Native Vegetation Establishment and Enhancement Guidelines

Section 3. Project Site Preparation, Planting and Maintenance

Contents

This section provides an overview of site preparation, planting and maintenance strategies that are commonly used for restoration and conservation practices. More detailed information about site preparation, planting and maintenance can be found in Guidance Documents, Tools and Other Resources on BWSR's website. A summary of practitioner "What's Working" information can be found at https://bwsr.state.mn.us/whats-working-conservation .

Site Preparation Methods

Transitioning from Other Uses

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

Field prepared for broadcast seeding

Many conservation planting sites are transitioning from corn or soybean production (soybean is typically the preferred crop prior to restoration). Fields that are in agriculture often have control of most weeds, though additional control of species such as Canada thistle is sometimes needed in the fall after harvest. Another consideration is that several chemicals being used for weed control, along with Glyphosate in Glyphosate-resistant crops, act as pre-emergents or post-emergents (designed to inhibit germination) and can inhibit native vegetation establishment from seed. Temporary cover crops (oats is most common) planted for one or two seasons can allow these chemicals to break down in the soil if they have been used. Investigate prior chemical use and labels to help assess the probability of chemical carryover that could/should be addressed by using temporary cover crops. If in doubt seek consultation from others with applicable experience. Funding programs typically allow 3-4 years for project installation, which can limit the amount of time for use of temporary cover crops to one year (The RIM Handbook has guidance for the Reinvest in Minnesota Program).

If a site is in perennial weeds such as smooth brome, quack grass or bluegrass and cannot be put into agricultural production for one or two seasons, intensive site preparation may be needed for the control of these perennial invasive species with extensive rhizomes. Herbicide application is often recommended, as tilling alone may re-suspend the rhizomes, allowing them to continue growing. For species such as reed canary grass and giant reed grass, combinations of mowing, herbicide application,

prescribed burning, and tilling (or possibly additional herbicide application) may be needed. The Minnesota Wetland Restoration Guide provides detailed management recommendations for a wide range of species.

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

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

The removal of fill as part of a shoreline restoration project

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

Seedbed Preparation

Methods that are used to prepare a seedbed can vary depending on the type of seeding equipment to be used. If a traditional native seed drill will be used, a smooth, firm seedbed is required. Soybean fields generally are sufficiently prepared for a native seed drill, but sites that were recently tilled will require additional soil treatment such as harrowing and rolling to prepare an adequate seedbed and prevent seed from being buried too deep. Broadcast seeding can be conducted on soybean or corn fields, or fields that have been disked, if the soil is allowed to settle before seeding. Some practitioners have found that broadcast seeding on a smooth

Harrowing to prepare for seeding

surface (not tilled or disked) leads to the establishment of higher diversity. It is important that the soil surface is not too hard packed, so cultipacking or light harrowing of crop fields before broadcast seeding may be needed. Seed can be lost on smooth surfaces, so it is recommended to seed into temporary cover crops or to roll sites after seeding.

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

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

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

Planting Considerations

Seed Mixes

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

Wetland grass, forb, sedge and rush seeds

Native seed vendors in Minnesota are listed on the following DNR website: https://www.dnr.state.mn.us/gardens/nativeplants/suppliers.html

Temporary Cover Crops and Mulch

Slough grass established as a temporary cover crop

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

Planting Dates

Spring seeding is generally favored for native grass establishment, while fall seeding is often favored for planting forb, sedge, and rush seed to allow winter conditions to naturally break seed coats. Fall dormant seeding should be conducted after October 15th in the northern half of the state and after November 1st in the southern half of the state, and before the soil freezes. Dormant seeding or frost seeding (seeding into a few inches of snow) can also aid the establishment of forbs and sedges in uplands where grasses can become more dominant with spring plantings. Dormant seeding is also beneficial for pollinator projects with a high

percentage of forbs if hydrology will be restored in the fall, as it may be difficult to access the site after spring snowmelt. It is common to conduct dormant seeding shortly before snowfall to ensure that seed is not lost to wind, birds or rodents.

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

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

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

Planting Date Guidance for Restoration & BMP Projects

Table 3-1. Seeding - Recommended Dates/Vegetation Type

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

Table 3-2. Plant Installation - Recommended Dates/Vegetation Type

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

Expected Success Rates:

High Success
Medium Success
Not Recommended Without Watering or Favorable Weather Conditions
* Low Success
** Not Recommended

Note: Late fall dormant planting can be conducted earlier if National Weather Service soil temperature data is showing a consistent soil temperature below 40 degrees F for cool-season grasses and legumes or below 50 degrees F for native warm season grasses, forbs and legumes.

Seeding Considerations

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

Fall Dormant Seeding: It is common to wait until around November 1st when dormant seeding. It is important that conditions will be cold enough to prevent germination right before winter. It is also

common to wait until shortly before snowfall to prevent the loss of seed from wind, birds and rodents. Fall dormant seeding is commonly done when forbs, cool-season grasses and sedges are a primary goal for a project. Fall dormant seeding and winter seeding typically should not be conducted in areas where there will be flowing or standing water in the spring as seed may be lost.

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

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

Plant Installation Considerations

Plant Condition: It is important to ensure that containerized plants are fully rooted into containers prior to planting, that pre-vegetated mats delivered for projects have well established and diverse vegetation, and that herbaceous, and woody bare root plants (and cuttings) are stored in optimal conditions prior to planting. It is also important that seed is stored in climate controlled conditions prior to use.

Weather Conditions: Weather conditions during a season can influence the ideal planting dates for vegetation. Planting dates may need to be adjusted based on drought condiitions or extreme rainfall that can cause water levels to fluctuate or cause flooding.

Seeding Wetlands and Retention Basins

The use of wetland seed mixes is generally based on planned hydrology conditions that are influenced by groundwater levels as well as seeps and swales. The following information summarizes considerations for different types of mixes used for wetland restoration projects, starting with upland conditions transitioning to marsh.

- Upland mixes are used approximately 1-1.5 feet above pool elevation (elevation where standing water will occur most frequently) and can be broadcast or drill seeded.
- State wet meadow and wet prairie seed mixes are designed to be used from the planned edge of open water (pool elevation) to around 1-1.5 feet in elevation depending on soil texture and capillary action of soil. Other considerations for the use of these mixes include the extent of hydric soils, and swales coming into a wetland.

Broadcast seeder being used to seed a wet meadow restoration

- The state “emergent seed mix” is commonly used in a 10 to 20-foot wide band that straddles the edge of open water. This strip of emergent seed is hand broadcast after water levels have stabilized within the wetland. It is not recommended to seed in areas that will have open water, as most wetland seed will float.
- A deep marsh seed mix has been designed for project areas that will ultimately have around 2-4 feet of standing water. Establishment will be most successful when water levels are slowly raised in a wetland.

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

Prairie, Savanna and Woodland Edge Seeding

Native seed drill

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

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

Mulching

Care should be taken to ensure that upland soils do not erode into wetland areas and cover wetland seedlings. As much as one centimeter of sediment can prevent germination of many wetland species. The planting of temporary cover crops can be an effective way of stabilizing projects prior to the installation of permanent seed mixes. If temporary cover crops are not planned for constructed areas of sites, additional mulch is recommended at one-ton per acre in wetland area in upland areas. It is essential that a weed-free mulch be used; MCIA Certified Weed Free mulch (MnDOT Type 3) is

recommended. It is important that any erosion control fabrics used for stabilization do not contain plastics.

Use of Native Seedbank

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

Tree Planting

Planting seedling trees and shrubs

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

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

Aquatic Plant Installation

For shallow marsh restorations, lakeshores and open water portions of retention ponds, the establishment of emergent plants can help increase plant diversity and environmental benefits. Species such as arrowhead, water plantain, giant burreed, bulrushes, sweet flag, wild iris, and pickerelweed can be planted near the edge of open water and allowed to spread into deeper water. Burreed and three-square bulrush are less desirable by muskrats, so they are beneficial where muskrats are a risk. Lakeshore restorations are often planted with a higher density of both wet meadow and emergent plants with a spacing of 1.5-4 feet between plants. The spacing of individual species is often based on how quickly the species can spread by underground rhizomes or other means.

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

Planting of emergent plants on the edge of open water

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

Upland Plant Installation

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

supplemental watering may also be required. Flags may be needed for large areas to mark the location of plants and aid watering efforts.

Inter-seeding

Inter-seeding forbs into native grasses to increase diversity

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

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

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

Inter-seeding into reconstructed native prairie: In reconstructed prairie (crop fields converted to prairie) inter-seeding is most often conducted after a prescribed burn. An alternative method is to conduct a spring application of glyphosate herbicide to stunt prairie grasses that dominate the site. Forbs are commonly broadcast in the fall or late winter to increase diversity. Species with larger seed such as grasses can be drilled with a no-till drill. Repeated mowing at six to eight inches is recommended during the first year to allow light for seedlings. Mowing into the second season may also be beneficial.

Inter-seeding into remnant prairie communities: Inter-seeding into remnant communities should be planned by an experienced resource manager. In most cases, only seed collected from the remnant, or very local sources is used. Seeding after prescribed fire is the most common method of inter-seeding remnants. Disking or other soil disturbance should not be used in remnants to incorporate seed.

Node establishment into grasses: In stands of native or nonnative grasses a technique that has been successful involves establishing 15-foot square nodes within grass-dominated stands. Approximately 25

percent of the site should be covered by nodes. Nodes should be prepared with a tractor-mounted rototiller in October followed by dormant (late October) broadcast seeding. As the nodes establish, they will generate a source of propagules to colonize the surrounding vegetation matrix and increase species diversity (Grygiel et al. 2009) across the site. Prescribed burning in subsequent years will aid the spread and establishment of species planted in nodes.

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

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

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

Seeding Forb Diverse Mixes for Pollinator Habitat

Native bee on wild bergamot

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

Project Maintenance

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

Mowing/Cutting

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

ATV used to mow Canada thistle before flowering

Mowing of annual and biennial weeds is also beneficial in wetland transition areas for species such as giant ragweed, barnyard grass, and Canada thistle, but should only be conducted if rutting and soil compaction will not result. Pressure from annual and biennial weeds is generally less with increased soil saturation and water depth. For smaller projects, brush cutters, string trimmers, or hand equipment can be used to target weeds and work around native plants. See the Minnesota Wetland Restoration Guide appendix 6, mowing: https://bwsr.state.mn.us/sites/default/files/2019-01/6a-3%20Mowing2.pdf

Haying

Haying can be used as a management tool to remove weed growth and thatch to provide sunlight for establishing native species and to help control woody plants in prairies and wetlands. Haying can also be

used to help maintain diversity levels. The total number of species and proportion of native species can be similar between planted grassland plots that are hayed in the fall and plots where early season prescribed burns are conducted. Haying can be a good alternative to prescribed burning where burning is not feasible due to the presence of desirable woody plants, unfavorable weather or surrounding land uses. Another role of haying can be to remove tall growth of weeds or woody plants prior to burning, herbicide treatment or flooding. If allowed by conservation programs, and consistent with project goals, haying of uplands can also provide forage for cattle producers and biomass for energy production. When considering haying as a management strategy it is important to consider potential influences on pollinators, bird nesting, soil disturbance, soil nutrients, and long-term diversity levels. See the Minnesota Wetland Restoration Guide, Appendix 6, Haying.

Hand Weeding

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

Biological Control

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

Leafy spurge bio-control beetle

Conservation Grazing

Cattle grazing reed canary grass in a restored wetland

Conservation grazing is conducted by a variety of species, including cattle, bison, horses, sheep and goats, to target specific invasive plants and non-native species or to replicate natural grazing regimes and promote nutrient cycling and species diversity. For example, early spring grazing by cattle has been used to control Kentucky bluegrass in prairies, while later spring grazing has been used to control smooth brome grass. Goats have also been used for the management of buckthorn and non-native honeysuckles, as they eat a variety of woody plants. Detailed grazing plans are an important component in the planning and implementation of prescribed grazing. Grazing plans should include objectives and information about timing, potential disturbance, herd size, fencing and water sources. See https://bwsr.state.mn.us/sites/default/files/2019-01/6A-5%20Conservation%20Grazing.pdf

Water Level Control

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

Burning

Prescribed burning to control woody plants in a wetland restoration

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

On large project sites (over 50 acres), and sites that lack an adjacent refuge for wildlife species (such as other conservation lands), burning one-half or less of a project site at a time is recommended. Partial burns and burns that are patchy may also benefit pollinator populations if timed correctly (when pollinators are not actively foraging or have pupated and are mobile).

Spot Treatment of Weeds

Spot herbicide treatment of reed canary grass

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

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

When using broad-spectrum herbicides and surfactants it is important that aquatic safe forms are used near open water. Herbicide labels must be followed and certified applicators must conduct the treatment.

Woody Tree Control

Cottonwood treated with herbicide

Tree and woody brush control is often needed in restoration of prairie and open wetland plant communities. Tree control in the prairie region of Minnesota is a common practice to improve habitat for ground nesting grassland birds. Methods of control include prescribed burning; mowing/cutting; mowing/cutting followed by stem herbicide treatment or basal herbicide treatment; foliar herbicide treatment; hand-weeding and/or grazing. The method that will be most effective in a certain situation will depend on site conditions, size of woody plants, density and timing. Prescribed burning in the fall and mowing with a flail type mower (leaving the cut surface rough vs. a clean cut) in late summer are generally the most cost-effective methods for smaller trees and shrubs.