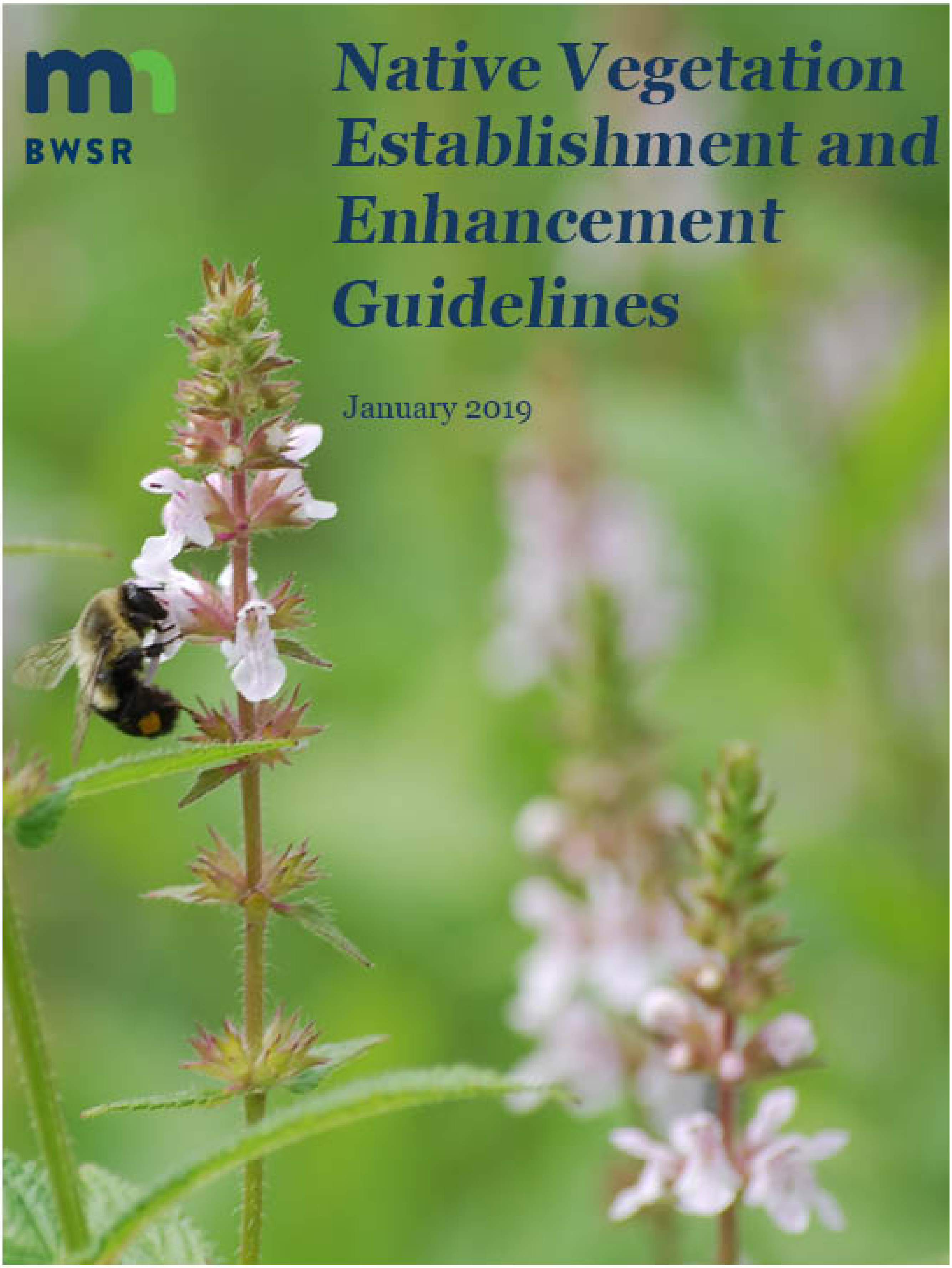
BWSR

Native Vegetation Establishment and Enhancement Guidelines

January 2019



Contents

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Purposes: Native plants and plant communities play an essential role in sustaining environmental and human health, providing wildlife habitat, and adding resiliency to our landscapes. The purpose of these guidelines is to assist resource professionals and landowners across Minnesota in meeting state vegetation policies and standards and to guide the successful planting and management of restoration and other conservation projects. The guidelines are also designed to develop consistency among state programs; to avoid the use of invasive species; and to ensure that plantings function at a high level and meet project goals. The guidelines will be updated periodically, as new research and field experience becomes available.

Contents: As listed below, the structure of the guidelines include an introduction summarizing their purpose, applicability and use; general considerations for the use of native vegetation; and specific guidance for a variety of project types.

Applicability and Native Species Requirements

Requirements: These guidelines apply to all BWSR programs that have vegetation restoration components, as well as other state programs that have adopted the guidelines. These guidelines replace BWSR's Invasive Non-Native Species Policy (Sept. 8, 2004). Environmentally suitable native annual, biennial and perennial plant species (following the source selection criteria included in the Guidelines) are required for projects to meet legislative requirements and provide multiple landscape benefits. See pages 7 and 8 for the seed and plant source sequence that must be followed for all BWSR-funded projects.

Flexibility: For BWSR funded projects, non-native species may be approved by BWSR's Vegetation Specialist/Ecologist, Board Conservationists, RIM Technical Staff, Wetland Specialists, or Clean Water Specialists in cases where the species will provide increased ecological function, and not pose a risk to natural plant communities (an example would be urban stormwater plantings such as green roofs and tree trenches).

For BWSR funded projects, local conservation professionals can also make decisions about the use of non-native temporary covers/cover crops for soil health and soil stabilization, as well as for grass waterways, and projects to meet Minnesota's Buffer Law (riparian buffers and alternative practices when applicable program requirements allow) that will be hayed, grazed, and/or exposed to pesticides (see buffer width requirements and other details on page 42 of these guidelines). BWSR should be consulted for project-specific guidance, as needed.

Contact Information: Specific questions about these Guidelines can be directed to Dan Shaw, BWSR Vegetation Specialist/Senior Ecologist,
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Bottle gentian in a wet meadow plant community

General Considerations

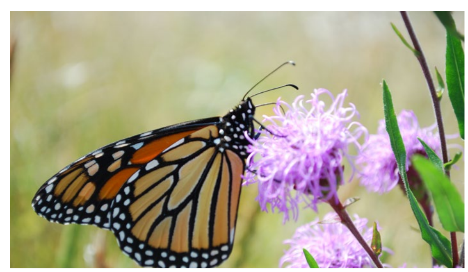
Benefits of Native Vegetation

Native annual, biennial, and perennial plants and the plant communities that they support provide a wide range of ecological and human services. The following information is a summary of key benefits of native vegetation.

Vegetation providing water quality and wildlife habitat benefits

1) **Environmental Quality Benefits:**
   - Removal of nutrients and pollutants, providing protection for water resources
   - Carbon sequestration by drawing carbon into root systems and soil
   - Increased water infiltration and groundwater recharge through the creation of deep root channels
   - Water interception and filtration by leaves, stems and roots
   - Slope stability provided by extensive root systems
   - Prevention of soil erosion and sedimentation caused by water and wind
   - Soil heath promoted by stabilizing soils, adding organic content through root decomposition, and by supporting healthy microorganism populations
   - Evapotranspiration (releasing excess stormwater through leaves)
   - Cooling and temperature moderation of soil and water
   - Flood attenuation by slowing flood waters
   - Healthy nutrient cycling and food chain support
   - Preservation of biodiversity
2) **Wildlife Habitat Benefits:**
   - Pollinator habitat and food sources, supporting hummingbirds, bees, moths, butterflies, and other insects
   - Host plants for a wide variety of insects
   - Food sources for insects and other animals
   - Source of fruit and seed used by insects, birds, and other animals
   - Shelter and nesting habitat for birds and other animals
   - Aquatic habitat for insects, fish, birds and other animals
3) **Landscape Resiliency Benefits**
   - Suitability to local conditions
   - Providing connectivity between essential habitat
   - Ability to adapt through genetic adaptation, succession and natural colonization
   - Providing competition for invasive species
4) **Other Human Services**
   - Regional character and identity
   - Urban cooling from tree and shrub canopies
   - Landscape aesthetics
   - Human health benefits from healthy ecosystems
   - Low maintenance once established
   - Educational opportunities

Raingarden designed to infiltrate and filter stormwater



Monarch butterfly on meadow blazing star

Shorebirds using a restored wetland

Strategies for Restoring Resilient, Functional Landscapes and Maintaining Ecological Diversity

The following information summarizes strategies for restoring landscapes to be more resilient to climate change and other stressors, provide important landscape functions and services and maintain ecological diversity. These strategies are integrated from the disciplines of conservation, ecological restoration, landscape ecology, and sustainable farming and are key methods for developing landscapes that are resilient to changing land use practices and extreme weather conditions.

1) ***Strategic Site Selection*** - Work with project partners to identify the functions that are most beneficial for an individual landscape and where projects should be located to best provide those functions. In many cases, this involves restoring habitat complexes or buffering key water resources or plant communities to restore natural processes, nutrient cycling and plant and animal populations. Site projects in locations where ecological stressors such as un-natural water fluctuations, decreasing water tables, or invasive species will not significantly inhibit key functions into the future. See the Nature Conservancy's Resilient and Connect Landscapes tool as a resource.

2) ***Designing for Multiple Functions*** - Be strategic in the selection of primary and secondary goals but remember that multiple functions including wildlife habitat, plant diversity, food production, stormwater treatment, soil quality, carbon sequestration, and nutrient cycling can often be accomplished together.

3) ***Making Landscape Connections*** - Establish strong connections through landscapes. Create habitat and genetic dispersal corridors and decrease landscape fragmentation. Or, create a network of conservation practices in agricultural areas. Linking small parts plays a key role in restoring landscape resiliency and providing refugia for pollinators and other at-risk species.

4) ***Matching Plant Communities to the Site*** - Match your targeted vegetation to the native plant community that best fits the topography, soils, hydrology, and climate conditions (including the potential future climate) of your site. Restore natural hydrologic regimes to aquatic and wetland systems as applicable. Historic plant community information can be used as a guide for decision making. Determine the kinds of native wildlife that live in the area or migrate through, and include native plants natural to the site that will provide food and shelter for target species.

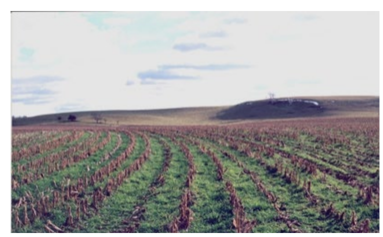
5) ***Restoring and Maintaining Diversity*** - Plant diversity (and structural diversity of plant communities) supports wildlife species and increases resiliency by helping plant communities and agricultural systems to continue functioning as intact systems during climate variation and other disturbances. Filling niches with native species also prevents the establishment of invasive species. Restoring natural disturbances such as prescribed fire, grazing and water fluctuations plays a key role in maintaining diversity. In addition to plant species diversity, protect genetic diversity of individual plant species by using site appropriate sources that can adapt to future conditions.

6) ***Working with Ecological Adaptation*** - Natural plant communities have the ability to adapt. They develop a natural dynamic through genetic adaptation, succession and natural colonization. Incorporate these processes into projects to complement restoration efforts, provide desired ecological functions, and buffer the community during future changes in climate and associated disturbance. Assisted migration may be needed in some ecosystems to help maintain plant community integrity.

7) ***Providing Habitat for Pollinators and other Beneficial Insects*** - Pollinators and other insects play an essential role in supporting ecosystems by pollinating around 70% of flowering plants and providing food sources for a wide range of wildlife species. Support insect populations by minimizing pesticide use, buffering natural areas and diverse plantings from pesticide exposure, restoring habitat complexes and wide natural corridors, increasing plant diversity, managing invasive plants, providing nesting sites and shelter, and restoring clean water sources.

8) ***Effective Water Management, Treatment and Use*** - A variety of practices including perennial crops, conservation tillage, conservation drainage, cover crops, buffer strips, infiltration basins, raingardens and wetland restoration help manage water resources. Incorporate these practices in urban and rural landscapes to reduce runoff, erosion and sedimentation, recharge groundwater, maintain agricultural productivity, improve water quality, and reduce flooding. Promote the wise use of water resources and the use of catchment systems to help ensure adequate supplies into the future.

9) ***Preserving and Restoring Soil Health*** - Soils that have good soil structure, organic content and microorganism populations translate into healthy and productive ecological and cultural landscapes and play a key role in sequestering carbon. Soil health can be restored through planting cover crops, no-till farming, and establishing perennial vegetation.



NRCS

10) ***Managing Invasive Species Across Boundaries*** - Invasive species are effective at dispersal, giving them an advantage in adapting to climate change. Plan to work in partnerships, prioritize species and manage invasive plants across ownership boundaries to restore resilient landscapes.

11) ***Practicing Adaptive Management*** - Adjust management practices based on monitoring efforts and experience with successes and failures to improve the long-term effectiveness of management practices and resiliency of plant communities. Practices such as prescribed burning, water level management and prescribed grazing may replicate natural disturbances and promote diversity and resiliency.

12) ***Learning from Project Experience*** - Information about project successes and innovative practices is valuable. What practices provide the most benefits in our landscapes? What common activities are not worth the cost, or make a problem worse? BWSR's "What's Working" web page collects and shares practitioner experience about real-world outcomes.

Species Diversity

In most cases, high species diversity is recommended for projects to increase ecological function. Many studies (Knops et al 1999, Tilman, 1997, 1999, Biondini 2007, Piper 1996) have shown benefits from having high diversity, including resistance to invasive species, rapid establishment, improved plant community structure, increased biomass, decreased spread of fungal diseases, and increased richness and structure of insect populations.

There are many considerations when determining target diversity levels for a project, including target plant communities, site conditions, functional goals, and budget. As a general rule, natural regeneration, including establishment from the seedbank, should be maximized at restoration sites to promote local plant establishment, and contribute to diversity levels.

There are certain situations (particularly in urban areas) where projects may be planted in phases with lower diversity planted initially to aid weed control and more diversity added in subsequent years. There have been many efforts in Minnesota to increase diversity levels in existing projects. BWSR has developed inter-seeding guidelines for grasslands to provide information about techniques that can be used to increase diversity levels (www.bwsr.state.mn.us/native_vegetation).

The following table is a general guide to native diversity levels for a range of project conditions and functional goals. Target diversity levels for a particular project also depend on the size of the site, its natural regeneration potential, and the type of plant community being restored. A smaller number of species may be appropriate for smaller lakeshore projects, raingardens, and other projects less than half an acre in size to create a sense of order and simplify maintenance. It is important that species abundance is also considered along with the number of species present, to ensure that individual species provide sufficient cover to meet vegetation goals. In some cases, high diversity pollinator plots/zones of a few acres in size may be planted in restoration sites to provide enhanced habitat for pollinators.

Minimum Recommended Number of Species

Current Site Conditions \ Project Function/Goals	Soil Stabilization	Water Quality	Grassland Bird Nesting	Habitat for Multiple Wildlife Groups	Native Plant Community Restoration (marsh and sedge meadow)	Native Plant Community Restoration (prairie, savanna, forest)
Natural Areas with High Species Diversity	15	20	30	30	30	40
Some Intact Ecological Characteristics	10	20	25	25	25	35
Agricultural Field Conversion	10	15	15	20	20	25
Disturbed Site (Urban Soils, Compaction etc.)	5	10	15	20	20	25
Disturbed Site with High Invasive Species Risk	5	5	15	20	20	20

Seed and Plant Source

There has been a transition in Minnesota over the last few decades from the use of non-native species for conservation projects to "native" species. Much of the discussion about appropriate seed and plant sources is now focused on "how close is close enough" for native plants. The following discussion is intended to give resource professionals an overview of source considerations for native plants.

Methods and distances of seed and pollen dispersal vary significantly among species. For example, seed of some wetland species may be distributed widely by waterfowl or flowing water, while seed from some forest and prairie species that is spread by insects or falling seed may be dispersed relatively short distances. Available research (Appendix D) suggests that some species that have seed (or pollen) that is not dispersed widely by wind, water, animals or other factors could be negatively impacted if seed of that species is introduced from far distances (Keller et al. 2000, Edmonds & Timmerman 2003, Hufford & Mazer 2003, Heiser & Shaw 2006). Unfortunately, information is available for only a small percent of species used in restoration, so more research is needed on this topic.

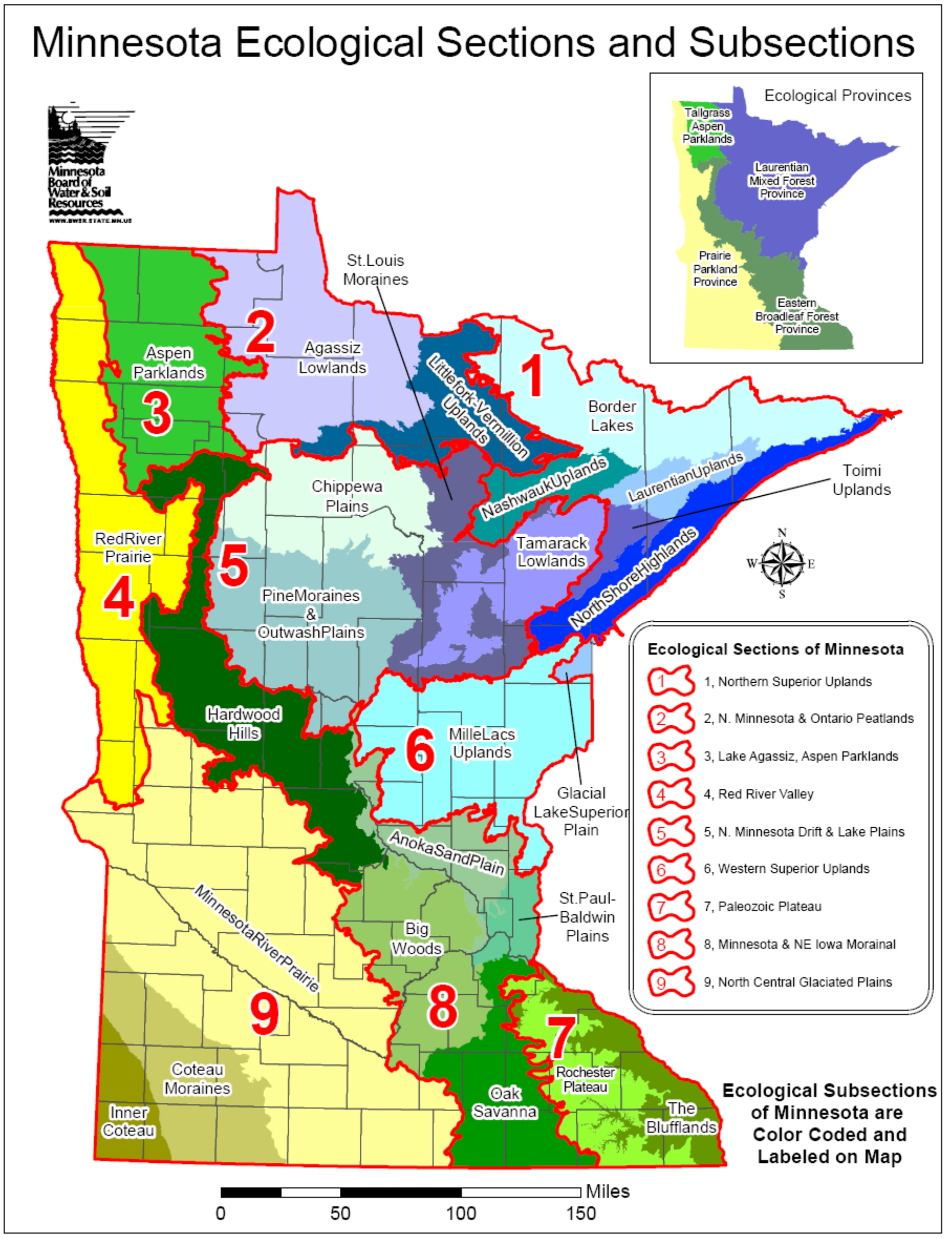
The following are some **primary concerns regarding origin distance** for seed and plants, they include:

1) Whether plants will produce viable seed, particularly if they are brought to areas with significantly different climatic conditions
2) Whether populations adapted to local site conditions will be affected by the introduction of new genes or genotypes, causing local populations to be "swamped" by non-local sources that are not locally adapted, decreasing the long-term fitness of the population.
3) Whether plants introduced from a different region will become aggressive and compete with other species.

There are also cases where isolated populations of species can benefit from the introduction of new genetic material (such as populations with inbreeding depression). This is most often a concern for small, isolated remnant plant communities. Unfortunately, we still need more information about what species used in restoration are most at risk from inbreeding depression. If this is a concern for a species, it is most common that seed is introduced from populations within the same ecological subsection to improve the plants' vigor, and to act as genetic stepping stones to link the isolated population to a wider genetic diversity.

As a general rule, it is recommended that seed and plants be selected that match site conditions (soils, hydrology, precipitation, elevation, drainage, aspect, sun/shade and climate) and to have original harvest locations (original remnant populations, sometimes defined as seed "provenance") from as close to the project site as possible to protect local ecotypes from genetic contamination. It may also be beneficial to collect seed from multiple sites to promote genetic variation, particularly for disturbed sites. Collection sites to the south of projects should be utilized when possible due to climate change concerns (see "Climate Change Considerations" on page 19.) The map and selection sequence on the following page is recommended when obtaining seed for restoring native plant communities. The first step in the sequence recommends looking for seed in areas with **similar site conditions, and from areas located as close to the project site as possible** (including native seedbank and site collected seed); followed by seeking seed from **Ecological Subsections** (areas of similar ecological condition); then by looking in **Ecological Sections** (including extensions of Minnesota ecological sections into adjoining states); followed by seeking seed within **increasing distances from the project site, with 175 miles as the maximum recommended distance** (including seed and plants from an adjoining state or province). This maximum distance should only apply to species that have wide seed and pollen dispersal. It is important to work with local resource staff and seed/plant vendors through the process of seed and plant selection, and seek outside advice when needed.

If a project encounters seed or plant availability issues, potential solutions are to use species substitutions or to change the project schedule/sequence to accommodate the availability of appropriate seed or plants.



Recommended sequence for obtaining seed/plants:

A. Areas with similar site conditions, located as close to the project site as possible (including seedbank and site-collected seed)

B. Ecological Sub-sections (colored areas on map)

C. Ecological Sections (red boundaries on map)

D. Working outward from the site with 175 miles as the recommended maximum range. Moving plant material from south of the site is preferred.

Native Variety/Cultivar Use

As stated under "Seed and Plant Source", the first preference is typically for seed and plants that come from similar site conditions, and as close to the project site as possible. Named germplasms/varieties (also called "ecovars") are plants that have multiple harvest locations of varying geographic range, and have been tested for performance across hardiness zones. Examples of these varieties include Red River Germplasm Prairie Cordgrass, Itasca Little Bluestem, and Bad River Blue Grama. These varieties have not been selected for specific traits. They may be appropriate for projects if they meet the origin requirements (based on the recommended sequence). Information about NRCS varieties can be found at the following website: (http://plant-materials.nrcs.usda.gov/ndpmc/pubs/publications_available.pdf). Similar to "ecovars", Iowa Ecotype Project "variants" are species that have pooled genetic sources from across provenance zones (three zones arranged north to south in the state). "Variants" should be considered like "ecovars" when considering seed sources for southern Minnesota.

Water quality projects such as raingardens, biofiltration areas, and filter strips may have unique functional needs where a variety of a native species may be appropriate. Decisions about the use of native varieties can be made by local staff when the variety will increase the function of a project, and will not cause ecological harm due to their landscape setting, or lack of dispersal mechanisms. An example may be an urban raingarden where a variety may increase ecological function or have an aesthetic value that will increase public perception of the project; and the project is not near or connected to a native plant community.

Insecticides and Chemical Carry-over

To protect pollinator populations, any native seed and plants supplied for projects must not be treated (seed coatings or foliar application) with insecticides including but not limited to neonicotinoid insecticides (such as imidacloprid, clothianidin, thiamethoxam, dinotefuran and acetamiprid) that can harm pollinators. Also, to the extent possible, place pollinator habitat enhancement plantings on soils free of persistent pesticides such as insecticides. Systemic insecticides, like neonicotinoids, can persist in the soil and be absorbed by new plantings and transferred to pollinators that forage on them (Hopwood et al. 2012). Use temporary cover crops such as oats or winter wheat in areas where insecticides may be a problem to allow time for the chemicals to break down.

Diverse pollinator plantings ("pollinator plots") should not be located adjacent to agriculture where insecticides will be used as seed treatments or through foliar application. A minimum buffer of 200 feet is recommended. Minnesota pesticide laws and rules define landowner responsibilities to minimize pesticide drift. The Minnesota Department of Agriculture oversees the state's Pesticide Applicator Licensing. NRCS Agronomy Technical Note 9 "Preventing or Mitigating Potential Negative Impacts of Pesticide on Pollinators Using Integrated Pest Management and Other Conservation Practices" as well as a BWSR fact sheet on Protecting Conservation Lands from Pesticides provide detailed information about methods to minimize impacts to pollinators.

Several chemicals being used for weed control along with Glyphosate in Glyphosate resistant crops act as pre-emergents or post-emergents (designed to inhibit germination) and can be a problem for native vegetation establishment from seed. Temporary cover crops planted for one or two seasons can also allow time for these chemicals to break down in the soil if they have been used. Investigate prior chemical use and labels to help define probability of having chemical carryover that could/should be addressed by using temporary cover crops. If in doubt seek consultation from others with applicable experience such staff at University of Minnesota Extension.

Seed Mixes

It is important that seed mixes are selected or designed to meet project goals. The following are some key principles for seed mix design:

1) Determine the target plant communities for a project and develop mixes based on these communities.
2) Add all functional groups ( )into seed mixes that would be found in a natural plant community.
3) Make sure that mixes are an appropriate fit for soils and hydrology conditions.
4) Include early, mid, and late successional species into mixes.
5) Develop seed mixes based on seeds per square foot.
6) Develop diverse seed mixes but ensure that individual species are included at a high enough rate to show up in the planting.
7) Add at least three spring, summer, and fall blooming species in mixes to benefit pollinators.
8) Consider using temporary cover crops prior to seeding that are suppressed before planting instead of high rates of cover crops in mixes as they can compete with native species.
9) Seed specifications should be used for all projects when ordering seed (see sample specification on page 18).

Seed harvested from local remnant populations is often the most desirable source. If seed from remnant populations, or plants grown from the local seed are not available, or if locally harvested seed needs to be supplemented with additional species, custom seed mixes can be developed. For many conservation projects NRCS job sheets with seed calculators that define mix specifications are used to develop mixes. A guide to developing site specific seed mixes has also been developed and is available at: http://www.lrrb.org/PDF/201020.pdf. A focus of the guide is on developing mixes that are appropriate for site conditions and incorporating plant guilds (warm season grasses, cool-season grasses, legumes, asters, etc.) that are important for weed competition and ecological function.

State seed mixes have also been developed for many project types (wetland mitigation, conservation, stormwater projects, etc.) and are available at the following website: (www.bwsr.state.mn.us/native_vegetation). Around forty new "pilot" mixes are also being refined for a wide range of unique conservation practices. The state seed mixes are designed based on seeds per square feet for individual species to help us understand how they will interact with other species in the mix. The mixes contain combinations of early and later successional species, warm and cool season grasses, forbs, sedges and rushes to meet the needs of specific projects/programs. Substitutions/site specific changes or site specific mixes that follow similar design criteria are acceptable for projects if they meet the intended goals of a project/program and are approved by local resource staff. Additional species, such as tree and shrub seed can also be added to mixes. Mixes that are particularly beneficial for pollinator habitat (at least 15 species of forbs and at least 30% forbs by seed count) are noted with a * in the table below.

Summary of State Seed Mixes		
Seed Mixes	**Name/Description**	**Mixes Replaced by New Mixes**
Cover Crop for Restoration and Roadsides		
21-111	Oats Cover Crop	MNDOT110, BWSR UT1
21-112	Winter Wheat Cover Crop	MNDOT 100
21-113	Soil Building Cover Crop	MNDOT 130
Mid-term Stabilization Native		
32-241	Native Construction	BWSR U12, BWSR U11
Stormwater Facilities		
33-261	Stormwater South and West	MNDOT 310, MNDOT 328
33-262	Dry Swale/Pond	BWSR W4
33-361	Stormwater Northeast	BWSR W7
Wetland		
34-171	Wetland Rehabilitation	BWSR WT3
34-181	Emergent Wetland	BWSR W1
34-261	Riparian South and West	BWSR R1
34-262*	Wet Prairie	BWSR W3, MNDOT 325
34-271*	Wet Meadow South & West	BWSR W2
34-361	Riparian Northeast	BWSR R1
34-371	Wet Meadow Northeast	BWSR W2N
Native Grassland		
35-221*	Dry Prairie General	MNDOT 330
35-241*	Mesic Prairie General	MNDOT 350
35-421	Dry Prairie Northeast	BWSSR U2
35-441*	Mesic Prairie Northwest	BWSR U1
35-521	Dry Prairie Southwest	BWSR U4
35-541*	Mesic Prairie Southeast	BWSR U6
35-621	Dry Prairie Southeast	BWSR U6
35-641*	Mesic Prairie Southeast	BWSR U5
Woodland		
36-211*	Woodland Edge South & West	BWSR U7,
36-311*	Woodland Edge Northeast	BWSR U13, BWSR U14
36-411*	Woodland Edge Northwest	
36-711*	Woodland Edge Central	

* Seed mixes that are particularly beneficial for pollinator habitat

*See sample seed specifications on page 16

Yellow Tag Seed

Yellow tag seed has a verifiable source that is certified by the Minnesota Crop Improvement Association (MCIA). Yellow tag seed should be used over non-source identified seed when it is available. See the following website for a survey of yellow tag seed availability: (www.mncia.org/). Flexibility regarding the use of yellow tag seed can be granted by local staff when seed from local remnant communities (generation 0 seed) will be used for a project, or the available yellow tag seed is not of a local source. Yellow tag seed may not be available for tree and shrub species.

Invasive Species

Invasive species are species that are not native to Minnesota and cause economic or environmental harm or harm to human health. BWSR uses the Minnesota DNR "Plant Checklist" (Excel or pdf) for these Native Vegetation Guidelines as well as for administration of the Wetland Conservation Act to list what species are non-native and cannot be planted with BWSR funding or on wetland replacement projects. The lists also designates which plant species are Minnesota designated Noxious Weeds.

The definition of Minnesota Noxious weeds is similar to the definition of invasive species but noxious weeds are associated with the Minnesota Noxious Weed Law. The Minnesota Noxious Weed Law (MN Statutes 18.75-18.91) defines a noxious weed as an annual, biennial, or perennial plant that the Commissioner of Agriculture designates to be injurious to public health, the environment, public roads, crops, livestock or other property. Prohibited noxious weeds must be controlled or eradicated as required in Minnesota Statutes, section 18.78. Additionally, transportation, propagation, or sale of noxious weeds is prohibited except as allowed by Minnesota Statutes, Section 18.82.See the Minnesota Department of Agriculture's Noxious Weed List website for description of categories including prohibited noxious weed: eradicate list, prohibited noxious weed: control list, and specially regulated plant.

In some cases, the list of species on the DNR invasive plant webpage (both terrestrial and aquatic pages) is used to help with decision making about what non-native species (that may be found on DNR "checklist" of native vs. non-native species) should be prioritized for management on conservation projects and wetland replacement projects.

Prevention of Palmer Amaranth and other Noxious Weeds in Conservation Projects

Guidance for Project Managers and Vendors

The introduction of *Palmer Amaranth* and other noxious weeds through seed and seed mixes is a major concern in Minnesota. It is important that MN and federal seed laws are followed for all projects and that other steps are taken to prevent introduction of noxious weeds. The following diagrams summarize stakeholder roles in noxious weed prevention (Diagram 1) and specific steps for prevention of noxious weeds in conservation plantings (Diagram 2). The diagrams are followed by detailed information about methods for addressing *Palmer Amaranth and other noxious weeds in conservation plantings.* The information summarizes the role of project managers, local governments, vendors, landowners and agencies. Figures 1-3 provide examples of a label, seed testing results, and DNA tests all needed to properly label native forb seed mixtures for sale and figure 4 is a seed specification that can be included as part of project bids to address noxious weed issues.


Palmer amaranth

Diagram 1

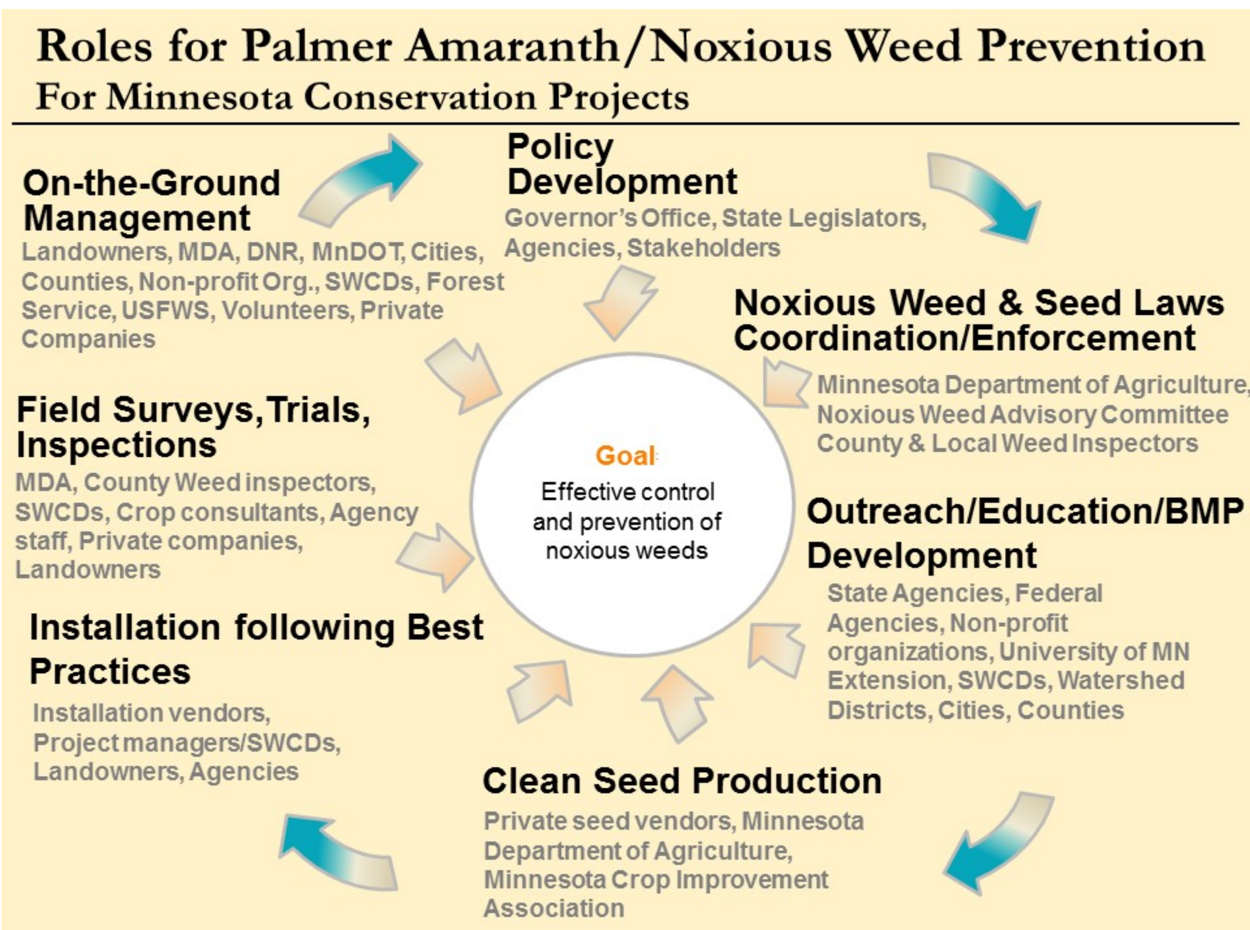
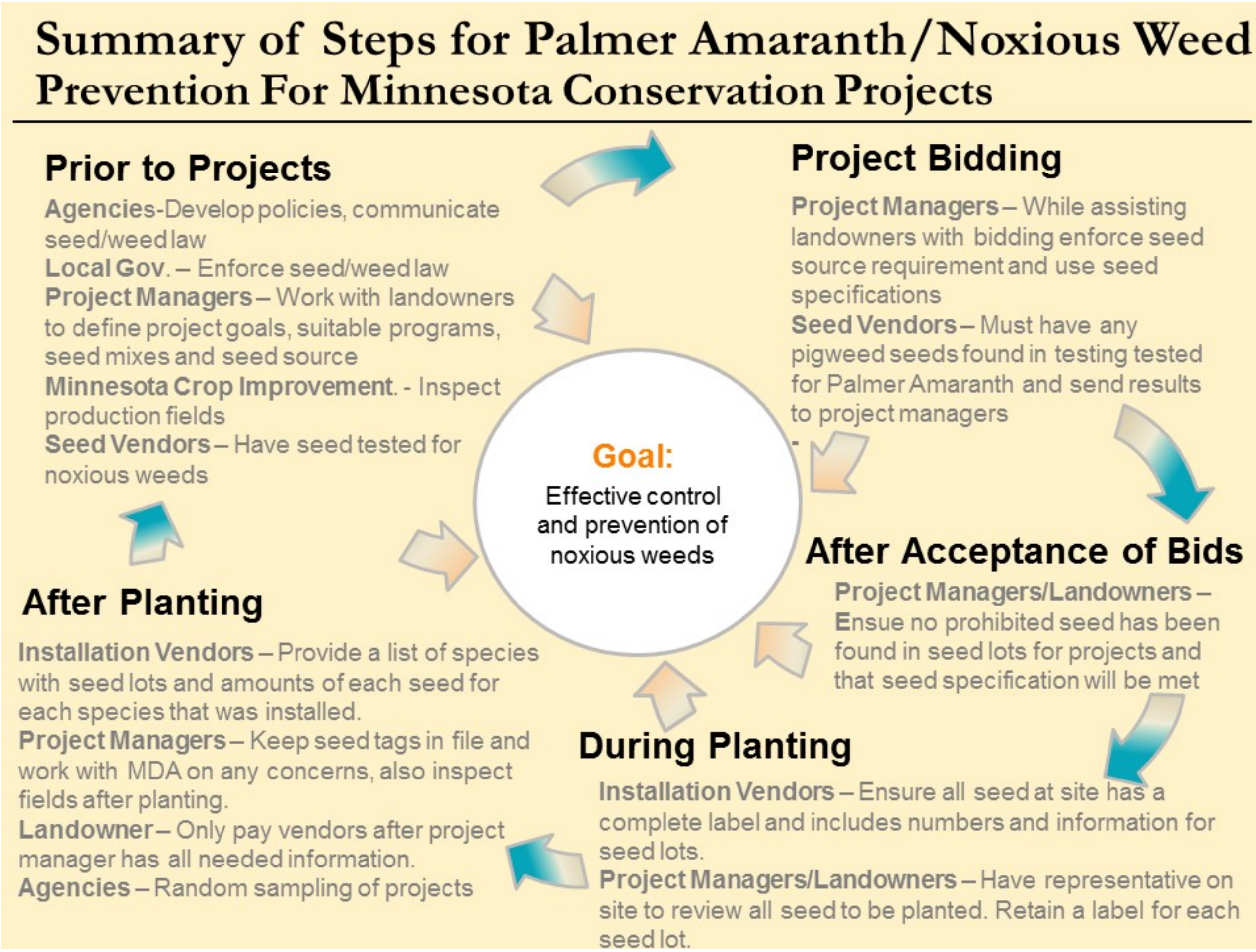


Diagram 2



Methods for Addressing Palmer Amaranth and Other Noxious Weeds

1) Prior to Projects

Agencies: Minnesota Department of Agriculture (MDA) is working with seed vendors to ensure that they know state requirements for meeting state and federal seed law requirements and are taking steps to prevent the introduction of noxious weeds. All vendors with a permit to label seed for sale in Minnesota are listed on the MDA website.

Local Governments: County, city and township officials inspect land and ask owners to control and eradicate noxious weeds that are present in order to keep them from spreading and harming neighboring lands.

Seed Production Vendors: To be in compliance with the state seed law, any seed being sold must be tested for weed seeds including restricted and prohibited noxious weed seeds. Seed that is harvested from the wild must also be tested for noxious weeds and labeled appropriately.

2) Project Bidding

Project Managers: Seed source requirements defined for projects must be followed and seed can only be purchased from vendors that provide the documentation listed in this guidance and meet other seed specifications for the projects. See the seed specifications below (figure 4).

Seed Production Vendors: If Amaranth species were found in the purity or noxious weed seed test, MDA requires that the vendor conduct a genetic test to determine if the Amaranth species are Palmer Amaranth. Genetic test results must be made available to MDA during inspections.

3) After Acceptance of Seed Bids

Project Managers: For acceptance of seed bids, project managers must ensure that vendors can meet all seed specifications.

Project Managers: Soon after the acceptance of a seed bid and any final changes to mixes, it is recommended that project managers have seed vendors provide a preliminary seed label/tag for the proposed seed mix(s). The manager should review the noxious weed seed section of the label (Fig. 1C). If any restricted noxious weed seeds are listed, the manager should confirm that in total there are less than 25 restricted noxious weed seeds per pound of the seed mix. A seed mix that contains any prohibited noxious weed seeds is not legal for sale in the state. If seed testing results are available for review (Fig. 2) the manager should review both the weed seed percentage, common weed seed found, and noxious weed seed sections of the Report of Analysis. Some labs provide a comprehensive list of all weed seeds found in the noxious exam. If Palmer amaranth or any Amaranth species is listed in the noxious weed seed section of the report (Fig.2C), the report should indicate whether genetic testing has been conducted. Most seed mixes are blended after each single species component has been tested, so a project manager may also receive seed testing results for each single component in the mixture. This review step is intended to allow project managers to verify the mix prior to seeding and the seed label/tag can be used to verify that the correct seed has been delivered to the targeted project site.

4) During Planting

Seed Installation Vendors: All seed delivered to sites must have a complete label and mixes must include information for individual seed components and their lot numbers. Installers must allow MDA staff to take seed samples when they arrive for a random planting inspection.

Project Managers: Have a representative on site at planting to review labels and other paperwork for all of the seed to be planted. All seed must be appropriately labeled and mixes must include information for individual seed components and their lot numbers. Reject any seed that does not have a label or does not correspond to the preliminary seed label/tag that was provided after acceptance of the seed bid. If seed substitutions are necessary, all required information must be provided in advance for the project manager's review. Reject any seed that does not have a label, is improperly labeled and/or does not correspond to the preliminary seed label/tag that was provided after acceptance of the seed bid.

Project Managers: Count the number of bags of each seed lot and retain a label for each lot indicating the number of bags at the site on the back of the label. Review the label(s) and contact MDA for a label review if there are any concerns.

5) After Planting

Seed Installation Vendors: Must provide a final list of species (with seed lots) and amounts of seed for each species planted for the project.

Project Managers: Keep the seed tags and a copy of the final list of species planted in the project file. Project managers should work with the MDA if they have any concerns about seed mixes. MDA can assist with taking official seed samples at planting, as needed. MDA also has an official complaint process for cases where there is reason to believe that a violation of state seed law has occurred.

Landowners: Project payments should not be made to seed installers until coordinating project managers feel confident that they have received all of the appropriate seed information for the project. Landowners should periodically inspect fields and report back to the project manager or MDA any observations of excessive weeds or plants of concern.

Project Managers: Project inspections by local staff with plant identification expertise will play an important role as a final assurance that Palmer Amaranth and other noxious weeds are not introduced into plantings.

Agencies: MDA will conduct a noxious weed seed exam on a random sample of native seed mixes collected in each county. They will work with each SWCD to establish a sampling plan for their district that defines a specific number of plantings to be sampled. MDA is also conducting field inspections for Palmer Amaranth and other noxious weeds through grant funding.

Figure 1. Example of a label for a native forb mixture. The lettered sections A, B, and C are related to the Report of Analysis for seed testing in Fig. 2. This seed would not be legal for sale in Minnesota because it contains Palmer Amaranth.

Native Forb Mixture

Lot BPSIMN1802

Kind	Variety	Source Lot	Genetic Origin	Pure Seed%	Germination %	Hard or Dormant%	Total Viable%	PLS%
Partridge Pea	VNS	IA1010	IA	20.71	41	54	95	19.67
Canada Tick Trefoil	VNS	MN2020	MN	20.18	36	61	97	19.57
Wild Bergamot	VNS	MN2021	MN	10.05	78	10	88	8.84
Black-eyed Susan	VNS	MN2023	MN	25.23	85	8	93	23.46
Hoary Vervain	VNS	MN2024	MN	21.78	45	35	80	17.42
Purity	97.95							
Other Crop	1.87							
Weed Seed	0.17							
Inert Matter	0.01							
Noxious Weeds	#/lb							
Giant Foxtail	21 /lb					Best Prairie Seed In Minnesota		
Palmer amaranth	11/lb					100 Prairie Way		
						Green, MN 11111		
Test Date	12/1/2017							

A

B

C

Figure 2. Example of Report of Analysis for seed testing results from a native forb mixture. The purity analysis in section A, the viability analysis in section B, and the noxious weed seed exam in section C, all correspond to the same sections on the seed label in Fig. 1. This report shows a seed lot that is positive for Palmer Amaranth and indicates that genetic testing has been conducted. If this report were for a single species only one pure seed component would be listed on the purity analysis.

Name and Address of Testing Lab

Sample number: 1539087
Date Received 11/2/2017
Report Date: 12/19/2017

Tests Requested: Purity/Noxious All-States, Germination Tests

Sender's Information
Kind: Native Forb Mixture
Varieties: Not Stated
Lot Number: BPSIM1802
Origin: MN, IA
Bag Weight: Not Stated
Size of Lot: Not Stated
Labeler's Name: Best Prairie Seed in Minnesota.
Product Name: Native Forb Mixture
Date Sampled: 10/2/17
Note: the information listed here is that of the send and not the laboratory

Laboratory Test Results

A

Purity analysis

4.488 g analyzed	%Pure Seed
Pure seed components	
Partridge Pea Cassia fasiculata	20.71
Canada Tick Trefoil Desmodium canadense	20.18
Wild Bergamot *Monarda fistulosa*	10.05
Black-eyed Susan *Rudbeckia hirtai*	25.23
Hoary Vervain *Verbena stricta*	21.78
Other Crop Seed	1.87
Inert Matter	0.01
Weed Seed	0.17

B

Viability analysis

%normal	%dormant	%hard	%total viable	Seeds tested	Days tested	Date Completed
41	x	54	95	400	12	12/17/2017
36	x	61	97	400	12	12/17/2017
78	10	x	88	400	10	12/17/2017
85	8	x	93	400	12	12/17/2017
45	35	x	80	400	12	12/17/2017

Comments: Palmer amaranth identification confirmed by PCR testing on single seeds.

Other Crop Seed

Kind:	No. found
Illinois Bundleflower	4
Purple Prairie Clover	2
New England Aster	1

C

All-States Noxious — Noxious weed seeds in 40.47 grams

Kind:	No.found	No./lb
Palmer Amaranth *Amaranthus palmeri*	6	11.1
Giant foxtail Setaria faberii	10	21.2

Inert matter
Broken seed pieces, plant material, soil

Other determinations:
Also found in 40.47 grams: 1 common lamb's quarters, 2 common chickweed

Common Weed Seed
Kind: No. found
Lamb's Quarters *Chenopodium album* - 2

Rules Followed: AOSA

Figure 3. Sample of Palmer Amaranth Test Report

Palmer Amaranth Report

Customer Name: Best Prairie Seed in Minnesota
Address:
Phone:
Date Received:
Date Completed:
Date Reported:

Sample Number	Customer Sample ID	Seed Number	Lot	Number of Seeds Tested	Plate	Well Location	Results Palmer Amaranth
217236321	1539087	1	BPSIM1802	1	A4211	A1	Negative
217236321	1539087	2	BPSIM1802	1	A4211	A2	Negative
217236321	1539087	3	BPSIM1802	1	A4211	A3	Negative
217236321	1539087	4	BPSIM1802	1	A4211	A4	Negative
217236321	1539087	5	BPSIM1802	1	A4211	A5	Negative
217236321	1539087	6	BPSIM1802	1	A4211	A6	Negative

Figure 4. Seed Specifications

Note: The following specifications are included in this bid package to help ensure the quality and success of the restoration or BMP project and to protect the integrity of local plant communities.

- •Substitution of species in the specified seed mixes/species lists must be approved by the project manager.
- Yellow tag seed must be used if it is available, unless otherwise directed by the project manager.
- All seed that is supplied for projects must be labeled according to the requirements of the Minnesota Seed Law, section 21.82, including limits on noxious weed seed.
- The origin of seed is required to be listed on the seed tag for all species in a mix to provide verification of original (generation 0) seed source. The smallest known geographic area (township, county, ecotype region, etc.) shall be listed.
  - Information pertaining to pure seed, germination, and hard (dormant) seed of individual components in a mix is required on seed tags.
  - When submitting seed bids, seed vendors must list any *Amaranth* seeds that were found in official seed tests. If *Amaranth* species are found in the test results, the Minnesota Department of Agriculture (MDA) requires that the vendor pay for genetic testing to determine if the *Amaranth* seeds present are *Palmer amaranth.*
- Soon after the acceptance of a seed bid, seed vendors must provide a preliminary seed label/tag for the proposed seed mix that lists any regulated weed seeds (Restricted and Prohibited Noxious Weed seeds and other plant seeds not intended to be part of the mix) that were identified through official seed lot tests.
- Seed must be cleaned to an extent sufficient to allow its passage through appropriate seeding equipment.
- All wild harvest mixes must be tested. Germination, hard seed and Pure Live Seed information is required on seed tags for the number of species that are required through a program or project diversity standard. Any Amaranth species in wild harvest mixes must be identified and have the same genetic testing required for seed that is produced. There should also be categories for inert matter and weed seeds. Unless otherwise requested, small, large, and cover crop seeds should be packaged separately.
- Seed source standards for conservation programs must be followed for seed mixes. For Minnesota Board of Water and Soil Resourced (BWSR) funded project the seed zone map and source sequence on page 8 of BWSR's Native Vegetation Establishment and Enhancement Guidelines must be followed for obtaining seed.
- All seed delivered to sites must have a complete label and include information about individual component seed lots. Installers must allow MDA staff to take seed samples when they arrive for a random inspection.
- A final list of species (with seed lot information) and amounts of each species seed planted for the project must be sent to project managers following the installation.
- Project contracts provided to landowners must state that if it can be determined that seed installers were responsible for introducing regulated state noxious weeds into plantings, seed installers will be responsible for controlling or eradicating noxious weeds on those properties for a time that is sufficient to be effective.

Note: When using these specifications for bidding, it is also recommended to include a seed zone map. Upon project installation retain and file all seed information.

Protecting Natural Communities

Intact native plant communities such as remnant prairies, savanna and calcareous fens are now uncommon in the Minnesota landscape and are losing plant diversity from fragmentation, invasive species, and negative impacts from surrounding land uses. These plant communities should be buffered with conservation plantings and connected to habitat corridors and larger habitat complexes when possible to minimize edge effect and other consequences of fragmentation; and to promote plant and animal dispersal.

Remnant prairie in Goodhue County

It is also important that these areas are protected from non-local sources of seed that may cause outbreeding depression. Experienced resource professionals should be involved in seed collection and management planning when working in, or near, remnant communities. Varieties/cultivars (selected germplasms) of native species cannot be used adjacent to these areas (within a one-quarter mile buffer) to limit genetic influences. Seed must come from local sources when planting buffers adjacent to medium and high quality remnant communities. Whenever possible, seed should be collected directly from local remnants (generation 0) or from the first generation of production (generation 1), or from the ecological subsection when a further distance is needed (such as when species are being re-introduced). The DNR County Biological Survey Program can provide more information about remnant communities in the state. Data about mapped remnant prairie communities can be found at https://gisdata.mn.gov/dataset/biota-dnr-native-plant-comm .

Riparian Buffer Planning and Design

Riparian buffers play an important role in landscapes by filtering pollutants, slowing and infiltrating stormwater, and providing habitat for a wide range of species. It is important that environmentally suitable annual, biennial, and perennial species are used for buffer areas that will maximize landscape benefits. Recommendations for buffer planning and design are included under sections of these Guidelines titled “Project Site Preparation, Planting and Maintenance” and “Guidance by Project Type”. Individual project types that are covered and relate to buffers include: Native Prairie Reconstruction; Pollinator Habitat; Wetland Restoration; “Agricultural BMPs” (including Agricultural Buffers); “Stormwater Basins”; “Raingardens and Biofiltration Areas”; “Lakeshores”, “Forest/Woodlands”; “Native/Remnant Plant Community Restoration”; “Temporary Cover”, “Streambank Stabilization and Ravine Stabilization”. More information about buffer planning and design can be found in the BWSR Buffer Establishment and Management Toolbox.

Providing Pollinator Habitat

Insect pollinators including native and domesticated bees that play a key role in crop and native plant pollination have seen significant population declines in during recent years from habitat loss, disease and pesticide use. As a result, it is important to incorporate pollinator habitat into a wide range of project types.

Site selection is an important consideration when planning pollinator habitat to ensure that insects will not be impacted by pesticide drift. It is also important that bees have clean water sources nearby, sufficient nesting sites, and a diversity of flowers that provide pollen and nectar through the entire growing season. Even smaller project types such as raingardens or biofiltration areas can support many types of insects that play a key role in supporting healthy ecosystems. State legislation from 2013 states that "**prairie restorations conducted on state lands or with state funds must include an appropriate diversity of native species selected to provide habitat for pollinators throughout the growing season**". The section of these guidelines titled "Guidance by Project Type" includes a section on restoring pollinator habitat. The list of state seed mixes (page 11) identifies mixes that are particularly beneficial for pollinator habitat with at least 15 species of forbs and at least 30% forbs by seed count. The Minnesota Board of Water and Soil Resources also has a pollinator webpage with a "pollinator toolbox", peer to peer resources and links to other pollinator efforts.

Climate Change Considerations

The effects of a changing climate such as extreme storm events and temperature variation can cause stress to aquatic and terrestrial ecosystems. Rare plant and animal species are often most at risk from these changing conditions and may need additional adaptation strategies to ensure the health of populations. The "Strategies for Restoring Resilient, Functional Landscapes and Maintaining Ecological Diversity" on page 5 of these guidelines outline key strategies for increasing the resilience of our remnant and reconstructed plant communities to disturbance and adapting to climate change, while Climate Change Considerations for Plant Selection are listed below.

Conditions in Minnesota have changed rapidly over the last few decades and an overwhelming base of scientific evidence projects that Minnesota's climate will see additional significant changes through the end of the 21st century. Over the last several decades, the state has experienced substantial warming during winter and at night, with increased precipitation throughout the year, often from larger and more frequent heavy rainfall events. These changes alone have damaged buildings and infrastructure, limited recreational opportunities, altered our growing seasons, impacted natural resources, and affected the conditions of lakes, rivers, wetlands, and our groundwater aquifers that provide water for drinking and irrigation. The years and decades ahead in Minnesota will bring even warmer winters and nights, and even larger rainfalls, in addition to other climatic changes not yet experienced in the state (2017 Interagency Climate Adaptation Report (https://www.pca.state.mn.us/sites/default/files/p-gen4-07c.pdf)

It is challenging to predict the effects of climate change on remnant and restored native plant communities and they will have varying impacts across different regions of the state. It is likely that extended and moister spring and fall seasons are already favoring cool season invasive species such as smooth brome grass and reed canary grass, as well as woody invasive species such as buckthorn. These type of changes require management actions for existing plant communities in addition to site preparation and seed and plant selection considerations when planning restorations. Maintaining and restoring native plant diversity across landscapes will play an important role in maintaining resilience of ecosystems.

Moving plants and seed for climate change (assisted migration) is a topic of significant debate amongst ecologists. One concern about moving plants and seed relatively long distances is that there can be risks to the genetic fitness of existing populations if plants are introduced from too far away. A positive trait of most herbaceous native plants is that they have high genetic diversity, often giving them the ability to adapt to changing conditions, if the conditions are not too extreme, and if their populations are of a sustainable size. As a result, these guidelines are focused on the use of locally adapted sources. However, it is recommended to favor seed and plants from sources located just to the south of projects due to the risk of climate change. Plant species that are at the southern edge of their range and at risk of population declines with a warming climate may need special consideration by conservation professional to determine strategies to support their populations.

Climate Change Mitigation and Adaptation Considerations for Plant Selection

1. A partnership approach between conservation partners with knowledge about plant ecology and native plant communities should be used to select restoration strategies as well as species and sources adapted to climate change.

2. Plant selection should take into consideration current and projected site conditions, potential plant stressors (extreme weather, diseases, invasive species, pollutants, etc.), unique natural features, and sensitive plant and animal species. Ecological assessments should be conducted that take into consideration the strategies that will be needed to maintain and increase plant community resilience.

3. Diversity levels and seed mix components should be selected for restoration projects that will increase the overall resiliency to stressors. High diversity levels, as well as early, mid and late successional species, should be provided in seed mixes.

4. As extreme precipitation events have been increasing statewide, select plant species for stormwater projects and shorelines that are adapted to challenging conditions (see Plants for Stormwater Design).

5. Assisted migrations of trees and shrub species has become more commonplace in response to expected forest changes, as it may take woody vegetation many years to produce seed. Generally, gradual shifts of common species should be implemented (Hunter 2007). In most cases, forests should also be managed for diversity and multi-aged stands to increase their resiliency and forest management plans should be developed to guide management activities based on site ecological and production goals. Assisted migration efforts for trees and shrubs should involve input from teams of foresters and ecologists knowledgeable about forest ecosystems to select species that meet project goals and won't have negative consequences.

6. When selecting herbaceous native plants and seed sources it is important to focus on matching environmental conditions (using ecological subsections and sections) to help ensure that plantings will thrive within the restoration site. It may be beneficial to mix seed sources (of local origin) of species for individual restoration projects, particularly for highly disturbed sites (Lesica 1999) where successful establishment may be less predictable and aided by increased genetic diversity. If seed cannot be found locally, then sources to the south of projects should be the first preference to aid adaptation to warming temperatures.

7. Conservation plantings can have a key role in climate mitigation as well as adaptation. Plantings can be designed to maximize their carbon sequestration benefits. Some key methods include 1) ensuring all key functional groups are represented in prairie and wetland plantings; 2) designing seed mixes and selecting other plant materials that are well suited to soil types; 3) focusing on deep rooted herbaceous plants; and 4) when appropriate, focusing on a combination of fast growing and later successional tree and shrub species.

8. In agricultural landscapes, cover crops, perennial vegetation, and strip tilling play important roles in sequestering carbon in the soil while also protecting water quality.

9. Our remnant and reconstructed native plant communities are under increasing pressure from invasive species, and require prioritization to determine the greatest regional threats. Local organizations such as Cooperative Weed Management Areas play a key role in setting priorities, developing plans and sharing resources to accomplish control.

10. Monitoring is needed to track the response of plant communities and individual species over time. Monitoring can help us understand if the abundance of certain species is changing and if new species are appearing. As part of monitoring efforts it will be important to separate potential explanatory factors such as current land use, past land use, exotic species invasions and climate change.

11. The need for adapted management of restored and native plant communities is increasing due to invasive species, herbivores, extreme precipitation and other stressors. This management should be based on monitoring information and will vary for plant communities but may involve prescribed fire, conservation grazing, conservation haying, water level management, biocontrol and other methods.

Project Site Preparation, Planting and Maintenance

The following information provides an overview of site preparation, planting and maintenance strategies that are commonly used for restoration and conservation practices. More detailed information about site preparation, planting and maintenance can be found in the Minnesota Wetland Restoration Guide at www.bwsr.state.mn.us/publications/restoration_guide.html . A summary of practitioner "What's Working" information can be found at http://www.bwsr.state.mn.us/grants/WhatsWorking.html.

Site Preparation Methods

Transitioning from Other Uses

Field prepared for broadcast seeding

Effective site preparation is essential to getting a conservation practice or restoration project off to a good start as well as for long term success. Primary goals of site preparation are to control weed species and to provide ideal growing conditions for the seed or plants to be installed. Site preparation methods vary depending on past uses of the site and the weed species that are present. The protection of microorganism populations and native seedbanks, preventing soil erosion, and managing weed establishment are all considerations during the site preparation process. In most cases, non-herbicide methods are preferred over herbicide intensive methods to protect aquatic organisms and soil microfauna, but herbicides may be the most efficient method of controlling some invasive perennial species.

It is common for many conservation plantings to transition from corn or soybean production. Fields that are in agriculture often have control of most weeds, though additional control of species such as Canada thistle is sometimes needed in the fall after harvest. Another consideration is that several chemicals being used for weed control, along with Glyphosate in Glyphosate-resistant crops act as pre-emergents or post-emergents (designed to inhibit germination) and can be a problem for native vegetation establishment from seed. Temporary cover crops planted for one or two seasons can also allow time for these chemicals to break down in the soil if they have been used. Investigate prior chemical use and labels to help define probability of having chemical carryover that could/should be addressed by using temporary cover crops. If in doubt seek consultation from others with applicable experience.

If a site is in perennial weeds such as smooth brome, quack grass or bluegrass and cannot be put into agricultural production for one or two seasons intensive site preparation may be needed for the control of perennial invasive species with extensive rhizomes. Herbicide application is often recommended, as tilling alone may re-suspend the rhizomes, allowing them to continue growing. For species such as reed canary grass and giant reed grass, combinations of mowing, herbicide application, prescribed burning, and tilling (or possibly additional herbicide application) may be needed. The Minnesota Wetland Restoration Guide provides detailed management recommendations for a wide range of species.

For small lakeshore or stormwater projects perennial weeds can often be dug with shovels or garden forks, making sure to remove all of the rhizomes. Heavy mulches or clear plastic (solarization) have also been used as part of site preparation for small areas. When removing sod for lakeshores or raingardens, sod kickers, sod cutters or other mechanical equipment can be used to remove roots and weed seeds.

Scraping with backhoes and bulldozers is sometimes conducted to remove species such as reed canary grass and giant reed grass, or to remove fill materials or sediment that has deposited in wetlands or along shorelines. Sediment removal can be expensive and there must be a plan for the disposal of scraped material. An advantage of sediment removal is that it can remove accumulated nutrients and expose remnant native seedbank. Shallow scraping, mechanical raking or brushing , or other means to remove the duff layer from a site can also aid the control of species such as cattails, giant reed grass and reed canary grass.

The removal of fill as part of a shoreline restoration project
Photo: Ramsey-Washington Metro Watershed District

Inundation can also be used for the control of perennial weeds such as cattails, giant reed grass and reed canary grass. This technique requires the ability to retain water. Inundation should be initiated early in the season when the target species is short and snowmelt is contributing to water levels. Mowing to decrease vegetation height is recommended if inundation is started during other times of year. It may take a full growing season at a depth of one to two feet to accomplish full removal, making sure that sufficient hydrology is necessary. Reed canary grass on the edges of the inundated areas will likely require herbicide treatment. A plan should be in place to control seedlings following inundation.

Seedbed Preparation

Methods that are used to prepare a seedbed can vary depending on the type of seeding equipment to be used. If a traditional native seed drill will be used, a smooth, firm seedbed is required. Soybean fields generally are sufficiently prepared for a native seed drill, but sites that were recently tilled will require additional soil treatment such as harrowing and rolling to prepare an adequate seedbed and prevent seed from being buried too deep. Broadcast seeding can be conducted on soybean or corn fields, or fields that have been disked, as long as the soil is allowed to settle before seeding. Some practitioners have found that broadcast seeding on a smooth surface (not tilled or disked) leads to the establishment of higher diversity. It is important that the soil surface is not too hard packed, so cultipacking or light harrowing of crop fields before broadcast seeding may be needed. Seed can be lost on smooth surfaces, so it is recommended to seed into temporary cover crops or to roll sites after seeding.

Harrowing to prepare for seeding

For sites where containerized plants will be installed, a firm, weed free surface is desirable to aid planting efforts and to ensure that soil will not bury seedlings after rainfall. For raingardens, shredded hardwood mulch is often applied before planting containerized plants to prevent compaction of the soil during planting, and so seedlings are not buried by mulch when it is installed. Shoreland plantings commonly use wood mulch or erosion control blanket to suppress weeds, retain moisture, and stabilize soils. Shoreland plantings may also use bio-logs and/or wattles or wave break structures to decrease wave energy and to hold upland soils in place while plants establish. On flat or moderately sloped sites a light layer of prairie straw (available from some native plant companies) or weed free straw can be used as mulch to help retain moisture and suppress weeds. On some shoreline and upland sites, fencing, repellents, and/or tree/shrub protectants may be needed to prevent animal herbivory until plants are established.

Raingarden where mulch has been applied before planting to prevent compaction Photo: Metro Blooms

Shoreline restoration using wood mulch, coconut fiber bio-logs, wattles and fencing

Planting Considerations

Seed Mixes

Seed mixes for projects can include seed collected from the project site, or nearby natural areas, State seed mixes, private vendor mixes, or custom mixes developed for site conditions. State seed mixes have been developed for a variety of project types including wetlands, prairies, forest edges, roadsides, riparian areas, and stormwater treatment systems. These mixes have been designed to increase diversity, create competition for invasive species, and promote plant community resiliency. Single-species cover crops are not recommended in addition to permanent state seed mixes, as they already contain oats or winter wheat (depending on the season of planting). The State seed mixes are available at www.bwsr.state.mn.us/native_vegetation

Wetland grass, forb, sedge and rush seeds

The following website lists native seed vendors in Minnesota: http://www.dnr.state.mn.us/gardens/nativeplants/suppliers.html.

Temporary Cover Crops and Mulch

The use of short lived temporary cover crops help stabilize project sites and minimize the need for additional mulch in preparation of planting native seed mixes. They can also provide time to observe weed problems, and to allow for proper weed control before fall seeding. If cover crops are seeded at the same time as the native species, they can act as a germination indicator as they grow faster than the native species and show that the seeding was successful. Temporary cover crops such as oats or winter wheat (the two species most commonly used) should be mowed to 10-12 inches before seeds mature (or harvested upon maturity) to prevent re-seeding. Slough grass is a common cover crop for wet areas. Annual rye grass was commonly used but is generally avoided now due to its ability to inhibit germination of native species. Perennial species are discouraged as temporary cover crops, as they require herbicide application before conducting seedbed preparation and seeding. Other cover crops typically used in agricultural fields, such as buckwheat, pennycress, and radishes, can help stabilize soil, build soil quality, or provide weed competition as part of restoration projects. See NRCS Agronomy Technical Note 31.

Slough grass established as a temporary cover crop

Planting Dates

Spring seeding is generally favored for native grass establishment, while fall seeding is often favored for planting forb, sedge, and rush seed to allow winter conditions to naturally break seed coats. Fall dormant seeding should be conducted after October 15th in the northern half of the state and after November 1st in the southern half of the state, and before the soil freezes. Dormant seeding or frost seeding (seeding into a few inches of snow) can also aid the establishment of forbs and sedges in uplands where grasses can become more dominant with spring plantings. Dormant seeding is also beneficial for pollinator projects with a high percentage of forbs and if hydrology will be restored in the fall, as it may be difficult to access the site after spring snowmelt. It is common to conduct dormant seeding shortly before snowmelt to ensure that seed is not lost from wind, birds or rodents.

If a wetland project will be constructed in the spring/early summer, or will have flowing or fluctuating water levels it may be better to seed later in the spring after water levels stabilize. Spring seeding of wetland and upland areas should be conducted before June 30th, as summer temperatures can lead to the loss of seedlings.

Containerized plants, vegetated mats, and bare root plants are most often planted in the spring when there is adequate rainfall and soil moisture, but fall plantings can also be successful. Containerized trees and shrubs can also be planted in late fall, before the ground freezes, but frost heave is sometimes a problem in high moisture areas. The installation of woody plant cuttings is typically conducted from early spring until leaves start to develop.

The table below summarizes preferred seeding and planting dates for different types of seed and plants.

Planting Date Guidance for Restoration & BMP Projects

Seeding - Recommended Dates/Vegetation Type

Seed Type	Spring/Early Summer	Mid-Summer	Early Fall	Mid-Fall	Late Fall (Dormant Seeding)	Frost Seeding
	(see date below)	Jun 30 - Aug 1	Aug 1 - Sep 10	Sep 10 - Oct 15	Nov 1 - Frozen Soil (see note about soil temp.)	Feb 15 - April 7
Cool-season Prairie Grasses	Apr 1 - Jun 15	**		*		
Warm-season Prairie Grasses	May 15 - Jun 30		*	*		
Prairie Sedges and Forbs	May 15 - Jun 30		*	*		
Wetland Grasses	Apr 1 - Jun 30	**		*		
Wetland Sedges and Forbs	Apr 1 - Jun 30	**		*		
State Native Construction Mix	Apr 1 - Jun 15		*	*		
Oats Temp. Cover	Apr 1 - Jun 15			*	*	*
Winter Wheat Temp. Cover	**	*			*	*

Plant Installation - Recommended Dates/Vegetation Type

Plant Type	Early Spring Green-up-May 15	Late Spring May 15 - June 30	Mid-Summer Jun 30 - Aug 1	Early Fall Aug 1 - Sep 10	Mid-Fall Sep 10 - Oct 15	Late Fall (Dormant Planting) Nov 1 - Frozen Soil (see note about soil temp.)
Bare-root Herbaceous			*	**	**	
Bare Root Woody			*	**	**	
Containerized Prairie				*	*	*
Containerized Wet Meadow				*	*	*
Containerized Marsh				*	*	*
Containerized Woody					*	
Submergent Plant Fragments				*	*	**
Vegetated Mats				*	**	**
Woody Cuttings			**	**	*	

Seeding Considerations

Spring/Summer Seeding: Spring and summer tends to be the best season for grass establishment and forbs such as pasque flower, prairie smoke, phlox, shooting star, golden alexanders, gentian, meadow rue, and many violets that do not require stratification. Forbs and sedges that require a winter for stratification tend to do better with fall planting but when planted in the spring they can sit dormant for a season until they are ready to germinate.

Fall Dormant Seeding: It is common to wait until around November 1st when dormant seeding. It is important that conditions will be cold enough to prevent germination right before winter. It is also common to wait until shortly before snowfall to prevent the loss of seed from wind, birds and rodents. Fall dormant seeding is commonly done when forbs, cool-season grasses and sedges are a primary goal for a project. Fall dormant seeding and winter seeding typically should not be conducted in areas where there will be flowing or standing water in the spring as seed may be lost.

Snow Seeding: Snow seeding is conducted during early or late winter when there is less than a foot of snow, and on sunny days when seed can move to the soil surface. This technique has been successful for a wide variety of species types. Refer to the Minnesota Wetland Restoration Guide for more information about snow seeding.

Cover/Companion Crop Use: Cover crop species are included in state seed mixes. Oats (Avena sativa) should be used in spring or summer, and winter wheat (Triticum aestivum) in fall. If a project is focused on stabilization and slopes are between 5-10%, cover species should be increased by 35 pounds per acre. If slopes are more than 10% cover species should be increased to 56 pounds per acre.

Plant Installation Considerations

Plant Condition: the planting dates listed in the table assume that containerized plants are fully rooted into containers, that pre-vegetated mats have established vegetation, and that herbaceous, and woody bare root plants (and cuttings) are stored in optimal conditions prior to planting.

Weather Conditions: Weather conditions (including rainfall and temperatures) during a season can have a big influence on the ideal planting dates for vegetation. Planting dates may need to be adjusted based on past and projected conditions.

Seeding Wetlands and Retention Basins

State wet meadow and wet prairie seed mixes are designed to be used from the planned edge of open water (pool elevation) to around 1-1.5 feet in elevation depending on soil texture and capillary action of soil. Other considerations for the use of wetland seed mixes include the extent of hydric soils, and swales coming into a wetland. Upland mixes are used approximately 1-1.5 feet above pool elevation and can be broadcast or drill seeded. The state “emergent seed mix” is commonly used in a 6 to 10-foot band that straddles the edge of open water. This strip of emergent seed is hand broadcast after water levels have stabilized within the wetland. It is not recommended to seed in areas that will have open water, as most wetland seed will float.

Broadcast seeder being used to seed a wet meadow restoration

In most cases, wetland seed is broadcast-seeded followed by rolling or packing, as most wetland seed needs light to germinate. Wetland grasses can be drill-seeded followed by broadcasting forbs and sedges. If a seed drill will be used for installation of wetland seed the drill must be calibrates carefully to ensure that small seed is placed correctly, at the surface.

Prairie, Savanna and Woodland Edge Seeding

Upland prairies, savannas and woodland edges are most often restored through the installation of seed. A variety of seeding equipment is used for upland seeding including broadcast seeders, traditional native seed drills, no-till drills, Brillion seeders and Trillion seeders. Specialized no-till grass drills have depth bands designed to handle a wide variety of seed (fluffy, smooth, large and small) and low seeding rates. Since no-till drilling can plant directly into a light stubble layer, this method reduces erosion on the newly seeded site. Conventional grain drills are not capable of handling diverse seed sizes and are unlikely to provide satisfactory results. While no-till native seed drills can plant through light stubble, success is still likely to be greatest when most excess residue is removed.

Native seed drill

Seed mixes should be chosen that will be suited to the soils and hydrology of the site. State seed mixes are available for prairies and woodland edges in different regions of the state. Mixes are also available from native seed vendors and site specific seed mixes can also be developed. It is important to consider project goals when selecting species for projects, and determining the percentage of individual species in a mix. It can be helpful to overlap upland and wetland mixes a few feet to ensure successful establishment in areas where hydrology levels are unpredictable.

Mulching

Care should be taken to ensure that upland soils do not erode into wetland areas and cover wetland seedlings. As much as one centimeter of sediment can prevent germination of many wetland species. If temporary cover crops are not used as mulch and if sufficient crop stubble is not present additional mulch is recommended at one-ton per acre in wetland areas, and two-tons per acre in upland areas. It is essential that a weed-free mulch be used; MCIA Certified Weed Free mulch (MnDOT Type 3) is recommended. The mulch should be disk-anchored to prevent movement. If the mulch windrows along the edge of open water, it should be removed or re-spread.

Use of Native Seedbank

Maximizing the use of native seedbank is encouraged for wetland projects as a means to promote the establishment of local seed/species. Seedbanks often contain annual species such as fleabane, beggarticks, smartweeds and jewelweed that provide important environmental benefits and often are not included in seed mixes. If native seedbank is planned as a method to establish vegetation, a seedbank test or survey of existing vegetation will assist in determining the need for supplemental seeding. A method for testing seedbank viability can be found in *Section 5, Appendix D* of the "Minnesota Wetland Restoration Guide": www.bwsr.state.mn.us/publications/restoration_guide.html. If a survey of existing vegetation has been conducted or will be conducted as an alternative to a seedbank test the overall percent cover of individual species should be recorded to gain an understanding of additional species that may be needed. The composition of state wetland seed mixes can be used as a reference to see if additional grass, sedge or forbs species should be seeded. Survey information from nearby remnant communities can also be used as a guide for developing a diversity standard and determining what additional species may be beneficial.

Tree Planting

Planting 200 to 400 seedling trees or shrubs per acre is recommended for upland and wetland forested communities and shrub wetlands. Spacing should depend on the size of plant material, seedbank of woody species, potential for colonization, expected aftercare, and potential losses. It is not uncommon to lose between 25-50% of seedling trees and shrubs or cuttings. Nursery grown plants may not do well when planted in saturated soils, so planting on mounds or berms (1-2 feet tall) can be helpful. The seeding of trees and shrubs has become a more common practice to plant large areas. Thorough site preparation and weed control is needed for seeding trees and shrubs, similar to methods used to prepare and maintain prairie plantings.

Planting seedling trees and shrubs

As tree and shrub seedlings are susceptible to deer and rodent browsing, protection (bud caps, tree tubes, wire exclosures, etc.) is often necessary to ensure their survival. An exception is when large numbers are planted through tree and shrub seeding, when some loss is expected. Repellents can be applied on and around seedlings until they are established. Watering is needed for trees and shrubs if rainfall is less than one inch per week.

Aquatic Plant Installation

For shallow marsh restorations, and the edge of retention ponds and lakeshores (without significant wave action), the establishment of emergent plants will help ensure sufficient establishment in open water areas. Species such as arrowhead, water plantain, giant burreed, bulrushes, sweet flag, wild iris, and pickerelweed can be planted near the edge of open water and allowed to spread into deeper water. Burreed and three-square bulrush are less desirable by muskrats, so they are beneficial where muskrats are a risk. Lakeshore restorations are often planted with a higher density of both wet meadow and emergent plants with a spacing of 1.5-4 feet between plants. The spacing of individual species is often based on how quickly the species can spread by underground rhizomes or other means.

It is recommended that aquatic plants be installed in May or June; recent research and project experience has shown this to be the best time for establishment. Late summer plantings seem to have lower survival rates. Install emergent plants at a depth where they will not be covered with standing water. Waves may also influence plantings, particularly on east shorelines, so it may be beneficial to plant some emergent species a little further up slope from the open water edge to aid establishment. Wave break structures, wattles, or coconut fiber logs can be used to minimize wave damage. Temporary fencing may be needed for projects where waterfowl or muskrats may graze young plants; in some cases this can be as simple as flagging tape attached to stakes to deter waterfowl. Watering may be needed in drought conditions.

Planting of emergent plants on the edge of open water

Submergent and floating leaved species such as wild celery, coontail, lotus, and sago pondweed can be used in deeper portions of a site. Plant vendors should be contacted for availability of species and propagule types, and to provide recommendations on how best to anchor/establish new plantings. All efforts should be taken to prevent the spread of Aquatic Invasive Species.

Upland Plant Installation

Similar to aquatic plants, prairie plants can be installed from containers. Containers are typically used for species that do not establish well, or quickly from seed (liatris, lilies, butterfly milkweed, etc.), and for species where little seed is available. The number of containerized plants used for projects often depends on project budget. For raingardens, biofiltration areas and many other BMPs it is common to use containerized plants instead of seed to ensure rapid establishment and a predictable spacing and distribution of species, adding to an ordered appearance. Containerized plants are commonly planted in late spring after plugs have a chance to mature. Some plantings are also conducted in the fall. It is important that plants will not have too much weed competition and are watered. In the summer months during the first year, new plantings require 1 inch of water per week, either by rainfall or by supplemental watering. If drought conditions occur during the second year, supplemental watering may also be required. Flags may be needed for large areas to mark the location of plants and aid watering efforts.

Inter-seeding

Inter-seeding is most effective in stands where grass is not overly dominant. It does not work well in monoculture stands of switchgrass, and reed canary grass or in Kentucky bluegrass sod. Forbs and grass species can be inter-seeded. Forbs are generally broadcast seeded while grasses are commonly drilled. Individual species and seeding rates should be selected based on existing vegetation, site needs and project goals.

Inter-seeding forbs into native grasses to increase diversity

Site preparation generally involves the removal of thatch through burning or haying to provide light for seedlings. Weed removal through herbicide treatment is sometimes needed to decrease competition and open areas for establishment. An alternative method is to cultivate nodes within larger areas for seeding. A year or longer may be needed for site preparation if perennial weeds are dominant.

Converting non-native grasslands may require cropping for a year or two, or combinations of tilling and herbicide application to prepare for seeding. In some cases, inter-seeding can be successful without tilling, particularly when existing vegetation is not vigorous due to sandy soils or other factors. When removing existing weeds such as smooth brome and goldenrod, fields are typically burned to remove thatch, and then treated with herbicide as vegetation reaches about six inches tall. Several herbicide applications, or combinations of herbicide and tilling may be conducted before seeding occurs. Repeated mowing to about six to eight inches during the first two years can be important to aid seedling establishment.

Inter-seeding should be timed to correspond to site-preparation methods. The installation of forb seed is commonly conducted in late fall or late winter. Seeding during these times of year provides time for forb seeds to be stratified (break dormancy). Inter-seeding can be conducted in spring or early summer, but some type of packing or dragging is beneficial. A potential strategy is to broadcast forb seed followed by seeding grasses with a seed drill that is equipped with a roller that can enhance establishment by promoting seed to soil contact.

During the first two years after inter-seeding, burning should be avoided to prevent damage to seedlings. Mowing is an important method to promote seedling establishment and growth after seeding. Frequent mowing (bi-weekly if possible) to a plant height of 6-8 inches is recommended for two seasons in non-native grasslands and restored/reconstructed native prairie.

Monitoring the success of inter-seeding efforts is important to better understand the effectiveness of methods and to guide future efforts.

Native bee on wild bergamot

Seeding Forb Diverse Mixes for Pollinator Habitat

Pollinator seed mixes typically include greater than 30% forbs by seed count for large areas and over 50% for smaller pollinator plots/zones of a few acres in size. As a result, it is important that weeds are thoroughly controlled before seeding through combinations of herbicide application and tilling or other methods that will decrease the weed seedbank. It is also important that pesticides that persist in the soil were not used prior to seeding. The persistence of individual pesticides need to be investigated if they were used. Seed should be dormant seeded in late fall to allow forb seed to stratify over winter and be ready to germinate in the spring. Forb species are sometimes planted in masses to make them easier for pollinators to find and to decrease travel distance. Broadcast seeding or seeding with a native seed drill should be conducted followed by rolling to improve seed to soil contact and prevent erosion. See page 37 for information about pollinator habitat.

Project Maintenance

Proper site maintenance is essential to ensure the success of a restoration project. A schedule summarizing planned maintenance activities each month is very helpful to guide contractors and project managers. It is also helpful to have information in vegetation management plans about problematic weed species that may establish at a site, as well as details about how they will be controlled. *Appendix B* of the "Minnesota Wetland Restoration Guide" provides information on invasive species control. It is common that the management methods listed below are used in combination for effective site maintenance. Indeed, Integrated Plant Management, or IPM, which is using multiple management methods over time, will yield the best results. Just as in agricultural settings, invasive plants can become resistant to certain herbicides after repeated applications. Some species may respond better to certain management methods, so using IPM, or "all the tools in the toolbox," will be most effective over time. As a general rule, mechanical or bio-control options should be considered before herbicide methods to limit damage to aquatic organisms and pollinators that may be using the restoration project. However, there are cases where herbicide application will be the most efficient method of removing some perennial invasive species.

Mowing/Cutting

Mowing can be an important step in the establishment of upland prairie restoration sites. Mowing at least twice the first season and at least once the second season with a flail mower or stalk chopper (to prevent smothering plants) is often needed to decrease competition and to provide sufficient sunlight for seedlings. Weeds should be mowed to between five and eight inches before seed is allowed to set (usually as weeds reach 12-14 inches). Mowing height should be raised as native plants establish. The timing and frequency of mowing should be planned to allow sufficient light to reach native plant seedlings and preventing weed seed production. Sites with low weed competition due to sandy soils or other factors may not need mowing. Annual weeds can be controlled by mowing or cutting alone by cutting them before they produce seed.

ATV used to mow Canada thistle before flowering

Mowing of annual and biennial weeds is also beneficial in wetland transition areas for species such as giant ragweed, barnyard grass, and Canada thistle, but should only be conducted if rutting and soil compaction will not result. Pressure from annual and biennial weeds is generally less with increased soil saturation and water depth. For smaller projects, brush cutters, string trimmers, or hand equipment can be used to target weeds and work around native plants. See the Minnesota Wetland Restoration Guide appendix: http://bwsr.state.mn.us/restoration/resources/documents/appendix-6a-3mowing.pdf

Haying

Haying can be used as a management tool to remove weed growth and thatch to provide sunlight for establishing native species and to help control woody plants in prairies and wetlands. Haying can also be used to help maintain diversity levels. One study found that the total number of species and proportion of native species was similar between planted grassland plots that were hayed in the fall and plots where early season prescribed burns were conducted. Haying can be a good alternative to prescribed burning where burning is not feasible due to the presence of desirable woody plants, unfavorable weather or surrounding land uses. Another role of haying can be to remove tall growth of weeds or woody plants prior to burning, herbicide treatment or flooding. If allowed by conservation programs, and consistent with project goals, haying of uplands can also provide forage for cattle producers and biomass for energy production. When considering haying as a management strategy it is important to consider potential influences on pollinators, bird nesting, soil disturbance, soil nutrients, and long-term diversity levels. See the Minnesota Wetland Restoration Guide appendix: http://bwsr.state.mn.us/restoration/resources/documents/appendix-6a-4haying.pdf

Hand Weeding

Hand weeding can be an effective method of controlling small populations of weeds, or for weed management for BMP projects. For rain gardens, biofiltration areas, and lakeshores, hand weeding may be more effective (and more desirable in some cases) than using herbicides. Hand weeding should be done when soils are moist and care should be taken to avoid disturbing the root systems of desirable plants. Soil pulled up with the weed should be knocked off and placed back on the ground, covering the hole left by the pulled weed to prevent the introduction of more weeds. It is also important that proper pulling technique is used to avoid injury. If weeds are not producing seeds they can sometimes be left in place to act as mulch. Tools such as weed wrenches and weed talons can be used for pulling woody plants such as buckthorn and non-native honeysuckles. Perennial invasive plants may need to be dug out with a shovel or other tool. An Minnesota Department of Agriculture website provides information about disposal of weeds.

Biological Control

Biological control is an effective management tool for large infestations and environmentally sensitive areas. Biological control agents are currently being used for purple loosestrife, leafy spurge, Canada thistle, common tansy, and spotted knapweed and they are in development for several other species. State or federal agencies should be contacted for recommendations on obtaining bio-control agents. Other practices such as mowing, prescribed fire, grazing, and inundation can influence bio-control agents, so their use should be part of a comprehensive management plan.

Leafy spurge bio-control beetle

Conservation Grazing

Conservation grazing is conducted by a variety of species, including cattle, bison, horses, sheep, and goats, to target specific invasive plants and non-native species or to replicate natural grazing regimes and to promote nutrient cycling and species diversity. For example, early spring grazing by cattle has been used to control Kentucky bluegrass in prairies, while later spring grazing has been used to control smooth brome grass. Goats have also been used for the management of buckthorn and non-native honeysuckles, as they eat a variety of woody plants. Detailed grazing plans are an important component in the planning and implementation of prescribed grazing, defining objectives and factors such as timing, potential disturbance, herd size, fencing and water sources. See http://bwsr.state.mn.us/restoration/resources/documents/appendix-6a-5conservationgrazing.pdf

Cattle grazing reed canary grass in a restored wetland

Water Level Control

If water level controls are available in wetland, ponds, or lakes it may be possible to adjust hydrology to allow access with equipment or to flood undesirable species. Available hydrology will influence the effectiveness of flooding. Flooding has been an effective method of management for cattails and non-native phragmites. Mowing or clipping may be necessary prior to inundation to eliminate oxygen transport to roots (even some dead stems can still transport oxygen). The influence of drawdowns or flooding on wildlife species should be considered, particularly during reproductive periods when nests might be drowned or amphibian eggs dried out by changing water levels. DNR permits are needed for control of cattails in public waters and are likely needed for controlling water levels.

Burning

Prescribed burning is beneficial to remove thatch, control invading woody and invasive plants in wetlands, prairies, and savannas, fertilize the soil with ashes, stimulate seed germination and new plant growth, and increase diversity in plantings. Some practitioners feel that burning may increase reed canary grass in wet meadow plantings where the species is a threat, likely due to added nutrients and light levels promoting germination (fall burning may have less benefit for invasive species). Other rhizomonous species may also be stimulated by burning, so other management methods (e.g. herbicide application or mowing) may be needed after burning. Burning is typically initiated after the third or fourth years of establishment, after native vegetation is reaching maturity. Uplands benefit from burning every three to five years. Fall and spring burns should be alternated periodically to simulate natural variation. Burn plans are needed to define the details of how the burn will be conducted, who will be involved and for contingency planning. In many cases, permits are also required.

Prescribed burning to control woody plants in a wetland restoration

It is recommended to only burn one-half or less of a project site at a time if they are large (over 50 acres), or don't have any adjacent refuge such as other conservation lands adjacent to the site for wildlife species. Partial burns and burns that are patchy may also benefit pollinator populations if timed correctly (when pollinators are not actively foraging or pollinators have pupated and are mobile).

Spot Treatment of Weeds

Problematic perennial weeds that cannot be managed effectively with other methods may require spot treatment with herbicide for sufficient control. Examples include reed canary grass, smooth brome, quack grass, purple loosestrife, Canada thistle, Kentucky bluegrass, crown vetch, and birds-foot trefoil. In some cases, herbicide treatment is not conducted during the first or second year of establishment to avoid impact to seedlings but it may be important to control some weeds before they have a chance to spread. A common practice for Canada thistle control involves clipping seedheads while they are in the bud stage (usually early June) and conducting herbicide application with a broad-leaf specific herbicide in the fall (mid to late October). This timing limits the application of herbicide while pollinators are active.

Spot herbicide treatment of reed canary grass

Grass-specific herbicides are used to control reed canary grass in wet meadow restorations, particularly on sites dominated by forbs and sedges that will not be affected. Grass-specific herbicides are most effective on young reed canary plants than on mature plants. There is some evidence that using surfactants along with herbicides and disking prior to application may improve effectiveness. It should be noted that grass specific herbicides are not aquatically certified and should not be used near open water.

When using a broad-spectrum herbicide it is important that an aquatic safe form of glyphosate and surfactant be used near open water. When using herbicides, labels must be followed, certified applicators must conduct the treatment and Personal Protective Equipment (PPE) must be used according to label instructions.

Woody Tree Control

Tree and woody brush control is usually essential in most projects to prevent woody species from outcompeting the desired plant community. Tree control in conservation plantings is a common practice in the prairie region of Minnesota to improve habitat for ground nesting grassland birds. Methods of control include prescribed burning; mowing/cutting; mowing/cutting followed by stem herbicide treatment or basal herbicide treatment; foliar herbicide treatment; and grazing and pulling. The method that will be most effective in a certain situation will depend on site conditions, size of woody plants, density and timing. Prescribed burning in the fall and mowing with a flail type mower (leaving the cut surface rough vs. a clean cut) in late summer are generally the most cost effective methods for smaller trees and shrubs.

Cottonwood treated with herbicide

Guidance by Project Type

The following subsections of the guide provide recommendations for selecting seed and plants for specific project types. Project types include:

- **Native Prairie Reconstruction**
- **Pollinator Habitat**
- **Wetland Restoration**
- **Agricultural BMPs**
- **Stormwater Basins**
- **Raingardens and Biofiltration Areas**
- **Lakeshores**
- **Forests/Woodlands**
- **Native Plant Community Restoration**
- **Temporary Cover**
- **Streambank Stabilization**
- **Ravine Stabilization**

Buffer planting in Austin, Minnesota

Topics covered for each project type include: **General Considerations, Achieving High Function, Diversity, Source Recommendations**, and **Information Sources**.

Two BWSR publications that relate to a wide range of project types include:

The BWSR "What's Working" Web Page- http://www.bwsr.state.mn.us/grants/WhatsWorking.html; this site includes practitioner information about restoration, and BMP techniques that have proven successful.

The BWSR website document "Summary of Functional Benefits of Native Plants in Designed and Natural Landscapes"- http://www.bwsr.state.mn.us/native_vegetation/Plant_Function_Resources.pdf. This resource provides a summary of research papers and other information about specific functions provided by native species.

Native Prairie Reconstruction

A variety of state programs focus on the reconstruction of native prairie communities. Reconstruction refers to efforts to establish a native plant community in a disturbed site such as an agricultural field. Program goals for native prairie reconstruction can vary widely from establishing perennial species to stabilize soil, and provide cover for game birds; to establishing high diversity plantings to provide habitat for a variety of wildlife species.

Achieving High Function - Deep rooted prairie grasses and forbs are often a focus of native prairie reconstruction projects for soil holding, water filtering and infiltration, and year round wildlife cover. Species from multiple plant guilds (warm season grasses, cool-season grasses, legumes, asters, and other forbs) are selected to ensure that complete plant communities are established, and benefits are provided to multiple species. Dry prairie mixes are used for upland sites with sandy or dry soils, while mesic prairie mixes are used for uplands with medium soil moisture and wet prairie mixes are used where the water table is within twelve inches of the soil surface during extended periods, resulting in saturated soils.

The NRCS 643 practice standard "Restoration and Management of Declining Habitats" (www.bwsr.state.mn.us/grantscostshare/native_buffer.html) provides specific seed mix and use specifications for RIM/WRP projects, as custom mixes are often developed for this program. State seed mixes have been developed for different prairie types in different regions of Minnesota and are another option for prairie restoration projects.

2103 state legislation states that "prairie restorations conducted on state lands or with state funds must include an appropriate diversity of native species selected to provide habitat for pollinators throughout the growing season". To provide good habitat for pollinators a diversity of flowers providing nectar and pollen though the growing season is needed as well as nearby clean water sources and protection from pesticides. See additional pollinator guidance on page 30 of this guide as well as BWSR's pollinator webpage. Specific species beneficial to pollinators may be added to mixes to aid declining pollinator species. Specific pollinator plots/zones of a few aces in size may also be added to projects to maximize pollinator habitat.

Site Selection – Native prairie reconstruction projects should be located in areas that will have high value to wildlife and/or provide soil stabilization and water quality benefits. The "Minnesota Prairie Conservation Plan" provides guidance for the establishment of prairie habitat complexes across Minnesota by protecting and buffering existing prairie.

Key Plant Species - Grasses and forbs are the most common plant types in prairie seed mixes, with some low growing shrubs, as well as sedges and rushes being present in some prairies. Species should be selected that are native to the area and well adapted site conditions. The following table lists species commonly included in native prairie reconstruction projects.

Shrubs:	Wild roses, Leadplant
Grasses:	Big bluestem, Switchgrass, Little bluestem, Indian grass, Slender wheatgrass, Canada wild rye, Sideoats grama, Prairie cord grass, Kalm's brome, Fringed brome, Western wheatgrass
Forbs:	Yellow coneflower, Butterfly milkweed, Common milkweed, Black-eyed Susan, Smooth aster, Golden alexanders, New-England aster, Maximillian sunflower, Purple prairie clover, Bush clover, Narrow-leaf coneflower, Coreopsis, Spiderwort, Wild bergamot, Mountain mint, Partridge pea, Cup plant, Blazingstars, Showy goldenrod, Stiff goldenrod, Penstemons, Canada milk vetch.

Source Recommendations - The source sequence outlined in this guide is recommended for native prairie reconstruction projects to ensure long-term sustainability of projects and to protect remnant prairie communities. The NRCS 643 practice standard has been updated to correspond to these guidelines and can be used along with these guidelines to set specifications and standards for RIM/WRP projects. Ecovars (varieties) that have not been selected for certain traits and meet the source requirements of the program may be used for conservation programs focused on grassland establishment; however, native cultivars and varieties should not be used within 1/4 mile of remnant communities.

Establishment - Most prairie reconstructions are conducted on fields that were previously in soybeans or possibly corn, as agricultural production can help ensure that weeds are controlled. However, it is important to make sure that chemicals that inhibit germination have not been used, requiring use of a cover crop for one or two seasons to allow time for the chemicals to break down in the soil. Most agencies recommend drill seeding into soybean stubble, though broadcast seeding is conducted for some projects. Some loosening of the soil with cultipackers or harrows may be needed prior to broadcast seeding if a crust has formed on the soil surface. Fields that are in brome grass and other perennial weeds often need a combination of treatments such as mowing, herbicide application and tilling to prepare for seeding and multiple treatments may be needed for weedy sites dominated with brome grass, quack grass, Canada thistle and other perennial species.

Maintenance - Key steps to maintenance involve mowing annual and biennial weeds to 5-8 inches during the first couple of years as needed to provide sunlight and to decrease competition for seedlings. After the second year, spot herbicide treatment of perennial weeds is common; and prescribed burning to maintain diversity and to control woody species is common after year three. Conservation grazing, bioenergy harvest and biocontrol of invasive species may also be long-term maintenance strategies, though these management methods often require amendments to conservation plans.

Information Sources -
NRCS practice standard 643
www.bwsr.state.mn.us/grantscostshare/native-buffer.html

Minnesota Wetland Restoration Guide www.bwsr.state.mn.us/publications/restoration_guide.html

Pollinator Habitat

Each year native and domesticated bees pollinate around 30% of crops in the United States with a value of approximately $23 billion. They also pollinate around 70-80 percent of flowering plants in the Midwest, playing a key role in their seed production. Native bee populations that include more than 4,000 species in North America have declined in recent years due to habitat loss and pesticide use among other factors. At the same time, managed colonies of European honey bees have suffered a 50% decline in recent decades.

While Honey Bees and Bumble Bees are the most commonly known pollinators, they only make up about 2% of bee species in Minnesota. The remaining species are solitary bees that do not live in colony systems like Honey or Bumble bees (with division of labor and cooperative rearing of young). Supporting native solitary bee habitat is important, as like honey bees, their populations are also in decline. Pay attention to the various pollinators and their habitat needs in the landscape to help protect and enhance their existing habitat.

> Habitat complexes and corridors are important nesting and food sources for pollinators

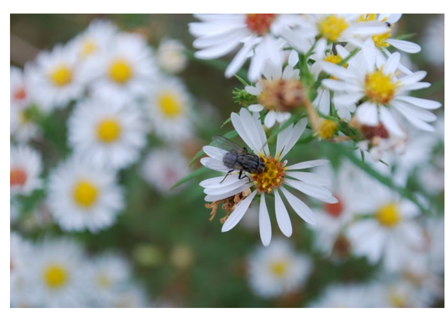
Other pollinators of concern include beetles such as the Longhorned beetle, flies such as the Syrphid fly, moths and butterflies. Many of these pollinators have their own unique habits and needs, for example, many moths tend to pollinate white or dull colored blossoms that flower at night. Some pollinator species are dependent on certain plant species for the completion of their lifecycle, such as the Monarch butterflies dependence on milkweed, and the endangered Karner Blue butterflies need for Wild Lupine. By establishing native vegetation, one can support the intricate relationships forged between native pollinators and native vegetation and keep both populations healthy.

Bees pollinating marsh Milkweed

State legislation from 2013 states that “prairie restorations conducted on state lands or with state funds must include an appropriate diversity of native species selected to provide habitat for pollinators throughout the growing season”.

Site Selection- Adequate food, shelter, and nesting sites are all needed to support healthy pollinator populations. The following are key considerations for selecting areas for pollinators:

1) Look for areas away from pesticide and fungicide use, as well as areas that lack widespread disturbances that may impact pollinators.
2) Habitat complexes and corridors provide “safe zones” and natural passageways for pollinators, as well as nesting and forage sites, and sources of water.
3) Some bees have a relatively small flight distance and benefit from having water and food sources within 200 feet of nesting sites.
4) Ground nesting bees benefit from planting clump forming native grasses. Bees that nest in tree and stem cavities benefit from farm hedgerows, windbreaks and treelines, as well as man-made nest structures. As a general rule, plant communities that historically existed at a site will provide the most beneficial nesting habitat.



A native fly pollinating an aster

Achieving High Function - Seed mixes for pollinators should include at least fifteen species and have a high percentage of forbs (30-60% by seed count). At least 30% forbs is recommended for large acreage areas (over 50 acres) and at least 50% forbs is recommended for pollinator zones/plots of a few acres in size. Grasses are also important for community structure, nesting sites and to provide fuel for prescribed burning. Shorter grasses can benefit forb growth and pollinator use. It is recommended to include at least three flowering species in each bloom period so there is a continuous food source throughout the season (few early blooming species are typically included in mixes). It is also helpful to plant forbs in masses to make them easier for pollinators to find and to increase foraging efficiency. Including a wide range of flower colors and shapes will benefit a variety of pollinator species. Annual species that commonly establish from native seedbanks such as jewelweed, fleabane, beggarticks and smartweeds also provide important pollinator habitat. These species, along with annual cover crops can often effectively compete with weeds and stabilize sites prior to the installation of seed mixes. In addition to herbaceous plants, flowering trees and shrubs can be an important source of pollen and nectar for pollinators, particularly early in the spring. Avoid clearing fallen or dead trees (unless the trees are inhibiting the use of ground nesting prairie bird species), as they help create nesting sites for a wide range of pollinators.

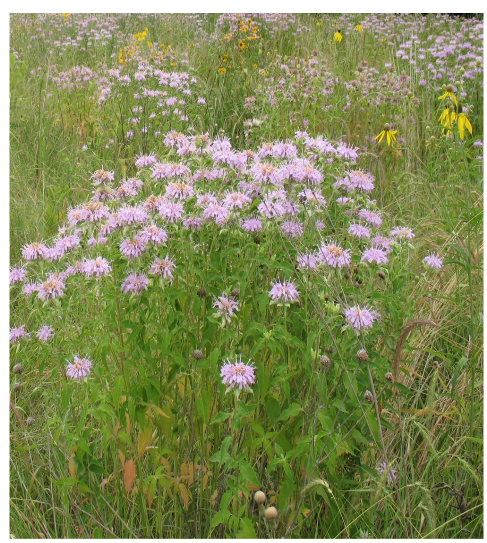
Key Plant Species -Plant species can be selected for projects to support specific insects, such as planting milkweed species for monarchs (and a variety of pollinators), lupine for Karner Blue Butterfly, or basswood for a variety of bee species. The following are key pollen and nectar sources for pollinators in the spring, summer and fall. Species should be selected that are native to the area and well adapted to site conditions.

Spring:	Willows, Basswood, Dogwoods, Viburnums, Juneberries, Plums, Cherries, Blueberry, Lupine, Bloodroot, Buttercups, Dutchman's breeches, Columbine, Virginia bluebells, Spiderwort, Lobelias, Golden alexanders
Summer:	Buttonbush, Dogwoods, False indigo, New Jersey tea, Wild rose, Prairie clovers, Milkweed, Wild bergamot, Giant hyssop, Penstemons, Bush clovers, Canada milkvetch, Culver's root, Hedge nettle, Evening primrose, Ironweed, Leadplant, Coreopsis, Canada tick trefoil, Lobelias, Obedient plant, Mountain mint, Partridge pea, Yellow coneflower, Cup plant, Joe-pye weed and Blazing stars.
Fall:	Asters, Sneezeweed, Grass-leaved goldenrod, Gentian, Boneset, Goldenrods, Sunflowers

A native bee collecting nectar from obedient plant

Source Recommendations - Local seed and plant sources are recommended for pollinator habitat projects to protect nearby native prairie populations and to provide plant species that are compatible with local insect populations. It is important that plants are purchased from nurseries that do not use pesticides as part of their production process.

Establishment - Thorough weed control is essential prior to establishing pollinator habitat. In many cases, projects are seeded into fields that were previously in soybeans or corn, as agricultural production can help ensure that weeds are sufficiently controlled. Additional management may be needed to ensure that Canada thistle is sufficiently controlled prior to planting as it is not always effectively removed as part of agricultural production.



Wild bergamot in a conservation planting

It is important that pesticides (such as neonicotinoids) that persist in the soil were not used prior to planting, as they can be taken up into plant tissues and affect pollinators. Individual pesticides should be investigated to determine their persistence in the soil. When converting pastures or fields dominated with perennial weeds such as smooth brome grass, quack grass and Canada thistle multiple treatments of herbicide application and tilling may be needed to achieve sufficient control prior to planting. In residential yards it is recommended to cut away the sod prior to planting to remove weed roots and seed.

Beyond bees, many other insects are useful pollinators like this sand wasp

Cover crops such as oats or winter wheat can be used to stabilize sites if additional time is needed for pesticides to break down in the soil or to stabilize soils prior to the planned seeding date. Drill or broadcast seeding is often conducted in the fall to allow forbs to naturally stratify over winter and compete with grasses in the spring. Some forbs that are important for pollinators such as sneezeweed, Dutchman's breeches, bugleweed, wild bergamot, evening primrose, smooth blue aster, mountain mint and aromatic aster do not require pre-stratification and can be successful seeded in the spring. If broadcasting seed, light raking and/or rolling can be used afterward to help ensure good seed to soil contact and prevent the loss of seed from wind and birds.

Maintenance – The maintenance of pollinator plantings can be challenging due to the high forb diversity and difficulty of removing weeds such as thistles without harming native plants or pollinators. Key steps to the maintenance of pollinator plantings involve:

Early spring prescribed burn

- Mowing annual and biennial weeds to 5-8 inches as needed during the first one to two years of establishment provides sunlight and decreases competition for seedlings. After the site is established mowing can be used to help control noxious weeds. Spot mowing is recommended to maintain insect refugia and vegetative cover should be maintained into the fall for overwintering habitat.
- Hand pulling of weeds is an effective strategy for smaller plantings. This is often most effective after rainfall when weeds are easier to pull
- Prescribed burning is often initiated after the third year and can help to maintain diversity and to control woody species. Burning should only be conducted on 1/4-1/2 of large sites each year to minimize impact on insects and patchy burns are ideal to provide areas of refuge. Burns are often conducted in the fall or early spring to promote floral diversity and minimize impact to pollinators.
- Conservation grazing following grazing plans can be used to reduce the percent of cool-season grasses in conservation plantings and promote floral diversity. Separate grazing units are often needed to effectively manage the timing and duration of gazing.
- Biocontrol of invasive species may also be a long-term maintenance strategy to minimize herbicide use and control weeds. Biocontrols are available for leafy spurge, spotted knapweed, purple loosestrife and Canada thistle.
- When herbicides will be used for management it is important that target species (such as Canada thistle or wild parsnip) are not in bloom when they are sprayed and that spot herbicide application is conducted rather than

broadcast spraying. Herbicide is typically not conducted the first or second year after planting, as it can damage native plant seedlings.

Information Sources -

BWSR Pollinator Toolbox
Minnesota NRCS Pollinator Conservation Planning Documents
Pollinator Habitat Assessment Form and Guide
Upper Midwest Plants for Native Bees
Pollinators and Roadsides, Roadside Management for Bees and Butterflies
Pollinator Conservation in Minnesota and Wisconsin
Pollinators in Natural Areas
Protecting Bees from Neonicotinoids in Your Garden
Using Farm Bill Programs for Pollinator Conservation
Monarch Habitat Guidebook
Conserving Bumblebees

Wetland Restoration

Individual conservation and mitigation programs provide guidance for goals related to native vegetation establishment in wetlands. Some programs primarily focus on the use of native seedbanks that are present in the soil, while others focus more on seeding grasses, sedges, rushes and forbs. Invasive species control, particularly reed canary grass is often a concern for wetland projects and need sufficient control to allow native vegetation to thrive. Native seedbank plays an important role in the establishment of wetland vegetation as a primary source of native vegetation. The viability of native seedbank can vary depending on the number of years a site has been in agricultural production, the amount of sediment that has accumulated and weed invasion. A wide variety of wetland species are also becoming commercially available for seeding wet meadows and shallow marshes and restoration professionals are learning how to effectively conduct wetland seeding.

Site Selection – The Minnesota Wetland Restoration Strategy provides a framework for selecting wetland restoration projects. It is important that individual projects be selected to meet specific program goals such as water quality improvement, flood reduction, wetland replacement and wildlife habitat. GIS analysis of watersheds, water quality testing, and wildlife habitat assessments are all useful tools that may be used to guide project selection. Multiple state and federal programs focus on wetland restoration and local conservation staff plan a key role in working with landowners to identify projects.

Shallow marsh restoration

Achieving High Function - Wetland grasses, sedges, rushes and forbs all play important roles in providing habitat for a wide range of wildlife species. Some research has shown that higher diversity levels can also aid in water quality functions such as denitrification in open water areas and increase carbon sequestration rates. Ensuring sufficient control of invasive species will aid native species establishment and ensure long-term sustainability of ecological functions.

Native seedbank may supplement wetland restoration projects, but seedbanks are sometimes unpredictable, and not all species do well from seedbank. Most wet meadow seed mixes contain around 20-30 species. Shallow marsh communities may be seeded with mixes of 10-20 species; it is also common to use containerized plants when establishing emergent species, as it is difficult for seedlings to grow from seed along the edge of open water where waves and water level fluctuations can inhibit growth. Specific conservation and mitigation programs will define diversity goals. Higher diversity mixes will help support pollinators and other invertebrates that play a key role in the health of wetland habitats.

Key Plant Species - Trees, shrubs, grasses, forbs, sedges, rushes and ferns are all commonly used as part of wetland restoration projects. Species should be selected that are native to the area and well adapted to site conditions.

Trees:	Tamarack, Black spruce, Red maple, Silver Maple, Black ash
Shrubs:	Willows, Red-osier dogwoods, Nannyberry viburnum, Spiraea sp., High bush Cranberry, Bog birch, Blueberry, Buttonbush
Grasses:	American slough grass, Prairie cordgrass, Manna grasses, fowl bluegrass, rice-cut grass, Canada blue-joint grass
Forbs:	Marsh milkweed, Culver's root, Blue lobelia, Cup plant, Mountain mint, Grass-leaved goldenrod, Joe-pye weed, Boneset, Red-stemmed aster, Sneezeweed, Swamp aster, Marsh aster, Giant goldenrod, Giant-bur reed, Sweet flag, Wild iris
Sedges:	Tussock sedge, Bottlebrush sedge, Lake sedge, Slough sedge, Porcupine sedge, Pointed-broom sedge
Rushes:	Torrey's rush, Riverbulrush, Soft-stem bulrush, Spikerushes, Green bulrush, Soft rush, Three-square bulrush
Ferns:	Sensitive fern, Marsh fern

Source Recommendations - Most wetland species common to prairie potholes and river systems likely had a wider dispersal through waterfowl and water flow than many prairie species. As a result, a wider source distance may be appropriate for some species, but local resource staff should be involved in decision making about source distance. Calcareous fens are a rare plant community type in Minnesota, only very local sources should be used in and around calcareous fens.

Wet Meadow Restoration

Establishment - Wetlands are typically dormant seeded in the fall or seeded in spring after hydrology conditions have stabilized. An advantage of fall dormant seeding is that forb and sedge seed is allowed to stratify over winter. Most wetland seed is very small and should be planted near the soil surface, so it is common broadcast wetland seed. Emergent wetland species may be seeded but are also commonly planted on the edge of open water and allowed to move to deeper areas on their own.

Maintenance - Similar to prairies, wet meadow restoration also benefit from mowing during the first couple years of establishment, particularly in dry conditions where agricultural weeds may be common. Mowing should not be conducted where rutting and soil disturbance will occur. It is common to spot treat problematic perennial weeds such as reed canary grass and Canada thistle with herbicide. Aquatic safe herbicides and surfactants should be used in areas of standing water. Biocontrol is commonly used for purple loosestrife. Cattails may be controlled depending on project diversity and wildlife goals.

Information Sources -
Minnesota Wetland Restoration Guide www.bwsr.state.mn.us/publications/restoration_guide.html

Agricultural BMPs (Including Harvestable Perennials and Cover Crops)

There are a wide variety of agricultural BMPs designed to stabilize soils and promote water quality, including grass waterways, filter strips, windbreaks, cover crops and riparian buffers. In many cases, these projects are funded through federal and/or state programs. Primary goals of these projects are to stabilize soil, to filter and infiltrate stormwater, and to protect surface water and groundwater resources. In some cases, they may also provide wildlife cover and food sources.

There is also increasing interest in perennial crops that can be grown and harvested for biomass, livestock forage and feed, and, in some cases, food. Examples include switchgrass, native prairie grasses such as big bluestem and Indian grass, intermediate wheatgrass/Kernza (the harvestable seed), alfalfa, and other legumes such as clovers. These crops may replace conventional row crops or may be used as part of a rotation with corn or soybeans.

Site Selection – Agricultural BMPs should be targeted where they can make significant improvements in soil stabilization, water quality and protection of downstream resources. GIS mapping of watersheds and water quality monitoring data are useful tools for prioritization of projects. Local conservation staff play a key role in working with willing landowners in priority areas. To define the specific benefits of projects BWSR has developed calculators for soil and water quality benefits.

Achieving High Function - Deep rooted prairie grasses are often a major component of agricultural BMP plantings, as they have many stems, stand upright in flowing water, and their root systems help increase organic content in soil, prevent erosion and develop root channels that increase infiltration rates. The root systems of trees and shrubs can also effectively filter, intercept and absorb stormwater.

Forbs may not be an appropriate focus of planting if pesticide drift is a concern. Pollinators that are attracted to forbs may be negatively impacted when pesticide overspray occurs. Higher diversity buffers, including environmentally suitable annual, biennial and perennial species are commonly planted in areas of low pesticide use where project goals may include providing habitat for pollinators, birds and a wide range of other species, or to develop areas for future seed collection. The Minnesota Department of Agriculture oversees the state's Pesticide Applicator Licensing. NRCS Agronomy Technical Note 9 "Preventing or Mitigating Potential Negative Impacts of Pesticide on Pollinators Using Integrated Pest Management and Other Conservation Practices" as well as a BWSR fact sheet on Protecting Conservation Lands from Pesticides provide detailed information about methods to minimize impacts to pollinators.

Shorter lived cover crops such as annual ryegrass, winter cereal rye, buckwheat, oats, radish, field peas, etc. also play a key role in stabilizing soils in agricultural areas. Cover crops can substantially reduce wind and water erosion when the soil would otherwise be bare in early spring, fall or winter. Cover crops can improve water and soil quality by adding soil organic matter via more roots more of the time that holds plant available water and creates an open soil structure that promotes water infiltration, reducing runoff. Cover crops also protect groundwater quality by reducing or preventing nitrogen from leaching into the water table.

Key Plant Species - Agricultural BMPs tend to focus on trees and shrubs for windbreaks and some buffer plantings, and grasses and forbs for grass waterways, filter strips, critical area plantings, and riparian buffers. Species should be selected that are native to the area and well adapted to site conditions.

Shrubs:	Willows, Red-osier dogwoods, Gray dogwood, High bush cranberry, serviceberry, prairie plum, black cherry, chokecherry, wild rose
Grasses:	Big bluestem, Indian grass, Little bluestem, Switchgrass, Canada wild rye, Virginia wild rye, Slender wheatgrass, Kalm's brome, Prairie brome
Forbs:	Yellow coneflower, golden alexanders, New England aster, Maximillian sunflower, Prairie clovers, Bergamot, Mountain mint, Grass-leaved goldenrod, Showy goldenrod, Canada goldenrod, Stiff goldenrod, Penstemons, Canada milk vetch, Sneezeweed, Cup plant

Source Recommendations - The source requirements for native vegetation summarized in these guidelines should be followed for agricultural BMP projects, with the exceptions discussed below. Cultivars and certain varieties of native species (and non-native forage species) should not be used if the agricultural BMP is next to a remnant prairie (within 1/4 mile).

For BWSR funded projects, native vegetation should be the first priority for planting. However, local conservation professionals can make decisions about when non-native temporary covers (cover crops) can be used to stabilize soils. Harvestable perennials that are non-native and non-invasive can also be used as forage crops, as part of a conservation crop rotation, for grass waterways, and for required buffers. These species (including perennial rye grass, timothy, Kentucky bluegrass, orchard grass, smooth brome grass, red clover, alsike clover, white clover, etc.) can also be planted in buffers that will be hayed, grazed, or exposed to pesticides." Local conservation professionals are able to make decisions about use of these species, and should contact BWSR with questions, or when additional flexibility is needed. These non-native species are treated differently in these guidelines than other conservation practices, because they are typically introduced into small areas and commonly integrated into agricultural production systems where frequent disturbance or pesticide drift can harm pollinators and other wildlife species, and inhibit the establishment of native vegetation Invasive species, state Noxious Weeds and aggressive species, such as reed canary grass, sweet clover, Phragmites species and Miscanthus species cannot be used (see invasive species section of these guidelines).

Establishment - Drill seeding into fields that were in corn or soybeans is most commonly conducted for agricultural BMPs. Broadcast seeding followed by rolling may be conducted for areas inaccessible for seed drills. It is important that seed has good contact with the soil; some projects may need erosion control mulching or blankets to prevent erosion.

Maintenance and Harvest - Key steps to maintenance involve mowing annual and biennial weeds to 4-6 inches during the first couple years, as needed to provide sunlight and to decrease competition for seedlings; hand weeding or spot herbicide treatment of perennial weeds, and may involve prescribed burning to maintain diversity and to control woody species after establishment. Conservation grazing, and biocontrol of invasive species may also be long-term maintenance strategies. Haying for feed or bioenergy may be allowed by some conservation programs. Conservation plans may need to include information about the timing, frequency and mowing height for haying. Haying should be planned during times that will minimize impact to ground-nesting birds. The nesting season is generally considered to be between June 1 and August 1st in the north half of the state and between May 15 and August 1st in the southern half of the state (for state and federal programs). As a result, haying is commonly conducted in August or September.

Typical cutting heights of grass for haying are between 4-6 inches. Cutting at this height leaves more leaf area for rapid re-growth to rebuild root reserves for future growth and maintains stubble to filter stormwater. Cutting height should be increased if the cutting date is delayed, or if the site has a slow growth rate.

Mowing equipment can be a vector for the spread of weed seeds due to seeds becoming lodged on the mower, in dried clippings, or mud attached to equipment. It is important that seed be removed from mowing equipment before the mower is brought to a new part of a restoration site, or to a new project. To the extent possible, mowing should be conducted shortly before invasive plants flower to prevent them from setting viable seeds.

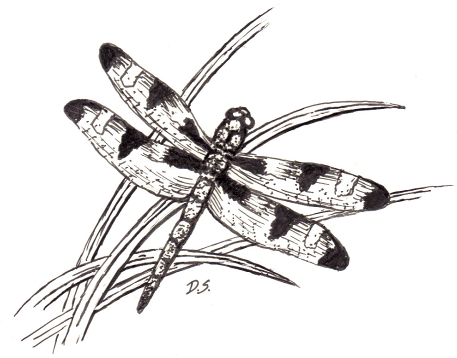
Forage or biomass production sites with a dominance of warm season native grasses are typically hayed once a year or every other year to allow for adequate growth of plant material. The re-growth is essential for rebuilding root reserves and for providing important nesting and wintering cover for grassland wildlife. The yield gained from a second cutting in one season will often reduce yields by the same amount the following year.

To avoid significant impacts to wildlife, it is recommended that no more than fifty percent of a field be hayed in any given year. This can dramatically improve production in the future and maintain adequate cover for wildlife habitat. It can also help maintain species diversity that otherwise might be lost by harvesting the same time each year. While a rest-hay rotation may seem inefficient, prairies managed under this scenario can produce as much tonnage from one-half of the prairie as when the entire prairie is hayed annually. The rested portion will often produce enough forage the year after resting to compensate for production lost the year of rest. Brushy vegetation will be less of a concern even in a rest-hay rotation, especially if prescribed burning is introduced. A rest-hay rotation will also help lower equipment and fuel costs for the operator.

Information Sources -

NRCS Field Office Technical Guide: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/fotg
Agricultural BMP Handbook for Minnesota (MN Department of Agriculture): https://bbe.umn.edu/agricultural-best-management-practices-handbook-minnesota
Buffer Toolbox [new link]
Buffer Program: What to Plant in Buffers

Stormwater Basins



Stormwater basins are often areas of high disturbance due to fluctuating water levels, pollutants and sedimentation that are associated with stormwater treatment. Plants are often needed that can handle these conditions such as floodplain forest species. More water tolerant species are commonly planted in the base of retention (open water) basins, while dry prairie, mesic prairie or woodland species are typically planted on side slopes. Basins that are typically dry detention basins need to be able to handle periods of wetness as well as periods of dryness, floodplain species are often well suited to these conditions. Stormwater basins are prone to invasion of weed species, so routine weed control is often needed.

Site Selection – Stormwater basins may be required along with other water quality management practices for new developments. Locations and sizing can be determined by subwatershed assessments and water quality modeling. Models commonly in use include Win SLAMM: the watershed runoff model, WAM: Watershed Assessment Tool, and AGWA: Automated Geospacial Watershed Assessment. Existing basins may also require updating and improvement. The size of basins generally depends on soils and the amount of impervious surfaces in a watershed but also will depend on the number of other stormwater management practices to be used, such as raingardens that will decrease flows to stormwater basins.

Achieving High Function - A key to achieving high function in stormwater ponds involves creating suitable conditions for species as they establish; and planting species that can thrive in the site conditions - as plants that are healthy will aid water infiltration, filtering, toxin remediation, and evapotranspiration. The design of forebays to capture the majority of sediment entering a system will help sustain plantings. The establishment of shallow water shelves will also promote emergent plant growth that can increase water treatment effectiveness. The base of retention basins typically are not planted as they will be too deep to sustain most commercially available species.

Urban stormwater basin

Medium diversity levels are often used for stormwater basin side slopes (10-30 species). A combination of native grasses and forbs on side slopes will help provide competition from weed species. The sides of stormwater basins can provide important habitat for pollinators so it is beneficial to plant species that will provide nectar and pollen sources through the entire growing season.

Key Plant Species - Stormwater basins are often planned in zones to aid species selection, establishment and maintenance. Species should be selected that are native to the area and well adapted to site conditions.

Upper Slope Grasses:	Big bluestem, Indian grass, Switchgrass, Slender wheat grass, Little bluestem, Canada wild rye, Kalm's brome, Fringed brome
Upper Slope Forbs:	Yellow coneflower, Black-eyed Susan, Golden alexanders, New England aster, Maximilian sunflower, Sawtooth sunflower, Prairie clovers, Spiderwort, Showy goldenrod, Canada milk vetch, Stiff goldenrod
Edge of Open Water	River bulrush, Wild iris, Sweet flag, Soft-stem bulrush, Three-square bulrush, Lake sedge
Dry Pond Base	(Grasses) Switchgrass, Rice-cut grass, Prairie brome, Fowl bluegrass, Virginia wild rye, (forbs), Golden alexanders, New England aster, Bergamot, Mountain mint, Grass-leaved goldenrod, Sneezeweed, Green-headed coneflower, Canada anemone

Source Recommendations - Stormwater basins are typically connected to downstream wetlands and other waterbodies, so species should not be used that may negatively influence downstream resources. It is also important that invasive species be controlled in stormwater basins to avoid downstream impacts.

Establishment - separate zones (upper slopes, edge of open water, etc.) are often planted differently as part of vegetation establishment. Upper slopes are typically drill seeded unless they are too steep, where they may be broadcast seeded and rolled or hydroseeded and rolled or harrowed. It is important that seed has good seed to soil contact on side slopes. The edge of open water is commonly planted with a combination of seed and containerized plants, or pre-vegetated mats; many emergent species will spread into deeper water. It is important that water levels do not raise above the height of establishing plants. Dry pond bases are typically grass dominated and seeded with native seed drills.

Maintenance - Key steps to maintenance involve mowing annual and biennial weeds to 4-6 inches during the first couple years as needed to provide sunlight and to decrease competition for seedlings; hand weeding or spot herbicide treatment of perennial weeds, and prescribed burning as applicable to maintain diversity and to control woody species after establishment. Biocontrol of invasive species such as spotted knapweed, leafy spurge and purple loosestrife may also be long-term maintenance strategies.

Information Sources -
Plants for Stormwater Design www.pca.state.mn.us/publications/manuals/stormwaterplants.html

Minnesota Stormwater Manual http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/stormwater-management/minnesotas-stormwater-manual.html

Raingardens and Biofiltration Areas

Urban rain gardens and biofiltration areas are typically small in size and are in front yards or other visible locations where aesthetics is a consideration. Engineered soils consisting of sand and compost are often used in raingardens and biofiltration areas to aid water infiltration and the base of these systems are designed to be flat; as a result, mesic prairie or woodland species are most adapted to the site conditions.

Site Selection – Subwatershed assessments and stormwater modeling are useful to aid raingarden site selection. The Recarga model is one that is commonly used. Local conservation staff play a key role in finding willing landonwers and projects that will have significant water quality benefits.

Achieving High Function - Deep rooted prairie grasses and flowers have been shown to increase infiltration rates in these systems over time, and should be a focus for projects. It is often beneficial to create a matrix of prairie grasses and then add desired forbs for large areas but to group species to aid in weed identification. Some plantings can also include woody plants, as they have extensive root systems that can have higher rates of evapotranspiration and may require less maintenance. Plantings with only shrubs have been established where little maintenance will occur. Stormwater plantings can be great places to support pollinator populations by planting species that will provide nectar and pollen sources through the entire growing season.

Key Plant Species - Trees, shrubs, grasses, forbs, sedges, rushes and ferns are all commonly used as part of wetland restoration projects. Species should be selected that are native to the area and well adapted to site conditions.

Shrubs:	Dwarf-bush honeysuckle, Black chokeberry, Winterberry Holly, Red-osier dogwoods
Grasses;	Switchgrass, Little bluestem, Indian grass
Forbs:	Butterfly milkweed, Marsh milkweed, Joe-pye weed, Cardinal flower, Blue lobelia, Culver's root, Liatris species, Narrow-leaf coneflower, Smooth aster, Panicled aster, golden alexanders, Wild iris
Sedges	Fox sedge, Bottlebrush sedge, Porcupine sedge, Tussock sedge
Rushes:	Soft rush, Path rush

Diversity - Often low to medium diversity levels (10-30 species) are often used due to a focus on aesthetics and water treatment. As long as the intended functions are being accomplished, diversity levels can be adjusted as needed. Species are sometimes grouped together in these plantings to aid weed identification by maintenance crews.

Source Recommendations - The source sequence outlined in these guidelines should be used for these systems, though additional native cultivars may be used in raingardens and biofiltration areas where aesthetics are a major consideration. Cultivars/varieties of native species should not be used if the project is connected to or directly drains into a wetland or other natural system.

Raingarden with a diversity of grasses, forbs and sedges

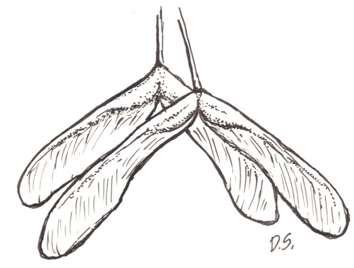
Establishment - Raingardens are commonly planted with containerized plants (often plugs) spaced 12-24 inches apart. Most plantings are mulched with double shredded hardwood mulch and watering is important to ensure the success of plantings.

Maintenance - Maintenance typically involves hand weeding every few weeks the first year or two followed by weeding about three times a year after plants are established. Removing sediment, ensuring proper function of berms and pipes and mulching are also periodic maintenance tasks.

Information Sources -

Plants for Stormwater Design www.pca.state.mn.us/publications/manuals/stormwaterplants.html
Plants for Stormwater Design Volume II
Blue Thumb Plant Selector http://bluethumb.org/plants/
Minnesota Stormwater Manual http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/stormwater-management/minnesotas-stormwater-manual.html

Lakeshores



Lakeshores are typically areas of high wildlife use and can play an important role for water quality improvement and slope stability.

Site Selection – Projects should be located where they will have the greatest functional water quality or habitat benefits (depending on program goals). When selecting projects for wildlife it is important to define specific species that will be targeted by the project. The Minnesota Wildlife Action Plan is a document that outlines a set of species of greatest conservation need for different areas of Minnesota. Fact sheets about habitat needs for specific species are also available. Buffers should be planned based on slopes, topography, watershed size, soils, vegetation cover, target wildlife species, adjacent corridors and natural areas, as well as landowner and partner input. Buffer widths should typically be a minimum of 30-100 feet landward of the ordinary high water level for water quality projects, and 100-330 feet for wildlife habitat projects depending on habitat needs of target wildlife species.
Buffers should also cover at least 75% of the shoreline lengthwise.

Achieving High Function - A variety of trees, shrubs, grasses, sedges and flowers can be used along shorelines to provide wildlife and water quality functions. Shrubs and various bioengineering techniques are sometimes used if there is a focus on stabilizing soils along steep banks.

Medium to high diversity levels (20-40+ species) are typically planted to provide habitat for a variety of wildlife species ranging from pollinators to amphibians, reptiles and bird species. To support pollinators species should be planted that will provide nectar and pollen sources through the entire growing season.

Key Plant Species - Trees, shrubs, grasses, forbs, sedges, rushes and ferns are all commonly used as part of shoreline restoration projects. Emergent species (plants that grow in and next to the water) can be an important component. Species should be selected that are native to the area and well adapted to site conditions. The Minnesota DNR's "Restore Your Shore" website is an effective tool for species selection.

Trees:	Tamarack, Black spruce, Basswood, Oaks, Maples, Hackberry, Birch, Cherries
Shrubs:	Willows, Dogwoods, Viburnums, Elderberry, Alder, Serviceberries, Prairie plum, High bush cranberry, Buttonbush, False Indigo
Grasses:	Prairie cordgrass, Manna grasses, fowl bluegrass, rice-cut grass, Canada blue-joint grass, Big bluestem, Indian grass, Kalm's brome, Prairie brome
Forbs:	Marsh milkweed, Butterfly milkweed, Culver's root, Blue lobelia, Cup plant, Mountain mint, Grass-leaved goldenrod, Joe-pye weed, Boneset, Red-stemmed aster, Swamp aster, Marsh aster, Giant goldenrod, Giant-bur reed, Sweet flag, Wild iris, Common ox-eye, Black-eyed Susan, Stiff goldenrod
Sedges:	Tussock sedge, Bottlebrush sedge, Lake sedge, Slough sedge, Porcupine sedge
Rushes:	Torrey's rush, Riverbulrush, Soft-stem bulrush, Spikeruses, Green bulrush, Soft rush

Source Recommendations - Local sources of seed and plants are recommended for shoreline projects, as these areas may have direct connections to natural plant communities where genetic interactions may be a consideration. The seed/plant source sequence outlined in the guide is recommended for shoreline projects.

Shoreline restoration with native grasses, forbs, sedges and rushes

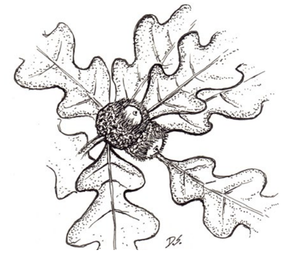
Establishment - A variety of techniques are commonly used to establish shorelines depending on slopes, moisture levels, and erosion. Seeding is commonly conducted in upland portions of projects, while containerized plants are typically used along the edge of open water for more rapid establishment. Biologs are commonly used along the water's edge to break the force of wave and to prevent erosions as plants establish. A variety of bioengineering techniques may also be used for eroding slopes.

Maintenance - Upland portion of plantings may be mowed during the first couple years to suppress annual and biennial weeds and promote seedling growth. Hand weeding is commonly conducted in smaller lakeshore plantings to control weeds. Spot herbicide treatment may be used for perennials such as reed canary grass but it is important that aquatic safe herbicides be used.

Information Sources -

A Soil Bioengineering Guide for Streambank and Shoreline Stabilization: www.fs.fed.us/publications/soil-bio-guide/
Restore Your Shore: http://www.dnr.state.mn.us/restoreyourshore/index.html

Forest/Woodlands



The goals of forest plantings can vary greatly from natural regeneration efforts following logging operations, to efforts to increase diversity in forest stands, to the seeding or planting of trees and shrubs into agricultural fields to establish forest stands.

Site Selection – Projects should be planned to meet functional goals for soil stabilization, water quality, and habitat. When selecting projects for wildlife it is important to define specific species that will be targeted by the project. The Minnesota Wildlife Action Plan is a document that outlines a set of species of greatest conservation need for different areas of Minnesota. Fact sheets about habitat needs for specific species are also available. Local forestry staff play a key role in providing site selection recommendations and developing forest stewardship plans.

Achieving High Function - Target species for forest/woodland projects will vary depending on the plant community being restored, and project goals for water quality, wildlife and lumber production. High diversity levels of 10 to 25 species are recommended for wildlife habitat focused projects. Diversity levels will often be limited by the number of species available that are suitable for a project site. Herbaceous species may also be planted at the same time as trees and shrubs if the site is transitioning from a disturbed conditions (agricultural field, etc.). Mix diversity will depend on site conditions and project goals. Relatively low diversity mixes may be used if woodland trees, shrubs, forbs, ferns, and grasses may re-establish at the project site. Appropriate species will vary depending on project locations. The Minnesota Department of Natural Resources nurseries are a good information source for species selection.

Key Plant Species - Species should be selected that are native to the area and well adapted to site conditions. As there is a wide variety of forest types in Minnesota the DNR Field Guides to Native Plant communities of Minnesota http://www.dnr.state.mn.us/npc/classification.html are a good resource for species selection. These guides will list the dominant tree, shrubs, grass, forb, rush, sedge and fern species for each community type.

Source Recommendations - Many forest nurseries document the seed source for their trees and shrubs, this is useful information for making decisions about suitable sources and to ensure that trees and shrubs that are planted will produce viable seed. Some nurseries can also contract grow trees and shrubs from seed or cuttings. The Minnesota Department of Natural Resource has developed seed zones for Minnesota that are widely used for determining appropriate seed sources: http://www.dnr.state.mn.us/forestry/ecs_silv/fieldpractices/seedcollection.html for forest projects.

Establishment - A variety of techniques are used for forest/woodland establishment. Seedling trees are commonly used with tree tubes or other protection from herbivores. Seeds of trees and shrubs planted into a prepared seedbed has also become a common practice for restoring large areas. After logging is conducted, natural regeneration is often the primary method of establishment, though additional species may be added to increase diversity or improve wildlife habitat.

Trees in protective plastic tubes

Maintenance - Maintenance often involves mowing around trees and shrubs so it is important that they are well marked and spaced far enough apart to allow for mowing. Mowing can also be conducted above the height of woody plants that have been planted as seed. Herbicide treatment may also be used around seedlings with herbicides that will not affect woody plants or by taking precautions to go around the seedlings. Cutting and treating stumps of undesirable woody plants such as buckthorn is also commonly conducted.

Information Sources –

DNR Forestry Website: http://www.dnr.state.mn.us/forestry/index.html

Plant Community Restoration

Plant community restoration refers to efforts to restore intact/remnant plant communities such as prairies, savannas and rare wetland communities. Restoration is often accomplished by removing invasive species, or restoring natural disturbance such as prescribed fire or natural hydrology conditions.

Site Selection – Intact native plant communities can degrade over time due to invasive species, lack of natural disturbance, changes in hydrology and other factors. As a result, restoration efforts may be needed to promote plant community resiliency and plant diversity. Projects are often selected based on the quality of plant communities, how rare individual communities are, and the threat posed by invasive species or other impacts. Local resource managers and ecologists play a key role in prioritizing restoration areas and prescribing restoration methods.

Achieving High Function - A common goal of plant community restoration is to increase ecological function through removing invasive species and increasing the diversity and cover of native plant populations. Some efforts focus on improving wildlife habitat for rare and declining species and may involve the restoration of key plant species that are important for wildlife.

Diversity goals typically focus on restoring diversity to levels that are characteristic of high quality communities. The diversity of natural communities can vary significantly with some marsh communities having relatively low diversity, and mesic prairies having around 200 species.

Remnant prairie in the blufflands of Goodhue County

Key Plant Species - The species growing at project sites or species that may establish from the seedbank after restoration efforts are the focus for native plant community restoration projects. It is uncommon to bring new species to plant community restoration sites unless specific species are missing that play a key role for a plant community integrity or wildlife habitat (such as introducing lupine for Karner blue butterfly habitat).

Source Recommendations - If seeding will be conducted as part of a restoration effort there should be a focus on collecting seed from the restoration site or intact communities nearby the site. In some cases, seed is obtained from ecological subsections, particularly if species are being re-introduced to a community.

Establishment and Maintenance - Methods of managing native plant communities can vary depending on the community type and the natural disturbance that is part of that community. Prescribed fire is an important management tool for fire dependent communities such as prairies, savannas and some woodlands. Removal of invasive species through a variety of methods is also a common technique to allow native vegetation to thrive. A long-term approach is needed to effectively manage native plant communities.

Information Sources –

Minnesota Wetland Restoration Guide www.bwsr.state.mn.us/publications/restoration_guide.html
Going Native, A Prairie Restoration Guide for Minnesota Landowners
www.dnr.state.mn.us/eco/pubs_restoration.html

Temporary Cover for Restoration

Temporary covers are used in a wide variety of situations related to conservation plantings. In some cases, cereal grains may be planted to stabilize sites in preparation of seeding permanent seed mixes. In other cases, perennial native grasses are planted in low diversity stands to stabilize construction areas to prepare sites for adding more species after weeds are controlled, or to allow for the colonization of native trees and shrubs, such as floodplain forest restorations where species such as switchgrass or Virginia wild rye are planted to stabilize the site. Annual species such American Slough grass can also be used to stabilize areas to be established with shallow and deep marsh plant communities or where native seedbanks will aid establishment.

Site Selection – The decision about whether to use temporary cover crops should be based on whether their use will aid in reaching project goals by decreasing erosion, providing weed competition and promoting the germination and growth of seedlings.

Canada wild rye providing temporary cover

Achieving High Function - The goal of temporary stabilization involves promoting sufficient establishment of grass species to hold soil and prevent sediment loss while creating good conditions (such as allowing microbial populations to increase) for native vegetation establishment. Once additional species are added to (or colonize) a site additional wildlife and plant community functions can be attained.

Key Plant Species - Annual and perennial grasses as well as perennial legumes play a key role in providing temporary cover

Cereal grain annual grasses:	Oats (Avena sativa), Winter wheat (Triticum aestivum)
Non-native annual legumes:	Field peas (Pisum sativum)
Perennial Grasses:	Big bluestem, Side oats grama, Fringed brome, Nodding Wild Rye, Slender Wheat grass, Virginia wild rye, Switch grass, Fowl bluegrass, Indian grass
Perennial legumes:	Canada milk vetch, Partridge pea, American vetch

Source Recommendations - The source sequence included in this guide is recommended for temporary cover plantings, particularly if perennial species are planted near natural communities. Source is less of a concern for short lived native species that are used for stabilization such as cereal grains.

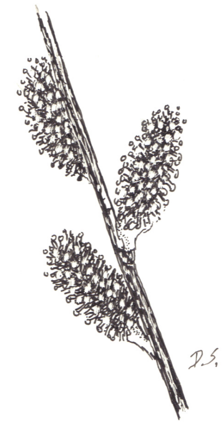
Establishment - Seeding with agricultural seed drills or broadcast seeders in fields that were in corn or soybeans is commonly conducted to aid establishment of cover species.

Maintenance - Little maintenance is typically needed in established temporary cover plantings. The use of temporary covers can be an effective method of spotting and treating perennial weed problems before permanent native seed mixes are seeded.

Information Sources –

Minnesota Wetland Restoration Guide www.bwsr.state.mn.us/publications/restoration_guide.html

Streambank Stabilization



Stabilization of stream banks and river banks has been part of many projects in Minnesota focused on decreasing soil loss, preventing damage to infrastructure, improving water quality, and improving wildlife habitat. Thorough assessments are needed for streambank projects- investigating geology, soils, existing vegetation, flow velocities, normal high water levels, extent of the project floodplain, and use of the watercourse. Various engineering or bioengineering solutions are often needed in addition to revegetation strategies for areas with severe erosion. As each reach of a stream is unique, streambank protection techniques must be selected on a site by site basis and often require the involvement of technical specialists. Streams are dynamic and constantly changing, so it is important to note that not all areas of erosion are in need of repair. Also, additional measures may be needed in the watershed to address hydrologic fluctuations that are stressing streams.

Engineering solutions may include the installation of rock (and underlying fabric) to secure the toe of the slope, or regrading to direct stormwater flows or to decrease the steepness of the bank. Bank stability will vary depending on soil type with stability being reached in clay soils with slopes around 1:1, and in sandy soils stability is reached with slopes of 2-4:1. Erosion usually occurs at the outside bank of a stream bend where the water velocity is the highest, so rock may be used along the toe of the slope for the entire bend. Bioengineering techniques can include branch packing, brush layering, brush mattresses, live fascines, toe wood sod mats, and live stakes. A variety of methods may be used to plant steep slopes along streambanks including hydroseeding, broadcast seeding, tree plantings, and promoting natural succession. Erosion fabrics are often needed in combination with seeding to ensure good seed to soil contact, to prevent the loss of seed, and to hold moisture. A combination of fast establishing species, and species that will persist into the future are typically used for slope stabilization. Deep rooted plants are also needed to promote future slope stability.

Bank stabilization with cedar revetments and erosion fabric along the St.Croix River

Site Selection – Program and project goals should be reviewed as a first step for site selection, Projects for streambank restoration are commonly selected based on identified threats to human safety, infrastructure and homes, impairment of water quality and wildlife habitat needs. Streambank projects may be part of efforts to widen habitat corridors that can provide multiple landscape benefits. Before a project is started the watershed should be assessed to determine the factors that may influence the success and sustainability of the project. The assessment can also help identify the highest priority areas along a waterway. As stabilization efforts can be costly it may be beneficial to start at the head of the stream and work downstream. Some projects also focus on stabilizing the toe of the slop along larger areas and letting the upper slope naturally re-vegetate, though this can lead to invasive species dominance.

Achieving High Function - The goal of slope stabilization is to provide rapid establishment as well as long term slope integrity. Fast growing species are often used to ensure initial stability. More long lived and deep rooted species are used for long term stability. Native legumes that add nitrogen and promote plant growth are also commonly planted and can have an added benefit of supporting pollinators. Many trees and shrubs can play an important role in providing long-term slope stability. Species with tap roots such as bur oak, hickory, pines and walnut can be effective at anchoring slopes. Species such as willow and dogwoods that establish from cuttings can also be used as part of bioengineering methods (branch packing, brush layering, brush mattress, live fascines, live stakes, etc.). Sufficient moisture in needed for establishment of vegetation on steep slopes so supplemental watering is typically needed.

Key Plant Species -A combination of fast growing native species, deep rooted species, legumes, trees and shrubs are commonly used for bank stabilization.

Cover Crops	Oats (Avena sativa), Winter wheat (Triticum aestivum)
Fast growing native grasses and forbs:	Side oats grama, Fringed brome, Nodding Wild Rye, Slender Wheat grass, Virginia wild rye, Fowl bluegrass,
Long lived deep rooted native grasses:	Big bluestem, Indian grass, Switch grass, Little bluestem, Hairy grama, Blue grama, Western wheat grass, Prairie dropseed
Long lived deep rooted native forbs:	Liatris, Coreopsis, Coneflowers, Asters, Sunflowers, Showy goldenrod
Native legumes:	Canada milk vetch, Partridge pea, American vetch, Prairie clovers, Lupine
Deep rooted native trees and shrubs:	Bur oak, White Oak, Northern pin oak, Red oak, Walnut, Butternut, hickory, Red oak, Basswood, Pines, Ironwood, Blue beach, Hazelnut, Paper birch, Hackberry, Hawthorn, Red cedar, Black cherry, American basswood
Plants that establish from cuttings:	Dogwoods, Willows, Viburnum

Source Recommendations - The source sequence included in this guide is recommended for bank stabilization projects, particularly if perennial species are planted near natural communities. Source is less of a concern for short lived cereal grains, and native cover species that are used for stabilization such as wild ryes and slender wheatgrass.

Establishment – Engineering solutions such as the installation of rock or re-grading are typically conducted as a first step in slope stabilization, followed by bioengineering practices. Upland portions of restored slopes are typically broadcast or hydroseeded, as they are often too steep for seed drills. Seed to soil contact is very important for successful establishment, so the use of rollers or erosion control fabric to cover seed will aid establishment. Very steep eroding banks can be very difficult to stabilize. In some cases, slopes can be re-graded to decrease steepness. If re-grading is not possible, willow cuttings can sometimes be inserted from the base of the slope. Hydroseeding may also be an option where seed and water is simultaneously blown onto slopes followed by a tackifier to improve seed to soil contact. Plants that can germinate and grow on dry slopes should be a priorty for these types of plantings. Trees and shrubs are commonly planted into slopes to aid stabilization and establishment.

Steep bank stabilized with flowers, grasses and erosion fabric

Maintenance - Upland portions of plantings may be mowed with mechanical or hand held equipment during the first couple years to suppress annual and biennial weeds and promote seedling growth. Hand weeding is conducted in some smaller plantings to control weeds. Spot herbicide treatment may be used for perennial weeds, but it is important that aquatic safe herbicides are used when applying next to water. Supplemental watering is often necessary on steep slopes to support the growth of trees and shrubs and herbaceous plant seedlings. A water truck with a fine spray nozzle may be needed to spray water from the top of steep slopes. Fencing or signage may be needed to minimize foot traffic as vegetation establishes. Streams are subject to changes over time so periodic monitoring is needed to ensure the future success of projects.

Information Sources

Slope and Site Stabilization http://www.pca.state.mn.us/index.php/view-document.html?gid=7421
A Soil Bioengineering Guide for Streambank and Shoreline Stabilization www.fs.fed.us/publications/soil-bio-guide/
Restore Your Shore http://www.dnr.state.mn.us/restoreyourshore/index.html
Minnesota Soil Bioengineering Handbook, Minnesota Department of Transportation, 1999.

Ravine Stabilization

Stabilization of eroding ravines and bluff slopes requires detailed analysis of watershed and site conditions and often involves both engineering strategies as well as re-vegetation strategies. In addition to the reduction of sediment loss, restoration of severely eroded areas often provide important water quality and wildlife habitat benefits. Stormwater runoff is the biggest source of ravine erosion, so it is important that sources of water from agricultural fields and developed areas be managed with appropriate best management practices such as vegetated buffers, raingardens, biofiltration, and stormwater detention before vegetation establishment practices are implemented. Engineering solutions often involve re-grading to decrease the angle of slope, the use of rock to stabilize the toe of the slope, as well as a variety of solutions to manage water flow including terraces, swales, pipes and check dams. A variety of methods may be used to plant steep eroding slopes including hydroseeding, broadcast seeding, tree plantings, and promoting natural succession. Erosion fabrics are often used in combination with seeding to prevent erosion, ensure good seed to soil contact, prevent the loss of seed, suppress weeds and maintain soil moisture. A combination of fast establishing species, and species that will persist into the future is often needed for slope stabilization. Deep rooted plants are also needed to promote future slope stability. Early successional trees such as elm, boxelder, ash, cottonwood and buckthorn are sometimes removed from the edges of ravine restoration projects to allow access of earth moving equipment and to allow sufficient light levels to promote seedling germination and growth but tree removal should be limited to the extent possible to prevent further erosion.

Site Selection – Ravine restoration projects are often selected based on identified threats to human safety, infrastructure, homes, and impairment of water quality. When multiple eroding ravines are being assessed for water quality projects, potential sediment reduction, cost-effectiveness and long-term sustainability are important considerations.

Achieving High Function - Goals of slope stabilization involve providing rapid establishment, as well as long term slope integrity. Fast growing species are often used to ensure initial stability. More long lived and deep rooted species are used for long term stability. Native legumes that add nitrogen and promote plant growth are also commonly planted and can have an added benefit of supporting pollinators. For severely eroding slopes non-native legumes such as red clover and alfalfa that establish quickly and have deep root systems are sometimes used in combination with native species to add nitrogen and anchor the slope with deep roots, though the proportion of these species should be carefully considered in mixes to ensure that they do not out-compete native species that are planted. In many cases, these non-native species will decrease in abundance as woody plants establish in ravines or riverbanks. Many trees and shrubs can play an important role in providing slope stability. Species with tap roots such as bur oak, hickory, pines and walnut can be effective at anchoring slopes. Species such as willow and dogwoods that establish from cuttings can also be used as part of bioengineering methods (branch packing, brush layering, brush mattress, live fascines, live stakes, etc.). Slopes may be heavily compacted after the earthwork is completed.

Key Plant Species -A combination of fast growing native species, deep rooted species, legumes, trees and shrubs are commonly used for ravine stabilization.

Cover Crops	Oats (Avena sativa), Winter wheat (Triticum aestivum)
Fast growing native grasses and forbs:	Side oats grama, Fringed brome, Nodding wild rye, Slender Wheat grass, Virginia wild rye, Fowl bluegrass,
Long lived deep rooted native grasses and forbs:	Big bluestem, Indian grass, Switch grass, Little bluestem, Hairy grama, Blue grama, Western wheat grass, Prairie dropseed
Native legumes:	Canada milk vetch, Partridge pea, American vetch, Prairie clovers, Lupine
Deep rooted native trees and shrubs:	Bur oak, White Oak, Northern pin oak, Red oak, Walnut, Butternut, Hickory, Red oak, Basswood, Pines, Ironwood, Blue beach, Hazelnut, Paper birch, Hackberry, Hawthorn, Red cedar, Black cherry, American basswood
Plants that establish from cuttings:	Dogwoods, Willows, Viburnum

Source Recommendations - The source sequence included in this guide is recommended for slope stabilization projects, particularly if perennial species are planted near natural communities. Source is less of a concern for short lived cereal grains, and native cover species that are used for stabilization such as wild ryes and slender wheatgrass.

Ravine stabilized with stone, seeded grasses and flowers and planted shrubs

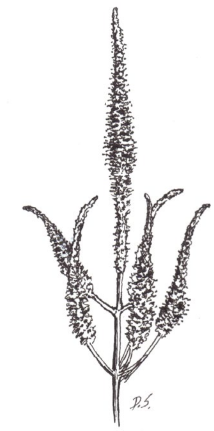
Establishment - Upland portions of restored slopes are typically broadcast or hydroseeded, as slopes are too steep for drill seeding. Seed to soil contact is very important for successful establishment, so the use of rollers or erosion control fabric to cover seed will aid establishment. For steep portions of slopes hydroseeding may be the most viable seeding option. Seed should be applied to slopes with water followed by the application of a tackifier to aid seed to soil contact. Trees and shrubs are commonly planted into slopes (in areas where trees and shrubs would have historically occurred) to aid stabilization and establishment. It is important that compaction is loosened in planting holes as trees and shrubs are planted to allow their roots to spread.

Maintenance - Upland portion of plantings may be mowed with mechanical or hand-held equipment during the first couple years to suppress annual and biennial weeds and promote seedling growth. Hand weeding can be conducted for smaller patches of weeds. Spot herbicide treatment may be used for perennial non-native plants but it is important that aquatic safe herbicides be used near water. Supplemental watering may be needed for seeding herbaceous and woody plants. A water truck with a fine spray nozzle may be needed to apply water from the top of the slope.

Information Sources –

Slope and Site Stabilization http://www.pca.state.mn.us/index.php/view-document.html?gid=7421
A Soil Bioengineering Guide for Streambank and Shoreline Stabilization www.fs.fed.us/publications/soil-bio-guide/
Restore Your Shore http://www.dnr.state.mn.us/restoreyourshore/index.html
Ravine Restoration Toolkit http://www.greatlakes.org/document.doc?id=1370

Appendix A. Recommended Steps for Obtaining and Documenting Plant Materials:



1) Determine the Project Type (Native Prairie Reconstruction; Wetland Restoration; Agricultural BMPs; Stormwater Basins; Urban Raingardens and Biofiltration Areas; Shorelines; Forests/Woodlands; Native Plant Community Restoration etc.)

2) Analyze the project site (topography, soils, hydrology, precipitation, elevation, drainage, aspect, sun/shade, climate, habitat needs, existing native plants, native seedbank potential, invasive species, erosion problems, other environmental stressors, etc.). Also investigate surrounding land uses, and populations of native and non-native species

3) Set project functional goals (soil stabilization, water quality, wildlife habitat, diversity, native plant community restoration, etc.).

4) Determine the site preparation, installation and maintenance restoration strategies that will be used to establish native vegetation including the use of native seedbank and local seed collection. Refer to restoration publications as needed such as the "Minnesota Wetland Restoration Guide" www.bwsr.state.mn.us/publications/restoration_guide.html , "Restore Your Shore" http://www.dnr.state.mn.us/restoreyourshore/index.html or other design resources).

5) Develop a restoration schedule, and determine when plant materials are needed.

6) Determine an appropriate diversity level, and list of plant species/materials needed.

7) Work with project partners to determine the best way to find local, and site appropriate plant materials (local seed collection/harvest, seedbank, purchasing from local seed/plant vendors etc.). Look at the project location in relation to state seed zones Use the seed zone map and source sequence as guidance for obtaining seed.

8) Develop or select seed mixes that are needed for the project. Factors that will influence seed mix development include: availability of local harvested seed, native seed bank potential, state seed mixes and substitution tables, and seed availability from vendors. If local locally harvested seed will be used, pure seed must be tested and "germination", "hard seed" and "Pure Live Seed" information provided on seed tags for all species that are required through a program or project diversity standard. Supplement locally harvested seed mixes as needed to meet diversity, or quantity requirements. When purchasing standard mixes, investigate availability of yellow-tag seed (http://www.mncia.org/).

9) Obtain multiple bids that include specifications for plant materials and use the BWSR best value calculator to factor both cost and source into bid selection. Revise seed mixes or project sequencing as needed based on availability of seed and plants. It is recommended that project managers print, sign, date and file the final approved species list.

10) Upon installation, keep seed tags (showing origin).

Appendix B. Definitions:

Allele – A variant (one of two or more forms of a gene) of the DNA sequence at a given locus (location of a gene or DNA Sequence on a chromosome).

Cultivar – A cultivated plant that has been selected and given a unique name because of desired characteristics and when propagated (usually vegetatively) retains those characteristics.

Generation 0 – Seed harvested from remnant prairie tracts that will be used to grow new plants (G1). Generation 0 seeds are considered genetically unaltered by human activity and the collection site should be in a natural state. Generation 0 seed has not been through an intentional selection process and its origin is generally definable by a geographic location from which the seed is collected.

Generation 1 - Seed harvested from fields reconstructed with source-identified Generation 0 seed.

Genetic contamination – Loss of native plant population fitness due to the addition of non-local genes into native populations via pollen, seed or plant material.

Genetic sensitivity – The sensitivity of an individual species to inbreeding, loss of adaptation or out-breeding depression.

Genotype – The genetic makeup of a cell or organism (the allele makeup of an organism).

Germplasm – The hereditary material that is transmitted from one generation to another.

Hard seed–- Seeds that remain hard at the end of the prescribed test period because they have not absorbed water due to an impermeable seed coat.

Herbicides – Chemicals that are used to target and kill plant species.

Inbreeding – The breeding of related individuals within an isolated or a small population of plants, sometimes leading to decreased genetic diversity and fitness.

Insecticides – Chemicals that are used to target and kill insects.

Locus – The specific location of a gene or DNA sequence on a chromosome. A variant of the DNA sequence at a given locus is called an allele.

Native Plant Community Restoration or Reconstruction. Re-establishment of a native plant community, such as a prairie, wetland or forest, using seeds, seedlings, cuttings, or transplants on a site. Reconstructions are typically defined as sites with little/no actively growing remnant vegetation. Restorations augment degraded remnants by replacing missing species and/or species abundance. The aim of restoration or reconstruction projects is to replicate ecologically complete historic native plant communities; re-establish wildlife and aquatic habitat by returning elements of a site's natural ecological structure and composition; and/or restore ecological components of native forest communities.

Out-breeding depression – When offspring from crosses between individuals from two different plant populations have lower fitness than progeny from crosses between individuals from the same population.

Pesticides – Chemicals that are used to kill living organisms such as fungus, bacteria, insects, plant diseases, slugs, or weeds.

Plant fitness – An individual's contribution of young to later generations, measured by longevity and reproductive success.

Prairie reconstruction – The establishment of prairie species on a site that contains no actively growing remnant vegetation; such as an agricultural field or lawn.

Provenance – **T**he geographic sources where the seeds/plant material naturally originated.

Pure live seed (PLS) – The measurement of the amount of seed that germinates in a standard (14 day) germination test, plus the amount found to be alive from a viability (tz) test. PLS is determined by multiplying the percent germination success by the purity of seed.

Pure seed – Seed exclusive of inert matter and all other seeds not of the kind of seed being considered as defined by the rules for testing seeds of the Association of Official Seed Analysts.

Remnant – Fragment of a climax plant community that remains from a former period, typically before European settlement.

Resilient Native Plant Communities. Those communities which have the ability to absorb or adapt to the effects of climate change or other external forces and continue to function, although possibly in different ways or with a different suite of species than in a prior state. The resilience of a native plant community often depends on the degree of genetic variation that resides within the species which comprise that community.

Seed Transfer Zone – The geographic range in which a given plant population will likely thrive, based on variables such as soils, topography, geology, precipitation, and temperature range.

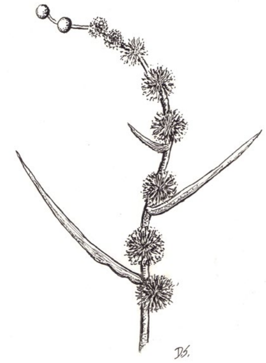
Selected traits – Traits that are promoted intentionally or in some cases unintentionally such as height, flower color, form, leaf color, forage quality and leafiness.

Variety – A taxonomic subdivision of a species consisting of naturally occurring or selectively bred populations (usually propagated by seed) or individuals that differ from the remainder of the species in certain minor characteristics.

Wild harvest – Seed that is harvested from remnant native plant communities.

Yellow tag seed – Source identified seed that is comprised of the least selected germplasm for a species. The location where the material was originally collected from native stands (genetic origin) is indicated on the certification label.

Appendix C. Literature Cited



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