SECTION

6 Site Management and Monitoring

Wetlands are dynamic ecosystems that slowly change and evolve in response to natural processes, climatic conditions, and human activities. For wetlands that are restored or created, these changes are rapid and extreme, especially during the first few years of establishment. For these sites, development of sustainable, functional ecosystems can take years of active management before they truly represent natural systems. Proper site management strategies encourage species diversity and allow for successional development of these wetlands and surrounding upland vegetative buffers within the shortest time frame possible.

Figure 6.1 *Prescribed burn of a wet meadow restoration*

Understanding the project goals and outcomes is essential to developing and successfully implementing a management plan. Management plans anticipate project development and provide a means to control aspects of a project after initial construction and establishment. Management plans identify project-specific maintenance strategies (water level manipulation, mowing, burning, etc.) and schedule activities to address potential issues that could compromise project goals. Good management plans will also identify who is responsible for completing identified activities or strategies.

Project monitoring is one of the keys to effective long-term site management. Because project conditions can change unpredictably, routine project monitoring is essential to address any problems that develop. Monitoring also provides a means to determine if, when, and sometimes how site maintenance strategies should be implemented. To be effective, a monitoring plan should provide information relevant to project goals, anticipated outcomes, and maintenance strategies used.

A primary goal of this section of the Guide is to provide a basic level of understanding of long-term site management along with a discussion of maintenance strategies that can be used to successfully manage restored and created wetland sites and their associated upland vegetative buffers. The Guide also recommends site monitoring schedules and checklists for routine inspections and provides information for more advanced site monitoring that allows for measurement of specific goals, objectives, and project outcomes or performance standards.

Section 6 Technical Guidance Documents

6-A **Technical Guidance Documents for Site Management**

Figure 6.2 *Carp removal resulting from a fall drawdown*

6-1 Site Management

Wetland restoration and creation projects, particularly during their first few years of establishment, are dynamic and very sensitive to management activities. The effective use of management strategies can dramatically influence site conditions, improve species diversity, and maximize wetland function.

This chapter discusses considerations for long term management of a site, identifies components of a site management plan, and discusses important considerations and guidelines in developing effective management strategies.

Figure 6.3 *Mowing*

Figure 6.4 *Prescribed burning of a wet meadow wetland*

Figure 6.5 *Shorebirds foraging in a restored wetland*

Site Management

Management of restored and created wetlands and upland buffers requires a long-term commitment to achieve successful, sustainable ecosystems. The selection of appropriate maintenance strategies is an important and sometimes challenging task. A comprehensive approach will meet the needs of wildlife and plant species without compromising overall wetland function. In this Guide, wetland management is defined simply as actions that are taken to manipulate site features to achieve and sustain identified project goals. Understanding the goals for a project site is essential to developing effective management strategies.

The most effective management efforts reflect natural processes that occur in existing wetland communities such as fire, ice action, grazing, and natural water level fluctuations (Payne 1992). Selecting the appropriate management strategy or strategies will depend on a number of factors including cost, surrounding land use, equipment availability, as well as the skill and ability of the responsible person or entity to implement the strategy. A complicating factor is that there are often multiple strategies that can be used to achieve the same management purpose. In addition, strategies or techniques that are intended to affect one condition may negatively affect another. Consider the following examples:

Example 1: *The application of broad-leaf specific herbicide to control Canada thistle may inadvertently eliminate other forbs that are present and desired at a site.*

Example 2: *A planned drawdown of water levels in a wetland containing a diverse native plant community for a specific purpose such as flood control, fish removal, or even to improve vegetation conditions, could allow problematic vegetative species such as hybrid cattail or reed canary grass to establish and dominate the wetland.*

Figure 6.6 *Gray tree frog in a restored wetland*

Hydrology management can have a big influence on the development of wetland plant communities and meeting project goals and outcomes. Wetlands with naturally-occurring hydrologic regimes usually provide little opportunity for hydrology management. Restored and created wetlands that include opportunities for water level management can be actively managed, providing greater opportunities to improve site conditions. The manipulation of wetland water levels provides opportunities to control certain undesirable plant and animal species and promotes high productivity, which then attracts a diverse community of desirable flora and fauna. Water level management also provides a more direct means to accomplish flood control and may provide increased opportunities for targeting certain water quality benefits.

> When available, the manipulation of water levels is one of the most effective wetland management strategies, provided water level changes are properly timed and controlled.

Vegetation often requires active management in the years following initial establishment to either limit the spread of invasive species or promote a certain successional level of plant communities. Where water level manipulation is available, wetland vegetation can often be managed through targeted, well-timed draw downs or periodic flooding. Where water level manipulation is not available, wetland vegetation can be much more difficult to manage and will be highly variable for the given site conditions. In contrast, the management of upland vegetation can more easily be accomplished through common strategies such as mowing, burning, and spraying. More discussion on the use and applicability of these management strategies occurs in **Chapter 6-2**.

Management strategies are best communicated in a well-written management plan. The management plan should identify a schedule of both general strategies and specific activities to deal with potential issues that could compromise projected outcomes. Management plans are often developed in conjunction with the establishment of project goals, objectives and outcomes. The management plan should identify all project-specific maintenance strategies (water level manipulation, mowing, burning, etc.) that may need to be employed to achieve and maintain previously-specified project goals For example, the plan may call for mowing at certain time intervals to discourage the growth of anticipated invasive vegetation, allowing the establishment of a diverse, dense stand of native vegetation. The management plan should also identify who will be responsible for implementing the listed activities or strategies.

Management Considerations

Project managers need to consider potential consequences associated with different vegetative and hydrologic maintenance strategies and how they can affect overall site management. **Chapter 6-2** discusses some common maintenance strategies, their advantages and disadvantages, and when and how they should be implemented. It is important to note that a strategy that is successful in one instance may not be in another. Therefore, project managers should tap the expertise of other managers and natural resource professionals who have had experience with utilizing one or more of the strategies being considered. Reference to other published resources is also suggested; many exist that are specific to select maintenance strategies and include

Figure 6.7 *Boom herbicide treatment of reed canary grass*

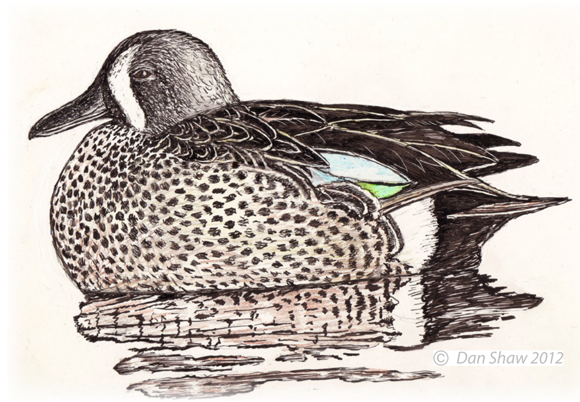
discussion of research results that are beyond the scope of this Guide. The variability of each restoration site makes strategy selection and implementation a less-than-precise process. In addition, it may be necessary to select more than one strategy to achieve a desired outcome.

In addition to the information provided in **Chapter 6-2** with regard to individual maintenance strategies, project managers also need to consider other variables that can influence the selection and use of these strategies. Following is discussion of some of these variables.

Costs

The cost of implementing maintenance strategies must be considered as management plans are prepared to ensure that adequate funding is or will be available for the strategies selected. A project that relies heavily on long-term management to perpetuate project goals can be severely compromised if the required staff resources and costs of management activities are not accounted for or are not available. Budgeting for management activities and associated monitoring is a key component to long-term project success. These activities should be incorporated into the overall project budget right from the start. Project owners or managers may want to consider an "escrow account" or a similar funding plan to ensure adequate financial resources for ongoing management activities. If staff resources or funding are in short supply, then less-active and lower-cost maintenance strategies should be selected or project goals and expectations may need to be adjusted.

Figure 6.8 *Installing fence to prevent muskrat burrows in an embankment*



Responsible Party

The management plan should clearly designate the person(s) or entities responsible for implementing maintenance strategies. That could be a resource professional from a public agency or private organization, the landowner, or a private consultant. The ability of the responsible party to implement the plan may vary considerably depending on their skills and resources available. For example, a resource professional or private restoration consultant may have a greater ability to implement a complicated and intensive burning and mowing regime to adapt to changing vegetation conditions than a landowner with a small tractor and limited plant identification skills.

> Development of the management plan for the project should be consistent with the abilities of the person or entity responsible for implementing the restoration activities.

Wetland restorations associated with regulatory and conservation programs may have mandatory management requirements or operation and management plans that define landowner responsibilities. Understanding program requirements and communicating them to those involved is an important duty for the responsible party. In these instances, the project management plan should reference program requirements and lay out how they will be implemented. A communication and oversight component could be as simple as a statement relating to communication requirements for conducting management activities. The level of detail and complexity will depend on program requirements, project management complexity, number of entities or individuals involved in the project, and other factors.

Figure 6.9 *Soybeans adjacent to a wetland restoration*

Figure 6.10 *Drop inlet structure for wetland outlet*

Surrounding Land Use and Properties

The selection and use of certain maintenance strategies may be incompatible with surrounding land uses. For example; water level manipulation at certain times of the year may have unacceptable negative impacts to upstream or downstream properties. Or, controlled burning to manage native vegetation may be incompatible with surrounding residential land uses or public infrastructure. The management plan must consider how long-term maintenance strategies will work in the context of not only current surrounding land uses and properties, but potential future uses as well. For example, adjacent to a restored wetland is a field enrolled under the Conservation Reserve Program (CRP). This field may be converted to cropland in the future, potentially delivering higher sediment and pesticide loads to the restoration project. This potential influx of sediment may require more frequent inspection and cleaning of the project's inlets and outlets.

Contingency Planning

Management plans should consider effects of climate variability and extreme precipitation events or patterns that can influence both short and long-term wetland function. For example, a large rain event or a prolonged drought will likely affect wetland hydrology and could influence specific wetland goals such as providing suitable brood habitat for waterfowl. Factoring in management options for unusual conditions strengthens the management plan by providing clear guidance and direction to respond and adapt appropriately to changing site conditions. The plan could identify specific maintenance strategies to be used during times of excess water or drought in order to meet and maintain specific project goals.

Goal-Focused Management

Strategies selected for a management plan should be adapted, as necessary, to specific goals of the current project. For example, many typical wetland buffer strategies focus on maximizing overall wildlife diversity by maximizing native species and plant structural diversity (tall grasses, short grasses, shrubs, saplings, trees). However, if project goals are for a specific wildlife habitat component such as winter wildlife cover, then specific strategies that will maximize woody cover may be necessary. If a buffer is intended to filter runoff from adjacent areas, then a focus on dense vegetative cover in buffer areas might take priority over a more diverse establishment of native grasses.

Restoration strategies should be chosen based on their ability to provide desired functions, not because they are commonly used or easily implemented.

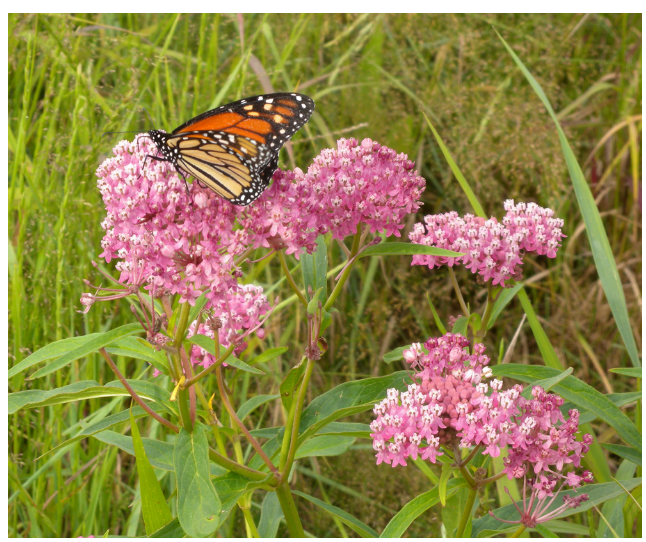


Figure 6.11 *Monarch on marsh milkweed*

Adaptive Management

By necessity, some amount of flexibility is needed when managing wetland restoration or creation sites. Changes in management strategies and timing are often necessary to react to changing or unexpected project conditions, whether they are due to natural circumstances such as weather or manmade circumstances such as incompatible adjacent land uses. For example, a site planned to be managed as a shallow marsh community that experiences hydrology more associated with a wet meadow community may need an adjustment in how vegetation is managed. If the wet meadow community still fulfills overall project goals , the management strategies can be adjusted to encourage and further develop and maintain the wet meadow community. If the project goals, objectives and outcomes are not consistent with a wet meadow community, then adjustments to the goals and objectives may be more practical than making corrective actions to the wetland.

> A good plan will anticipate potential changing conditions and provide at least some direction as to how the plan should be adapted in certain instances.

Management plans should clearly convey that management strategies are based on expected project conditions and may need to be adjusted over time to reflect actual project outcomes. If the project is associated with a program that has specific management requirements, the means to officially modify the plan in conformance with program requirements should be identified.

Figure 6.12 *Herbicide treatment of reed canary grass*

Figure 6.13 *Wood frog*

Management Plan Components

Management plans should summarize project goals, objectives and outcomes, and the strategies that will be conducted to achieve them. The management plan should be project specific but will often be governed by the program or purpose for which the project was completed. General components of a management plan include the following:

- Summary of project goals, objectives and outcomes
- Strategies intended to meet project goals, objectives and outcomes
- Anticipated schedule of strategies.
- Contingency plans for strategies that possibly can occur due to weather, site conditions, or other factors.
- Designation of responsible parties and funding sources, as necessary.
- Discussion of how monitoring will be conducted and how results will be used to modify or direct management strategies.

Figure 6.14

The organization and exact composition of the plan can vary considerably, but all plans should address the above components in some form or another.

Specific Management Issues/Problems

In Minnesota, there are several common issues and problems that are often associated with wetland restoration and creation projects. While not a problem for every project, the frequency at which they occur warrant special discussion with regard to site management. Additional discussion on the use of maintenance strategies to address these problems occurs in **Chapter 6-2**.

Undesirable Vegetation

Undesirable vegetation and weeds in restored or created wetlands and upland buffers can displace native species dominance, hindering goals related to plant and animal diversity. The control of some species is also required under the State's Noxious Weed Law. Invasive species may establish at the same time as native species and continue increasing in abundance, or they may enter a site after soil disturbance or other disturbances that favor weed growth. The rate of spread of invasive species depends on the particular plant species and site conditions. Sites with high nutrient inputs are prone to reed canary grass and cattail establishment. Woody species such as cottonwood often colonize from large trees or shrubs located within or adjacent to a project. Early woody establishment can hinder the establishment of native grasses and forbs. Also, maturing woody plants on earthen embankments can degrade structural integrity and possibly cause embankment failure.

Figure 6.15 *Perennial sow thistle in an upland buffer*

A wide variety of strategies are used to control undesirable species including cutting, mowing, haying, grazing, prescribed fire, biological control, pulling, and herbicide application. Most common agricultural weeds in dry portions of a site can be controlled through mowing, however mowing may not be effective at controlling many invasive species as they can continue spreading rapidly and often require other means of control. Species such as reed canary grass and purple loosestrife can be long-term threats to a wetland restoration or creation and their control often requires multiple years of management efforts and re-seeding. Frequent monitoring will spot weed problems early and aid management decisions.

Figure 6.16 *Hybrid Cattail Growing in a Deep Marsh*

Addition discussion about controlling invasive vegetation and weeds can be found in **Section 5**, **Vegetation Establishment**, and in **Appendixes 5-A** and **6-A**.

Narrow-leaf and Hybrid Cattail

Pollen records indicate that broad-leaf cattail (*Typha latifolia*) was native but not common to Minnesota prior to European settlement while narrow-leaf cattail (*Typha angustifolia*), a more aggressive species, was likely not native (Shih and Finkelstein 2008). A hybrid between broad-leaf and narrow-leaf cattail (*Typha x glauca*) is now common and aggressive in Minnesota wetlands. Narrow-leaf and hybrid cattail grow in dense colonies that decrease use by some wildlife species; many projects attempt to establish other emergent species before a monotypic stand of cattail develops. Resource professionals debate management needs and strategies for controlling or removing cattails. They can be costly and difficult to manage often with limited success. Cattail removal requires a DNR aquatic plant management permit for control in public waters. Information about DNR permits can be found at: http://www.dnr.state.mn.us/eco/apm/index.html.

Additional discussion about cattail control can be found in **Section 5**, **Vegetation Establishment**, and in **Appendix 5-A** and **6-A**.

Muskrat and Beaver

Muskrat and beaver are a natural part of Minnesota's wetland systems. Their presence, however, is not always welcome as significant resources are often needed to address problems they create. They can remove vegetation; their tunnels and dens can weaken or cause failure of earthen embankments and they can plug outlet structures. Maintenance and repair work as a result of muskrat and beaver activity can become a costly, annual event for many projects.

Efforts to control muskrat and beaver populations through trapping can be successful, although it usually requires a long-term commitment and only minimizes the extent of damage; it likely will not prevent it. For many projects, the best defense against potential muskrat and beaver damage is through well-designed and implemented construction strategies along with routine inspection and maintenance. Consider the following examples:

Example 1: *The design and use of wave berms and fencing within earthen embankments may prevent or greatly reduce burrowing activity from muskrat and beaver.*

Example 2: *The design and construction of special outlet structures may deter or prevent muskrats and beaver from blocking or plugging the outlet.*

Example 3: *The control of woody habitat reduces the food source for beavers and decreases the risk of their colonizing of a wetland site.*

Additional discussion on these strategies to address problems from muskrats and beaver occurs in **Appendix 6A-13**.

Figure 6.17 *Muskrat burrow in an embankment*

Figure 6.19 *Restored wetland associated with a stream in southeast Minnesota*

Fish

Wetlands in Minnesota, whether they are natural, restored, or created, can provide a suitable environment for fish as they inhabit and spawn in these shallow water systems. In some cases, these wetlands provide important spawning areas for game fish. Certain fish species (primarily bottom-feeding carp, buffalo, bullhead, and minnows) however, can pose a significant threat to the health and quality of a wetland. While feeding, some of these fish species will uproot desirable aquatic vegetation and stir up nutrient-laden sediments, which can lead to algal blooms and increased turbidity. This negatively affects the submerged plant community, invertebrate and amphibian populations, macrophytic plant growth, water quality, and ultimately provides poor habitat for most wildlife species including waterfowl.

Figure 6.18 *Carp control through water level management*

Fish will often not survive winter conditions in shallow wetland systems, but may survive in deeper wetlands or recolonize when wetland water levels are temporarily high due to above-average precipitation or flooding conditions. In restored wetlands, the presence of an open ditch or remnant reaches of open tile accessed through un-removed intakes can provide suitable overwintering habitat for these undesired fish species. .

> Many wetland outlets are connected to a vast network of drainage systems (ditch or tile) that may provide an opportunity each spring for the reintroduction of fish species into the wetland

Fish populations in wetlands are primarily managed by one of two methods. The first is a passive method that relies on periodic winterkill to control and remove undesired fish species. The second is a more direct approach where outlets are designed to prevent fish from entering the wetland or to allow wetland water levels to be temporarily lowered to accomplish a successful winterkill. In either case, the removal of undesired fish species will promote the growth of the aquatic plants and invertebrates which will improve wetland water quality.

Addition discussion on the design of wetland outlet structures to address potential problems from nuisance fish species occurs in **Section 4, Engineering Design and Construction** and **Appendix 6-A**.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6-2 Management Strategies

Figure 6.20

This chapter presents information about common strategies used for the management of wetland restoration and creation projects. Management of these projects is important to sustain diverse vegetative plantings, integrity of structures and other constructed features, and to ensure project goals are met and maintained over time. An adaptive approach to project management is promoted where strategies are adjusted as needed to adapt to changing site conditions.

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 6-A and referenced accordingly.

- Herbicide Application
- Prescribed Burning
- Prescribed Mowing
- Prescribed Haying
- Prescribed Grazing
- Biological Control
- Water Level Management
- Supplemental Planting
- Tree and Shrub Care
- Structural Maintenance and Repair
- Tree and Shrub Removal

Herbicide Application

Herbicide can be used to control invasive plants that begin to colonize after native vegetation has been established. The application of herbicide is typically accomplished by selectively treating specific areas or species, a method often referred to as "spot treatment". The type of herbicide used (grass-specific, broadleaf-specific, pre-emergence, etc.), when it is used (early spring, mid-summer, etc.), how it is applied (broadcast, hand spray, etc.) and potential impact to wildlife are all factors that need consideration in selecting the appropriate method to control problem plant species. Herbicide is applied using backpack sprayers, herbicide wands, boom sprayers, and other equipment. The application method used depends on the size of the area requiring treatment, the type of herbicide, and the species of plant(s) to be controlled.

Spot treatment of weeds is commonly conducted in combination with other maintenance strategies. It tends to be focused on removal of select undesired species (such as noxious weeds) that pose the greatest threat to vegetative communities on a project site.

Figure 6.21 *Post-establishment herbicide application*

More detailed information on **Herbicide Application** can be found in the Herbicide Application Technical Guidance Document located in Appendix 6A-1.

Figure 6.22

Prescribed Burning

Many plant communities in Minnesota, particularly those in the prairie region of the state, require fire to maintain diversity and structure. Prescribed burning is important for the long-term maintenance of fire-dependent plant communities. Burning and spot treatment of weeds in uplands are recommended indefinitely to manage unwanted vegetation. Burning can also remove thatch that suppresses germination and native plant growth. Restored wetlands and surrounding uplands in the prairie pothole region are prone to invasion by woody species. In this region where fire traditionally controlled such invasions, the growth of woody vegetation can suppress prairie species by producing excessive shade and decreasing habitat value for ground nesting grassland birds.

The use of burning as a maintenance strategy is dependent upon the availability of equipment and resources, timing, and the problem being addressed (suppress woody growth, stimulate native species germination, etc.). Spring burns in uplands are often used to control problematic cool season grasses, while fall burns are used for woody species control. Burns are typically applied on a multi-year schedule with the first burn usually being implemented around the third year of vegetation establishment. Although highly effective, the required equipment, expertise, and safety risks associated with utilizing prescribed burning as well as potential impact to wetland cool-season species complicate this control strategy.

More detailed information on **Prescribed Burning** can be found in the Prescribed Burning Technical Guidance Document located in **Appendix 6A-2**.

Prescribed Mowing

Mowing of established vegetation can be an effective maintenance strategy for both upland prairie and wetland plantings where mowing equipment can be used. Where prescribed burning is not possible or is cost prohibitive, or the treatment area is small, mowing can be an option for long-term maintenance, though it generally does not maintain or promote plant diversity as well as burning. Mowing can decrease thatch, set back unwanted woody vegetation and non-native cool season grasses, or can be used to control woody plants. Mowing will also allow for seedling germination and growth when inter-seeding forbs. Mowing in restored or created wetland areas can be limited and depends on site conditions. If the site is too wet, mowing equipment may become stuck or form ruts promoting conditions for the establishment of invasive vegetative species. Areas with steep slopes, uneven slopes or rocks can also be a limiting factors when mowing.

More detailed information on **Mowing** can be found in the Mowing Technical Guidance Document located in **Appendix 6A-3**.

Figure 6.23 *Wet blade mower*

Figure 6.24 *Reed canary grass bales*

Prescribed Haying

Haying can be used as a maintenance strategy to remove weed growth and thatch to provide sunlight for establishing native vegetation. Haying can also provide forage for cattle producers and biomass for energy production. Note that certain program restrictions or prohibitions may exist if haying is being considered on projects completed under conservation or regulatory programs.

When evaluating haying as a maintenance strategy, consider influences on bird nesting, soil disturbance, and long-term diversity levels. Haying should not be conducted directly along streams or other waterbodies or during the ground bird nesting season. Haying can be used in combination with other maintenance strategies such as spot treatment of weeds, biological control, mowing, grazing and prescribed burning. As with mowing and burning, the timing of cuttings will influence the effectiveness of the strategy for maintaining desired vegetation.

More detailed information on **Haying** can be found in the Haying Technical Guidance Document located in **Appendix 6A-4**.

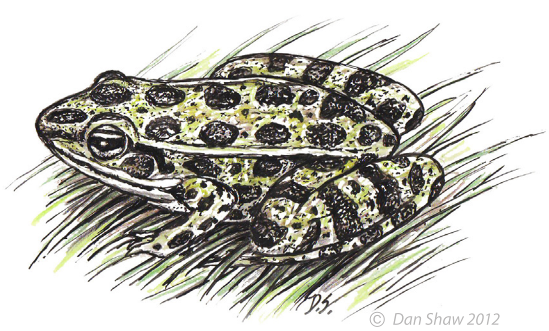

Figure 6.25 *Grazing in a wetland restoration*

Prescribed Grazing

Nomadic grazing by bison, elk, and deer was historically part of the ecological processes of Minnesota's natural plant communities. Today, grazing is sometimes used as a management tool for controlling non-native grasses and woody vegetation and for promoting the growth of forbs in planted prairies. Grazing can also minimize litter accumulation, promoting the germination of native plant seedlings. Note that certain program restrictions or prohibitions may exist if grazing is being considered on projects completed under conservation or regulatory programs.

The advantage of grazing as a maintenance strategy is that it can effectively control some invasive vegetative species while having a minimal impact on native species. Other advantages of grazing include decreased herbicide use in sensitive areas and potential cost savings. The disadvantages of grazing include a required dedication of time and resources to monitor a site to ensure that native species are not overgrazed, the ability and infrastructure (fencing) to quickly move animals from one area to another, and the increased potential for both soil compaction in wetlands and erosion issues on slopes.

Grazing is often used in combination with other maintenance strategies. On prairie plantings, for example, grazing may be used to control cool-season non-native grasses, while mowing or prescribed fire may be relied on to control invading trees and shrubs. The type of animals used in the strategy as well as the type of undesirable plant species present on a particular site will determine the type of grazing management plan selected.

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

Figure 6.26 *Biological control insect on spotted knapweed (Minnesota Department of Agriculture)*

Biological Control

Invasive weeds often out-compete more desirable native vegetation and can dominate vast expanses of land. This can result in economic damage, loss of species diversity, and degraded wildlife habitat. Invasive weeds that are not native to North America may have a competitive edge over native vegetation because the insects and diseases that keep these weeds in check in their native range are not present in North America. Biological control is a maintenance strategy that can be used that reunites the target pest with its natural enemies (insects and/or diseases).

> Biological control can be an excellent maintenance strategy for large infestations of invasive or noxious weeds or for environmentally sensitive areas.

Large continuous infestations of perennial weeds or many scattered infestations over a large area often make good biological control sites. This is the case when the infestation has been established for many years and there is a considerable seedbank present. If the infestation is small, control is best achieved by another method such as hand-pulling or chemical treatment. Extensive testing is required prior to using biological controls to ensure that they will attack only the identified target vegetative species. Minnesota's weed bio-control programs focus on managing certain species-specific infestations (purple loosestrife, spotted knapweed, leafy spurge). These programs are cooperative and bio-agents are a shared resource in Minnesota among agencies and private landowners.

Integrating biological control with other maintenance strategies can be an effective part of a project's management plan. Care needs to be taken however as insects used for biological control may be negatively affected or killed by other select maintenance activities such as herbicide applications, prescribed fire and flooding. It is important to work with bio-control experts to determine how maintenance activities should be combined to most effectively control problem species while maintaining necessary populations of bio-control agents.

More detailed information on **Biological Control** can be found in the Biological Control Technical Guidance Document located in Appendix 6A-6.

Water Level Management

Hydrology is the driver of wetland systems and thus is the major factor in any wetland restoration or creation project. When the hydrology conditions and outlet conditions allow; the manipulation of water levels in wetlands can achieve both temporary and long-term project goals and increase the benefit of other maintenance strategies.

Water level manipulation is used for a variety of management purposes. These include promoting moist soil management and habitat for migratory waterfowl, simulating natural hydrologic cycles, removing or reducing undesired plant and animal species (i.e. hybrid cattail, reed canary grass, carp, buffalo, bullhead, and fathead minnows), providing optimum flood control benefits from a wetland site, or simply to allow optimum working conditions for other maintenance strategies such as embankment repairs or herbicide use. These management techniques are achieved primarily through draw-

Figure 6.27 *Drawdown of a restored marsh*

ing down wetland water levels to target depths at key times during the year. Certain goals, such as vegetation control, can also be achieved by temporary flooding. The timing of raising or lowering water levels is of the utmost importance and can significantly influence management success. Done correctly, water level management may be able to replace or at least supplement other maintenance strategies that are more expensive and time intensive.

More detailed information on **Water Level Management** can be found in two separate Water Level Management Technical Guidance Documents, **Appendix 6A-7 (Drawdowns)** and **6A-8 (Flooding)**.

Supplemental Planting

Supplemental planting is usually necessary when seeded species have failed to establish or when native species have been eliminated as part of invasive species control. In many cases, supplemental planting will minimize the chances that invasive species will colonize areas of bare soil. The risk of invasive species establishment often influences the need for planting, particularly for small areas. Small areas may fill in from seed dispersal from surrounding native species, but larger areas may require planting. Inter-seeding into existing vegetation is also sometimes needed to increase diversity levels.

Supplemental planting can be conducted by hand for small areas or by mechanical means for large areas. As with initial vegetation establishment, proper seed bed preparation and the selection of the appropriate methodology (broadcast, drill) is essential for success. Other maintenance techniques such as mowing and herbicide application are often used in combination with supplemental planting.

Figure 6.28 *Replanting*

Figure 6.29 *Buttonbush, a wetland shrub*

More detailed information on **Supplemental Planting** can be found in the Supplemental Planting Technical Guidance Document located in **Appendix 6A-9**.

Tree and Shrub Care

Trees and shrubs are commonly planted within designated areas of wetland restoration and creation projects. They are, however, expensive to plant and their care, especially during the early years of their establishment. is critical to their success. Watering of newly planted trees and shrubs may be needed when field moisture conditions are inadequate. Fertilizer applications can also be beneficial for certain tree and shrub species, particularly in soils where nutrients are not as readily available for plants (very sandy or heavy clay). Fertilizing can also be beneficial for trees and shrubs that are suffering or recovering from disease or insect damage. Careful assessment of tree and shrub condition is necessary in order to determine the need for fertilizer applications.

Pruning is often necessary to improve tree and shrub appearance as well as to promote plant health and growth. Branches browsed by animals may need pruning to remove damaged twigs. Promoting good branch structure through pruning can enhance fruit production for wildlife use. Trees that are damaged by storms may require pruning of damaged limbs to save the tree and prevent insect infestations.

More detailed information on **Tree and Shrub Care** can be found in the Tree and Shrub Care Technical Guidance Document located in **Appendix 6A-10**.

Figure 6.30 *Muskrat burrows requiring an embankment repair*

Structural Maintenance and Repair

Both earthen and other types of structures are often integral components of wetland restoration and creation projects. Routine maintenance of these structures is essential to the function of those projects and their repair is sometimes necessary.

Repair of earthen structures can include but is not limited to excavation and grading of embankments to address problems from muskrat burrowing, wave action, rill erosion, and in some extreme cases to address problems with internal erosion or embankment seepage. Spillways also need occasional repair from erosion due to excessive use or failed vegetation establishment. Repair of non-earthen structures varies and usually includes replacing materials that have been damaged, were installed incorrectly, or just simply have met their lifespan and need replacement.

Although not necessarily considered as a maintenance strategy, repairs are a necessary part of routine maintenance and need to be performed when structural issues are identified.

More detailed information on **Structural Maintenance and Repair** can be found in the Structural Maintenance and Repair Technical Guidance Document located in **Appendix 6A-11**.

Tree and Shrub Removal

Tree and shrub removal is often conducted as part of wetland restoration and creation projects when trees and shrubs are not consistent with project goals, threaten the integrity of wetland structures, or are of a species that is not desired for the site. The removal of woody plants is most common in the prairie region of the state where fire would have controlled trees and shrubs in and around prairie pothole wetlands. Woody plants are also a concern for grassland birds such as pheasants, prairie chickens, meadowlarks, and other songbirds that require open prairie for nesting success. A combination of native and non-native species commonly invade restoration sites including, cottonwood, boxelder, buckthorn, Tartarian honeysuckle, Siberian elm, aspen, sumac, and willows.

Considerations for woody tree removal include: location within the state and geographic setting (near wooded river valleys etc.), invasiveness of woody species, target wildlife species, and other long-term goals for the project. It is common to need multiple strategies to accomplish control of woody vegetation.

More detailed information on **Tree and Shrub Removal** can be found in the Tree and Biological Control Technical Guidance Document located in **Appendix 6A-12**.

Figure 6.31 *Common buckthorn berries*

6-3 Project Monitoring

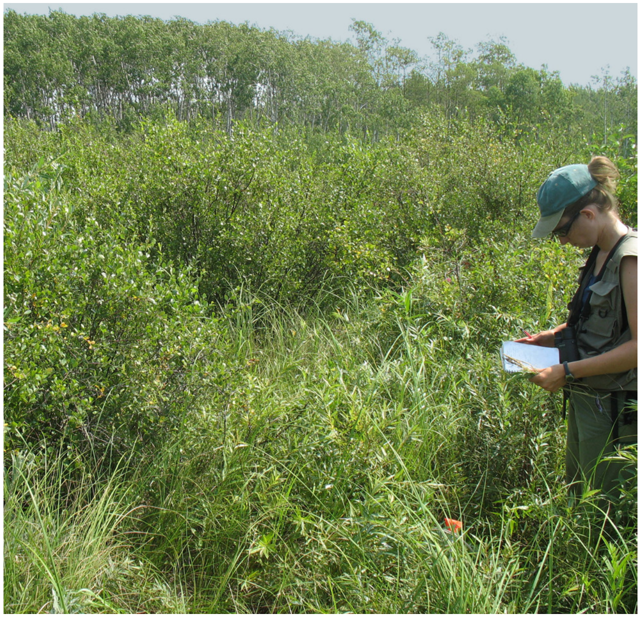

Figure 6.32 *Assessment of a shrub wetland*

This chapter provides an overview of the monitoring process and recommendations for developing and maintaining a monitoring plan.

- **Assessing Monitoring Needs**
- **Routine Site Inspections**
  - *General Requirements*
  - *Stewardship Guide*
  - *Inspection Schedule*
- **Advanced Monitoring**
  - *General Considerations*
  - *Monitoring Plan*
  - *Monitoring Schedule*
  - *Monitoring Attributes*
- **Standard Assessment Methods**

The primary goal of most wetland restoration and creation projects should be to develop wetland ecosystems that function like and resemble natural wetlands and their surrounding upland habitats. How well this occurs over the life of a project often defines a project's success. The ecosystems of all restored and created wetlands experience dramatic changes during the early years of their establishment. Hydrologic regimes and plant communities are establishing, and animals are re-colonizing the site. To measure the success of any wetland restoration or creation project will require several years of assessment through on-site monitoring.

> Monitoring helps ensure that planned ecosystem functions and values are being met.

Monitoring also includes inspecting and measuring characteristics of a project site at regular intervals to document changes over time. Regular site inspections provide the opportunity to identify problems or issues that might otherwise negatively affect a project. If identified early, corrective actions can often be more easily defined and undertaken with limited costs and resources needed. Monitoring also provides useful information to wetland planners and designers that can be applied to improve techniques and strategies used for designing and managing new projects.

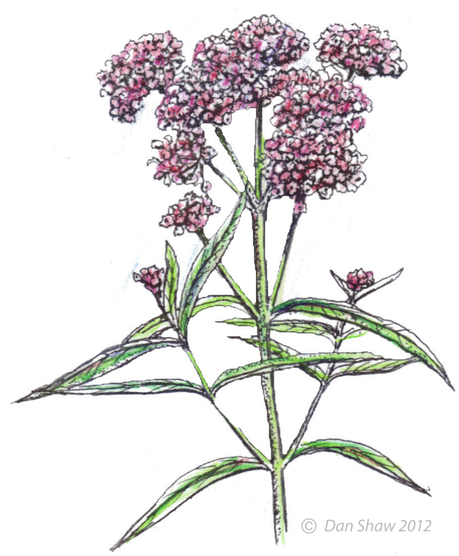

Figure 6.33 *Site Inspection*

Assessing Monitoring Needs

Monitoring of restored and created wetlands and their associated upland vegetative buffers occurs at two levels. The first level is more basic and frequent and is a required component of all wetland restoration and creation projects. It provides a broad overview of project performance and includes inspections of specific project components to identify problems. This level of site assessment is referred to as "**Routine Site Inspection**" and is needed for the life of the project.

The second level of monitoring is more advanced; it is done in addition to the first level site inspections. It includes a comprehensive assessment of project attributes that measure the success of a project in terms of the specific measurable outcomes that were set for it. This level of monitoring is referred to as "**Advanced Monitoring**". This level of monitoring will primarily be needed when wetlands are restored and created for regulatory purposes, where specific outcomes for a project are required. Advanced monitoring methods are also implemented during research of specific wetland attributes such as water quality. Advanced monitoring can be rigorous and utilize extensive resources. It is often more prevalent during the early years of a project's development with less application for older, fully established sites.

Both levels of monitoring are not required for every project. In addition, not every plan for inspecting or monitoring a project will be the same. It is important to understand program requirements, project needs, and available resources during plan preparation when inspection and monitoring needs for a project are being considered. When advanced monitoring is desired or required for a project, certain project attributes such as vegetation and hydrology will probably be assessed during both routine site inspections and advanced monitoring, with the later providing a more comprehensive approach to assessment.

Routine Site Inspections

General Requirements

Routine site inspections are considered the first level of monitoring and are an important component of project stewardship. They should include a simple assessment of general project components including: wetland hydrology, plant and animal communities, and any constructed or engineering features such as embankments or outlet structures. Depending on project scope, these inspections should occur at regular frequencies with limited investment of time. Routine site inspections represent the minimum level of monitoring necessary for evaluating sites to identify problems and document success.

For all wetland restorations or creations, it is good to be prepared for problems with wetland structures or vegetation. Site inspections that follow a well-thought-out plan and schedule should allow for the timely interven-

Figure 6.34

tion when problems occur. Problems are more likely to occur during the early years after a project's completion. The inspection and management plan should therefore include more-frequent inspections of a site during the first few years after its completion, with less-frequent inspections needed later.

Problems that are identified through routine site inspections range from issues with vegetation establishment, presence of undesired weeds or plant species, issues with hydrology, structures, or even boundary, land use, or other enforcement-related items. These problems will be more easily resolved if detected early and acted on promptly.

Stewardship Guidance

An operation and maintenance (O&M) plan, or a stewardship guide should be prepared for every wetland restoration and creation project. While standard O&M plans exist, they need to be modified to fit the specific needs of each site. An O&M plan should include a list of specific items to be observed and remedial actions to be taken when problems are observed. O&M plans guides are often used along with a site management plan. Routine site inspections will help determine if maintenance activities are needed or if they are being conducted as planned. Over time, the information gathered as a project is being inspected and maintained will help determine if adjustments are needed to its management plan.

It is important to note that, in some situations, more than one O&M plan (or a similar inspection document) may be prepared. An example might be for a wetland restoration or creation project completed under any of Minnesota's private lands programs where there is continued private ownership of the site. In these situations, there is often an O&M plan that is prepared for the landowner to follow and another document for the overseeing agency or program staff. The plan prepared for the landowner is usually somewhat basic, but no less important, since many of the necessary routine inspection and maintenance functions can be performed by the landowner. If implemented by the landowner, less time and resources are required by agency or program staff to inspect and oversee projects in their care.

The following areas should be routinely inspected, with appropriate remedial or management actions taken as necessary:

General

- Program and land use compliance issues
- Site, property, or easement encroachment
- Trespass

Vegetative Plantings

- Presence of noxious weeds and other undesirable vegetation
- Erosion of sloped areas
- Failed or poor vegetation establishment

Figure 6.35 *Wetland Encroachment*

Figure 6.36

Embankments, Spillways and Other Structures

- Tunnels and burrows in embankments caused by muskrats and other animals
- Presence of trees or other woody vegetation growing on embankments and in spillways
- Failed or poor vegetation establishment on embankments and other structures
- Cracking or sloughing of embankment fills
- Embankment seepage
- Sediment and debris blocking outlet structures
- Cracks or other performance issues with outlet structures
- Displacement of rock riprap and other materials

Technical Guidance document 6A-14 includes additional information about structural component inspection.

For an example of a stewardship guide see the BWSR Landowner Guide to Easement Stewardship.

Inspection Schedule

It is important that routine inspections be performed and continue for the life of the project. This will ensure that maintenance issues do not go unnoticed providing an opportunity to make corrections or repairs before the problem becomes unmanageable. A site inspection schedule provides regular reminders of inspection times and items to be inspected. For most projects routine inspections should occur in early spring, late spring, late summer, and late fall of each year. In certain situations, such as immediately after a significant rain or during the first four or five years after site establishment, more frequent site inspections may be needed. The following summarizes key information that should be inspected during each seasonal period identified:

Early Spring – Inspect the site as soon as possible after snowmelt. Identify any immediate maintenance needs or issues that have occurred over the course of winter. Floating debris and other obstructions should be removed from all outlet structures to ensure that they are operating efficiently. Make a careful inspection of all earthen embankments and spillways, as seepage and muskrat activity are most apparent in the spring. Record any repair or maintenance work that may be needed so that such work can be scheduled as soon as possible.

Late Spring – A late spring inspection is ideal for evaluating performance of outlet structures and identifying repair needs. Look for damage that may have occurred after runoff and flooding from spring rains. Remove floating debris and other obstructions from outlet structures to ensure their efficient operation. A careful inspection should be made of all earthen embankments and spillways to verify that vegetation is becoming well-established and that no erosion of constructed features has occurred. Schedule any repair or maintenance work to be performed as soon as possible. The timing of summer control activities such as mowing and spot treatment can be refined as part of spring monitoring.

> Late spring is the ideal time to spot weed problems to control them before they spread.

Late Summer – Early September is a good time to inspect the condition of structures, spillways, and embankments. Late summer monitoring also allows for the identification of weeds and other undesired vegetation that may have established over the course of the summer. Any fall treatment of vegetation can be refined as part of a late summer inspection.

Late Fall – Inspection late in the fall should occur just before winter freeze-up. Outlet structures should be cleared of any debris or obstruction. As vegetation goes dormant, muskrat and other animal burrows in constructed embankments can be more easily identified. If found, take notes so that preventive measures can be scheduled.

Figure 6.37 *Evaluation of a wetland buffer*

Advanced Monitoring

General Considerations

Advanced monitoring can include both collecting general, basic observations and detailed, specific project information that is related to a defined set of outcomes for the project. Typically the information, whether general or specific, is related to the condition (biological integrity) of the project. Monitoring plans usually include an assessment of the water regime along with the plant and animal communities that have successfully colonized a site.

Advanced monitoring can also include a more rigorous, narrowly-focused, science-based effort that produces detailed information on specific wetland attributes. This can help managers determine the effectiveness of specific management actions and more accurately measure the overall success and outcomes of the restoration or creation.

While advanced monitoring does provide better information in terms of project outcomes and accomplishments, it is time-consuming and requires more resources and special expertise. Because of these factors, this level of monitoring is typically limited to projects that are being held to specific performance standards or where there is a need or desire to perform research and measure specific outcomes.

Figure 6.38 *Soil profile description*

Figure 6.39 *Assessment of deep marsh*

Monitoring Plan

A monitoring plan is an integral part of adaptive management and is typically needed when advanced monitoring will be conducted. A monitoring plan provides guidance for collecting data about the wetland and its vegetative buffer over a period of time. The plan should identify the amount of time and resources needed to adequately evaluate that specific site. The time needed to monitor a site depends on the level of information needed. The level of information needed depends on project goals and desired outcomes.

Monitoring results should be evaluated to determine if the wetland is developing as expected or has reached its goals. Continued monitoring and management will then determine if the goals can be maintained. Results from the monitoring efforts will not only be used to direct specific management needs for a project, but also to inform others (funding partners, community, landowner) on project success.

Specific programs may provide guidance as to what is required in a monitoring plan. In general, a monitoring plan for a wetland project identifies:

- Objectives and expected outcomes of a project
- Who is involved with the monitoring and their responsibility
- What characteristics will be measured that will indicate project success
- Costs and funding sources for monitoring activities
- A copy of the vegetation planting and construction plans with noted implementation changes
- Management strategies to achieve goals, objectives and outcomes

- How the characteristics will be measured in quality and quantity (methods or protocols)
- Performance standards or criteria for the project
- When the information will be collected
- The format in which the collected information will be documented
- Who receives the reports of the documented information

Development of a monitoring plan should follow "SMART" guidelines. Goals of monitoring should be specific, measurable, achievable, reasonable and time bound.

Monitoring Schedule

Both monitoring frequency and duration depend on the project goals and will likely vary as the project matures. The frequency and duration of monitoring should be planned so that sufficient evidence can be collected to support long-term project success. During the first few growing seasons, it is best to monitor the site at least twice a year to ensure planting success and weed control.

Specific project goals will influence the time of year to conduct monitoring activities. For example, if plant diversity is desired, the timing of observations can affect the outcome. Some wetland plant species will predominate early in the growing season, while others are more dominant in the fall. The index period corresponding to peak maturity for most of the plant communities in Minnesota is June 15 – August 15. If

Figure 6.40 *Restored shallow marsh*

wildlife use is a key component of restoration success, monitoring should coincide with which species and uses are of interest (e.g. waterfowl breeding, nesting, migration stop-over habitat). To minimize disturbance in high quality wetlands with sensitive substrates (fens, seeps, bogs), it is best to sample during the drier part of the growing season.

Regulatory programs tend to require monitoring reports on an annual basis until the regulatory officials agree that the restoration goals have been met. For most projects, this will be five growing seasons after project construction is completed.

Monitoring Attributes

Identify attributes that will be good indicators of the wetland's characteristics. For example, vegetative structure is often measured as an indicator of habitat quality. Some programs may pre-identify specific criteria that need to be met. Permit conditions for compensatory mitigation often include requirements as to size of the wetland, type of wetland, and qualitative performance standards such as percent cover of native hydrophytic vegetation and number of native species. Other programs may require more general information, such as percent cover of perennial species. Once desired qualities and site characteristics are identified, the level of intensity and investment to collect that information should be decided based on site conditions and resources available. Multiple methods are often used to document the various attributes selected for monitoring. Also, as goals and objectives vary among projects it is reasonable to expect attributes and monitoring methods used to vary as well.

Figure 6.41 *Diverse Wetland Restoration*

The following are recommended attributes to monitor and include in the advanced monitoring plan:

- **Wetland Hydrology**
- **Vegetation**
- **Soils**
- **Wildlife**
- **Water Quality**

Locations of sampling points should be in each plant community with similar soil and hydrolic conditions. The number of sampling points depends on site complexity (higher complexity = more samples) and the level of confidence you require from your data.

Wetland Hydrology

Hydrology is a key variable in wetland systems, driving the biology and chemistry of wetland soils and the establishment of vegetation. The hydroperiod (duration and frequency of inundation or saturation) is closely linked with the development and maintenance of the various wetland types and thus is an important predictor of project success. For example, sedge meadow wetland types have saturated soils; the plant community does best if surface inundation is relatively brief. Early monitoring can show if the hydroperiod is sufficient to support this wetland type or if there is too much water, indicating that some other wetland type can be expected. There may be a lack of adequate precipitation at certain times during the year that could prevent a wetland from developing into the expected type. Monitoring may also show an unexpected water loss from a restored wetland that can be an indication of a some other type of problem such as a functioning tile line that was not found and removed during construction. In some situations, pre-restoration data is useful as a comparison to show the extent of hydrologic restoration. Hydrology monitoring data should also be accompanied by meteorological records or observations.

> Hydrology monitoring helps ensure project success by measuring the attainment of hydrology targets and objectives.

Figure 6.42 *Measurement of Water Levels*

Basic measuring techniques include observations of high water marks or drift lines or direct observations of inundation or saturation. Water levels can also be determined using a graduated staff gauge placed in the wetland where frost and ice problems will not affect it. Higher-detail monitoring may be valuable where success is necessary to be in permit compliance or the target hydrology has a very narrow range, such as wetlands with no surface water.

Scientific hydrology monitoring often consists of quantifying in detail the overall water level changes throughout the growing season over two or more years. This may require installation of shallow groundwater wells, input/output weirs, and automated monitoring equipment. The expertise required for scientific hydrology monitoring is high and will likely require a professional hydrologist.

More detailed information on hydrology monitoring methods is available in **Hydrologic Monitoring of Wetlands, MN Board of Water and Soil Resources**.

Figure 6.43

Vegetation

Assessing how well target vegetation types are establishing is one good indicator of project success. This applies not only when a significant investment has been made to establish high quality vegetation, but also when water quality or wildlife goals are related to vegetative conditions. Vegetation coverage, target (and acceptable) vegetation types, and invasive or noxious weeds are common considerations for vegetation monitoring.

Vegetation coverage stabilizes soils, establishes wetland soil formation processes, and provides basic wildlife habitat. Identifying bare patches and taking early action to seed them can prevent problems such as erosion or the establishment of invasive species. Target vegetation may change as the site progresses and as hydrology develops.

Vegetation types are closely linked with hydrologic regimes. Thus, it is important to monitor vegetation in association with wetland hydrology. Good establishment of a cover crop may be the target for the first few years, with a transition to mid- and late-succession species over time. If the expected species are not observed, the long-term integrity of the site may be threatened.

> Target vegetation may change as the site progresses and as hydrology develops.

Finally, invasive species such as hybrid cattail and reed canary grass are very hard to control; once established, they can readily spread throughout a site. Identifying and eradicating invasions while the target vegetation is establishing will be critical when high quality vegetation is a goal.

Advanced monitoring of vegetation may be beneficial if the success of a project relies on specific aspects of plant growth such as the dominance of certain plants or the number of various species. At a minimum, the monitoring plan should include a requirement for a thorough assessment of the project to detect areas with poor establishment or areas where invasive species have become established.

More intensive scientific monitoring of project sites may help project managers determine the effectiveness of various planting or management techniques employed as part of the site's establishment. Advanced and scientific monitoring often use transects and plots as a tool to measure vegetative outcomes. Transects and plots can be drawn on the project monitoring plan so that the site can be monitored consistently as it develops. Selection of the monitoring method depends on what information is needed. For example, a line intercept method may be used to document changes in shrub canopy cover, while a series of plots may be used to document species diversity. Fixed photo monitoring points are also commonly used to document the change in vegetation over time. Photo monitoring points can also be drawn on the project planting plan.

Soils

Soils are the physical foundation influencing the development of biological communities within a wetland. Monitoring over time can identify trends or lack of trends in soil development, such as the accumulation of organic matter. Soil profiles can be reviewed for changes in color, texture, and structure. Because wetland hydrology will drive the development of wetland soils, monitoring efforts tend to focus more on the hydrology aspect of soil formation. Soil samples may be collected

Figure 6.44 *Assessment of a soil profile*

Figure 6.45 *Tiger Salamander*

for laboratory analyses of soil characteristics such as organic matter content, pH, nitrogen, phosphorus, and other structural or chemical properties.

Wildlife

Depending on project goals, outcomes and available resources, scientific monitoring of animals outside of routine assessment methods may be useful. For example, if providing high quality wildlife habitat is a restoration goal, detailed study of waterfowl productivity or breeding bird or nest counts may be desired. State and federal agencies routinely collects waterfowl survey data and could provide technical assistance to developing a scientific monitoring plan for a project. When planning for wildlife surveys, it is important to apply the appropriate methods for each target species or group.

Water Quality

If improving downstream water quality is an identified project goal, then chemical water quality testing and monitoring will probably be required to measure specific outcomes. Both field and lab analysis methods of testing are available and the wetland will likely require a suitable, point source outlet where sampling can be conducted. Temperature, conductivity, and pH can be measured in the field where lab analyses will be required to determine content of carbon, nitrogen, phosphorus, dissolved solids, or other trace elements. Carefully consider monitoring periods, frequency, and sampling locations ahead of time.

Standard Assessment Methods

There are a number of standard assessment methods that have been developed and are available to measure wetland functions and wetland condition. The standard assessment methods discussed below are commonly used in Minnesota. Some of these methods may be required by regulatory entities when assessing the development or success of a wetland restoration or creation project.

- The Minnesota Routine Assessment Method (MnRAM) is a narrative, question-based assessment of wetland functions. Wetland functions are graded as exceptional, high, medium, or low. While MnRAM was initially developed to support the state Wetland Conservation Act and measure no net loss of functions and values through regulatory actions, it also has been effectively used for local wetland resource inventories and wetland comprehensive plans. An interagency workgroup updates the questions and provides regular software upgrades as well as online do-it-yourself training documentation. An associated management classification tool assists users in customizing the application of functional ratings after

Figure 6.46

Figure 6.47 *Restored mesic prairie*

the assessment is complete. The MnRAM guidance and tools are available on the BWSR website at: **http://www.bwsr.state.mn/wetlands/mnram/index.html**.

- The Hydrogeomorphic (HGM) functional assessment method is the forerunner of many other wetland assessment methods. The foundation of HGM functional assessment is the HGM classification system, which organizes wetlands according to their source and flow of water and their physical form (Brinson 1993). Wetlands of different HGM types have varying capacities to perform functions. HGM assessment requires collecting quantitative data; as opposed to MnRAM, which often relies on best professional judgment and follows a narrative guidance. The US Army Corps of Engineers (ACOE) is the main proponent of HGM assessment and is actively developing HGM assessment guidebooks for the wide variety of HGM classes that exist throughout the country. Currently, a guidebook designed to assess depressional wetlands is available for use in Minnesota (Gilbert et al. 2006); and a guidebook for organic flats is in progress.

- The Index of Biological Integrity (IBI) is a multi-metric condition assessment based entirely on a wetland's biological community and how that community as a whole responds to human- caused disturbances (i.e., hydrologic alterations, excess sediment loading). The Minnesota Pollution Control Agency has an active program to develop wetland condition assessment techniques and has developed plant and macroinvertebrate IBIs for depressional marshes in the state (Gernes and Helgen 2002, Genet and Bourdaghs 2006, Genet and Bourdaghs 2007). While the IBIs are calibrated for ambient wetland monitoring and assessment, they could also be used to measure restoration and creation success.
The IBIs require a high level of expertise in either wetland plant or macro-invertebrate identification. Scaled-back versions of the IBIs for citizen volunteer wetland monitoring have been made available by the Wetland Health Evaluation Program (WHEP); these versions require less expertise, but the assessment is more coarse and not as well calibrated as the professional grade IBIs.

- Floristic Quality Assessment (FQA) is another wetland condition assessment that has been shown in many scientific studies to be effective. FQA relies on a measurement called the Coefficient of Conservatism (C), which is a numerical rating (0-10) for each wetland plant species that reflects its tolerance to human disturbances. To perform a FQA, plant species are identified at a site then a number of simple metrics are calculated from the C-values that are associated with those species. C-values have recently been developed for all Minnesota wetland plants (Milburn et al. 2007) and a rapid FQA method has been developed.

- Other vegetative assessment protocols have been developed such as a releve used by MNDNR (**www.dnr.state.mn.us/eco/mcbs/vegetation_sampling.html**) and a grassland standardized monitoring protocol developed by a team of MN grassland managers (**http://www.fws.gov/bmt/database_gmd.htm**). A classic interagency reference from 1985 is also available titled "Sampling Vegetation Attributes." This document describes the benefits and drawbacks of the most common sampling methods (**www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1041379.pdf**).

Figure 6.48

Wetland Monitoring Resources

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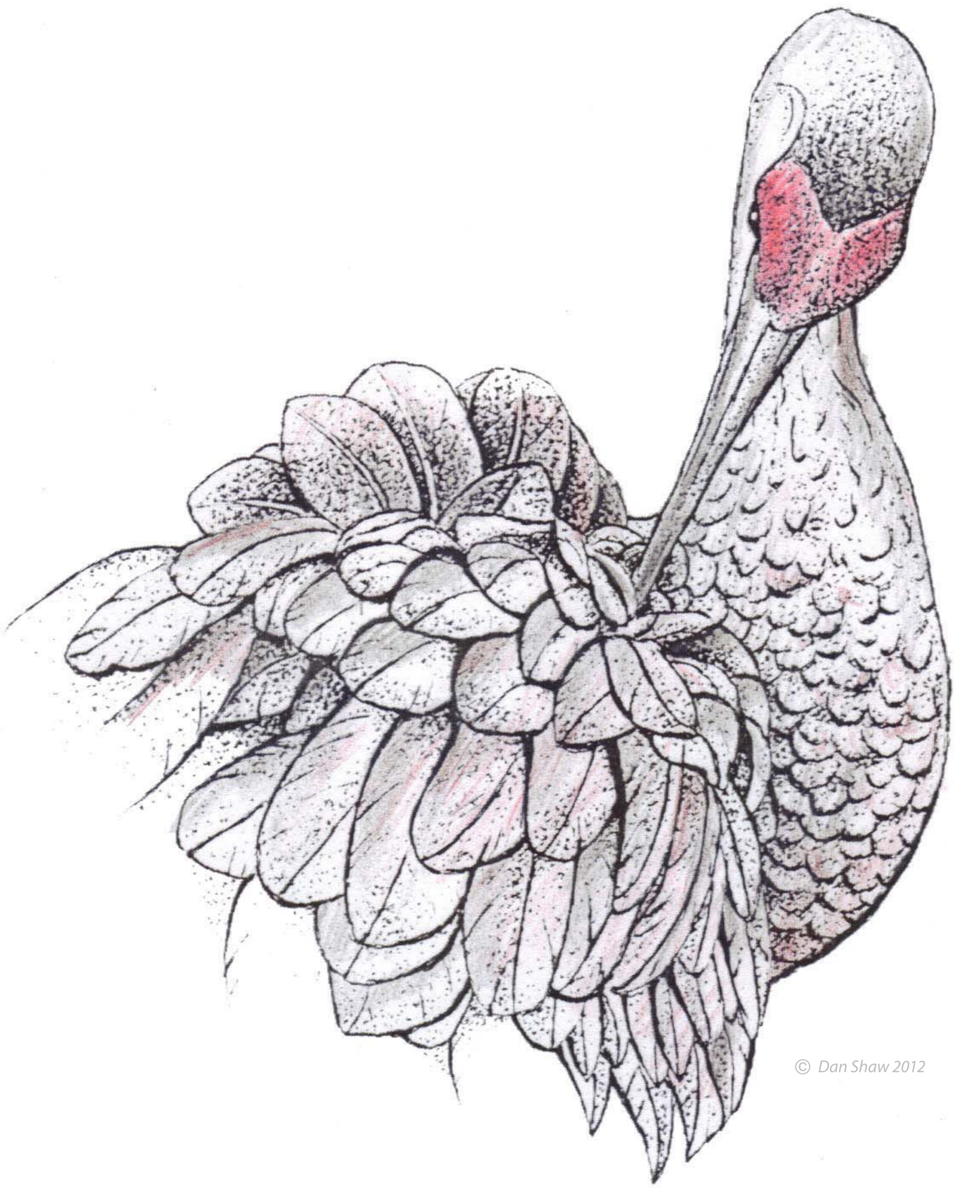
Figure 6.49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