🌸/🍃	
		A/C/R/N	🌸/🍃	

ABUNDANCE* | BLOOMING?† | ⚠ (Highly Problematic)

STEP 5—Calculate Species Diversity & Abundance

Tracking the levels of the desirable and unwanted species on a site over time will help to decide when management is necessary.

Desirable Species Total

	STEP	A	C	R	TOTAL
1	Tally present species by abundance (Calculate total number of species)	3	1	5	9
2	Count the number of species that are currently not present (Compare with Pollinator Habitat Installation Plan)				1
3	Calculate TOTAL Bloom Score (Step 3) (If the TOTAL Bloom Score is ≤2, record this date as a Gap in Bloom on the Pollinator Habitat Evaluation Form) ☛				5

Unwanted Species Total

	STEP	A	C	R	TOTAL
1	Tally present species by abundance (Calculate total number of species)	0	2	3	5
2	Count the number of species that are currently not present (Compare with previous Monitoring Forms)				1
3	Calculate TOTAL Highly Problematic Weeds (Highly Problematic species require immediate action—track actions taken on the Pollinator Habitat Management Log) ☛				3

Figure 3.3: Wildflower bloom can shift rapidly in a short period of time, which is why it is it is important to monitor wildflower plantings regularly during the growing season—approximately every 2–4 weeks—in order to document species diversity and abundance over time.

Evaluation

After monitoring data has been collected, use it to evaluate the status of your pollinator habitat. Evaluation can be simplified by recognizing that pollinator habitat often falls into one of the following conditions: dominated by a few planted species, mixed desirable and unwanted species, or mostly unwanted weedy species. Use the Pollinator Habitat Evaluation Form (p. 13–14) to evaluate the status of the wildflower community. Evaluate the habitat every year, adding additional data annually to refine your habitat management program. The assessment form is designed to provide answers to the following questions which will help identify the best management practices:

- Is a diverse array of wildflowers present?
- Are there gaps in bloom?
- Is the site dominated by one or a few species?
- Are problematic species present? If so, are their numbers high enough to warrant a management action?

Management

When deciding among management techniques, select practices that maintain the existing diversity while controlling weeds in the habitat. The Pollinator Habitat Decision Trees (p. 32) can help identify appropriate management technique(s) for a variety of conditions commonly found in pollinator habitat. The timing of management actions is often critical to their success. Appendix D provides detailed descriptions of the different techniques we recommend for various conditions.

Figure 3.4: A red clover (*Trifolium pratense*) crop on both sides of the wildflower strip—outlined in white— provides additional (although temporary) food resources for pollinators

We recommend recording all management actions and outcomes in a Pollinator Habitat Management Log (p. 35–36). Recording information can help guide future management by logging whether a management action achieved the desired results and should be repeated in the future, or whether it needs to be altered in order to generate preferred outcomes.

Setting action thresholds for percent cover of weeds can help to decide when to take targeted management actions to reduce an unwanted species. Thresholds often vary by personal preference and by species identity. For example, for a pernicious weed like musk thistle (Carduus nutans), a threshold of 10% cover may motivate management, whereas for a weedy species that is not particularly aggressive and likely to diminish over time—such as yellow foxtail (Setaria pumila)—a threshold may be higher, such as 25% cover, before action is warranted.

Figure 3.5: This diverse wildflower meadow on an Oklahoma ranch is managed by annual mowing and an occasional prescribed burn to maintain wildflower diversity.

Re-evaluation

Habitat management is a long-term commitment and requires reassessment and adjustment in order to maximize success. Continued monitoring over time allows flexibility in adapting a management approach when new conditions arise or management actions do not have the intended effect. The data collected by monitoring provides a baseline for comparison of management strategies used (see Pollinator Habitat Management Log, p. 35–36). Repeated monitoring and review of past management actions will highlight potential problems quickly. For example, if targeted weed populations continue to increase, then different and/or more aggressive management is likely required. Remember that each site is different and may respond to techniques in a different way. Adaptive management can help to tailor habitat maintenance to the site's unique conditions.

Figure 3.6: *Example* Pollinator Habitat Evaluation Form

(use the record from the middle of the species' bloom period) in order to indicate if a species has low or high abundance and requires action.

1. **Low Abundance Species Management**—Highlight species that are expected to be Abundant or Common, but were found to be Rare or Not Present at least two years in a row or Rare species that were Not present for multiple years. Only wildflower species not present for more than three consecutive years should be considered to have disappeared (some may lie dormant for a brief period, then suddenly return). NOTE: in exceptionally diverse plantings (common in some regions like the Midwest), many species will be Rare for the lifetime of planting; OR some annual species that are early successional are expected to disappear over time and do not need to be re-seeded if other high value perennial species are present and abundant;
2. **High Abundance Management**—Mark species that are Abundant for multiple years in a row. If the abundance of a native species increases consistently over time and maintains high numbers, it may limit the presence of other species. Consider management actions to reduce its population (e.g., disking, hand-weeding, or spot-spraying herbicide);
3. **Bloom Time**—Note the average bloom time of each species in your planting;

#	Species (Common or Scientific Name)	Bloom Time	Year 1: 2013	Year 2: 2014	Year 3: 2015	Year 4: 2016	Year 5:
1.	California poppy (Eschscholzia californica)	Early ☑ Mid ☑ Late ☑	*A	C	C	C	
2.	Globe gilia (Gilia capitata)	Early ☑ Mid ☐ Late ☐	C	N	R	N	
3.	Clarkia (Clarkia spp.)	Early ☐ Mid ☑ Late ☐	A	C	C	A	
4.	western yarrow (Achillea millefolium)	Early ☐ Mid ☑ Late ☑	C	C	C	C	
5.	Bigleaf lupine (Lupinus polyphyllus)	Early ☐ Mid ☑ Late ☐	C	C	R	R	
6.	oregon sunshine (Eriophyllum lanatum)	Early ☐ Mid ☑ Late ☐	C	C	C	C	
7.	Douglas aster (Symphyotrichum subspicatum)	Early ☐ Mid ☐ Late ☑	C	C	C	R	
8.	western goldentop (Euthamia occidentalis)	Early ☐ Mid ☐ Late ☑	*A	*A	*A	A-C	
		Early Mid Late					

Example Low Abundance Species Management

Consider interseeding bigleaf lupine into the site (row 1). California poppy is declining, but because it is an annual, that can be expected and it can be allowed to drop out of the mix (row 4). In the case of globe gilia (row 2), we would recommend substituting a different species that blooms at the same time of year because it appears to be poorly suited to the site. For Douglas aster, a perennial species, we would recommend interseeding, or plug planting if seeding is not highly effective multiple times in this site, as it offers great late-season pollen and nectar resources to pollinators.

Example Dominant Species Management

For native species with very high abundance, like western goldenrod (row 5), consider mowing a patch before they set seed in order to reduce their abundance in the following year, providing the opportunity for other wildflowers to establish. It may be advisable to interseed following this management action if other wildflowers that bloom during the same time period are absent or present in very low numbers.

Gaps in Bloom	Year 1:	Year 2:	Year 3:	Year 4:	Year 5:
1. Record sampling dates with a TOTAL Bloom Score of ≤2 in the appropriate column by year (this information can be found in Step 5 of the Pollinator Habitat Monitoring Forms).			3/20/15	3/28/16	
2. Compare these dates with the average predicted Bloom Times to identify gaps in bloom greater than two weeks—potentially caused by low abundance or a lack of species diversity during certain times of year—that should trigger management actions.				5/28/16	

Example Gaps In Bloom

In this example, there are gaps in bloom in mid-March and in late September/early October. We would recommend interseeding species whose bloom period would overlap the spring gap in bloom and others that help extend the season later in the year. Appropriate species will vary by region. See Additional Resources (p. 43) for links to regional plant lists that can help with species selection.

POLLINATOR HABITAT EVALUATION FORM

Evaluating habitat annually can help identify conditions and facilitate selection of management activities. **BEFORE YOU BEGIN:**

STEP 1—Monitoring Record

1. **Photocopy or print a copy** of this form in advance (www.xerces.org/habitat-assessment-guides); AND
2. **Record all of the species** initially seeded into the site on your Pollinator Habitat Installation Plan BEFORE first monitoring (i.e., during or immediately after planting).
3. Gather all Monitoring Forms from previous year.

STEP 2—Site Details

SITE NAME: _____

STEP 3—Desirable Species Persistance

Recording all the species initially seeded into the site and their abundance over time can help determine whether they are persisting, or are in danger of either disappearing or taking over the meadow. Use this information to determine when a management action, such as interseeding (seeding into existing stands of vegetation), is necessary.

NATIVE FORBS

Use the Pollinator Habitat Monitoring Forms to determine whether each native forb species is present year after year and estimate average abundance (use the record from the middle of the species' bloom period) in order to indicate if a species has low or high abundance and requires action:

1. **Low Abundance Species Management**—Highlight species that are expected to be Abundant or Common, but were found to be Rare or Not Present at least two years in a row or Rare species that were Not present for multiple years. Only wildflower species not present for more than three consecutive years should be considered to have disappeared (some may lie dormant for a brief period, then suddenly return). NOTE: in exceptionally diverse plantings (common in some regions like the Midwest), many species will be Rare for the lifetime of planting; OR some annual species that are early successional are expected to disappear over time and do not need to be re-seeded if other high value perennial species are present and abundant;
2. **High Abundance Management**—Mark species that are Abundant for multiple years in a row. If the abundance of a native species increases consistently over time and maintains high numbers, it may limit the presence of other species. Consider management actions to reduce its population (e.g., disking, hand-weeding, or spot-spraying herbicide);
3. **Bloom Time**—Note the average bloom time of each species in your planting;

#	Species (Common or Scientific Name)	Bloom Time	Year 1:	Year 2:	Year 3:	Year 4:	Year 5:
		Early ☐ Mid ☐ Late ☐					
		Early ☐ Mid ☐ Late ☐					
		Early ☐ Mid ☐ Late ☐					
		Early ☐ Mid ☐ Late ☐					
		Early ☐ Mid ☐ Late ☐					
		Early ☐ Mid ☐ Late ☐					
		Early ☐ Mid ☐ Late ☐					
		Early ☐ Mid ☐ Late ☐					
		Early ☐ Mid ☐ Late ☐					
		Early ☐ Mid ☐ Late ☐					

GAPS IN BLOOM	Year 1:	Year 2:	Year 3:	Year 4:	Year 5:
1. Record sampling dates with a TOTAL Bloom Score of ≤2 in the appropriate column by year (this information can be found in Step 5 of the Pollinator Habitat Monitoring Forms). 2. Compare these dates with the average predicted Bloom Times to identify gaps in bloom greater than two weeks—potentially caused by low abundance or a lack of species diversity during certain times of year—that should trigger management actions.					

STEP 3—Desirable Species Persistance *continued*

NATIVE GRASSES

Native Grass Management—using the Pollinator Habitat Monitoring Forms, determine whether each native grass species is present year after year, then estimate average abundance throughout the year in order to determine if a species requires management, and circle any species that have reached a threshold amount. Track these species to ensure that their populations remain under the levels you deem acceptable.

#	Species (Common or Scientific Name)	Year 1	Year 2	Year 3	Year 4	Year 5

STEP 4—Unwanted Species Persistance

Keeping track of the levels of weedy species present will help to decide when management is necessary. We recommend setting a threshold level that weed populations should not exceed. When weeds get to those levels, it should trigger a management action.

Weeds, Non-natives, Invasive Species, etc.

Weed Management—using the Pollinator Habitat Monitoring Forms, determine which weedy species are present year after year and which species are Highly Problematic in order to determine if a species requires management. Circle any species that have reached a threshold amount or require immediate action. Track these species to ensure that their populations remain under the levels you deem acceptable. Many weed species are easy to control when their populations are low, but can quickly take over a site, necessitating re-starting when their numbers get too high.

TREES/SHRUBS

#	Species (Common or Scientific Name)	Year 1	Year 2	Year 3	Year 4	Year 5

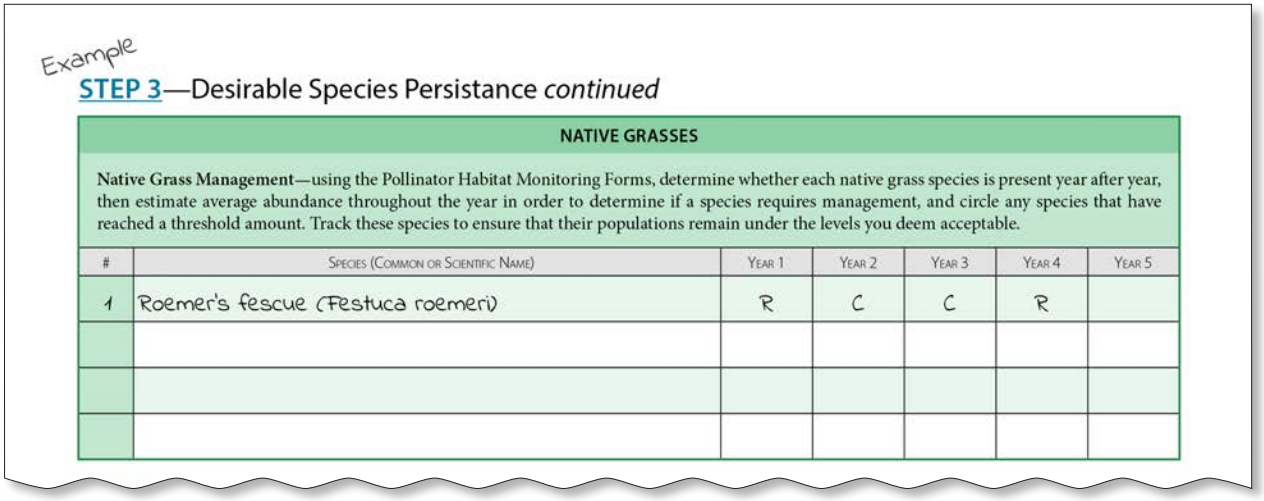
FORBS

#	Species (Common or Scientific Name)	Year 1	Year 2	Year 3	Year 4	Year 5

GRASSES

#	Species (Common or Scientific Name)	Year 1	Year 2	Year 3	Year 4	Year 5

Figure 3.6: *Example* Pollinator Habitat Evaluation Form *continued*



Example

STEP 3—Desirable Species Persistance *continued*

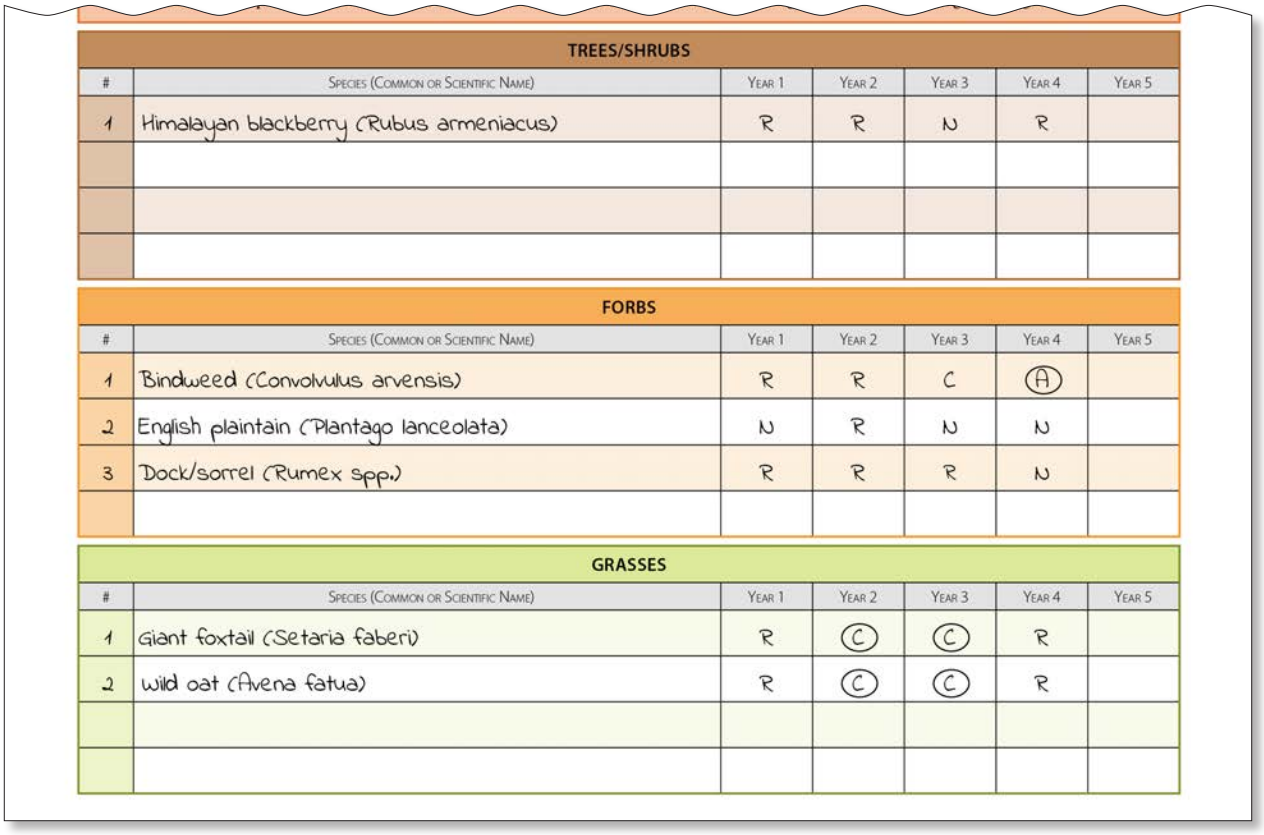
NATIVE GRASSES

Native Grass Management—using the Pollinator Habitat Monitoring Forms, determine whether each native grass species is present year after year, then estimate average abundance throughout the year in order to determine if a species requires management, and circle any species that have reached a threshold amount. Track these species to ensure that their populations remain under the levels you deem acceptable.

#	Species (Common or Scientific Name)	Year 1	Year 2	Year 3	Year 4	Year 5
1	Roemer's fescue (Festuca roemeri)	R	C	C	R	

Example Weed Management

When unwanted species reach a threshold level, in this case over 10% for all weedy species (circled), they should be aggressively targeted to reduce the potential that take over the site. This form also lets you see when management actions achieve their intended function. Management of non-native grasses in year 3 led to decreased levels in subsequent years.



TREES/SHRUBS

#	Species (Common or Scientific Name)	Year 1	Year 2	Year 3	Year 4	Year 5
1	Himalayan blackberry (Rubus armeniacus)	R	R	N	R	

FORBS

#	Species (Common or Scientific Name)	Year 1	Year 2	Year 3	Year 4	Year 5
1	Bindweed (Convolvulus arvensis)	R	R	C	(A)	
2	English plaintain (Plantago lanceolata)	N	R	N	N	
3	Dock/sorrel (Rumex spp.)	R	R	R	N	

GRASSES

#	Species (Common or Scientific Name)	Year 1	Year 2	Year 3	Year 4	Year 5
1	Giant foxtail (Setaria faberi)	R	(C)	(C)	R	
2	Wild oat (Avena fatua)	R	(C)	(C)	R	

4 Management Strategies

The goal of long-term management is to create a high diversity of bloom across seasons with minimal weed pressure that can be easily managed. In order to maximize management effectiveness, it is important to use the appropriate tools and schedule management actions to be implemented at a time when they are likely to have the highest impact. Timing of techniques varies by region (see Regional Differences Table, p. 46), but is often connected to growth stages of unwanted weedy plants, which may change annually given local weather conditions. Paying close attention to when weeds or other dominant species are growing, flowering, and setting seed will help plan management to avoid missing a critical window that could cause problematic species to increase their populations.

Some management actions can negatively affect some wildlife, including pollinators. Mowing or haying during the bloom period of wildflower species can remove needed flowers and may also harm pollinators and other insects nesting and feeding in the habitat. Pollinator plantings are also excellent habitat for ground nesting birds; therefore, management should avoid disturbing nesting birds. Nesting dates generally range from mid-late spring to late summer, depending on the region. State wildlife agencies can provide regional nesting dates. A flush bar can also help remove mobile wildlife from an area being mowed.

I. MOWING

Mowing is consistently rated as one of the most effective management tools for increasing or maintaining the diversity and density of forbs. Mowing can be also used to control weeds. Timing of mow events determines whether mowing is more effective for maintaining wildflower diversity or providing weed control.

A. Mowing for Diversity

Mowing for diversity can involve: (a) mowing in the fall, (b) mowing rotationally across seasons and across different areas of the pollinator habitat, or (c) coupling these two mowing strategies.

Figure 4.1: Pollinator habitat can be ideal nesting habitat for ground-nesting birds and other wildlife. In order to avoid disturbing ground-nesting wildlife, management should be timed to avoid peak nesting dates.

Figure 4.2: Many desirable perennials are slow-growing and will tolerate mowing—like this gumweed (*Grindelia* spp.) seedling, shown here seven days after a mow event.

i. ***Seasonal Mowing***

In many cases a single mow event, usually in the fall after seed shatter of late-blooming wildflower species, and preferably before extended rain periods, can help maintain wildflower diversity and persistence over the long-term by breaking down senesced stems and leaves. Thatch removal can complement mowing by removing build-up of materials that can limit wildflower germination and growth (see Thatch Removal, sidebar). Fall mowing also targets woody species that can invade pollinator habitats.

To reduce the cover of dominant species (either planted or unwanted), mow during their growing season (prior to bloom) or before seed set. This action can help limit new growth the following year, and create space for other species to grow. Perennial wildflowers (and weeds) can often rebound easily from mowing, however annual wildflowers can suffer long-term consequences that reduce or eliminate their populations. Be cautious when using mowing during the bloom period of annual wildflowers.

Flail mowing is an effective mow method, as it results in small pieces of vegetation which typically break down quickly. Place mow bar at high setting (at least 12" above the soil) to avoid disturbing bumble bees that may be nesting in the area. Available equipment can affect mowing frequency, particularly when the goal of mowing is to reduce woody invaders in the habitat area (e.g., mow less frequently if using a brush hog and more frequently if using a weed-eater).

ii. ***Rotational Mowing***

Mowing across patches at different times of year can help maximize diversity within pollinator habitat by favoring different sets of species and reducing dominance of some species. For example, mowing in the early spring can reduce vegetation that would compete with later-blooming wildflowers, thus allowing for potentially increased germination, growth or flowering of later-blooming species. However, mowing the entire site in the spring could prevent early-blooming species from flowering, leading to a decline in their populations. We therefore recommend mowing only small areas, either in patches or strips, at any given time. This heterogeneous mowing strategy can help prevent gaps in bloom and enhance diversity of flowering species across the site.

Breaking the site into 3–5 segments and rotating mowing regimens through them (at different times of year) can also help bolster diversity. It is important to keep track of which areas were mowed to avoid mowing the same area during the same time period in sequential years. Conversely, if the goal of mowing is to reduce dominance of a species, continue mowing during time period that has the largest impact.

When mowing does occur before a species is able to bloom, expect varied responses based on the species. In some cases an early mow during a vegetative state can trigger a plant to go into bud, with flowers forming closer to the ground than their normal growth pattern. If this occurs, the plant is still able to set seed and persist in the site. While most perennial wildflowers will recover from a mowing event (particularly if the mow height is above 12"), some may not be able to flower and re-seeding in the same year of a

Thatch Removal

Thatch, undecomposed plant material, can reduce light penetration to the soil and limit the ability of new wildflower seeds to germinate and grow. Thatch removal can favor wildflower communities by removing excess nutrients, especially in formerly cropped lands. Many native plant species thrive in nutrient-poor environments, while high soil fertility can promote non-native species, especially during the early stages of habitat establishment. Mowing can help facilitate decomposition and reduce thatch build up, although additional removal of thatch with a rake is sometimes necessary. A hay rake, tedder tractor attachment, or hand rake can help clear the area. Conservation haying (Section VI) is another method that removes excess thatch. If significant thatch continually occurs in the site, consider a prescribed burn (See Section IX. Prescribed Fire).

mowing event and thus will not increase their populations. Some annuals are sensitive to mowing. If mowed before they bloom, many are unable to recover in time to bloom at a later date, and may subsequently disappear from a site.

B. Mowing for Weed Control

Mowing can also be used to manage weedy vegetation growing in pollinator habitat. In the Midwest, where most species in wildflower habitat are perennial, mowing to control weeds typically occurs regularly during the first 1–2 years following habitat establishment. After this period, mowing typically targets weedy species prior to seed set. By mowing weeds before they set seed, the weed seed bank can be greatly reduced. This technique is especially effective for eradicating annual weed species. When mowing to control a perennial weed species, mow events may need to occur multiple times during critical plant develop stages to reduce seed set and plant vigor. If an unwanted weed species is distributed throughout the habitat and the best time to target it is during the bloom period of planted wildflower species, we recommend only mowing ⅓–⅕ of the habitat at any given time or considering a different management strategy for the target weed species.

Mowing for weed control is easiest to implement either when weedy species have grown taller than wildflower species or when weeds only occur in specific areas. For example, in western regions, many cool season weeds grow significantly taller than wildflowers very early in the spring, so a carefully timed high-mow can manage weeds with minimal harm to wildflowers germinating underneath. In cases where weeds are not taller than the wildflowers, focusing only on trouble-spots and/or avoiding mowing while wildflowers are blooming is recommended, except when in regions where mowing during the first few years of establishment is recommended (see Regional Differences Table, p. 46).

It is important to be familiar with the characteristics of target weeds. Like wildflowers, some weed species will set seed lower to the ground when mowed and may need to be eradicated through hand-weeding or other management methods. Other weed species—including bindweed (*Convolvulus* spp.) and mugwort (*Artemisia* spp.)—are stimulated by mowing, thus mowing is not advisable as a control method when they are present.

When mowing non-native grasses, determining whether they are annual or perennial and warm or

Figure 4.3: Mowing can be an excellent way to encourage wildflower diversity and reduce cool season weeds when timed correctly—as in this site in California, which was mowed in early spring before the perennials had begun blooming.

Figure 4.4: Weed-eaters are excellent for spot-mowing because they allow users to target small patches of weeds that are mixed in with desirable plants.

cool season can help inform management timing. Target cool season perennials in the early spring and again in the fall if they resume active growth (typically triggered by a moist fall). Cool season annuals need to be mowed before they set seed early in the spring. Many cool season annuals are considered winter annuals—they germinate in fall, overwinter as a rosette (low-lying leaves) and flower in the early spring. Mowing should target the flowering stems in the spring.

Warm season annual and perennial forbs can both be targeted in the late spring, with mowing timed before flowering. However, mowing is not particularly effective for eradicating warm season perennial grasses. Repeated mowing will generally favor grasses over forbs, therefore it is generally not an effective standalone method for perennial weed control. Instead, combine mowing with an herbicide treatment. We recommend mowing, waiting for regrowth, then spraying the unwanted species.

i. *Spot-mowing*

When weeds are clumped together, spot mowing may be an option. Weed-eaters tend to have a limited range, between 6–10", making it possible to avoid wildflower patches. A weed-eater (a.k.a. string-trimmer, 'weed whacker') is the recommended tool for spot mowing. A tri-blade is most effective at cutting thick stemmed weeds or small woody stems—e.g., invasive thistles or Himalayan blackberry (*Rubus armeniacus*)— while string is best for thin-stemmed weeds like annual grasses and mustard (*Brassica* spp.). Follow all safety guidelines when operating weed-eaters. Time spot mowing so that unwanted plants are cut back before they set seed. Weed- eaters can also be used to mow around the site edges (Section V).

II. HAND-WEEDING

Figure 4.5: Hand-weeding is often the most effective way to remove weeds without harming desirable species, although it can be time-consuming in large sites.

While hand-weeding can be time consuming, in some cases it is a highly effective, targeted method. It is particularly well-suited for removal of weedy species that occur in low numbers or are scattered throughout a site. Hand-weeding is often the least invasive way to remove weedy species.

Numerous tools can facilitate hand-weeding, from hoes and hula hoes, to pick axes and pulaskis, to shovels and trowels. We recommend wearing gloves and long sleeves to protect from spiny plants and sap from plants in the carrot family which cause skin irritations. Weeds are often best targeted during active growth stages, before they have flowered and set seed. If the plant only flowers once in its lifetime and flowering already occurred you don't need to remove the entire plant, instead clip off the seed heads

and leave the roots in place. Be aware that some weed seeds—like musk thistle (*Carduus nutans*)—are viable almost as soon as the plant has bolted. These weeds will need to be bagged and removed from a site if they have been allowed to flower.

For perennial and rhizomatous species, make sure to remove as much of the root material as possible, as they can quickly sprout from small root fragments. Weeding when there is some moisture in the soil can make it easier to remove the entire root structure. However, heavily saturated soils can be easily disturbed by hand-weeding leaving areas for new weeds to recolonize. If weed removal results in large bare patches, consider interseeding the gaps to avoid re-colonization by unwanted species.

III. SPOT-SPRAYING

Spot-spraying refers to the targeted application of herbicide on specific weedy species. The goal is to minimize non-target application and drift to adjacent wildflower species. Backpack sprayers or rope wick applicators are the most commonly used spot-spraying tools. Spot-spraying can also result in bare patches; we recommend interseeding into large areas that were sprayed after the herbicide residues have dissipated. Information on residual periods of herbicide residue can usually be found on the product label.

It is important to follow the instructions on the label when applying herbicides. Most weedy species should be targeted during their active growth phase. We do not recommend using herbicides on weeds when they are in bloom, because weeds are least susceptible to herbicides during the flowering stage and because such spraying could expose pollinators to harmful chemicals. In addition, avoid any herbicide that is toxic to bees (e.g., paraquat and gramoxone). Information about where to find out about herbicide toxicity to pollinators is listed in the Additional Resources at the end of this document. Guidance on active ingredients that target non-native or invasive weeds and appropriate application timing is usually available from statewide Invasive Plant Councils (e.g., California Invasive Plant Council) or extension agencies. Certified Crop Advisors can also provide offer assistance with application rates and timing.

Figure 4.6: Many conservation programs spot-spray invasive or noxious weeds and to avoid disturbing adjacent established native plants—like the the Glacier Exotic Plant Team is targeting Canadian thistle and bindweed while avoiding milkweed and globemallow (left), or as added insurance against invasive woody species in northern tallgrass prairie restoration (right).

IV. GRASS-SELECTIVE HERBICIDE

If non-native grasses are a major weed threat, then grass-selective herbicide may be an appropriate treatment option. Grass-selective herbicide treatments are most effective during the early plant growth phase—not during flowering—when grasses are small (typically <6" tall). It is often necessary to spray multiple times throughout the year to target both warm and cool season grass species. Be aware that grass-selective herbicides can damage forbs if they are applied at high rates or applied multiple times over a short period. Most forbs are able to recover, but may show signs of herbicide damage. If well-established native bunch grasses are present, grass-selective herbicides can still be used, as vigorous perennial native grass stands often recover from a single herbicide treatment. However, recently planted native grasses can be eradicated by the use of grass selective herbicide. If non-native grasses are known to be a major issue at the site, consider seeding only forbs in the initial planting to allow ease of grass-selective herbicide use. Native grasses can be interseeded in the future following successful grass-selective herbicide treatment. Be aware that some grass-weeds—like annual ryegrass, (*Lolium multiflorum*)— appear to be resistant to grass-selective herbicides; other removal strategies will be required when targeting those species. Make sure to follow all directions on the label when applying herbicides.

V. WEED REMOVAL AROUND SITE EDGES

When site preparation has been successful, weeds within pollinator habitat may be minimal, but weeds surrounding it could invade from the edges. To combat weeds around pollinator habitat we recommend managing site perimeters through mowing, herbicide application, mulching (best for smaller sites), or a buffer of native bunch grasses. It is likely that weed management will need to occur multiple times throughout the year to target weeds present in different seasons. When mowing outside the site, set the mower bar to the lowest level without it touching the ground. Time mowing to just before or immediately after flowering of

Figure 4.7: Established sites may need weed management around the edges—outlined in white below—where undesirable plants can be removed by mowing or targeted herbicide applications.


Figure 4.8: Conservation haying reduces light competition from tall grasses by allowing spring-blooming flowers and other short-statured plants to thrive, and it may also help bees to more easily find these resources. On the left, a strip of spring-blooming wildflowers is no different from the surrounding area except that it was hayed in the previous fall. The 85 ac site in Minnesota on the right shows conservation haying on a larger scale—a mosaic of 5–10 ac hayed and unhayed treatment plots has been established, such that only a portion of the site is hayed in any given year.

unwanted forbs; annual grasses should be mowed prior to seed production. Perennial grasses can be regularly mowed throughout the year to prevent seed production, limit their spread, and reduce their vigor. If there are low-growing or creeping invasive plants on the edge—such as birdsfoot trefoil (Lotus corniculatus)—we do not recommend mowing. If spraying (instead of using a rope wick applicator), take special care to ensure that herbicides do not drift off target and kill wildflowers. In addition, do not spray any weeds that are in bloom, as this poses a risk to pollinators. If combating nearby weeds with herbicides, consider a long term strategy such as expanding the existing habitat to encompass the problem areas, if the adjacent area contains suitable conditions for wildflowers (e.g., flat terrain that is not frequently driven over). If mulching the borders of a planting, apply weed-free mulch (e.g., straw or wood chips) on an annual basis. If weeds penetrate the barrier, hand-weeding or herbicide applications may be needed. Another option is to plant a buffer of native bunch grasses around wildflower habitat that can be mowed or weeded regularly to help resist weed invasion from the outside edges. If space permits, mulch can also be applied around the native grass border to extend the width of the buffer around the habitat area.

VI. CONSERVATION HAYING

Like mowing and other disturbance regimes, conservation haying is an important management tool for enhancing plant diversity and suppressing the growth/encroachment of woody vegetation in a prairie setting. Conservation haying also reduces light competition from tall grasses, allowing spring blooming flowers and other shorter-statured plants to thrive. Haying differs from mowing in that the resulting thatch is removed from the site. As such, haying can be even more effective than mowing at promoting wildflowers and mining excess nutrients (e.g., in an effort to build soils that better favor desired plant communities over weeds). Moreover, haying can provide direct economic value from pollinator habitat, since the cut and dried herbage can be sold or used as livestock forage, bedding, or mulch.

While haying can benefit plant communities, it can also pose risks to pollinators and other wildlife by abruptly removing flowers at a site. Careful consideration of scale, technique, and timing can help protect pollinators from these impacts. Mow in strips or patches, instead of haying an entire site, to leave refuges for pollinators. Another common method is to divide an area in thirds and cut only one third each year, rotating the cut area annually, such that each parcel is cut every three years. Cutting should occur at reduced speeds (less than 8 mph) in order to give pollinators and other wildlife more time to disperse. Use of a flushing-bar on the mower can also help minimize risk to pollinators. Set the mower blades at a high height (12–16"), in order to maximize the vegetative structure (nesting/overwintering habitat) that is left on site.

Cutting late in the summer or fall (after peak bloom) is recommended for pollinators, since cutting at this time can minimize sudden reductions in nectar and pollen resources, and also ensures that most plants have set and dropped seed. However, if hay is to be harvested for livestock forage, these objectives may need to be balanced with the protein content and other nutritional qualities of the hay. Note that some wildflower species like wild buckwheat (*Eriogonum* spp.) and buttercups (*Ranunculus* spp.), and some weedy species like hemlock (*Conium maculatum*) and St. John's wort (*Hypericum* spp.) may be toxic to livestock. If conservation haying is planned, do not plant toxic species and make sure that toxic weeds are adequately treated before haying or are not present. Consider occasionally interseeding additional desirable native grasses and forbs into the site by broadcast seeding the area immediately after haying. This will help mitigate the loss of natural seed drop by wildflowers that are cut during the haying process.

VII. PRESCRIBED FIRE

Prescribed fire is an excellent tool for managing pollinator habitat. Fire is a natural component of many native plant communities, particularly those with native grasses that can carry fire. Fire can be used for many purposes: to reduce thatch, suppress woody species, release nutrients, open space for new growth, stimulate germination of some seeds, enhance flowering, and reduce weedy competition. Fire can be the most effective tool for combating invasives while invigorating growth of native species, particularly when compared with strip disking, herbicide, or hand-pulling. The value of prescribed fire, however, depends on specific site conditions, timing of burn, and plant community composition. For example, a few invasive species can benefit from fire or carry a hotter, more damaging fire than the native plant community; therefore, fire should be avoided when these kinds of species are present—such as cogongrass (*Imperata cylindrica*), cheatgrass (*Bromus tectorum*), and Chinese bushclover/sericea lespedeza (*Lespedeza cuneata*). As with other habitat management techniques, it is best to spread management across several years, trying not to disturb more than one third of the managed area at any one time. This ensures refuge for wildlife and supports quicker recolonization of previously disturbed areas. Refuge from disturbance also helps sustain healthy populations of pollinators and natural enemies of crop pests close to crop fields.

Training and permits will likely be needed for burning, and a prescribed burn should be conducted by a trained professional. Before using prescribed fire, consult with local forestry or natural resources departments to find out if state permits and/or training are required. Always include fire breaks—paths cleared of leaves or other dry plant material to expose green vegetation, bare soil, rock, or bodies of water— when using prescribed fire. If fire is planned as an ongoing management technique, include fire breaks in the planting and management design process by incorporating clovers, cool season grasses, or other plant groups along the edges of the habitat,

Figure 4.9: Prescribed fire can be highly effective for managing native plant populations to favor wildflowers over aggressive grasses and woody species—here the Michigan Department of Natural Resources and The Nature Conservancy conduct an annual burn to preserve habitat for the endangered Karner blue butterfly (*Plebejus melissa samuelis*).

they have a green period during the typical burning windows in the spring and fall. We recommend splitting the site into three to five sections, with the aim of burning one section per year.

VIII. GRAZING

Selective grazing in pollinator habitat can help decrease the cover of non-native grass species. Grazing may not be right for every site; for example, it is more effective in larger sites. Improperly managed grazing can reduce or eliminate wildflower cover in habitats where non-native grasses are not a primary concern or grazers are allowed to overgraze the site.

Cattle are the preferred grazing livestock in pollinator habitat because at low stocking rates they generally prefer grasses over wildflowers; however, be aware that cattle do find some wildflower species palatable—such as prairie clover (*Dalea* spp.). Check to see which wildflower species are highly palatable before choosing grazing as a management strategy to avoid adverse impacts on desirable plants. We also recommend determining whether any plants in the area to be grazed are toxic to livestock before deciding whether grazing is an appropriate technique (see Additional Resources: Grazing).

Goats and sheep are less selective grazers and will consume both wanted and unwanted species; they are therefore less preferred grazers for pollinator plantings. Sheep or goat grazing is often more appropriate for areas dominated by woody plants or non-native and aggressive forbs. For example, goats are increasingly being used in the Midwest to manage invasive buckthorn shrubs, as well as Canada goldenrod, a native wildflower that often dominates wildflower plantings and can require management to set it back so that other species can thrive.

A light stocking rate helps ensure that livestock are only eating their preferred forage, and that they are

Figure 4:10: Cattle grazing around various native wildflowers—including boneset (*Eupatorium* spp.) and blue lobelia (*Lobelia siphilitica*).

not overgrazing a site. Alternatively, a heavy stocking rate for a short time (mob grazing) can ensure that all areas of the site are quickly grazed. Consider the duration of grazing period when planning for an appropriate stocking rate that favors pollinator plants; grazers will consume more forage and become less selective the longer they are kept in an area. Avoid overgrazing as an overgrazed pasture is vulnerable to weed incursion. If an area is accidentally overgrazed it may require interseeding to restore any wildflower species consumed by grazers.

Timing of grazing can help address different site conditions. For example, to reduce the dominance of cool season grasses, graze in early spring (before warm season grasses are active) or in the fall (after warm season grasses have set seed). To combat warm season grasses, graze in late spring or early summer. Whether controlling either warm or cool season grasses, try to graze unwanted grasses especially hard during their active growth stage prior to bloom. If the overall goal is to increase wildflower biodiversity without targeting a specific non-native grass species, use a light stocking rate and rotational grazing. As with prescribed fire, a rotational grazing system splits the site into three to five segments that are grazed at different times and with varied intensity and duration across years. Such a grazing pattern promotes site heterogeneity.

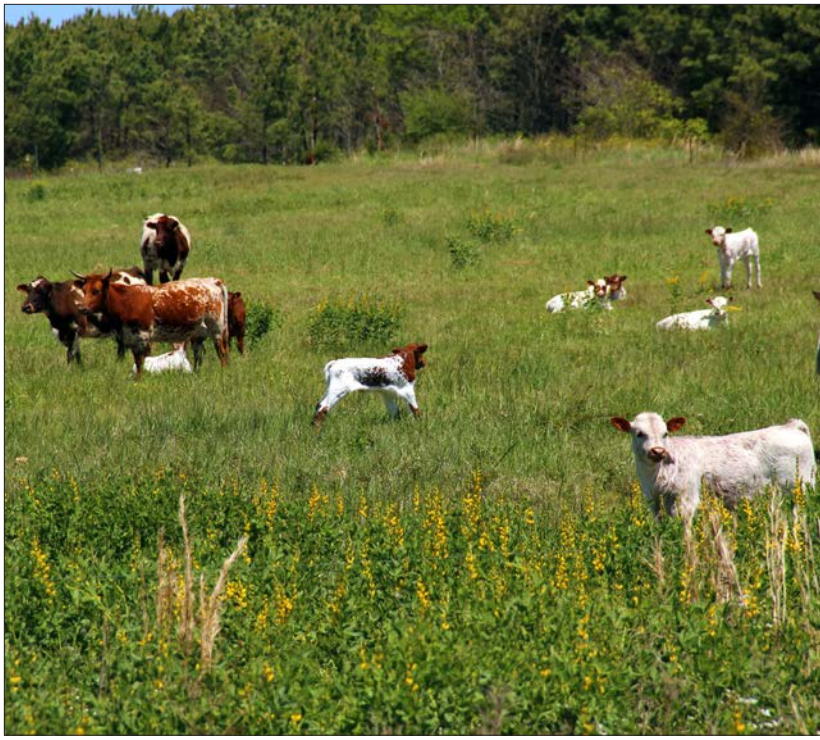


Figure 4.11: When properly managed at a low stocking rate, cattle grazing is a highly efficient method for clearing grasses from pollinator habitat.

IX. REINTRODUCING WILDFLOWER DIVERSITY

A. Interseeding

Interseeding is the addition of seeds to an existing site without extensive site preparation. It is used to restore species that have been lost from the site, or introduce new species not originally included. Interseeding can address the following issues: (1) restore a missing species, (2) add a critical species (e.g., milkweed that support monarchs), (3) add a species to fill a gap in bloom, or (4) provide a seed bank to fill in after weed eradication leads to exposed and/or disturbed patches of soil.

Perennial wildflowers generally take more time to establish than do annuals but can have long lifespans and are less dependent on recruitment of new plants from seed. Perennials therefore seldom require interseeding once established within a site. Annual wildflowers tend to provide abundant resources during the establishment phase, however, most only persist a few years, requiring periodic reintroduction to a site if they are a desirable species to retain in the habitat. This is particularly true on the West Coast (especially in California). Nevertheless, in some ecosystems (e.g., tallgrass prairie) a shift in species composition (from annual to perennial) over time is natural and interseeding may not be necessary. Some species can take years to establish at a site (e.g. gentian, camas), and in these cases, we recommend patience while waiting for them to appear.

Snow Seeding

Snow seeding is an option for interseeding during the dormant season in cold climates. Because seed is broadcast on top of snow, it easy to see seed coverage and achieve even distribution of seed across the site (Figure 4.12a). A light cover of snow of just a few inches is preferred to heavy snow since the seed must work its way through the snow to reach the soil. Before snow-seeding, check the weather to make sure that heavy rains are not expected in the near future—since rain or rapid snow melting could cause the seed to wash around (or off) the site before it has found its way to the soil. Snow seeding can be done by hand, with a belly crank, or a broadcaster (Figure 4.12b).

Figure 4.12A: Seed Distribution on Snow

Figure 4.12B: Broadcasting Seed on Snow

A portion of the seeded species may fail to establish due to several factors (e.g., poor seed quality, low seeding rate, weed pressure). When, however, key species are missing, we recommend interseeding those species, or other wildflowers that can fulfill the same function, back into the site.

Interseeding can also be a valuable tool to use following weed removal, particularly if a large area of weeds is removed from the site. In this case, interseed with species that have already performed well at the site or that are known to be somewhat vigorous. This course of action can help quickly fill in the exposed area, reducing competition from the weed seed bank. Consider including new species that can fill the same niche as the unwanted weed. For example, if the weed species removed was a deep-tap rooted species, seed a wildflower with a deep tap root so that it directly competes with the weed. For example, when removing star thistle (*Centaurea solstitialis*) in California, seed in tarweed (*Hemizonia* spp.).

The simplest approach to interseeding is to broadcast seed directly into existing habitat. Though easy, this approach requires approximately 30% more seed to achieve the same establishment rates as methods that improve seed to soil contact. An accurately calibrated and carefully operated seed drill (planting no deeper than ⅕") can improve seed to soil contact. We recommend a native plant seed drill for this kind of seeding, as they were developed to handle native seeds. Raking a site before broadcasting can also increase seed to soil contact. In sites where non-natives species or native bunch grasses are dominant, it is possible to open up areas for seeds to colonize by shallow disking in sections of the site (see the California Almond Orchard case study, p. 40–41 for a more detailed description of disking). Heavy disking or disking in sites with large stands of existing wildflowers is not recommended, as it may irreparably harm those plants and encourage weeds to germinate from the seed bank.

The best timing for interseeding is during periods of regional precipitation (e.g., during the monsoon season in the southwest or during the winter dormant season in the west). Ideally, seed before heavy rains to reduce soil impacts and avoid limited equipment entry. If the climate permits, snow-

Figure 4.13: This California pollinator meadow features numerous native wildflower species with overlapping bloom times to support pollinators throughout the growing season. In order to maintain a diversity of bloom over time, the site was mowed and interseeded with additional high quality wildflowers in November 2014.

seeding is another option (see Snow Seeding, sidebar).

In the years following interseeding, new seedlings will emerge in and amongst existing wildflowers, some of which will be fully mature (if they are perennials). This highly competitive environment can limit seedling establishment. Management to reduce this competition can promote the establishment of newly interseeded species. Selecting a management option depends on the importance of the previously established vegetation versus the added species. If existing wildflower species won't be harmed, mowing vegetation to a height of 4–6" can increase sunlight to the seedlings and increase their success rates. If, however, the existing vegetation is composed mostly of grasses (whether native or non-native), multiple cuts above the height of the seedlings will likely be necessary. If non-native grasses pose the greatest threat, it may be necessary to apply a grass-selective herbicide prior to interseeding to reduce non-native grass dominance enough to allow for seedling establishment. Don't be discouraged if the newly seeded species do not immediately appear within the habitat; the results of interseeding can take years to become apparent.

B. Plug or Bare Root Planting

Some plant species don't germinate reliably from seed in field settings when planted in a seed mix—such as vinegar weed (*Trichostema lanceolatum*). Other species have a better chance of survival when they are planted from a container than when planted from seed—such as some milkweed species (*Asclepias* spp.) or blazing stars (e.g., *Liatris spicata*). Using transplants provides these difficult-to-establish species an opportunity to develop a strong root structure and compete with other species in diverse systems. Plugs are often the smallest size container available, making them the most affordable option. In arid climates, plugs are best planted in the fall with the rains; in other regions, they can be planted during the growing season, timed with rains, such as spring or fall. Avoid transplanting in summer during periods of extreme heat as this can lead to plant stress and limit successful establishment. Watering is almost always necessary after planting plugs.

X. IRRIGATION

We recommend planting native, locally adapted species that are drought-tolerant. Nevertheless, when areas experience severe drought, water scarcity can decrease the survival and establishment of drought-adapted species. Providing just enough water to mimic 'normal' rainfall patterns (i.e., winter in California, monsoons in the southwest) during drought years can greatly improve wildflower germination and persistence.

Figure 4.14: Installing drip-tube irrigation to help establish plant plugs in a Minnesota pollinator planting.

Figure 4.15: This pollinator conservation cover—consisting mainly of native wildflowers—was planted between rows of almond trees to provide habitat to pollinators after the almond bloom.

Irrigation is most critical in drought-prone regions during the initial establishment phase (typically 1–3 years); however, supplemental irrigation can be necessary during multi-year droughts. Even in non-drought years, occasional summer irrigation can also be used to prolong the bloom period into late summer and fall in arid regions.

When repeated irrigation is anticipated, it can be practical to install an irrigation system. The most efficient and easily installed irrigation systems for pollinator habitat are drip irrigation with in-line emitters or micro- sprinklers. Drip-tubing with in-line emitters on 1' centers can be used and laid approximately 2' apart, so that 1' of dripline will soak about 2 ft^2. Micro-sprinklers need to be mounted on tall risers (3' or more, depending on height of wildflowers being planted). Adequate water-pressure is essential if micro-sprinklers are to be used, and maximum circumference will vary with nozzle design and water pressure. It is also possible to use overhead impact sprinklers on risers instead of micro-sprinklers.

Watering in the evening or at night will minimize evaporation regardless of irrigation method, but is particularly important if using micro-sprinklers. Water every 2–4 weeks, depending on heat and soil moisture conditions.

It is helpful if there is an existing irrigation system to hook into. Because wildflowers need significantly less water than most crops and will often die if over-watered, a separate line and shut-off for the habitat areas is necessary. A remote water timer can be programmed for the habitat area. Dripline conversion materials will be needed if hooking into most agricultural irrigation systems. If there is no existing system, water trucks can be used to irrigate as-needed. However, fine nozzles will be necessary to protect seeds and small seedlings from the force of the water.

XI. STARTING OVER

Hopefully following the advice in this guide will help to avoid situations in which starting over is necessary. In some cases, however, such as when initial weed control at a site was inadequate, restarting the project

by implementing intensive, non-selective weed control might be the best solution. If re-starting, it is a good idea to complete a year of weed control prior to seeding, to control the major issues that lead to the need to start over. We recommend initiating site preparation by May (at the latest) the year of intended re-planting. One year of intensive weed management using techniques such as chemical fallow or solarization is usually sufficient. If the mix is high in wildflowers that require stratification then planting in the fall or winter (after October 15) is generally more successful than a spring planting. For guidance on weed control prior to establishment of pollinator habitat, as well as habitat installation recommendations, see the Xerces Society/NRCS series of establishment guides (see Additional Resources: Re-starting Habitat).

If some wildflower species are thriving, consider saving their seeds the year prior to re-starting a project to reduce the cost of seeds when replanting. Different species need to be harvested at different times, and usually require cleaning prior to storing. Make sure to store them in a cool, dry place. Adding silica packets can help prevent buildup of excess moisture. Some seeds respond best to stratification, or storage in a cold environment, such as a fridge. If new seeds are purchased, they can be sown in fall prior to frosts, which provide natural stratification. Seed mixes with high percentages of seeds requiring stratification that are seeded in spring tend to perform less well than if seeded in fall, unless they are placed in cold storage before sowing. For information on seed saving, cleaning and storage, we recommend reviewing regionally available guides (see Additional Resources: Seed Saving).

XII. EXTREME WEATHER CONDITIONS

Extreme weather, including droughts and flooding, is becoming more prevalent. Extreme weather can affect the ability of even the most proactive manager to maintain wildflower diversity and abundance within a site. We recommend increasing monitoring frequency in the years following an extreme event in order to track and manage novel undesirable conditions.

In multi-year droughts, seeds may lie dormant and their viability may be reduced over time (See Section X. Irrigation). Floods can scour a site, removing seed from the seed bank. When floods occur, it might be necessary to add seeds or plugs in subsequent years (See IX. Reintroducing Wildflower Diversity). Floods can also introduce seeds of weedy species, thus monitoring for new weedy species after a flood can help prevent new problems. If seasonal flooding is known to be a common occurrence, including flood-tolerant species in the initial seed mix to help habitat withstand inundated conditions. Installing erosion/scour resistant materials over the seed bed can help retain seeds if flooding becomes a frequent occurrence.

While none of the sites we have worked on have been affected by wildfire, fires are becoming increasingly common, particularly in the arid west. As described above, fire can facilitate the germination of wildflowers. In the case of severe fire, however, it is important to monitor in the following year to observe changes in site conditions. Re-seeding or adopting different management techniques to address altered conditions may be necessary following a burn.

5 Deciding Which Management Technique to Use

Identifying Conditions

The data collected from routine monitoring will help to identify the conditions present in the pollinator habitat. See Table 5.1 for a list of the most common conditions we've observed in native wildflower meadows. Figures 5.1–5.3 provide additional assistance for identifying the condition of your meadow and determining which management techniques to use over time. After initial establishment, planted pollinator habitat often follows one of these common trajectories:

High Diversity of Bloom

The goal of a pollinator habitat planting is a diversity of bloom across seasons with minimal/manageable weed pressure. Some plantings maintain their intended function and plant community structure without much intervention, while others may lose one or many species. Species losses can create gaps in bloom that need to be filled in order to attract and maintain pollinators throughout their foraging season, which can last 4–6 weeks for solitary species with a single generation and many consecutive months for social species or species with multiple generations a growing season. A less frequent condition occurs when one or a few desirable plants grow to dominate the habitat, such as native bunch grasses or a vigorous wildflower species, like goldenrod (*Solidago* spp.). These dominant plant species will compete with other native species and can eventually prevent the habitat from supporting a diverse array of flowering plants, as well as their associated pollinators. If vigorous native plants dominate the habitat, it can require light management to facilitate conditions that foster a high diversity of native wildflower species.

Figure 5.1: This pollinator habitat in Virginia provides late-season bloom through the inclusion of long-blooming wildflowers, such as blanketflower (*Gaillardia* spp.) and black-eyed Susan (*Rudbeckia hirta*).

Mixture of Desirable and Unwanted Plants

In some cases, unwanted species may co-exist with desirable planted species as a patchwork, with weeds dominating in some areas and wildflowers in others. Alternately, weeds may be intermixed with desirable species. These scenarios present different management challenges. In plantings with patchy areas, it is possible to manage

Figure 5.2: Weedy radish (*Raphanus* spp.), prickly lettuce (*Lactuca serriola*), and mallow (*Malva* spp.) are intermixed with desirable native wildflowers like lupine (*Lupinus* spp.) and baby blue eyes (*Nemophila menziesii*) in this pollinator planting, requiring targeted weed management.

weeds intensively without worrying about damaging adjacent wildflowers (i.e., spot-mowing). Interseeding with additional wildflower species is often necessary, however, to fill in the disturbed area after management and repel new unwanted species from taking hold. In plantings where weeds and wildflowers are interspersed, more targeted weed management (e.g., hand-weeding or spot-spraying) is often best.

Figure 5.3: A large patch of yellow star thistle (*Centaurea solstitialis*)—outlined in red—is pushing out native wildflowers that include gumweed (*Grindelia* spp.) and California poppies (*Eschscholzia californica*), allowing for intensive management practices like spot-mowing.

Dominated by Undesirable Species

Even a habitat that starts off with a robust wildflower population may succumb to weed invasion over time. On the one hand, weeds might co-exist with wildflowers, necessitating some light management. However, when one or many weeds species takes over a more intensive approach is required.

Table 5.1: Common Site Conditions

DOMINANT SPECIES	DESCRIPTION	PRIMARY CONDITION » SECONDARY CONDITION		EXAMPLES†
DESIRABLE SPECIES Native wildflower and grass species cover at least 75% of the site	**Diverse wildflower bloom with minimal weed cover**	Diversity of Bloom*		At least three wildflower species in bloom in each season (except winter), with overlapping flowering periods
	Lacking one or more key species	Key planted species missing‡		One or more planted species did not germinate or failed to establish at site
		Gap(s) in bloom		Lacks early or late-blooming species
	Dominated by one or a few native species	Native grass		Fescue (*Festuca* spp.)
		High value		Goldenrod (*Solidago* spp.)
		Low–moderate value		Yarrow (*Achillea millefolium*)
MIXTURE Both weeds and wildflowers present	**Weeds are present in significant amounts in some—but not all—areas of the site**	Intermixed	» Mostly Woody	Weedy trees/shrubs are interspersed in both well-established and poorly-established areas
			» Mostly Forbs	Flowering weeds are interspersed in both well-established and poorly-established areas
			» Mostly Grasses	Weedy grass(es) are interspersed in both well-established and poorly-established areas
		Patches		Distinct patches where weeds dominate and distinct areas where wildflowers dominated
UNWANTED SPECIES Weeds—including non-native, invasive, and noxious species—cover 70% or more of the site	**Dominanted by one or a few weed types or species with few to no native species**	Grass(es)	» Warm season	Cheat grass (*Bromus tectorum*)
			» Cool season Annual	Medusahead (*Taeniatherum caput-medusae*)
			» Cool season Perennial	Harding grass (*Phalaris aquatica*)
		Forbs		Bindweed (*Convolvulus* spp.); Russian thistle (*Salsola tragus/S. kali*)
		Woody plants		Blackberry (*Rubus* spp.); Eastern redcedar (*Juniperus virginiana*)
	More than one form of weedy species present	Mixture		May include mixed weedy grasses, forbs, and woody species

TABLE 5.1 *Notes:*

† These are just a few representative examples of different native and weedy species—contact your local extension office for examples specific to your region.

Decision Tree #1: Sites Dominated by Desirable Species

The goal of long-term management strategies is a Diversity of Bloom across seasons with minimal/manageable weed pressure (see *Notes* below). We define dominance as the condition when one class of species (wildflowers or weeds) are more abundant that the other, with the consequence that they can potentially suppress the other.

No — **Dominance: Are desirable species dominant (i.e., most abundant)?** — **Yes**

Go to Decision Tree #2

No — **Species Diversity: Are there at least 2–3* wildflower species present?** — **Yes**

Pollinator Value: What is the value of the dominant species present to pollinators?

Low value native grass(es)

1. Selectively remove grass(es) by:
   - **Grass-selective herbicide*** *OR*
   - **Hand-weeding** *OR*
2. Create space for forbs by:
   - **Conservation haying** *AND*/*OR* **thatch removal** *OR*
   - **Disking** into grasses to create room for forbs

☆ *If necessary*, consider reintroducing wildflower diversity by **interseeding***

Low–moderate value wildflower(s)

Selectively remove patches of dominant low value species by:
- **Hand-weeding** *OR*
- **Spot-spraying herbicide*** *OR*
- **Spot-mowing**

☆ *If necessary*, consider reintroducing wildflower diversity by **interseeding*** additional high value wildflower species

High value wildflower(s)

Selectively remove patches of dominant species by:
- **Hand-weeding** *OR*
- **Spot-spraying herbicide*** *OR*
- **Spot-mowing**

☆ *If necessary*, consider reintroducing wildflower diversity by **interseeding***

No — **Overlapping Bloom: Do species bloom continuously* throughout the growing season?** — **Yes**

How is the site lacking species?

Key species missing‡

Reintroduce wildflower diversity by **plug-planting** *OR* **interseeding** wildflowers to fill in gaps

Gap(s) in bloom

1. **Mow for diversity**; **AND**
2. Reintroduce wildflower diversity by **plug-planting** *OR* **interseeding** to fill in gaps

IDEAL CONDITIONS: Diversity of Bloom*

1. Manage to maintain this state by:
   - **Mowing for diversity** *OR*
   - **Conservation haying** *OR* **thatch removal**; **AND**
2. Targeting aggressive weeds:
   - **Mowing for weed control**
   - **Hand-weeding**
   - **Weed removal along perimeter**

Decision Tree #1 *Notes:*

* A Diversity of Bloom is defined by overlapping bloom periods of at least 2–3 species during each season (spring, summer, and fall).
** During active growth phase.
† These are representative examples of native species—contact your local extension office for examples specific to your region.
‡ Some species don't establish well from seed and may require transplants.
☆ See When to Use Interseeding, p. 27.

Decision Tree #2: Sites with a Mixture of Desirable & Unwanted Species

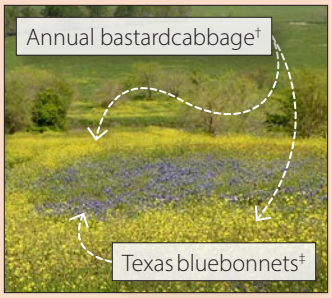
No — **DOMINANCE: Are desirable species *more* abundant than weed species?** — **Yes**

Go to Decision Tree #3

DISTRIBUTION: How are wildflowers and weeds distributed throughout the site?

Patches

1. Use technique(s) timed to selectively target weeds' vulnerable growth phase:
   - **Spot-mowing** *OR*
   - **Spot-spraying herbicide*** *OR*
   - **Hand-weeding; AND**
2. Reintroducing wildflower diversity by **interseeding** wildflower species is recommended after clearing a large patch of weeds to help wildflowers re-colonize the area and compete with weed seeds that might germinate from the seed bank.



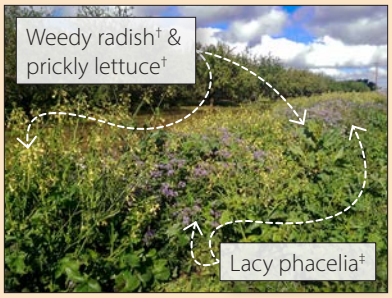
Intermixed

What types of weeds are present?

Mostly woody

Use technique(s) timed to selectively remove *OR* target the weeds' vulnerable growth phase:
- **Mowing for weed control** annually in fall *OR*
- **Hand-weeding** (with pulawskis or other tools) is often best for woody species like broom *OR*
- **Spot-spraying herbicide*** *OR*
- **Rotational grazing** for a short period—rotate grazers out before they start consuming the forbs *OR*
- **Prescribed fire**

Mostly forbs



Use technique(s) timed to the target weeds' vulnerable growth phase:
- **Hand-weeding** *OR*
- **Mowing for weed control** *OR*
- **Spot-spraying herbicide*** *OR*
- **Rotational grazing**—move grazers out before wildflower bloom (early spring) *OR*
- **Prescribed fire**

Mostly grasses

Selectively remove grass(es) by:
- **Grass-selective herbicide*** *OR*
- **Rotational grazing** for a short period—rotate grazers out before they start consuming the forbs *OR*
- **Prescribed fire** (note: only for cool season grasses) or
- **Hand-weeding**

DECISION TREE #2 *Notes:*

* During active growth phase.
† These are common widespread weedy species—contact your local extension office for examples specific to your region.
‡ These are representative examples of native species—contact your local extension office for examples specific to your region.
☆ See When to Use Interseeding below.

When to Use Interseeding

Interseeding is a tool that can help restore diversity lost from a site (see Management Strategies: Interseeding). It often is most successful when coupled with other forms of weed management, particularly if management is targeted at reducing abundance of dominant wildflowers or weeds and results in large areas of bare soil that could be colonized by unwanted species. Interseeding can be costly and may not always be necessary. We recommend waiting to determine whether management actions alone stimulate the habitat to move closer to the desirable conditions. If not, consider interseeding after completing other management actions in future years

Decision Tree #3: Sites Dominated by Unwanted Species

DOMINANCE: What weed forms dominate the meadow?

Mixture

If a variety of species are present, use a combination of techniques timed to target weeds during their vulnerable growth phase*, including:

- **Mowing for weed control** *OR*
- **Spot-mowing** *OR*
- **Spot-spraying herbicide*** *OR*
- **Hand-weeding**

☆ *If necessary*, consider reintroducing wildflower diversity by **interseeding*** wildflower species

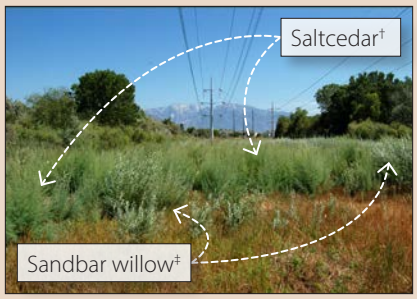
Mostly forbs

Use technique(s) timed to the target weeds' vulnerable growth phase*, including:

- **Mowing for weed control** *OR*
- **Spot-mowing** *OR*
- **Spot-spraying herbicide*** *OR*
- **Hand-weeding**

☆ *If necessary*, consider reintroducing wildflower diversity by **interseeding*** wildflower species

Mostly woody



Use techniques to target woody weeds (which are more vulnerable to disturbance):

- **Hand-weeding** *OR*
- **Spot-mowing frequently** *OR*
- **Spot-spraying** foliar herbicide frequently, cut and stump treatment *OR*
- **Prescribed fire**

Mostly grasses

Growing season?

Cool

Life cycle?

Perennial

Selectively remove perennial cool season grass(es) by:

- **Grass selective herbicide***in early spring and again in fall *OR*
- **Seasonal mowing** in early spring and again in fall *OR*
- **Rotational grazing** *OR*
- **Prescribed fire**

☆ *If necessary*, consider reintroducing wildflower diversity by **interseeding*** wildflower species

Annual

Selectively remove annual cool season grass(es) by:

- **Seasonal mowing** in early spring once grasses have bolted but before flowering *OR*
- **Grass selective herbicide***in early spring *OR*
- **Rotational grazing** *OR*
- **Prescribed fire**

☆ *If necessary*, consider reintroducing wildflower diversity by **interseeding*** wildflower species

Warm

Selectively remove warm season grass(es) by:

- **Seasonal mowing** before flowering (late-spring) *OR*
- **Grass-selective herbicide***in late-spring *OR*
- **Conservation haying**, if the targeted grass species is tall-growing and sets seed late in the year after most wildflowers have set seed *OR*
- **Rotational grazing** *OR*
- **Prescribed fire**

☆ *If necessary*, consider reintroducing wildflower diversity by **interseeding*** wildflower species

DECISION TREE #3 *Notes:*

* Targeting weeds during the vulnerable stage is critical. This can include flowering of a monocarpic plant, spraying a perennial during phloem flow to the roots in the fall, etc. For more information on successfully targeting weedy species in your area, contact your local extension office.

† These are representative examples of weedy species—contact your local extension office for examples specific to your region.

** Note: Sites with high weed pressure—like the one pictured—will likely need multi-years of management before interseeding.

‡ Sandbar willow (*Salix exigua*) is a desirable species for streambank stabilization *in its native range*, but can become weedy without proper management.

☆ Interseeding wildflower species is recommended after clearing a large patch of weeds to help wildflowers re-colonize the area and compete with weed seeds that might germinate from the seed bank. See When to Use Interseeding on p. 33 for details.

POLLINATOR HABITAT MANAGEMENT LOG

Keeping track of management techniques helps assess effectiveness of timing and method, allowing for improved implementation in future years.

STEP 1—Photocopy or print copies of this form in advance (www.xerces.org/habitat-assessment-guides)

STEP 2—Site Details

SITE NAME: _____ _____

STEP 3—Management Practices Record

Record all management techniques used. Be sure to include the timing of when the action was taken so if it is not effective, management can be adjusted in the future. In addition, record what the intended goal for the management (for example, "to reduce or eradicate Harding grass from the meadow").

NOTE: **Before implementing techniques the following year, be sure to evaluate whether the technique utilized met the intended goal.** If not, adapt the existing technique (e.g., different timing and/or frequency) or trial a new one.

BEFORE Implementation					AFTER Implementation			
#	Management Techniques Log				Efficacy Assessment			
1.	YEAR:		MONTH(S):		EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
2.	YEAR:		MONTH(S):		EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
3.	YEAR:		MONTH(S):		EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
4.	YEAR:		MONTH(S):		EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			

STEP 3—Management Practices Record *continued*

Continue to record all management techniques used, including: 1), timing of when the action was taken (so if it is not effective, management can be adjusted in the future); 2), the intended goal for the management (for example, "to reduce or eradicate Harding grass from the meadow"); AND 3), **before implementing techniques the following year, be sure to evaluate whether the technique utilized met the intended goal—**if not, adapt the existing technique (e.g., different timing and/or frequency) or trial a new one. If you run out of space, print ***Supplemental*** Management Practices Record sheets online at: www.xerces.org/habitat-assessment-guides.

BEFORE Implementation					AFTER Implementation			
#	Management Techniques Log				Efficacy Assessment			
5.	YEAR:		MONTH(S):		EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
6.	YEAR:		MONTH(S):		EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
7.	YEAR:		MONTH(S):		EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
8.	YEAR:		MONTH(S):		EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			
9.	YEAR:		MONTH(S):		EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:				NOTES			
	INTENDED GOAL:				SUGGESTED CHANGES/ NEXT STEPS:			

Selecting Management Treatment:

Once the condition of the planting has been identified, determine the appropriate management technique(s). We provide decision trees to facilitate this process (p. 32). A number of different management techniques can be utilized to address one or more conditions. We recommend trying first using familiar, known techniques, prioritizing those that also have the least negative impact on wildflowers.

Timing of implementation of a management technique is critical to its success. For example, mowing after seed set by a weedy species provides little weed control and may even exacerbate the invasion by distributing seeds throughout the site. Careful timing of a management action can help achieve different goals. For example, mowing in the spring can target many weeds (e.g., cool season grasses) during their active growth stage, whereas mowing in the fall targets late-flowering weeds that produce seeds in the fall. Late season mowing is also a good option for control of woody species. While many management strategies are effective throughout the U.S., implementation timing varies by region. For this reason, we recommend monitoring to ensure that actions occur during the optimal window.

Each wildflower planting is different and therefore responds differently to management actions. It is important to track the success of the techniques used (see Wildflower Habitat Management Log). If undesirable conditions persist in spite of management, then we recommend re-evaluating the technique used and either altering the timing or trying a different method. Continued monitoring will inform management and assist in the decision-making process.

Figure 5.4: *Example* Pollinator Habitat Management Log

BEFORE Implementation					AFTER Implementation			
#	Management Techniques Log				Efficacy Assessment			
1.	YEAR:	2015	MONTH(S):	Jun + Nov	EVALUATION DATE(S):	02/15/16	TECHNIQUE SUCCESSFUL?	Y / (N)
	TECHNIQUE USED:	Sprayed grass-selective herbicide			NOTES	Abundance of non-native grasses increased		
	INTENDED GOAL:	Decrease non-native grass cover, specfically harding grass + wild oat			SUGGESTED CHANGES/ NEXT STEPS:	Spot-spray more frequently, starting in early spring to target during active growth		
2.	YEAR:	2016	MONTH(S):	Mar, Jun, Aug + Nov	EVALUATION DATE(S):	11/25/16	TECHNIQUE SUCCESSFUL?	(Y) / N
	TECHNIQUE USED:	Repeatedly spot-spray grass-selective herbicide, starting in early spring			NOTES	Reduced non-native cover so both target species were Rare		
	INTENDED GOAL:	Decrease non-native grass cover, specfically harding grass + wild oat			SUGGESTED CHANGES/ NEXT STEPS:	None		
3.	YEAR:	2016	MONTH(S):	Oct + Nov	EVALUATION DATE(S):		TECHNIQUE SUCCESSFUL?	Y / N
	TECHNIQUE USED:	Interseeded site in fall with globe gilia + bigleaf lupine			NOTES			
	INTENDED GOAL:	Increase abundance of declining spring/ early summer wildflower species			SUGGESTED CHANGES/ NEXT STEPS:			

6 *Management is a Moving Target*

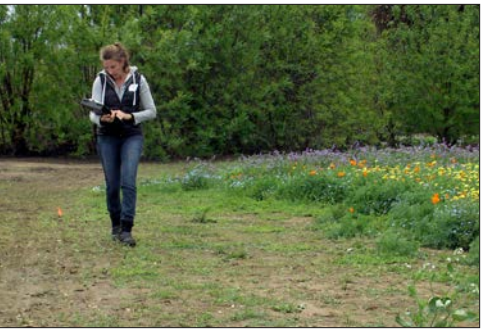
Pollinator habitat is a dynamic living system that changes based on weather conditions and past management actions. Weed populations that have previously been controlled can re-emerge as issues in wet years or if management events were not properly timed (See Case Study: Pennsylvania Apple Orchard). Sometimes this requires re-evaluation of management techniques. As you learn the principles of habitat management described in this guide, you will become more comfortable adapting and modifying these practices to improve your pollinator habitat. The results may work well, or it may be time to go back to the drawing board. We continually fine-tune our management actions with the goal of achieving the best results. After a few years of monitoring and managing, it will likely get easier to dial in timings and treatments, and ultimately increase the longevity of your pollinator habitat.

Remember that follow up monitoring and assessment it critical. Checking up on a management action, and the conditions it subsequently fosters, is key to maximizing planting success. It is easier and more cost-effective to do annual maintenance than to re-start an entire project every few years. After a year or two of monitoring, checking up on the status of the pollinator habitat will become a more rapid process as familiarity with desirable and unwanted species increases (See Case Study: Oregon Blueberry Farm). In addition, implementation of specific management techniques should also become easier. Once the desired conditions are created and wildflower species have a strong foothold (usually five years post-establishment), monitoring and management activities can decrease.

We recommend not only recording which management actions you use, but also whether they were successful. If the condition targeted was unaffected, alter the technique by changing timing, coupling it with another strategy, or taking an entirely new approach (see Case Study: California Almond Orchard). If new undesirable conditions arise, consider altering the technique or substituting it for a different one. When a management strategy is effective, however, implement it in the same way until conditions appear to change.

This guide represents a starting point for assessing and managing site conditions. Over time a site and it's unique needs will become familiar, recognizing shifting conditions and implementing new techniques to help maintain habitat to optimize pollinator conservation and minimize management activities will hopefully become more intuitive.

Figure 6.1: Prescribed fire can be highly effective for managing native plant populations to favor wildflowers over aggressive grasses and woody.



Case Studies 7

This section provides real world examples of management used in wildflower habitat in three different regions: the Pacific Northwest, California, and the Mid-Atlantic states. The case studies illustrate different techniques that can be implemented with varying intensities and coupled with one another. All of these meadows contain a high diversity of bloom, indicating that management actions continue to be successful over time.

CASE STUDY

Oregon Blueberry Farm: Selectively Removing Non-Native Weeds

This ½ acre wildflower planting was initiated in 2012 alongside a conventionally managed blueberry field. Weeds were managed chemically prior to seeding with native wildflowers. Not all weedy species were eradicated; therefore, some unwanted species have persisted over time. No native bunchgrasses grasses were included in the seed mix because the farmer wanted to retain grass-selective herbicides as a treatment option to combat the non- native grasses prevalent throughout the farm, which posed a high threat of reinvasion.

Many wildflower species have thrived in the site, including farewell-to-spring (*Clarkia amoena*) (Figure 7.1), an annual that vigorously re-seeds itself. Other species never established, necessitating interseeding in 2014 and 2015 to fill in gaps in bloom early and late in the year—including lupine (*Lupinus* spp.), California poppy (*Eschscholzia californica*), and gumplant (*Grindelia* spp.).

Non-native cool season grasses have continued to be a major problem, despite annual spraying with a grass-selective herbicide. Other persistent weeds include Western salsify (*Tragopogon dubius*) and Queen Anne's lace (*Daucus carota*)—circled in white—are hand-weeded or dead-headed once a year to prevent spread into crop fields. The site is mowed annually in the fall to prevent Himalayan blackberry (*Rubus armeniacus*) from establishing. Despite continued issues with weeds present at low levels, the management actions and interseeding have been highly successful and the habitat continues to contain high- performing wildflowers that re-seed year after year.

Figure 7.1: While some species like California poppy and lupine thrived in the planting early—shown in May 2013—additional interseeding was required to fill gaps in bloom where other species failed to establish. Now a flourishing wildflower meadow, this planting supports abundant blooms year after year thanks to a fall mow once a year, twice annual spraying with grass-selective herbicide, and targeted dead-heading to remove individual weeds—like salsify (circled in white)—that was invading the site otherwise dominated by farewell-to-spring in July 2014.

California Almond Orchard: Balancing Wildflowers with Native Bunch Grasses

Figure 7.2: In June of 2013 the site was dominated by *Stipa pulchra* with little wildflower cover.

This ½ acre pollinator habitat project was initiated in 2010. It is bordered by commercial almond orchards, partially restored native grasslands, chaparral, and degraded grasslands. Prior to the 2010 planting, the site was dominated by exotic annual grasses and invasive broadleaf weeds. The original planting consisted of both native forbs and native grasses. While native bunch grasses, such as purple needle grass (*Stipa pulchra*), thrived in the site (Figure 7.2), wildflower establishment was poor. Therefore, in 2013, the landowners began managing the meadow to achieve a balance of native grasses and wildflower cover with a 50:50 ratio. The low initial wildflower establishment indicated that the existing seed bank was likely insufficient to reach the desired condition through management alone, therefore, a decision was made to interseed the area with a diverse mix of native wildflowers.

To prepare for seeding, the area was mowed and shallowly disked in the fall of 2013. Seed was sown at a rate of approximately 50 seeds/ft^2, using a native seed drill on ½ the field (Figure 7.4) and a manual seed slinger on the other half—testing the effectiveness of different seeding methods. A ring-roller was used to push the seed down into the soil on the portion of the field that was seeded

Figure 7.3: The interseeding successfully increased native wildflower cover without reducing the abundance of native bunch grasses.

using the seed-slinger. In the end, there was no noticeable difference in wildflower establishment between the sections seeded with different equipment.

Despite a multi-year drought that impeded seed germination, the current wildflower cover in the site has improved—approximately 30:70 forb:grass ratio (Figure 7.3). Management of the site since interseeding has consisted of mowing the perimeter to prevent weed encroachment and annual fall mowing to prevent thatch build-up and open up areas for new wildflower germination. There has been some encroachment of cool-season, exotic, annual grasses. If these grasses persist, they will be managed through a high mow early in the spring, carefully timed to cut the grass before it goes to seed. Because the exotic grass germinates very early, it is usually taller than the native vegetation in early spring. This allows for the mower blade to be set such that it cuts the weedy grass species without harming the native grasses and wildflowers germinating underneath.

Figure 7.4: The site was mowed and shallowly disked (top) before wildflowers were planted using a native seed drill in Novemeber 2013 (bottom).

CASE STUDY

Pennsylvania Apple Orchard: Managing Aggressive Weeds During Establisment

This one-acre pollinator meadow, located adjacent to an apple orchard, was first seeded with perennial wildflowers in 2011. Prior to planting, the site had very high weed pressure, including field bindweed (*Convolvulus* spp.), knapweed (*Centaurea* spp.), and thistle (*Cirsium* spp.) (Figure 7.5). These species tend to thrive in open, cultivated ground and soil rich in nitrogen (i.e., typical conditions found in gardens and farms). Although the site was mowed and tilled prior to seeding, weeds were not completely eradicated. In addition, perennial wildflowers are often slower to establish than annual wildflowers, even though they are persistent once established. This combination of slow wildflower establishment and inadequate site preparation allowed weeds to outcompete the wildflower seedlings, quickly leading to a weed-dominated planting. Despite this high weed pressure, some desirable plants like goldenrod (*Solidago* spp.) and asters (*Symphyotrichum* spp.) were still found in high abundance. Because of this mix of desirable and undesirable plants, starting over did not seem necessary. In general, however, we recommend thorough site preparation to avoid such weed issues early on in wildflower establishment.

To achieve the goal of restoring diversity and function, a combination of weed control and interseeding have been employed. The site was flail-mowed several times in 2013 to remove as much weedy vegetation and thatch as possible to promote good seed-soil contact in preparation for a fall dormant seeding. Care was taken during site preparation to disturb the soil as little as possible to avoid bringing up dormant weed seeds, which would likely cause additional weed problems in the future. Due to an unusually early snowfall event, seeding was delayed until early spring 2014, as the planting area was not accessible to planting equipment due to wet soil conditions. Note: If fall dormant seeding is delayed until spring and the seed mix has already been obtained, be sure to store the seed in an airtight container in a cool location (e.g., unheated shed or barn). Another option is to consider snow seeding (see Snow Seeding, p. 26). The site was interseeded at a half rate of 5 lbs/ac or 30 seeds/ft^2 (compared to the typical recommended seeding rate for wildflower meadows; 10 lbs/ac or 60 seeds/ft^2).

Wildflowers have slowly reestablished in small patches, but aggressive management is still required to continue to control weeds. Thistle has been spot-treated with herbicide during the flowering stage, when control is most effective. Large patches of bindweed also received targeted spot-treatment with herbicides using a backpack sprayer. Smaller patches of bindweed required a different control method because some of the dense vines were tangled around desirable wildflowers that would also be killed if contacted by herbicide. For these smaller patches, it was recommended that bindweed be continuously cut to ground level, but not mowed which can stimulate growth. In addition, portions of the site containing poison ivy (*Toxicodendron radicans*), knapweed, fleabane (*Erigeron* spp.), plantain (*Plantago* spp.), and Queen Anne's lace were spot-mowed as needed. By August 2015, a diversity of wildflowers occupied a large portion of the site (Figure 7.6); however, the site will be continuously monitored and managed to maintain a diversity of wildflower and bloom times to support apple pollinators before and after apple tree bloom.

Figure 7.5: Bindweed (circled in orange) initially covered a large portion of the meadow, mounding up on top of other weedy species as well as desirable wildflower species like asters and goldenrod—which made preparing the site without harming the wildflowers more difficult.

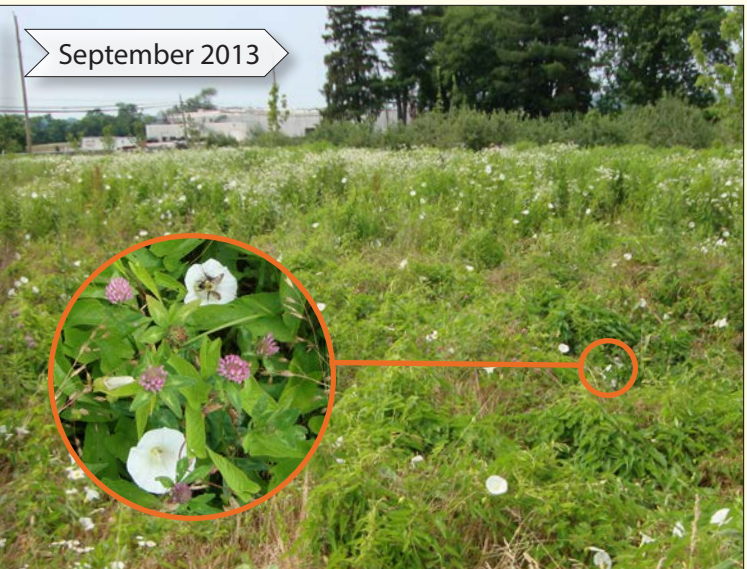


Figure 7.6: By April 2015, native wildflowers—including wild bergamot (*Monarda fistulosa*) and purple coneflower (*Echinacea purpurea*)—have rebounded in the site, thanks to a combination of aggressive weed control measures, continous monitoring, and interseeding.

Additional Resources 8

Re-starting Habitat

Jordan, S. F., J. K. Cruz, K. Gill, J. Hopwood, J. Fowler, E. Lee-Mäder, and M. Vaughan. 2016. *Wildflower Establishment: Organic Site Preparation Methods.* 44 pp. Portland, OR: The Xerces Society for Invertebrate Conservation.
www.xerces.org/organic-wildflower-establishment
These regional installation guides include in-depth guidance on installing and maintaining pollinator habitat in the form of wildflower meadow plantings or hedgerows, including example seed mixes and recommended plants.

Habitat Installation Guides (The Xerces Society)
www.xerces.org/pollinator-habitat-installation-guides
These regional installation guides include in-depth guidance on installing and maintaining pollinator habitat in the form of wildflower meadow plantings or hedgerows, including example seed mixes and recommended plants.

Seed Saving

Collecting and Seed Storage. (Ladybird Johnson Wildflower Center)
www.wildflower.org/howto/show.php?id=8&frontpage

Drying, Cleaning and Storing Prairie Seed. (Tallgrass Prairie Center)
www.tallgrassprairiecenter.org/sites/default/files/pictures/techguide2_dryingcleaning_2015_web.pdf

Eckberg, J., J. Hopwood, and E. Lee-Mader. 2016. *Expanding Pollinator Habitat on Farms: Collecting and Using Your Own Wildflower Seed.* 12 pp. Portland, OR: The Xerces Society for Invertebrate Conservation.
www.xerces.org/collecting-wildflower-seed

Seed Collecting from Tallgrass Prairies. (Tallgrass Prairie Center)
www.tallgrassprairiecenter.org/sites/default/files/pictures/techguide1_seedcollecting_2015_web.pdf

Tchida, C. *Collecting Wildflower and Prairie Seeds.* (University of Minnesota Extension: Sustainable Urban Landscape Information Series.)
www.extension.umn.edu/garden/landscaping/implement/wildflower.htm

Wall, M., and J. MacDonald (photographer). 2009. *Processing Seeds of California Native Plants for Conservation, Storage, and Restoration*. CD. Claremont: Rancho Santa Ana Botanic Garden
www.amazon.com/gp/product/0981971709

Figure 8.1: Collecting wild seeds—such as milkweed (*Asclepias* spp.)—can be a good way to obtain locally-adapted ecotypes..

Herbicides

Best Management Practices for Wildlands Stewardship
www.cal-ipc.org/ip/management/BMPs/BMPHerbicide.pdf

Johansen, E., L. A. Hooven, and R. R. Sagili. 2013. *How to Reduce Bee Poisoning from Pesticides*. 35 pp. Corvallis: Oregon State University.
https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/pnw591.pdf

Bee precaution pesticide rating (University of California [UC] Integrated Pest Management)
www2.ipm.ucanr.edu/beeprecaution/#

Weed Management:

DiTomaso, J. M., et al. 2013. *Weed Control in Natural Areas in the Western United States*. Davis: UC Weed Research and Information Center.

New Jersey Invasive Species Strike Team
Species List with Control Recommendations (Includes Target, Watch and Widespread Species): www.njisst.org/documents/SpeciesListandControlRecommendations15.xlsx

Radosevich, S., R., J. S. Holt, C. M. Ghersa. 2007. *Ecology of Weeds and Invasive Plants: Relationship to Agriculture and Natural Resource Management*. John Wiley and Sons.

Weed Research and Information Center. (UC Cooperative Extension and Agricultural Experiment Station)
http://wric.ucdavis.edu/

DiTomaso, J. M, G. B. Kyser, and M. J. Pitcairn. 2006. *Yellow starthistle management guide*. 78 pp. Berkeley: California Invasive Plant Council.
www.cal-ipc.org/ip/management/pdf/YSTMgmtweb.pdf

Figure 8.2: Intensive managed cattle grazing is used to improve wildflower diversity on this ranch in Texas.

Grazing

Database of Plants Poisonous to Livestock (Cornell University)
http://poisonousplants.ansci.cornell.edu/php/plants.php

Range and Pasture Technical Resources (USDA–NRCS)
www.tinyurl.com/NRCS-Grazing-Lands

Using Cattle Grazing & Fire to Increase Pollinator Habitat in the Central United States
www.xerces.org

Resource value of plants in the Southern Plains (Oklahoma State University Extension Service)
www.okrangelandswest.okstate.edu/files/grazing%20management%20pdfs/F-2872.pdf

NRCS Field Offices
www.nrcs.usda.gov/wps/portal/nrcs/main/national/contact/local/
Visit your local field office to find more information on desirable species for grazing.

Weed Identification

Introduced, Invasive, and Noxious Plants
https://plants.usda.gov/java/noxiousDriver
Federal and state lists noxious, invasive, and introduced plants, with links to more information.

National Invasive Species Information Center (United States Department of Agriculture)
www.invasivespeciesinfo.gov/
This website has a compilation of fact sheets and identification guides for invasive plants.

New Jersey Invasive Species Strike Team
Info Center: www.njisst.org/index.asp

Weed Identification Tool. (University of Wisconsin–Madison Cooperative Extension)
www.weedid.wisc.edu/weedid.php

Weed Image Search. (Weed Science Society of America)
http://wssa.net/wssa/weed/weed-identification/
Weed Research and Information Center. (UC Cooperative Extension and Agricultural Experiment Station)
http://wric.ucdavis.edu/
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Prescribed Fire

Resource Center: Prescribed Fire (eXtension.org)
http://articles.extension.org/prescribed_fire
Prescribed Fire Equipment (eXtension.org)
http:tinyurl.com/RxFireEquip

Appendix A: Regional Differences Table

MANAGEMENT STRATEGIES	CALIFORNIA	GREAT LAKES
VEGETATION MONITORING	› **JAN–JUN:** every 2–3 weeks › **JUL–DEC:** once a month	› **MAY–SEP:** once a month
MOWING FOR DIVERSITY: SEASONAL MOWING	› **OCT:** fall mow	› **LATE JUN:** to reduce dominance of native warm season grasses › **AFTER OCT 1st:** fall mow
MOWING FOR DIVERSITY: ROTATIONAL MOWING		
MOWING FOR WEED CONTROL	› **EARLY SPRING:** high mow to target early-germinating, tall weeds (e.g., annual grasses and malva/mustard). › **MID- SUMMER:** high mow to target warm season weeds (e.g., prickly lettuce).	***During meadow establishment (years 1–3):*** › **JUN–MID-SEP:** mow to 6–8" 2–4× ***Long term:*** › **SUMMER:** one to many times, whenever a significant amount of priority weeds are close to flowering (prior to seed set)
GRASS-SELECTIVE HERBICIDES	› **MID-JAN:** begin mid-month and continue throughout winter and spring as needed ⓘ *Most commonly used to manage cool-season grasses; most effective when grasses are small (<6" tall); may need multiple treatments*	
CONSERVATION HAYING	ⓘ *Not commonly used in this region*	› **AFTER OCT 1st** (ideally) or after peak bloom. However, haying may need to occur earlier if the nutritional quality of the hay is a concern ⓘ *Try to avoid haying at the same time every year*
INTERSEEDING	› **OCT–NOV:** seed with fall rains	› **FALL OR DORMANT SEASON:** fall or snow seed
PLUG AND BARE-ROOT PLANTING	› **OCT–NOV:** plant with fall rains	› **EARLY FALL** or **SPRING** ⓘ *Plugs may require irrigation if soils are dry and/or rain does not follow planting event*
IRRIGATION	ⓘ *Required for transplants; can be necessary to add supplemental irrigation during drought conditions*	ⓘ *Generally not required unless plug planting is subjected to unusually dry conditions*
PRESCRIBED FIRE	› **FALL** prescribed burn could substitute for fall mow, but only recommended in sites with lower weed pressure; fire is a higher disturbance than mowing, and can result in increased germination of cool season weeds	› **DORMANT SEASON:** in fall after vegetation has dried out; ***or*** › **SPRING**: before significant green-up—a spring burn can be effective to control cool season grasses
GRAZING	ⓘ *Cattle can effectively manage grass-weeds if managed properly; horses can be good grazers in wet meadows (e.g., vernal pools)*	ⓘ *Rotational grazing of cattle or goats during peak growth of target weed (typically before flowering)*
STARTING OVER	› **JAN:** begin site prep in unless solarizing. › **OCT–NOV:** plant with fall rains	

MID-ATLANTIC, NORTHEAST	PACIFIC NORTHWEST	SOUTH
➤ **MAR–OCT:** every 2–3 weeks	➤ **FEB–SEP:** every 2–3 weeks	➤ **JAN/FEB–NOV:** every 2–3 weeks, depending on weather conditions
➤ **FEB–MAR:** late winter mow for woody plant regulation ➤ **SEP–OCT:** fall mow ⓘ *Do not mow vegetation shorter than 4"*	➤ **AUG/SEP:** fall mow (for woody plant regulation)	ⓘ *Rotational mowing is preferred*
ⓘ *Remove thatch following mowing*	ⓘ *Not advised in the PNW due to the prominence of blackberry, which should be mowed every fall*	ⓘ *More frequent mowing may be needed depending on woody plant growth*
	ⓘ *Not a commonly used technique in this region*	***During meadow establishment (years 1–2):*** ➤ Mow to 6–8" when weeds are 12–15" to allow sunlight to reach seedlings, yet avoid smothering them ***Long term:*** ➤ Dependent on weed growth
➤ **EARLY-SPRING OR MID-FALL** for cool-season grasses	➤ **SPRING–SUMMER:** commonly applied a few times ➤ **MID- TO LATE-AUG:** final spray ⓘ *Make sure not to spray just before wet conditions are predicted to avoid movement of herbicides to non-target plants or off-site*	➤ **EARLY-SPRING OR MID-FALL** for cool-season grasses
ⓘ *Not commonly used in this region*	ⓘ *Not commonly used in this region*	➤ **FALL:** harvest typically in fall for greatest diversity, with hand harvesting of earlier ripening species
➤ **NOV 15th–DEC 15th:** fall seed before first hard-frost; ***or*** ➤ **MAR–APR** is typically the best time of year for spring planting ⓘ *Interseeding is more successful in the fall*	➤ **SEP 15th AND OCT 15th:** plant following some rain and before a frost; ***or*** ➤ **MAR** is typically the best time of year for spring planting ⓘ *Interseeding is more successful in the fall*	➤ **NOV 1st:** seed after the first frost; ***or*** ➤ **APR 1st:** before the last frost ⓘ *Light disking is generally recommended instead of or in addition to interseeding; annuals tend to outperform interseeded perennials.*
➤ **SEP 15th–NOV 18th:** plant in the fall after the rains and before frosts; ***or*** ➤ **SPRING** planted plugs usually require irrigation for the first season	***Fall planting:*** ➤ **SEP 15th–OCT 15th:** plant after the rains and before frosts ***or*** ➤ **SPRING:** planted plugs usually require irrigation for the first season	➤ **FALL OR DORMANT SEASON** plantings are recommended, so that roots can develop when there is likely to be adequate moisture. ⓘ *May require irrigation if soils are dry and/or rain does not follow planting event*
ⓘ *Container stock or transplants may require supplemental irrigation until established*	ⓘ *Not required unless planting in the spring or during multi-year droughts*	ⓘ *Container stock or transplants may require supplemental irrigation until established*
➤ **FEB 15th–MAR 15th**	➤ **AUG 15th–OCT 15th**	➤ **YEAR-ROUND:** Can occur throughout the year
ⓘ *Not commonly used in this region*	ⓘ *Not very common in this region; cattle preferred in "grassland" habitats; goats are good for steep hillsides, particularly along waterways; horses can be good grazers in wet meadows (e.g., vernal pools)*	ⓘ *Cattle and other grazers (horse and sheep) help maintain diversity in some areas, particularly balds and some boggy sites*

Appendix B: Management Techniques Table

TECHNIQUE	WHEN TO USE	TIMING
I. MOWING		
A. Mowing for Diversity	To maintain diversity and dominance of existing wildflowers—best when used in combination with thatch removal.	Mid- to late-fall
B. Thatch Removal (see fall mowing)	To remove thatch build-up left as a result of mowing, which could inhibit wildflower bloom by covering the ground; can also be used to remove nutrients from site to favor native plants.	Late fall
C. Mowing for Weed Control	To reduce weed cover—best when used in combination with herbicide treatment during the regrowth phase of the targeted weedy species.	Mow annual weeds prior to seed set; depends on the weed(s) and is often required more than once per year. If wildflowers are present and mowing would affect their seed drop, mow only in sections, or only once a year in late-fall and combine mowing with other targeted treatments.
II. HAND-WEEDING	When weed populations are small and easy to remove by hand; also a good technique in small sites.	Ongoing from late winter through late summer, ideally before the target species sets seed
III. SPOT-SPRAYING HERBICIDE	To target one or a few weedy species when weeds are clumped together.	During active growth stage of target weed(s)—usually late winter through late summer
IV. GRASS-SELECTIVE HERBICIDE	When non-native grasses are the dominant weed and native bunch grasses were not included in the wildflower seed mix.	During early active growth stage of target grass(es)—usually late winter through early summer
V. WEED REMOVAL AROUND SITE EDGES	When weeds are in high numbers around borders and threaten encroachment.	During active growth stage of target weed(s)—usually late winter through late summer
VI. CONSERVATION HAYING	To remove tall grasses and thatch, thereby creating space for early blooming wildflowers growing beneath them; can also be used to remove nutrients from site to favor native plants.	Late summer/fall
VII. REINTRODUCING WILDFLOWER DIVERSITY		
A. Interseeding	To add additional species into a site where they are absent in specific seasons (to address gaps in bloom) *OR* where bare spots are present due to spot herbicide use *OR* where diversity or cover are diminished over time.	Fall or early spring
B. Plug or bare root planting	To add additional species into a site that are absent in specific seasons and/or are difficult to start from seed or where key species to address a resource concern are lacking (e.g., milkweed for monarch recovery)..	Fall or early spring
VIII. IRRIGATION	To prolong bloom period into summer and fall in arid climates; in drought years, to improve germination by emulating normal rainfall.	During the establishment phase of plantings in drought regions mimic season rainfall patterns—in extended droughts, water every 2–4 weeks as needed.
IX. PRESCRIBED FIRE	To reduce encroachment by woody plants and some unwanted weedy species—burning stimulates growth and flowering of grasses and wildflower by increasing light availability and reducing thatch build-up.	Consult a professional
X. GRAZING	To decrease the cover of non-native grass and forb species.	Varies depending on species targeted
XI. STARTING OVER	When a site has lost most species initially seeded into it or has weed cover >75%	Various options are available, see Section 8: Additional Resources for details

EQUIPMENT	ADDITIONAL NOTES
▸ Flail or rotary mower	Mow after seed shatter of late-blooming wildflower species, before rains to reduce thatch build-up. Flail mowing is the preferred method. Place mow bar at high setting (leaving 6–8" of vegetation). Thatch removal after mowing can help remove excess vegetation that can impeed wildflower growth.
▸ Hay/york rake/dethatcher	Harrows can get clogged and box scrapers can scrape too deep.
▸ Flail or rotary mower ▸ Small mower or string-trimmer (for spot-treatments)	Focus on trouble spots (e.g., woody encroachment, areas with high weed pressure). When mowing during wildflower bloom use rotational mowing or spot mowing. Only mow the entire site if weeds are significantly taller than wildflowers. We recommend only mowing ⅓ of a planting in rotation or targeting trouble spots.
▸ Hoe, shovel, hand pick, pulaski, or by hand	If pulling by hand wear long sleeves and gloves to reduce photosensitivity development from wild carrots and relatives.
▸ Backpack sprayer or rope-wick applicator	Often needs to be combined with interseeding to fill in bare areas.
▸ Any available farm spray rig (e.g., boom sprayer, rope-wick applicator, or backpack sprayer)	Most effective when grasses are <6". Note that some grass-weeds (e.g., annual ryegrass) appear to be herbicide resistant. In addition, when applied at high rates or in multiple applications, grass-selective herbicides can damage forbs.
▸ Flail or rotary mower ▸ Backpack sprayer or rope-wick applicator	If spraying around site during bloom, avoid spraying in conditions that can cause drift. We recommend targeted spraying instead of tractor-mounted rigs.
▸ Tractor ▸ Mower ▸ Rake ▸ Baler	Use cation as this technique abruptly removes all blooms from the treated area. Hay in patches after peak bloom or use a flush bar. Use this treatment in a mosaic pattern.
▸ Seed drill or broadcaster or belly grinder or hand scattering	Aggressive weed management (e.g., mowing or spot weeding) prior to interseeding helps create spaces for new wildflower seeds. Disking can also help create space for new plants and increase seed to soil contact, but be cautious about harming existing plants. Good seed to soil contact is important, in some cases disking is appropriate.
▸ Shovel or trowel	Works best with perennial species.
▸ In-line drip emitter tubing and drip conversion materials ▸ Remote water timer	We recommend drip irrigation with in-line emitters or micro-sprinkers on risers. Overhead impact sprinklers can also be set up. In arid climates we recommend installing irrigation even if use drought-tolerant, native wildflowers are used.
▸ Drip torch ▸ Fire rake ▸ Axe ▸ Fire swatter	A permit is required—work with a trained professional. Split the meadow into 3–5 sections, with the aim of burning one section per year.
▸ Cattle/goats/sheep; ▸ Electric fencing	To increase diversity while reducing damage to the whole pollinator planting split the area into 3–5 segments and graze with different timing, intensity, and duration across years. If an entire habitat is invaded by the same species, graze the whole areas prior to interseeding. Note that grazing may only temporarily remove non-native grass biomass and, if that is the target, should be combined with another method, such as herbicide.
▸ Depends on technique(s) used	When initial weed control at a site is inadequate, restarting the project with intensive weed management might be the best solution.

Appendix C: Additional Acknowledgements

Photographs

We are grateful to the photographers for allowing us to use their wonderful photographs. The copyright for all photographs is retained by the photographers. None of the photographs may be reproduced without permission from the photographer:

Nancy Lee Adamson, The Xerces Society—Figure 5.1 (p. 30).

Bear Paw Battlefield, National Parks Service [flickr.com/bearpaw]—Figure 4.6 (p. 20): Glacier Exotic Plant Team spot-spraying Canada thistle (*Cirsium arvense*) and bindweed (*Convolvulus* spp.).

Jessa Kay Cruz, The Xerces Society—Cover (*front*); Figures 3.3 (p. 9), 4.3 (p. 18), 4.7 (p. 21), 4.13 (p. 27), 5.2 (p. 30), 5.3 (p. 31); Decision Tree #1 (p. 32): Lacy phacelia (*Phacelia tanacetifolia*), distinct patches, intermixed, key planted species missing, gaps in bloom; Decision Tree #2 (p. 33): Prickly lettuce (*Lactuca serriola*) & Radish (*Raphaenus* spp.); Figures 7.2–3 (p. 40–41).

Sarah Foltz Jordan, The Xerces Society—Figures 1.1 (p. 1), 3.4 (p. 10), 4.8 (p. 22), 4.10 (p. 24), 4.12A & 4.11B (p. 26), 4.14 (p. 28), 4.15 (p. 28); Decision Tree #1 (p. 32): Common yarrow (*Achillea millefolium*), April 2015, May 2016; Decision Tree #3 (p. 34): Plumeless thistle (*Carduus acanthoides*).

Tony Frates [flickr.com/tonyfrates]—Decision Tree #3 (p. 34): saltcedar (*Tamarix chinensis*) and sandbar willow (*Salix exigua*) taking over a frequently-mowed site.

Kimberly Gallagher: Figure 7.4 (p. 41).

Kelly Gill, The Xerces Society— Decision Tree #2 (p. 32): Mostly Grasses; Figure 7.5–6 (p. 42).

Jennifer Hopwood, The Xerces Society—Cover (*back*); Figures 3.5 (p. 11), 4.11 (p. 25); Decision Tree #1 (p. 32): Low-moderate value wildflower.

Chris Hoving [flickr.com/pcrucifer]—Figure 4.9 (p. 23): Prescribed burn in Newaygo county for Karner blue butterfly (*Plebejus melissa samuelis*) habitat.

Matt Lavin [flickr.com/plant_diversity]—Decision Tree #1 (p. 32): Low value native grass; Decision Tree #3 (p. 34): Cheat grass (*Bromus tectorum*).

Eric Lee-Mäder, The Xerces Society—Figure 7.1 (p. 39).

Mark Mathosian [flickr.com/markgregory]—Figure 4.1 (p. 16): Florida burrowing owl (*Athene cunicularia floridana*).

Justin Meissen [flickr.com/40855483@N00]—Figure 4.6 (right, p. 20): Spot-spraying herbicide on woody weeds.

Montana Fish, Wildlife, and Parks—Decision Tree #3 (p. 34): Hooked bristlegrass (*Setaria verticillata*).

Oregon State University [flickr.com/oregonstateuniversity]: Decision Tree #3 (p. 34): Medusahead (*Taeniatherum caput-medusae*).

Harry Rose [flickr.com/macleaygrassman]—Decision Tree #3 (p. 34): Harding grass (*Phalaris aquatica*).

Hillary Sardiñas, The Xerces Society—Decision Tree #3 (p. 34): Mixed weedy forbs and grasses.

Tina Shaw, USFWS Midwest Region [flickr.com/usfwsmidwest]—Figure 7.1 (p. 43): Collecting milkweed (*Asclepias* spp.) seeds.

Lan Shen, Houstan NPAT [flickr.com/hnpat]—Decision Tree #2 (p. 33): Mostly woody weeds.

Ken Slade [flickr.com/TexasEagle]—Decision Tree #2 (p. 33): Patchy weeds.

Anne Stine, The Xerces Society—Figure 8.2 (p. 44).

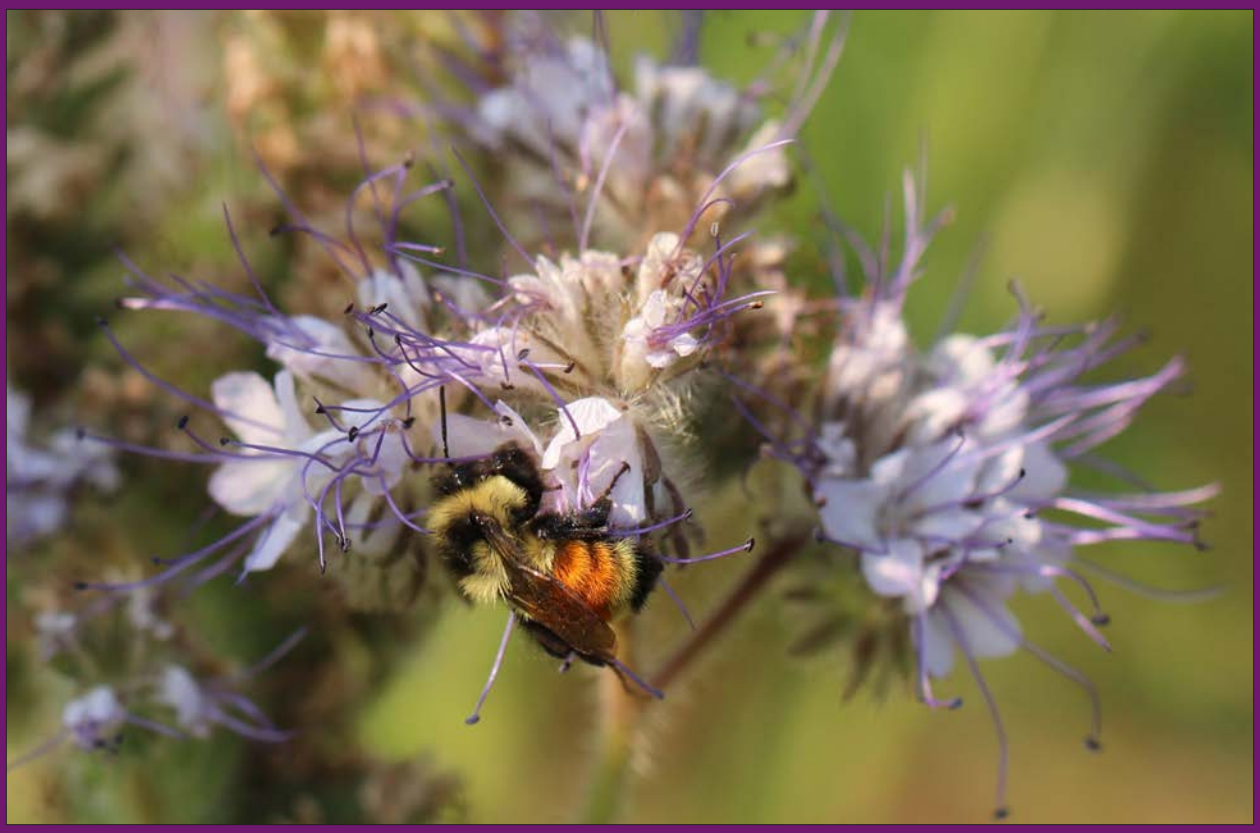
Claudia Street, Glenn County RCD—Figure 4.2 (p. 16): Tarweed (*Grindelia* spp.) seedlings seven days post-mowing.

Sandor Weisz [flickr.com/santheo]—Figure 4.5 (p. 19): Hand-weeding at Meadowbrook Farm.

Suzie's Farm [flickr.com/suziesfarm]—Figure 4.4 (p. 19): Using a string-trimmer for targeting between sunflowers (*Helianthus annuus*).

Stephen Thomforde, Great River Greening—Figure 4.8 (p. 22): Conservation haying.

Mace Vaughan, The Xerces Society—Figure 6.1 (p. 38).



Hunt's bumble bee (*Bombus huntii*) on lacy phacela (*Phacelia tanacetifolia*) in Montana pollinator planting. (Photograph by Jennifer Hopwood, The Xerces Society.)

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