Mid-Atlantic Native Meadows

Guidelines for Planning, Preparation, Design, Installation, and Maintenance

Alice Sturm, Mahan Rykiel Associates
Stephanie Frischie, Xerces Society for Invertebrate Conservation

XERCES SOCIETY
for Invertebrate Conservation

MAHAN RYKIEL
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Contents

An eastern tiger swallowtail (*Papilio glaucus*) nectars on ironweed flowers in a summer meadow. (Image: Mahan Rykiel Associates)

Introduction

Native meadows, filled with perennial wildflower mosaics and waving grasses, are growing in popularity with property owners and designers because they provide benefits to people, pollinators, and wildlife while demonstrating sustainability values. These meadowscapes offer economic and ecological advantages over intensively managed horticultural landscapes. Seeded meadows are low-input alternatives to containerized plantings or certain turf spaces, and so they have a role to play in institutional, commercial, and multifamily residential projects. The successful use of meadows depends on a thoughtful plan that includes proper design, installation, management, and project (or client) expectations. With this guide, we highlight the advantages of meadows and provide a framework for successfully implementing meadow projects.

Seeded meadows are often used in the ecological restoration of natural and seminatural landscapes. However, the scheduling[1] and aesthetic requirements of institutional or commercial meadow projects differ from those of ecological restoration projects—ecological restoration places a priority on timing activities within optimum seasons, uses a reference community, and emphasizes ecological goals over aesthetics or human uses. Meadows have been used in the residential market for some time, though few designers or contractors have the comfort and experience to specify,[2] install, and maintain this type of landscape. Meadows offer landscape architects and designers an opportunity to expand their creative and technical toolbox, and a fundamental understanding of meadows is key to using them successfully.

This guide outlines the unique considerations for native meadows in landscape architecture, with the goal of helping green industry professionals in the mid-Atlantic create successful meadow projects. We provide an overview of the benefits of native meadows and how to establish them from seed. (For the purposes of this guide, a meadow refers to a plant community made up of native grasses, sedges, and forbs, grown from seed.) This is not a complete manual, but rather a foundation to inspire more consideration and use of meadows, while also setting expectations and planning requirements for site preparation, installation, maintenance, and adaptive management. We highlight the advantages of successful meadow projects and provide a framework for addressing their challenges.

Additionally, this guide is designed with property owners and managers in mind, addressing a variety of factors—ranging from soil conditions and proposed site uses to desired aesthetics. Lastly, we provide tools to help people decide if a meadow is the right choice for their site.

Opportunities and Resources to Help Your Community Become a Certified Bee City USA

Bee City and Bee Campus USA is a Xerces Society program that helps communities and campuses create sustainable habitats for pollinators. For Bee City USA communities and campuses, this guide can support the process of creating and enhancing pollinator habitat through meadow plantings. See Appendix D for more information on Bee City USA.

1. Scheduling refers to the timeline of construction projects, which is often governed by regulatory or contractual requirements. Sometimes, scheduling constrains when plant materials can be installed, and this may go against ideal horticultural practices. The scheduling requirements are an additional constraint on seeded meadows that are installed as part of a larger construction contract, as opposed to a stand-alone installation.
2. This industry term means to create and follow construction specifications, which are technical documents that describe the attributes and performance requirements of materials and methods for a construction project.

Humans and wildlife, such as bumblebees and birds, benefit from the range of textures, colors, and shapes of the plants and flowers in native meadows. Meadow plants tolerate dry periods, and their deep roots help absorb and store water after high rainfall events. (Images: Mahan Rykiel Associates)

For Landscape Architects and Designers

Meadows provide an attractive option for a range of project types. They offer a rich palette for a low plant materials cost and can be designed with high ornamental value, making them worth considering when projects have limited budgets for planting and long-term maintenance. Compared to other landscape types, the lower inputs and higher plant diversity associated with a meadow are beneficial to local and regional wildlife and can increase climate resilience of habitat.

No one wants to return to a site after completion and be disappointed, so you should know that while meadows are low maintenance compared to lawns, they do require specific maintenance that is both time sensitive and requires understanding of the meadow system. Site selection and preparation are important steps for a successful project in which the design results in good plant establishment and meets the owner's goals for aesthetics, maintenance requirements, human use, and ecological value.

Attractive design is central to the success of every project (don't miss Design on page 12), but owner buy-in is also critical, and we recommend beginning discussion of maintenance, budget, and benefits during the concept or schematic design phases. Get specific! While detailed and appropriate specifications are part of the story, the earlier the owner and contractor understand the maintenance requirements and the important benchmarks for preinstallation site preparation, the better. These issues need to be communicated early and often, and the schematic design and design development phases are great times to share the many benefits, aesthetic and otherwise, of including seeded landscapes on project sites.

If possible, a warranty period lasting three growing seasons (or at least two years) helps ensure that a meadow establishes well. However, if that is not possible, this guide can serve as a helpful tool to educate maintenance professionals who will take on important postinstallation management. This guide will also provide information on the impact of design, specifications, and schedule on the success of these projects.

For Property Managers or Owners

For property managers, maintenance and operations professionals, and facilities managers, meadow plantings provide the opportunity to save money on lawn-care maintenance, irrigation, fertilization, pesticides, and labor. Meadows can also help achieve sustainability goals, improve a landscape's climate resilience, increase carbon sequestration services, beautify a property, provide beneficial wildlife habitat, and aid public image.

However, all this begins by choosing an appropriate place for a meadow: an agricultural field, underused lawn area, or other site with appropriate conditions. Next, getting acquainted (and getting your team acquainted) with the specific requirements of meadow maintenance is important. While you can expect to save money when maintaining a meadow as opposed to lawn, maintaining a meadow requires specific knowledge and care. This guide can help your team gain the skills and information they need to understand the benefits of meadows, choose a site, design a planting, and successfully install and maintain a new landscape in partnership with landscape architects and contractors.

For Landscape Contractors

If you've been tasked with installing a meadow, the first thing to know is that site preparation may take longer than a typical landscape of seeded lawn and containerized ornamental plants. Site preparation prior to seeding—in particular weed suppression and removal of competing vegetation—is the most important factor in meadow establishment. This generally takes a minimum of one growing season. The good news is that inputs to the site, such as imported soil and fertilizers, are not commonly required.

In addition, we recommend a three-year warranty period (minimum of two years) on meadow installations because they involve relatively slow-growing species, established from seed over multiple years. While the amount of labor involved should decrease substantially during establishment, appropriate weed management during the first and second growing seasons is critical to the success of the project. This guide can be used by contractors to establish reasonable owner expectations of meadow appearance and to provide performance guidelines for every step, from site selection to long-term maintenance.

Bluejacket (*Tradescantia ohiensis*) and foxglove beardtongue (*Penstemon digitalis*) provide colorful blooms, pollen, and nectar in the early summer. (Image: Mahan Rykiel Associates)

2

The Benefits of a Meadow

Ecological Value

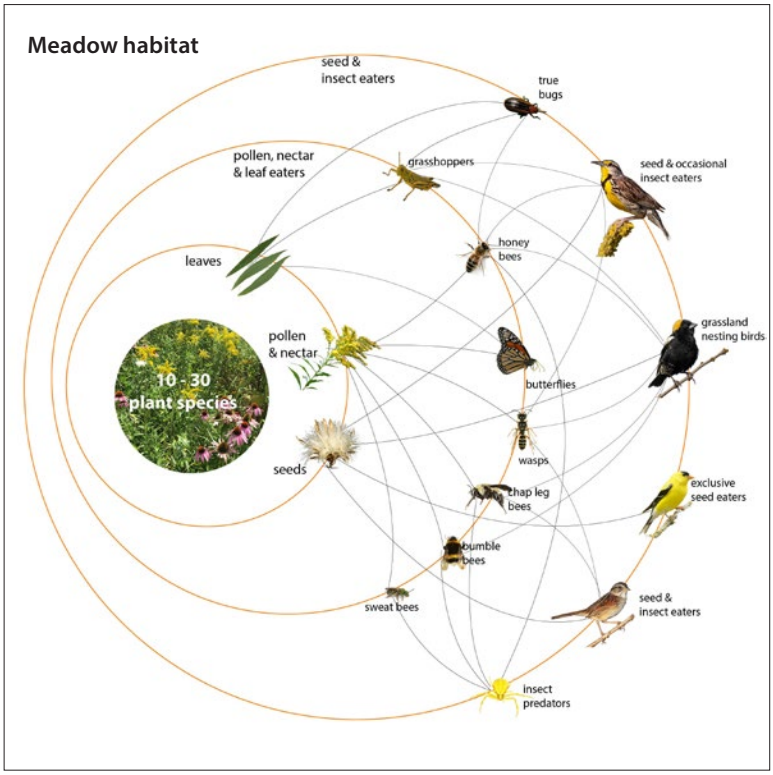
Meadows are diverse, usually with 10 or more wildflower and grass species. Creating a meadow of native species offers an attractive, climate-smart alternative to intensively developed landscapes, invasive plants, and pesticide-heavy maintenance regimes that limit good quality habitat for wildlife.

Drastic declines of pollinators and birds have been recorded throughout North America. A native meadow (and the diversity of plant species within) can help stem this loss by providing food and habitat for pollinators such as bees and butterflies, beneficial insects, and birds, which depend heavily on insects as food for raising chicks (see figure 1). Adult birds feed on insects and seeds and use a variety of plants for nesting material. Because of native diversity and a meadow's intended use as a wildlife habitat, meadows should be managed as pesticide-free as possible to limit the exposure and harmful effects to pollinators, wildlife, water, and people.

Climate Resilience

As the effects of climate change become increasingly apparent, it is more important than ever to consider climate change when designing landscapes for our communities. Extreme downpour events (defined as more than three inches of rain) will become more common in the mid-Atlantic region, as will flooding. Drought will also become more common, along with extreme weather events. Temperatures will increase, with higher high temperatures and higher lows—meaning it won't cool down as much at night. The biodiversity of meadows increases their resilience to ever more frequent extreme weather events. Some species will grow and bloom in drier, hotter weather, while other species will provide a balance of foliage and flowers when the weather is wetter and cooler. This flexibility allows meadows to survive in variable, hard-to-predict conditions. The total plant coverage and deep root systems of meadows (see figure 4) soften the impact of rainfall and reduce stormwater runoff through improved infiltration into the soil, where the moisture is held and used by the plants over time, increasing drought tolerance.

The native plant diversity within a meadow also makes it good habitat to increase climate resilience for pollinators and other wildlife (see figure 1). Higher plant diversity supports a more diverse pollinator community, which will be important for maintaining pollinator services under future climate scenarios. In general, larger and interconnected habitats support a higher number of species and greater population sizes (meaning more individuals of each species) than smaller habitats. Larger meadows or multiple, connected meadow patches support larger populations of wildlife, which are more likely to withstand bad years and extreme weather events that will become more frequent with climate change than smaller populations. Meadows also provide important pollinator microhabitats (small spaces that differ from the surrounding habitat). Often these microhabitats are cooler or more protected than surrounding environments, providing important refuge for pollinators and other insects during heatwaves and extreme weather events.



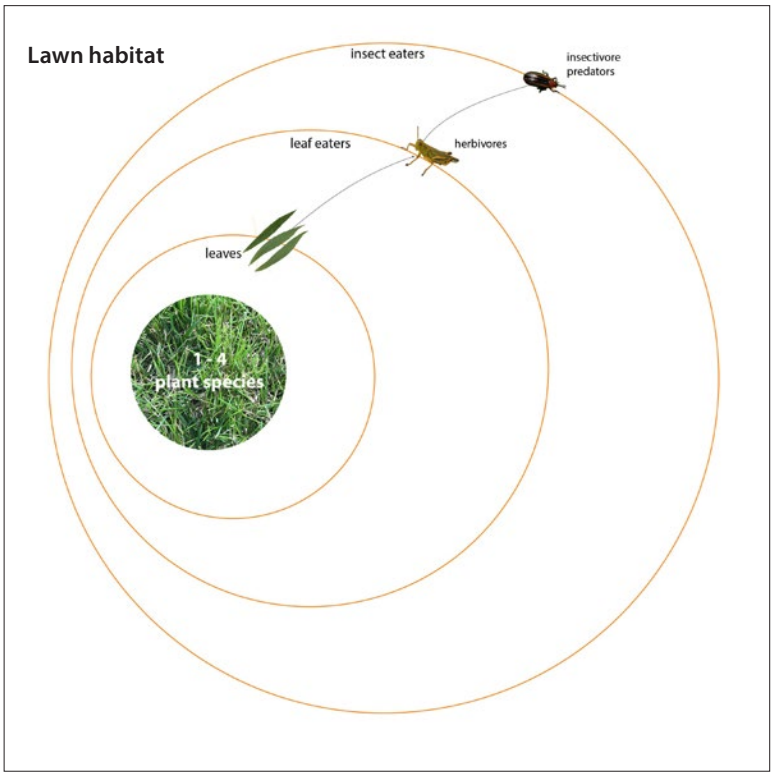


Figure 1. Food web in a meadow habitat vs. lawn habitat. (Images: Mahan Rykiel Associates)

Planting meadows can also help mitigate climate change through natural climate solutions. Healthy, diverse ecosystems store much more carbon than degraded habitat. Research has shown that soils in grasslands and meadows with a variety of plant species store much more carbon than weedy areas and areas with low plant diversity. This means that every meadow you plant is an important part of the solution to climate change.

Aesthetics

The love affair with the lawn may never fully go away—but in terms of seasonal color and variation, lawns tend to have two seasons: "good" and "bad." On the other hand, meadows offer a range of textures, fragrances, heights, shapes, and colors that vary not only over the seasons, but across years as longer-lived perennials emerge three to eight years after the initial planting (see figure 3). Over time, meadows reveal more about a site's personality—its micro-topographies and underlying geologies. Instead of failure or success, as experienced with containerized plantings, a meadow will see certain species cluster in wetter areas and others thrive in shady corners. Unlike most types of ornamental plantings, the species composition in meadows will also adjust to changing site conditions and variable weather patterns. This is crucial as climate and context change over time.

Economics

While landscape maintenance costs vary widely by region and standard of care, for most property owners, seeded meadows will likely be significantly cheaper to install and to maintain than seeded lawns (see table 1).

Because meadow plants thrive on "poor" soils and can be seeded onto raked subsoil, seeded meadows are less expensive to install than seeded or sod turf lawns (except in the uncommon case when site topsoil has been protected in place during construction). A native meadow seed mix is often more expensive than a turf mix, but this initial seed cost is offset by the cost of site preparation needed for lawns—typically involving importing two to six inches of topsoil, rototilling the site, and adding amendments, such as compost, fertilizer, and lime.

When sod is used, the plant materials costs exceed those of a seeded meadow. During the establishment period, meadows are also mowed less frequently than lawns—greatly reducing costs, from fuel to operator hours to wear and tear on mowers.

Postinstallation operational differences when choosing meadow over turf result in a number of benefits (see figure 2). Irrigation, pest control, and applications of fertilizer and lime are not a regular part of meadow maintenance. Pesticides are also not recommended, not only because they would interfere with the ecological goals of a meadow, but also because problematic pest infestations are less likely in such a diverse landscape. Meadows need to be mowed a maximum of once per year once established, and meadows reduce or eliminate demand for energy—usually fossil fuel—from mowing and repeated inputs of fertilizers and preemergent herbicides (established meadows compete as effectively as lawns with most weeds). Permanent irrigation is not needed on meadows, though temporary irrigation is sometimes beneficial for spring installations.

In contrast with turf lawns or containerized plantings, meadows can flourish and look good under heat, drought, and excess rainfall, and meadows don't usually build up disease pressure, reducing the need to spend money on irrigation or pesticides. Meadows with plants that don't need as much water will survive and persist periodic drought, which is expected to become more frequent. Deep-rooted plants common in meadows infiltrate more rainfall and runoff than lawns, improving water quality and reducing water pollution; some jurisdictions provide environmental mitigation credits for this. In the mid-Atlantic region, flooding is predicted to be much more common due to increased frequency of extreme downpour events, and the capacity of meadows to absorb water and therefore reduce runoff and counteract flooding is highly beneficial. When water management in the face of climate change is taken into consideration during planning, meadows can provide cost savings through reduced volume of stormwater and water-treatment infrastructure and irrigation costs.

Table 1. Life Cycle Costs over 20 Years

Product	Installed Price* ($/acre)	Length of Establishment** (years)	Establishment Maintenance Price ($/acre/year)	Maintenance Price** ($/acre/year)	Maintenance Equipment	Life Expectancy (Years)	Life Cycle Price ($/acre/year)
Conventional Lawn	$7,260.00	0.25	$5,452.00	$5,452.00	Standard Mower & Fertilizer	20	$5,815.00
Seeded Meadow**	$4,840.00	2.00	$950.00	$750.00	Brush Hog & Skilled Hand Weeding	20	$1,012.00

*Maryland State Highway Association Cost Manual. ** JWTownsend Landscapers. (Images: Mahan Rykiel Associates)

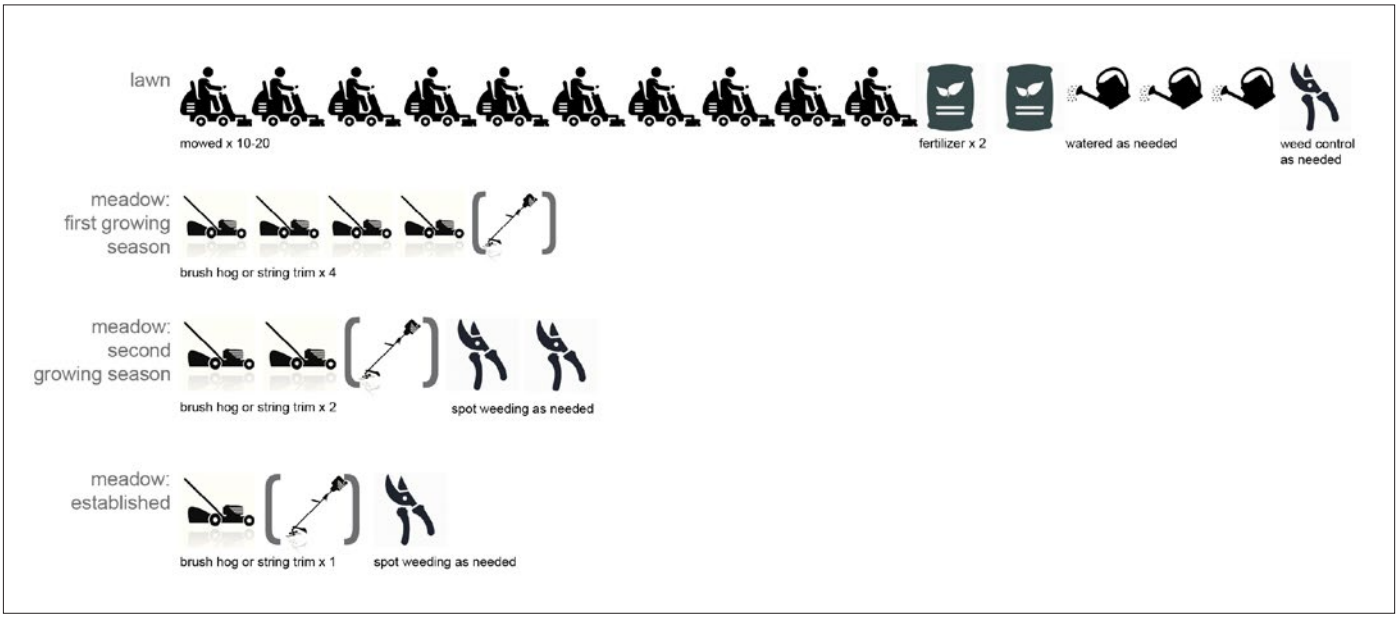


Figure 2. Maintenance comparison between lawn and meadow. Estimated annual inputs and operations for seeded meadows and lawns. (Image: Mahan Rykiel Associates)

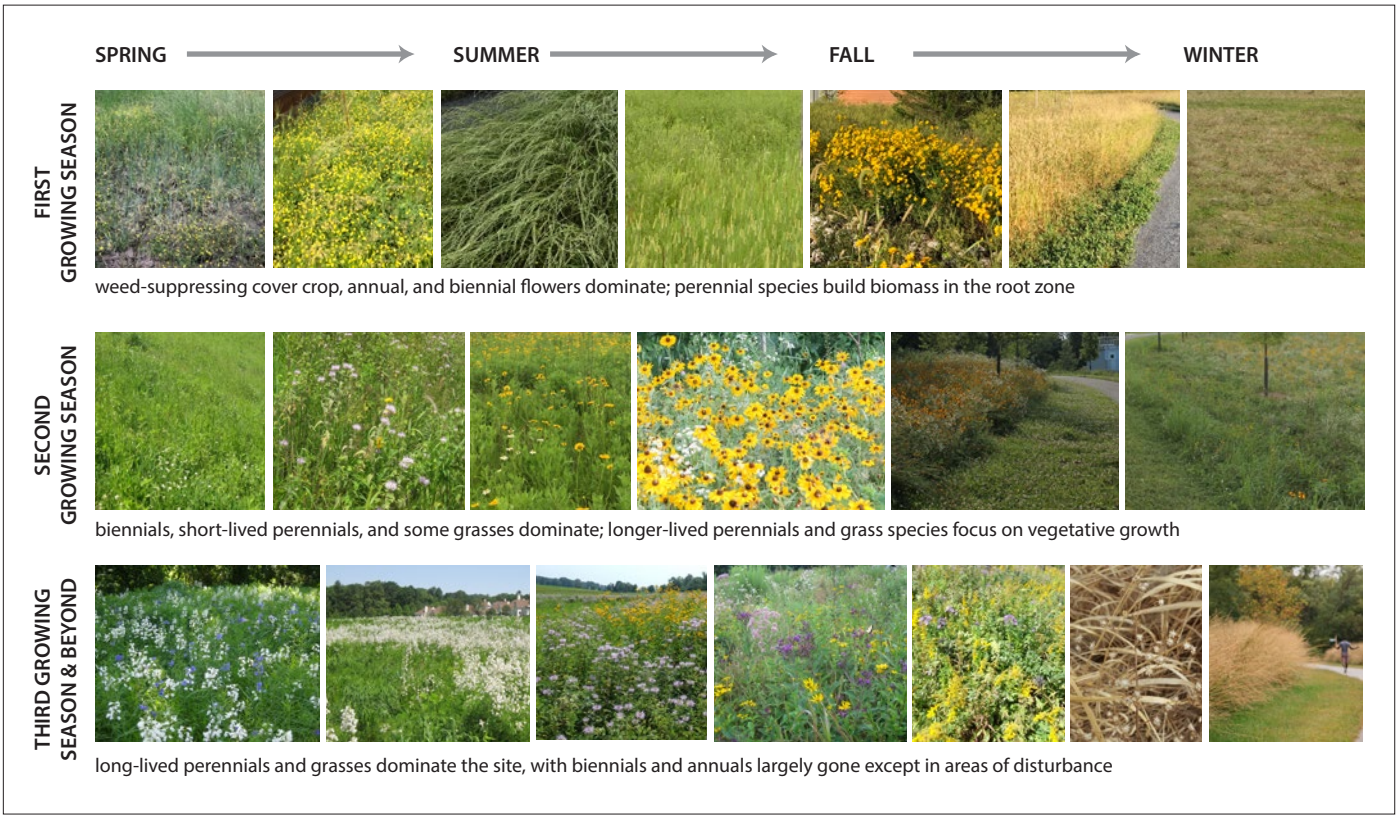


Figure 3. Expectations and appearance of meadows over time. (Image: Mahan Rykiel Associates)

3

The Meadow Mindset—What to Expect

Containerized plant beds such as bioretention facilities, foundation plantings, and garden spaces require maintenance best characterized as gardening—the goal is to maintain plant species and arrangement over time to achieve a desired aesthetic or environmental effect. In gardening, we interact with individual plants and usually deal with problems (such as weeds, drought, or disease) on an individual basis: a dead plant is replaced or an unsightly weed is pulled.

Lawns, by contrast, are not gardened, they are managed. Rather than interacting with individual plants, we maintain them as a cohesive community—we don't prune or replace them, we mow them to a desired height to encourage certain types of growth, and we keep the community healthy with methods like aeration (where a certain percentage of the individual plants are killed, which would seldom be used in a garden setting). We deal with problems systematically rather than individually—a lawn is more likely to be treated for weeds through a blanket application of fertilizer or selective herbicide than through pulling weeds individually, for example. Mowing remains the main form of management for aesthetics, plant health, and weed control in lawns. Management can often be done by personnel with less horticultural knowledge than gardening, and it can be done with a lower ratio of staff to area.

Project maintenance budgets are often constrained, and the ability of many institutions and property owners to garden can be limited. In this way, lawn often becomes the default landscape of choice because it can be managed. There are many good reasons to choose lawns: lawns allow people to gather, play sports, relax, and convey a specific aesthetic. However, when lawn is chosen primarily because of its ability to be managed, it is worth considering other landscape types that can be similarly managed. Meadows are one such type. In contrast to ornamental beds, meadows have the added advantage of requiring comparable equipment and management skills as lawns, our most common landscape type.

Native meadows are distinct from annual wildflower mixes, which often contain a variety of exotic annual species. These annuals grow and bloom profusely in the first year after sowing but do not persist over multiple years nor provide the same degree of benefits to wildlife or reduced maintenance as a native meadow.

The yellow flowers of lanceleaf tickseed (*Coreopsis lanceolata*) glow in early summer. (Image: Mahan Rykiel Associates)

4

Steps for Planning, Preparation, Design, Installation, and Maintenance of Meadows

Planning and Preparation

Site Selection

In general, meadows require sun and do best on sites with slightly acidic soils and low fertility. Often, meadow sites have dry or rocky soils that drain quickly and have low organic matter, but seed mixes are available for wet sites and rain gardens as well. Heavy clay soils generally do not favor most meadow plants, though a seed mix could be designed with heavier soils in mind. A number of mixes for different conditions are available commercially, and most are designed to accommodate a range of site conditions.

While meadows can be established on steep slopes, this does require consideration for installation and maintenance. Care must be given to control erosion during maintenance and establishment, and slopes cannot be too steep to mow safely.

Meadows are an option that balances installation costs with high ecological and aesthetic goals, but the intended site use is also important to consider when thinking about the meadow option. Sites that are a good match for meadows are open, sunny areas without the programmatic requirements of turf; areas where desired ornamental containerized plantings exceed the budget; or generally inaccessible but easily visible sites, such as a woodland edge across a service drive or medians within roadways.

Site Assessment and Soil Amendment

Test the soil. Low organic matter does not need remediation. If there is existing vegetation in good condition, soil amendment is likely unnecessary. Do not apply nitrogen, though if a soil test indicates that you should do so, it is OK to add phosphorus or potassium. Do not apply lime unless pH is below 5.5. Consider adding sulfur if the pH is 7.5 or higher—lowering the pH will help suppress agricultural weeds. If soil is compacted, use a subsoiler (also called a flat lifter) to break it up. Complete any mechanical soil amending before suppressing weeds—once a weed suppression regime has begun, it is important to disturb the soil as little as possible to avoid stirring up the seed bank.

If preemergent herbicides have been used on a site in the past, such as from a prior lawn-care contract, wait at least a full growing season after the last application before seeding a meadow. Otherwise, residual preemergent herbicide can kill the germinating seeds of the meadow mix. In sites where insecticides were used previously, it is ideal to leave the land fallow or plant a nonflowering cover crop for one season prior to planting the meadow. At a minimum, all applications should be terminated to avoid

contaminating the habitat. Likewise, if any other pesticides, such as fungicides have been used at the site, terminate applications to avoid the impact of toxic residues on the habitat quality of the meadow.

Note the type of vegetation currently growing on the site, and, in particular, if any perennial broadleaf weeds or other problem weeds are present. Take special effort toward weed suppression if there is a problem with a weed included in Appendix C, which lists weeds known to interfere with meadow establishment. Take the time to learn about any challenging weeds and how to best manage them. For example: Canada thistle (*Cirsium arvense*) has extensive root systems that can regrow even after shoots have been destroyed. Therefore, management methods must destroy or exhaust the resources of the root system, or the thistle can reestablish. The herbicide clopyralid is known to be especially effective against Canada thistle, but it is long-lived and can harm some meadow plants, such as lupine and aster. Other management options for Canada thistle include smothering, shading, or late-season tilling, as exposed roots are susceptible to frost.

Design

Placement and design are important factors in determining the success of a meadow planting—location and context need to work not only for the chosen plant species, but also for the site users and the proposed site uses. Also consider factors like the size of the area, the distance from which most site users will view the meadow, the aesthetics and composition of the rest of the site, and the main seasons of use.

Designing the Plant Palette

Native plants are typically adapted to local climate and tend to support more species of pollinators, particularly specialists, which use only a narrow subset of plants. Specialist pollinators tend to be more vulnerable to climate change than generalists, which use a wide variety of plants. Include plants used by specialist pollinators to provide critical food sources for local native bees. Choose native plants and cultivars that can handle periodic flooding or drought, as well as warmer temperatures—factors we expect to be more prevalent as climate changes. It can be difficult to find species that will do well in all future conditions, which is why it is important to use a wide variety of species.

Native species are sold as either straight species or cultivars. Straight species are truer to a wild type and are also indicated on the label as variety not stated, or VSN). Cultivars, commonly called nativars, are native species bred for specific stable traits such as biomass, flower color, flower shape, or flood tolerance. A nativar is assigned a name to associate it with its specific traits, and these names distinguish a nativar from a straight species. Nativar traits are focused on human aesthetic needs, and those same traits are often in conflict with the plant's value for pollinators. Native pollinators are adapted to the color and shape of native flowers, which is a powerful reason to choose straight species over a nativar.

Next, consider the goals of the planting, including whether they are primarily aesthetic, ecological, or both. Looking at a list of grass and forb species native to your ecoregion is a good place to start. Depending on aesthetic or ecological requirements, species native to the broader region but not your subregion may fit your needs (for example, if you need a short meadow to ensure necessary sight lines, and most grasses native to your ecoregion are five feet tall). If the goal of the planting is interpretive and habitat-focused, narrowing the geographic criteria and selecting only species observed on or adjacent to the site may be a better match for the project.

Also evaluate how the plants relate to each other—the goal is a community of plants that support and complement each other. They should use different resources above and below ground. Above ground, maximize the use of space and solar resources by using a combination of tall, thin plants that create a canopy; brushier, mid-height plants; and spreading, low-growing plants. Below ground, ensure that species with a mixture of taproots, fibrous roots, and horizontally spreading stoloniferous or rhizomatous

roots can stabilize the soil and make the most of the available moisture; one or two plants should also have nitrogen-fixing properties (see figure 4). To maximize resource use throughout the year, some plants should be warm-season species and some should be cool-season species (see figure 5). To ensure the longevity of the planting, the plants should range from short-lived but quick-growing species to slow-growing but long-lived species (see figure 6).

When it comes to what species should be included from an aesthetic perspective, texture and height are the main considerations; smaller sites, or areas immediately adjacent to lawns or walkways (other than nature trails or footpaths), may be more compatible with a meadow mix of fine-textured, short plants. While species such as blackeyed Susan (*Rudbeckia hirta*) and lanceleaf tickseed (*Coreopsis lanceolata*) would look nice in any context, the beautiful, dinner plate–sized leaves of a cup plant (*Silphium perfoliatum*) might fit in better on the back forty than right next to a main entrance or a campus promenade. Smaller, finer textured plants are more likely to be visually accepted in a setting where people expect to see a more formal landscape treatment.

Color and season are also factors to consider. While, in general, meadows provide four-season interest (with a pause between the last mowing and late winter), mixes can be designed for an added emphasis on spring and fall in a campus setting or on summer near a pool or swimming hole, for example. You can also explore color themes, though it is worth noting that the majority of quickly developing perennials bloom yellow, and that, at least for the first few years, yellow will be a prominent color. Yellow flowers are very attractive to many native bees and other pollinators.

Once you have chosen a base mix, determine if there are areas you would like to overseed with a taller species to get a "drift" or focal point—or, alternatively, areas where you may want to use a different mix with only shorter species.

Limiting the number of species or making sure a few distinctive species repeat across the site help to create an intentional-looking meadow that is

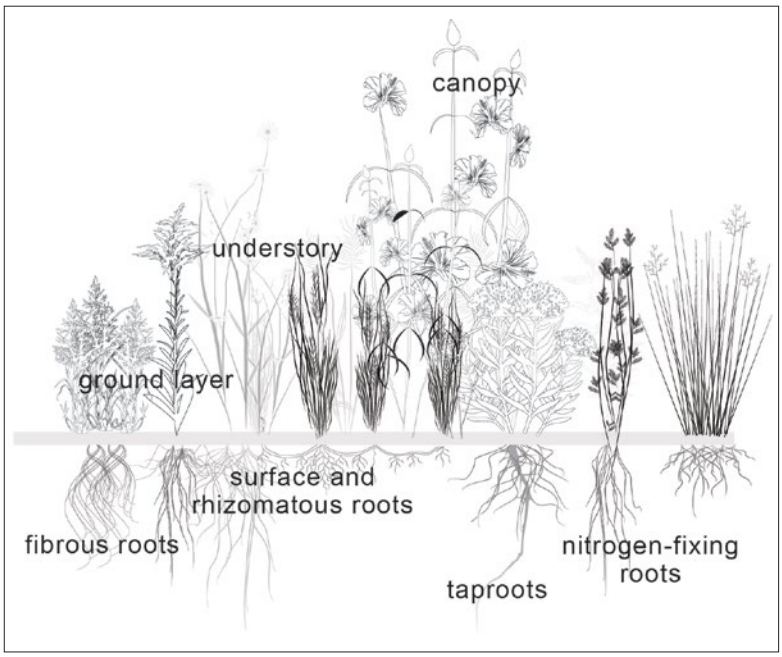


Figure 4. Spatial niches in a meadow. When selecting species and designing a seed mix, keep in mind how the architecture and size of roots, stems, and leaves fill spatial niches and complement each other. (Image: Mahan Rykiel Associates)

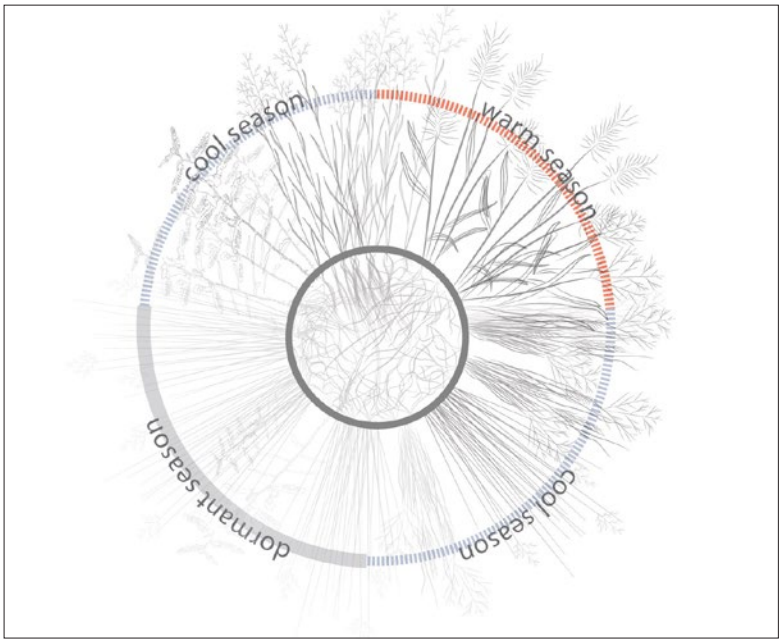


Figure 5. Seasonal niches in a meadow. Each species has a particularly active niche for growth or flowering within the growing season. These are annual cycles: cool season (spring) grades into warm season (summer) back to cool season (fall) to dormant season (winter) and around again. (Image: Mahan Rykiel Associates)

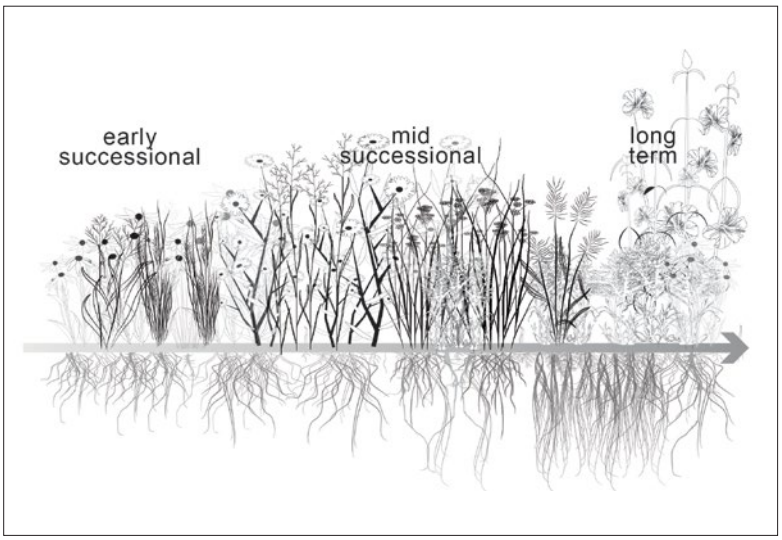


Figure 6. Successional niches in a meadow. Successional niches span years and the lifetime of a meadow. (Image: Mahan Rykiel Associates)

harder to mistake for weeds—in urban areas especially, where unkempt or weedy-looking areas often have negative perception and can make people feel unsafe. Designing a meadow to appear intentional is important for aesthetic acceptance by the public at large.

Seed Mixes

Once the plant palette has been decided, the next step is translating that to a seed mix. (If you are not comfortable designing your own seed mix, use a predesigned mix or work with the seed provider to design a mix.) There are a number of important factors to consider in selecting a predesigned seed mix and, of course, even more if you opt to design your own seed mixes. Appendix A provides guidelines for reading and understanding seed labels, which may help you in designing and purchasing seed mixes.

Seed mix design is often an iterative process. A good place to start is with a list of desired species and their quantities based on ecological, aesthetic, and maintenance criteria, then work with the seed provider to check availability and make a cost calculation. At this point, it may be necessary to adjust the species and their amounts, or both, to stay within budget, and then check that selected species and amounts will achieve your desired design aesthetic, function, and other considerations, and adjust once more if needed. Most seed vendors can work with you to design a custom seed mix.

Site Design

In addition to the design and composition of the seed mix, thought needs to be given to how the meadow area fits into the larger site, and how it is experienced by the site user. In general, it is important to frame the meadow in such a way that people can appreciate its beauty and movement without feeling like it is weedy, unkempt, or intimidating.

When thinking of transitions between different types of spaces, there are important logistical considerations related to imported soil and maintenance regimes, which may contrast starkly between meadow plantings and other common types of designed landscapes. Do yourself a favor and do not put a meadow area, which requires low fertility and occasional mowing, immediately adjacent to a mulched bed of woody shrubs that cannot tolerate mowing and require regular fertilization. This will complicate installation, such as needing to import or amend soil for the mulch bed but not the meadow, as well as subsequent maintenance.

A common way of handling the interface between meadow and hardscape areas is with the use of a mown edge. This could simply be a section of the meadow mown short, or it could be planted with grass seed or sod. This is especially useful along trails through a tall meadow mix, along narrow trails, or where a meadow is close to a more gardened area. Beyond any functional role, the main job

Create Cues to Care

Landscape architect Joan Nassauer coined the term "cues to care," which uses maintenance or hardscaping to frame a meadow or wildflower planting and communicate that a meadow is intentional and being managed. There are several ways to manage or frame a meadow with cues to care.

of a mown edge is symbolic: it serves as a sign of intentionality and care.

In some sites, a mown edge may not be practical or desired, such as if no other lawn is present on the site, for example. In these cases, edging the meadow with a planting of containerized ornamental grasses and perennials—using species found in the meadow mix—can create a transition between formal aspects of the landscape and a meadow, and it has the added benefit of being quicker to fill in than a meadow started from seed. Planting shorter or more familiar grasses and perennials, and using a mix of only two or three, can create an area that will serve as a transition to a more intentional-looking landscape. Using species from the meadow mix also means species have the same soil and culture requirements, so soil-preparation and maintenance regimes can be standardized across the area. To avoid the need to use precision equipment at the edge, use species that can tolerate mowing immediately adjacent to a meadow planting.

Another way to frame the meadow is by using hardscape elements such as ornamental fences or gates, or even a simple post-and-rope plant bed

Top: At Blandair Park in Columbia, MD, a mown edge of cool-season turf frames the interface between the path and the meadow area. (Landscape architect and photograph: Mahan Rykiel Associates)

Bottom: At McCormick headquarters, the strong central element of the building, the floral abundance, and the repetition and frequency of recognizable species help this meadow look intentional. (Landscape architect and photograph: Mahan Rykiel Associates)

marker. Interpretive signage on the benefits of meadows, their ecological role, or common birds and insects that might be seen in the meadow can also help visitors contextualize the landscape.

In landscapes with a formal or designed anchoring element, such as a large, contemporary building or a path with strong geometry, it may not be necessary to employ smaller framing devices—the context provided by the dominant design element may be enough to signal both intentionality and comfort.

Installation

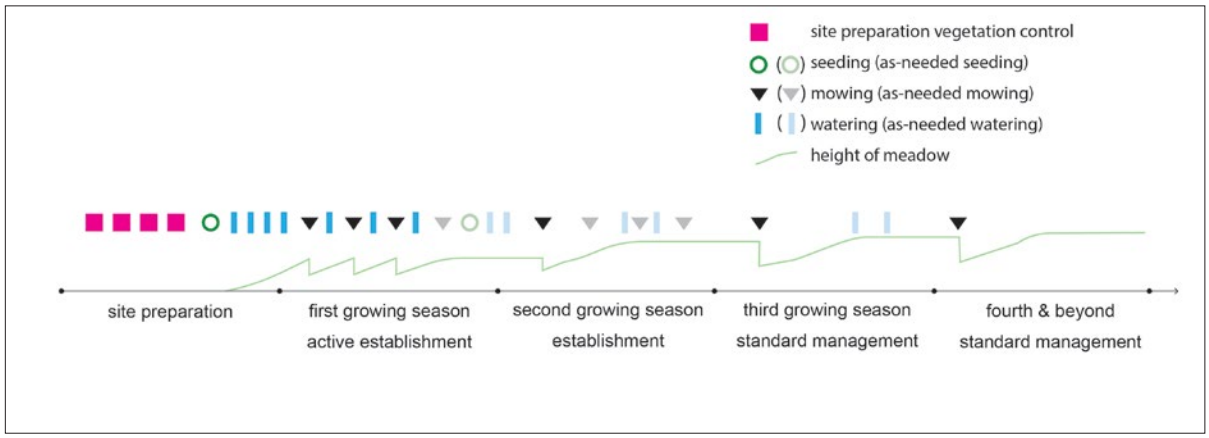


Figure 7. Timeline of activities during the lifetime of a meadow. (Image: Mahan Rykiel Associates)

Site Preparation—Weed Suppression

The importance of sufficient weed control during site preparation cannot be stressed enough (see figure 8). Site preparation should include a focus on prompting the germination of the existing weed seeds at the site and then controlling those weeds. The top priority in weed suppression is killing warm-season weeds that will provide the most direct competition with desired meadow species. This is one of the reasons that fall seeding is preferred, as it allows the summer to be spent suppressing weeds. And while spring seeding is still possible (see Timing on page 18), a meadow can be seeded any time after early June, but not before. This allows the first flush of warm-season weeds to emerge and to be killed before seeding, giving the desired species a head start. In the long term, most cool-season weeds will not threaten the success of your meadow, but warm-season weeds will, so making sure the preseeding weed suppression regime addresses these warm-season weeds is critical.

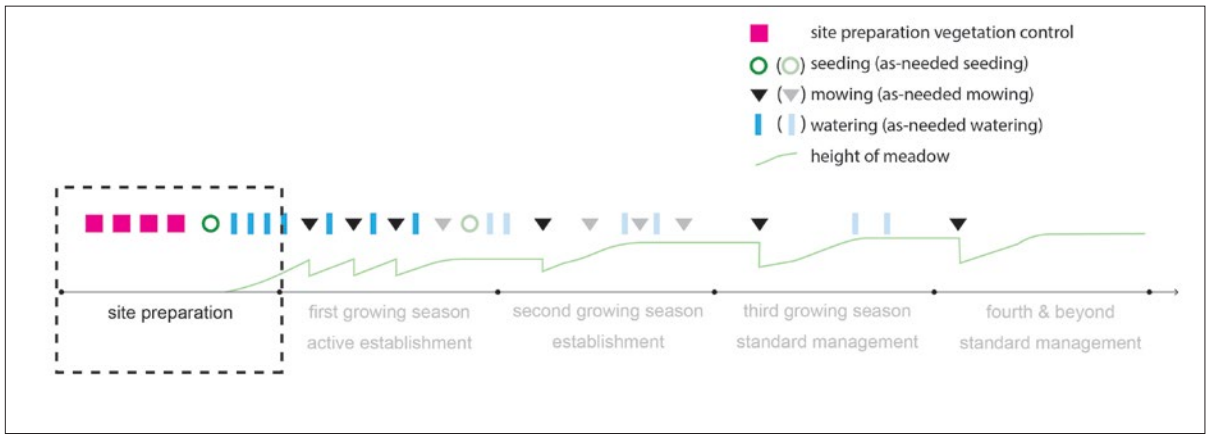


Figure 8. Timeline of activities during site preparation. (Image: Mahan Rykiel Associates)

Depending on the size of the area to be seeded, as well as owner preferences, you can use any of the following site preparation options described here. Each has advantages and disadvantages.

Option: Sheet Mulching or Solarizing

Sheet mulching. (Photograph: mwms1916 / Flickr, CC BY-NC-ND 2.0)

A chemical-free option, which is practical on smaller sites, is laying cardboard (smothering) or clear plastic (solarizing) over the ground to kill existing vegetation and weed seeds in the top inches of soil. If the site is currently a well-established lawn with relatively low weed presence, using cardboard or another opaque cover, such as black plastic, for a season can kill existing sod so that the following season it can either be mowed on the lowest setting to expose the grass stems or raked and then seeded.

On a site with more diverse existing vegetation or more weed pressure, you can solarize the site using UV-stabilized, clear agricultural plastic (use anticondensation materials if available) to cover the entire area—lack of water kills weed seeds as they germinate, and heat kills other seeds in the soil. Ideally, solarizing would be done for an entire growing season, but it is important to solarize during at least part of the summer to target warm-season weeds.

A word of caution: when solarizing plastic is placed under the dripline of a tree, solarization can weaken or kill the tree. Protect trees by keeping the solarization plastic outside of the dripline. Smothering is a better option for weed control beneath trees.

Option: Stale Bedding

Stale bedding. (Photograph: frankieleon / Flickr, CC BY 2.0)

Another chemical-free option, and somewhat easier to do on a large scale than mulching or solarizing, is to "stale bed" a site. The process involves preparing a seedbed early in order to encourage weed germination and flush out the weed seed bank. To stale bed a site, repeat shallow tillage every two weeks from the beginning of April to the beginning of June.

This method should not be attempted on wet or poorly drained sites, sloped sites, or areas prone to erosion. Keep in mind other downsides of tillage, such as a reduction in soil health and quality and the destruction of nest sites for ground-nesting bees.

Option: Applying Herbicides

Herbicide-treated turf. (Photograph: Xerces Society / James Eckberg)

For very large sites, herbicides may be the most efficient and lowest cost option for site preparation. Despite this, and quite understandably, concerns around herbicides are prompting more people to seek out and implement nonchemical site preparation methods. To support alternatives to herbicides, Xerces has produced a detailed guide, *Organic Site Preparation Methods: A Comparative Overview*, available at xerces.org.

One of the most common site preparation methods is the use of postemergent herbicides. In order to deplete the weed seed bank, routinely apply herbicides before weeds go to seed and throughout a full growing season, before planting. This generally involves spraying every two months from late spring until fall, then seeding November through January.

If, in the spring, broadleaf perennial weeds such as Canada thistle (*Cirsium arvense*), Canada goldenrod (*Solidago canadensis*), or others are observed (see Appendix C), it may be necessary to incorporate another management technique into site preparation. For example, glyphosate, an herbicide commonly used in restoration, may not control these more difficult weeds. Therefore, applying a broadleaf postemergent herbicide or incorporating another technique will help manage problematic weed species. If broadleaf herbicides are applied, it is important to use them only through June, as these herbicides can inhibit meadow species' germination if used too close in time to seeding. If herbicides are used, take steps to avoid off-site movement, such as drift or runoff, especially when sensitive sites such as croplands, a stream, or other intact pollinator habitat are in the area. To limit potential harm from herbicide use, follow all advisory language on herbicide labels and seek best management practices for vegetation control.

Smother cropping. (Photograph: Karin Jokela)

Option: Smother Cropping

Smother cropping is the act of planting a series of annual cover crops that will outcompete and smother weeds on the site of your meadow. Use of cover crops differs from the other methods discussed here because it has the capacity to improve the soil. Sometimes called green mulches, cover crops can improve soil structure, support a healthy soil microbiome, and add nutrients and organic matter to the soil—all of these in addition to providing weed suppression. Similar to the other weed-suppression methods, it should be done throughout a growing season and possibly over multiple seasons. Just as solarizing is appropriate for small sites, cover cropping is suited to larger, field-sized sites. Smothering with cover crops is a dynamic and complex process, and many rotations and combinations can be used. We present the option of cover cropping in this guide but recommend consulting other resources and experts on the use and management of cover crops in more detail. Universities or other institutional settings may use a site as a learning opportunity to test cover cropping methods prior to meadow installation or have staff available for consulting on cover cropping practices.

Sowing

Timing

The ideal time to seed a meadow is during fall and winter, the dormant period for plants in the mid-Atlantic. This could be September through January, varying by region. While this may seem counterintuitive, there are several reasons why sowing in the dormant period is effective. Native plants are adapted to the region and the seeds have some degree of dormancy. Exposure to the cold moisture of winter weather cues the seed to break dormancy, improving germination in the spring, when seasonal precipitation, temperature, and soil moisture are favorable to developing seedlings. Another reason to sow in the fall and winter is that you can take advantage of the previous spring and summer for weed suppression. Sow the seed mix after the first hard frost to avoid periods of warm days when seeds might germinate before the dry, freezing conditions of coming winter months, which would kill tender seedlings.

While dormant seeding works well on flatter sites, take care on steeply sloped sites to stabilize and prevent erosion as soon as possible after seeding; this may mean adjusting the season of planting or using an erosion-control blanket (made of straw, jute, coconut coir, etc.). Increase the rate of seeding to account for decreased germination due to season of planting. On steeply sloped sites, seeding should be completed by September 15 to ensure that a nurse crop has grown enough before winter (see Seeding and

Use of Nurse Crops on page 19). If necessary, a meadow can be seeded between the spring thaw and June 30; however, this assumes either that the site's weed seed bank is very low (such as with a weed-free lawn not treated with preemergent herbicides) or that weed suppression was accomplished throughout the previous growing season. In spring-sown meadows, small seedlings will benefit from additional watering over the first two or three months and during particularly hot or dry conditions.

If you use any herbicides in site preparation, be sure to build in time between the last herbicide application and seeding—read all label information to determine the minimum time period. While the amount of time needed between an application and seeding depends on the product, assume you'll need to wait at least a week.

Seedbed

A good seedbed should be lightly packed and firm but free of soil compaction. If site preparation activities or other circumstances have compacted the soil, it's crucial to lightly, shallowly till or rake (depending on project scale) to give the seeds a place to settle into the soil and have good contact with moisture for germination, rooting, and growth.

Prior to seeding, remove any debris, such as leaf litter, brush, stumps, or wood chips that might inhibit seed-to-soil contact.

Seeding and Use of Nurse Crops

Because the seeds of most meadow species are very small, bulking agents are essential to evenly spreading a relatively small volume of seed over a meadow area. Mix the seeds with a bulking agent such as nonclumping cat litter, crushed agricultural lime, rice hulls, clean sand, or cracked corn. Choose a bulking agent that is economical for your region and the scale of the meadow planting. Add a nurse crop of common oat (*Avena sativa*), or alternatively cereal rye (*Secale cereale*) or winter wheat (*Triticum aestivum*), to the seed mix at around 20–40% of the full rate. (Nurse crops are annuals typically planted with the meadow seed mix—they fill niche space and compete against annual weeds while the perennial native seedlings grow at their slower rate, hold moisture in the soil, protect sloped sites from erosion, lightly shade developing seedlings, and generally nurse the meadow along in the first months. Nurse crops should be chosen for their ability to grow quickly without persisting in the landscape.) Some projects use cereal rye, also known as annual rye, as a nurse crop, but when planted in winter it tends to return in the spring as a weed and can inhibit other plants from growing. Oats, however, are reliably winter-killed.

Option: Broadcast Seeding. Either a hand seeder or broadcast seeder can be used. If broadcasting seed, the broadcasting should be followed by shallowly incorporating (one-quarter to one-half inch deep) the seed using either a spring-tooth harrow, or, on a smaller site, a garden rake. Following incorporation, the seedbed should be firmed using a cultipacker, lawn roller, or ATV tires. For very small sites, you can firm the seedbed by walking on it.

Option: Seed Drilling. A tractor with a seed drill designed for no-till seeding works really well for sowing meadow mixes. Seed drills can be used on open soil as well as directly into the dead turf of sites that were previously lawns. There are a few brands and models of seed drills specifically designed to plant native seeds. These drills are designed to deliver the seed at a shallow depth of one-quarter to one-half inch, which is ideal for small seeds that may not be able to germinate from greater depths. As they operate, these drills clear the soil surface, drop the seed, and firm the seedbed. The native seed drills have separate seed boxes, each for specific seed types (smaller seeds, larger seeds, and fluffy or appendaged seeds). Each box is uniquely engineered to meter and move that type of seed evenly through the drill to the soil. If you are using a seed drill, request that your seed company supply the mix separated by species or by the drill's configuration of seeding boxes.

Option: Hydroseeding. While hydroseeding is the standard seeding method for lawns, it does not work well for wildflower seeds or native grasses. Hydroseeding is not recommended for meadows because it can inhibit wildflower germination and often does not provide sufficient seed-to-soil contact for good germination of native grasses. However, if it is the only method available, such as on steep slopes or highway roadsides, hydroseeding can be done successfully with some modifications. Increase the seeding rate to account for seeds that could be buried or washed away. To keep seeds and the mulch layers separated, apply them in a two-step application of no more than 500 pounds per acre of mulch with the seed, followed by 1,000 pounds per acre of mulch over the top. Do not use a tackifier, as it will inhibit wildflower seed germination, and make sure any fertilizer that is included does not contain nitrogen, as this will promote weeds over meadow species. It is not necessary to firm the seedbed after seeding, but if possible, the site should be either rolled or raked to encourage good seed-to-soil contact.

Mulching

Mulch the site with a thin layer of straw mulch after seeding; weed-free oat or wheat straw (not hay) is recommended as mulch to aid in seedling establishment. Mulch should cover about half the soil, generally at a rate between 1,000 and 4,000 pounds per acre.

Rye straw generally contains seed and should be avoided, as germinating rye inhibits growth of other plants. Leaf mulch, wood chips, sawdust, or other wood-based mulches should not be used; they may physically obstruct the meadow seed from germinating and remove nitrogen from the soil.

In some cases, due to steep slopes or for regulatory reasons, you may need to use erosion-control matting. This is typically a biodegradable woven matting pinned down over the ground once it is seeded. This is not ideal for meadow establishment, but if it is required, some strategies to improve success include:

- ensuring the matting is well pinned so that it does not shade the surface of the ground, and thus the developing seedlings;
- increasing the overall seeding rate to allow for decreased germination due to interference from the matting; and
- choosing a matting that is as loosely woven as possible.

Maintenance

Expectations

Maintaining a meadow is different from many types of ornamental horticulture maintenance. With the exception of addressing a few problem or high-visibility weeds, maintaining a meadow does not involve touching or interacting with individual plants; rather, it requires using largely mechanical means to encourage a consistent and invasion-resistant stand of desired vegetation. Because a meadow is a naturalized plant community, it requires less management over time, and large areas can be maintained with very little labor. During the establishment period, procedures favor desired species over undesired species (or weeds) by exploiting the differences between them, such as growing season. Once establishment is complete, there should be very little competition or risk of invasion from undesired species. Now that the site preparation phase is complete, herbicides are largely left out of our toolkit (with a few possible exceptions). From here on out, it's you and your mower.

A classic mantra describing the establishment of native forbs and perennials from seeds is: the first year they sleep, the second year they creep, and the third year they leap. "Sleep-Creep-Leap" is helpful to keep in mind with your meadow. The first year is all about root growth, so important activity is happening below ground, but not much will be visible on the surface. Many meadows will look patchy in year one—this is not generally a cause for concern. The annual species in the mix will provide flowers

in the first year. In year two, biennials and reseeded annuals should beautify the meadow. And during year three you will first see perennial species that will be typical for years to come. Through year five, you will see new blooms in the meadow from perennials that take longer to flower.

Ideally, the warranty period of a meadow will extend three growing seasons past the meadow installation so that this early maintenance is performed by a contractor familiar with meadows and their needs. Beginning in year two, and especially in year three, the maintenance staff who will be taking care of the meadow following the warranty period should be educated on weed scouting and appropriate methods and times of mowing. At a minimum, the warranty period should extend for two years. This is so that year-one maintenance, which is very different from subsequent maintenance on meadows, can be done with the appropriate knowledge and equipment, and so that an experienced meadow installer can recommend appropriate year-two maintenance, which will depend on how rapid growth was during year one (which will vary based on weather, site conditions, and more). By year three, maintenance should look more typical and require less specialized knowledge. In any situation, it is important that whoever is taking charge of maintenance receives education, not only in the form of this document but also in face-to-face meetings with the installer and landscape architect.

First Growing Season Maintenance

The first growing season is when the meadow will need the most maintenance in order to keep weeds and erosion at bay; a well-established nurse crop—ideally common oat (or winter wheat or cereal rye) and a few annual or biennial wildflowers—will help achieve this by stabilizing the soil and outcompeting the weeds until the longer-lived grasses and perennials become established (see figure 9). However, even with a nurse crop in place, in order to prevent annual weeds from making seed and becoming problematic in the landscape, you will need to mow the meadow frequently in its first year. Every time the meadow reaches a height of 12–18 inches, mow it to a height of 8 inches. A flail mower is ideal for this, but a string trimmer can work well in smaller or steeply sloped areas, and a brush hog is also good. If using a rotary or sickle bar mower, remove clippings so that they do not smother the seedlings. Alternatively, mow frequently enough that clippings are fine and do not create a thick thatch layer. In general, any plant sticking up above the rest in year one is a weed—whenever there are many, mow at 8–12 inches.

Avoid pulling weeds from the roots. The disturbance from pulling weeds and the potential to create root cuttings that may spread the weed are not worth it. Instead, cut off individual weeds above the ground, spot treat with an herbicide, or just mow the whole field. Toward the end of fall, stop

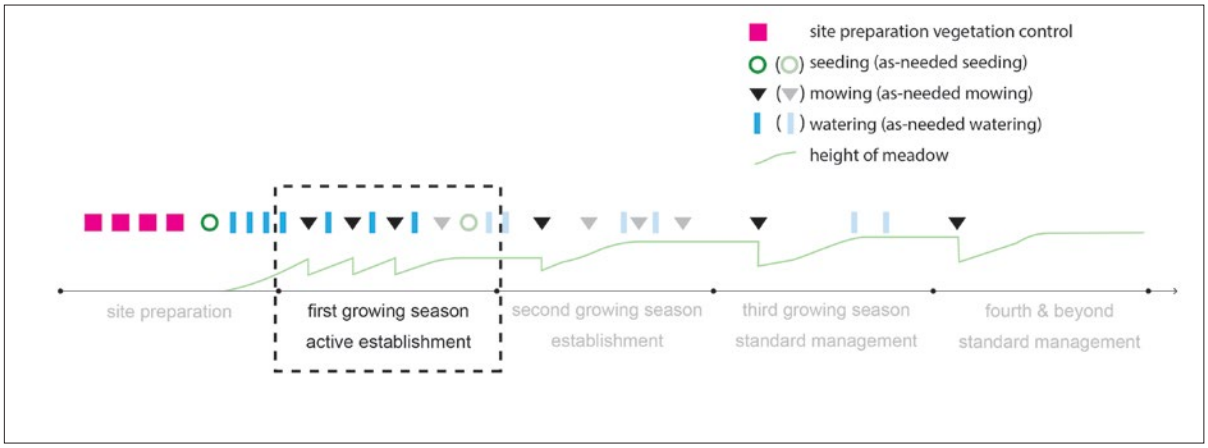


Figure 9. Timeline of activities during the first growing season of a meadow. (Image: Mahan Rykiel Associates)

In year one, the weed-suppressing nurse crop, annual, and biennial flowers dominate; perennial species build biomass in the root zone. The planting may look patchy at times, especially in winter. (Images: Mahan Rykiel Associates)

mowing even if the meadow gets higher than 12 inches—this will help insulate the plants against winter.

Is being able to identify every species in the meadow important? And should you know how to distinguish between sown seedlings and those that could be weeds? While having this knowledge is ideal, it is often not realistic. A more practical approach can be to follow the suggested mowing regime for the first few seasons and, at the same time, be mindful of pressure from true weeds. An online image search of the species in your seed mix is a good way to help you recognize and manage the plants growing in the meadow.

If you're seeing a lot of a particular plant and wondering if it is a weed or not, in addition to the tips above, check Appendix B for plants you can expect to emerge early and Appendix C for problem weeds and steps you should take to address them.

Second Growing Season Maintenance

In year two, assuming you mowed correctly in year one, you will not have any remaining nurse crop. The perennial meadow plants will be bigger, and the biennials should return or emerge. However, year two is important for managing biennial weeds such as sweetclover (*Melilotus officinalis*), Queen Anne's lace (*Daucus carota*), and lesser burdock (*Arctium minus*). If you see a lot of these or other biennial weeds, then the best management strategy is to mow similarly to year one (down to 8 inches every time the meadow gets taller than 12 inches) (see figure 10). If you are not sure, you can mow to be on the safe side; it will not hurt the perennials, and if anything, it will encourage stronger root growth. The only downside is that you might not get to see some of the *Coreopsis*, *Rudbeckia*, and other quick-developing perennials bloom until the following year. If you are confident that you do not see

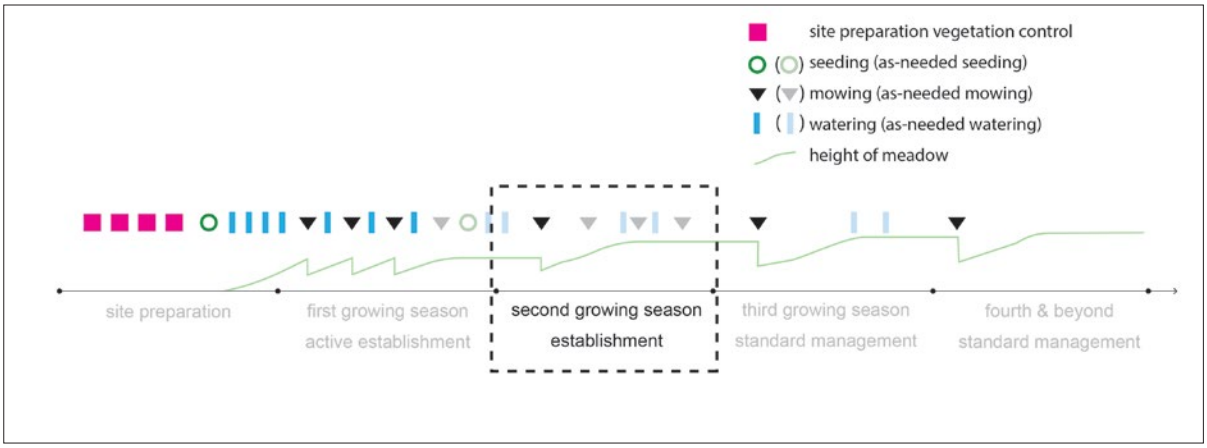


Figure 10. Timeline of activities during the second growing season of a meadow. (Image: Mahan Rykiel Associates)

many biennial weeds (or annual nurse crops or weeds that escaped during year one) then there is no need to mow other than one time in late winter or early spring.

If you see only a few of these (or other) weeds and you want to allow the biennials and quick-developing perennials to bloom for aesthetic reasons, you can also individually remove weeds. Instead of pulling them out at the roots, which causes soil disturbance that could encourage other weeds to colonize, clip the weed below the lowest leaves but above the ground. See Appendix C for common weeds and how to manage them.

As more of the native vegetation fills in, year two is when you can expect birds, bees, and butterflies to stop by and check out the new habitat in town! As word travels back to nests and hives, you can expect more wildlife visitors making the habitat their home.

In year two, biennials and early succession perennials and grasses dominate; longer-lived perennials and grass species focus on vegetative growth. (Images: Mahan Rykiel Associates)

Third Growing Season and Beyond: Regular Maintenance

In the third growing season, the meadow will likely be ready for you to begin its regular maintenance regime (see figure 11). You should only need to mow once during late winter or early spring. Make sure to do this mowing when perennials are still dormant (before any signs of green growth on the plants), or else their growth will be damaged.

There are two options for this annual maintenance: you can mow one-half of the meadow to 4–6 inches or the entire meadow to 8–12 inches. If your mower cannot mow higher than 4 inches, mowing half of your meadow each year is probably the best solution—at this height, mowing only half is important to maintaining the habitat benefit of the winter biomass. If you have a brush hog or other large mower, you can opt to mow the entire meadow to 8–12 inches or, like the other option, mow half to a shorter height according to your preference. This regular mowing keeps your plants healthy,

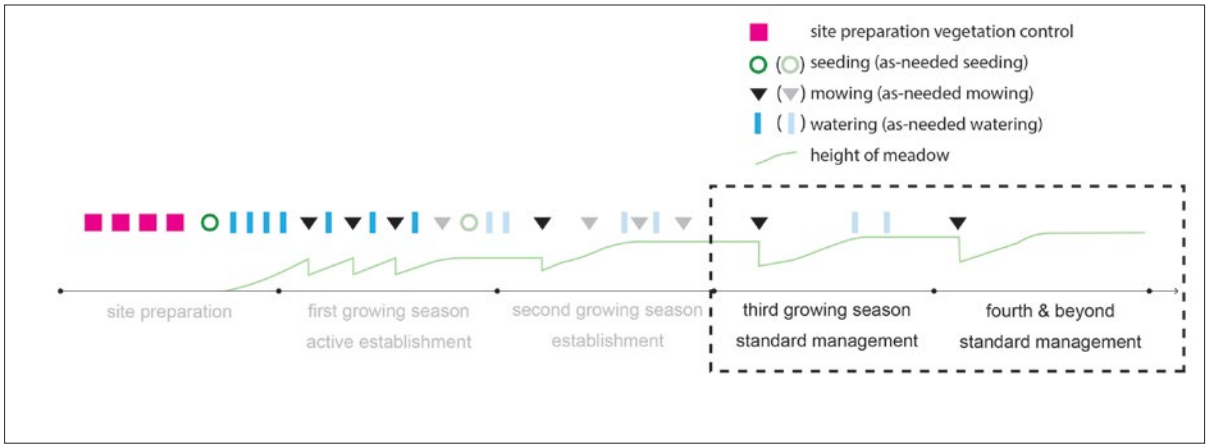


Figure 11. Timeline of activities during the third and additional growing seasons of a meadow. (Image: Mahan Rykiel Associates)

In year three and beyond, long-lived perennials and grasses dominate the site, with biennials and annuals largely gone except in areas of disturbance. Pollinators will likely find the food and habitat resources on site in increasing numbers. (Images: Mahan Rykiel Associates)

encourages spring growth, and prevents woody plants from invading or taking over the meadow—in the wild in our area, meadows occur in places of disturbance, and after the disturbance is gone, woody plants gradually intrude until the meadow becomes a forest. Assuming you do not want this to happen, the regular disturbance of mowing keeps the meadow open.

Periodic spot-checking for weeds is also a good idea. If the establishment period went well, there should be very few weeds, but having someone knowledgeable check the site and spot-treat problematic weeds every year or two is a good investment in the long-term health, function, and beauty of the meadow. See Appendix C for common weeds and how to treat them.

Just because your meadow is now established does not mean it is done changing. Many beautiful perennials only start flowering in years five through seven, and some of the early showstoppers, like blackeyed Susan (*Rudbeckia hirta*) and common yarrow (*Achillea millefolium*), may become less abundant as time goes on. Your meadow will also grow and change relative to the conditions on your site—you may start to notice different flowers and colors in areas where soil may be a bit wetter or drier. A year with a late spring might be an opportunity to see a new color combination when things that usually bloom at different times bloom together, while a year with an early spring might provide other surprises.

This adaptation to a site and environment over time demonstrates the resilience of meadows as ecological communities. This resilience, which is due in part to the high biodiversity found in meadows, means that these plantings are well situated to persist as the effects of climate change become more and more apparent. This also means that well-managed meadows planted today can continue to provide important habitat for pollinators into the future. They are also opportunities for continued design: the relationship between the manager and the meadow, much like the relationship of a skilled gardener and a garden, is one that allows a dialogue between the changing climate and context of the site and the needs and desires of its stewards.

Appendix A: Understanding Seed Mixes and Labels

Even if you do not plan to design your own seed mix, a little knowledge about the basic principles goes a long way in becoming an informed consumer.

One basic concept of seed mixes is the seeding rate: how many seeds, expressed either as weight of seeds (in pounds) or as number of seeds, are sown over a given area. Many seed vendors use the first method, describing each species in a mix as a percentage by weight. This is a useful measurement for calculating cost and figuring out the logistics of spreading the seed, but it is not effective for envisioning the blend of species that will be present on the site when established, mostly because the seeds of different species weigh radically different amounts. Some species have large, heavy seeds and some species have tiny, light seeds—per pound, a species with heavy seeds will have fewer individual seeds than one with light seeds. Designing and thinking about a seed mix in terms of the number of seeds per species over a given area (and therefore the number of potential plants) is a much more accurate way to plan the composition and look of a meadow. Considering that each seed is a potential plant but that a portion of seeds will be buried, washed away, or eaten before germinating, a rough range for seeding rates is 40 to 120 seeds per square foot. The target seeding rate also depends on how much weed pressure you expect, how quickly or slowly you want the meadow planting to fill in, and the project budget (a higher seeding rate will result in more plants establishing in a shorter time frame but will cost more).

Even though knowing the number of seeds is important, seed mixes are sold by weight. It is possible to calculate the number of seeds using the average weight of a seed for each species. Information on the average number of seeds per pound for a species can be provided by vendors, found through the USDA fact sheet for a species or located in other online databases such as Kew's Seed Information Database (see Resources).

The next thing to understand is the difference between bulk seed pounds and pure live seed (PLS) pounds. Bulk seed refers to the total weight of a bag of seed. Much of this is viable seed, but this weight includes things like chaff, debris, or dead seeds. PLS refers to how many pounds of bulk seed you need to get a pound of viable seed. Purchase and design seed mixes based on PLS pounds, for accuracy and value. The calculation for PLS pounds for a seed lot is:

$$\text{PLS} = (\%\ \text{purity} \times \%\ \text{total viability}^{*})/100$$

*% total viability = % germination + % hard seed + % dormant

The first number in the PLS calculation, percent purity, refers to the percentage of the total weight that is made up of seeds (omitting chaff, weed seeds, or other inert debris). The second number in the calculation, percent total viability, is the percentage germination (the seeds you can expect to germinate right away), plus the percentage of hard seed (another type of dormancy, where the seed coat is impermeable to water), plus percentage of dormant seed (still alive and viable, but which may not germinate right away). All of these numbers should be listed on the seed packet or label and are based on independent seed lab tests.

Let's take a closer look at percent total viability. In contrast with seeds of domesticated crop species, which are larger and have been selected for low dormancy, the seeds of native species are prepared for natural conditions. One of these adaptations is dormancy—not all seeds will germinate at once; instead,

germination occurs over months or years to spread out the risk of seedlings facing dangerous conditions, such as periods of drought or extreme cold. Many native species have high degrees of dormancy, and because of this, the label of a high-quality seed mix might indicate a percent germination that is lower than a typical lawn seed mix. When the seed tag indicates that a seed mix has high percentage viability but low percentage germination, this means many of the seeds are dormant. The implication is that the dormant seeds may germinate in future years, but not in the first year.

One final concept to cover related to seed mix design is field emergence. This is the proportion of viable seeds that become adult plants. Field emergence factors can help you estimate how many plants are likely to grow from the proposed amount of seed. Not all good seeds germinate and grow: some seeds are sown too deeply, others too shallowly, or they may be eaten before growing, or a seedling may start but wither. An estimated 30%–90% of healthy seeds fail to establish and grow. Seed companies are a source of information on how to adjust for field emergence, as is as the book *Sowing Beauty: Designing Flowering Meadows from Seed* by James Hitchmough, listed in the Resources. For some states, the NRCS (Natural Resource and Conservation Service) office has information on field emergence for native species. Some native seed companies and some state NRCS offices have developed field emergence guidance for native species. This is a newly emerging concept that isn't precise, but it helps to avoid using too much seed and wasting it, or using too little seed and getting poor establishment. The following calculation gives an example of how many plants per unit area will result from a certain amount of seeds for a given species:

$$\frac{(\text{PLS pounds of seed of species 'A'} \times \text{seeds per pound of species 'A'} \times \text{percent field emergence of species 'A'})}{\text{total area to be seeded}} = \text{average number of seedlings of species 'A' per unit area}$$

For example, let's figure out how strong a presence butterfly milkweed (*Asclepias tuberosa*) will be expected to have in a 2,000 square yard meadow planted with a given seed mix. If a seed mix calls for 20 PLS pounds of seed to be planted over 2,000 square yards, and the seed mix is 5% butterfly milkweed by weight, that means we use one PLS pound of milkweed seed for the total area. The calculation would look like this:

$$\frac{(\text{1 PLS pound milkweed seed} \times \text{70,000 milkweed seeds per pound*} \times \text{18\% field emergence of milkweed**})}{\text{2,000 square yards}} = \text{an average of 6.3 milkweed plants per square yard}$$

*from Ernst Seed (see Resources)

**from Hitchmough (see Resources)

Appendix B: Successional Phases of Native Meadow Species

Common and scientific names follow the USDA PLANTS database.

Early Successional Species

This covers the first growing season—annuals, biennials, and fast-emerging perennials.

- columbine (*Aquilegia* spp.)
- common boneset (*Eupatorium perfoliatum*)
- blackeyed Susan (*Rudbeckia hirta*)
- foxglove beardtongue (*Penstemon digitalis*)
- nurse crop, such as common oat (*Avena sativa*), winter wheat (*Triticum aestivum*), or cereal rye (*Secale cereale*)
- partridge pea (*Chamaecrista fasciculata*)
- sedge (*Carex* spp.)
- swamp sunflower (*Helianthus angustifolius*)
- swamp verbena or blue vervain (*Verbena hastata*)
- tickseed (*Coreopsis* spp.)
- Virginia wildrye (*Elymus virginicus*)
- wild bergamot (*Monarda fistulosa*)

Long-Lived Perennials

You can expect to see these plants emerging and blooming for the first time in seasons three and beyond (don't worry—it's not a weed!).

- blue mistflower (*Conoclinium coelestinum*)
- butterfly milkweed (*Asclepias tuberosa*)
- closed bottle gentian (*Gentiana andrewsii*)
- Culver's root (*Veronicastrum virginicum*)
- little bluestem (*Schizachyrium scoparium*)
- mountainmint (*Pycnanthemum* spp.)
- wild indigo (*Baptisia* spp.)

Appendix C: Common Weeds and How to Manage Them

This appendix provides strategies for managing weeds after sowing and during establishment. See Site Preparation—Weed Suppression on page 16 for site preparation options.

Common and scientific names follow the USDA PLANTS database.

Annual Weeds (mow)

These annual weeds can be managed through high mowing to prevent them from going to seed and from shading meadow seedlings. Without soil disturbance, annual weed abundance fades over time.

- American burnweed (*Erechtites hieraciifolius*)
- annual ragweed (*Ambrosia artemisiifolia*)
- bristlegrass or foxtail (*Setaria* spp.)
- Canadian horseweed* (*Conyza canadensis*)
- common chickweed (*Stellaria media*)
- common dandelion (*Taraxacum officinale*)
- crabgrass (*Digitaria* spp.)
- eastern daisy fleabane (*Erigeron annuus*)
- jimsonweed (*Datura stramonium*)
- Pennsylvania smartweed (*Polygonum pensylvanicum*)—this native plant, with flowers that have some pollinator value and seeds that are food for wildlife, can outcompete planted meadow species and should be managed against if it occurs abundantly
- redroot amaranth (*Amaranthus retroflexus*)
- shepherd's purse (*Capsella bursa-pastoris*)
- velvetleaf (*Abutilon theophrasti*)

Biennial Weeds (mow or cut)

In their first year, these biennial weeds are rosettes that stay close to the ground and may be beyond the reach of a mower. In the second year, the plants will bolt, sending up vertical flowering stems. Depending on the extent the plants are present and the size of the area, these stems can be managed by mowing (larger areas, or when there are more individual plants) or cutting with clippers (smaller areas, or when there are fewer individual plants).

- lesser burdock (*Arctium minus*)
- mullein (*Verbascum* spp.)
- nodding plumeless thistle or musk thistle (*Carduus nutans*)
- Queen Anne's lace (*Daucus carota*)
- spotted knapweed (*Centaurea stoebe* ssp. *micranthos*)
- sweetclover (*Melilotus officinalis*)
- wild parsnip (*Pastinaca sativa*)—avoid skin contact with plant foliage and sap, as it can cause rash and burning

Perennial Weeds—Broadleaf (apply broadleaf herbicide)

Due to the challenges of managing these weeds, when a site is being prepared, use of broadleaf herbicides might be the most efficient choice, especially in larger sites with extensive infestations.

- Canada thistle* (*Cirsium arvense*)
- Carolina horsenettle (*Solanum carolinense*)
- crownvetch* (*Securigera varia*)
- field bindweed* (*Convolvulus arvensis*)
- field sowthistle (*Sonchus arvensis*)
- hedge false bindweed* (*Calystegia sepium*)
- plantain (*Plantago* spp.)
- white clover (*Trifolium repens*)

Perennial Weeds—Grasses and Sedges (burn or apply herbicide)

- Kentucky bluegrass (*Poa pratensis*)
- orchardgrass (*Dactylis glomerata*)
- quackgrass (*Elymus repens*)
- reed canarygrass (*Phalaris arundinacea*)
- smooth brome (*Bromus inermis*)
- tall fescue (*Schedonorus arundinaceus*)
- yellow nutsedge (*Cyperus esculentus*)

*These species might not be effectively controlled solely by broadleaf herbicides, such as glyphosate. Anticipate multiple applications or the need for other cultural, mechanical, or chemical methods.

Appendix D: Bee City USA

https://www.beecityusa.org/

Bee City USA is an initiative of the Xerces Society that raises awareness of the role that pollinators play in our communities and what each of us can do to provide them with healthy habitat.

The Bee City USA program endorses a set of commitments, defined in a resolution, for creating sustainable habitats for pollinators. Incorporated cities, towns, counties, and communities across the United States can make these commitments and become certified as a Bee City USA affiliate. Becoming an affiliate institutionalizes the local government and community's commitment to pollinator conservation and provides support for widespread collaboration to establish and maintain healthy pollinator habitat on public and private land. Affiliates are active participants in a national movement committed to pollinator conservation supported by conference calls and webinars to promote sharing and collaboration among affiliates.

Being a Bee City USA affiliate also provides accountability for achieving pollinator conservation results each year, to be shared with one another and the public through annual reporting. Bee City USA disseminates information regarding funding opportunities, pollinator research, and habitat enhancement through email, e-newsletters, the Bee City USA website, and social media channels. Bee City USA shares resources for program promotion—press release templates, brochure templates, T-shirt designs, bee decals, pollinator garden signs, and more.

Bee City USA Affiliate Commitments

- Establish a standing Bee City USA committee to advocate for pollinators
- Publicly acknowledge Bee City USA affiliation with signage and webpage
- Host annual pollinator-awareness events
- Create and enhance pollinator habitat on public and private land
- Make city or county policies and plans pollinator conscious
- Annually apply for renewal and report on last year's activities
- Pay a modest initial application and annual renewal fee

Benefits of Being a Bee City USA

- Help to ensure the survival of vital animal species crucial to our planet's complex food web
- Raise community awareness of how our food grows and improve local food production through expanded pollination
- Improve local plant nursery markets by increasing demand for native, pollinator-friendly plants
- Mobilize community to remove nonnative invasive plants to make way for locally native plants
- Raise community awareness of the least toxic ways to deal with home and garden pest problems
- Raise community awareness of the local environment's seasonality as understanding grows about pollinators' reliance on blooming plants and trees
- Support growth of niche business—pollinator-friendly landscaping, beekeeping suppliers, chemical-free lawn care, and native seed suppliers
- Provide credibility for local grassroots pollinator conservation efforts
- Open doors to widespread collaboration for establishing and maintaining healthy pollinator habitat within the community's boundaries

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About

Founded in 1983, Mahan Rykiel Associates is a 35-person landscape architecture, urban design, and planning firm located in Baltimore, Maryland. The firm works across scales to imagine and realize projects that enrich the human condition and support vibrant natural systems. Research and discovery guide project development that includes public parks, civic plazas, state infrastructure, mixed-use housing, private residences, healthcare facilities, hotels, and commercial centers. The firm cultivates this diversity to deepen and broaden its creative capacity to shape the built environment. Active collaboration across disciplines and sectors ensures that technical knowledge and resources are leveraged in support of each project.

The Xerces Society is a nonprofit organization that protects the natural world by conserving invertebrates and their habitat. Established in 1971, the society is a trusted source for science-based information and conservation advice. The organization draws together experts from the fields of habitat restoration, entomology, plant ecology, education, farming, and conservation biology with a single passion: protecting the life that sustains us.

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