SECTION

5 Vegetation Establishment

The Vegetation Establishment Section of the Minnesota Wetland Restoration Guide provides a comprehensive approach to establishing native vegetation in restored and created wetlands and surrounding upland areas. The chapters in this section of the Guide include detailed information about the steps involved in establishing plant communities from developing a vegetation plan to project implementation and maintenance.

The practice of establishing wetland and buffer vegetation has evolved as project goals have changed and as restoration professionals gain a better understanding about how to establish and manage native plant communities. In recent years, there has also been a greater emphasis on maximizing landscape function: including the creation of stable habitat for a wide variety of species, providing competition for invasive plants by diversifying plant communities, and providing benefits for soil and water resources. Expanding project goals to include landscape-level functions has led to the development of new techniques to manage invasive species, plant upland and wetland vegetation, and provide long-term care.

Figure 5.1

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A primary goal of the Vegetation Establishment Section of the Guide is to provide information on current methods to restore vegetation in wetlands and surrounding uplands. The information provided is intended to inform practitioners about their options, so they can achieve project goals and ultimately advance the field of wetland restoration. The section provides detailed information about a wide range of strategies used in the restoration of upland and wetland plant communities.

It is important to keep in mind that every wetland restoration and creation project is unique. Several different strategies may exist to accomplish the desired project functions. Project goals, program requirements, personal preference, and available funding are all important considerations. The recommendations and project schedules provided for each strategy in this guide should be considered as a starting point in the planning process and be adapted as needed to meet project goals and objectives.

The practice of vegetation establishment is constantly evolving. Input regarding information in this section of the Guide will be welcomed; it is intended that the information will be updated as new research and practitioner information is obtained.

Section 5 Technical Guidance Documents

5-1 Vegetation Establishment Overview

Figure 5.2 *Lake Sedge*

The establishment of diverse wetland and upland plant communities is an important component of a healthy, functioning restored wetland. To be successful, the vegetation establishment process requires a thorough assessment of the project site, and a well coordinated approach for project planning, implementation and maintenance.

This chapter includes an overview of key concepts for restoring wetland and buffer vegetation. Many of the topics covered are "big picture" considerations such as project planning considerations, approaches for different wetland plant communities, and project phasing. This information will influence how the vegetation plan is developed and implemented. While reviewing this information, it is may be helpful to make notes about topics that relate to an individual project for incorporation into the vegetation plan.

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The following topics are included in this chapter:

- **Vegetation Goals**
- **Project Planning**
- **Vegetation Establishment Strategies**
  - *Site Preparation*
  - *Seeding and Planting*
  - *Maintenance*
- **Plant Community Types**
  - *Wetland Buffers (Uplands)*
  - *Sedge Meadows, Fresh (Wet) Meadows and Wet to Wet-Mesic Prairies*
  - *Shallow Marshes, Deep Marshes and Shallow, Open Water Communities*
  - *Shrub Swamps and Wooded Swamps*
  - *Peatlands*
- **Special Project Types**
  - *Wetland Creations*
  - *Wetland Enhancements*
- **Plant Materials**
  - *Propagule types and sources*
  - *Plant Selection*
- **Project Sequencing**
  - *Project Timing/Sequencing*
  - *Weed/Invasive Species Management*
  - *Site Cover and Stabilization*
  - *Establishment Phasing*

Vegetation Goals

Every wetland restoration or creation project should have unique, well defined goals that will influence the scope of the project and the strategies (restoration techniques) that will be used to establish vegetation. These goals should be defined early in the planning of the project and should be consulted throughout the restoration process. Typical project goals that can influence vegetation establishment needs of a project include:

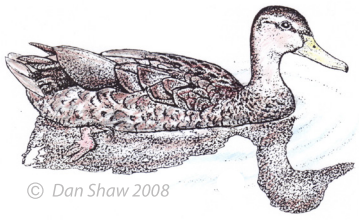
- Maximize habitat benefits for wetland/upland wild life species
- Improvement of water quality
- Soil and water conservation
- Replacement of lost wetland functions
- Increase diversity of upland/wetland plant species
- Establish plant communities that can compete with invasive species and
- Propagate local sources of plant species.

Figure 5.3 *Giant Bur-reed*

Figure 5.4

Project Planning

This section of the Guide is focused on providing information to effectively plan projects and develop vegetation plans. The site analysis of projects that was covered in Section 3 of the Guide is an important component of project planning, ensuring that information is collected about conditions of the site and surrounding landscape that may influence the project. As part of the planning process it is important to select restoration strategies for project site preparation, planting and maintenance that will attain project goals while making efficient use of program or project funds that are available. Information in this section of the guide is intended to help designers think through all of the potential strategies that could be used for a project and to select strategies that will work efficiently together. Information is also included about how to incorporate information about restoration strategies into a vegetation establishment plan. Budgets should be considered through all stages of the project. As part of project



planning it is important to consider how the project budget will influence appropriate strategies for project implementation, monitoring and maintenance. Related to budget, it is useful to think about additional resources that could be brought to a project such as additional funding through grants, the use of seed collected from pertaining organizations, the trading of restoration services, and the use of donated materials. Minnesota has a long history of partnerships that focus on collaboration to strengthen conservation efforts.

Vegetation Establishment Strategies

Strategies refer to individual restoration techniques that can be applied to a project; examples include herbicide application, drill seeding, and mowing. Strategies chosen for site preparation, planting, and maintenance will define how work will be conducted at a project site. Plan all phases of a project to work together and ultimately meet project goals. An overview of the more general vegetation establishment stages follows, with more specific and detailed strategy discussions occurring in the site preparation, planting, and maintenance chapters that follow.

Figure 5.5 *Tilling, Photo by Prairie Restorations, Inc.*

Site Preparation

The success of many projects can be attributed to the effort and methods used to prepare a site for planting. Proper site preparation is essential. The strategies for site preparation involve methods to eliminate undesirable plants and prepare the site soils for planting. Invasive species can be a significant impediment to the establishment of native vegetation. Strategies to remove or control them take careful consideration. Reed canary grass, in particular, has been a significant hurdle for many projects in Minnesota. It it is a component of many wetlands in the state and once established it is very difficult to remove. When invasive species are present in a wetland, decisions need to be made as to whether the project can be successful. If they cannot practicably be removed or can easily re-enter a site after their removal, the feasibility of the project and its goals need to be reassessed. Specific site preparation strategies are discussed and included in **Section 5-3 - Site Preparation**. Those strategies include clearing and grubbing, sediment removal and scraping, vegetation removal for site preparation, seedbed preparation, planting temporary cover crops, mulching and stabilizing plantings, and native seed collection and storage.

Planting

Planting strategies include the consideration and selection of seed mixes and plant materials along with the various methods available to plant and stabilize a project site. Planting strategies are included in the Guide for both uplands and wetland areas. Successful wetland restoration and creation projects consider all available strategies for establishing vegetation and manage the implementation of those strategies with respect to the goals, objectives and outcomes of the project as well as the implementation timeframe. This includes coordination with any on-site construction activities that are planned along with the expected timing of hydrology being restored to the site.

Section 5-4, Establishing Upland Vegetation includes specific strategies for establishing vegetation on upland areas including; upland seeding, planting upland (Non-woody) containerized plants and rootstock, planting upland trees and shrubs, and promoting beneficial soil microorganisms.

Figure 5.6 *Planting Containerized Plants*

Section 5-5, Establishing Wetland Vegetation includes specific strategies for establishing vegetation in wetland areas including; promoting native seedbank, wetland seeding , planting wetland (Non-woody) containerized plants and rootstock, planting wetland trees and shrubs, peatland restoration and wild rice seeding.

Section 5-6, Selecting Seed and Plant Materials includes discussion on the development of seed mixes and the selection of seed and plant materials for a project. including; general seed and plant material considerations, seed mix selection, seed mix standards, seed mix development, selecting plants, and seed and plant placement.

Monitoring and Maintenance

Figure 5.7

Frequent site visits to monitor the establishment of vegetation are essential to controlling the establishment of weeds and invasive species. The most successful projects tend to have well-timed monitoring and rapid treatment of invasive species.

Controlling weeds is essential to the success of any project, particularly during the first three to five years after vegetation establishment as desired plant species are beginning to germinate and develop. It is important for every project that vegetation maintenance is planned and that funding is set aside or made available for this work. Specific short term maintenance strategies are discussed and included in **Section 5-8, Maintenance for Vegetation Establishment**. Those strategies include protecting plants from herbivores, and promoting plant germination and growth.

Restoration projects should be planned to sustain the restored community into the future. Problematic plants in the watershed may influence future maintenance needs. Weeds will always be a threat to the restoration site, particularly if there is a disturbance that allows for their establishment. The development and adherence to long-term maintenance schedules provides direction, establishes budgeting needs for projects, and ensures that project goals will continue to be met. Long term strategies for maintenance and management of both upland and wetland vegetation is discussed in **Section 6 – Project Monitoring, Maintenance and Management. Appendix 5-A** provides specific guidance and management schedules for invasive species common to restored wetlands. The information for individual species can be useful in the development of maintenance schedules.

Plant Community Restoration

The identification of historic wetland types and associated plant communities, along with some understanding of the extent that these areas can be hydrologically restored, should have some influence on the plant communities that should be planned for a site. The plant communities that previously existed at a site should be the goal for most restoration projects, as the on-site soils, hydrology, and other environmental conditions will be best suited to support the establishment of these same historic communities. There are cases where existing and restorable conditions are no longer conducive to the historic community due to changes in soils, hydrology, or surrounding land use. Other communities that are better adapted to these modifications should be considered.

During the site assessment and evaluation phase of the project, a concept plan of some type should have been developed that identified locations and types of preiminary plant communities for the site. As the actual vegetation plan is now ready for development, the type and location of plant communities should be refined

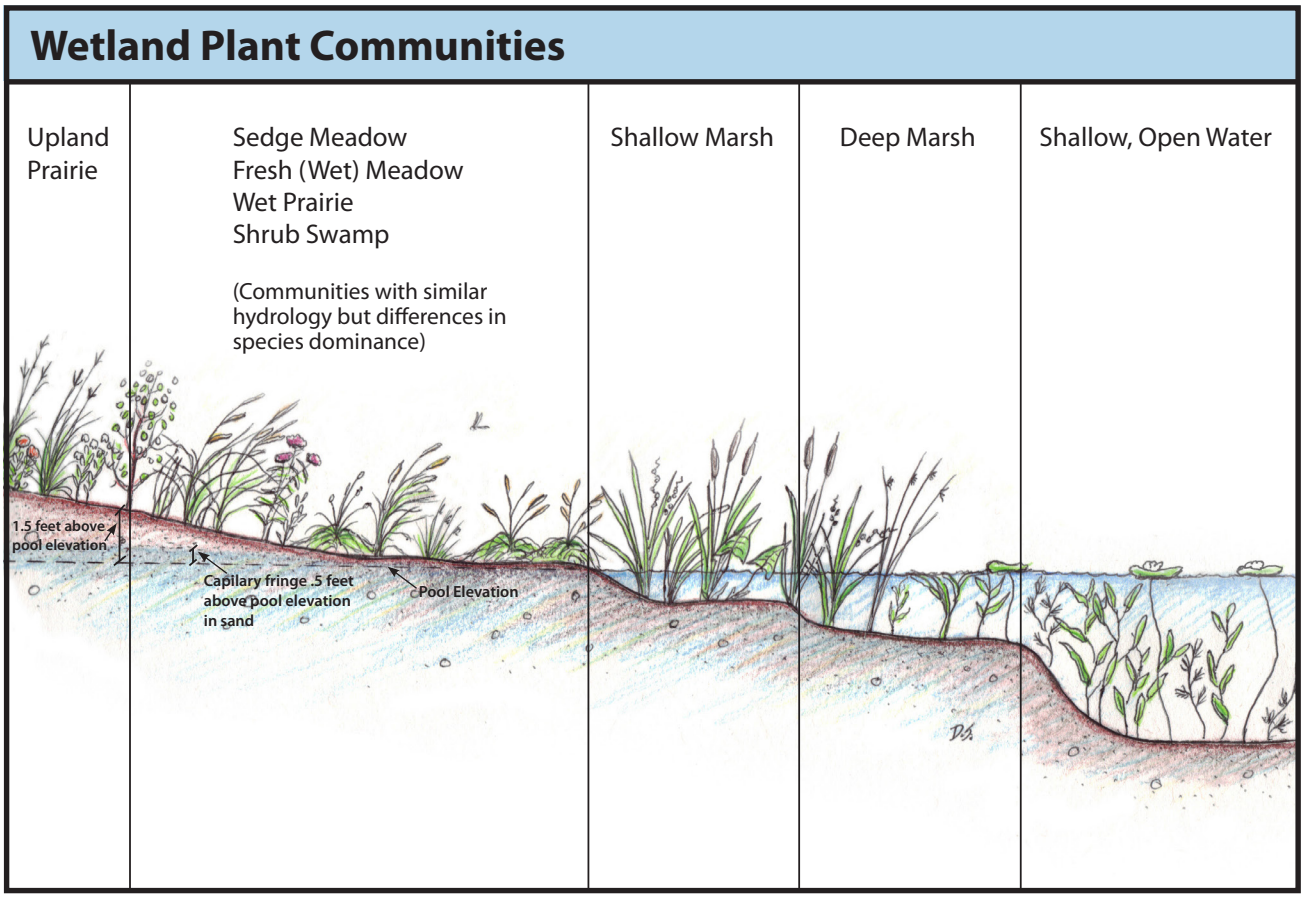


Figure 5.8

with respect to the site's goals, limitations and available funding. Figure 5.8 shows common plant communities that are found in Minnesota's landscapes and are used as a guide for developing a project's vegetation plan. The plant community types that are referred to in this Guide follow Wetland Plants and Plant Communities of Minnesota and Wisconsin (Eggers and Reed 1997).

Figure 5.9 *Diverse upland buffer*

Wetland Buffers (Uplands)

The buffer around a wetland provides upland nesting and brood cover for wildlife species and protects the biological integrity of restored wetlands. As a general rule, wetland buffers should be made as large as possible to increase use by species that require large areas for successful nesting and to decrease predation. Promoting buffering within the watershed will improve water quality and minimize the influence from invasive species.

Site evaluation information that is important to consider in the design of buffers includes soils, slope, existing vegetation, historic vegetation, and surrounding land uses. As with wetlands, the historic community that existed at a site is commonly the goal for the restoration of upland buffers. Forested communities can sometimes be more expensive to re-establish than prairie but new advances have been made in the establishment of forests through the direct seeding of tree and shrub seeds. The restoration of upland prairie communities is receiving increased attention due to their value for biofuel production, along with the well documented benefits of soil and water conservation, plant diversity,

and habitat restoration. Recent research has demonstrated the importance of soil fungi, prescribed fire, and grazing on prairie diversity. Strategies are presented in this guide for both forest and prairie establishment strategies.

Sedge Meadows, Fresh (Wet) Meadows and Wet to Wet-Mesic Prairies

Sedge meadows, fresh (wet) meadows, and wet to wet-mesic prairies tend to have saturation within one foot of the surface and transition up slope into upland plant communities or down slope into other wetland types. Site evaluation information that is important to consider during the planning of these communities include

Figure 5.10 *Wet Meadow*

soils, hydrology, existing vegetation, historic vegetation, potential seedbank, and influences from surrounding landuses. Remnant seed banks can sometimes be relied upon for some species in these communities but many sedge meadow species, especially sedges that do not establish well from remnant seed, require additional seeding to provide a diverse mix of vegetation types.

These communities are prone to the invasion by reed canary grass and other undesirable species. As a result, there should be careful selection of site preparation strategies to remove any unwanted plant species and to establish more desirable species that will create competition into the future. Long-term maintenance is required; reed canary grass is a threat even to restoration sites that have been established with diverse vegetation.

Figure 5.11 *Shallow Marsh*

Shallow Marshes, Deep Marshes and Shallow, Open Water Communities

Shallow marshes, deep marshes, and open water communities occur in areas with permanent to seasonal shallow water. The dominant vegetation type is emergent aquatic plants in shallow marshes with a transition to floating-leaved and submergent plants with increasing water depths.

Site evaluation information that is important to consider during the planning of these communities include soils, hydrology, existing vegetation, historic vegetation, potential seedbank, and influences from surrounding land uses. Natural dispersal and seedbanks can often be relied on to establish shallow and deep marsh species. Additional seeding is often necessary if repeated disturbance or sediment accumulation has influenced the native seedbank. Fluctuating water levels and wave action can make it difficult to establish seed in shallow marsh zones, so it is common to plant live plants along the edge of the water and let them spread into deeper water. Narrow-leaf and hybrid cattails frequently colonize marsh communities and sometimes require management to allow other emergent vegetation to establish and persist.

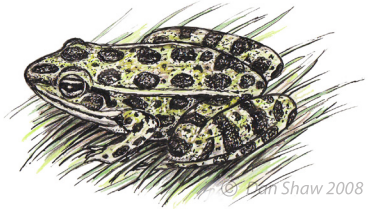


Figure 5.12 *Shrub Wetland*

Shrub Swamps and Wooded Swamps

Wooded swamps have a dominance of mature trees, while shrub swamps lack mature trees and have a dominance of woody deciduous shrubs.

Site evaluation information that should be considered during the planning of shrub and forested wetland communities include soils, hydrology, existing vegetation, historic vegetation, potential seedbank, potential regeneration from nearby trees and shrubs, and influences from surrounding land-uses. The ground-layer,

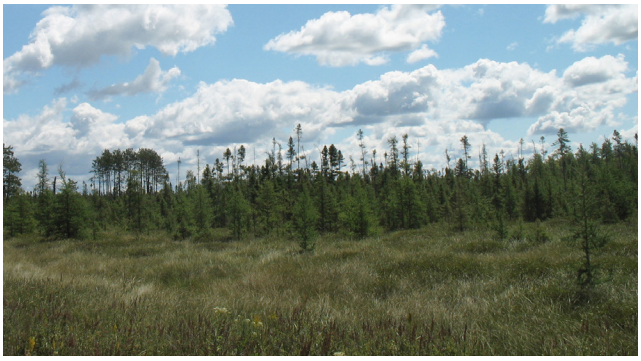


Figure 5.13 *Coniferous bog in Aitkin County*

shrub layer, and canopy layer should receive equal consideration during the planning process. Establishing forested wetlands is a long-term process and requires careful consideration of maintenance and herbivore control strategies. See **Section 5-6, Wetland Planting, Wetland Trees and Shrubs** for additional information.

Peatlands

Peatlands include open bogs and coniferous bogs. Peatlands have water-saturated soils that are composed of partly decayed remains of plants. The plant material accumulates as a result of slowed bacteria and fungal action in the waterlogged environment. Peatlands are found primarily in the boreal forest biomes, which have cool temperatures and short summers. Site evaluation information that should be considered during the planning of shrub and forested wetland communities include thickness of existing peat, hydrology, existing vegetation, historic vegetation, nearby donor sites, and influences from surrounding land uses such as nutrients that may promote weed growth. During peatland restoration, an existing area of bog commonly is used as a borrow site for collecting Sphagnum moss to be spread on the restoration area (Quinty and Hood 1998). The mulching of re-introduced plant fragments can also be an important part of the restoration process. The planting of shrubs or other perennial species can also aid in the establishment of Sphagnum by providing shade and protection from wind (Bourdreau and Rochefort 1998).

Special Site Conditions

Wetland Creations

Wetlands that are created through excavation have unique challenges related to the establishment of native vegetation. In most cases, excavated wetlands do not promote the rapid growth of vegetation since soils tend to be nutrient poor and lack wetland seedbanks. Soils that will provide the best growing conditions for plants have a substrate for rooting, nutrients, and sufficient aeration. It is common to add topsoil over excavated wetlands to improve conditions for plant establishment and growth. However, adding soils rich in nutrients may aid the establishment of reed canary grass and cattails. The soils found in nearby natural wetlands may provide clues that help guide decision making related to the use of topsoil at a site.

Donor soil from existing wetlands may be used as a substrate for created wetlands. It is crucial that topsoil or donor soils do not contain seeds of invasive species. In some cases, donor soils are a source of desirable seed and propagules of native species and will aid the establishment of the wetland. Piles of topsoil that will be used for a wetland should be kept small to minimize loss of soil organisms. Placing topsoil in rows is often an effective strategy. Topsoil should be spread as soon as site conditions allow. Soil compaction after topsoil grading should be avoided; soil should be loosened with rippers when compaction occurs. The site prepara-

Figure 5.14

tion, planting, and maintenance strategies discussed in this section of the Guide will apply to wetland creation sites as well as traditional wetland restorations.

Wetland Enhancements

The enhancement of existing wetlands involves the removal of invasive species or establishment of native species to increase plant diversity. The restoration strategies proposed in this section of the Guide can also be used for the enhancement of existing wetlands.

Figure 5.16

The creation of wildlife habitat is a common goal of wetland restoration projects and is often part of wetland enhancement projects. It may be possible to connect high quality habitats or environmental corridors that exist near the project area to enhance wildlife habitat. Environmental corridors are areas of natural vegetation that can act as passageways between isolated habitats. One example is a tree-lined stream corridor that connects two wetlands that are otherwise separated by a developed area. Another example is a field row of tall herbaceous vegetation, shrubs, or trees that provide cover for wildlife. If such areas exist nearby, connecting wetland's buffer to them will increase the usefulness of the wetland for wildlife species.

Existing wetlands that connect to a restored or created wetland can act as a source of desirable native seed or of undesirable invasives. Floating wetland seeds and plants can be transported from one wetland to another during high water events.

Plant Materials

Propagule Types and Sources

The availability of existing native seedbank, seeds, and plants can influence the strategies that are chosen for a site. If native seedbank is present, it can be a source of "local" seed. Marsh communities can be difficult to establish from seed alone and are often planted with containerized plants, pre-vegetated mats, transplanted material or bare-root plants.

There may be some areas of the state where local seed and other plant materials cannot be found. Seed that

Figure 5.16

Figure 5.17

is moved from long distances may result in plantings that are less adapted to site conditions. It is encouraged that project partners work together to find local sources of plant materials.

Plant Selection

High diversity is generally recommended for plantings. Diverse seed mixes tend to result in more stable plant communities that fill available niches and prevent invasion by undesirable species. Seed mixes should be selected to match hydrologic conditions at a site and have a combination of early and later successional species to ensure that the planting will persist and regenerate.

There are many seed mixes used in the state ranging from mixes based on NRCS Practice Standards, private vendor mixes and State seed mixes. Ultimately, seed mixes should be chosen that fit project goals. In some cases, custom seed mixes are developed for sites. This can be a good strategy to match species to specific site conditions and to replicate historic plant communities. See Section 5-6 Selecting Seed and Plant Materials for more information on the use and selection of seed and plant species.

Project Sequencing

Timing/Sequencing

The timing of restoration strategies is often essential to project success. Investments in expensive seed mixes or other plant materials can be lost if restoration strategies are not well coordinated. Individual phases of a project should be summarized in project schedules so that contractors can understand when various phases of work should be conducted. Activities related to vegetation establishment should be timed appropriately with seasonal conditions and coordinated with planned construction activities. Contractors that are conducting construction activities and those focusing on vegetation establishment should be aware of each other's schedules to ensure that each phase of the project will be conducted at the correct time. Detailed timelines are very useful to keep all phases of a project working together. Periodic adjustments to timelines and contingency plans are recommended as it is common for projects to get off schedule due to weather and other factors.

Weed/Invasive Species Removal

The removal of undesirable weeds such as reed canary grass, Canada thistle, and wild parsnip often takes more than one year to complete. This is especially true with reed canary grass, as this species is a prolific seed producer and tends to have extensive rhizomes. Reed canary grass is commonly sprayed in the fall and then treated through the next year to obtain sufficient control before planting in the fall or following spring. Species such as reed canary grass, Canada thistle, and wild parsnip must be thoroughly controlled at a site before seeding is conducted. Additional discussion on strategies for weed and invasive species removal occurs in Section 5-3 - Site Preparation.

Site Cover and Stabilization

Stabilizing the site as part of the vegetation establishment process can be critical to the success of the project. For example, most wetland seeds will not germinate if covered by more than 0.25 inches of soil. Therefore, it is important the site be stabilized after any construction or site preparation activities to limit the movement of on-site sediment and protect the investment and effort put forth in seeding and planting the site. The use of temporary cover crops, mulching, or establishing upland buffers before seeding or planting wetland vegetation are all recommended stabilization strategies to consider that can improve the success of wetland seedings and plantings.

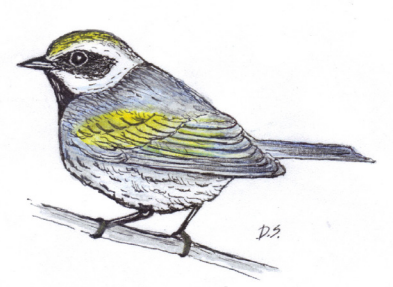


Figure 5.19 *Slough Grass*

Seedbed Preparation

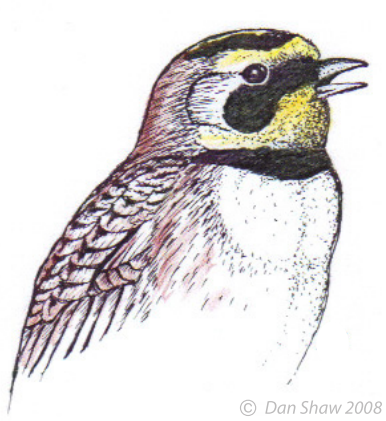
The preparation of the seedbed should only occur after invasive species and weeds are controlled to the extent desired and possible. Seedbed preparation techniques can vary significantly from seeding shortly after soybean harvest to combinations of disking, harrowing, and cultipacking. The ultimate goal of seedbed preparation is to provide ideal growing conditions for the species being planted. Additional discussion on site preparation strategies occurs in **Section 5-3 - Site Preparation**.

Establishment Phasing

The timing of hydrology restoration is important for the success of new wetland plantings. The ideal situation is to restore hydrology slowly as vegetation increases in height to minimize the risk of drowning new plantings. On sites that do not have water control structures, it is common to plant after the hydrology is restored to a relatively stable state, but this limits the types of equipment that can be used on saturated soils. If possible, the seedbed can be prepared in the Fall, followed by seeding. Spring seeding can also be conducted if the hydrology will not cause the seeds to float or wash away.

In some cases, it may be beneficial to wait until water levels of wetland pools stabilize in the spring to plant emergent species as seed or containerized plants to protect seedings.

Coordinate the planning and design of wetland vegetation plans with the engineers and others involved in the planning and design of construction plans to ensure that everyone is aware of the needs and issues associated with restoring hydrology to the site. The management of hydrology during vegetation establishment is covered under **Section 5-8, Maintenance for Vegetation Establishment**.



5-2 Developing a Vegetation Plan

Figure 5.20

The steps involved in developing a vegetation plan include the following:

- Information Review
- Writing a Project Overview
- Developing the Planting Zone Map
- Selecting Restoration Strategies
- Writing Specifications and Notes
- Selecting Project Details
- Developing Project Schedules

Before planting work begins it is important to conduct planning that provides sufficient detail for the contractor and others involved in the vegetation establishment effort. This occurs through the preparation of plans, specifications, and other contract documents. The clearer, more comprehensive, and detailed the vegetation plan documents, the greater the likelihood for project success.

This chapter focuses on the process of developing a vegetation plan and how to implement the plan to achieve the intended project goals and objectives. Plan development is discussed early in this section of the Guide to provide a framework for the selection of vegetation establishment strategies that are discussed in later chapters.

This chapter presents a comprehensive process for developing a vegetation plan using examples and templates. As this Guide is intended to be useful for a wide variety of project types with varying goals and budgets, the discussion of plan development allows designers to select steps and to utilize a level of detail that fits individual project needs.

Figure 5.21 *Cup Plant*

The appearance of vegetation establishment plans varies depending on project scope and ultimate goals for project vegetation. For example, a plan may be very detailed for a mitigation project and less detailed for a conservation planting. It is up to the project designer to determine the level of detail and what steps will be used to develop a plan for an individual project. The more involved the designer or project manager are in the actual on-site implementation activities, the less detailed the plan may need to be.

Nonetheless, all vegetation establishment plans need to consider the type(s) of establishment strategies that will be used. There will need to be a planting map of some sort along with instructions for site preparation, planting, and maintenance. To support those instructions and to ensure they are properly implemented, notes and specifications need to be prepared that provide the specific requirements for implementation.

Vegetation plans can take many forms depending on the type of project and designer preference. Most plans, however, should consist of both written and graphical information that will guide all work related to establishing vegetation at a project site. The graphical portion of the plan is usually represented on what is often called the planting zone map. The written portion of the plan will provide detailed information about how the work will be conducted and will describe all restoration strategies to be used as well as accompanying specifications, notes, details, and project schedules.

The process to develop a vegetation plan as proposed in this Guide involves preparing a comprehensive planting zone map that includes important project notes and having the accompanying written portion of the plan include a project overview, written description/specifications of strategies for site preparation, planting and maintenance, along with details and project schedules. See **Appendix I, Vegetation Plan Examples**.

A template for the written portion of a plan is presented below. Plan components can be inserted as they are completed, with more or less detail depending on project scope. Even the simplest project should have basic information for each of these components.

Figure 5.22 *Green Bulrush*

Table 5.1 *Vegetation Plan Template*

Project Name
Date:

A. Project Overview:

B. Project Administration
- *Bidding and Contractor Selection Specifications:*
- *Permits and Certification Requirement Specifications:*
- *Measurement and Payment Specifications:*

C. Site Preparation
- *Site Preparation Description/Specifications:*
- *Site Preparation Schedule:*

D. Planting
- *Planting Description/Specifications:*
- *Planting Details:*
- *Planting Schedule:*

E. Plant Materials
- *List of Seed Mixes and Other Plant Materials:*
- *Seed and Plant Specifications:*

F. Site Maintenance
- *Maintenance Description/Specifications:*
- *Maintenance Schedule:*

G. Project Implementation Schedule:
- *Implementation Schedule:*

Note: see accompanying planting zone map

Figure 5.23 *Establishing Emergent Plants*

Information Review

Prior to developing the vegetation plan, conduct a thorough review of the information collected during the site assessment and evaluation phase of the project. The collection and evaluation of this information is discussed in **Section III of the Guide.**

The information collected as part of the site assessment and evaluation is important in the development of a concept plan and will continue to be important through all stages of a project including vegetation plan development, implementation, and maintenance. The following table summarizes the information that should have been collected during the site assessment and shows how that information relates to the development of the vegetation plan.

Table 5.2 ***Use of Site Information in Development of the Vegetation Plan***

Information	Importance for Vegetation Plan Development
Site topography	Site contours will help determine the location of planting zones, seed mixes, and other planting strategies at the site.
Geology and soils information	Aids in the determination and location of historic wetland communities.
Land use information from aerial photo graphs and site visits	Helps determine possible threats to the site such as invasive species, nutrients, and changing water levels. May influence the restoration site and the selection of restoration strategies.
Previous land use	Look for evidence of sedimentation of wetland basins or other erosion problems, as well as the introduction of aggressive species as well as fertilizer, herbicide and pesticide use.
Historic vegetation	Helps to select plant communities and species appropriate for the site.
Existing Seedbank potential	A threat or a benefit, the presence of an existing may influence the planting strategies, seed mixes, and control efforts.
Site photography	Aerial and ground-level images can be a good reference during the vegetation plan developement. Also useful for tracking restoration establishment.
Existing native vegetation	May influence the planning of site preparation, planting, and maitenance strategies.
Existing invasive vegetation	May influence the planning of site preparation, planting, and maitenance strategies.
Reference wetlands	Wetlands in surrounding areas may aid in selecting restoration strategies and vegetative communities.

Figure 5.24 *Marsh Milkweed*

The development of a **concept plan** is discussed in Section III of the Guide as part of the Site Evaluation Chapter. If a concept plan was developed for a project, it should be reviewed and revised as necessary to meet the current needs of the project. The information in the concept plan should be used to guide the development of the detailed vegetation plan. Generally, the concept plan will have included the following information as it relates to establishment of site vegetation:

- Areas of Invasive Species to Control
- Areas of Native Vegetation to Protect
- Connection to Habitat Corridors
- Existing and Desired Extent of the Wetland Buffer
- Type and Locations of Plant Communities to be Restored

The type and location of plant communities to be restored will guide the selection of restoration strategies and plant species for the site. Information about invasive species and native vegetation will inform the selection of site preparation, planting, and maintenance strategies. Information about the extent of wetland buffers and connection to habitat corridors will aid in decision-making about upland planting strategies.

One final piece of information to review in preparation for developing the vegetation plan is the **Vegetation Establishment Considerations** that were discussed in Chapter 1. Notes that were taken during the review of establishment considerations should be reviewed and considered during the development of the vegetation plan.

Writing a Project Overview

As part of developing the vegetation plan, it may be helpful to write a brief summary about the restoration project including the vegetation goals for the project and how restoration will be conducted. The overview can act as a reference as the plan is developed to ensure that the whole document is working in a way that meets the overall goals for a project. The overview can also be used for project promotion or to educate the public about the project.

Figure 5.25 *Sawtooth Sunflower*

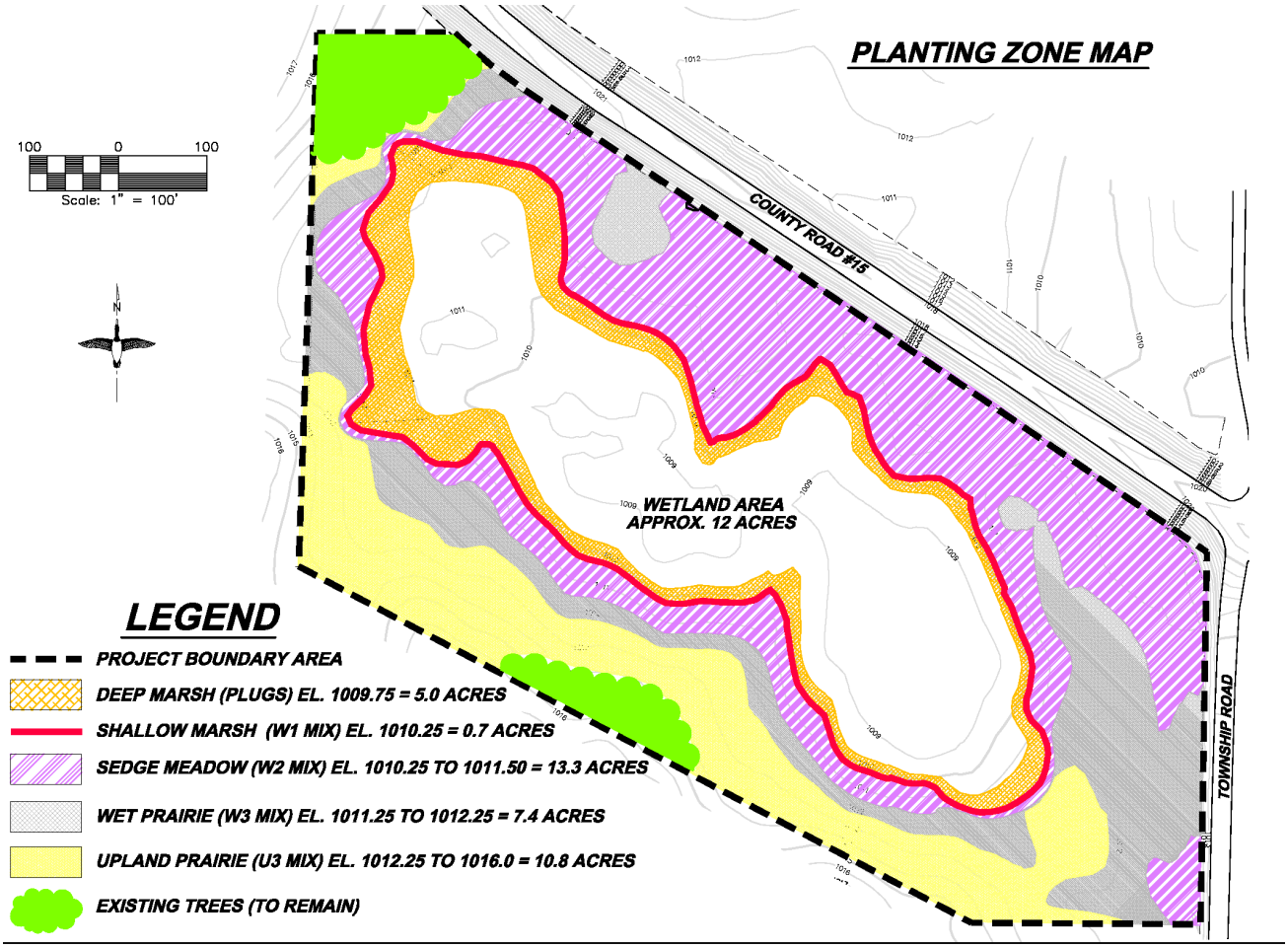


Figure 5.26 *Sample Planting Zone Map*

Developing the Planting Zone Map

The planting zone map is a graphical portrayal of the vegetative plant communities that are planned for a site. Information that should be included on a planting zone map includes existing features such as trees, remnant plant communities, property/easement lines, roads/access and drainage ditches, as well as planned features such as location of seed mixes, other plant material to be used at the site, and any erosion control measures that will be required. The location of different seed mixes can best be represented by using different hatching patterns on the map. The locations of tree plantings, containerized plants, and other types of plant material are often represented by symbols on the map. A key or legend summarizes the meaning of hatch patterns and symbols.

Depending on complexity or scope of the project, it may be beneficial to utilize the site topographic map as the base for preparing the planting zone map. The creation of different planting zones is often elevation-based. The detailed topographic map provides a nice platform to depict the location for specific plantings. Projects with simple vegetative plans can easily be portrayed on an aerial photo or sketch of the site. Incorporated within or attached to the planting zone map should be a seeding/planting table that summarizes seed mixes to be used, areas and amounts for each seed mix, seeding rates and methods, lists of species in seed mixes, species to be planted as containerized plant and rootstock, the number of plants needed for the project, and the type of plant material that will be supplied (i.e., seed, potted plants, cuttings, and rootstock).

Table 5.3 ***Example Seeding/ Planting Table***

Planting Zone	Area Planted (Acres)	Seed/Plant Mix	Seeding/ Planting Method	Seed/Plant Rate (PLS seeds/sf)
1	2.26	34-181	Broadcast	166
2	3.47	34-271	Broadcast	200
3	9.45	35-641	Drill	60

It is also common to include key notes about a project on the planting zone map depending on the scope of the project and space available on the plan.

Computer programs such as AutoCAD and ArcMap are useful for drawing the boundaries between planting zones and can be used to calculate planting areas to aid in the determination of plant material needs.

In some cases, complex project sites need to be separated into different units. Each unit may have separate seeding zones.

Selection of Restoration Strategies

As part of preparing a vegetation establishment plan, the entire vegetation establishment process needs to be considered to determine how best to achieve success and meet project goals. All strategies must work together, taking into consideration effectiveness and costs. Chapters to follow introduce the most common strategies used to restore wetland vegetation and technical guidance documents provide detailed information about restoration strategies. All of this information is intended to aid in the development of the vegetation plan and result in a successful implementation process. As restoration strategies are chosen for a site, related project specifications, notes, and details should be inserted into the plan.

Writing Specifications and Notes

Project specifications and notes provide specific written direction to contractors and field crews on how individual strategies should be conducted. They help ensure that the goals of the project designer are clearly communicated to implementation crews.

Specifications are commonly incorporated into the written portion of the project in a paragraph format. They can also be written directly on the planting zone map or compiled as a separate document, depending on the number of specifications included for a project.

Project specifications for all phases of a project are included in **Appendix 5-B** for bidding and contractor qualifications, equipment needs, site preparation strategies, planting strategies, maintenance strategies, layout, and staking. It is recommended that project designers will select specifications that best fit the specific needs of their project and adapt specifications as needed for their project. Additional specifications may need to be written to fit specific site conditions and project needs.

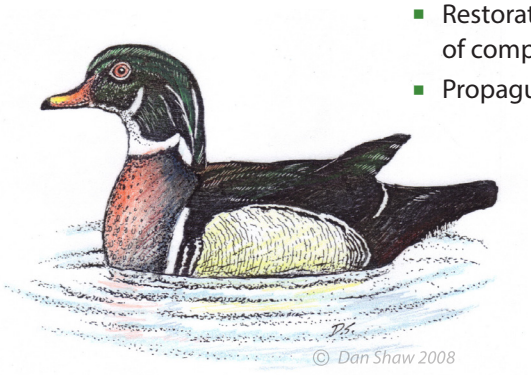
Figure 5.27 *Installing emergent plants*

Contract specifications should be clearly written and detailed benchmarks should be incorporated into specifications. The following key areas can pose problems and should have clear specificatons to prevent problems during the restoration process:

- Compliance with specified seed mixtures (species mix, purity, seed source & germination rates)
- Delays due to inclement weather
- What constitutes acceptable seed bed preparation
- Compliance with weed control specifications
- Overall warranty of the contractor's work

The graphical information on the planting zone map often needs written information to accompany it to clearly state what is required and how it is to be accomplished. This information can be provided in the form of notes. Notes are key specifications that contractors absolutely need to know about a project. The information in notes is often repeated in the written portion of the plan. It is important that project notes and specifications do not have conflicting information. Project notes tend to focus on the following topics:

- Project timing and sequencing
- Site features to protect
- Sediment and invasive species control considerations
- Restoration strategies that have a high degree of complexity
- Propagule handling



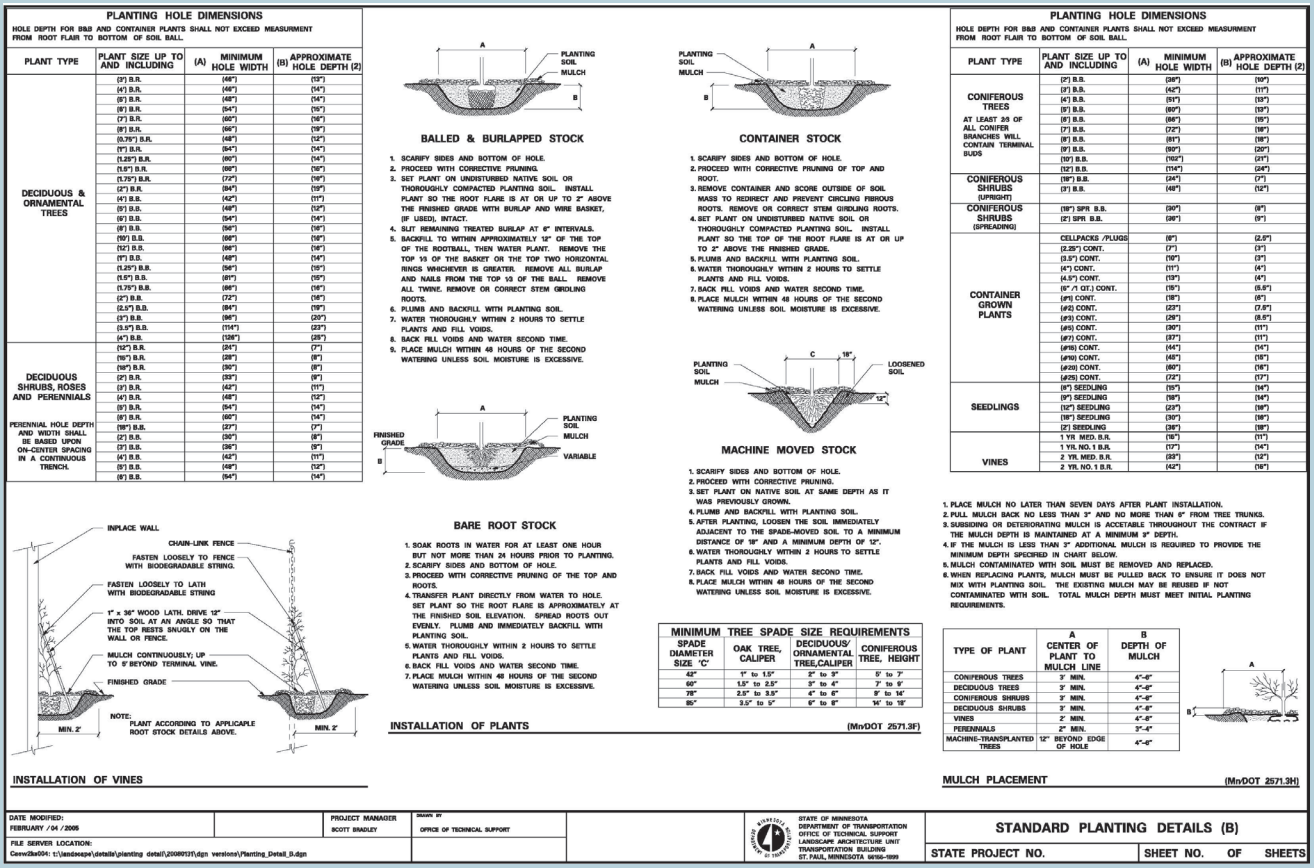


Figure 5.28 *Sample project detail from the Minnesota Department of Transportation*

Selecting Project Details

Details are diagrams/illustrations that show how site features are to be constructed or installed. Common details related to planting include tree and shrub planting, wave break structures, and herbivore control techniques. When used, project details are commonly located on a separate plan sheet or in the written portion of the plan. **Appendix V-C** includes project details that can be incorporated into the vegetation plan.

Developing Project Schedules

Project schedules include site preparation, planting, and maintenance schedules. Schedules are generally included in the written portion of the plan and may also be included on the planting zone map.

Project schedules should summarize timetables for specific restoration strategies that will be conducted and show the projected date for and a description of the activity. The process of developing schedules will aid in the understanding of how site preparation, planting, and maintenance strategies will work together. In some cases, site preparation and planting schedules are combined; as these are often a continuous process.

The maintenance schedule for vegetation establishment summarizes the timing of maintenance activities for a project site during the first three to five years. It is common to show site monitoring visits on the maintenance schedule as these activities are often combined. In other cases, separate monitoring schedules will be developed for a site. **Chapter 7** provides additional discussion on **Maintenance for Vegetation Establishment** whereas discussions of project monitoring and long-term maintenance are included in Section 6.

Table 5.4 *Sample Site Preparation and Planting Schedule*		
2009	September	Harvest Crops
	September	Spot treat problematic perennial weeds such as Canada thistle
	Early October	Spot treat problematic perennial weeds
	October 15 - freeze-up	Conduct Dormant Seeding

Figure 5.29 *Blue Vervain*

Table 5.5 *Sample Maintenance Schedule*	
year 1	Mow uplands to 6-8 inches approximately every 30 days after planting until September 30th. Mowing frequency should depend on weed height, with a goal of mowing as weeds reach 12 inches. Mow wetlands to 6-8 inches approximately every 30 days if equipment will not cause soil disturbance. Monitor monthly for weed and erosion problems. Spot treat Reed Canary Grass, Canada thistle, and other problem species in wetlands and uplands as needed.
year 2	Mow uplands to 6-8 inches twice, one time around June 15th and once around July 30th, before weeds set seed. Mow in uplands and wetland areas if equipment will not cause soil disturbance. Conduct monitoring monthly between April and September. Spot treat Reed Canary Grass, Canada thistle and other problem species as needed.
year 3	Monitor for weeds in April, June, and August. Spot spray perennial weeds as necessary. Collect seed from established areas and re-seed sparse areas as needed.
year 4	Monitor for weeds in April, June, and August. Spot spray perennial weeds as necessary. Collect seed from established areas and re-seed sparse areas as needed.
year 5	Conduct prescribed burns of uplands in May. Monitor for weeds in April, June, and August. Spot spray perennial weeds as necessary. Collect seed from established areas and re-seed sparse areas as needed.
year 6 +	Continue monitoring and spot treatment of weeds and conduct burning on a 3-5 year rotation. Collect seed from established areas and re-seed sparse areas as needed.

Note: Maintenance schedules may need to be adapted to changing management needs. Dates included in the example are for the southern half of the state; northern half may be two weeks later.

It is often useful to have one master schedule that summarizes how the site preparation, planting, and maintenance strategies will work together with site construction and the restoration of hydrology. This comprehensive schedule is often referred to as an implementation schedule. Implementation schedules help ensure that all stages of the project are working together. It is not uncommon for restoration projects to get off schedule. If a project gets off schedule due to weather, invasive species, or other variables, it is a good idea to revise project schedules. Make sure that everyone understands the new project timeline and how it influences specific restoration strategies, and contract payments.

Figure 5.30

5-3 Site Preparation Methods

Figure 5.31 *Diverse Native Vegetation*

Preparing a site for revegetation can range from a relatively simple removal of undesirable plants to an equipment-intensive preparing of the soil surface and stabilizing soils. Use information that is collected during the project site assessment to choose site preparation strategies. What is the makeup of the existing soils? How will the restoration of hydrology affect the location of plant communities? Is there invasive vegetation not only in the site itself but also upstream, contributing a never-ending supply of weeds? How reliable is the seedbank potential and could the existing remnant native vegetation be counted on to supply some, if not all, of the new growth? The planting strategies (Drill or broadcast seeding? Bare-root planting? Self-regeneration only?) to be used for the project, along with vegetation goals and budget, influence the selection of site preparation strategies. Thorough site preparation increases the potential for successful vegetation establishment and limits the amount of aftercare needed, so incorporate site preparation methods into the vegetation establishment plan. It is common for several site preparation strategies to be combined for a project. For example, scraping may be used to remove reed canary grass but additional herbicide treatment and loosening of the soil surface may be needed before seeding.

An overview of the following list of strategies is discussed in this chapter of the guide with more specific and detailed information provided in **Technical Guidance Documents** that are located in Appendix 5-A and referenced accordingly.

- Clearing and Grubbing
- Sediment Removal and Scraping
- Vegetation Removal for Site Preparation
- Seedbed Preparation
- Planting Temporary Cover Crops
- Mulching and Stabilizing Plantings
- Native Seed Collection and Storage

Figure 5.32 *Reed Canary Grass Dominated Wetland*

Consider how site preparation, planting, and maintenance strategies will work together. For example, drill seeding and broadcast seeding have different requirements for seedbed preparation. Site preparation methods can be conducted in a way that will promote the establishment of a native plant seedbank, influencing the additional planting strategies, seed mixes, and maintenance activities that will be needed as the project develops. Developing clear implementation schedules for a project will help define how all phases of a project will work together.

Invasive woody plants on the edge of sites need to be removed to avoid long term maitenance problems.

Clearing and Grubbing

Clearing and grubbing involves the removal of trees and shrubs from a project site prior to other site preparation activities. Invasive trees and shrubs tend to dominate disturbed wetlands in Minnesota. Commonly establishing trees and shrubs include quaking aspen, sandbar willow, American elm, boxelder, Siberian elm, and common and glossy buckthorn. In prairie regions of Minnesota, fire and herbivores historically controlled trees and shrubs in and around wetlands but without these natural disturbances, tree and shrub establishment is much more common.

Encroaching trees and shrubs inhibit desired herbaceous species by competing for nutrients, light, and water. They can negatively influence wildlife populations in prairies and prairie potholes; grassland birds will avoid nesting near trees and shrubs that can act as predator perches. In northern Minnesota, forested wetlands are common; there, trees and shrubs are promoted as part of restoration projects.

The selection of tree and shrub removal methods depends on site conditions, the availability of equipment, and the level of disturbance that is acceptable for the site. On sites where additional soil movement will occur, bulldozers will efficiently remove unwanted vegetation. On sites where heavy machinery is not otherwise needed, less intensive methods can help preserve soil structure, microorganisms, native seedbank, and other propagules. Here, chain saws and brush cutters may be a better option. Brushhogs or forestry grinders and mulchers that can chop or grind woody plants are used for shrubs such as willows, non-native honeysuckles, and buckthorn. Follow-up herbicide treatment is then required to prevent re-sprouting, unless repeated prescribed burning can be conducted to control re-growth. Large seed-producing trees on the edge of prairie and wetland restoration projects are sometimes removed to prevent seed dispersal and the long-term management needs that result. For large trees, sheers on larger equipment or chain saws are used; stumps may be removed with backhoes or bulldozers.

Although brush piles are commonly burned after tree and shrub removal, there is an increasing demand for woody vegetation for bioenergy production and firewood. A nearby facility may accept excess biomass, thereby reducing the project's contribution to air pollution. It is common to bury woody material when significant earthwork will be part of a wetland restoration project. This can be the most efficient method to dispose of large stumps.

More detailed information on **Clearing and Grubbing** can be found in the Section **4-10 Construction Implementation**.

Figure 5.33 *Cleared Trees and Shrubs*

Figure 5.34

Sediment Removal and Scraping

Sediment accumulation in wetlands can alter hydrology and bury the native seedbank. Agricultural wetlands with steep side slopes tend to accumulate sediment from erosion. It may be possible to remove sediment to expose a native seedbank at the same time that historic contours are being restored. Excavation can be expensive and impractical if the soil must be hauled a long distance for disposal. The correct depth of excavation should be investigated thoroughly beforehand and the excavation must be conducted by qualified operators to maximize the exposure of the remnant seedbank. Excavating to the correct depth can be difficult and is rarely relied on as the only strategy to establish native vegetation. Because species such as sedges and rushes may not establish successfully from seedbank, additional seed installation will promote diverse vegetation. Sediment removed during excavation should be used onsite to minimize costs; one potential use is the filling of ditches.

Scraping is closely related to sediment removal in that it involves removing an upper layer of soil to strip away invasive plant biomass and rhizomes or to create open water areas in wetlands. When scraping is conducted to remove reed canary grass mats, precision is important. Reed canary grass root depths can vary between six and twelve inches. Check the appropriate depth of scraping periodically to make sure that all rhizomes are being removed. Even removing just a shallow layer is enough to stress the plants in preparation for other management techniques.

Like sediment removal, scraping is sometimes conducted with the goal of exposing a native seedbank. A thorough investigation will be needed to determine the appropriate depth for scraping to reach but not destroy the potential seedbank.

Treat scraped material with care. Remove clumps of reed canary grass from the soil surface to minimize future maintenance needs. Like sediment, scraped material containing invasive plant seeds and rhizomes needs to be taken offsite or buried deep enough to prevent re-establishment. This material is sometimes placed at the base of ditches prior to adding additional sediment.

Existing hydrology will influence whether large equipment can be used for scraping. Scraping is sometimes conducted in early or late winter when frost depths are approximately the same as the desired removal depth, so that the entire soil layer comes up at once.

More detailed information on **Sediment Removal and Scraping** can be found in Section 4-6 Sediment Removal, Scrapes and Other Excavations.

Figure 5.35

Figure 5.36 *Boom Application of Herbicide*

Figure 5.38 *Smooth Brome Grass*

Effective weed control is essential to get a restoration project off to a good start. Site preparation methods vary depending on past uses of the site, existing native vegetation (figure 5.36)often have control of weeds, though additional spot treatment of species such as Canada thistle is sometimes needed after the fall harvest. Planting temporary row crops on a fallow site is a recognized method of reducing invasive species prior to wetland restoration.

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, it is common to treat the vegetation with herbicide in the fall or spring followed by disking or field cultivation to break up rhizomes. A combination of spraying and tilling will remove seedlings and re-sprouts before seeding. Where herbicide treatment cannot be conducted due to water quality or other concerns, repeated tilling is an option for perennial weed control but may take a season or longer for effective control. It is important to thorough investigate old fields to determine if any remnant vegetation exists that may be worth saving before all vegetation is removed. If remnant vegetation is present less intensive practices such as prescribed burning, spot herbicide treatment, restoring historic hydrology and grazing may be enough to shift the floristic quality of the site.

Figure 5.37 *Mixed Perennial Weeds*

A combination of site preparation methods are commonly used for removal of perennial weeds.

More intensive management may be needed for species such as reed canary grass that have large rhizomes. Sites dominated by reed canary grass are difficult to convert to native vegetation. It is essential that the existing population of grass and its seed source be thoroughly removed before seeding. Rhizome clumps resprout with ease—chopping them only increases the plant's opportunity to regrow unless every piece is removed from the site. It may be difficult to keep reed canary grass out of a project if the site or the surrounding landscape is dominated with the species.

The removal of reed canary grass is most often initiated in the fall, as this is the time of year when glyphosate is effectively taken into the rhizomes. A common sequence for removal involves summer mowing, followed by fall herbicide application. Sites may then be burned in early spring followed by additional herbicide treatment and tilling as needed.

Scraping with backhoes and bulldozers is sometimes conducted for weeds with extensive rhizomes such as reed canary grass and giant reed grass. This technique is most effective when the material can be pushed into nearby ditches, as it is often not practical to haul the material off-site. Scraping is typically conducted to eight inches, though the depth will vary depending on hydrologic conditions and root depth. If exposing native seedbank is a goal for the project, the depth of seedbank will also influence the depth of scraping. Scraping should not be conducted in places where upper soil layers are thin.

Scarifying the ground surface with blades or mechanical brushes removes the thatch layer and stresses species such as giant reed grass, hybrid and narrow-leaf cattail, and reed canary grass, often in preparation for other management techniques. Other non-herbicide site preparation methods include repeated tilling, prescribed burning, the use of heavy mulches (sometimes used for tree planting areas), and inundation.

Repeated tilling can be used to control weeds, but it may take multiple applications for sufficient control of perennial species. It is one of the preferred methods when organic farms are nearby, or when there are other concerns with herbicide application. Grazing, prescribed burning, inundation or mowing may be beneficial to deplete plant reserves before tilling is initiated.

Figure 5.40 *Disking*

Inundation is used for the control of perennial weeds such as cattails, giant reed grass, and reed canary grass. This technique requires the ability to retain sufficient hydrology on the site. In some cases, plants are cut below the water surface during the growing season but inundation is most often initiated early in the season when the target species is short and snowmelt is contributing to water levels. Mowing prescribed burning or grazing is recommended before inundation is started, as dead stems can allow for oxygen transport to submerged plants. It may take a full growing season at a depth of one to two feet to accomplish full removal, so sufficient hydrology is required. A plan should be in place to control seedlings following inundation.

Figure 5.39 *Reed Canary Grass*

Figure 5.41 *Harrowing for Seedbed Preparation*
Photo by Prairie Restorations, Inc

More detailed information on **Vegetation Removal for Site Preparation** can be found in the Vegetation Removal for Site Preparation Technical Guidance Document located in **Appendix 5A-1**

Seedbed Preparation

The purpose of seedbed preparation is to establish suitable growing conditions for native vegetation. Suitable conditions often include a firm soil that is not too loose or too compacted. The vegetation that was previously on a site can have a big influence on the seedbed preparation methods that are needed. Transitioning from perennial weeds will often require plowing and disking, or tilling to expose the soil surface to an extent where seeding can be conducted (**Figure 5.41**). Fields that were previously in agricultural production may need spot treatment of weeds such as Canada thistle or baling of corn stubble but may otherwise be ready for drill seeding and only need the surface loosened before broadcast seeding.

Prepare the seedbed to accommodate the seeding equipment and method to be used. Broadcast seeding is conducted on a wide range of surfaces, from smooth surfaces following soybean fields to rough surfaces where fields were previously disked or tilled. A benefit of seeding onto a smooth surface is that seeds will be at uniform depth with good sun exposure; though a risk is that seed is unprotected from wind, birds, and rodents. Additional harrowing, cultipacking, rolling, or mulching may be needed to keep seed in place. An advantage of broadcast seeding on a rough surface is that there will be more microhabitats for the establishment of a diverse planting.

A rough seedbed may be beneficial for wind-swept fields or fields prone to drought or construction areas that have been compacted. A limitation of a rough surface is that the settling of soil may bury tiny seeds too deep. Allow soil to settle from rainfall after disking or cultipack the site to smooth the seedbed. Other disadvantages of disturbing the soil are that disking and tilling can take time and energy, disrupt soil structure and microbes, and can promote weed growth such as reed canary grass in moist soils (Kline 1997).

Broadcast seeding in the winter (often called winter seeding) has become a popular practice to ensure adequate soil moisture for seed while minimizing loss from wind, birds, and rodents. Winter seeding can make use of less-processed seed and is conducted during a time of year (February to March) when field crews are less busy. It is common to winter seed on fields that were previously in corn or soybeans, though it can also be conducted on fields that were previously disked; the soil will stabilize over winter from snowpack, decreasing the risk of settling and weed competition from disturbed soil.

Seed drills require a firm seedbed. Sites that have been plowed or disked will require additional smoothing through the use of harrows, cultipackers, and rollers to smooth the soil surface before seeding. As a general rule, footprints left in the soil should not be deeper than one inch in preparation for seed drill use. If the soil is too loose, rainfall may give the additional compaction that is needed.

Seed as soon after seedbed preparation as possible to prevent weed competition. An exception is fall dormant seeding, when weed seeds will not germinate. It is best to seed shortly before snowfall,

Figure 5.42 *Prepared Seedbed*

as snowcover will prevent seed loss from wind and birds. An advantage of winter seeding is that seed will germinate in the spring when conditions are favorable. Seeding temporary cover crops such as oats (or winter wheat in the fall) prior to seeding permanent seed mixes can also minimize weed competition, as these species allow time for additional weed control prior to seeding native seed mixes. When no temporary cover crops or other vegetation will be used to stabilize soils, additional mulches may be needed.

Temporary cover crops allow sites to stabilize before planting permanent mixes.

More detailed information on **Seedbed Preparation** can be found in the Seedbed Preparation Technical Guidance Document located in **Appendix 5A-2**.

Planting Temporary Cover Crops

Temporary cover crops are used to stabilize soils and provide weed competition prior to seeding permanent native seed mixes. Temporary cover crops provide additional time for weed control and development of soil structure and microorganisms. They reduce the need for additional mulches. Temporary covers also stabilize aquatic areas where a native seedbank is expected to germinate, establish, and colonize the wetland.

Oats and winter wheat are the two most commonly used temporary cover crops, though other grains such as barley are used. Ryes are known to have allelopathic effects (release of chemicals that influence seed germination) that disrupt seed germination; they are avoided. Slough grass is a wetland grass used as a temporary cover crop for wet areas. Soybeans can be used as a temporary cover crop in preparation for seeding, as both the weed control associated with soybean production and mulch that remains after harvesting is beneficial.

Temporary cover crops should be mowed to around five inches before seeds mature, or harvested upon maturity to prevent re-seeding. Mowing to around five inches will aid the use of native seed drills by preventing their plugging from thatch. Thatch left after harvesting or clipping creates conditions where seed will stay in place and seedlings will be protect-

Figure 5.43 *Establishing Temporary Cover Crop*

ed from moving soils and wind. If farmers can harvest the cover crop, they may be willing to pay for the cover crop installation and harvesting, which helps to decrease project costs. Whether the seed can be harvested will depend on the planned timing of permanent seed mix installation. Some cover crops can be clipped to prevent seeding at 10-12 inches if they will be disked into the soil prior to seeding.

Perennial species such as clovers, alfalfa, and perennial grasses are discouraged as temporary cover crops. They require herbicide application before seedbed preparation and their seed may persist in the soil, requiring additional control after native vegetation is established.

More detailed information on **Cover Crops** can be found in the Planting Temporary Cover Crops Technical Guidance Document located in **Appendix 5A-3.**

Mulching and Stabilizing Plantings

Stabilizing upland soils either before or after planting is an important part of the planning process. The current NPDES General Permit for Minnesota requires that final stabilization of construction areas be done within 14 days after the construction activity has temporarily or permanently ceased. For large projects, compliance may require that stabilization methods such as seeding, mulching, or other temporary erosion products occur in several stages. Beyond that, stabilization provides protection and moisture for planted seeds and can decrease erosion, improving the success of efforts to establish vegetation in wetland areas.

Care should be taken that upland soils do not erode into wetland areas and cover wetland seedlings. As little as 0.5 centimeters of sediment can prevent germination of the many wetland species that have tiny seeds.

Figure 5.44 *Slough Grass from a Temporary Cover Crop Seed Mix*

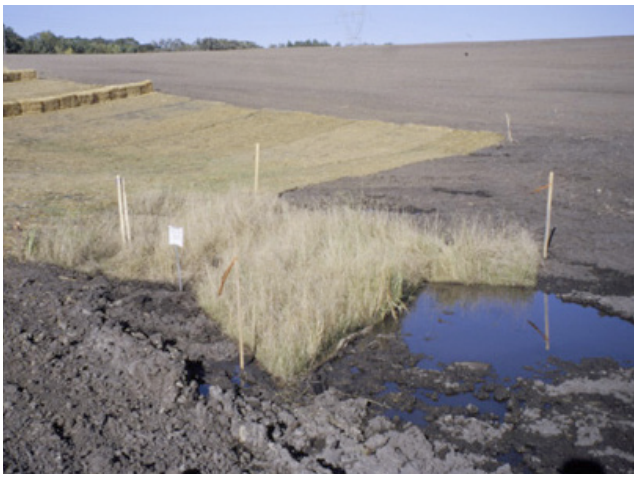


Figure 5.45 *Upland Stabilization Strategies*

Figure 5.46

Uplands with sloping topography can be stabilized through the use of temporary cover crops or they can be planted a season before the wetland planting is conducted: spring seeding of uplands and fall seeding of wetlands. If uplands are seeded first, it may be possible to plant a temporary cover such as oats in the wetland area if hydrology has not been restored.

Temporary cover crops such as oats and winter wheat can stabilize restoration sites prior to the use of permanent seed mixes. Oats can be planted in early spring, harvested or clipped in late May or early June, followed by the installation of permanent native seed mixes. The cover species are harvested (if ripe), clipped or treated with herbicide prior to planting. An advantage of temporary cover crops is that they allow time for additional weed control prior to planting. Also, the remaining thatch can eliminate the need for additional mulch.

If temporary cover crops are not used as mulch and little crop residue is 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 weed-free mulch be used; MCIA Certified Weed Free mulch (Mn/DOT 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.

In areas with steep slopes or flowing water, additional protection will likely be needed to stabilize soils. Erosion fabrics or pre-vegetated mats work well for this. Combinations of wave break structures, wattles, pre-vegetated mats and bio-logs may be needed along open water areas to protect plantings from waves.

These practices are used for lakeshore restorations but may be too expensive for many wetland restoration projects.

More detailed information on **Mulching and Stabilizing Plantings** can be found in the Mulching and Stabilizing Plantings Technical Guidance Document located in **Appendix 5A-4 .**

Native Seed Collection and Storage

The collection and storage of seed is an important part of many restoration efforts. Collection of seed from project sites or nearby areas helps ensure that vegetation at the restoration site will be adapted to local conditions. Done correctly, collection can minimize project costs. It can also be an effective educational opportunity for volunteers and school groups.

Like everything else involved in wetland projects, seed collection should not be undertaken without planning ahead. Even a nearby source may be inappropriate for use on a project if the seed cannot be collected and processed without harming the source or taking shortcuts that reduce the chance of project success. First, ensure that collection areas will not be negatively impacted. Leave sufficient amount of seed at the collection site to ensure regeneration of the source. Calculating this amount depends on the species being collected and how much it relies on seed dispersal to regenerate the population. A general rule is to only collect between ¼ and ½ of the seed from a population. Be sure not to damage plants during the collection process. Clean boots and equipment of possible weed species seed. Permits are required to collect seed from

Figure 5.47

public lands and permission from the landowner if the land is private. Seed should not be collected from state or federally listed species without special approval from appropriate agencies.

In most cases, seed is collected by hand, though it can also be collected with specially-designed equipment. In the case of trees, tarps are used to collect seed as it falls. For most grasses and forbs with spike-like inflorescence, seedheads can be stripped from the stem and seed placed into paper bags or feed bags. For seed that is hard to collect, entire seedheads may be collected to be processed later.

Seed collection can provide a good source of site adapted vegetation.

It is important to dry seed and process it effectively after collection to prevent mold and loss of germination. Drying is conducted by spreading seed onto a dry floor, elevated screens or boards in areas with good air circulation. Seed cleaning equipment includes thrashers, blenders, and different-sized screens. The amount of processing required will depend on the type of seeding equipment to be used. If seed will be hand-broadcast, very little processing will be needed. Slightly more processing is needed for Vicon-type broadcast seeders, and a high degree of cleaning is needed for use in traditional native seed drills.

To understand how much of the seed can be expected to grow, testing of seed is recommended after collection. There are a number of labs where seed can be sent for testing. The results will inform you how much additional seed will be needed through collection or purchasing to meet project diversity goals and seeding rates.

Seeds should be stored in conditions with consistent temperatures, ideally 50 degrees Fahrenheit or less) and humidity (ideally 50 percent humidity or less). Seed can be stored in refrigerators, but should not be frozen. It is common to store seeds in paper bags to allow air movement ; plastic bags may promote mold. As a general rule seed should not be stored more than one year, though some species can remain viable after several years of storage.

More detailed information on **Seed Collection and Storage** can be found in the Native Seed Collection and Storage Technical Guidance Document located in **Appendix 5A-5**.

5-4 Establishing Vegetation in Uplands

Figure 5.48

An overview of the following list of strategies is discussed in this chapter of the guide with more specific and detailed information provided in **Technical Guidance Documents** that are located in Appendix 5-A and referenced accordingly.

- Upland Seeding
- Planting Upland (Non-woody) Containerized Plants and Rootstock
- Planting Upland Trees and Shrubs
- Promoting Beneficial Soil Microorganisms

Upland buffers are integral to a healthy wetland ecosystem. Areas of upland buffer are established with most wetland restoration or creation projects and can vary from open prairies to forested plant communities. The upland buffer around a wetland should be as large as the site will accommodate to protect the wetland from surrounding land use disturbance and to prevent predation of nesting wildlife. Upland buffers provide many benefits and functions including:

- Erosion protection.
- Reduction of sediment and pollution loads to wetlands improving water quality.
- Habitat corridors.
- Food sources as well as nesting, breeding, and winter cover habitat and shelter for animals.
- Reduction of invasive species.

A wide variety of techniques are used to restore upland plant communities. The methods used for a particular project depends on the site conditions, project goals, available equipment, and project budgets. Prairie habitats are a common choice due to lower costs, but savannas and forested buffers are becoming more common on restoration projects in the central and northern parts of the state. Although the planting of prairies has been a common practice for many years, there is still more to be learned related to seed mix development, the role of microorganisms, and how best to use mowing, prescribed burning, and grazing to maximize project functions. A variety of methods are being used to establish trees and shrubs in upland buffers. The use of tree and shrub seed is showing promise for the re-establishment of forest while minimizing damage from herbivores and providing competition for invasive species. This chapter includes information about the use of rhizobial bacteria and mycorrhizal fungi, as well as general methods to promote microorganism populations. The following techniques are covered in this chapter: The sequence of upland restoration can be important. When there are steep slopes around a wetland, it can be beneficial to establish vegetation in the upland buffer areas before planting the wetland. This allows time to stabilize uplands and minimize the risk of sediment from uplands covering expensive wetland seed. Establishing uplands first can also allow for additional weed control in wetlands.

Figure 5.49 *ATV with Broadcast Seeder*

Upland Seeding

Seed installation of prairie grasses and flowers is the most common method of restoring upland buffers. There are different types of seeders used for planting prairies. Seed drills are chosen for sites that are sloping and prone to erosion and where successful grass establishment is a primary goal. No-till native seed drills are used when planting into turf or corn stubble. Broadcast seeders are chosen for sites that have a rough seedbed, moist soils, where forb, sedge, and rush establishment is a priority, and for projects that are using seed that is not thoroughly cleaned.

Diversity can vary for upland buffer projects depending on project goals. Projects that are planted primarily for nesting cover may be planted with lower diversity than a project planted to benefit a wide variety of wildlife species including pollinators and grassland birds that require insects as a food source.

Uplands may be seeded at the same time as wetlands or a season before wetlands are planted (such as spring upland seeding and fall wetland seeding) to aid in the stabilization of uplands and to prevent the burying of wetland seed from erosion (as little as 0.5 cm can prevent seed germination). If rapid grass establishment is a goal, spring seeding is recommended. For good forb establishment, fall dormant seeding is recommended, but if dry weather is predicted, it is often better to wait until shortly before snowmelt or to conduct winter seeding to prevent the loss of seed to wind, birds, and rodents. Temporary cover crops such as oats or winter wheat are planted and later harvested clipped or sprayed prior to seeding uplands to stabilize soils, act as mulch, and add time to control weeds. Cover species are often included in upland seed mixes for weed competition and also to act as an indicator for where the seeding might have failed. Unless a site has steep slopes it is common to keep cover crops as a low percentage of seed mixes, so there isn't too much competition for native species. After seeding uplands, mow to prevent faster-growing weed seeds from maturing and to allow sufficient light to reach seedlings as they develop root systems. It may also be necessary to conduct spot treatment of problematic weeds.

> Uplands are sometimes planted a season before wetland seeding to stabilize soils.

More detailed information on Upland Seeding can be found in the **Upland Seeding** Technical Guidance Document located in **Appendix 5A-6**.

Figure 5.50 *Tractor Mounted ATV Seeder*

Figure 5.51 *Truax Seed Drill*

Planting Upland (Non-woody) Containerized Plants and Rootstock

Upland containerized or bareroot herbaceous plants are installed in combination with seed to increase the rate of establishment in uplands. Species that do not grow well (or rapidly) from seed such as gentians, lilies, and liatris species are best installed as plants. Consider the timing, size, and maintenance requirements of plant materials ahead of time. Container sizes include 1" (plugs), 2", 4" and 6" (gallon) containers. It is best to plant as early in the spring as possible to use available soil moisture after snowmelt and spring rains. This timing works well for the use of bare-root plants that were transplanted from nursery beds, or for containerized plants that were over-wintered. Planting is sometimes conducted in the late fall if there is sufficient soil moisture. Plants that were planted in greenhouses the season of planting need to be grown through May to be large enough for transplanting. Using larger containers increases the rate of establishment but also adds considerable cost to projects compared to relatively inexpensive plugs. Bare-root plants have significant root systems; they can grow quickly and are less susceptible to environmental stressors.

The maintenance requirements of upland plantings involve weeding, watering, and herbivore protection. In some cases, wood mulch is placed around plants to control weeds and retain water. Where wood mulch is not used, some hand weeding or spot spraying may be needed to control competition. Newly-installed plants require approximately one inch of water a week from rainfall or watering. Time plantings with predicted rainfall when possible. Water trucks or tanks on ATVs are commonly used to water newly-installed plants. If a large number of plants are put in, install flags so they can be found later for maintenance and watering.

Figure 5.52 *Photo by Prairie Restorations, Inc*

More detailed information on **Planting Upland Non-woody plants** can be found in the Planting Upland (Non-woody) Containerized Plants and Rootstock Technical Guidance Document located in Appendix 5A-7.

Planting Upland Trees and Shrubs

Upland trees and shrubs are often planted as part of wetland restoration projects in central, eastern, and northern parts of the state to initiate forested plant communities. Tree planting is generally discouraged as part of restorations in the prairie portion of the state to support habitat for grassland birds that avoid nesting near trees and shrubs. Trees can be planted as seed, bare-root, from containers, or in combinations of these methods. The rate of establishment depends on the thoroughness of site preparation, restoration strategy, size of starter plant materials, herbivore pressure and the corresponding protection of trees and shrubs from herbivores, and the amount of maintenance conducted. Planting strategies chosen for a project depend on the type of community to be restored, project goals, and budget.

Planting 200 to 400 seedling trees or shrubs per acre is recommended for forest plantings when planted into herbaceous cover. Spacing depends on the size of the plant material, seedbank of woody species, potential for colonization, expected aftercare, and potential

Figure 5.53 *Planting Bare Root Trees*

losses. Tree planters pulled behind tractors create a furrow that trees are placed in. Rows that result from this type of planting can aid maintenance activities but result in a less natural appearance. In some cases, trees and shrubs may be planted five or six feet apart to allow natural thinning but this type of planting is more expensive. It is not uncommon to lose between 25-50% of seedling trees and shrubs or cuttings; incorporate this potential loss into project planning. Tree and shrub

Figure 5.54 *Containerized Tree*

Figure 5.55

seeding has been an effective method of establishing uplands as deer and other herbivores cannot impact all of the trees, leading to higher success rates. The density of woody plant establishment also provides competition for weeds.

Tree and shrub seedlings susceptible to deer and rodent browsing require protection such as bud caps, fencing, and repellents to ensure their survival. Three inches of wood mulch conserves water and decreases weed completion but as much as five to six inches of mulch can be used to decrease long-term weed growth. Water trees and shrubs during planting and in the weeks after planting if rainfall is less than one inch per week.

More detailed information on **Planting Upland Trees and Shrubs** can be found in the Planting Upland Trees and Shrubs Technical Guidance Document located in Appendix 5A-8.

Figure 5.56

Figure 5.57

Promoting Beneficial Soil Microorganisms

Soil microorganisms including bacteria, fungi, and algae play an important role in promoting soil health and vegetation growth within native plant communities. Bacteria are the most abundant microbes in the soil and provide many ecosystem services including nutrient cycling, development of soil structure, disease suppression, improvement of infiltration, and water retention. Bacteria populations tend to change as plantings develop and become more stable. Fungi also play an important role in soil and plant community health. Their services include decomposition and nutrient cycling, disease suppression, development of soil structure, increased soil infiltration, and water retention.

Most prairie legumes have associated nitrogen-fixing bacteria (Rhizobia) that aid their growth. Nitrogen can be limiting in upland habitats, so the addition of nitrogen-fixing bacteria can support plant communities. Sites that have been in agriculture or are heavily compacted or disturbed in other ways, often lack nitrogen-fixing bacteria. Innoculum is mixed directly with legume seeds prior to seeding. Seed, inoculants, and a sticker that binds microorganisms to the seed are mixed until the seeds are uniformly covered. Check with the vendor providing seed mixes to ensure that appropriate bacterial inoculum is included with legumes.

Mycorrhizal fungi is the most common type of fungi incorporated as part of restoration projects. They colonize plant roots and establish a symbiotic relationship, receiving 3-20% of the carbon produced by plants. In return, plants benefit from a wider source network for nutrients and water transport, increased tolerance to heavy metals, and increased disease resistance. Mycorrhizae also improve soil structure and increase cycling of organic matter.

Mycorrhizae appear to be associated with specific plant genus. They are beneficial in restorations on severely disturbed or nutrient poor soils. Some species such as bur oak have been shown to grow much quicker when mycorrhizae are incorporated into their root systems. Mycorrhizal fungi are most commonly incorporated by the inoculation of potted plants or by spreading inoculated soil, seed, or pellets in trenches or by broadcasting it over the restoration site.

In addition to the specific introduction of nitrogen-fixing bacteria and mycorrhizae fungi, certain steps can be taken to promote microorganisms. Avoiding site preparation methods such as tilling and chemical application, which can decrease microorganism populations, is one. Planting temporary cover crops in fields that have been in agricultural production may promote the development of soil structure and beneficial microorganisms. Also, protect intact areas on restoration sites; they can act as a refuge for beneficial microorganisms.

More detailed information on **Promoting Beneficial Microorganisms** can be found in the Promoting Beneficial Microorganisms Technical Guidance Document located in Appendix 5A-9.

Figure 5.58

Figure 5.59

5-5 Establishing Vegetation in Wetlands

Establishing vegetation in wetlands ranges from promoting native seedbank to planting wetland trees and shrubs. Specific techniques may be used to restore unique communities such as calcareous fens, peatlands, and wild rice beds. When planning wetland vegetation, many factors come into play including: target plant communities, existing site conditions, surrounding land-use, potential sedimentation, planned construction activities, hydrologic conditions, project sequencing, and project budget. Assess existing site conditions to gain a full understanding of project constraints and opportunities.

Project goals and budget play a significant role in the selection of planting strategies for wetlands. Projects that have limited budgets for plants and seed often rely on native seedbanks or natural colonization for wetland vegetation establishment. This may lead to lower diversity and a higher percentage of invasive species than projects that are planted with seed and plants. Project designers should explore the techniques that will most likely result in successful vegetation establishment on each project.

The information about planting strategies in this chapter is intended to include practices that have been successful for practitioners. It will be updated as new information is obtained through research and field experience. This is important, as there is still much to be learned about many practices such as predicting seedbank potential, seeding of trees and shrubs in wetlands, peatland restoration, seeding wild rice, and providing competition for invasive species. The following restoration techniques are covered in this chapter:

Figure 5.60

An overview of the following list of strategies is discussed in this chapter of the guide with more specific and detailed information provided in **Technical Guidance Documents** that are located in Appendix 5-A and referenced accordingly.

- Promoting Native Seedbank
- Wetland Seeding
- Planting Wetland (Non-woody) Containerized Plants and Rootstock
- Planting Wetland Trees and Shrubs
- Peatland Restoration
- Wild Rice Seeding

Figure 5.59

Figure 5.61 *Vegetation From a Native Seedbank*

Promoting Native Seedbank

Maximizing the use of native seedbank is encouraged for projects as a means to promote the establishment of local plants and supplement seed mixes. The viability of the existing remnant seedbank in a drained wetland is a function of how long the wetland has been drained and in agricultural production. If the wetland has been drained for less than 20 years, some seeds in the seedbank are probably viable (Galatowitsch and van der Valk, 1994). Wienhold and vander Valk (1989) found that less than three wetland species were present in restored prairie potholes that had been drained for 40-70 years, five to seven species in those that were drained for 5-30 years, and more than eleven species in wetlands that were never drained. Regardless of the amount of time that a site has been drained and in agricultural production, a test of the remnant seed bank can help determine the re-vegetation potential of the site. A method for testing seedbank viability can be found in Section 5, Appendix D of the "Minnesota Wetland Restoration Guide".

> Native seed bank plays an important role in promoting diversity and project resiliency.

If a seedbank test (or a survey of species that are establishing at the site) is available, this information can be compared to the composition of reference wetlands near the restoration site to gain a better understanding of what species may need to be added to restoration seed mixes. 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.

When the use of native seedbank is planned for a project, it is sometimes beneficial to seed temporary cover crops to prevent weed germination until wetland hydrology is restored. Temporary cover crops help stabilize soils and prevent erosion until the seedbank can germinate. Oats, winter wheat, and slough grass are the most common species used for this purpose. Ryes should be avoided as they can inhibit seed germination.

Excavation or scraping can be used to expose seedbank that has been buried from sediment deposition. Measure the appropriate depth to reach the seedbank and conduct sufficient oversight to ensure that exact depth is exposed. In some cases, deep plowing can turn over soil and expose a native seedbank.

More detailed information on **Promoting Native Seedbank** can be found in the Promoting Native Seedbank Technical Guidance Document located in **Appendix 5A-10**.

Figure 5.62 *Sediment Removal*

Figure 5.63 *Broadcast Seeding by Hand*

Wetland Seeding

Weed species must be thoroughly controlled and other site preparation practices completed before wetland seeding is conducted. Broadcast seeding with Cyclone, Vicon, or other mechanical broadcast seeders and by hand broadcasting is the most common method of seeding wetlands because the seed of most wetland species requires light to germinate and should not be buried. Gleason et.al. (2003) found that as little as 0.5 cm of sediment reduced wetland seedling emergence by 91.7 percent and total invertebrate emergence 99.7 percent. Unless the seed is of a species that floats or is of relatively large size, a small amount of sediment has the potential to ruin a planting. Stabilize both the upland and wetland to protect the seeding of wetland species. Also, while broadcast-seeding, ensure an even distribution of seed to avoid bare areas. Bare soil allows weedy species an opportunity to establish.

Figure 5.64 *Winter Seeding*

Wetland seeding is often conducted before hydrology is restored to allow access with equipment.

Higher seeding rates are required with broadcast seeding. A relatively high number of seeds per foot are used for wetlands. The use of seed drills is discouraged for wetland seeding; they can bury seed too deep for germination. Seed drills are sometimes used to seed wetland grasses, followed by broadcast seeding of sedge, forb, and rush seed. Wetland broadcast seeding followed by rolling ensures that seed stays in place. In some cases, seeding is also conducted shortly before or after snowfall to protect seed from wind, birds, and rodents.

Wetland seeding should be planned to coincide with the restoration of hydrology. It is common to conduct wetland seeding in the fall or winter before wetland hydrology will be restored the following spring. Planting in the fall allows for the use of larger equipment before soils become too wet. However, in areas where there will be flowing or open water after snowmelt, it may be beneficial to wait to conduct seeding in late spring or early summer after hydrology has stabilized. This is particularly true along the edge of open water where seed is easily displaced.

Wet meadow and wet prairie seed mixes are used from the planned edge of open water (pool elevation) to around one or one-and-a-half feet in elevation above the pool 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. The State emergent mix is used in a six- to ten-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 common to overlap wetland mixes a few feet with upland mixes, as moisture conditions can be variable.

Figure 5.65

If water control structures are available, manage water levels to keep soils saturated and to prevent seed from washing away. Use containerized plants in combination with seed for species that establish slowly from seed. Although more expensive, containerized plants help ensure the establishment of emergent species along the edge of open water where seed establishment is less predictable. Mowing and spot herbicide application may be needed to control weed species.

More detailed information on **Wetland Seeding** can be found in the Wetland Seeding Technical Guidance Document located in **Appendix 5A-11**.

Planting Wetland (Non-woody) Containerized Plants and Rootstock

Containerized or bareroot plants are often installed in combination with seed to increase the rate of establishment and to introduce species that do not grow well (or rapidly) from seed such as wild iris, river bulrush, lake sedge, sweet flag, and bur-reeds. Timing, size, and maintenance are the three requirements to consider in choosing to use whole plants instead of, or in addition to, seed.

Time the planting of containerized and bare-root plants with the restoration of hydrology. Plants must have sufficient moisture from the start. In some cases, plants are installed during the second year of a restoration, after water levels have stabilized. Watch weather forecasts around the time of planting to see if water levels could change significantly in the days before or after planting. If bare-root plants are being dug from nursery beds or otherwise transplanted, conduct the planting relatively early in the spring to limit leaf growth that could lead to excessive moisture loss during establishment. (**Figure 5.67**). Containerized plants can be put in through June if the weather is favorable. Plugs and pre-vegetated mates need to be grown through May in greenhouses in order to be large enough for transplanting into restoration projects. Using larger containers increases the rate of establishment but will add significant cost compared to relatively-inexpensive plugs. Bare root plants have well-developed root systems, so they can establish quickly.

It is important that water levels will not rise above newly installed plants.

Figure 5.66 *Planting Along Open Water*

Figure 5.67 *Shoreline Planting with Erosion Control, Photo by Prairie Restorations Inc.*

Figure 5.69 *Spreading Masses of Emergent Plants*

The edge of open water is a difficult zone to plant. Containerized emergent plants are installed about ten feet apart (often 100-150 plants per acre) and staggered along the shoreline. 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.

Research has shown that May or June is the best time for aquatic plant establishment. Late summer plantings have low survival rates. There has been some success with planting plugs in late fall after they are dormant but they can be susceptible to desiccation over winter or flooding in the spring. Emergent plants should be installed at a depth where they will not be covered with standing water. It is common that emergent plants will have competition from cattails, so pulling or herbicide treatment of cattails may be beneficial (figure 5.70) Waves may damage plantings, particularly on east shorelines; plant some emergent species a little further up slope from the open water edge to hedge against disturbance. Wave-break structures or coconut fiber logs can also be used to minimize wave damage but may not be practical for many wetland restoration projects. Fencing may be needed for projects where geese may graze young plants; in some cases this can be as simple as flagging tape attached to stakes. Watering may be needed in drought conditions.

Figure 5.68 *Pre-vegetated Mat*

Submergent and floating-leaved species such as wild celery, coontail, lotus, and sago pondweed can be used in deeper portions of a site. Some species need to be planted from containers while others can be planted as bare-root plants or plant fragments. Contact plant vendors for availability of species and propagule types and to provide recommendations on how best to anchor and establish new plantings.

More detailed information on **Planting Wetland Non-woody Plants** can be found in the Planting Wetland (Non-woody) Containerized Plants and RootstockTechnical Guidance Document located in **Appendix 5A-12**.

Figure 5.70 *Fencing to Exclude Geese*

Figure 5.71 *Narrow-leaf Cattail*

Figure 5.72 *Floating-leaved Pondweed*

Planting Wetland Trees and Shrubs

Wooded swamps, floodplain forests and shrub wetlands are a long-term goal for some projects. Planting trees and shrubs in wetlands is a relatively new science and more information will improve survival and growth rates. Some estimates show that it may take 35-50 years before restored or created forested wetland sites have wetland vegetation and wildlife similar to mature forested wetlands, due to plant mortality and slow growth rates of nursery stock (Perry et. al.). The rate of establishment will depend on the restoration strategy and size of plant materials used and the amount of maintenance. Planting strategies chosen for a project depend on the type of community to be restored, project goals, and project budget.

Planting 200 to 400 seedling trees or shrubs per acre is recommended for forested or shrub wetlands. Spacing should depend on the size of plant material, seedbank of woody species, potential for colonization, expected aftercare, and potential losses. Planting is most commonly conducted with shovels as conditions are typically too wet for mechanized tree planters. It is not uncommon to lose between 25-50% of seedling trees

Figure 5.73

Figure 5.74 *Mixing Tree and Shrub Seed*

Figure 5.75

Figure 5.76 *Wire Fencing Around Trees*

and shrubs or cuttings. Nursery-grown plants may not do well when planted in saturated soils; planting on mounds can help replicate the natural topography of hummocks and downed logs.

Nursery grown trees often do not grow well in saturated soil and benefit from planting on mounds or other microtopography.

As tree and shrub seedlings are susceptible to deer and rodent browsing, their survival depends on protection. The other alternative is to plant large numbers by seed and then to expect some loss. Species such as northern white cedar are attractive to deer, so fencing or other methods of protection are particularly important. Watering is needed for trees and shrubs if rainfall is less than one inch per week.

More detailed information on **Planting Wetland Trees and Shrubs** can be found in the Planting Wetland Trees and Shrubs located in **Appendix 5A-13**.

Peatland Restoration

Peatland restoration involves the restoration of bog and poor fen communities.(use figure 5.76) It has been conducted most commonly in Canada in areas where peat has been harvested for the horticulture industry. Peatland restoration is a more recent practice in Minnesota, having been attempted in peat-harvest areas as well as in gravel pits in the northern parts of the state as a means to re-establish bog communities.

Peatlands have water-saturated soils that are composed of partly-decayed remains of plants. The plant material accumulates as a result of slowed bacterial and fungal action in waterlogged environments. Different classifications of peatlands include non-forested bogs, forested bogs, rich fens, and poor fens (Tester 1995). These communities are found in the boreal forest biome that has cool temperatures and short summers. Bogs and poor fens have low-nutrient conditions conducive to the growth of sphagnum as well as other mosses, cottongrass, and a variety of low-growing shrubs.

Peatland restoration projects require careful analysis of the peat thickness and chemistry of harvested peat bogs, hydrology, topography, and proximity to a suitable donor area. It is best to select donor sites where impacts are already planned as the harvest will change the community functions for a period of several years.

Figure 5.77

Figure 5.78 *Establishing peatland species*

Figure 5.80 *Mulching with Straw, Photo by Natural Resources Research Institute*

Saturated soil is essential for the re-establishment of sphagnum mosses that are the primary plant species in acid peatlands. Block drainage ditches or use other water management techniques to restore water levels to be at or near the surface of the ground on which the donor peat will be spread.

Grade to create topography that is either level or with a slightly concave surface. This will increase water availability. In the case of gravel pit areas, significant grading may be needed. At the donor site, chop the bog surface early in the spring (after snowmelt) to provide moss fragments for restoration. After harvest, transport moss fragments to the restoration site with minimal delay.

Fragments are spread with an agricultural manure spreader at a rate of 1:10, one square foot of donor area to ten square feet of bare peat surface, resulting in a layer one to two centimeters thick. Cover the introduced fragments with mulch to protect them until they establish. Straw mulch is applied with a forage blower at a rate of 1.5 tons per acre. Herbaceous seed of some bog species may be in the donor material and introduced to the site; this will aid restoration efforts.

Sites that have retained an acidic, low-nutrient substrate may not have much invasive species pressure. Sites without these qualities may have problems with invasive species such as reed canary grass, requiring spot herbicide treatment.

Sphagnum regeneration without introduction from donor sites has been observed on some wetland restoration projects in restored wild rice paddies. The growth of sphagnum moss in these situations may be slower than introducing peat from a donor site but it will add to the structure of the restored plant community.

More detailed information on **Peatland Restoration** can be found in the Peatland Restoration Technical Guidance Document located in **Appendix 5A-14**.

Figure 5.79 *Spreading Moss Fragments*

Wild Rice Seeding

Wild rice has significant cultural and ecological significance in Minnesota. Culturally, it was a primary food source for Native Americans and played a key role in their day-to-day lives. Wild rice is still harvested today and is an important part of the northern Minnesota economy. Ecologically, wild rice is a major food source for a variety of bird and animal species. Wild rice provides an important energy source for waterfowl during fall migrations. It also provides habitat for invertebrates that, in turn, sustain many species of fish.

Unfortunately, wild rice populations have been on the decline in Minnesota. Exact causes for the decline are not known but likely reasons include: competition with invasive species, climatic conditions, boat traffic, carp, pollutants, and hydrology alterations. The largest populations of wild rice are in the central and northeast parts of the state. Historic accounts and herbarium collections show that it had a very wide distribution across Minnesota, likely covering most, if not all, of the state.

Wild rice requires clear, shallow, slow moving water.

Wild rice is an annual, meaning that it only lives one season. The seed ripens in the fall and then drops. The seed can remain viable in the soil for many years. The seed germinates under water and opens floating leaves before sending up a main stem that produces separate male and female flower parts.

Wild rice is likely adapted to local site conditions; as a result, it is recommended to plant wild rice as close to the collection site as possible. It is believed that populations growing in the northern part of the state are genetically different than plants growing along the Minnesota and Mississippi Rivers in the southern half of the state. Cultivars being used in wild rice production have different genetics and growth habitats than the native wild rice populations and should not be used for restoring wild rice populations.

Wild rice grows in shallow water from six inches to three feet deep. The species tends to do well in areas where there is some water movement, such as along slow moving rivers. Water movement provides oxygen and nutrients that are needed by the plant. As wild rice germinates under water, it requires clear water for sufficient sunshine to grow. On lakes, wild rice tends to establish in bays and sheltered areas.

The presence of broad-leaf arrowhead, water lilies, and pondweeds can be good indicator species of where wild rice may do well, though too much competition may inhibit growth.

Most seed harvest is conducted around the end of August through the first week of September by traditional methods using canoes and harvesting paddles. It is believed that seed must be stored wet or it will lose germination. As a result, most seeding efforts are conducted shortly after harvest.

Seed tends to be broadcast at rates of 6-30 pounds per acre by hand dispersal from boats or, in some cases, by mechanical seeders.

More detailed information on **Seeding Wild Rice** can be found in the Wild Rice Seeding Technical Guidance Document located in Appendix 5A-15.

Figure 5.81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5-6 Selection and Placement of Seed and Plant Materials

Figure 5.82 *Emergent Planting Zone*

The information in this chapter summarizes the selection of seed and plant materials and provides guidelines for their placement on project sites. There are many types of plant materials that can be selected for a project . An increasing number of species are becoming available as seed and plants. As seed and plant material can be a significant project cost, project designers should understand options for a project, selection considerations, and where seed and plant materials can most effectively be used to provide the greatest project benefits.

The information in the previous two sections of the Guide, Sections **5-4 Upland Planting** and **5-5 Wetland Planting** should have already been reviewed and considered as the decisions regarding plant selections are being made.

Topics covered in this section include:

- **General Seed and Plant Material Considerations**
- **Seed Mix Selection**
- **Seed Mix Standards**
- **Seed Mix Development**
- **Selecting Plants**
- **Seed and Plant Placement**

General Considerations

Many projects in the past have used native seedbanks or natural re-colonization for vegetation establishment. This has been successful for many projects, and can promote local seed use, but cannot be relied on if invasive species are present, if landuse has depleted the native seedbank, or if sediment accumulation has buried the seedbank. An increasing number of projects are beginning to focus on the planting of seed for wetland plant communities in addition to upland buffers to maximize wetland functions. Wetland seed can be expensive, so it is important to find local sources for collection or to select appropriate mixes for the given soil and hydrologic conditions. Plants, including containerized plants, pre-vegetated mats, bare-root plants, and transplants will jump-start vegetation establishment, particularly in situations where fluctuating water levels or other variables related to hydrology will prevent seed from establishing.

Planting decisions should be made by a plant specialist coordinating with the site hydrologist, soil scientist and/or geotechnical engineer.

Figure 5.83 *Mixing Wetland Seed*

Figure 5.84

Seed Mix Selection

Major considerations when selecting seed mixes for projects include the project type, availability of locally collected seed, target plant community, seeding rates, geographic location, budget, seed availability, project maintenance requirements, and cover crop needs.

Project type

There are many types of conservation and ecological restoration projects that are conducted in the state of Minnesota with varying goals that may include soil and water conservation, wildlife habitat, native seed production, bio-energy production, mitigation and recreation. Seed mixes tend to be designed to maximize the goals of individual projects. Projects may also have specific statutory or program requirements that may influence the design of seed mixes.

Seed Mixes

There are many seed mixes to select from in Minnesota including State seed mixes, mixes developed following NRCS practice standards, and mixes available from private seed vendors. Custom seed mixes can be developed to meet specific project needs. Seed mixes should be selected based on how well they will meet project goals and individual site needs.

Seed Mix Links

Minnesota Board of Water and Soil Resources
www.bwsr.state.mn.us/native_vegetation/

Department of Transportation
www.dot.state.mn.us/environment/erosioncontrol/seedmixes.html

Minnesota Native Wildflower/ Grass Producers Association
www.mnnwgpa.org

Natural Resource Conservation Service Practice Standards
www.nrcs.usda.gov/Technical/efotg/index.html

Target Plant Community

The species that occur in sedge meadow and wet meadow community types have many similarities. Dominance of sedges vs. grasses and composites in these communities is likely determined by soil type and moisture conditions. State wet meadow mixes have been developed for use in establishing sedge meadows and wet meadows with the assumption that species will establish and sort themselves out over a few years.

Figure 5.85

Wet prairie contains many of the same species that are found in sedge meadows and wet meadows, however, there are some species that are unique to wet prairies. Wet prairies contain a number of species common to more mesic and even dry prairies such as big bluestem and Indian grass. BWSR Mixture W3 has been developed for wet prairie establishment.

Seed for tree and shrub planting can be obtained from some vendors. Species that have been available include tamarack, maples, ash, alder, and dogwood. Some vendors can collect for specific projects if given enough time for seed collection.

Table 5.20 summarizes the intended use of wetland seed mixes. These seed mixes are used throughout the state for wetland restoration; mixes have been developed for a wide variety of plant community types. Seed mixes can be found on the BWSR website at: **www.bwsr.state.mn.us/native_vegetation/**

Seeding rates

Target seeding rates vary depending on the type of community being restored. The target for upland tallgrass prairie mixes is 30 - 70 seeds per square foot and for short-grass prairie mixes it is around 100 seeds per square foot. Between 150 – 200 seeds per square foot are recommended for wetland mixes. The higher density for wetland seed is to compensate for the higher seed mortality inherent with smaller seed sizes and loss due to broadcast seeding. These seed densities are based on seed counts for some species that have been cleaned down to bare seed.

Table 5.21 ***Use of Seed Mixes***

Wetland Type	Mixture(s)	Planting Notes
Shallow marshes (Type 3), deep marshes (Type 4), open water wetlands (Type 5)	Emergent seed mixes	If possible, draw down water, plant emergent mix in ten foot band where normal pool edge is expected. As plants are establishing water levels can be brought back up. Many emergent species will spread into open water. Containerized plants or pre-vegetated mats are recommended in addition to seed to ensure establishment along the edge of open water.
Floodplain (Type 1), sedge meadow & wet meadow (Type2)	Wet meadow seed mixes or custom mixes to increase dominance of floodplain or sedge meadow species. Modified riparian mixes may also be used for floodplains.	Plant mixes in saturated to moist soil zone. Floodplain plantings often include three and shrub seed, seedlings or larger containerized plants.
Floodplain (Type 1), sedge meadow & wet meadow (Type2)	Wet prairie seed mixes	Plant wet prairie mix in saturated to moist soil zone. Plant upland mix where soils are expected to be dry (usually around 1.5 feet in elevation above pool edge).
Shrub swamps (Type 6) & wooded swamps (Type 7)	Custom wet meadow seed mixes	Plant wetland seed mixture in saturated to moist soil zone. Shrubs and some trees may be established as cuttings. Trees and shrubs can also be established with seed, seedlings or containiezed plants.
Bog (Type 8)	Peat application from donor site or custom mixes	After site is prepared with peat, supplemental custom seed mix can be planted in saturated to moist soil zone.
Riparian-stream with shallow banks and associated floodplains	Riparian seed mixes and custom wet meadow seed mixes	Riparian mixes are planted on the stream banks and in the associated floodplain zone where soils are saturated to moist. Plant upland mix where soils are expected to be dry.
Riparian-streams with long and/or steep banks	Riparian seed mixes with upland mixes	Riparian mix used along the lower streambank and in floodplain areas. The upland mix is planted going up the slopes.

Figure 5.86

Geographic Location

Soils, climate, hydrology, and vegetation can vary widely across the state of Minnesota. It is common to develop seed mixes that are suited to different areas of the state. It is a recommended practice to obtain seed that originates from similar site conditions and from as close to the project site as possible.

Climate change is a growing concern related to ecological restoration. More research is needed to determine how climate change could be factored into restoration planning and the development of seed mixes.

Budget

Project budget often has a significant influence on the number of species purchased for projects and the number of forbs versus grasses. CRP seed mixes from vendors tend to be the most inexpensive as species in these mixes are harvested in large volume. Seed mixes are that have increased diversity tend to have increased cost. However, on a per seed cost many forb seeds are not more expensive than grasses but it generally depends on the species selected.

Seed Availability

Seed availability tends to depend on the propagation and demand for individual species and seasonal variation in production.

Propagation of individual species – Some species are easier to propagate from seed than others. Native grasses are relatively easy to germinate from seed while many forbs need special methods of stratification. There are examples of some species where no reliable methods have been developed to grow the plants from seed. The ease of propagation influences the overall production of species and the use of species in seed mixes.

Demand for individual species – The demand for individual plant species from seed can depend on how well known the species is to the restoration community. The species most commonly seen in the landscape are the species that are used the most in seed mixes. This may help the propagation of common species but not species that are less common. Less common species will also be more expensive from seed, as less seed tends to be available for collection. Research and education efforts play an important role in ensuring that the full composition of native communities is considered when designing sites and seed mixes.

Seasonal variation in production – Like most crops, native seed production can vary from year to year due to climatic conditions, bird and animal use, insects, and disease. Low supply during a particular season will influence seed costs or may lead to an increased use of substitutions or cultivars.

Figure 5.87 *Separate Grass and Forb Bags*

Project Maintenance Requirements

Select seed mixes with an eye to the amount and type of maintenance that will be conducted at a project site. Ultimately, the amount of time that will be spent monitoring and maintaining a site will influence the diversity that can be sustained over time. Burning, mowing, spot treating herbicides, and grazing are strategies that can be used to maintain diversity over time but they all require the commitment of time and resources.

Cover Crop Needs

Cover crops are plant species that establish quickly and are short lived, making way for slower-developing native plants. Cover crops prevent soil erosion and provide cover for establishing native species. Cover crops include common grains such as oats and annual rye grass as well as native species such as Canada and Virginia wild rye, fowl bluegrass, and slough grass.

Recent research has indicated that cover crops in wetland mixes may not inhibit the growth of reed canary grass. Cover crops in wetlands may actually delay the establishment of native species, allowing reed canary grass time to become established (Iannone and Galatowitsch 2008). Cover crops are generally needed in seed mixes but appropriate percentages will be investigated in the future.

Figure 5.88 *Giant Bur-reed*

Seed Mix Standards

Seed mix standards ensure that high quality local seed is used. Seed standards include the certification of seed source, the use of pure live seed, seed cleaned to high standards, the verification of seed tags and standards for substitution and shipping.

Local Ecotype Seed

The use of seed with a local genetic origin is a goal of most restoration projects. Source-identified (yellow tag) certified seed has a known genetic collection site from which the germplasm was first collected. The collection site is verified and documented on the certification label usually identifying the county of origin of the germplasm. Currently, genetic testing is not part of the certification process. The certification program is operated by the Minnesota Crop Improvement Association (MCIA). The use of the yellow tag system relies on demand for yellow tag certified seed. The system is not a requirement for many programs, so it has been used inconsistently.

In addition to yellow tag certification, MCIA has two additional levels of seed classes that differ in the amount of intentional selection that has taken place. "Selected" seed is marked with a green tag and is the progeny of phenotypically selected plants with traits or parentage that has promise but no proof of inheritance. "Tested" seed is marked with a blue tag and is the progeny of plants whose parentage has been tested and proven to possess distinctive traits for which the inheritance is stable but for which a variety has not been named or released. In addition, all certified seed is required to be tested to verify that the seed complies with Minnesota Seed Law requirements and to allow accurate labeling.

It is common that projects specify an acceptable distance for the origin of native species. As a general rule, plant materials should originate from as close to a project site as possible. Using local sources of seed will help protect the genetics of remnant plant communities.

Pure Live Seed

Pure live seed is a measurement of the amount of seed that germinates in a standard (14 day) germination test plus the amount found to be alive (but didn't germinate in 14 days or is dormant) from a viability (tz) test. Pure live seed is determined by multiplying the percent germination success by the purity of seed (purity refers to the amount of actual seed versus stems or other plant material left in with the seed).

The PLS number can then be multiplied by the number of seeds per pound or kilogram to give an estimate of the number of seeds per pound or kilogram that are expected to germinate. The number that is attained through these calculations is useful in determining the number of viable seeds in a unit of weight (Diboll 1997).

Figure 5.89 *Canada Anemone*

Figure 5.90 *Wetland Forb and Sedge Seed*

It should be noted that most native species take longer than 14 days to germinate, so tests resulting in low germination but high viability are not uncommon. "Standard" seed tests for germination were developed for agricultural crops such as corn and soybeans. To date there have been no "standard" seed testing protocols developed for seed derived from wild native plants (Jacobson 2006).

When wild collected seed is used for a project it is useful to have the germination and viability of the individual species in the mix tested to determine how much of the seed is likely to grow, and what rate should be used for the seeding.

Seed Cleaning Considerations

If a seed supplier does not clean their seed down to bare seed for the listed species, then the seed test must include the seed count. Additional bulk seed needs to be added to match the design seeding rates. One example of this is with Canada Blue Joint Grass. Some suppliers sell the seed with the lemma, palea, and pappus intact. Some clean this species down to the bare seed (careopsis). It takes about ten pounds of "fluffy" seed to yield one pound of bare seed. The PLS of un-cleaned and cleaned seed may be the same, say 90 percent, however, the seed count per pound will vary as much as ten fold. There are no species-specific standards for cleaning wetland seed; be aware of this fact and ask enough questions to know how many seeds you are getting.

Seed Tags

The Minnesota Seed Law requires that all seed offered for sale in Minnesota be labeled with analysis labels. In addition, certified seed must be labeled with a certification label or be accompanied by a certification certificate. Project designers should compare seed tags on each bag with the invoice for the purchase. It is also recommended that native seed vendors supply a copy of the seed test for each species in the mix. In Minnesota, seed tests are legal for 15 months for native species. If a period longer than this has transpired, it is required that tests be performed again. **Figure 5.91** shows an example of a seed tag.

Required labeling for MnDOT seed

Mixture Name:	*Total PLS #:	*Total Bulk #:			*Area Covered:			Lot Number:		
Labeler's Name:			Labeler's Mailing Address:							
*Scientific Name	Common Name	*Mix %	Variety	Origin	*PLS %	*Purity %	Total Germ %	Germ %	Hard + Dormant %	Pure Seed %
Germ Test Date (mm/yyyy):		Weed Seed:			Noxious Weed Seed (Name of Each Present):					
Sell By Date (optional):		Other Crop:								
			Inert Matter:		Number per Pound:					

Figure 5.91

Notes:
*Headings with an asterisk represent information required in addition to Minnesota Department of Agriculture standards.

Also in addition to MDA standards, information is required for all components of mix, including those that constitute less than 5% of mix.

If large and small seed are bagged separately they must have separate tags.

Mixture Name: Labeling a mix as a Mn/DOT mixture requires adherence to all applicable Mn/DOT specs.

Area covered: Area covered by amount of seed in bag when applied at rate specified for that mix in Mn/DOT Specs, Table 3876-5

Mix %: PLS wieght of species divided by total PLS weight of mix

Variety: Includes Source Identified (Yellow Tag), Wild Type, or Variety

Origin: Location of Genetic Origin. County(ies) must be listed for native species.

PLS % = (Purity x Total Germination)/100

Total Germ % = (Germination %) + (Hard + Dormant Seed %)

Pure Seed % = (Pure Seed weight of species)/(total bulk weight of mix)

Germ Test Date: Date for component with earliest test date. Must not be more than 15 months prior to date of sale, exclusive of the month of test.

Species Substitutions

Due to seed supply limitations from year to year, there is often the need to work out an agreeable substitution for one or more species with seed suppliers. Substitutions should be based on functional needs, the wetland indicator status, genus of the substitution, and successional status of the species.

Shipping

Most native seed suppliers will ask how seed should be mixed before they ship it. Many suppliers provide the smaller and larger seed components of a mix in separate bags to allow proper seed installation with a typical seed drill used for seeding upland native mixes. State wetland mixes are often supplied as three components; grasses, forbs, and sedges/rushes/bulrushes. Small, heavier forb, sedge, and rush seed can be placed in separate compartments of native seed drills or added periodically to broadcast seeders to ensure even distribution. Most suppliers will break down the mixes into components and provide them this way at no extra charge.

Seed Mix Development

The development of seed mixes can be a complicated process factoring site conditions, goals, seed costs, seed density targets, planting strategy, species diversity, species germination potential, combining early and later successional species, grass to-forb-ratios, cool and warm season species, and historic composition of plant communities.

Figure 5.92 *Seed Bags*

The first step in developing a seed mix involves creating a list of species based on the project goals and functional needs. A mix developed for erosion control may have a different composition of species than a mix focused on species diversity and plant community reconstruction. When reconstructing plant communities, lists of species from remnant communities or historic lists of plant communities are often used as a guide. Species that are not available as seed will ultimately need to be taken off of the list.

After developing a rough species list, the final percentage of each species in the mix should be determined, again using the natural communities as a guide. Determine species that will co-exist well without individual species being overly aggressive. Also consider having early and later successional species, having a balance of warm and cool-season species, and include grasses and forbs typical to the target plant community. When attempting to re-create the composition of natural communities, it is common to have around 50% of a mix (by seed count) composed of forbs. This varies depending on the community to be restored.

Once percentages of species are determined, the next step is to determine the number of species planned per square foot. It is common to seed between 150 - 200 seeds per square foot for wetland mixes. The target for upland tallgrass prairie mixes is 30 - 70 seeds per square foot and for short-grass prairie mixes it is around 100 seeds per square foot. These seed densities are based on seed counts for some species that have been cleaned down to bare seed.

The higher density for wetland seed is in part to compensate for the higher seed mortality inherent with smaller seed sizes. These rates per square foot typically correspond to 10 pounds PLS grasses/acre and two lbs. PLS forbs/acre for both wetland and upland mixes. The final seeding rate is 12 pounds PLS/acre (Bohnen and Galatowitsch 1999). This rate is doubled during broadcast seeding because not all of the seed will be dispersed in ideal conditions for germination (Morgan et al. 1995). Rates for rough cleaned, wild-collected seed may require a seeding rate as high as 30 to 40 pounds per acre, depending on the amount of plant material with the seed (Diboll 1997).

To determine the amount of seed of any given species to order, know the seed weight (seeds in an ounce) for each species in the mix. The weight of various species can be determined by contacting nurseries that sell that species. In addition, the Prairie Moon Nurseries catalog provides information on average weights for many species. Weighing certain amounts of seed and counting the number of seeds in the sample can also determine seed weight. Seed size can vary greatly from the large seeds of compass plant and cup plant with around 800 seeds per ounce, to the very small seeds of cardinal flower, blue lobelia, and Culver's root with around 800,000 seeds per ounce (Diboll 1997).

Determining Ounces Needed Per Species

The best method of determining the number of ounces needed for each species is to start with the number of seeds that are planned per square foot. For this example, let's assume that 200 seeds per square foot will be planned for a wetland seeding. The next step is to multiply the percentage of individual species in the mix by 200 to determine how many seeds of each species will be found in the one square foot of area. For example, if fox sedge will make up 10% of the mix (by seed count), multiply 0.10 by 200 to determine that 20 fox sedge seeds would be needed per square foot: (200 seeds per square foot x 10% or 0.1 = percent of fox sedge in the mix = 20 fox sedge seeds per square foot.)

Once the number of seeds needed for each species for one square foot is known, that number can be multiplied by the number of square feet that make up the entire project area. If the project site is 43,560 square feet (one acre) then 43,560 square feet would be multiplied by 20 to determine the number of fox sedge seeds needed for the project: (43,560 ft (entire project area) x 20 (number of fox sedge seeds in one square foot) = 871,200 fox sedge seeds needed for the project).

The final step is to divide the number of seeds needed by the number of seeds per ounce for a species. Fox sedge has 100,000 seeds per ounce. 872,000 should be divided by 100,000 to determine the number of ounces needed for the species:

$$\frac{\text{871,200 (number of fox sedge seeds for entire project)}}{\text{100,000 (number of seeds in an ounce of fox sedge)}} = \text{8.7 ounces of fox sedge seed}$$

These steps should be conducted for each species in the mix.

One final consideration is that more seed of species that have small seeds should be added to a seed mix when using a seed drill. Seed drills place seed at a pre-specified depth. This depth is often not ideal for very tiny seed, which needs to be planted at very shallow depths or simply dispersed on the soil surface. Increasing the quantity of small seed in a seed mix ensures that some of the seed will germinate. Following the previous example using fox sedge, to increase by ten percent: 8.7 ounces x 0.10 (ten percent) = 0.87; add this to the original amount: 8.7 + 0.87 = 9.57 ounces.

Selecting Plants

Plants are often used in addition to seeds or in some cases without seeding. Plants are used in situations where seed may not establish or rapid establishment is needed such as along the edge of open water or areas prone to erosion or flowing or fluctuating water. Some species do not do well from seed and are often planted as mature plants. It is also common to plant trees and shrubs as plants to increase the rate of site establishment.

There are many options available for the establishment of plants in wetlands and uplands. Containerized herbaceous plants are the most common type of plant material used along with bare-root trees and shrubs. Other options include pre-vegetated mats, bare-root herbaceous species, containerized trees and shrubs, and transplanted vegetation. The selection of plant ma-

Figure 5.93 *Planting containerized plants, Photo by Prairie Restorations, Inc.*

terials for a project should be based on site conditions, project goals, and budget. It is recommended to work with nurseries to fully understand options for a project and the costs, benefits, condition, and availability of plant materials being considered.

Contract Growing Plants

Contract growing wetland plants is a good way to ensure that the species desired for a project will be available. Contract growing also allows for use of local sources of seed to grow wetland plants. Nurseries should be contacted as early as possible to discuss contract growing. Plugs can be grown between early spring and June. Plants in larger containers may take one full growing season or longer to become fully rooted in their containers. It is important that everyone understands the timeline for a project and how long it will take to grow the desired plant materials.

Plant Specifications

When purchasing wetland plants, pay attention to the quality of the plant material. Plant roots should be about the same density as above ground growth. Roots should extend to the bottom of the container and have well developed rhizomes in addition to root hairs. If contract growing, make sure that the grower understands the project plant specifications and expected planting date (Hoag 2000).

Inspect plant materials upon delivery to the site to ensure the shipment includes the correct species, is appropriately labeled, and that the plants were not damaged during transport. Plan for a shady area at the restoration as a staging area for delivered plants. If shade trees are not available, provide shade by erecting tents or other constructed shade structures. Along with shade, there should be a water source, especially when planting bare root plants on warm days.

Figure 5.94 *Photo by Prairie Restorations, Inc.*

Seed and Plant Placement

The distribution of wetland and upland seed mixes and plant materials at a site are based on the planned site conditions including soils, topography and hydrology. Information about soils, hydrology, existing vegetation observed during site visits, and information collected in the office, will be useful in placement of both wetland and upland plant species. As the location of seed mixes and plant materials are selected for a project, their location should be shown on the planting zone map that is prepared as part of the vegetation plan.

Mixes focused on emergent species are often placed in a ten foot band around the planned wetland water edge and are installed after water levels have stabilized and are somewhat predictable. Wet meadow and sedge meadow mixes are used from the planned water edge to 1.5 to 2 feet higher in elevation. The elevation above the water edge that wet meadow and sedge meadow are used should be based on the soil holding capacity of the soil. Heavy soils tend to draw water approximately one foot above the water level due to capillary action while sandy soils draw water up approximately 6 inches.

Soils will have a significant role in the distribution of prairie seed mixes. Wet prairie species will require soil saturation within 12 inches of the surface. Mesic prairie

Figure 5.95

Figure 5.96 *Broadcast Seeding, Photo by Rusty Schmidt*

species require soils that remain moist and dry prairie species are adapted for dry soils. The transition from wet meadow, sedge meadow and wet prairie mixes to upland prairie mixes commonly occurs at about 1.5 to 2 feet above water levels.

It is recommended to overlap seed mixes a few feet, particularly between wetland and upland mixes to ensure that seed mixes will be located to take advantage of changing hydrologic conditions.

The planned topographic and hydrologic conditions for a site typically have there greatest influence on the type and distribution of seed mixes. As wetland seed needs light to germinate and is susceptible to sediment accumulation, steep slopes will require seeding methods

Figure 5.97

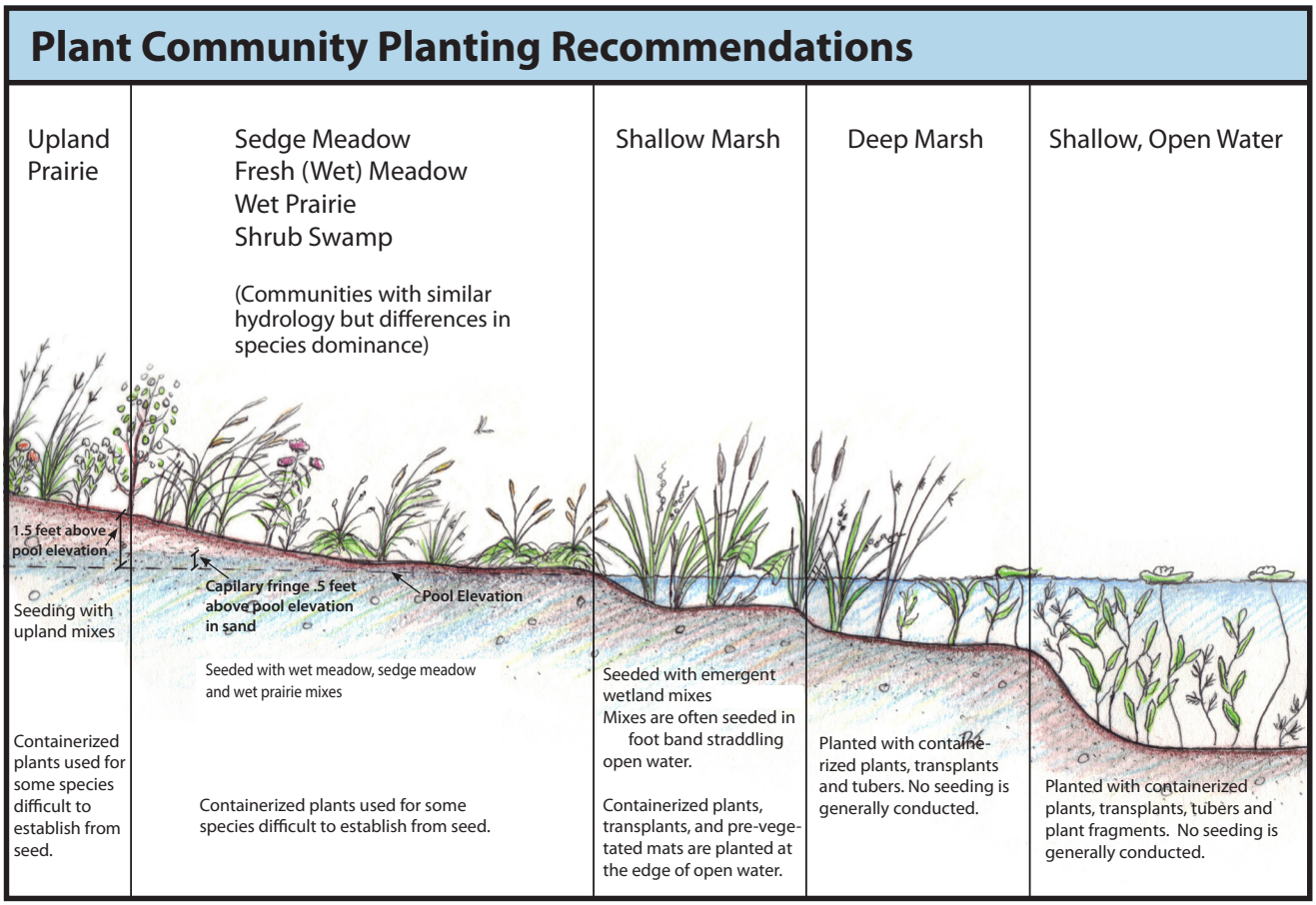

Figure 5.98 *Detailed guidelines for planting seed mixes and plant materials for specific plant communities and corresponding hydrology conditions.*

to stabilize the uplands. In some cases, temporary cover crops may be established during the spring to stabilize slopes. These cover crops are mowed or lightly disked before permanent seeding in the fall. In this example, temporary cover crops are being planted in areas that will have standing water. Temporary cover crops will help stabilize soils as available native seed banks germinate. Another option for stabilization is to establish permanent upland mixes before the seeding of wetland areas. Once the uplands are established, wetland seeding can be conducted. As water levels may change rapidly in wetlands with steep side slopes, the timing of seeding emergent vegetation can be an important consideration. In many cases, it is best to allow water levels to stabilize in later spring and to seed the open water edge when water levels are slowly receding. It is common to seed a narrow band/zone of emergent species along the edge of open water. An example of this band is shown in **Figure 5.100**. As hydrology conditions change rapidly with steep slopes, the width of seeding zones are narrower than when shallow slopes lead into a wetland. It is common to have higher plant diversity in situations with shallow slopes as there is more surface area for plant species and subtle changes in hydrologic conditions. **Figures 5.99** and **5.100** show a wetland with steep slopes while **Figure 5.101** and **5.102** show a wetland with gradual slopes.

In **Figure 5.102**, gentle slopes are shown extending into a wetland with hydrology to the soil surface. In this case, a sedge meadow mix is planted across the entire basin; there is no emergent vegetation zone. Erosion is less of a concern in this example but if site preparation is completed in the spring it may still be desirable to plant a temporary cover crop in preparation of seeding a permanent seed mix in the fall. The temporary cover crop will provide time for additional weed control. If the site is coming out of agriculture in the fall, it may be ready for broadcast seeding and little additional site preparation may be required. During a fall seeding, mulch is recommended to hold soil and help seedlings establish in the spring. **Figure 5.100** shows the use of

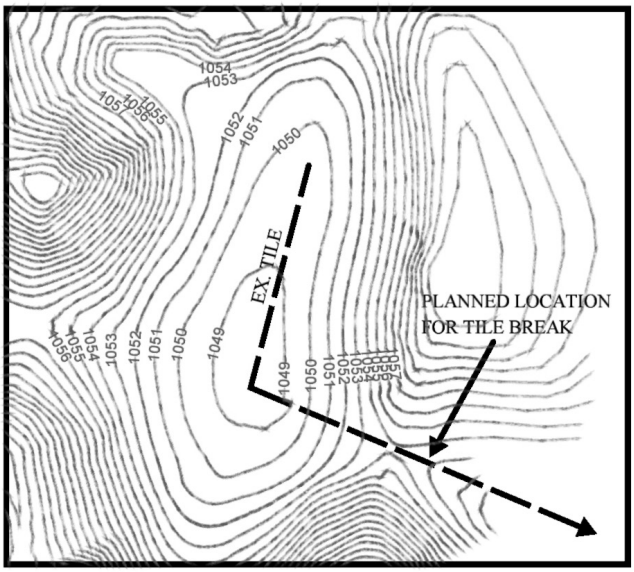

Figure 5.99 *Topography of a Typical Drained Deep Water Wetland*

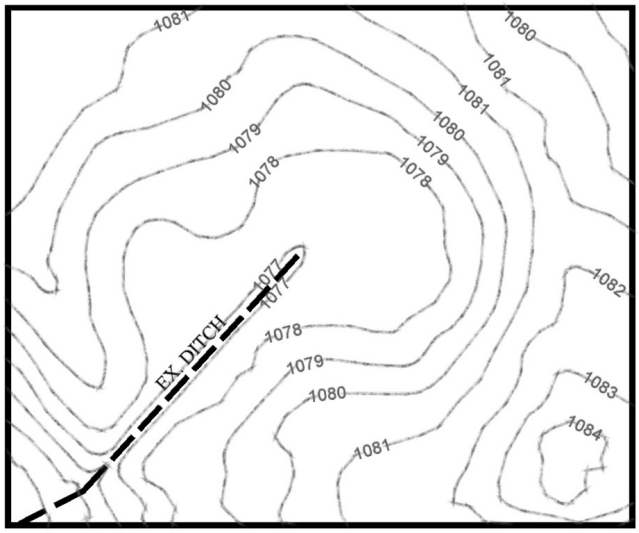

Figure 5.101 *Topography of a Typical Drained Sedge Meadow Wetland*

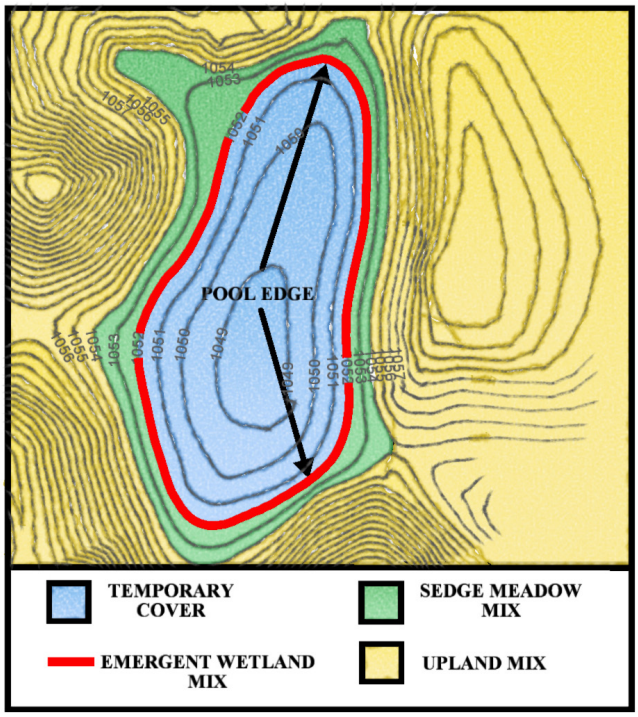

Figure 5.100 *Deep Marsh Wetland Restored*

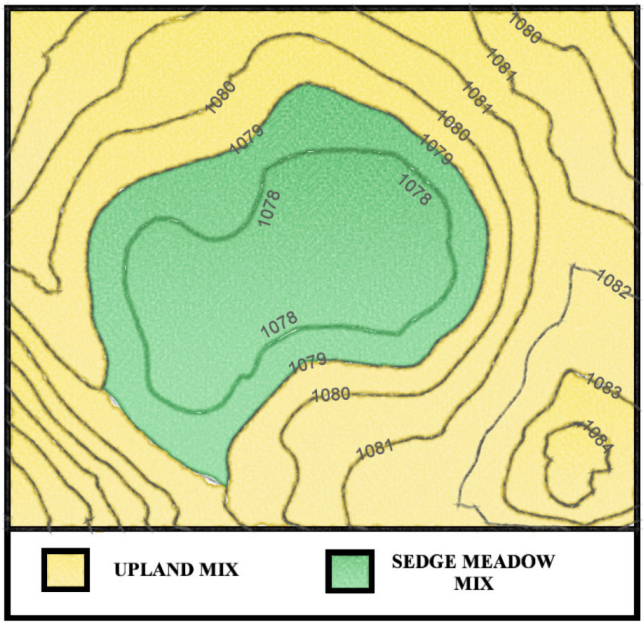

Figure 5.102 *Restored Sedge Meadow Wetland*

a temporary cover where there will be standing water. The temporary cover will stabilize soils while hydrology is restored.

Plant materials are commonly used in combination with seed when establishing vegetation in deeper water habitats. Plants should be strategically placed to maximize their benefits for vegetation establishment. It is common to plant submergent and floating leaved species between six inches and two feet deep depending on individual species. Seed banks and natural colonization can sometimes be relied on to aid vegetation establishment but rapidly spreading cattails can often inhibit the growth of planted species.

It is common to plant emergent vegetation staggered along the edge of open water and allow it to spread into deeper water. Emergent vegetation is often planted along with seed to ensure establishment in case either the seed or containerized plants fail.

Native seedbank and natural recolonization can sometimes be relied on for the establishment of vegetation in open water communities.

The following table summarizes plant materials that are commonly available and general spacing recommendations. In the table below, bare root refers to the planting of any type of bare root system (rhizomes, root fragments etc.) Spacing is based on the mature size of plants and rate of spread.

Table 5.22 ***Propagule Type and Spacing for Wetland Plant Species***

Common Name	Scientific Name	Type of Plant Material	Spacing
Sweet Flag	Acorus calamus	Seed, bare root, container	3-4'
Swamp Milkweed	Asclepias incarnata	Seed, bare root, container	2'
Panicled Aster	Symphyotrichum lanceolatus	Seed, bare root, container	3'
Red-stemmed Aster	Symphyotrichum puniceus	Seed, bare root, container	2'
Canada Blue-joint Grass	Calamagrostis canadensis	Seed, bare root, container	2'
Wild Calla	Calla palustris	Bare root, container	2'
Marsh Marigold	Caltha palustris	Seed, bare root, container	2'
Slough Sedge	Carex atheroides	Seed, bare root, container	3'
Bebb's Sedge	Carex bebbii	Seed, bare root, container	2'
Bottlebrush Sedge	Carex comosa	Seed, bare root, container	2'
Lake Sedge	Carex lacustris	Seed, bare root, container	3'
Tussock Sedge	Carex stricta	Seed, bare root, container	2'
Fox Sedge	Carex vulpinoidea	Seed, bare root, container	2'
Turtlehead	Chelone glabra	Container	2'
Creeping Spikerush	Eleocharis palustris	Seed, bare root	3'
Joe-Pye Weed	Eupatorium maculatum	Seed, bare root, container	3'
Boneset	Eupatorium perfoliatum	Seed, bare root, container	2'
Rattlesnake Mannagrass	Glyceria canadensis	Seed, container	2'
Sneezeweed	Helenium autumnale	Seed, container	3'
Giant Sunflower	Helianthus grosseserratus	Seed, bare root, container	4'
Blue Flag Iris	Iris versicolor	Seed, bare root, container	3'
Soft Rush	Juncus effusus	Seed, bare root, container	2'
Slender Rush	Juncus tenuis	Seed, container	2'
Prairie Blazingstar	Liatris pycnostachya	Seed, bare root, container	2'
American Lotus	Nelumbo lutea	Bare root, container	5'
White Water Lily	Nymphaea tuberosa	Bare root, container	5'
Sensitive Fern	Onoclea sensibilis	Bare root, container	2'
Sago Pondweed	Potamogeton pectinatus	Bare root, container	5'
Pickerelweed	Pontederia cordata	Bare root, container	2'
Big-leaved Arrowhead	Sagittaria latifolia	Seed, bare root, container	4'
Hardstem Bulrush	Schoenoplectus acutus var. acutus	Seed, bare root, container	4'
Green Bulrush	Scirpus atrovirens	Seed, bare root, container	3'
Woolgrass	Scirpus cyperinus	Seed, bare root, container	3'
River Bulrush	Schoenoplectus fluviatulis	Seed, bare root, container	4'
Softstem Bulrush	Schoenoplectus tabernaemontani	Seed, bare root, container	4'
Giant Bur-reed	Sparganium eurycarpum	Seed, bare root, container	4'
Prairie Cord Grass	Spartina pectinata	Seed, bare root, container	4'
Wild Celery	Vallisneria americana	Bare root, container	4'
Culver's Root	Veronicastrum virginicum	Seed, bare root, container	3'

5-7 Project Coordination and Implementation

Figure 5.103

This chapter summarizes the steps involved in preparing for project implementation. Topics covered in the chapter include the following:

Reviewing the Vegetation Plan

The final vegetation plan prepared for a project should include the project overview, planting zone map, project details, project specifications and notes, and project schedules. Time should be taken to review the vegetation plan to ensure that it is complete. It is important that all of the components are working together to provide sufficient detail for contractors to be able to conduct the installation. The vegetation plan may need additional refinement as the installation project begins, particularly if site conditions and project schedules change.

Pre-bid Meetings

Pre-bid meetings are recommended for larger projects to review the scope of work with contractors interested in bidding on the project. The pre-bid meeting, usually includes discussions by the project designer about the following topics:

- Submission Dates
- Permit Requirements
- Bonding Requirements
- Prequalification Requirements
- Payment and Completion Dates
- Site Access
- Project Scope
- Specifications
- Bid Information
- Project Schedules
- Property Boundaries
- Measurement and Payment
- Performance Standards.

Essentially, the pre-bid meetings are intended to help everyone understand the details of the project. The pre-bid meeting provides an opportunity for contractors to ask questions about the project before submitting a bid.

Bidding and Contractor Selection

If contractors will be selected through a bidding process, it is essential to develop project specifications that are clearly understood, practical, and enforceable. Performance standards aid in setting expectations for a project in preparation for bidding.

Figure 5.104

Quality of work can be maximized by hiring contractors that have a good reputation and a great deal of experience. It is recommended when possible to work with contractors that can conduct all aspects of site preparation, planting, and maintenance work to keep consistency through the length of the project. The vegetation plan should be as specific as possible to achieve the best results. For example, on a large or complex site that has a reed canary grass infestation, the specifications should require a contractor with demonstrated experience in long-term control of reed canary grass.

Government entities, such as the State of Minnesota, typically hire contractors by:

1) A sealed bid advertised through the Construction Bulletin; or
2) Soliciting professional services via a request for proposal (RFP) in the State Register.

Units of government are subject to specific laws, rules, and procedure that must be followed when contracting for services.

The laws that apply to a unit of government are complex and subject to change. It is important that contracts for local units of government, state departments, and federal agencies are compliant with the laws and rules that govern the unit of government. In order to minimize inadvertent violations of applicable contracting law, legal counsel should approve all substantial government contracts.

When using a public bid process, specifications must clearly spell out the level of experience that is acceptable for the project. **Appendix 5-B Bidding and Contractor Qualifications** summarizes specifications for bidding and contractor selection.

Measurement and Payment

Measurement and payment refers to the measurement of how restoration implementation activities will be compensated. For example, mowing may be paid for by the acre or by the hour. It is important to clarify how each activity defined in the vegetation plan will be paid for. It is most common that activities related to vegetation establishment are bid by the acre. There are exceptions where activities such as spot treatment of weeds or watering are paid for by the hour to ensure that sufficient time is spent for the activity.

It is recommended to bid project construction and implementation together with project maintenance activities through the first three to five years. It is common to bid separate contracts for long-term maintenance activities based on site conditions.

Permit and Certification Requirements

DNR Waters

The Minnesota Department of Natural Resources is in charge of issuing permits for work to be conducted within waterbodies designated as protected waters. The DNR "data deli" has GIS layers of the waters of the state. DNR staff can provide information about when a permit is needed.

Prescribed burning

It is often necessary to obtain a burn permit from the Mn DNR Forestry office with additional approval by the local fire department. This permit usually includes a requirement to notify the sheriff's office and/or the local fire department on the day of the burn. Permits may also require a detailed burn plan. Requirements vary in different regions, so be sure to obtain information ahead of time when planning a burn.

Figure 5.105

Herbicide use

All personnel applying chemicals must have a Commercial Herbicide Applicator License. The only exception is for landowners who are applying herbicides on their own property. The Minnesota Department of Agriculture administers the herbicide certification program.

Link to Appendix 5-B Permit and Certification Requirement Specifications

Pre-implementation Meetings

Pre-implementation meetings are an important step to ensure that everyone understands the implementation process. Pre-implementation meetings should be attended by project designers, contractors, and any other project partners that will have a role in the implementation process. During pre-implementation meetings, all components of the vegetation plan should be covered including the project overview, specifications, notes, details, the planting zone map, and project schedules. Project schedules should be discussed so that all contractors understand how engineering and vegetation portions of the project work together and how various restoration strategies will be coordinated. Pre-implementation meetings should also include a discussion of how the project will be managed and how effective communication can be maintained among project designers and contractors. Additional topics that are covered during pre-implementation meetings include:

- Requirements of the Contract
- Permit Requirements
- Scope of Work
- Project Schedules
- Equipment Cleaning
- Site Access
- Property Boundaries
- Staging Area
- Material Storage
- Work Hours
- Permits and Certification Requirements
- Project Meetings and Communication
- Site Inspection Schedule
- Measurement and Payment
- Change Orders
- Safety

Layout and Staking

Project layout involves marking project boundaries, transitions between seeding zones, and specific locations for trees, shrubs, or other specific types of plant material. It is best to use color-coded flags to keep flagging understandable. When marking the transition between seeding zones, careful attention should be paid to site elevations. Attention to survey markings will ensure that seed mixes are located at the appropriate elevation. Flags must be placed close enough together to be recognized by seed installers.

Handling Restoration Materials

Before plants are delivered to a restoration site, systems should be in place to check materials to ensure that deliveries include the correct species, are appropriately labeled, and were not damaged during transport. A shady area at the restoration site should be prepared as a staging area for delivered plants. If shade trees are not available, provide shade by erecting tents or other constructed shade structures. Along with shade, there should be a water source, especially when planting bareroot plants on warm days. Many wetland species also need a temporary wet storage area.

Figure 5.106 *Flagging of Seed Zones*

Seed has specific requirements to ensure that it maintains viability. The seed vendor is responsible to deliver all seed in properly labeled bags, mixed in accordance with the installer's specifications and to the location specified by the installer. Upon delivery, an invoice should be presented to the project manager that matches the total pounds of Pure Live Seed of each mix purchased by the project manager and the total bulk weight delivered. The project manager should also collect all seed tags for the project and ensure that the seed tags are accurate. Seed tags may be requested from installation contractors as part of payment requests.

Upon the delivery of seed, the contractor should provide for storage in a cool, dry environment until the seed is delivered to the site on the selected day of installation. If the seeding takes more than one day, all seed should be protected from the elements and stored in a secure, cool, dry location overnight. No seed should be stored overnight in the field.

Between purchase and installation, seed should be stored at approximately ten degrees Celsius (50º F) and 50% humidity. Seed should be protected from moisture before seeding. Wet or molding seed should not be used.

Project Coordination and Communication

A well-developed vegetation plan will help get a project off to a good start and is the first step in ensuring good communication. Pre-bid and pre-implementation meetings are important steps to ensure that contractors understand the vegetation plan. The implementation schedule should be reviewed during the pre-implementation meeting. It will act as a guide for everyone involved in the project to ensure that work is completed on time and in the correct sequence.

The project designer or a representative should be on site as much as possible as the project is implemented and periodically to inspect the work. One project manager representing the contractor oversees the construction of a project and acts as the main contact between consultants and designers. The project manager is responsible for overseeing the entire construction process and ensuring that engineering and vegetation portions of the project are compatible.

Nearly any project can take an unexpected turn, getting the project off schedule and requiring quick decisions from consultants and contractors. Examples include large storms that cause erosion or loss of seed, mechan-

ical problems with equipment, and excessive establishment of weed species. When unexpected problems occur, good communication will result in timely and cost effective solutions. Being prepared for as many variables as possible ahead of time will help make a project go smoothly even under adverse conditions.

Site Inspection and Vegetation Establishment

Setting establishment goals through performance standards helps managers to determine if projects are developing as planned and if, ultimately, they meet the anticipated project outcomes. If written and communicated clearly to contracted staff, performance standards serve as milestones to show progress towards outcomes.

An important role of the project manager involves inspecting work to ensure that the project is being installed as planned and that the project can be implemented as scheduled. Timely site inspections can help catch problems before they get out of hand and provide an opportunity to correct them, hopefully keeping the project on schedule.

Site inspections should also be conducted for maintenance activities such as mowing, herbicide treatment, and prescribed burning. Inspections for vegetation should not be done right after a mowing because plants will be nearly impossible to identify. Six to eight weeks should elapse before seedlings have grown enough to identify following a mowing. Wetland fringes and sedge/wet meadows usually are not mowed, so inspections can be done in mid-season and in late season.

Figure 5.107

Figure 5.108 *Wild Rice*

5-8 Maintenance for Vegetation Establishment

Figure 5.109 *ATV Gas Powered Mower*

The information in this chapter summarizes wetland and buffer maintenance strategies for the establishment phase of a project. Strategies included in this chapter represent techniques that are used during the first few years of a project as vegetation is establishing. Additional strategies such as biocontrol, prescribed fire and grazing are included in Section 6 (Monitoring and Maintenance); these are used for maintaining vegetation after establishment.

A combination of site monitoring and frequent maintenance visits during establishment is essential to ensure that restoration projects will get off to a good start. An adaptive approach for maintenance is recommended as it allows plans to be adjusted to compensate for changing site conditions and, when needed, to combine multiple strategies to control problem species. Invasive species that are common to restored wetland include reed canary grass (Phalaris arundinacea), purple loosestrife (Lythrum salicaria), narrow-leaf cattail (Typha angustifolia), hybrid cattail (Typha x glauca), and the introduced genotype of reed or cane grass (Phragmites communis). Appendix 5-A of the Restoration Guide includes specific guidance and management schedules for invasive species common to restored wetlands and upland buffers.

Mowing, spot herbicide treatment, hand pulling of weeds, watering, and water level management are common maintenance practices. These practices can be combined to promote growth or to control weeds. Herbivore control may be needed to prevent damage from species such as geese, deer, muskrat, rabbits, and carp. Maintenance strategies that are selected for a project should be summarized in the maintenance schedule for the project's vegetation plan.

An overview of the following list of strategies is discussed in this chapter of the guide with more specific and detailed information provided in **Technical Guidance Documents** that are located in Appendix 5-A and referenced accordingly.

- Protecting Plants from Herbivores
- Promoting Plant Germination and Growth

Protecting Plants from Herbivores

Newly-planted restoration projects can be attractive to wildlife as a food source. Wetland plugs and woody tree and shrub seedlings are subject to predation by deer, rabbits, geese, muskrat, carp, and other animals (Marburger, 1993). Deer graze seedling herbaceous plants and can do significant damage by eating the leaves and buds of tree and shrub plantings. Bucks can damage young trees by rubbing with antlers. A variety of methods are used to control damage by deer including wire exclosures, bud caps, and deer repellents. Rabbits can damage newly-planted trees and shrubs by eating bark during winter months. Geese can be a serious problem in urban areas if there is a large resident population nearby or in new restorations before vegetation is tall enough to deter use by geese. Geese pull up seedling plugs and will graze areas germinating by seed. Wire fencing or flagging tape can be effective to deter geese. Muskrats graze on newly-planted plugs and can damage wetland structures by burrowing in embankments or plugging pipes. Carp are a significant threat to emergent and submergent vegetation. Their eating habits destroy vegetation directly as well as by decreasing water clarity. Carp can be a factor in urban as well as agricultural areas of the state.

Figure 5.110 *Stem Protection*

Figure 5.111

The size and location of a restoration influence the amount of predation that may occur. Large restorations where many acres of vegetation are establishing may not be significantly impacted by herbivores, as the impact is spread across the entire site. Urban restorations can be more prone to herbivory due to limited food sources for species such as deer and muskrats and because of large urban goose populations.

More detailed information on **Protecting Plants from Herbivores** can be found in the Protecting Plants from Herbivores Technical Guidance Document located in Appendix 5A-16.

Promoting Plant Germination and Growth

After planting, proper site maintenance is essential to ensure the success of restoration projects during the establishment phase of the project. A schedule summarizing planned maintenance activities each month will guide project managers and contractors as vegetation establishes. It is also helpful to have information in project plans about the most problematic weeds that may establish at a site and how they will be controlled if they establish. Appendix A of the "Minnesota Wetland Restoration Guide" provides information about control methods for individual invasive species. Different management methods such as mowing, herbicide application, hand weeding, water level control, and watering are frequently combined to promote plant growth and control weeds.

Figure 5.112 *Rotary Mower*

Mowing is an essential step in the establishment of upland buffers. Mowing is often conducted twice the first season and at least once the second season with a flail type mower (to prevent smothering plants). 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. Primary goals of mowing are to allow sufficient light to reach native plant seedlings and to prevent weed seed production.

Mowing of annual and biennial weeds is beneficial in wetland transition areas for species such as giant ragweed and Canada thistle but should only be conducted if rutting and soil compaction will not result. Problematic perennial weeds that do not fade away over time typically need to be spot treated with herbicide for sufficient control. Examples include reed canary grass, smooth brome, quack grass, purple loosestrife, Canada thistle, Kentucky bluegrass, and birds-foot trefoil. Native plant seedlings can be sensitive to herbicide so spot treatments are usually delayed until the second season establishment. 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.

Figure 5.113 *Boom Sprayer*

Figure 5.114
Backpack Sprayer

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 work better on young reed canary plants than on mature plants. Note that grass-specific herbicides are not aquatically certified and should not be used near open water.

When using a broad-spectrum herbicide, check that only aquatically-certified forms of glyphosate are used near open water to avoid harming aquatic organisms.

For small areas, it may be more effective (and more desirable in some cases) to hand weed instead of using herbicides. Weeding should be done when soils are moist and care should be taken to avoid disturbing desirable plants. If weeds are not producing seeds, their remains can sometimes be left in place to act as mulch after soil is shaken from their roots.

Having sufficient moisture is essential for plants. How to get them the water they need at the right time throughout implementation and maintenance of a project should be planned ahead of time. The season of planting can have a big influence on the water needs of plants and should be the first consideration. As part of the installation process, containerized and bareroot plants should be well watered and should receive one inch of water from rainfall or supplemental watering per week though the remainder of the growing season until the ground is frozen. Plants that are installed as seed will germinate and grow when conditions are favorable but can still benefit from watering if it is practical for the project.

If water level controls and sufficient hydrology are available, it may be possible to manipulate water levels to aid vegetation growth. It is common to keep soils saturated as seeds germinate and begin to grow and then to raise water levels as plants reach several inches tall. Do not allow water levels to rise above the level of young wet meadow and emergent plants—they cannot survive prolonged inundation.

More detailed information on *Promoting* **Plant Germination and Growth** can be found in the Promoting Plant Germination and Growth Technical Guidance Document located in **Appendix 5A-17**.

Figure 5.115