The Creation and Management of Meadows

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Contents

Fig 1. (Meadow Plantings 2016)

Key Considerations

Aims

This document aims to address the topics involved in the creation and management of meadows as well as provide informational supplementary sources.

In this case, we are examining the potential of meadows to be used as alternatives to open grass spaces that require frequent mowing. These mowed open spaces are maintained as a buffers that suppress ecological succession and resist the spread of invasive plant species. The decision to use a meadow requires research and analysis to understand if a meadow an appropriate and viable option for a specific location.

Methods

Creating a meadow should be addressed in three key phases:

- Installation
- Establishment
- Maintenance

and each phase has its own list of considerations.

Considerations in preparing a meadow include site location, boundaries, bordering typologies, soil type, climate, and time of year. Installation includes considerations of budget, resources, meadow purpose, and meadow type. Finally, a maintenance plan should address meadow type, meadow purpose, species preference, location, season, and meadow maturity.

Costs

When replacing mowed areas with meadows, it is essential to understand both short- and long-term costs. This report includes a number of sources on the costs of creating various meadow types.

Precedents

Precedent case studies offer observed options for preparing, installing, and maintaining a meadow by providing an in-depth analysis of aims, approaches, actions, and outcomes used for a unique location. Case studies show what worked, what didn’t, potential restraints, positive

outcomes, what needs to change, and why. Several case studies have been included in this report to provide an overall understanding of the steps involved to create a meadow, and what has been successful in meadow restoration.

Background

It is important to understand the traditional condition of Maryland's landscape when considering strategies to implement and maintain native biodiversity.

Deciduous forest is the dominant vegetation typology occurring naturally in the eastern U.S. This means that any cleared or open grassy areas left un-maintained will naturally revert to the deciduous forest. When a cleared area is not mowed, ecological succession will take over and an increased diversity of plant species will emerge. The mix of plants will typically be grasses or similar species like graminoids; wildflowers such as Goldenrods, Asters, and Milkweeds; Shrubs, such as Sumacs (Rhus spp.); and pine trees including Eastern Red Cedar (Juniperus virginiana) and Virginia Pine (Pinus virginiana) (Simmons and Walsh 2012).

The return of deciduous forest is currently affecting Maryland properties and it is critical that strategies such as meadows or alternatives measures be considered for their ability to resist the succession of deciduous forest creeping into open un-maintained land.

Fig. 2 The natural succession to forest from open grassy areas (Simmons and Walsh 2012)

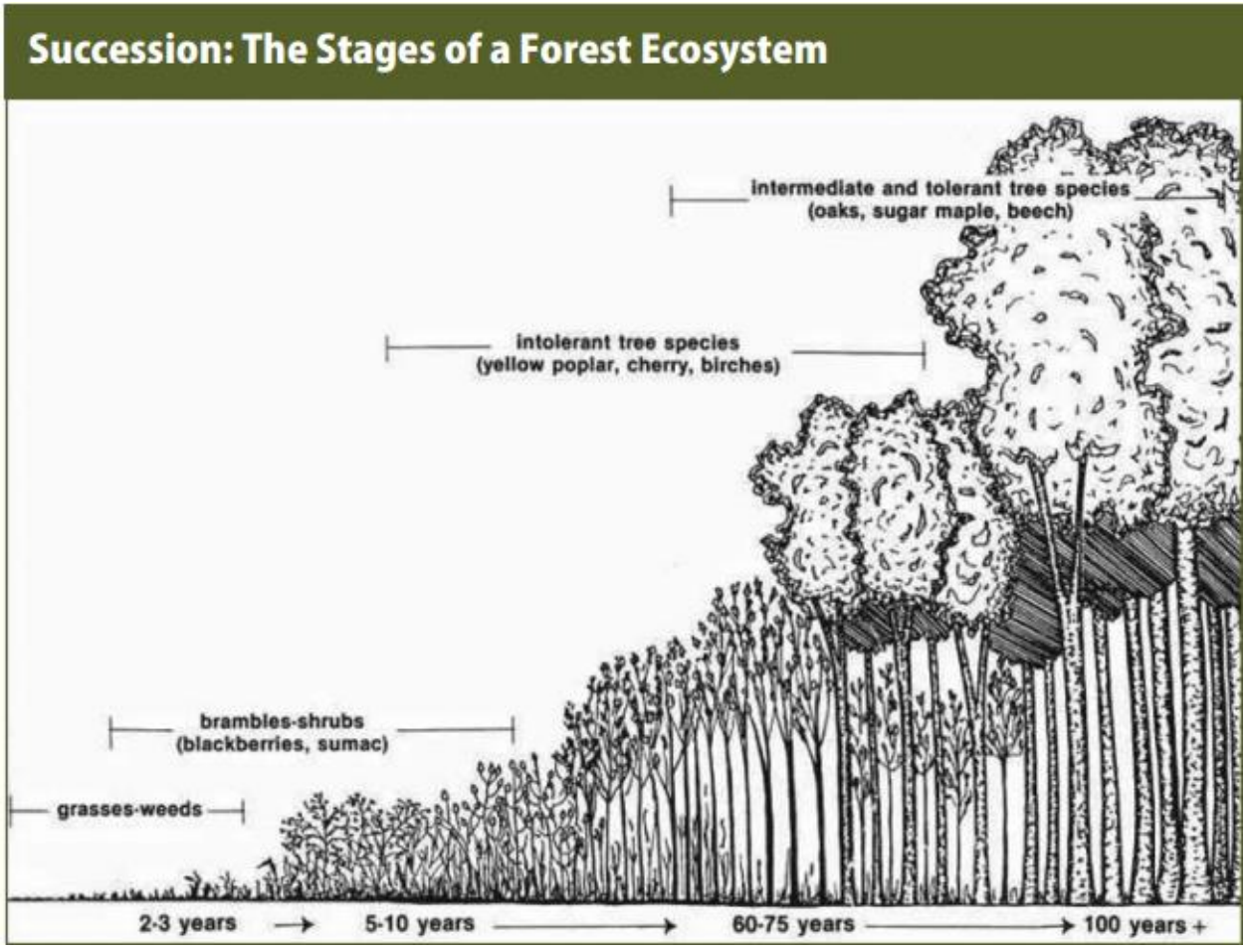

Fig. 3 The successional progression from grass to deciduous forest (Highfield and Sprague 2016).

At one time, Maryland was nearly entirely covered in forest vegetation, which was cleared by settlers for agricultural purposes. Since farming has slowed, these empty plots of land have been left for succession.

In the initial stages of abandonment, the ground layer is covered in rapid growing plants that thrive in full sun, largely small to medium grasses and forbs. After a couple of years, slightly larger perennials and woody plants begin to smother the initial vegetation layer. Then small, shade-tolerant trees emerge and increase the height of the vegetation. Eventually, large trees shade out their ground dwelling competitors and become the dominant vegetation community (Highfield and Sprague 2016).

What are meadows?

People often have a preconceived idea of what meadows are and what they look like, often oversimplified. But a meadow is more than just a wild open space of low to medium height flowering plants mixed among tall grasses. Ecologically, they can be defined as a mix of native grasses and herbaceous plants that will remain as a stable environment under a limited maintenance regimen (Novic 2010).

Types of Meadows

There are three key meadow types: wet, mesic, and dry.

According to the U.S. Environmental Protection Agency ("Wet Meadows" 2015) wet meadows are a type of marsh that typically occurs in poorly-drained areas like shallow lake basins, low-lying farmland, and the spaces between shallow marshes and upland areas. Wet meadows are normally drier than marshland, except in periods of exceptionally high water. Most of the time, despite seasonal highs in rainfall, wet meadows are not inundated in constant water, but their soil is typically always saturated as a result of the water table level. Wet meadow soil types are more nutrient rich than the soil in dry meadows, which affects the species found in this type of meadow.

One key benefit of wet meadows is that during periods of excessive rainfall, they collect the runoff and mitigate flood damage to low lying, downstream areas. The plants in wet meadows also fulfill to varying degrees the same process of wetland plants, filtering water and extracting nutrients. This nutrient richness creates an excellent food source for a diverse wildlife habitat ("Wet Meadows" 2015).

The most critical aspect of a wet meadow is its hydrology. The consistency and reliability of fluctuations in water moving in and out of the vegetation community dictates the stability of the wet meadow. In the succession of natural environments, wet meadows normally succeed bogs and are then succeeded by both mesic and dry meadows (Ratliff 2016).

Mesic meadows are an intermediary vegetation community found on soil types ranging from well-drained to semi-poor draining soil. Herbaceous mesic meadows that experience intensive grazing become susceptible to invasive non-native plant species (Herbaceous Planting For Pollinator Habitats 2012).

Much of Maryland's landscape once featured grasslands and prairie-like habitats interspersed with tree groves and woodlands. These lost meadows are critical to the survival of native Maryland wildlife. The native herbaceous species formed in meadows provide habitats for many animals, including birds, mammals, and insect pollinators. Without the habitats, it is difficult to protect Maryland's native fauna ("Anacostia Riparian Meadow Restoration" 2015).

The plant species in a dry meadow landscape enjoy the low fertility soil. Larry Weaner of from Larry Weaner Landscape Associates, who specializes in meadows, insists that the lower the soil's fertility the better the end result, if you are seeking a flowering dry meadow (Garmey 2008).

Meadows serve as important refuges for native plants that were once common and thrived along the edges of woodlands, open areas, and roadsides but appear less frequently. Meadows and grassy areas can also act as natural buffers that preserve a high quality standard of waterways, wetlands, and water resources. The decline of both plant and wildlife species native to the eastern U.S. is linked to the disappearance of meadows and open grassy areas in the region.

Fig. 4 Tiger Swallowtail and Field Thistle (Cirsium discolor), an important native meadow wildflower once abundant in Alexandria (Simmons and Walsh 2012).

Species

When choosing appropriate plant species to create a meadow, considerations that will affect the final plant palette include:

- What is the meadow's purpose?
- Where will the meadow be situated?
- Will it be a wet or dry meadow, or perhaps will be intermittently wet?
- What are the area's site conditions?
- What is the soil type?
- Are you trying to preserve particular species of plants?
- Are you trying to create a specific habitat for certain wildlife species?

The Maryland Department of Natural Resources (Wixted 2016) has proposed a plant species list with recommendations for both wet and dry meadows. The lists are included in Appendix A and B.

For more information on meadow plant species, see Raymond Ratliff's (Ratliff 2016) in-depth analysis on wet meadows structure, composition, and vegetation completed in conjunction with the California Wildlife Habitat Relationships System, California Department of Fish and Game, and the California Interagency Wildlife Task Group, in Appendix C.

Conservation landscaping promotes habitat provision for local and migratory animals, conserves native plants, and improves water quality. The concept allows landowners to benefit from using this type of landscaping to reduce their levels of mowing and water requirements, as well as the need for herbicides to control weeds. The concept focuses on using native plant species to reduce the maintenance regimens as well as solving other environmental issues such as erosion, soil quality, steep slopes, or poor drainage.

For a full list of recommended plant species for both wet and dry meadows see pages 68-69 *Native Plants for Wildlife Habitat and Conservation Landscaping: Chesapeake Bay Watershed*, published by the U.S. Fish & Wildlife Service.

Some of the typical problematic weed species in meadows located in the northeastern U.S. include (Weaner 2012):

- *Artemisia vulgaris*: Chrysanthemum-Weed
- C*irsium arvense*: Canadian Thistle
- *Celastrus orbiculatus*: Oriental Bittersweet
- *Lonicera japonica*: Japanese Honeysuckle
- *Lythrum salicaria*: Loosestrife (Wet meadows)
- *Phytolacca americana*: Pokeweed
- *Rosa multiflora*: Multiflora Rose
- *Solidago canadensis*: Canada Goldenrod

Typically, meadows at lower elevations that have been disturbed tend to feature plant species such as:

- *Poa pratensis*
- *Bromus inermis*
- *Phleum pratense* (Herbaceous Planting For Pollinator Habitats 2012).

Installation

Prior to the installation of any meadow, the site should be evaluated to determine what amendments if any, are needed to prepare the soil for planting or sowing.

A critical first step is to understand the planting method to be used. Some criteria to consider include cost, time frame for establishment, resources for installation, and the accepted contingency factor. There are four typical strategies used to restore meadows and grassy areas (Wixted 2016).

Sowing Seeds: requires soil preparation and the human resources required to spread seed. Sowing also requires additional watering throughout establishment period. Sowing is a relatively low cost strategy.

Planting seed plants: involves planting species prone to seeding, relying on them to naturally spread over time through self-seeding. Maturity rates will vary depending on the existing seed bank and access to water. Establishment success rate is increased, but the meadow's density is not guaranteed, which may provide the opportunity for natural succession to take over.

Planting bare-root plants: requires careful preparation, large amounts of resources and money, but provides the best chance for successful establishment and least amount of long-term maintenance.

Planting and sowing combination: is a less expensive alternative than planting bare-root plants and has the added benefit of the more mature plants self-seeding and complimenting the sown seed.

For more information on planting methods, refer to the Maryland Seeding Association in Appendix D.

Weaner collaborates with landscape architects and has completed over 100 meadows. He offers an insight into the ratio of plants to seeds that has proven successful. Weaner only uses species proven to thrive in the specific soil location chosen. For sites smaller than three acres, Weaner uses a mix of 60 percent plants to 40 percent seeds which allows him to better control the spread of color throughout the meadow. This is only essential if the consistency and overall aesthetic of the desired meadow is a high priority. On larger sites, where dispersal can be less precise, the seed percentage can be increased. On a 40-acre project in Connecticut, Weaner used eight different seed mixes each with roughly 25 varied plants or grasses, including annual oat and winter wheat grass used as a "nursing crop," which stops aggressive weeds from choking seedlings (Garmey 2008).

According to Weaner, for wildflower meadows, preparing the site appropriately is crucial. The goal is to create a finely graded seed bed, incorporating the seed into the soil and to tamp or roll for good seed-to-soil contact. Preparation begins by eliminating existing growth. The most common methods are repeated applications of short-lived herbicide sprays (such as Roundup), repeated tilling, or a combination of the two. Tilling brings dormant weed seeds to the surface where they must be allowed to germinate and then shallowly cultivated or sprayed with herbicide before planting. This step can be avoided with a no-till seeding if a shallow seed bed can be worked up amid the dead plant material.

For more information on seed and installation methods used, refer to the website of Larry Weaner Landscape Associates (Weaner 2012).

One of the newest, most innovative approach to meadow creation is through products such as Wildflower Turf, a U.K. company specializing in diverse mixes of plants in specific turf installations. The company is an industry leader in supplying wildflower turf products. Their Wildflower Turf product has many advantages, such as the ability to pre-fabricate a desired plant

mix, as well as time saving by laying turf to cover the ground. A turf application limits the threat of competition from invasive species as seeds mature.

Research hasn't located an American equivalent yet. However, this could be a strategy for future projects. For more information on wildflower turf refer to "Wildflower Turf - Instant Meadows" 2016.

Establishment

There are many factors that need to be considered when trying to successfully establish a meadow. The first is site selection. Meadow species require full sun to thrive and keep competing species at bay. Also important is the site's topography, which will influence the species chosen; sloped banks will require plants suited for erosion control with root structures that can stabilize the embankment. As previously mentioned, matching the soil type with species selection will greatly influence the meadow's success. For example, nutrient loving, wet meadow species will not be sustainable in highly-drained soil.

The second key step is site preparation, which, at a minimum, requires removing as much weed vegetation and seed as possible. It may require the use of herbicides to ensure that weed rhizomes are eradicated. However, layering newspaper is another method sometimes used as an alternative to chemicals (Weaner 2012). Competing with weeds during establishment is an ongoing process, and requires a strategy such as mulching to suppress weeds once the seed or plants are installed. Mulching options vary from wood chips to crushed rock as demonstrated in the Riem Landscape Park case study.

Other concerns for establishment include seed rates, seed sourcing, installation timing, and seeding methods. Each aspect can influence a meadow's success. For more information on these techniques see The Xerces Society for Invertebrate Conservation (Establishing Pollinator Meadows From Seed 2013).

Establishment is the most difficult phase in achieving success for a meadow. The preparation prior to planting and seeding is just as crucial in reducing maintenance and improving success as the actions that follow. Heiner Luz, a designer of the Riem Landscape Park in Germany used a dominant species in the meadow mix based on his knowledge of natural conditions, noting that some meadows will typically feature one or two dominant species due to natural succession. Rates are also carefully chosen to thicken ground vegetation as quickly as possible to reduce the potential of unwanted species establishing themselves.

The critical component of Luz's design to minimize maintenance and create the optimum circumstances for establishment was the use of a grey granite mulch layer. It was laid at a thickness of 50mm (2 inches) prior to planting. A mineral mulch has three key attributes—it is superior for weed prevention, has increased water holding capacity and reduced evaporation rates, and it does not extract critical nutrients from the soil like bark does. The success of Luz's design has largely been attributed to the mineral mulch, as it allows the meadow species to establish themselves across a wide variety of conditions with minimal competition from unwanted species (Margolis and Robinson 2007).

In Weaner's experience, additional watering is not required for seeding meadows if the species are chosen carefully. He notes that the seeds may take longer than desired to mature, but if the ratio and species are correct, the meadow will be able to develop and keep out competitive weeds (Garmey 2008).

Maintenance

All managed meadows and maintained open areas need to be consistently monitored for invasive and unwanted exotic plants that may establish when regular mowing has stopped. If meadows are not actively managed, undesired species can overcome the existing native vegetation. Alternatively, natural succession will overtake the area with woody shrubs and trees, returning the space to a forest community.

Soil compaction and disturbance can also promote the spread of invasive species. Therefore, to avoid compacting the soil, mowing is not recommended when the ground is wet. Wet grassy glades, meadows, and trails along streams and lowlands should only be trimmed by hand, not mowed, to minimize risk of erosion (Simmons and Walsh 2012).

Meadows along rivers, on floodplains, and on dry sites are often reliant on natural processes such as flooding or droughts. These processes give meadow plants enough time to establish themselves while minimizing the ability of woody species to establish and transition the open space into forest. However, the natural processes are unreliable and can't always provide the optimum setting for the success of meadow restorations. The key to long-term meadow maintenance is to balance herbaceous grasses and woody species. If trees and woody shrubs increase, selective removal will be required to maintain the meadow's function and aesthetic. Some unwanted species can be controlled using a heavy-duty mower or hand-held brush saw. (Delaney 2004).

Restoration Management of a Floodplain Meadow and Its Cost-Effectiveness—the Results of a 6-Year Experiment (Liira 2009) is an experimental research project conducted in Estonia's Sooma National Park that demonstrates the results of species richness under five different management strategies: mowing, mulching, traditional, burning, and unmanaged.

The Xerces Society report, *Establishing Pollinator Meadows From Seed* (2013) provides information on herbaceous pollinating meadows including an establishment and maintenance plan. The maintenance plan identifies different strategies to prevent weed invasion, such as the application of herbicides or a specific mowing regime. It also looks at suppressing woody growth and the appropriate course of action to implement at the 2-3 year stage after installation.

Costs

The 2012 report, *An Economic Analysis of Sierra Meadow Restoration* (by Ecosystems Economics for the Environmental Defense Fund under the National Fish and Wildlife Foundation's Sierra Meadows Initiative) featured a table of costs for pond and plug meadow restoration projects between 1995 and 2008 in Plumas County, California. (see Appendix E or the original document, pages 27-28 (Aylward 2012)).

According to the report, the costs of restoration for pond and plug projects are for excavating the ponds and replacing the material in plugs. The length of the incised channel restores is a fairly obvious candidate variable or predicting restoration costs. The cost variations are likely due to the depth of the channel. In the Plumas County dataset, only groundwater rise is provided and the source of this information is not explained; nor does it prove to be a significant predictor of cost. The channel width is not provided in the dataset. But the amount of acreage restored appears to be a useful explanatory variable. This may result from a relationship between the size of the meadow, the amount of stream flow, and the channel's cross-section (Aylward 2012).

The cost of meadow restoration is difficult to research, probably due to significant variations in site preparation and size, and installation methods. However, Larry Weaner Landscape Associates, experts in meadow installation, did provide a cost estimate for a wildflower meadow, ranging between $3,000 and $10,000 per acre, depending on preparation requirements (Garmey 2008).

Case Studies

Anacostia Riparian Meadow Restoration

Northwest Branch of the Anacostia River, downstream from the 38th Avenue Bridge, Hyattsville, Maryland

Project Goals

A. The primary research goals were:
    1. To introduce soft-stemmed, native, herbaceous vegetation to the site and see if it had the effect of reducing channel roughness (the vegetation should lie flat during a flood, softening the impact of the angular riprap on flowing water) thus improving channel conductivity
    2. To monitor the impact of three vegetation management regimens on plant community composition
    3. To determine if the different management regimens would impact the soils at the site (for example accretion or erosion)
    4. To determine if changes in plant community composition resulted in an increased use by native pollinators and native birds

After reviewing the research phase, new objectives were created.

1. Remove 100 percent of the woody plants growing on the streambanks in all the areas currently subjected to the mowing-and-spraying vegetation management regime. This applies to all the plants containing woody tissues regardless if they are native or non-native and includes shrubs, vines, woody herbaceous plants (not true woody plants), and trees. This is a channel maintenance requirement set by the Army Corps of Engineers.
2. Stop the extensive use of herbicide to control the vegetation along the stream banks, and gradually reduce it by using a targeted herbicide application regime until an herbaceous plant community with a dominant cover of native species is successfully established at restored sites.
3. Replace the mowing-and-spraying vegetation management regime used along the stream banks with an open-land habitat restoration management approach that encourages the establishment of a diverse herbaceous native plant vegetation cover, which supports more wildlife.
4. Reduce the populations of non-native highly invasive plant species at the restored sites to increase the area of habitat available for native plant species.

The Anacostia Riparian Meadow Restoration project was initiated by the Anacostia Watershed Society in 2007. Riparian meadows of native species can create essential habitat for native wildlife, including birds and insects. AWS took on this experimental project in conjunction with outside interdisciplinary professionals to research and discover alternative methods of riparian buffer restoration. The key areas were along floodways where reforestation is not permitted due to constraints regarding the engineering of stream channels.

The project's central focus was to demonstrate how native herbaceous plant species specific to riparian meadow habitats can be established without interfering or conflicting with floodway management strategies. The created meadow can provide an improved habitat for urban wildlife and enhance the aesthetic value of the Anacostia Tributary Trail System ("Anacostia Riparian Meadow Restoration" 2015).

Today, the Planted Plot has close to twice the plant species diversity of the Control Plot, based on the larger number of native species observed within the plot. The Planted Plot contains 23 naturally occurring native species. It is reasonable to credit greater presence of naturally occurring native species to the management of invasive species, which allows more space and other resources for native plants. The diversity advantage of the Planted Plot was enhanced by the survival of 20 of the planted native species. Both individual native plants (35 percent) and patches of native plants (55 percent) thrived in the Planted Plot in comparison to the others. Overall, the difference appears to be from the control of invasive species.

Managed Meadows and Grassland Habitats

City of Alexandria, Virginia

The natural resource management staff at Alexandria's Department of Recreation, Parks & Cultural Activities focus on the preservation and management of the city's natural ecosystem and biodiversity. In 2010 they chose to expand their existing Managed Meadows and No-Mow Areas Program (Simmons and Walsh 2012).

In expanding the program, Alexandria amended its mowing regimen at specific sites, moving from a consistent schedule throughout the growing season to annual or infrequent mowing, determined by the natural resource management staff. One of the program's integral elements was to regularly monitor for invasive exotic species and to take control measures if deemed necessary. The results have demonstrated that both infrequent mowing and regular monitoring is sufficient in maintaining the meadows in a healthy state.

Examples of both natural and semi-natural open herbaceous/grassy meadows include:

- Low-lying, seasonally-flooded wet meadows along the Potomac River, such as at Daingerfield Island, Hooff's Run, and along the George Washington Memorial Parkway
- Wet meadows and glades along open stream banks; woodland edges and glades, including sandy-gravelly barrens; artificially maintained open areas along railroad tracks
- Open grassy areas along roadways and highways and areas of formerly maintained turf grass where mowing was gradually reduced to a low-maintenance level, allowing the re-emergence of native species

Alexandria now has 8 allocated meadow and "no-mow" sites that are formerly managed.

1. The former Virginia Native Plant Society, Potomac Chapter, native wildflower site on the south bank of Four Mile Run near U.S. Route 1
2. Eastern end of Mt. Jefferson Park and W&OD Greenway, Upland Park
3. Telegraph & Duke Meadow, two adjoining areas at the interchange of Telegraph Road and Duke Street
4. Beatley Library Meadow
5. Woodland glade at Timber Brach Park

6. Extensive grassy areas and swales at Fort Ward Park
7. Hammond School Meadow

For more case study examples see:

1. Flowering phenology in subalpine meadows: does climate variation influence community co-flowering patterns? (Forrest, Inouye and Thomson 2010)

2. Restoration Management of a Floodplain Meadow and Its Cost Effectiveness—the Results of a 6-Year Experiment (Liira 2009).

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Appendices

Appendix A

Recommended Wet Meadow Species

Common Name	Botanical Name
Cardinal Flower	*Lobelia cardinalis*
Cinnamon fern	*Osmunda cinnamomea*
Eastern gamagrass	*Tripsacum dactyloides*
Great blue lobelia	*Lobelia siphilitica*
Green-headed coneflower	*Rudbeckia laciniata*
Joe Pyeweed	*Eupatorium dubium*
Monkey flower	*Mimulus ringens*
Rough goldenrod	*Solidago rugosa*
Sensitive fern	*Onoclea sensibilis*
Common (soft) rush	*Juncus effusus*
Switchgrass	*Panicum virgatum*
Tall Meadow rue	*Thalictrum pubescens*
Turk’s cap lily	*Lilium superbum*
Tussock sedge	*Carex stricta*
White turtlehead	*Chelone glabra*

(Wixted 2016)

Appendix B

Recommended Dry Meadow Species

Common Name	Botanical Name
Beard tongue	*Penstemon digitalis*
Bee balm	*Monarda didyma*
Big bluestem	*Andropogon gerardii*
Black-eyed susan	*Rudbeckia hirta*
Blazingstar	*Liatris spicata*
Common milkweed	*Asclepias syriaca*
Butterflyweed	*Asclepias tuberosa*
Evening primrose	*Oenothera biennis*
Indian grass	*Sorghastrum nutans*
Little bluestem	*Schizachyrium scoparium*
New England aster	*Aster novae-angliae*
New York ironweed	*Vernonia noveboracensis*
Partridge pea	*Chamaecrista fasciculata*
Purple coneflower	*Echinacea purpurea*
Purpletop	*Tridens flavus*
Roundhead bush clover	*Lespedeza capitata*
Spotted beebalm	*Monarda punctata*
Sunflowers	*Helianthus annuus*
Virginia wild rye	*Elymus virginicus*

(Wixted 2016)

Appendix C
Raymond Ratliff: Common Wet Meadow Genera Found in California

- Agrostis
- Carex
- Danthonia
- Juncus
- Salix,
- Scirpus

Grass and grasslike species include:

- Thingrass
- Abruptbeak sedge
- Beaked sedge
- Nebraska sedge
- Tufted hairgrass
- Needle spikerush
- Few-flowered spikerush
- Common spikerush
- Baltic rush
- Pullup muhly
- Panicled bulrush

Important forbs include:

- Anderson aster
- Small white violet
- Jeffrey shootingstar
- Trailing Saint-Johnswort
- Hairy pepperwort
- Primrose monkeyflower
- Western cowbane
- Cows clover
- American bistort

Appendix D

Maryland Seeding Association

The Maryland Seeding Association was created in 1986 to protect the right of seeding contractors who require the use of water from public hydrants for seeding projects. Following the establishment of MSA, the organization joined the Maryland Turfgrass Council. Since its beginning, MSA has become the leading advocate for seeding contractors throughout Maryland. Members of the Maryland Seeding Association include seeding contractors, lawn care and grounds maintenance professionals, landscapers, sports turf managers, sod producers, seed and equipment suppliers, and researchers at University of Maryland and the Maryland Department of Agriculture.

The association is committed to evolving and improving the methods and technology for seeding in Maryland. MSA does this through uniting vendors, contractors, and researchers. With the intention of promoting quality standards and practices of seeding throughout Maryland, the association published *MSA Guideline Specifications 2005*. The document assists contractors, architects, designers, and others who require contracts or specifications for landscape seeding projects ("About MSA And Membership Application" 2005).

The *MSA Guideline Specifications 2005* include detailed specifications for various seeding project including:

- Turfgrass seeding
- Temporary seeding
- Erosion control seeding
- Meadow seeding and highway seeding.

There are three key sections in the guideline specifications that refer specifically to seeding meadows. These sections discuss the process of seeding, beginning with soil testing to the establishment phase for flower meadows, wet meadows, and dry meadows.

Flower Meadow Seeding

Section 10: Flower Meadow Seeding (pages 59-69) outlines and specifies necessary steps to provide the optimum chance for the success of establishing a flowering meadow through seeding. Section 10 applies to the seeding of ornamental flowering meadows for permanent low maintenance groundcover. The seed mixes specified for flower meadow seeding include species native to North America as well as exotic introduced species.

Wet Meadow Seeding

Section 11: Wet Meadow Seeding (pages 70-76) applies to the seeding of low-lying sites with wet or damp soils most of the year. Guidelines are to establish permanent low-maintenance native vegetation for lowland habitat restoration. The seed mix selected for wet meadow seeding consists entirely of native herbaceous broadleaf and grassy species that are compatible with permanent wet meadows.

Dry Meadow Seeding

Section 12: Dry Meadow Seeding (pages 77-86) applies to the seeding of native grasses, with or without native wildflowers, to establish permanent low-maintenance vegetation for upland habitat restoration.

Appendix E

Cost of Plumas County Pond and Plug Projects (1995–2008)

Table 1. GLM test results about responses of plant traits on plot-ID, elevation, treatment and yearly changes (left-hand-side half of the table). In case of significant interaction term Year × Treatment or Year, the slope estimates for significant successional effects are provided (right-hand-side half of the table). Detailed information about slopes by treatment is provided only in the case of significant interaction term Year × Treatment in the model. Parameter significance labels: ns = non-significant, $*P < 0.05$, $**P < 0.01$, $***P < 0.001$.

	Factor's test *P* value						The estimated slope of regression					
Trait	Plot	Year × Plot	Elevation (log)	Treatment	Year	Year × Treatment	Pooled trend	Mulching	Mowing	Trad. man.	Burned	Unman. control
Veg. Height												
Vegetation height (log)	0.002	0.002	0.005	0.004	0.009	0.004		−0.010*	−0.010*	−0.010*	−0.010*	−0.010*
Pot. height of plants	0.092	0.098	0.923	0.003	0.009	0.003		−0.183*	−0.298**	−0.483***	−0.050ns	0.065ns
Growth form												
Grass%	0.097	0.100	0.872	0.040	< 0.001	0.040		−1.017***	−0.959***	−1.455***	−1.135***	−1.239***
Sedge%	0.082	0.082	0.489	0.706	< 0.001	0.701	1.486***					
Forb & Legume%	0.019	0.019	0.220	0.078	< 0.001	0.077	−0.689***					
Leaf types												
Long-leaved%	0.002	0.002	0.001	0.658	< 0.001	0.655	−2.201***					
Winter-green%	0.334	0.340	0.036	0.011	0.001	0.011		−1.376***	−0.212ns	0.809ns	−0.521ns	−1.457**
Rosette%	0.315	0.331	< 0.001	0.022	< 0.001	0.023		0.221*	0.412**	0.525***	0.239*	0.067ns
Erosulate%	0.162	0.156	0.043	0.067	< 0.001	0.066	0.756***					
Vegetative spread												
Clonal plant%	< 0.001	< 0.001	0.003	0.024	< 0.001	0.024		−0.048ns	0.133ns	0.676**	0.019ns	0.343*
Phalanx%	0.843	0.839	0.434	0.851	< 0.001	0.858	−1.032***					
Guerilla%	0.031	0.031	0.661	0.970	< 0.001	0.970	0.375***					
Vegetative spread — Above	0.455	0.449	0.606	0.022	0.396	0.022		0.044ns	0.098ns	0.280ns	−1.158**	−1.069*
Vegetative spread — Below	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001		1.737***	1.670***	1.861***	3.381***	1.615***
Strategies												
Mowing tolerance	0.001	0.001	0.749	0.003	0.057	0.003		0.004ns	0.000ns	0.006*	−0.007*	−0.013**
Grazing tolerance	0.029	0.028	0.028	0.079	< 0.001	0.077	−0.026***					
Trampling tolerance	0.001	0.001	0.035	0.014	< 0.001	0.014		−0.045***	−0.054***	−0.053***	−0.040***	−0.048***
C-stategy	< 0.001	< 0.001	0.108	< 0.001	< 0.001	< 0.001		0.001ns	−0.001ns	−0.005***	0.003***	0.003***
R-stategy	< 0.001	< 0.001	0.000	0.041	< 0.001	0.041		−0.002ns	−0.001ns	< 0.001ns	−0.004**	< 0.001ns
S-stategy	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		−0.001*	< −0.001ns	0.003***	−0.003***	−0.003***
Pollination type												
Insect pollinated%	0.066	0.067	< 0.001	0.401	< 0.001	0.398	1.887***					
Ecological plasticity												
# floristic zones	0.325	0.321	0.956	0.410	0.001	0.408	−0.004***					
# hemeroby levels	0.196	0.193	0.065	0.084	0.217	0.084						

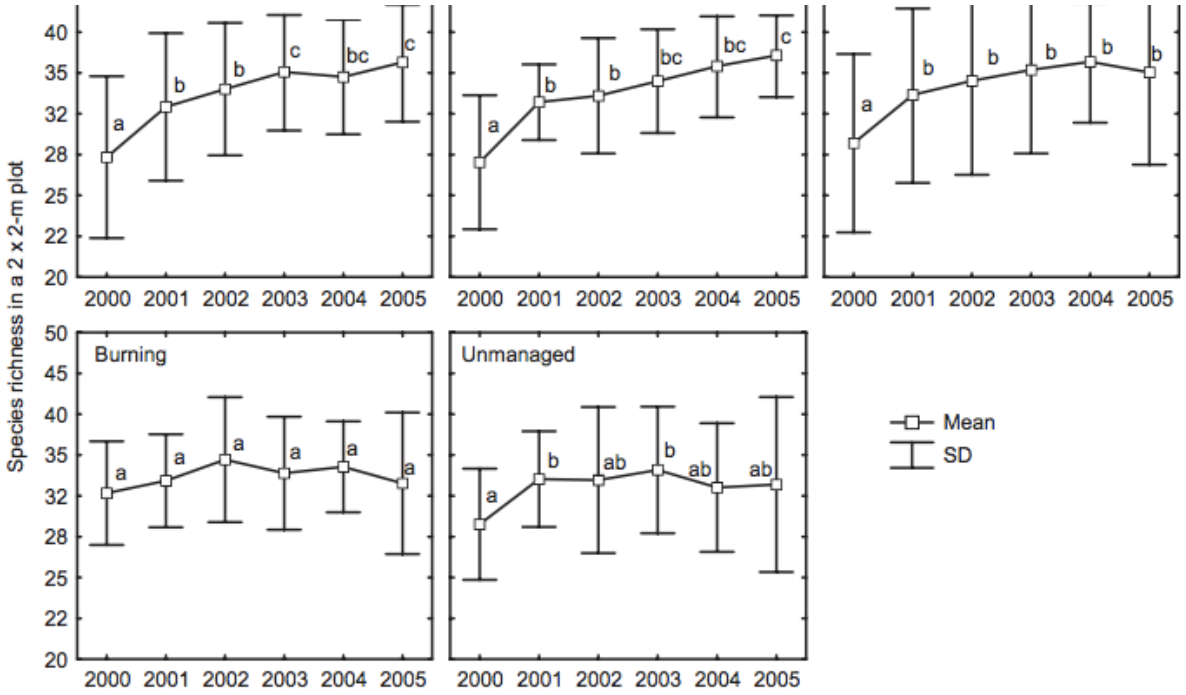

Fig. 2. Average species richness in 12 study plots (2 × 2 m) of the five different management treatments in Kuusekäära flooded meadow. Letters denote homogeneity classes within treatment according to the result of the Tukey multiple comparison test. The vertical axis is log-scaled.

Year	Project Name	Channel Length (miles)	Acres Restored	Ground-water Rise (ft)	Cost
1995	Big Flat	0.78	47	3	$9,000
1996	Bagley Creek II	0.26	10	9	$220,000
1999	Ward Creek	0.76	165	10	$213,000
2001	Clarks Creek	0.81	56	4	$170,000
2001	Stone Dairy	0.43	20	3	$250,000
2001	Carmen Creek (Knuthson Meadow)	1.5	200	5	$30,000
2002	Hosselkus Creek	0.28	25	7	$133,000
2002	Uppler Last Chance (Matley Ranch)	1.6	300	3	$5,500
2002	Elizabethtown/Hwy 70	0.06	5	6	$650,000
2002	Carmen Creek (Three-Cornered Meadow)	1	45	5	$130,000
2002	Greenhorn Creek - New England	0.13	10	4	$201,000
2003	Last Chance – PNF	4.1	800	2	$55,000
2003	Poplar Creek	0.15	15	4	$55,000
2004	Humbug-Charles	0.44	60	7	$64,000
2004	Last Chance – Charles	0.38	80	4	$110,000
2005	Dooley Creek/Downing Meadow	1	80	10	$1,300,000
2005	Jordan Flat Supplemental	0.34	50	5	$170,720
2006	Humbug-Charles II	0.4	5	7	$61,000
2006	Hosselkus Creek II	0.45	35	5	$139,000
2006	Red Clover/McReynolds Creek	4.2	375	7	$173,000
2007	Rapp-Guidici	0.4	13	7	$189,000
2007	Dixie Creek	0.38	12	3	$9,000
2007	Last Chance-Ferris Fields	0.85	85	9	$220,000
2008	Smith Creek	0.76	30	4	$90,000
	Average	0.89	105	5.58	$188,000
	Standard Deviation	1.08	175	2.2	$270,000
	Median	0.45	46	5	$132,000