CHAPTER 1

A Mandate for Sustainable Resource Management

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CHAPTER 1

A Mandate for Sustainable Resource Management

The Rationale for Sustainable Resource Management

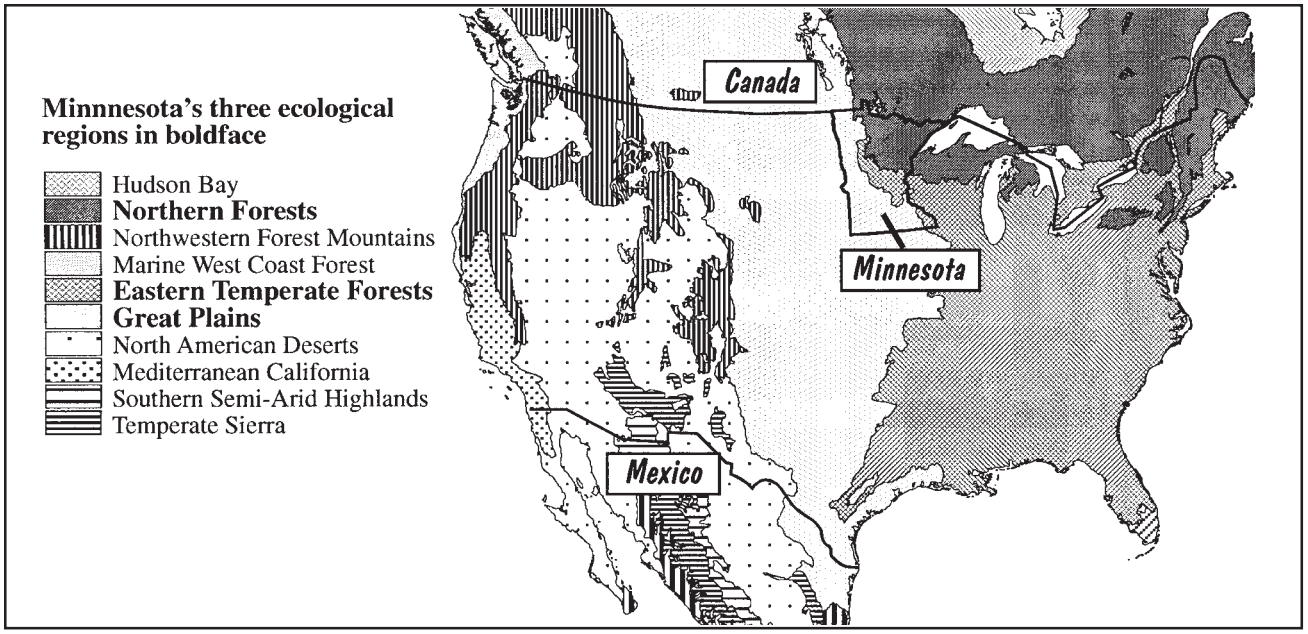
Minnesota's state trails, canoeing and boating routes, and water access sites provide recreational opportunities for Minnesota residents and visitors throughout the seasons:

These recreational facilities enable users to experience Minnesota's natural and cultural landscapes.

- ❒ State trails link urban places to country spaces and other recreation facilities, such as state parks and state forests.
- ❒ Designated canoeing and boating routes provide many miles of river recreation.
- ❒ Public water access sites provide boating and fishing opportunities on numerous Minnesota lakes and rivers.

These recreation facilities enable users to experience Minnesota's natural and cultural landscapes, as exemplified by the state's diverse geologic features and rich vegetation patterns. Unlike many other states, Minnesota is blessed with three major ecological regions, or biomes, which provide a high diversity of experiences for recreational users. (See Figure 1.)

Figure 1: Ecological regions of North America



A Vision for a Sustainable Quality of Life

In its *Directions for Natural Resources 2000,* the Minnesota Department of Natural Resources (DNR) established two sustainability goals:

- ❒ **Maintain, enhance or restore the health** of Minnesota ecosystems, so that they can continue to serve environmental, social and economic purposes.

- ❒ **Foster an ethic of natural resource stewardship** among all Minnesotans.

A land ethic changes the role of homo sapiens from conqueror of the land-community to plain member and citizen of it. It implies respect for his fellow-members, and also respect for the community as such.

Aldo Leopold
A Sand County Almanac

DNR Resource Management Principles

In consideration of the above goals, the following resource management principles were identified:

- ❒ **Expand the use of partnerships** to develop cooperative resource management approaches.

- ❒ **Promote a systems approach** to managing resources.

- ❒ **Accelerate the collection, interpretation and dissemination of scientific information** describing Minnesota's ecosystems and natural resources.

- ❒ **Improve communications** with all stakeholders and citizens.

- ❒ **Expand efforts to provide information and technical assistance** to citizens and local government.

- ❒ **Implementing the recommendations from the DNRs Corner stones Report** would effectively deliver natural resources stewardship education to all Minnesotans.

- ❒ **Establish performance measures** that will provide a comprehensive assessment of the DNR's success in managing for long-term ecosystem sustainability.
(See the *DNR Performance Report 2001.*)

- ❒ **Integrate resource management priorities** into existing discipline planning and budget development across area, regional and state levels and place more authority with area staff to manage budgets and staffing priorities.

Trails and Waterways Responsibilities

The guidelines are designed to assist resource managers in conducting management activities that enhance the quality of natural plant communities, wildlife habitat, regional landscape integrity and visual quality. DNR Trails and Waterways will strive to accomplish the following objectives:

❒ **Identify, manage and restore natural plant communities** during planning and development of new trails and water access sites.

❒ **Manage natural plant communities** according to ecological principles.

❒ **Expand partnerships with citizens and local government** to enhance the ecological quality of state trails, canoeing and boating routes, and water access sites.

❒ **Engage recreational users** in management activities.

❒ **Inform recreational users** about management successes and continuing challenges.

Before We Get Started: What the Guidelines Are... and What They Are Not

Wild ginger

What the Guidelines Are...

❒ **The guidelines are designed to be flexible**, recognizing that site conditions vary. Determining the most appropriate guidelines for implemention on a particular site depends on the informed judgment of the resource manager responsible for that site.

❒ **The guidelines are designed to help** resource managers conduct management activities that enhance the quality of natural plant communities, wildlife habitat, regional landscape integrity and visual quality.

❒ **The guidelines represent practical and sound practices** based on the most current scientific information.

❒ **The guidelines are designed to assist with site-level management.**
While they are not designed to provide broad-based landscape direction, site-level management efforts can be expected to enhance the larger landscape.

...and What They Are Not

❒ **The guidelines are not a substitute** for a natural communities management plan. They are intended to support implementation of a plan once it is in place.

❒ **The guidelines are not intended to replace** any existing rules or regulations, such as Operational Orders.

❒ **The guidelines are not intended as a substitute** for obtaining professional assistance as needed to achieve management objectives.

❒ **The guidelines are not designed to help determine** whether a particular management activity should or should not occur. They are designed instead to provide guidance in **how** to implement a particular management activity.

❒ **The guidelines do not cover all management options** in detail related to a particular resource. Additional references provided will assist in more intensive study of various management options.

The Ecological Classification System: A Framework for Sustainable Resource Management

The Ecological Classification System (ECS) is part of a nationwide mapping initiative developed to improve our ability to manage all natural resources on a sustainable basis.

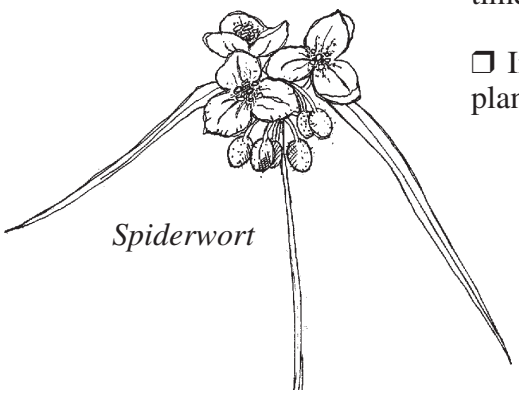
The ECS scientifically delineates and describes meaningful units of the natural landscape to form a basic framework for research and management. It identifies interrelationships and interactions among ecological components, such as climate, geomorphology, soil, topography, vegetation, hydrology, animals and land history.

As a framework for sustainabile natural resource management, the ECS:

- ❒ Provides a common means of communication among a variety of resource managers, as well as with the public.

- ❒ Improves predictions about how vegetation will change over time in response to various influences.

- ❒ Improves our understanding of the interrelationships among plant communities, wildlife habitat, water quality and human needs.



Spiderwort

A Framework for Managing Natural Resources

The Minnesota Ecological Classification System (ECS) identifies six ecological units in its classification and mapping. It follows the methodology used by the U.S. Forest Service and is part of the Great Lakes Region ECS. The classification is hierarchical or nested; small ecological units are contained within larger units.

The six ecological units are province, section, subsection, land type association (LTA), land type (LT) and land type phases (LTP).

Minnesota's Four Provinces

Prairie Parkland
about 16 million acres

Tallgrass Aspen Parklands
about 3 million acres

Eastern Broadleaf Forest
about 12 million acres

Laurentian Mixed Forest
about 23 million acres

Figure 2: ECS province map

Minnesota's Ten Sections

Figure 3: ECS section map

Level 1: Province

Minnesota has four provinces. Provinces are defined by climate (temperature and moisture), geology, and associated major vegetation patterns. The state's four provinces represent four broad climate/vegetation patterns: prairie/savanna, deciduous forest and boreal forest. (See Figure 2.)

Prairie Parkland Province: The Prairie Parkland Province covers about 16 million acres of southern and southwestern Minnesota. Before settlement, this area was primarily covered by tall grass prairie. Its topography is mostly level to gently rolling, and major landforms include lake plains and ground moraines.

Tallgrass Aspen Parklands Province: This Province covers about 3 million acres in northwestern Minnesota. Part of an extensive lake plain, it is level in the western portion with small dunes and a series of low beach ridges and swales to the east. Before settlement the vegetation consisted of aspen savannah, tallgrass prairie, wet prairie, gravel prairie, and floodplain forest along rivers.

Eastern Broadleaf Forest Province: The Eastern Broadleaf Forest Province covers another 12 million acres through the heart of the state. It forms a transitional zone between the prairie to the west and the boreal forest (conifer, conifer-hardwood mix or hardwood forest) to the northeast. Topography varies from level lake plains to very steep slopes in the Paleozoic Plateau of the southeast. Major landforms include lake plains, outwash plains, moraines and drumlin fields.

Laurentian Mixed Forest Province: The Laurentian Mixed Forest Province covers the northeastern 23 million acres of Minnesota. It is the boreal forest region of our state. Before settlement, this area consisted primarily of coniferous forest, coniferous-hardwood mix or northern hardwood forest. Topography is variable. Landforms range from lake plains and outwash plains to ground and end moraines.

Level 2: Section

Provinces are subdivided into sections. Sections are defined by the origin of glacial deposits, regional elevation, distribution of plants and regional climate. Minnesota has 10 sections. (See Figure 3.)

Level 3: Subsection

Sections are further divided into subsections. These county-sized areas within sections are defined by glacial land-forming processes, bedrock formations, local climate, topographic relief and the distribution of plants. Minnesota has 25 subsections. (See Figure 4.)

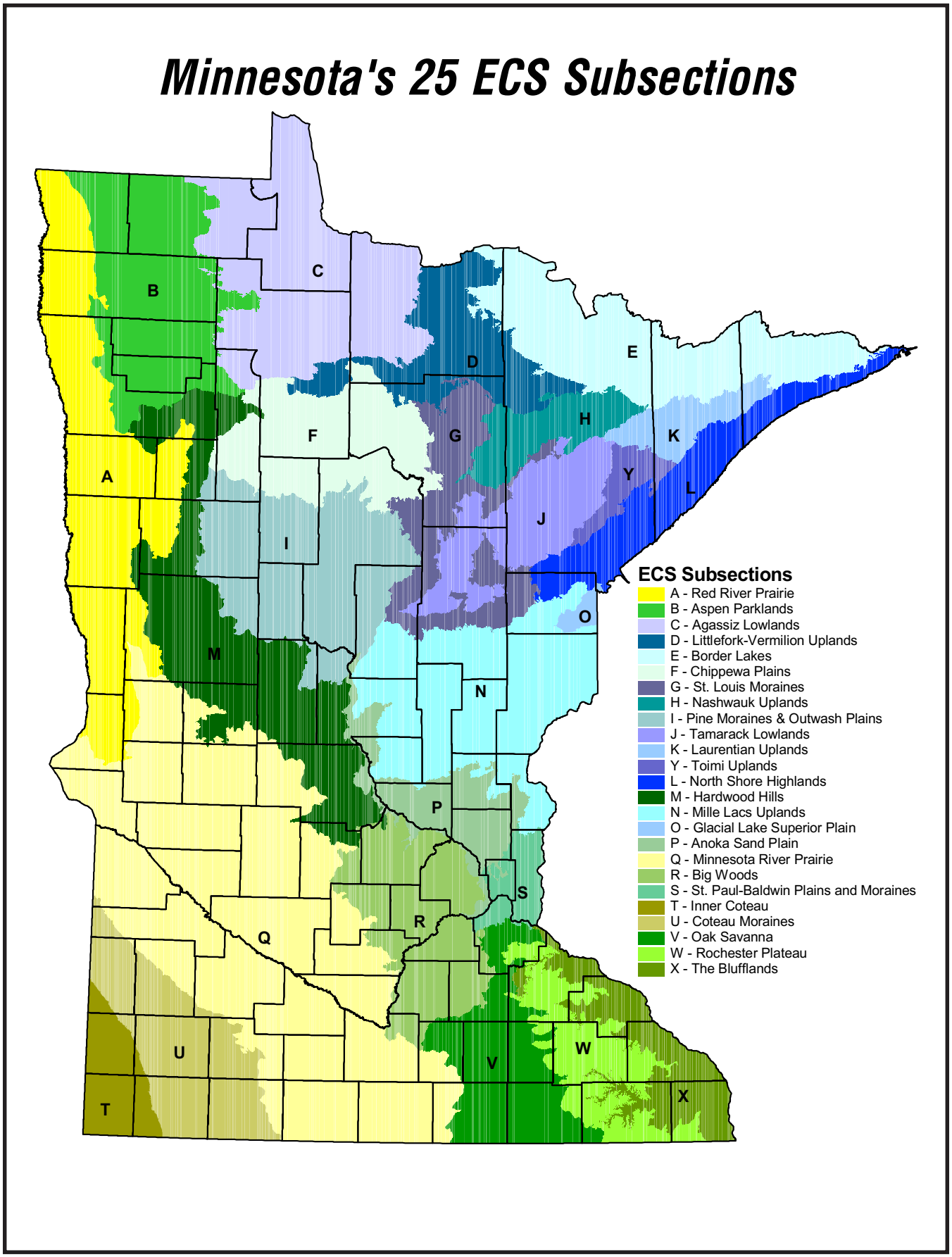


Figure 4: ECS subsection map

Upper Three ECS Levels for Minnesota

Province	Sections	Subsections
Prairie Parkland Province	2	4
Tallgrass Aspen Parklands Province	1	1
Eastern Broadleaf Forest Province	2	7
Laurentian Mixed Forest Province	5	13
	10	25

Level 4: Land Type Association (LTA)

Land type associations are landscapes within subsections. Land type associations (or LTAs) are characterized by glacial formations, bedrock types, topographic roughness, lake and stream patterns, depth to groundwater table and soil material. For example, the Alexandria Moraine is an LTA characterized by a particular glacial formation.

Level 5: Land Types (LT)

Land types are the individual elements of an LTA. Land types (or LTs) are defined by recurring patterns of uplands and wetlands, soil types, plant communities and fire history. For example, a fire-dependent dry pine-hardwood association is an example of a land type.

Level 6: Land Type Phases (LTP)

Land type phase or habitat type is a unique combination of plants and soils within a land type (LT). Land type phases are defined by characteristic trees, shrubs and forbs, by landscape position, and by soil texture and moisture. A sugar maple-basswood forest is an example of a land type phase.

Each biotic province needs its own wilderness for comparative studies of used and unused land.

Aldo Leopold
A Sand County Almanac

The Importance of Understanding the ECS

State trails are artificial long-distance corridors, and canoeing and boating routes are natural long-distance corridors. Trails and canoeing/boating routes range from a few miles to several hundred miles in length. They often extend across several different units of the Ecological Classification System (ECS). Water access sites are also located in various ECS units throughout the state.

A basic understanding of the ECS is essential for effective management of natural resources along these corridors and sites, as well as understanding their relationship to the surrounding landscape.

The ECS can also help us understand the interrelationships among plant communities, wildlife habitat and water quality, thereby helping us recognize the potential impact of recreational activities on natural resources.

The ECS also serves as a framework for planning and development of new trails and water access sites, and for the management and restoration of natural plant communities on existing sites.

The Guiding Principles

The Rationale for Our Actions

Three guiding principles provide the rationale for actions related to managing and restoring natural plant communities on Trails and Waterways sites:

Three guiding principles provide the rationale for actions related to managing and restoring natural plant communities on Trails and Waterways sites.

1. Restoration and management of natural plant communities:

- Enhances the ecological quality of all sites
- Contributes to the integrity and aethestic quality of the regional landscape
- Improves the quality of the recreational experience
- Reduces air and water pollution induced by motor driven maintenance procedures

2. New development should occur primarily in environments already influenced by human activity, with emphasis on restoring and re-establishing native vegetation in these environments for the benefit of people, and remaining natural systems.

3. New development must avoid:

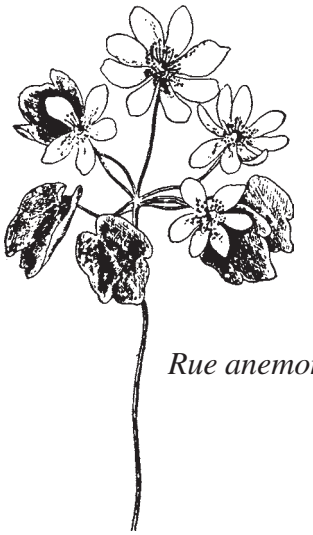
- Critical habitat of endangered, threatened and special concern species (as identified by the Natural Heritage Program)
- Large remaining natural areas
- Patches of high quality habitat

Action Steps To Implement Guiding Principles

❒ **Collaborate with an interdisciplinary team of resource managers** during all stages of new development, including site selection, planning and development.

❒ **Consider existing landscape-level and watershed-level planning activities,** which engage citizens in defining desired resource conditions.

❒ **Site new trail alignments** consistent with regional landscape management goals.



Rue anemone

❒ **Incorporate guiding principles** into existing management objectives and activities.

❒ **Minimize the crossing of natural corridors,** such as stream corridors, which are important for wildlife movement.

❒ **Use native plant material** that is landscape and site appropriate to revegetate areas disturbed by construction.

❒ **Strive to enhance the overall quality of remnant native plant communities** by applying appropriate management practices.

❒ **Collect and use native seed from existing sites** for restoration and expansion of native plant communities.

❒ **Encourage adjacent landowners** to become partners in managing existing natural plant communities beyond Trails and Waterways sites.

❒ **Foster user awareness** through information and interpretation regarding natural plant communities and associated management practices.

❒ **Engage local communities** to become better stewards of their natural resources.

❒ **Provide a safe recreational environment** by removing hazardous trees, creating buffer plantings, and assuring that vegetation does not impede visibility.

For Further Information

Ecology of Greenways: Design and Function of Linear Conservation Areas, by Daniel S. Smith and Paul Cawood Hellmund. University of Minnesota Press, Minneapolis, Minnesota, 1993.

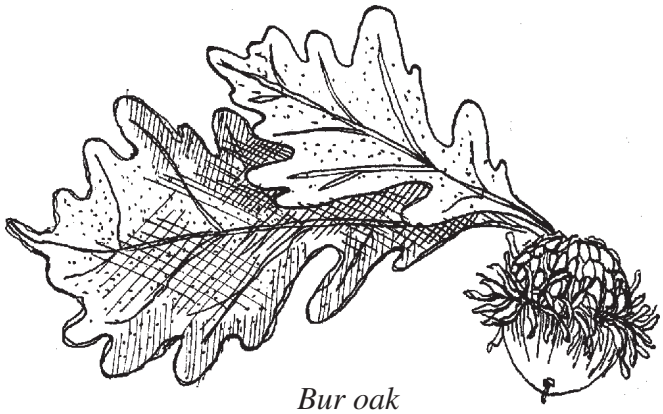
Field Guide to the Native Plant Communities of Minnesota, The Laurentian Mixed Forest Province, Minnesota Department of Natural Resources, Division of Ecological Services, 2003.

Landscape Ecology, by Richard T. T. Forman and Michel Godron. John Wiley & Sons, New York, 1986.

Minnesota's Native Vegetation: A Key to Natural Communities in Minnesota, Version 1.5. Minnesota Department of Natural Resources, Natural Heritage Program, St. Paul, Minnesota, 1999.

Minnesota's Natural Heritage: *An Ecological Perspective,* by John R. Tester. University of Minnesota Press, Minneapolis, Minnesota, 1995.

The Upper Levels of an Ecological Classification System for Minnesota (ECS), General Description of Sections and Subsections, Minnesota Department of Natural Resources, St. Paul, Minnesota, 1996. Web: www.dnr.state.mn.us/ecological_services/ecs/index.html



Bur oak

CHAPTER 2

Managing, Restoring and Re-establishing Prairie and Savanna Communities

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Indian grass
Drawing by Tom Klein

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CHAPTER 2

Managing, Restoring and Re-establishing Prairie and Savanna Communities

Introduction

At the time of the Public Land Survey in Minnesota (1847-1907), the Prairie Parkland Province was primarily comprised of upland prairie and prairie wetland communities, while savannas were a major community type of the Eastern Broadleaf Forest Province. (See Figure 1.)

Figure 1: ECS province map

Prairies are grasslands that are void of trees. They lack the moisture needed to support tree growth. (Prairie is the French word for meadow.)

Savannas are transitional landscapes generally occurring in areas of transition from grasslands to forests. True savannas are composed of grasses, forbs and shrubs with scattered stands of trees, the most characteristic being the dry-oak savanna. In Minnesota, however, oak woodland and brushland communities dominate in the southern part of the state, rather than true savanna communities. Pine barrens, another form of savanna, occur frequently in the northern and central parts of the state.

Prairies and savannas are fire-dependent ecological communities. Fire is the significant factor influencing the survival and extent of these communities.

These are the natural grassland communities we seek to manage, restore and re-establish on our state trails, canoeing and boating routes, and water access sites.

Trails and Canoeing/Boating Routes Crossing Prairies and Savannas in Northern Minnesota

Trails that cross prairie, brush prairie or pine barrens landscapes in Northern Minnesota include (see Figure 2, page 3):

Willard Munger State Trail (intermittent openings)
Paul Bunyan State Trail (intermittent openings)
Heartland State Trail (intermittent openings)

Canoeing/boating routes that cross prairie, brush prairie or pine barrens landscapes in Northern Minnesota include (see Figure 3, page 4):

Mississippi River (northern portion)
Pine River
Crow Wing River
Red Lake River

Trails and Canoeing/Boating Routes Crossing Prairies and Savannas in Southern Minnesota

Trails that cross prairie, brush prairie or oak savanna landscapes in Southern Minnesota include (see Figure 2, page 3):

Blufflands Trail system (western portion)
Douglas State Trail
Sakatah State Trail (eastern half)
Casey Jones State Trail
Luce Line State Trail (western third)
Glacial Lakes State Trail
Willard Munger State Trail (southern portion)

Canoeing/boating routes that cross prairie, brush prairie or oak savanna landscapes in Southern Minnesota include (see Figure 3, page 4):

Straight River
Cannon River (westernmost section)
Watonwan River
Des Moines River
Cottonwood River
Minnesota River (western two-thirds)
Chippewa River
Pomme de Terre River
North Fork Crow River
Rum River
Mississippi River (central portion)

Minnesota State Trails

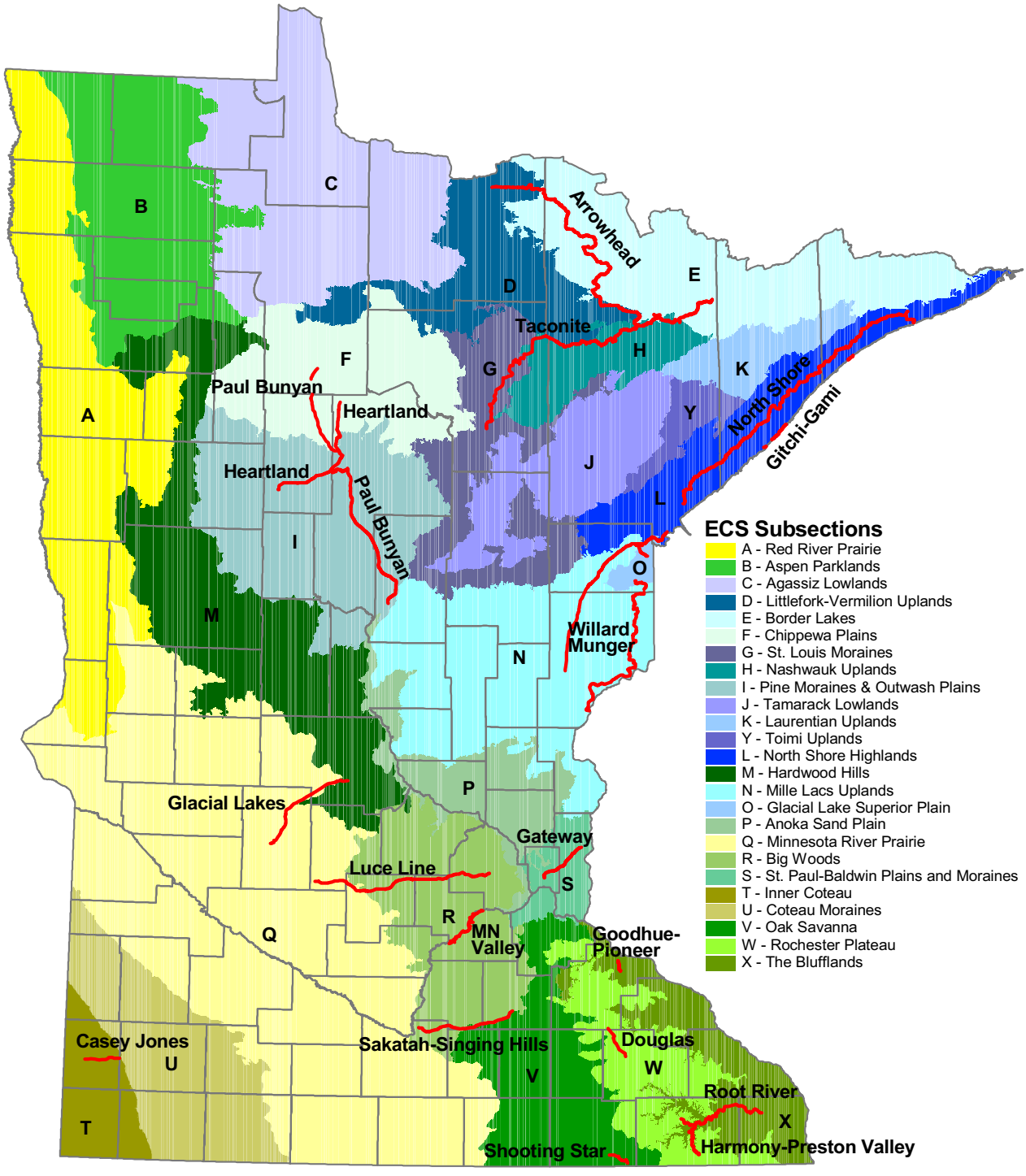


Figure 2: Minnesota state trails

Minnesota Canoeing/Boating Routes

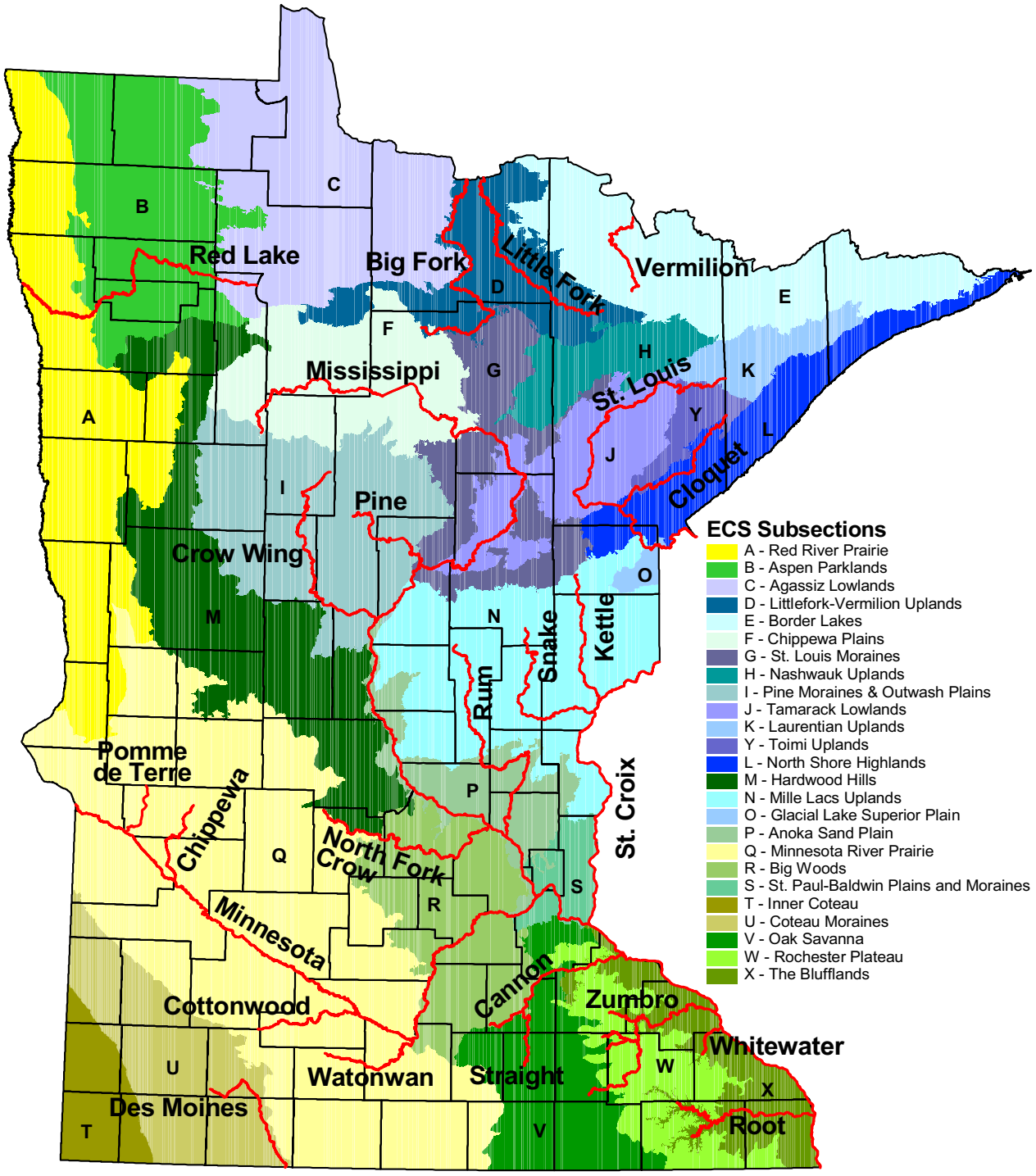


Figure 3: Minnesota canoeing/boating routes

Guiding Principle

To enhance the ecological quality of state trails,
canoeing and boating routes, and water access sites,
thereby increasing the quality of the recreational experience
and fostering user awareness and appreciation.

This principle can be achieved by:

- ❒ **Managing intact prairie remnants and restoring degraded prairie remnants,** striving to achieve connectivity through management.
- ❒ **Re-establishing native grasses and forbs** where appropriate.
- ❒ **Keeping construction disturbance to a minimum**.
- ❒ **Reseeding and replanting construction disturbance** with locally native plants.
- ❒ **Interpreting plant communities** and associated management and restoration activities.

Unlike books, which divulge their meaning only when you dig for it, the prairie plants yearly repeat their story, in technicolor, from the first pale blooms of pasque in April to the wine-red plumes of bluestem in the fall.

Aldo Leopold
from his essay
"Roadside Prairies"

Assessing Site-Specific Needs: Management, Restoration or Re-establishment?

When is management of a community sufficient? When is restoration the preferred approach? When is re-establishment needed?

Management means taking care of what's already there: encouraging and improving the continued growth and enhancement of natural communities already in place at a particular site. Management can also be considered a form of restoration—trying to improve a site ecologically.

Restoration represents a more intensive effort. It is a process of returning a degraded natural community to its original structure and species composition.

Areas in need of restoration usually offer the "basic ingredients" necessary to represent a natural community, but the quality of the overall community is less than what it should be. Restoration efforts

focus on enhancing what's already there, to improve the overall quality and long-term viability of the natural community.

Restoration can be thought of as nursing biodiversity back to health through such activities as burning, exotic species control, interseeding and interplanting.

Re-establishment represents the most intensive effort but is probably the least understood at this time. It is about attempting to re-establish a natural plant community that once existed in a specific location. This process is a beginning that gives us the opportunity to gain greater knowledge of the complexity of natural systems while actively participating in helping to heal the land, which is a satisfying activity in itself. DNR ecologists and resource managers can help identify a target community in a chosen location.

Things To Remember

✔ Conduct a comprehensive site analysis.

✔ Select a target community.

✔ Monitor management activities and evaluate outcomes.

Conducting a Comprehensive Site Analysis

A comprehensive site analysis is the first step in prescribing management activities for a particular site. It should include the following steps:

❒ Learn about the biological history of the site.

• Refer to *The Natural Vegetation of Minnesota at the Time of the Public Land Survey: 1847-1907.*

• Consult Minnesota County Biological Survey (MCBS) maps and descriptions.

❒ Survey and evaluate existing vegetation on the site.

• Consult *Minnesota's Native Plant Communities Classifiction, Version 2.0*

• Consult the *Field Guide to the Native Plant Communities of Minnesota 2004-2006*

• Solicit help from a botanist or ecologist, or learn to identify plants.

❒ Determine whether any listed plant or animal species are present.

• Check the Minnesota listing.

• Solicit help from an ecologist.

❒ **Analyze soil types and characteristics.**

• Refer to *Soil Surveys by County: NRCS in Cooperation with Minnesota Agricultural Experiment Station,* from the U.S. Department of Agriculture.

• Conduct a soil sampling onsite.

• Determine soil compaction or disturbance.

• Determine content of organic matter and nutrient levels.

• Determine pH factor.

❒ **Determine soil moisture** gauged on a gradient from dry to mesic to wet.

• Determine drainage patterns. For example, sandy soils and hilltops are dry, and depressions and clay soils hold water and therefore are more moist.

❒ **Consider topographic features,** such as slope and aspect.

• Determine whether the site is hilly or level; identify degree of exposure to the sun (south, north, east or west).

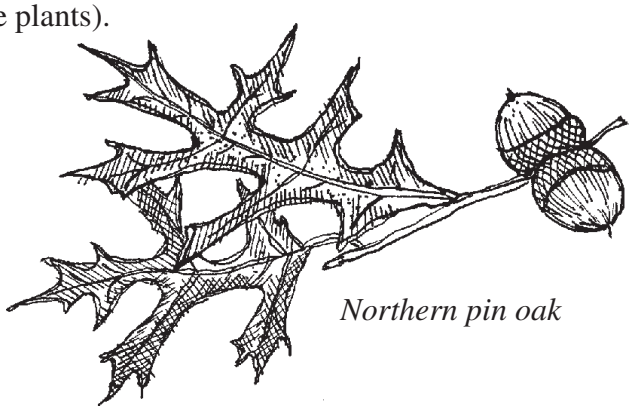
❒ **Consider the microclimatic conditions** of the site, within the regional context.

❒ **Select the appropriate plant species** according to site conditions and the specific landscape unit.

• Consult *Vascular Plants of Minnesota,* by G.B. Ownbey and T. Morley (1991).

• Consult the County Biological Survey database.

• Consult *Restore Your Shore* CD ROM (includes an encyclopedia of native plants).



Northern pin oak

Successional Stages Then and Now

Natural succession in a pre-settlement era prairie was a dynamic process whereby one group of plant species was replaced by another over time. Prairies at that time were often manipulated by Native Americans, using fire as a management tool.

Succession was an ongoing process. Prairie animals' activities—such as bison wallows, gopher mounds and badger diggings—would always create new areas of open ground, which were colonized by short-lived native species, such as horseweed, fleabane daisy and evening primrose, which would quickly stabilize the soil.

These species would be replaced by early prairie plants, such as black-eyed susan, grey-headed coneflower and wild bergamot. Eventually, legumes and other conservative species would move in.

This constant continuum existed along a gradient of disturbance, with short-lived pioneer species at one end and conservative long-lived species at the other end. This rich diversity of plants would assure the availability of seeds. This sequence repeated itself as long as fires occurred and seeds were available. In the absence of fire, the successional sequence would continue and grow into brushy prairie and, eventually, into oakwoods.

Today, natural succession has been profoundly affected. Exotic species (both herbaceous and woody), the amount of disturbed ground associated with agriculture and development, and the lack of fire have greatly reduced native seed sources. Native prairies have been reduced to remnants and are often islands surrounded by disturbed ground.

If not intercepted by management, a common successional sequence on abandoned farmfields and overgrazed pastures starts with exotic weeds, which are followed by long-lived perennial exotics, such as spotted knapweed, sweet clovers, leafy spurge, smooth brome, reed canary and weedy natives mixed with exotic and native invasive trees and shrubs.

Adapted from *Tall Grass Restoration Handbook,* Chapter 1: Orchards of Oak and a Sea of Grass, by Virginia Kline. Island Press, Washington, D.C., 1997.

Northern dropseed
Drawing by Tom Klein

FOCUS ON MANAGEMENT: Tools and Approaches for Managing Remnant Prairies and Savannas

While fire is considered to be the superior management tool for prairie remnants, mowing and raking is also an option. Both approaches control the invasion of woody vegetation and may also aid in the control of exotic plants, which is critical to the management of remnant native communities.

Removing decaying plant material through burning or mowing depletes nitrogen. Prairie communities are more stable in nitrogen-poor environments, due to less competition from exotic plants. Many exotic plants grow more vigorously in environments rich in nitrogen, such as fertilized areas, and in areas with fast-decomposing plant material.

The Significance of Small Remnant Communities Along Rail Trails

Remnant prairie and savanna communities still occur along state trails located on former railroad rights-of-way, especially in the southern and western parts of the state. In the north-central part of the state, pine barren communities may predominate.

These existing remnants, once part of an originally larger area, often persisted because of their location. During the railroad era, sparks from trains frequently ignited adjacent vegetation. Because these fires in some cases suppressed the invasion of woody vegetation, shade did not develop, and prairie grasses and forbs persisted.

When these rights-of-way were converted to trails, fires no longer occurred on these remnants. As a result, brushland and woodlands of exotic or invasive species developed over the years, creating a tunnel of woody vegetation along many trails.

Managing these prairie remnants with occasional prescribed fire will not only enhance the ecological quality of the remnant but also enrich user experience by providing visual diversity.

In the future, these remnants may serve as models for potential restoration efforts along trails and on adjacent land.

Fire as a Management Tool

Plan to burn unless it is not feasible to do so. Because prairies are fire-dependent ecological communities, prescribed burns are an important management tool.

Prairies are positively affected by periodic fire in many ways. For example:

Prairies are positively affected by periodic fire in many ways. Plants grow more vigorously, the growing season is extended, warmer soil favors prairie plants, fire controls invading trees and shrubs, and fire removes thatch.

❒ Following a burn, plants grow more vigorously and produce more flowers and seed.

❒ The growing season is extended, because the blackened soil warms sooner in the spring.

❒ Warmer soil also favors prairie plants over cool-season invasive weeds.

❒ Fire controls invading trees and shrubs.

❒ Fire removes thatch, benefiting plants and animals that require an open environment.

Timing for Prescribed Burns

Spring vs. fall

❒ **Burning in mid-spring** exposes black soil to the spring sun, acceler-ating the warming of the soil and boosting the growth of both warm- season plants and cool-season natives, like June grass. However, spring burning also favors cool-season exotics, like smooth brome grass.

❒ **Burning in the fall or late spring helps** to control woody plant invasion:

• Brush suffers greatly when burned after bud break in the spring or before it has sent food stores to root for the dormant season.

• Fire also stimulates prairie plants to form a dense sod, making it more difficult for woody plants to establish.

• Fire kills the above-ground parts of invading trees and shrubs. Deciduous trees and shrubs will resprout from the roots and will probably never be completely eliminated, ready to come back in the absence of a periodic fire.

❒ **Fall fires are more difficult to implement,** because vegetation may be too moist and air temperatures are cooler to fuel a hot fire.

❒ **Fall burns destroy potential winter cover** and food for wildlife.

Burning in rotation (spring and fall)

Plan to divide larger sites into two or three management units. One of the units is burned in rotation each year, leaving other units unaffected in "off years." Burning in rotation will:

❒ Preserve insect populations, such as overwintering butterfly chrysalises.

❒ Provide winter cover and food for wildlife.

❒ Create constantly changing patterns of vegetation, which will enhance ecological diversity and aesthetic appeal.

Frequency of Burning

Burning too frequently may increase the dominance of prairie grasses to the detriment of forbs, and frequent burning may also favor certain exotics:

❒ Burning once every 3-5 years is sufficient in most cases.

❒ For dry prairies that produce less plant material, burning in 7-year to 9-year intervals will be more successful.

Planning and Implementing a Prescribed Burn: Procedures and Guidelines

(Minnesota DNR Operational Order # 47)

www.dnrnet.state.mn.us/forms/
Forestry #NA-01990-03, available in PDF and WPD format

❒ Determine the management objective for the site.

❒ Mow firebreaks, and cut large shrubs and trees ahead of time.

❒ Prepare a burn plan (consult a regional burn boss and Operational Order #47), including a site map. (Aerial photos work well.)

❒ Identify a range of dates/hours for the burn.

❒ Secure all needed permits from local fire departments

and DNR Forestry.

❒ Alert and invite local fire departments as backup.

❒ Inform adjacent landowners and the general public.

Black-eyed Susan

Mowing as a Management Tool

Mowing is almost as effective as burning; in fact, for smaller areas, mowing to a minimum height of 6 inches and raking off the mowed material is a good substitute for burning. Mowing also removes the previous year's vegetation, and mowing in spring sets back cool-season plants.

Caution: Mowing after new growth has reached about 1 foot in height is undesirable. It may damage some of the prairie species, and it may destroy wildlife broods.

FOCUS ON RESTORATION: Approaches To Restoring "Old Fields"

"Old fields" are areas that share three common characteristics:

- ❒ They were once pastured intensively.
- ❒ They have not been used for agricultural purposes over an extended period of time.
- ❒ They are in some form of early succession.

❒ **Upland sites are often dominated** by exotic species, such as Kentucky bluegrass, timothy, smooth brome, and clovers, as well as some early succession prairie species, such as black-eyed Susan, evening primrose, various goldenrods, and asters.

❒ **Wet sites may be infested** by purple loosestrife and reed canary grass, which need to be eradicated before any restoration attempts are made.

Studying the Restoration Site

Careful study of each restoration site must include analyzing the soil, learning about the vegetation history of the site, and gaining an understanding of the larger landscape unit. (See also "Conducting a Comprehensive Site Analysis," page 6.) This information will then guide the identification of one or several target communities for a specific site, assuring more conservative use of costly seed.

Preliminary Burning or Mowing

One mowing or burning may be sufficient to open up the thatch enough to interseed with native seed gathered from nearby sites.

Another strategy sometimes used by restorationists is to conduct several late-spring burns to break down dense exotic grass turf, and then observe whether suppressed prairie plants emerge on their own. Instead of burning an entire site, several test patches could be burned and observed.

New England aster

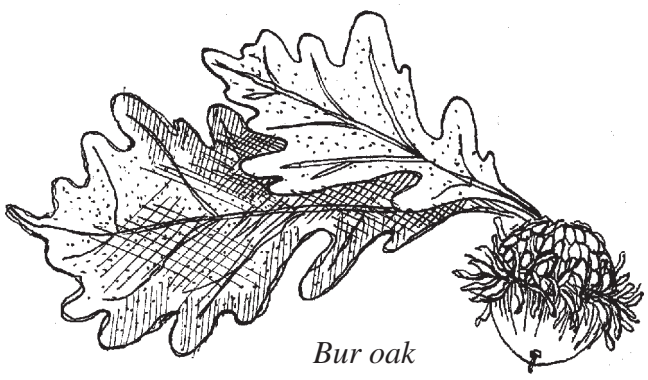
Interseeding

A combination of burning or mowing and interseeding with native grasses and forbs, preferably from nearby prairies, may be a good way to improve these impoverished sites. Interseeding is also a good approach when dealing with erosion-prone slopes or oak savannas, where cultivating might destroy any native plants already there and disturb the roots of trees.

❒ **Incorporate seeds into the soil** by hand-raking on small sites, and by harrowing, disking or drilling on larger sites.

❒ **Most seeds need to be covered with soil** in order to germinate. A seed should be covered with soil equal to twice the thickness of the seed itself. Very small seeds that need light to germinate are seeded on top and are not covered with soil. Packing the soil as a last step will assure good seed-to-soil contact.

❒ **A preferred seeding method** is to burn a site in late fall, then broadcast seed before winter sets in, or in late winter when there is less than one foot of snow on the ground. The seeds then go through their natural cycle, while rain, snow, freezing and thawing assure that seeds have the needed contact with the soil.



Bur oak

FOCUS ON RE-ESTABLISHMENT: Seeding Native Grasses and Forbs

A prairie community is a very complex natural ecosystem that cannot be duplicated. The best we can do is to try to imitate a native prairie. By using nature as a model, re-establishment techniques can result in the creation of natural-appearing grasslands.

Visit local prairie remnants and observe what they look like. Then carefully study your site and seek to imitate the composition of local remnants with similar site conditions before seeding your site.

Things To Remember

✔ Study the ecological behavior of species by visiting and observing natural remnant prairies and savannas.

✔ Avoid wasting precious seed by fine-tuning a planting to the greatest extent possible.

New Jersey tea

Basic Considerations for Seed Mix Design

❒ **Specify a seeding rate** of 8-10 lbs per acre if drill seeding a site, or 10-12 lbs per acre if broadcasting seeds on a site when obtaining seed from a commercial vendor.

❒ **The seeding rate should be tripled** when seeding rough-cleaned seed collected from the wild. (Seed suppliers who are familiar with the properties of various seeds can help determine the optimum amount of seed needed for each species.)

❒ **Consider the seed count of individual species** when designing the seed mix.

❒ **Balance the use of grasses and forbs** in a ratio of 70% grasses to 30% forbs, or a ratio of 60% grasses to 40% forbs.

❒ **Use as many species as you can afford** for a more diverse prairie later on.

❒ **A prescribed seed mix** should have a minimum of 3-5 species of grasses and 18-24 species of forbs initially. Diversity may be increased a few years later by interseeding those species that do not grow well in an open seedbed.

❒ **Select species from various successional stages,** including early succession species (such as black-eyed Susans, wild bergamot and blue vervain) and slow-to-establish, long-lived species (such as downy phlox, leadplant, gentians, New Jersey tea and compassplant).

❒ **Keep in mind that early succession species,** such as black-eyed Susan, Canada wild rye and purple coneflower, will not have staying power and will diminish as the planting matures.

❒ **Use cordgrass and switchgrass conservatively.** Both grasses can dominate a planting.

❒ **Big bluestem also has a tendency to dominate** a planting in heavy soils.

❒ **Use aggressive clonal or rhizomatous and allelopathic species conservatively,** such as goldenrods, bergamots, whorled milkweed and certain sunflowers.

❒ **Design several seed mixes** for a site that has varied soil moisture conditions due to topography and aspect.

❒ **Select appropriate plant species** according to the specific landscape region. Consult *Vascular Plants of Minnesota,* by G.B. Ownbey and T. Morley (1991), or the County Biological Survey database.

Guidelines for Designed Plantings on Small Sites Using Transplants

Trail rest areas, water access sites and other highly visible small sites should be landscaped with a focus on using native plants after construction is completed.

It is important to work with local communities, garden clubs and user groups to gauge public acceptance and appreciation for natural landscaping practices. It is also important to secure funding or volunteer help for maintenance over several seasons, to help assure that the planting will be successful.

The following general guidelines will help direct the outcome of a designed planting:

❒ **Choose a site with maximum sun exposure** and little competition from trees with high surface root density, such as elm, basswood and maple.

❒ **Enhance plantings** in the southern part of the state with oaks, and in the northern part of the state with pine, both of which will convey a savanna-like character.

❒ **Consider the following when designing a small planting:**

- Individual plant characteristics
- Plant requirements for optimum growth
- Composition in regard to ecological behavior, color, texture and seasonal appearance
- Visiting local natural plant communities

❒ **Plan initial plantings without aggressively spreading plants,** such as switchgrass, prairie coreopsis, roses, sunflowers and certain goldenrods. Some of these species may be added later, after the planting has established.

❒ **Balance the use of grasses and forbs.** When grasses and forbs are alternated every square foot, the grasses will eventually fill in and produce a more natural pattern. A ratio of 70% grasses to 30% forbs (or a ratio of 60% grasses to 40% forbs) is desirable, especially on sites that are in close-up view to recreational users.

(Guidelines continued on page 16)

For instance, on small dry to mesic sites, use finely textured shorter grasses, such as June grass, little bluestem, sideoats grama and dropseed. Select relatively short forbs, such as prairie smoke, prairie onion, pasqueflower, butterfly weed, purple prairie clover, short asters, dotted blazing star and grey goldenrod, to complement the grasses. The variety of contrasting textures—fine versus coarse—adds depth to a planting.

❒ **Plan the composition of flowers with color in mind**, as can be observed quite readily in nature. Flowers blooming at the same time in a given natural setting display beautiful color combinations and proportions. Because nature's colors are seasonal, use a variety of species for color throughout the seasons, while still aiming for a functional native plant assembly.

❒ **Consider height**. Height of forbs generally increases as the seasons progress. Fall blooming forbs will be taller than those blooming in the spring, because they are competing for light with the warm-season grasses.

❒ **Pay attention to how flowers naturally occur.** Some grow in concentrations of one species or in drifts, while others grow as isolated individuals.

❒ **Use one plant per square foot as a general guideline**. Over the years, grasses will use more space, becoming bigger clumps, while forbs will add only a few stalks each year. As grasses fill in, the planting will achieve a more natural look.

❒ **Use one-year-old plants** to help the planting fill in more quickly. Hand weeding will be needed.

Transplants or Seeds?

Depending on the size of a site, the need for accelerated results for public acceptance, and the budget available, natural-looking plantings can be created with the use of either transplants or seeds. Some factors to take into consideration:

❒ **A planted site will take 2 years, a seeded site 3 years** before native plants have filled in and the site becomes relatively weed free.

❒ **More hand-weeding may be required** with transplants initially.

❒ **Seeded sites should be kept mowed to 6-8 inches** above ground and before weed seeds form in the first 2 years after seeding.

❒ **Hand-weeding on seeded sites is not recommended** in the first 2 seasons. Native seedlings are very small then, and too many would be pulled out with the weeds.

Site Preparation Methods

Preparing for new seeding can require up to a full growing season on difficult, weed-infested sites. Thoroughness and patience are essential for later success. Site preparation can be done in several different ways; some include the use of herbicides, while others do not.

Tall sunflower

Thorough site preparation is the single most important factor for a successful planting later on.

Site Preparation Using Herbicides

❒ **The use of a short-duration glyphosate herbicide (like Round-up)** is one way to prepare a site for planting:

• Mow or burn in early spring to remove the previous year's plant material and encourage new growth.

• Apply glyphosate herbicide onto this new growth: once in mid-spring, again in mid-summer, and again in early fall (unless no plant growth is visible one month after the second spraying). This schedule attacks different weeds whose growths peak at different times.

• To prepare for seeding, tilling or disking should be shallow (tilling deep will bring up more weed seeds).

• Seed immediately. If seeding is delayed to the following spring, seed a cover crop, such as winter wheat or annual rye, if there is a potential for erosion. Conduct a shallow cultivation in the spring to eliminate the cover crop and freshly germinated weeds.

Site Peparation Without Using Herbicides

❒ **Cultivation is another form of seed bed preparation:**

• Begin cultivation in spring and continue through fall, every 2 to 3 weeks at a depth of 4-5 inches. Waiting longer than 2 or 3 weeks between cultivating allows perennial weeds that grow through rhizomes (like quackgrass) to recover and increase in density.

• To prepare for seeding, loosen heavy soil to a depth of 1-2 inches. On sandy soil, a surface scraping or scratching will suffice.

• Seed immediately. If planting is done the following spring, seed a cover crop over winter.

• On small sites, a rototiller can be used instead of a cultivator. Use the rototiller to break the soil into small chunks, making two passes at right angles. Rake by hand to create a smooth seedbed.

❒ **On small sites, using plastic or heavy mulch is an effective method to eliminate existing vegetation:**

• Cover the soil with heavy black plastic, old carpet, tarps or other opaque material, or a thick layer of leaves and burlap for an entire growing season.

• Make sure to secure the cover well, because it needs to stay in place for the entire growing season in order to kill weeds and seeds near the soil surface.

• Don't cultivate or till deeper than 1-2 inches with this method, to avoid bringing up weed seeds that will grow and compete with the prairie plants.

• If a site contains sandy or gravelly soils that do not promote heavy weed growth, several diskings prior to sowing seed may be the only cultivation needed.

❒ **To replace a lawn area with a native seeding,** simply remove the top three inches of sod with a sod-cutter. This usually creates a nearly weed-free seeding site. Keep in mind, though, that this area will be lower than the surrounding lawn. If you bring in extra topsoil, a sandy loam is best. Avoid peat, clay or heavy loam-based soil, and make sure it isn't contaminated with weed seeds.

Taking Precautions on Erosion-Prone Sites

❒ Avoid cultivation of slopes.

❒ Plant or seed immediately following soil preparation.

❒ Install a wood fiber blanket or straw blanket on slopes steeper than 3:1.

Do's and Don'ts for Soil Improvement

What to do

❒ **Add large quantities of organic matter**, like decomposed leaves, especially on sandy or clay soils.

❒ **Improve poor soils by planting a "green manure crop,"** such as buckwheat, winter wheat or legumes, as a pre-treatment in the season prior to seeding. Cut before the plants form seeds. These plants bring up nutrients and convert them to organic matter. The organic matter is then tilled in, incorporating roots and leaves into the soil. This is a relatively cheap, ecologically sound way to build up organic matter in the soil.

❒ **Be aware of herbicide residue in the soil** if the land has been in row crop production for many years. It may be advisable to plant green manure crops for a few years to detoxify the soil before attempting to seed to natives.

What not to do

❒ **Do not use fertilizer or bring in topsoil** to "improve" existing soils on a site. Imported soil may carry undesirable weed seeds.

❒ **Avoid manure,** as it contains large quantities of weed seeds.

❒ **Avoid using sawdust and woodchips,** since they require a long time to break down, and they rob the soil of nitrogen. Recognize that organic matter holds more nutrients and greatly helps to break up heavy soils and firm light soil. As the water-holding capacity of the soil improves, seedlings receive the moisture needed to develop strong roots.

Temporary Cover Crops

Temporary cover crops are primarily used on sites that are erosion prone and cannot be permanently seeded immediately, to help keep the soil in place until the native seed can be installed.

❒ **Loosen the topsoil** of the site to a minimum depth of 3 inches. Choice of seeds depends on the season the temporary cover crop is installed:

- May to early September: Apply annual rye at 35 lbs/acre.
- May to early September: Apply oats at 90 lbs/acre.
- October to mid-November: Apply winter wheat at 90 lbs/acre.

❒ **Install seeds** with a standard grain drill, or broadcast them.

❒ **Harrow or rake** after seeding.

❒ **Mulch or disc-anchor** the site. Use prairie hay or clean straw for mulch material. Certified weed-free mulch is available from some growers of native plants.

❒ **Install native seed mixture in the fall or spring** by lightly disking and then seeding with a broadcast seeder, or drill seeder.

When To Seed

Spring or fall seedings are appropriate. Both times have advantages and disadvantages.

Considerations for Spring Seeding

❒ **Best results occur when seeding in late spring to early summer**, from May 1 to July 10 (especially on clay soils).

❒ **Most prairie grasses and forbs are "warm season" plants,** which require warm soil temperatures for germination and growth.

❒ **Seeding in late spring increases the chance of sufficient rainfall** and also means less competition. Because cool-season exotics and weeds germinate 4 to 6 weeks earlier, they would have been eliminated by herbicide treatment or cultivation before a late-spring seeding.

❒ **Forb seed must be moist stratified** (see seed treatment) for optimum germination.

Considerations for Fall/Winter Seeding

❒ **Mimics the natural cycles of nature.** Seeding should occur in the Upper Midwest from early October to freeze-up, when temperatures are consistently cool, or in late winter, like March, in calm weather when temperatures are around 25-35 degrees and there is less than one foot of snow.

❒ **Generally results in better germination** and more rapid establishment of forbs.

❒ **Allows seeds to germinate on their own schedule** in the spring, when temperature and moisture conditions are optimum.

❒ **The natural "wintering over" helps break down germination inhibitors** associated with the seeds of many native plants.

❒ **Early mowing in the spring** is especially important to help control cool-season weeds.

❒ **Should never be attempted on sites subject to soil erosion** without sufficient cover crop or erosion control blankets. Runoff from snowmelt or heavy rains can wipe out a seeding.

❒ **Can be done from late October to late March.** Especially good for interseeding forbs into a grass stand and augmenting a prairie remnant.

❒ **Seed is hand or machine sown;** freezing and thawing will mix the seed with the soil.

❒ **Considered to be a good method for adding new species to an established planting**, or for reseeding gopher mounds or other bare spots.

❒ **Advantageous on wetland sites with soils high in organic content**. A wetland site is much more accessible in the winter, when the ground is frozen. The best conditions would be minimal snow cover, low water levels, with temperatures around 25 to 35 degrees.

Northern dropseed

❒ **Areas to be seeded in the winter should be burned or mowed in the fall** to remove old vegetation exposing bare ground that promotes seed/soil contact during the freeze and thaw cycle.

❒ **In early spring, when new growth is about 3 tO 4 inches high,** consisting primarily of cool season exotics, one timely application of glyphosate will eliminate unwanted plants. Native plants will not have germinated at that time.

Seed Treatment

When purchasing seeds from a vendor, be sure that the following processes have been incorporated into the vendor's seed treatment regime. If collecting your own seeds, be sure that these processes are appropriately incorporated into your own seed treatment.

The seeds of many native plants have a built-in dormancy mechanism, which protects them from germinating before a killing frost or in times of drought. In the wild, seeds lie dormant until proper conditions for growth occur, which sometimes takes several years. In cultivation, pre-sowing treatment methods unlock the dormancy mechanism and stimulate quicker and better germination.

The following treatment steps are a requirement of all suppliers of native seed.

Dry Stratification

Prairie grasses need "dry stratification," meaning that seeds have to be exposed to cold, dry conditions for 1 month or longer. For this reason, seeds should always be stored in a cold, dry place over winter.

Moist Stratification

Most wildflower and sedge seeds that are to be seeded in the spring germinate better when "moist stratified." Moist stratification mimics the conditions of freeze and thaw that seeds would naturally encounter in the soil over winter.

Pre-inoculation

All native legumes (such as clovers and beans) should be pre-inoculated with rhizobium, nitrogen-fixing bacteria that form nodules on the roots of these plants, especially when seeding into degraded soils. The inoculum improves their ability to "fix" atmospheric nitrogen, thus improving soil fertility.

De-bearding

All seed containing extensive hair or awns, such as Canada wild rye, should be de-bearded.

For more detail on seed processing, see "Processing Seed," page 33.

Seed Quality

If seed is purchased from a vendor, they must meet requirements for origin, purity and germination:

❒ **All bags of seeds must be labeled** with the mixture number and the vendor from whom it was purchased.

❒ **The level of quality is determined** by pure live seed (PLS)value. It is important to know PLS values for each annual harvest Seed of each species is tested for its purity and germination poten tial.

❒ **Purchased seed must be from the previous two growing seasons.** Tests for germination and/or viability must be current (conducted within 9 months of the date of installation).

❒ **All grass and forb seed must be wild type and must originate** from within 100 miles north or south of a site—or within 200 miles east or west of a site to maintain the local gene pool; the closer the seed source, the better.

Wild-type is defined as seed that is derived directly from native wild stock, including seed that was collected and put into production. Therefore, wild-type seeds must be of regional/local ecotype and not have undergone a selection process.

Nurse Crops

Protecting Seedlings and Helping Us Gauge Their Growth

A nurse crop or cover crop consists of an annual grass that is seeded together with the native seed mix. The nurse crop germinates quickly, shelters young prairie plants from adverse conditions, and takes the place of weeds.

Sideoats grama
Drawing by Tom Klein

Nurse crops, such as annual rye, oats, winter wheat and Regreen (a sterile grass), help suppress weed growth and hold the soil in place without harming or competing with the much smaller native seedlings. Nurse crops occupy the "ecological niche" that would otherwise be taken up by annual weeds, thus reducing the growth of undesirable weeds in the first year of a seeding.

Native plants expend most energy in their root growth the first 2 years; as a result, above-soil growth is minimal when compared to the nurse crop. If the nurse crop has germinated and is growing well, it is an indication that the native seeds are also germinating well, even if they cannot be identified easily.

❒ **Request certified nurse crop seed only;** otherwise, feed quality seed might be supplied, which could be full of weed seeds.

❒ **Do not use agricultural rye as a nurse crop.** Studies have shown that grain rye is allelopathic (its roots release a toxin that suppresses the growth of other plants in its immediate environment).

Seeding Rates for Nurse Crops

Nurse Crop	Seeding Rate	Seeding Season
Annual rye	5 lbs/acre (7-8 lbs on slopes)	May to mid-July
Oats	20 lbs/acre	May to mid-July
Winter wheat	20 lbs/acre	October to mid-November
Regreen	10 lbs/acre	October to mid-November, May to mid-July

Gray-headed coneflower

Seeding Methods

The size and makeup of the individual site, as well as the availability of the appropriate machinery, will determine the seeding method to be used.

Broadcast Seeding by Hand

Broadcast seeding by hand is usually done on areas smaller than one acre or on those located on slopes that are inaccessible by a mechanical seeder. Broadcast seeding creates no row effect, resulting in a more natural-looking seeding. (seeding rate see page 14)

Broadcast seeding into bare soil

The following guidelines apply:

❒ Loosen topsoil to a depth of 3 inches.

❒ Mix seeds with slightly dampened filler, such as sawdust, peat moss or vermiculite, to get a more even rate of seeds on the ground.

❒ Divide the seeds and spread the first half of the mixture.

❒ Then take the second half and spread it over the same area, walking perpendicular to your first pass.

❒ Seed the nurse crop.

❒ Rake or drag the area slightly, so that seeds are covered with soil equal to twice the thickness of the seed itself.

❒ Very small seeds that need light to germinate should be seeded on top and should not be covered with soil.

❒ Pack the site to ensure good seed-to-soil contact.

❒ Do not attempt broadcast seeding when the weather is hot and dry, or when soil moisture is low.

Broadcast seeding into existing cover crop

Sites that are subject to erosion and ready to plant in mid-summer to late summer should be seeded immediately to a cover crop, with the native seeding following in the fall:

❒ After the area is prepared for seeding, sow oats as cover crop, using 90 lbs/acre. Frost will kill oats in the fall before they set seed.

❒ Broadcast seed into standing dead oats in late October. Do not rake or drag into the soil.

❒ Frost action will work the seed into soil surface, and dead oats will mat down over the winter to provide good conditions for spring germination, while at the same time preventing soil erosion.

Machine Seeding

The following guidelines apply to machine seeding:
(seeding rate see page 14)

❒ Mechanical seeders are used for larger areas. A drill seeder or a broadcast seeder is the best equipment for native seed mixes.

❒ The seeder must contain at least two seed boxes: a fine seed box and a box for large/fluffy seeds.

❒ Set maximum row spacing for drill seeding at 8 inches. Set planting depth for large fluffy seeds at 1/4 inch.

❒ Most seeders have the ability to compact the soil directly over the seeds.

❒ Drill rows must follow the contour lines of the site.

❒ Nurse crop seeds are mixed with native seeds in the fluffy seed box prior to seeding.

❒ Soil must be packed to assure good seed-to-soil contact for small seeds on the surface.

Broadcast seeding into tilled sites

This method is the most common for spring and fall seedings on large bare-soil sites:

❒ Loosen the topsoil to a minimum depth of 3 inches.

❒ Install seed with a Truax Trillion Broadcast Seeder or equivalent.

❒ Very small seeds that need light to germinate should be seeded on top and should not be covered with soil.

❒ After seeding, pack the site to ensure good seed-to-soil contact.

❒ Mulch the site with clean straw or hay and disc-anchor.

❒ Apply straw or fiber blanket on erosion-prone sites.

Drill seeding into temporary cover crop

This method requires two separate seeding operations:

❒ The first seed in (the temporary cover crop) occurs at a time of year that is not optimal for installing native seeds. (See "Temporary Cover Crops," page 19.)

❒ The second operation (installing the native seed) occurs at a later date, either through inter-seeding with an inter-seeder type drill (Truax Flex II or equivalent) or by lightly disking the cover crop andthen seeding with a brodcast seeder.

An inter-seeder drill is outfitted with trash rippers, which cut through the vegetative mat to make a furrow in the underlying soil. Pack the site to ensure a firm seed bed. Mulching is not necessary, since the cover crop can serve as mulch in both instances.

Drill seeding into existing vegetation

With this method, existing vegetation is cut and, after a flush of new growth, treated with one glyphosate herbicide application. This method is commonly used on old pastures, slopes and degraded savannas, where tilling could cause erosion or damage existing root structures.

The following methods prepare for a winter (dormant) or spring seeding:

❒ Prepare a grassy site by mowing existing vegetation to a height of 6 inches.

❒ Allow the grass to re-grow for 1 to 3 weeks before applying glyphosate herbicide.

❒ Burn off existing dead material before seeding to avoid clogging the drillseeder.

❒ Seeding may occur 5 days after herbicide application.

❒ Use an inter-seeder drill (Truax Flex II or equivalent) outfitted with trash rippers, which cuts through the vegetative mat to make a furrow in the underlying soil.

❒ Very small seeds that need light to germinate should be seeded on top and should not be covered with soil.

❒ After seeding, pack the site to ensure good seed-to-soil contact.

Butterfly weed

More extensive preparation is required for sites containing large numbers of exotic weeds, such as Canada thistle, exotic legumes or spotted knapweed:

❒ Start site preparation in mid-spring by mowing previous year's vegetation.

❒ After new growth appears, apply glyphosate herbicide.

❒ Repeat above process two more times in mid-summer and early fall.

❒ Prepare seedbed for fall seeding.

Hydroseeding

Hydroseeding is an accepted method for native seeds, but it should only be used on steep slopes or areas otherwise inaccessible to a seed drill:

❒ Seeding should be done when the extended weather pattern will provide sufficient moisture.

❒ Prepare site by loosening the top 3 inches of soil, leaving a rough surface with many spaces and cracks for seeds to lie in.

❒ Seeding rates should be the same as for broadcast seeding.

❒ Apply the seed-water mixture within 1 hour of mixing.

❒ Harrow or rake the site after spraying the seed-water mixture to ensure good seed-to-soil contact.

❒ Then make a second application consisting of mulch only.

Watering, Mulching and Erosion Control

❒ Fall seedings do not need to be watered.

❒ If conditions are very dry, spring and summer seeded sites need to be watered.

❒ Be sure to provide regular watering until seeds have germinated (about 3-4 weeks), especially seeds that have been "moist stratified"; otherwise, they may go into dormancy or die in the dry soil.

❒ Water in early morning, which is best and most efficient, because evaporation is much higher during the day.

❒ Avoid watering in the late afternoon and evening, which encourages high moisture levels at the soil surface, promoting seedling loss due to fungal attacks.

❒ Mulch with a light covering of prairie hay or clean straw to help hold moisture in the soil, especially on dry sandy soils and heavy clay soils.

❒ Use chopped material and disc-anchor it, so that it will be less likely to be blown away by the wind.

❒ On slopes steeper than 3:1, install a straw or wood fiber blanket. Strive for 90% coverage of exposed soil. Mulching will slow the erosive action of heavy rains until the plants have established.

Evaluation and Management

Evaluating Re-establishment Efforts

Year 1

❒ The nurse crop should be visible within 2 weeks of installation.

❒ Native grasses and flowers will be small but visible by the end of the growing season. (Native plants will concentrate their energy on root establishment during the first 2 years.)

Year 2

❒ Approximately 5% of the grasses will flower and set seeds by the end of the second year.

❒ Residual seeds from the first season will germinate. Some early successional forbs, such as black-eyed Susan, wild bergamot and some asters, will flower.

Year 3

❒ Most grasses and many forbs will be blooming.

❒ Overall, the diversity of plants will be increasing.

Ongoing Management of Re-establishment Efforts

First growing season

❒ Mowing is the primary management tool for the first year. The site should be mowed as needed to control weeds going to seed. Mowing should take place with a flail mower when growth reaches about 16-18 inches. Cutting height should be set in a way that basal leaves of forbs are not damaged. Native seedlings should not be shaded out, and undesirable weeds should not overtake seedlings. Mow more often if foxtail is abundant.

❒ A vigorous nurse crop may reduce or eliminate the need for cutting weeds.

Beebalm

❒ Some growth should be left to stand over the winter. The plant litter and the snow that it catches insulate the soil from rapid changes in soil temperatures, which can prevent plant loss due to frost heaving.

Second growing season

❒ Mow only if the area "looks" neglected to the public (6-12 inch cutting height).

❒ Do not weed. The disturbance caused will only encourage more weeds to grow.

❒ Spot spraying may be needed for thistles and other aggressive spreading exotic plants.

❒ Do not water. Dry weather helps eliminate weed competition, and prairie plants are drought-tolerant.

❒ Do not fertilize.

❒ In the spring, mow plantings short and rake off cuttings. Mowing tends to facilitate germination of dormant seed and enhance the growth of prairie plants, allowing light and warmth to reach the soil.

❒ Keep biennial weeds in check the second year, especially sweet clover. Mowing in mid-summer, when these biennial weeds are in full bloom, will usually prevent them from setting seed to re-infest the planting.

❒ Seed germination of sweet clover is stimulated by fire and can become a long-term management problem.

Third growing season

❒ Management of the planting in the third year will consist of a spring burn (or mowing where burning is prohibited). Fire aids the prairie by suppressing weed and woody plant invasion. Planted prairies should be burned frequently from the third to the eighth year. After that, the planted prairie will be well established. If there are no serious weed problems, burning every 3-5 years will suffice.

❒ Although most prairies respond positively to annual burning or mowing, research indicates that regular spring burning tends to favor prairie grasses and legumes over most other flowers.

❒ Mowing or burning should not occur when new growth has reached 1 foot, as this could damage desirable plants.

❒ Plan burns for earlier in the spring. Many ground-nesting birds build their nests in late spring, and mowing or burning in late spring could possibly destroy the nests. If an early spring burn would by chance destroy nests, there is still enough time for most animals to raise a second brood.

❒ Careful hand weeding and spot spraying may be done as needed.

Collecting Seeds

A land ethic of course cannot prevent the alteration, management and use of these "resources," but it does affirm their right to continued existence, and, at least in spots, their continued existence in a natural state.

Aldo Leopold
A Sand County Almanac

Ethics of Seed Collection

An emphasis on restoration exerts a new pressure on our remaining native prairies: that of potentially intensive seed harvesting. Efforts to protect the local seed bank may result in over-harvesting without sufficient awareness of what it may do to remaining wildlands.

Prairie management is not yet a science that has been researched and documented over many years. It is instead a best guess, modified over the years by apparent successes or failures. Therefore, when harvesting native seed, it is important to act with intelligence, self-control and caution.

Adhere to the following rules when harvesting from the wild:

❒ Permission must be obtained from the landowner before collecting. Seeking permission beforehand allows the landowner to know who has harvested, track how many people have harvested, and protect the site from over-harvest.

❒ Get to know other local seed collectors and growers, to avoid sites being harvested more than once.

❒ Take no more than 30% of the seed of a given population of strong plant species.

Things To Remember

✔ Ask permission before collecting.

✔ Maintain local gene pools by collecting seeds close to the restoration site.

✔ Use seeds conservatively.

❒ Avoid wasting seed. Be prepared to process seeds as needed, and plant them in properly prepared areas.

❒ Do not collect from state-listed or federally listed species without a special permit.

❒ Be aware that taking seeds may disrupt the natural balance.

❒ Check the source of plant material for any collections from gardens or landscaped areas. Do not use seeds from horticultural cultivars in restorations.

❒ Collect seeds as close to the restoration site as possible. In terms of soil and topography, the collection site should be as similar as possible to the restoration site. Remnants along state trails can serve as seed sources for nearby sites.

❒ Collect seeds within 100 miles north or south of a site—or within 200 miles east or west of a site—to maintain the local gene pool. Some experts recommend narrower limits, such as 25 miles or less.

Collecting Your Own Seed

When restoring small sites, collecting seed by hand is probably the best method. It can be an educational and rewarding activity that helps individuals recognize and appreciate the effort as an integral part of the restoration process.

When restoring larger sites, collected quantities may be insufficient. Time, resources and the knowledge of how to collect and process seeds also may not be available. In these instances, the use of commercially grown, machine-harvested seed may be an alternative approach. Commercial seeds will also have fewer unwanted species and less chaff, and they will be easier to seed with commerical seed drills.

Indian grass

Collecting by hand

Collecting seed by hand is considered to be the preferred method from small sites. Collecting by hand is more selective than collecting with a machine.

Collecting by hand is basic, enjoyable and the least damaging to a site. It is also a good opportunity for individuals to actively participate in the restoration process.

An easy method for collecting larger quantities is to have a seed bag or other receptacle attached to the body, which leaves both hands free to collect.

Collecting by machine

Using seed-harvesting machines, from seed strippers to combines, makes large-area harvesting more efficient, yet less selective. The DNR Divisions of Wildlife and Parks have specialized equipment in prairie regions of the state.

When To Collect

Determining when to collect seed requires familiarity with plant species, as well as their life cycles.

Many species produce only small quantities of viable seed. It is important to be able to differentiate between good and poor seed. When a species is developing seeds, regular examination will show when a significant amount of ripe seed is present.

Consideration needs to be given to the amount of time it takes to get newly harvested seeds ready for planting. Collecting, treating and cleaning of seeds takes time and patience.

Indicators of harvest readiness include the following:

- ❒ Seeds are full sized.
- ❒ Seed coats are changing color, usually from green to a darker hue.
- ❒ Stems are dry and no longer nourished by the roots.
- ❒ Earliest seeds are dropping.
- ❒ Seeds are filled out and are too hard to bite.

Seed collection timing and method are difficult to standardize, because there are many variables:

- ❒ Some species have capsules or fruit that burst when they are ripe, such as New Jersey tea. Mesh bags put over those plants help capture the seed.

- ❒ Other species ripen over a period of several weeks, with flowers blooming gradually from bottom to top and seeds ripening accordingly.

- ❒ Some species are consistent producers every year, while others produce seed over considerable intervals of time, depending on moisture availability, pollinator efficiency and other factors.

- ❒ A good rule of thumb is to let the initial seeds drop to the ground for reseeding before collecting.

- ❒ People in the seed collection business have developed regional seed collection calendars over the years. Although the exact dates of maturity may vary from year to year, the order in which plants mature remains the same.

- ❒ Consideration needs to be given to the amount of time it takes to get newly harvested seeds ready for planting. Collecting, treating and cleaning of seeds takes time and patience.

New Jersey tea

Processing Seed

The seeds of many species need special treatment for proper storage, which provides for easier sowing and improved germination rates. The initial seed processing involves three basic steps: drying, cleaning and storing.

Drying

Seeds should be dried shortly after harvest. Properly dried seeds should have a moisture content of 5% to 14%. Seeds can be spread out on wire mesh trays or put in paper bags in a drying room, where the temperature rises slowly and does not exceed 95 degrees Fahrenheit. A dehumidifier may be needed to control the humidity in the drying room.

Cleaning

Threshing is one form of cleaning, which separates the seeds from the chaff or seedhead. Threshing may be done by hand for small quantities of seed by rubbing seeds against a coarse screen, or by using a rolling pin in a wooden tray.

Scalping is another form of cleaning. Various-sized screens are used to separate the loose chaff from the seed. Commercial growers favor fanning mills or air-screen cleaners to accomplish the separation of large quantities of seed more efficiently.

An alternative to threshing and cleaning is to run bulk seeds through a commercial shredder-mulcher, which will release the seeds and create a mixture of seeds, stems and other parts in manageable particle sizes. This material is only suitable for hand broadcasting and raking in.

The three most important factors affecting the viabilty and longevity of stored seeds are moisture content, storage temperature and relative humidity.

Storing

Storing seeds correctly minimizes the risk of having climate extremes, microorganisms, fungi, insects or small mammals affect seed viability.

The three most important factors affecting the viability and longevity of stored seeds are moisture content, storage temperature and relative humidity.

Seed can simply be stored in paper bags or burlap bags in an unheated building, barn or shed. The bags should be hung so that rodents cannot reach them, and they should hang high enough that the dampness of the floor does not affect them.

For long-term storage, seeds may be frozen in sealed containers with a moisture content that is below 14%.

Germination Requirements

For seeds to germinate, they must be able to imbibe water, be exposed to proper temperatures, and have adequate time to transform into living plants.

Seeds of some plants need specific treatment in order to germinate. These treatments include cold-moist stratification, warm-moist stratification, cold-dry stratification, scarification, inoculation, light treatment, and providing hosts for parasitic species.

Seeds bought from a certified commercial grower are sold with the treatment already applied.

Cold-moist stratification

This treatment mimics the winter season that seeds have to go through in order to germinate. A great number of species are treated with cold-moist stratification to prepare them for spring seeding.

Seeds are mixed with damp sand, vermiculite or sawdust at a ratio of 1:1 or 2:1. The mixture is then loosely packed into ziplock bags and stored at a constant temperature of 34-40 degrees Fahrenheit. Most seeds need 60-90 days before they are ready to be seeded.

Warm-moist stratification

Herbaceous woodland species, such as Solomon's seal and jack-in-the-pulpit, have complex double-dormancy requirements and need two treatments: one warm-moist stratification at 68-75 degrees Fahrenheit, followed by a cold-moist stratification. Each temperature period requires about 3 months.

Cold-dry stratification

Most grasses, asters, milkweeds and species of the mint family are treated with cold-dry stratification. This method simply stores seed in an unheated building or container that is free of insects and rodents.

Scarification

Some seeds have a very hard seed coat, which needs to be broken before the seed can imbibe water and germinate. New Jersey tea and many legumes, for example, are treated in this manner.

Rubbing the seeds between sandpaper works for some seed. Other seeds with very thick seed coats must be scarified with concentrated sulfuric or nitric acid, mimicking the conditions a seed may encounter passing through the digestive tract of an animal.

Still other seeds may need to be soaked in hot water (170-190 degrees Fahrenheit) to break down their waxy cuticle.

Inoculation

The growth of all legumes is enhanced by inoculating them with nitrogen-fixing bacteria. In general, the inoculant is applied to wet seed prior to sowing. Some propagators use soda pop to wet the seed, because its stickiness helps the inoculant adhere better to the seed.

Light treatment

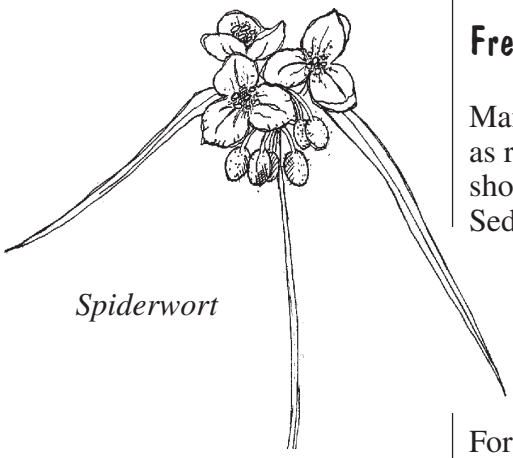
Very small seeds, as well as seeds that need light to break dormancy (such as lobelias and sedges), should not be covered with soil after seeding. Nevertheless, they do need good seed-to-soil contact and moisture to germinate, which can be accomplished by packing the soil after seeding.

Hosts for parasitic species

Some species are parasitic or semi-parasitic. The seeds of such plants need to be either seeded along with the seed of a host species or transplanted into pots containing host species. Indian paintbrush and louseworts are two of those species.

Fresh seed

Many woodland spring flowering species (spring ephemerals), such as rue anemone, bloodroot, spring beauty, and rushes and sedges, should be sown immediately after collection, as they lose their viability. Sedges will go dormant if not sown immediately.



Spiderwort

Vegetative Propagation

For species that either rarely produce viable seed or are difficult to germinate, effective vegetative methods of propagation include dividing, root and rhizome cuttings, and the use of bulb scales. Vegetative methods do restrict genetic diversity and are labor intensive.

❒ **Dividing:** Many prairie and savanna species can be divided, such as prairie smoke, shooting star, wild geranium, violets and a number of woodland species.

❒ **Root and rhizome cuttings:** Pucoons propagate readily from root cuttings; sedges, cordgrass, prairie coreopsis, and heath aster propagate from rhizomes.

❒ **Bulb scales:** Bulb scales may be planted to vegetatively propagate species of the lily family.

Monitoring Management, Restoration and Re-establishment Sites

It is critical to monitor these sites, so that we can learn how natural systems respond and change over time. We need to use ecological knowledge, statistical inference and informed intuition to interpret these responses and changes.

Our goal must be to design and implement a monitoring program that will best help us track our progress in striving for ecological functionality and increased diversity of species on these sites.

Our goal must be to design and implement a monitoring program that will best help us track our progress in striving for ecological functionality and increased diversity of species on these sites.

The following basic steps will help us get started:

- ❒ Establish a database for each site.
- ❒ Identify and implement appropriate management activities, such as exotic species control, prescribed burning, mowing, planting and seeding.
- ❒ Record and evaluate changes to each site annually.
- ❒ Adjust management activites as needed.

For Further Information

Guidelines for Wetland Restoration & Management, by MNDOT, Environmental Services, and MN Board of Water & Soil Resources, 2004 (includes upland information)

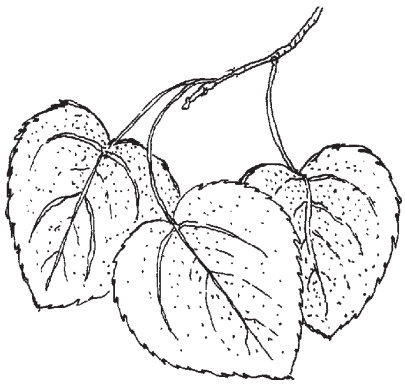
Natural Landscaping: Designing with Native Plant Communities, by John Diekelmann and Robert Schuster. McGraw-Hill Book Company, New York, 1982.

Prairie Moon Nursery Catalog and Cultural Guide, by Alan Wade. 31837 Bur Oak Lane, Winona, Minnesota 55987-9515, 2004. Web: www.prairiemoon.com

Restoring the Tallgrass Prairie-- An Illustrated Manual for Iowa and the Upper Midwest by Shirley Shirley, 1994

The Tallgrass Restoration Handbook for Prairies, Savannas and Woodlands, by Stephen Packard and Cornelia F. Mutel. Island Press, Washington, D.C., 1997.

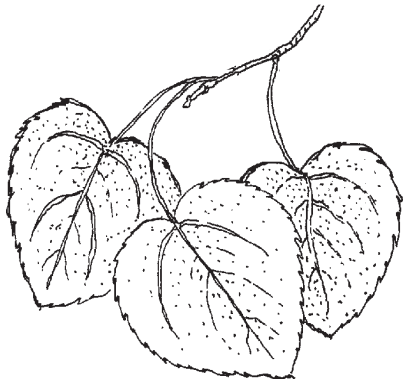
Restore Your Shore, CD ROM by the Minnesota Department ofNatural Resources. Copies are available through the Minnesota Bookstore; call 1-800-657-3757 for information on computer requirements and costs, 2001.



Aspen

For Suppliers of Native Seeds/Plants and Installation and Land Management Services, go to:

http://www.dnr.state.mn.us/gardens/nativeplants/suppliers.html



Aspen

CHAPTER 3

Managing and Restoring Woodland and Forest Communities

CONTENTS

Jack-in-the-pulpit

(continued)

SIDEBAR

FIGURES

Wild sarsaparilla

CHAPTER 3

Managing and Restoring Woodland and Forest Communities

Figure 1: ECS province map

Introduction

At the time of the Public Land Survey in Minnesota (1847-1907), the Eastern Broadleaf Forest Province was primarily comprised of savannas, woodlands and deciduous forest. The Laurentian Mixed Forest Province covering the northern and eastern part of the state was primarily comprised of northern hardwood-coniferous forests and pine forests. (See Figure 1.)

These are the natural communities we seek to preserve, manage and restore on state trails, canoeing and boating routes, and water access sites.

Forest or Woodland?

A **forest** is a dominant cover type of a landscape:

- ❒ It is a closed-canopy, wooded natural community that is not dependent on fire to maintain itself.
- ❒ It is often an area large enough to have a more or less undisturbed interior environment.
- ❒ A forest typically has four vegetation layers: a canopy; an understory of shade-tolerant small trees; shrubs; and a herbaceous layer of forest forbs.

A **woodland** is a natural community in which, in contrast to a forest, trees form an open canopy, with a ground layer made up of shrubs, grasses and forbs:

- ❒ A woodland may be an area differing in composition and appearance from the surrounding landscape (for instance, expanses of agricultural land may be the dominant cover type).

❒ Woodlands occur primarily in vegetation transition zones from prairie to forest.

❒ It often lacks adequate size to contain an undisturbed interior environment.

❒ It is very susceptible to disturbances, such as exotic species invasion, because it has a high amount of edge environment.

❒ It is a natural community that is often fire dependent.

Trails and Canoeing/Boating Routes in the Laurentian Mixed Forest Region

Trails consist of narrow corridors within a large forest expanse. Vegetation management here consists of keeping trail treadways clear of brush on a yearly basis. Trail access sites, as well as water access sites, are managed and restored individually as needed.

State trails in the Laurentian Mixed Forest region include (see Figure 2, page 4):

Arrowhead State Trail
Taconite State Trail
North Shore State Trail
Willard Munger State Trail
(Minnesota/Wisconsin border segment)

State Trails below are located in areas of mixed land use, woodland, farmland and urban development; they are located on abandoned railroad rights-of-way.

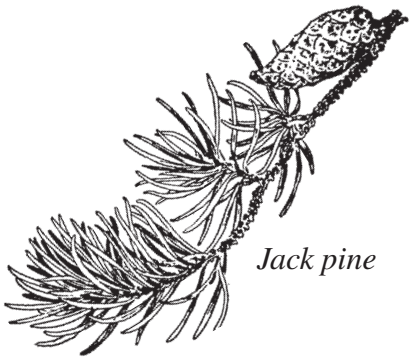
Heartland State Trail	aspen/birch, mixed hardwood and pine
Paul Bunyan State Trail	jack pine, mixed hardwood and pine, northern hardwoods
Willard Munger State Trail (Hinkley Fire segment)	pine, aspen/birch

Canoeing/boating routes in the Laurentian Mixed Forest region include (see Figure 3, page 5):

Big Fork River
Little Fork River
Red Lake River (eastern section)
Vermilion River
St. Louis River
Cloquet River
Mississippi River (northern section)
Pine River
Crow Wing River
Rum River
Snake River
Kettle River
St. Croix River
(northern section)

Trails and Canoeing/Boating Routes in the Eastern Broadleaf Forest Region

Trails, canoeing and boating routes, and water access sites crossing woodland/forest communities are most often located in areas of mixed land use, such as farmland and urban development. Trails are primarily located on abandoned railroad rights-of-way.



Jack pine

State trails that are within woodland/forest environments include (see Figure 2, page 4):

Luce Line State Trail	two-thirds maple-basswood forest
Sakatah Singing Hills State Trail	half maple-basswood forest
Douglas State Trail	some maple-basswood forest
Blufflands State Trail system	oak forest, some maple-basswood forest

Canoeing/boating routes within woodland/forest environments include (see Figure 3, page 5):

North Fork Crow River
Rum River
St. Croix River (southern section)
Mississippi River (southern section)
Minnesota River (eastern section)
Cannon River
Straight River
Zumbro River
Whitewater River
Root River

Minnesota State Trails

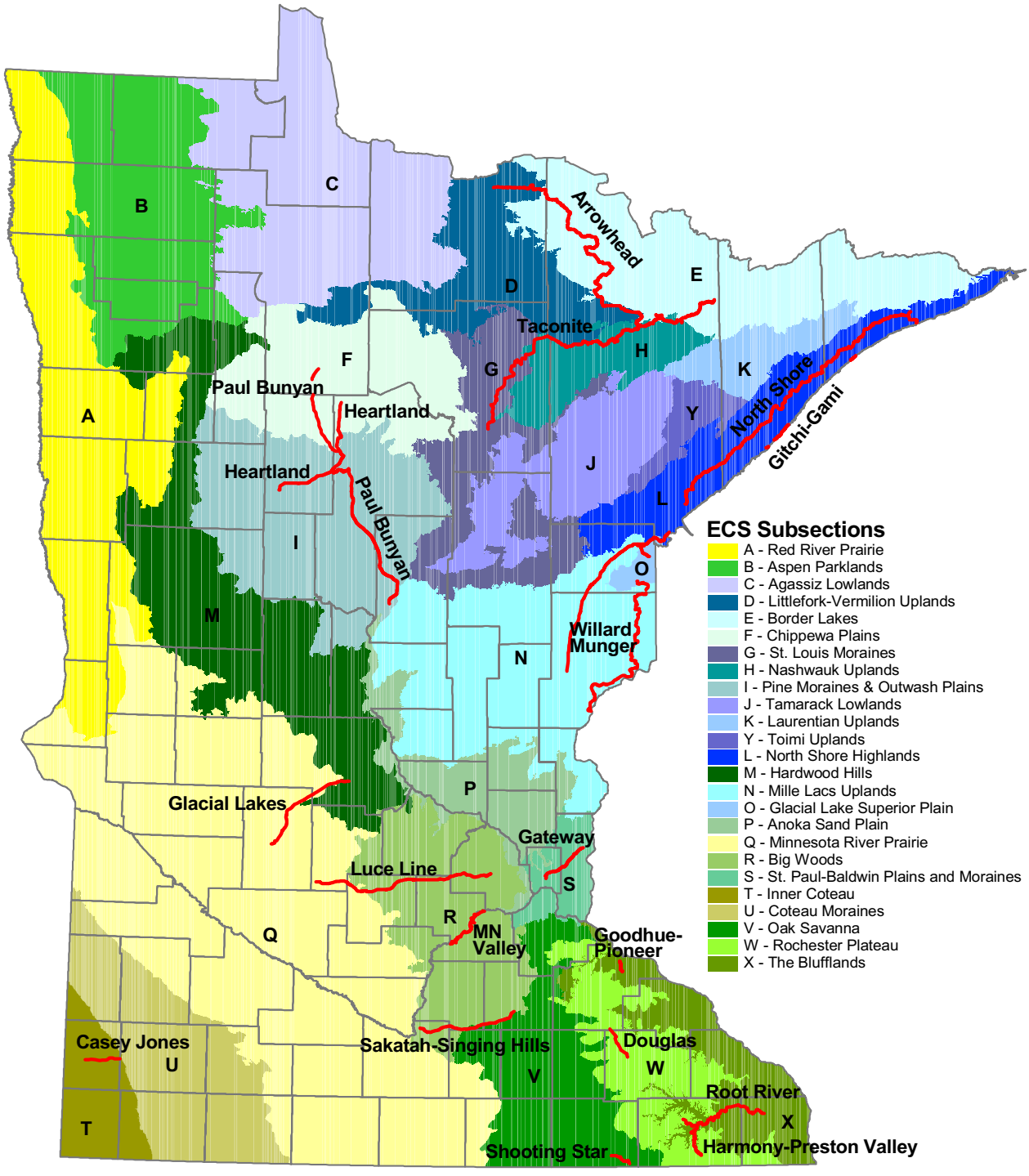


Figure 2: Minnesota state trails

Minnesota Canoeing/Boating Routes

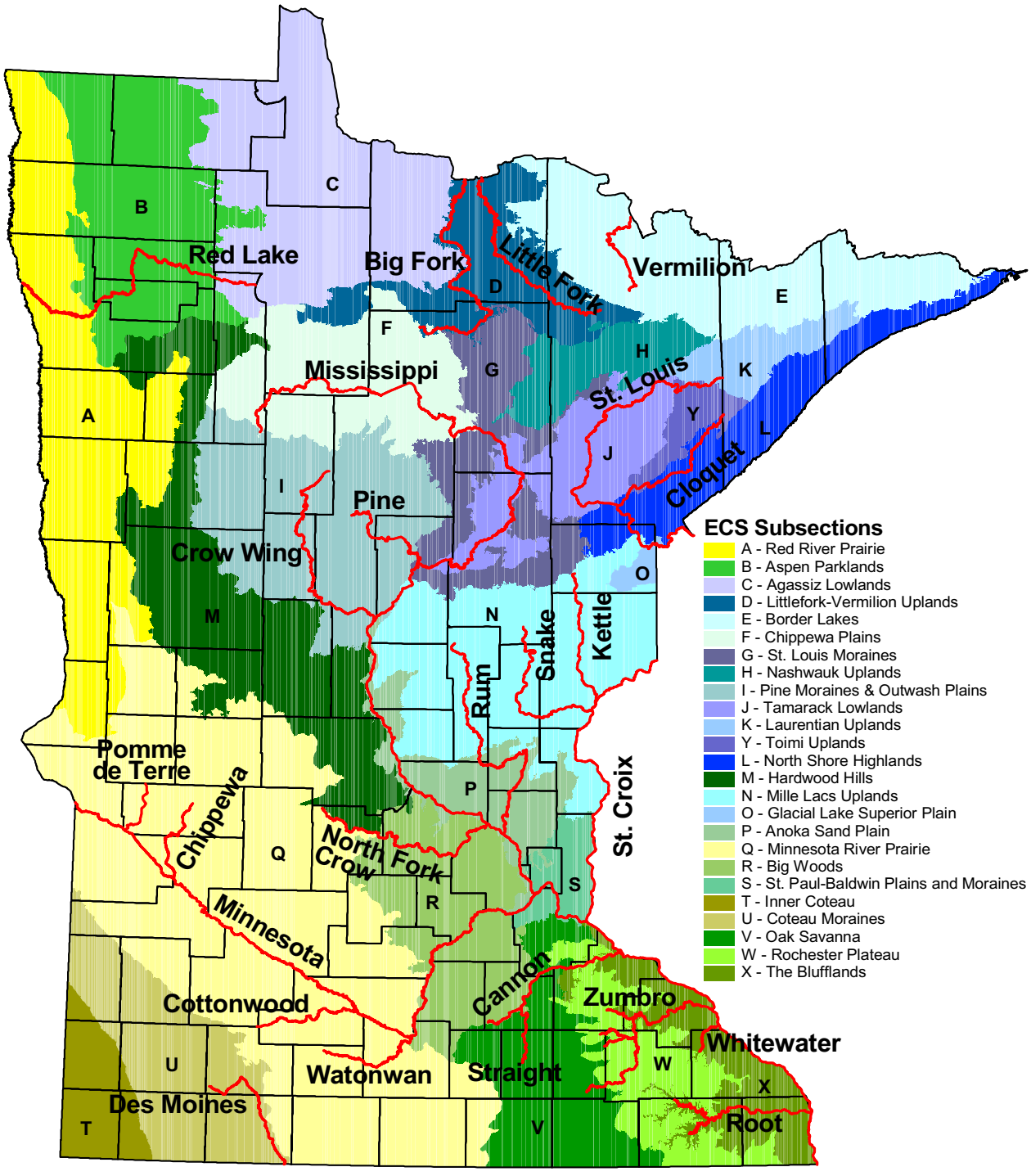
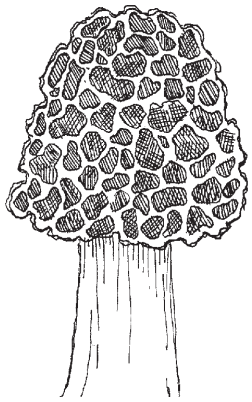


Figure 3: Minnesota canoeing/boating routes

Guiding Principle

To enhance the ecological quality of state trails, canoeing and boating routes, and water access sites, thereby increasing the quality of the recreational experience and fostering user awareness and appreciation.



Morel mushroom

This principle can be achieved by:

- ❒ **Preserving and managing woodland/forest communities** with high species diversity.
- ❒ **Identifying degraded woodland/forest communities,** and evaluating, ranking and restoring them if feasible.
- ❒ **Encouraging regeneration of native species** by removing exotic species.
- ❒ **Minimizing construction disturbance.**
- ❒ **Replanting disturbances** with locally native species.
- ❒ **Interpreting plant communities** and associated management and restoration activities.

Canada mayflower

Assessing Site-Specific Needs: Management or Restoration?

When is management of a community sufficient? When is restoration the preferred approach?

Management means taking care of what's already there: encouraging and improving the continued growth and enhancement of natural communities already in place at a particular site. Management can also be considered a form of restoration—trying to improve a site ecologically.

Restoration can be thought of as nursing biodiversity back to health through such activities as burning, exotic species control, interseeding and interplanting.

Restoration represents a more intensive effort. It is a process of returning a degraded natural community to its original structure and species composition.

Areas in need of restoration usually offer the "basic ingredients" necessary to represent a natural community, but the quality of the overall community is less than what it should be. Restoration efforts focus on enhancing what's already there, to improve the overall quality and long-term viability of the natural community.

Restoration can be thought of as nursing biodiversity back to health through such activities as burning, exotic species control, interseeding and interplanting.

Green ash

Understanding Forest Succession as a Factor in Restoration and Management Decisions

A natural plant community is never static. It changes its form and composition continually. This constant change is called **succession.** Consideration of successional principles must guide all restoration and management decisions.

Under natural conditions, a new forest is usually initiated as the result of a catastrophic disturbance. The five recognized stages in the natural development of a forest are:

Stage 1: Herb, shrub and seedling stage
Stage 2: Young forest (pioneer trees)
Stage 3: Mature forest
Stage 4: Subclimax old-growth forest
Stage 5: Climax old-growth forest

If uninterrupted by disturbances (either natural or induced by human activities), a forest will eventually become a climax forest. Small-scale and large-scale disturbances, such as windfalls, disease, forest fires or clearcuts, assure constant change in the composition of a forest, displaying various successional stages within the forest.

Each successional stage is characterized by specific tree species: pioneer species, gap phase species, subclimax and climax species. Pioneer species establish first after a catastrophic disturbance (natural or artificial). They dominate in the early stages of succession, providing shade and shelter to gap phase species.

Pioneer species in Minnesota include jack pine, red pine, aspen, white birch and bur oak. White pine is sometimes also considered a pioneer species, because it originates after forest fires and is less shade tolerant. Pioneer species have a shorter life span than successional species, with the exception of red and white pine and oak, which are long-lived and often survive to dominate sub-climax old growth forests.

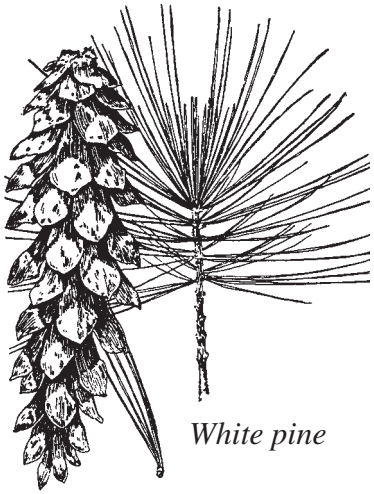
A mature forest is a stand that has reached its potential height, is even-aged, is capable of sexual reproduction, and has harvestable timber.

Gap phase species in Minnesota include red oak, red maple, yellow birch, basswood, white spruce and white pine. More shade tolerant than pioneer species, gap phase species fill in when a gap appears in the canopy, such as dying individual pioneer species.

Subclimax species in Minnesota include white pine, red pine, oak and Douglas fir; they are not shade tolerant and often persist in climax old growth forests.

Climax species in Minnesota include sugar maple and balsam fir, but also white cedar and white spruce. Climax species reproduce and persist under low light conditions. They are more sensitive to moisture stress and less resilient toward fire and animal damage.

Adapted from “Forest Ecology” factsheet, by K.A. Rusterholz, Natural Heritage Program, Minnesota Department of Natural Resources.



White pine

Conducting a Comprehensive Site Analysis

Conducting a comprehensive site analysis is the first step in evaluating a specific site. A site analysis should include the following steps:

❒ Learn about the biological history of the site.

• Refer to *The Natural Vegetation of Minnesota at the Time of the Public Land Survey: 1847-1907*.

• Consult Minnesota County Biological Survey (MCBS) maps and descriptions.

❒ Survey and evaluate existing vegetation on the site.

• Consult *Minnesota Native Plant Communities Classification Version 2.0*

• Consult *Field Guide to the Native Plant Communities of Minnesota,* 2004-2006

• Solicit help from a botanist or ecologist, or learn to identify plants.

❒ Determine whether any listed plant or animal species are present.

• Check the Minnesota listing.

• Solicit help from an ecologist.

❒ Analyze soil types and characteristics.

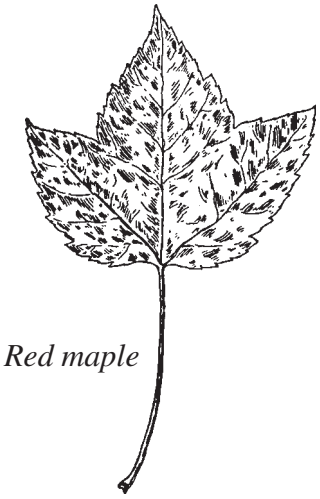
• Refer to *Soil Surveys by County: NRCS in Cooperation with Minnesota Agricultural Experiment Station*, from the U.S. Department of Agriculture.

• Conduct a soil sampling onsite.

• Determine soil compaction or disturbance.

• Determine content of organic matter and nutrient levels.

• Determine pH factor.



Red maple

❒ **Determine soil moisture** gauged on a gradient from dry to mesic to wet.

• Determine drainage patterns. For example, sandy soils and hilltops are dry, and depressions and clay soils hold water and therefore are more moist.

❒ **Consider topographic features,** such as slope and aspect.

• Determine whether the site is hilly or level; identify degree of exposure to the sun (south, north, east or west).

❒ **Consider the microclimatic conditions** of the site, within the regional context.

❒ **Select the appropriate plant species** according to site conditions
and the specific landscape unit.

• Consult *Vascular Plants of Minnesota,* by G.B. Ownbey and T. Morley (1991).

• Consult the County Biological Survey database.

• Consult the *Restore Your Shore* CD ROM (includes an encyclopedia of native plants).

Things To Remember

✔Evaluate individual sites.

✔Prioritize by commu- nity type, rarity and level of degradation.

✔Monitor management activities and evaluate outcomes.

Focus on Management and Restoration

Restoring woodland/forest communities and interpreting the process will help recreational users understand the beneficial beauty of natural areas and re-establish basic function to these communities, thereby enhancing their ecological quality. Restorations serve three purposes:

❒ **Restoring ecological function:** While human intervention can not recreate complex natural ecosystems, basic functionality can be re-established.

❒ **Preserving landscape integrity:** Restoration of disturbed plant communities helps preserve overall landscape integrity and continuity.

❒ **Providing opportunities for user education:** Management and restoration, coupled with interpretation, build awareness and appreciation of native plant communities without impacting rare habitats.

White trillium

Conditions Encountered on Disturbed Sites

Conditions encountered may include:

- ❒ Presence of exotic species and other undesirable vegetation
- ❒ Single-species canopy of exotic or invasive native species
- ❒ Reduction in mature tree density
- ❒ Absence of tree reproduction
- ❒ Shift in species composition
- ❒ Soil compaction and reduced organic matter

Restoration Considerations

❒ **The process and success of restoring these plant communities** takes a long time and is significantly influenced by adjacent land use.

❒ **Give management/restoration priority** to the following sites:

- Sites that are not yet significantly degraded
- Sites having a higher frequency of conservative species in them (indicative of a relatively stable community)
- Communities that are less common in a specific area

❒ **Avoid further fragmentation** of the woodland. Strive for connectivity.

❒ **Promote compatible adjacent land use.**

❒ **Work with the beneficial aspects** of natural disturbances (including windthrow, fire and drought).

❒ **Consider past human intervention**, such as fire suppression, logging, soil disturbance and compaction, or pesticide use.

❒ **Control exotic species or other undesirable vegetation.** Initial restoration implementation steps may involve such common techniques as cutting and stump treatment, or basal bark spraying with herbicides, mulching, burning, and girdling of trees.

❒ **Remove excessive stocking** of native trees where dense tree or shrub reproduction prevents establishment of ground layer vegetation or tree reproduction.

The process and success of restoring these plant communities takes a long time and is significantly influenced by adjacent land use.

❒ **Manage woodland sites with low-intensity fires** in intervals of 1-3 years to reduce woody invasive or exotic plants.

• Burn when leaf litter is dry to aid in fueling the fire.

• Burn only one-third to two-thirds of a site on a yearly basis on a revolving schedule to avoid negative effects on insects or other wildlife populations; fall fires also destroy potential winter food and cover.

• Reduce the frequency of burns to between 10 and 20 years, as native herbaceous ground layer vegetation develops.

❒ **Investigate whether the absence of tree reproduction** may be caused
by soil compaction due to past grazing or use of heavy machinery.

• Soil compaction can be remedied by letting the site rest for several years, which will allow litter to build up, decompose and eventually become integrated by soil fauna (organisms that assist the decomposing of leaves).

• Aeration of the soil or adding composted leaves or wood chips may aid this process.

• Cultivation of the site should be avoided, because it may be too injurious to shallow-rooted species and bring up undesirable weed seeds.

Solomon's seal

❒ **Collect seed from similar nearby sites** and sow in opened-up areas
as undesirable brush and trees are removed. It may be advantageous to plant plugs and seedlings. Success may vary widely from species to species. It is difficult to predict the establishment and spreading of forest herbs and shrubs. Some species may depend on a particular animal for their dispersal; others may depend on a microorganism in the soil; and still others may require openings in the litter layer to flourish.

❒ **Be aware of seed germination requirements.**

• **Warm-moist stratification:** Herbaceous forest species with complex double dormancy requirements, such as trillium, Solomon's seal,
and jack-in-the-pulpit, need two treatments: one warm-moist stratification at 68-75 degrees Fahrenheit, followed by a cold-moist stratification. Each temperature period requires about 3 months.

• **Fresh seed:** Many spring flowering species (spring ephemerals), such as rue anemone, trilliums, bloodroot, spring beauty, and rushes and sedges, should be sown immediately after collection, as they lose their viability. Sedges will go dormant if not sown immediately. (See also "Collecting Seeds," page 30, in Chapter 2: Managing, Restoring and Re-establishing Priaire and Savanna Communities.)

Focus on Woodland/Forest Plantings

Newly developed trails and water access sites need to be revegetated after construction is completed. In devising a planting strategy, apply the following evaluation criteria:

- ❒ Existing trees on the site
- ❒ Future use of the site by recreational users
- ❒ Aesthetic appearance
- ❒ Ease of management
- ❒ Landscape integrity
- ❒ Ecological functionality

In-depth familiarity with the individual site and its surroundings is the first step in selecting a target community that will both fit the natural landscape pattern and help in the selection of the appropriate plant community.

Things To Remember

✔Select a target community.

✔Select a planting strategy.

✔Observe and manage according to natural succession principles.

Identifying Distinct Community Requirements

Each community has distinctly individual requirements for light, moisture, slope/aspect, soil makeup and the presence of undecomposed and decomposing material.

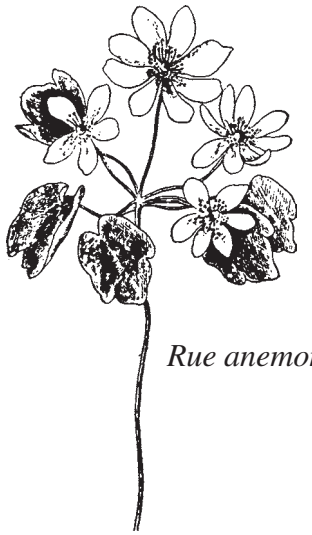
Light: While evergreen forest communities are deeply shaded all year, deciduous forest understories have low light levels in summer but much higher light levels in early spring. Light levels are also more intense or less intense, depending on the density of the tree canopy.

Moisture: Soil moisture is gauged on a gradient from dry to mesic to wet. Different moisture levels favor different populations of plants. For instance, pine and oak forest communities occur on relatively dry sites; maple basswood forest communities thrive on mesic soil; and floodplain forest communities require abundant moisture and tolerate temporary flooding.

Slope: The aspect and angle of a slope affect the composition of woodland/forest plant communities. For instance, north- and east-facing slopes, which are more protected from prevailing winds and direct sunlight, are favored by mesic communities. South- and west-facing slopes are favored by more drought-tolerant communities.

Soil: Soil characteristics to a great extent shape plant communities, as they relate to pH gradient, organic content and type of soil (sandy, clay, loam).

Undecomposed and decomposing material: Adding leaf compost or wood chips to a freshly disturbed site and letting it rest will aid the process of soil building.



Rue anemone

Planting Strategies

Great River Greening has utilized several planting strategies in its effort to enhance the ecological quality of the Mississippi River floodplain commercial area in St. Paul. These strategies can also be applied to Trails and Waterways sites in woodland and forest communities.

Great River Greening outlines five planting strategies, along with the advantages and disadvantages of each strategy:

Strategy 1: Final Spacing

With this method, plants are spaced at densities and proportions that consider the mature size of each plant. This very traditional approach is the most familiar to most people. It also requires the most maintenance for the individual plant.

Trees are typically spaced 15-25 feet apart, with shrubs planted in between. Maintenance mostly includes weeding and pruning to maintain some aesthetic appearance. Its ecological value is usually much less than a naturalized grove. Instead of mulching large areas, seed to a grass/forb ground cover.

Strategy 2: Dense Initial

Trees and shrubs are planted at greater densities (6-8 feet apart), allowing for self-thinning of plants as they mature. This method mimics natural processes much more effectively.

This method may require thinning of trees at a later stage. Tree and shrub canopy usually closes in 5 to 7 years. Less weeding and maintenance is needed after the first 4 years.

A greater variety of species can be planted, as plants support each other, shading the soil and thus maintaining more even soil temperature and moisture content. Increased leaf litter accumulation will improve the soil as well. Much more structural diversity will develop, and ecological value is increased.

Depending on browsing pressure by wildlife, the planting may need some protection in the first 5 years after planting.

Strategy 3: Sparse Initial

This method would mimic a savanna community at first. Trees are planted in less than ultimately desired densities. A ground layer of sun-loving grasses and forbs is planted beneath.

As shade develops and grasses and forbs diminish, shade-tolerant trees and shrubs are added, such as sugar maple, pagoda dogwood, elderberry and chokecherry in southern forests; mountain maple and bush honeysuckle in northern forests.

No mulching is needed, as the ground is planted with a herbaceous layer. There may be a need to control weeds by mowing periodically.

Aspen

Strategy 4: Cover Crop

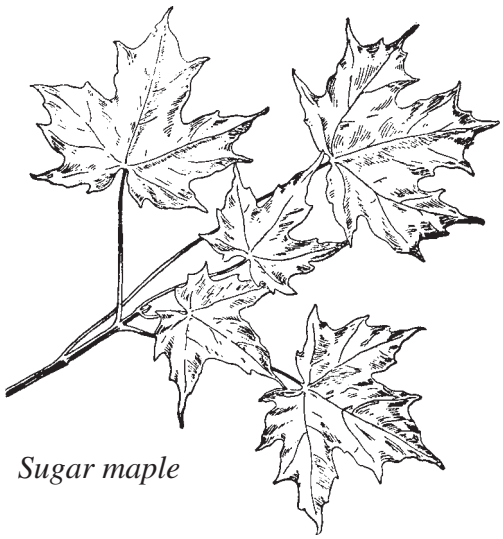
Plant short-lived, fast-growing tree species (pioneer species), such as poplar, willow, pin oak, green ash and silver maple. These species are tolerant of harsh conditions, including poor soil, fluctuating temperature and fluctuating moisture conditions.

These species act as cover crop, prepare the soil, and improve the microclimate for more sensitive species, which are added as shade develops and the soil improves. Spacing of initial plants should allow adding shade-tolerant species later.

Strategy 5: Natural Invasion

This method may be sufficient in small areas that have been disturbed by construction. Native species may naturally invade from a nearby site. Seeds could also be collected locally and seeded in a prepared area. The site will need monitoring for invasion by exotic species.

Note: Planting and caring for woody plants is addressed in Chapter 6: Planting and Pruning of Woody Plants.



Sugar maple

A Method for Assessing Buckthorn Infestation Levels in Woodland/Forest Situations

Buckthorn

In 1995, Minneapolis Parks and Recreation Board has developed criteria for assessing infestation levels of buckthorn to help standardize infestation terminology. These draft criteria will help resource managers assess individual sites through comparison. (Note: dbh = diameter at breast height)

Level I infestations include:

- ❒ No trees greater than 4 inches dbh
- ❒ Density of trees less than 1 per 100 sq. ft.
- ❒ Sapling density less than 5 per 100 sq. ft.
- ❒ Seedlings less than 3 per 10 sq. ft.

This level or less can be treated by pulling, cutting with stump treatment, and dormant spraying. Followup burns can help keep buckthorn in check.

Level II infestations include:

- ❒ Scattered trees greater than 4 inches dbh
- ❒ Density of trees less than 5 per 100 sq. ft.
- ❒ Sapling density less than 10 per 100 sq. ft.
- ❒ Seedlings less than 10 per 10 sq. ft.

This level can be slowed by removal of larger trees (2+ inches dbh) and regular fires. Fires will open the midstory and alter the species composition.

Level III infestations include:

- ❒ Trees larger than 4 inches dbh are common
- ❒ Density of trees greater than 5 per 100 sq. ft.
- ❒ Sapling density greater than 10 per 100 sq. ft.
- ❒ Seedling density greater than 10 per 10 sq. ft.

This level should receive the lowest priority for restoration because it is a pure stand of buckthorn. Removal will be very time consuming and expensive. The system will be shifted back to a grassy system with some large trees.

Control of common and glossy buckthorn is also addressed in: *Minnesota invasive non-native terrestrial plants,* an identification guide for resource managers 2003 or http://www.dnr.state.mn.us/terrestrialplants/index.html

Things To Remember

✔Control infestations in areas that have the most potential to recover on their own.

Monitoring Management and Restoration Sites

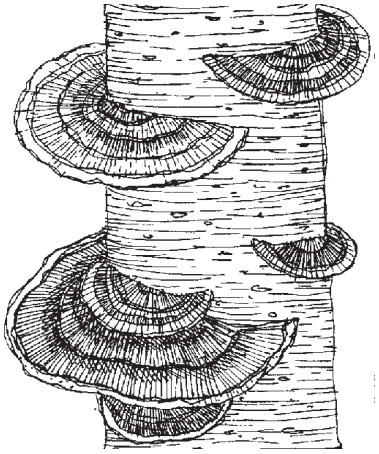
It is critical to monitor these sites, so that we can learn how natural systems respond and change over time. We need to use ecological knowledge, statistical inference and informed intuition to interpret these responses and changes.

It is critical to monitor these sites, so that we can learn how natural systems respond and change over time.

Our goal must be to design and implement a monitoring program that will best help us to track our progress in striving for ecological functionality and increased diversity of species on these sites.

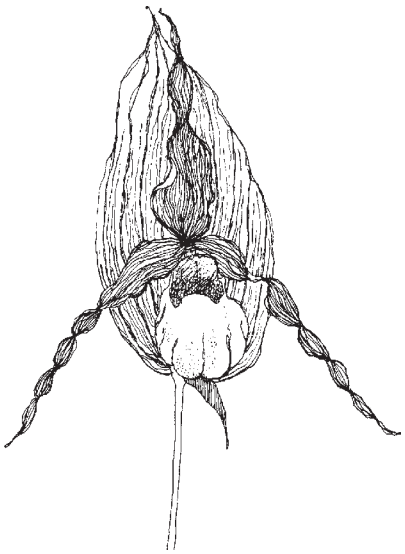
The following basic steps will help us get started:

- ❒ Establish a database for each site.
- ❒ Identify and implement appropriate management activities, including exotic species control, prescribed burning, mowing, planting and seeding.
- ❒ Record and evaluate changes to each site annually.
- ❒ Adjust management activities as needed.



Shelf fungus

Availability of Native Woody Plants



Lady's slipper

Nurseries grow a variety of woody plants native and non-native to Minnesota. While information on Minnesota source-identified stock is not readily available at this time, **be sure to ask for source identification when purchasing plants.**

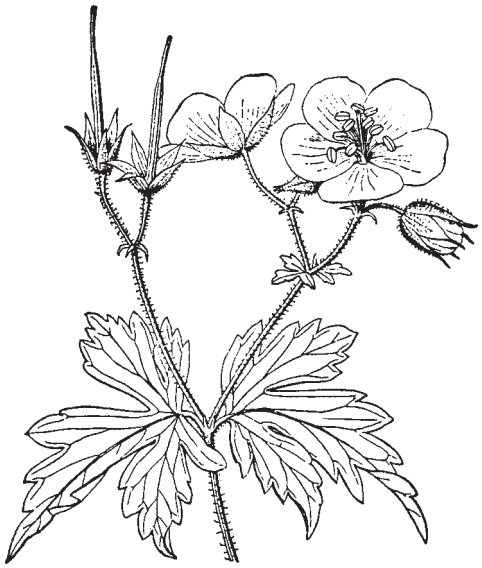
As the demand for truly native plant stock increases, suppliers will take notice and try to raise more native stock. As a result, availability of native stock will slowly increase, and nursery businesses and the public at large will begin to better understand the ecological importance of planting native species.

Exercise caution when ordering plants from local soil and water conservation districts (SWCDs). They are still promoting the use of some invasive exotic species, such as amur maple, honeysuckle, Russian olive, and out of natural range species such as blue spruce for wildlife plantings.

DNR's forestry nurseries encourage individual seed collection and will grow seedlings on contract for individual DNR division needs. Contact Badoura or General Andrews nurseries.

For Suppliers of Native Woody Plants go to:

http://www.dnr.state.mn.us/gardens/nativeplants/suppliers.html



Wild geranium

Juneberry

For Further Information

"Forest Ecology," by K.A. Rusterholz. Natural Heritage Program, Minnesota Department of Natural Resources.

Natural Landscaping, Designing with Native Plant Communities, by John Diekelmann and Robert Schuster. McGraw-Hill, New York, 1982.

Planting Strategies, Great River Greening Project, 35 West Water Street, Suite 201, St. Paul, Minnesota 55107. Phone: 651-665-9500.

The Tallgrass Restoration Handbook for Prairies, Savannas, and Woodlands, by Stephen Packard and Cornelia F. Mutel. Island Press, Washington, D.C., 1997.

"Woodland Restoration: An Overview," by Evelyn A. Howell. In *Restoration & Management Notes*, University of Wisconsin Press, Madison, Wisconsin, Summer 1986.

Restore Your Shore, CD ROM by the Minnesota Department ofNatural Resources. Copies are available through the Minnesota Bookstore; call 1-800-657-3757 for information on computer requirements and costs, 2001.

Wild ginger

CHAPTER 4

Managing and Restoring Riparian Environments

CONTENTS

Water plaintain

(continued)

(continued)

FIGURES

TABLE

CHAPTER 4

Managing and Restoring Riparian Environments

Blue flag iris

Introduction

Lakeshores, riverbanks and wetland fringes are impacted by public water access sites, canoeing and boating routes, and, to some extent, state trails.

The best protection for these riparian areas is achieved by maintaining a sufficient natural vegetation buffer that can withstand the erosive forces of wave action and stream current. These buffers must be enlarged in areas where runoff from parking lots, other hard surfaces and mowed turf could directly flow into a body of water. These enlarged natural vegetative buffers allow stormwater to infiltrate into the vegetation and soil rather than run off directly into the adjacent water body.

Shoreline or Streambank?

While shorelines and streambanks are both areas where land meets water, their geomorphological and biological makeup and function are very different. Any restoration work must be preceded by a thorough understanding and evaluation of each environment.

Characteristics of a Shoreline

❒ Surrounds an amorphous body of water, such as a lake.

❒ Is exposed to lapping motion of water.

❒ Is exposed to wave and ice action.

❒ Plant community makeup along the shoreline depends on each lake's chemistry (including rock, soil, climate and other factors).

❒ Requires an evaluation of water surface use and impact before restoration is attempted.

❒ Emergent vegetation, such as grasses and shrubs in the emergent zone, resists wave action, while roots hold soil particles in place. (See Figures 1 and 2, page 2.)

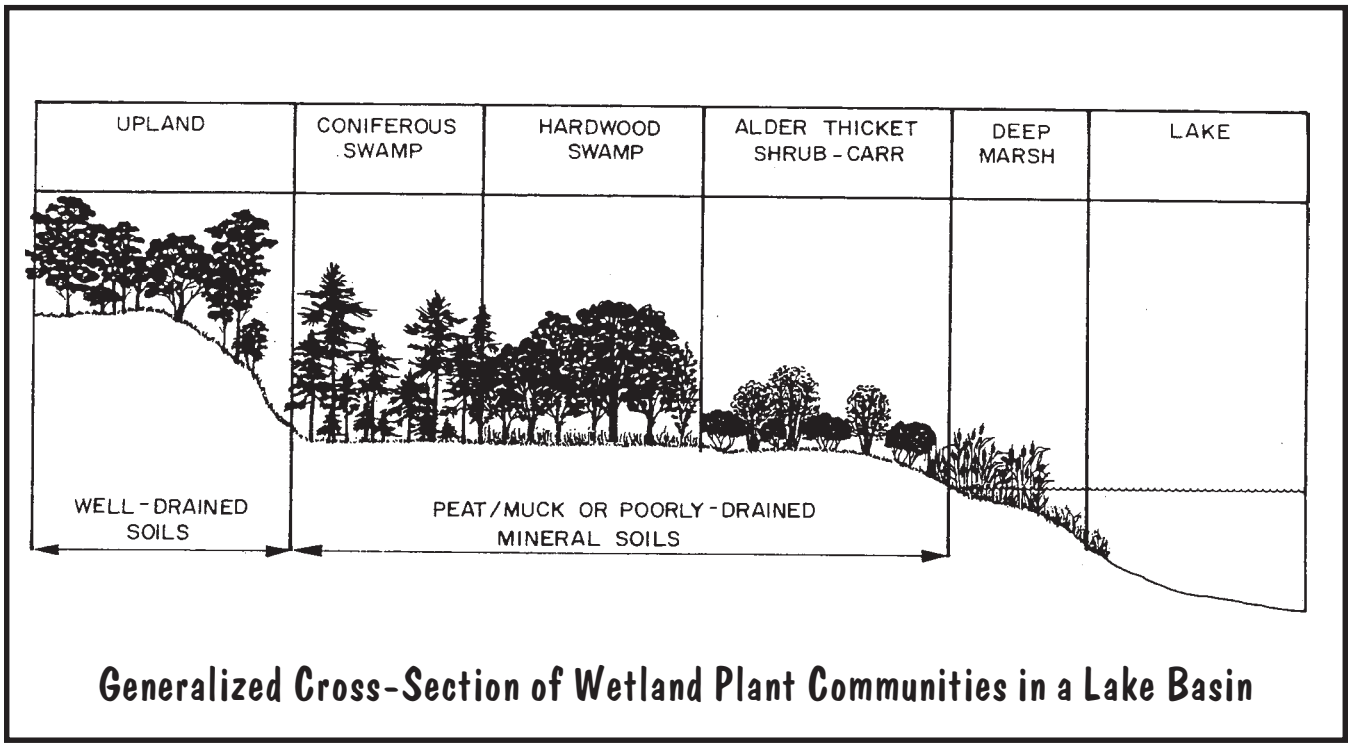


Figure 1: Generalized cross-section of wetland plant communities in a lake basin. From *Wetland Plants and Wetland Plant Communities,* by Steve D. Eggers and Donald M. Reed, U.S. Army Corps of Engineers, Second Edition, 1997. Reprinted with permission.

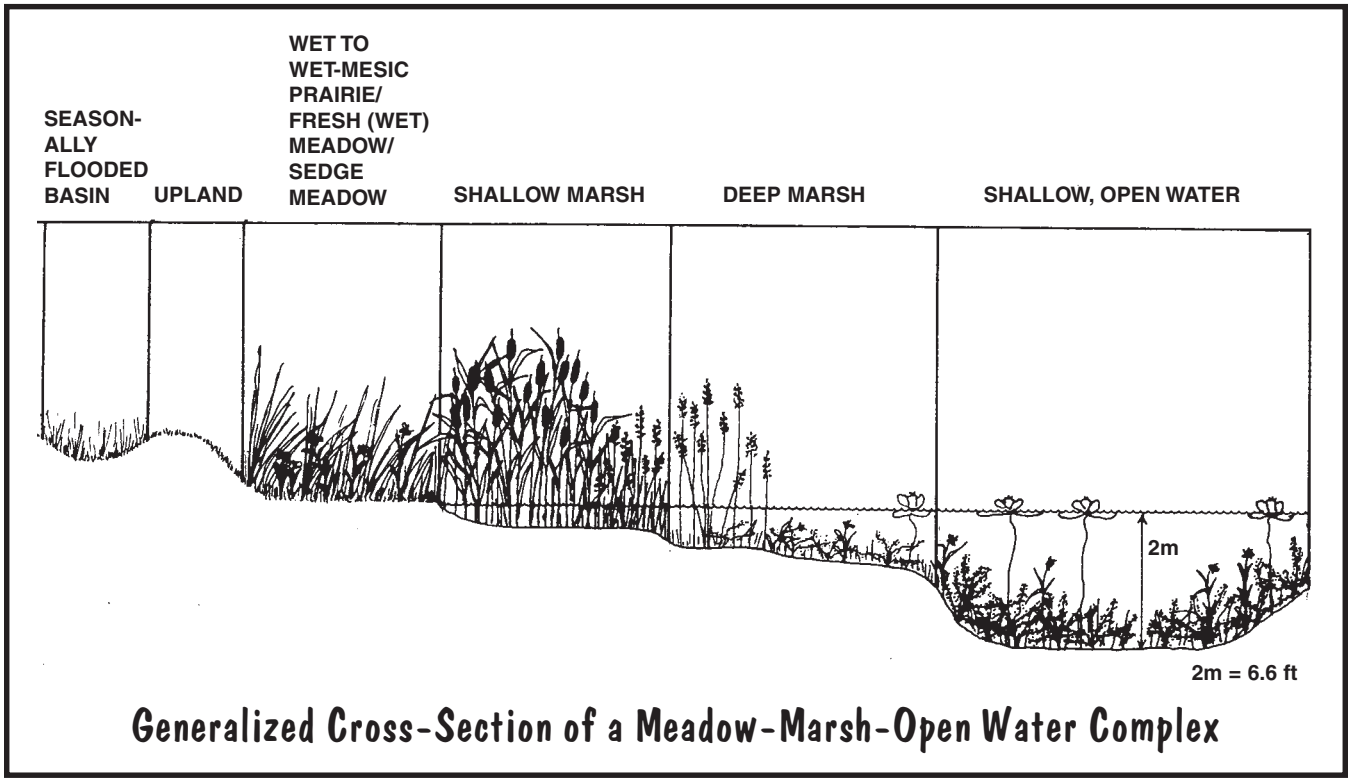


Figure 2: Generalized cross-section of a meadow-marsh-open water complex. From *Wetland Plants and Wetland Plant Communities,* by Steve D. Eggers and Donald M. Reed, U.S. Army Corps of Engineers, Second Edition, 1997. Reprinted with permission.

Characteristics of a Streambank

❒ Skirts a linear body of water.

❒ Is exposed to constant deposition of sediment and erosion of soil.

❒ Is exposed to constant fluctuation of quantity and velocity of water flow.

❒ Three major longitudinal zones determine the makeup of plant communities:

- Headwater zone: narrow channel
- Transfer zone: wide floodplain
- Depositon zone: flowing towards the mouth

❒ Requires a complex diagnostic process before restoration is attempted.

❒ Emergent vegetation, such as grasses and low shrubs at and near water level, reduces velocity, while roots hold soil particles in place. (See Figure 3.)

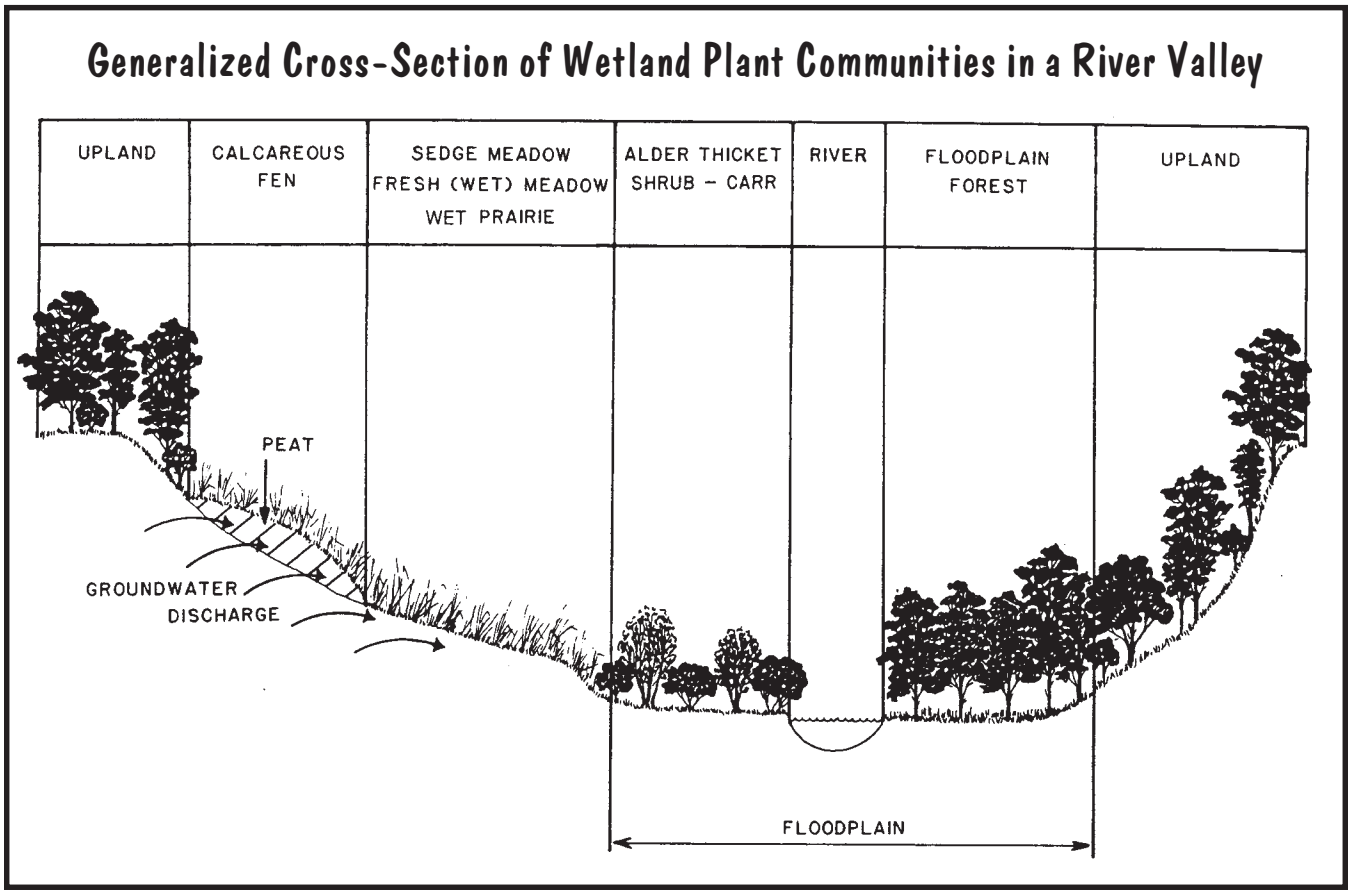


Figure 3: Generalized cross-section of wetland plant communities in a river valley. From *Wetland Plants and Wetland Plant Communities,* by Steve D. Eggers and Donald M. Reed, U.S. Army Corps of Engineers, Second Edition, 1997. Reprinted with permission.

Guiding Principle

To enhance the ecological quality of state trails,
canoeing and boating routes, and water access sites,
thereby increasing the quality of the recreational experience
and fostering trail user awareness and appreciation.

This principle can be achieved by:

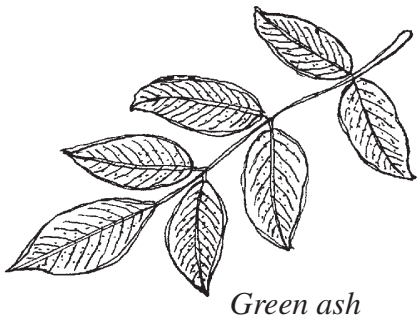
❒ **Preserving ecologically diverse riparian areas.**

❒ **Limiting the removal of natural vegetation** to the greatest extent possible.

❒ **Creating conditions that allow for natural recolonization** of native plants.

❒ **Re-establishing an ecologically functional shoreline/ streambank** with locally native plants.

❒ **Interpreting plant communities** and associated management and restoration activities.



Green ash

Assessing Site-Specific Needs: Management, Restoration or Re-establishment?

When is management of a community sufficient? When is restoration the preferred approach? When is re-establishment needed?

Management means taking care of what's already there: encouraging and improving the continued growth and enhancement of natural communities already in place at a particular site. Management can also be considered a form of restoration—trying to improve a site ecologically.

Restoration represents a more intensive effort. It is a process of returning a degraded natural community to its original structure and species composition.

Areas in need of restoration usually offer the "basic ingredients" necessary to represent a natural community, but the quality of the overall community is less than what it should be. Restoration efforts focus on enhancing what's already there, to improve the overall quality and long-term viability of the natural community.

Restoration can be thought of as nursing biodiversity back to health through such activities as exotic species control, interseeding, interplanting, and prescribed burning.

Re-establishment represents the most intensive effort but is probably the least understood at this time. It is about attempting to re-establish a natural plant community that once existed in a specific location. This process is a beginning that gives us the opportunity to gain greater knowledge about the complexity of natural systems while actively participating in helping to heal the land, which is a satisfying activity in itself. DNR ecologists and resource managers can help identify a target community in a chosen location.

Conducting a Comprehensive Site Analysis

Conducting a comprehensive site analysis is the first step in evaluating a specific site. A site analysis should include the following steps:

❒ Learn about the biological history of the site.

• Refer to *The Natural Vegetation of Minnesota at the Time of the Public Land Survey: 1847-1907*.

• Consult Minnesota County Biological Survey (MCBS) maps and descriptions.

❒ Survey and evaluate existing vegetation on the site.

• Consult *Minnesota Native Plant Communities Classification, Version 2*

•Consult *Field Guide to the Native Plant Communities of Minnesota* 2004-2006

• Solicit help from a botanist or ecologist, or learn to identify plants.

❒ Determine whether any listed plant or animal species are present.

• Check the Minnesota listing.

• Solicit help from an ecologist.

❒ **Analyze soil types and characteristics.**

• Refer to *Soil Surveys by County: NRCS in Cooperation with Minnesota Agricultural Experiment Station*, from the U.S. Department of Agriculture.

• Conduct a soil sampling onsite.

• Determine soil compaction or disturbance.

• Determine content of organic matter and nutrient levels.

• Determine pH factor.

❒ **Determine soil moisture** gauged on a gradient from open water to saturated to wet.

❒ **Consider topographic features,** such as slope and aspect.

• Determine whether the site is hilly or level; identify degree of exposure to the sun (south, north, east or west).

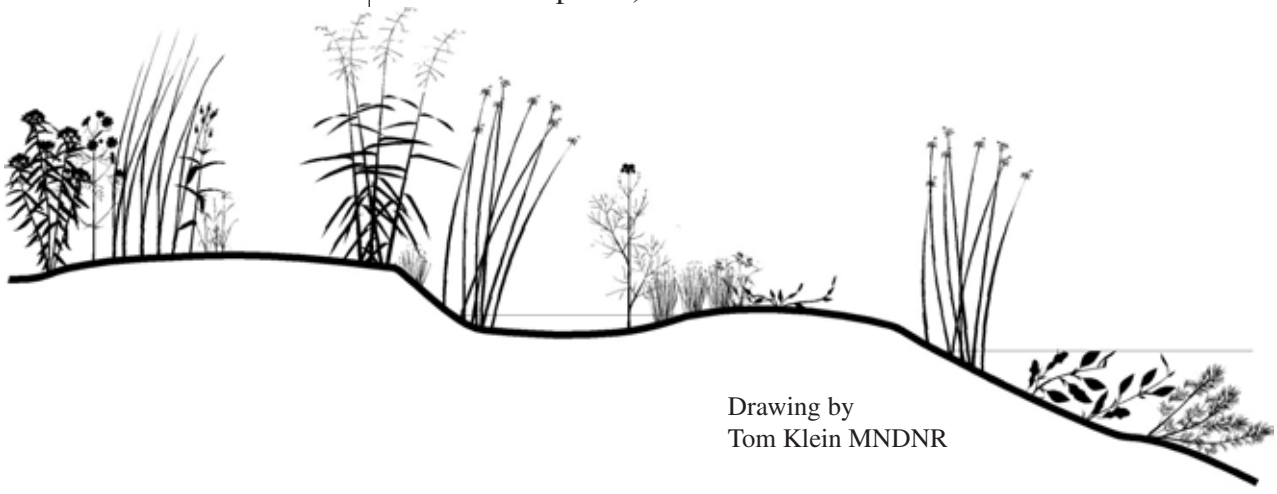
❒ **Consider the microclimatic conditions** of the site, within the regional context.

❒ **Select the appropriate plant species** according to site conditions and the specific landscape unit.

• Consult *Vascular Plants of Minnesota,* by G. B. Ownbey and T. Morley (1991).

• Consult the County Biological Survey database.

• Consult *Restore Your Shore* CD ROM (includes an encyclopedia of native plants).



Drawing by
Tom Klein MNDNR

Riprap and concrete create a physical barrier that disrupts continuous vegetation from the water's edge to the upland.

Choosing Bio-engineering Techniques over Riprap

The stabilization of riparian areas after a disturbance is essential in controlling negative impacts to the fragile riparian edge and the associated water body.

Using Bio-engineering Techniques

The use of bio-engineering (soft armor) techniques is the preferred alternative in most cases and should be applied to the greatest extent possible. These techniques combine mechanical elements (structures) and biological elements (plants), which function together in an integrated manner to blend ultimately into the native landscape, thereby providing ecologically functioning shorelines and streambanks.

Although initially more labor intensive than hard armor techniques, bio-engineering techniques are less expensive in regard to the use of material and energy.

Once established, the shoreline, streambank or any slope repaired with bio-engineering techniques continues to grow and become stronger. Diversity of plants and their flexibility, along with various root structures and their depth, hold soil in place. Roots also extract moisture from the soil via evapotranspiration. Plants and roots withstand the erosive forces of moving water and have indefinite life expectancy.

Bio-engineering techniques are effective both below and above the Ordinary High Water Line (OHWL). Techniques are tailored to the needs of each individual site.

Using Riprap

Structural protection with riprap or concrete is a typical "hard armor" technique that is still used too frequently today. Riprap and concrete create a physical barrier that disrupts continuous vegetation from the water's edge to the upland.

These techniques do not include the use of live vegetation and thereby forgo the gradual re-development of a naturalized shoreline. Hard armor, like concrete and rip-rap, will weaken with age, having a limited life expectancy.

Restoring and Re-establishing Native Plantings in Shallow Water Below the Ordinary High Water Line

Things To Remember

✔ Obtain required permits from DNR Divisions of Waters and Fisheries, and Corps of Engineers.

✔ Evaluate each site and select the appropriate site preparation method and plant species.

✔ Inventory nearby natural vegetation to guide species selection.

✔ Be mindful of potential native seedbank.

Permit Requirements

❒ **A permit is required** from the Corps of Engineers and the DNR Division of Waters to do any structural work in public waters below the Ordinary High Water Line (OHWL).

❒ **A permit is required** from the DNR Division of Fisheries for the following activities: using herbicides; physically removing plants; planting (either seeds or transplants); or harvesting plants below the OHWL.

❒ **A permit is required** from the DNR Division of Fisheries for placing temporary structures (such as wave breaks) below the OHWL.

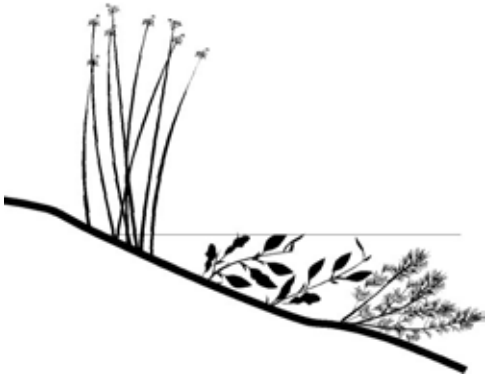
The Shallow Water Zone

This area includes emergent, floating and submerged vegetation. These plants are naturally adapted to withstand wave action, ice action and flowing water. They also hold sediment in place and provide food for fish and other wildlife.

This zone is an important part of the shore ecosystem. Therefore, riparian restoration often includes planting below the OHWL.

Limited numbers of species grow within the emergent zone in broad, simple patterns. Because most plants will spread on their own, it is sufficient to plant them 1-2 feet apart.

A planting in this zone will be nearly maintenance free after plants are rooted. Any pattern of native plants that evolves is fine. Only exotic plants should be removed.



Common arrowhead

Emergent Native Plants for Shoreline Anchoring That Are Common Throughout Minnesota

(alphabetical by scientific name)

Forbs:

Sweet flag *Acorus calamus*
Mud plantain *Alisma subcordatum*
Water plantain *Alisma triviale*
Water hemlock *Cicuta maculata*
Blue flag iris *Iris versicolor*
Marsh-vetchling *Latyrus palustris*
Fringed loosestrife *Lysimachia ciliata*
Monkey flower *Mimulus ringens*
Yellow pond lily *Nuphar luteum ssp. variegatum*
Smartweed *Polygonum ssp*
Pickerelweed *Pontederia cordata*
Northern arrowhead *Sagittaria cuneata*
Common arrowhead *Sagittaria latifolia*
Water parsnip *Sium suave*
Giant bur-reed *Sparganium eurycarpum*
Bladderwort *Urticularia vulgaris*

Grasses, sedges and rushes:

American slough grass *Beckmannia syzigachne*
Blue-joint grass *Calamagrostis canadensis*
Bottlebrush sedge *Carex comosa*
Porcupine sedge *Carex hystericina*
Lake sedge *Carex lacustris*
Woolly sedge *Carex lanuginosa*
Fox sedge *Carex vulpinoidea*
Spike rush *Eleocharis spp*
Cotton grass *Eriphorum angustifolium*
Tall manna grass *Glyceria grandis*
Fowl manna grass *Glyceria striata*
Common rush *Juncus effusus*
Slender rush *Juncus tenuis*
Hardstem bulrush *Scirpus acutus*
River bulrush *Scirpus fluviatilis*
Softstem bulrush *Scirpus validus*
Cordgrass *Spartina pectinata*
Broad-leaved cattail *Typha latifolia*

Natural Recolonization of Native Plants

It may not always be necessary to plant shallow water areas, because natural colonization may occur over time from plant propagules and the seedb ank in the soil, especially if the restoration site is connected to natural wetlands or shorelines. High water levels and associated deposition of silt (which contains seed) can also result in natural colonization.

Best natural response occurs when sediments are exposed to the air through natural or sometimes artificial lowering of water level (drawdown). Oxidation stimulates seed germination. Plants will also recolonize naturally as a result of seed distribution by wind, waves and animals.

Winter Wetland/Shoreline Seeding

Wet sites are much more accessible when the ground is frozen. In addition, winter seeding replicates nature in several ways. The seed is dispersed and stratified during the winter months, as it would occur naturally. Early winter seeding is best, because stratification works best when seeds are in the soil through the winter months.

Monkey flower

Weather and site conditions will largely determine how successful the seeding will be. The ideal situation would be:

- ❒ No snow on the ground
- ❒ Low water levels, to be able to include plant species that will later be submerged
- ❒ Warm enough weather to allow the soil surface to be lightly cultivated for good seed/soil contact
- ❒ Bird migration season already completed, so that seeds won't be eaten

Species selection is a critical factor in the site's future sustainability and diversity. Average water levels determine which species will be most successful in which location. It is important to include in the mix both early successional species for quick establishment, as well as slow-to-establish, long-lived species for long-term cover.

Use of a clean mulch can help retain soil moisture and add organic matter.

Planting in Shallow Water

Site Preparation

It is essential to eliminate exotic and invasive plants from a site. This effort can prove to be a tedious process that often requires an entire growing season. Species such as reed canary grass and purple loosestrife need to be cut and treated with herbicides to eliminate the entire plant. (See Chapter 5: Controlling Exotic Species.)

It is essential to eliminate exotic and invasive plants from a site. This effort can prove to be a tedious process that often requires an entire growing season.

Soil preparation is generally not required. Bringing in organic substances or other soil amendments would only jeopardize the success of a planting by potentially introducing exotic plants and excessive weed growth.

It is best to select plant species that fit the site. If needed, secure the help of a botanist, ecologist or fisheries expert. Nearby natural sites can also provide a model.

Obtaining Plant Material

It is important to secure an appropriate plant source before attempting a restoration planting. (See page 27 for suppliers of native seeds and plants)

When purchasing plants from a nursery, it is important to determine the source of the plants. The seed source should be as local as possible but no further than 200 miles from the site, in order to protect and maintain regional genetic makeup.

There may be an opportunity to harvest native plants from a site that will be destroyed by development. These rescued plants should be planted immediately in a temporary bed, with top greens cut back to help plants recover more quickly. Then they should be cared for until the final site is ready to be planted. It is important to check each plant for potentially attached exotic plants.

Planting

Late spring, after water levels have lowered, is the best time to plant aquatic plants. It also gives the plants time to establish a good root system over the summer.

Planting depth is crucial for optimum growth. Plant them so that the surface of the root ball matches the existing soil surface on the site. If the plant was rootbound in the container it came in, carefully break up the root ball to allow the roots to spread more easily in the new environment.

Recommended spacing of plants is one plant per square foot on center. Groupings should be random, and plants should be arranged in groups on center, not in rows. There are no rows in nature.

Installing Wave-Breaking Devices To Protect a New Planting

After planting, temporary wave-breaking devices may be needed to protect a new planting until it is well rooted. Leaving such devices through one growing season is usually sufficient. If the shoreline is a naturally protected site, a wave-breaking device may not be needed.

A DNR permit is required to build and maintain wave-breaking devices until they can be removed.

These devices are placed in the water ahead of the plantings to break boat- and wind-created waves. They may be constructed of commercially available coconut fiber logs, hardwood brush, reusable plywood or plastic fencing. Hardwood debris (such as logs and coarse brush) and bulky plant material (such as cattails) can provide the same protection and may be available near the site.

The breakers should protrude a few inches above the normal water level. **A DNR permit is required** (see page 8 Permit Requirements) to build and maintain these structures until they can be removed. Wave breaks need maintenance, because scouring occurs around and beneath them.

Coconut fiber logs

Coconut fiber logs can be anchored offshore as a wave breaker, or they be laid directly against the shoreline, using stakes to hold them in place. Seedlings are then planted in the calm water behind.

Brush bundles

Brush bundles are probably the least expensive yet effective wave breakers. Brush bundles are constructed by using live or dead branches up to 1 inch in diameter. Bundled tightly with twine or wire, they are staked in place with wood stakes, and secured to one another with twine or wire. If brush is heavily branched, additional pruning of side branches is advised, so the brush can be bundled tightly.

Using Plant-Anchoring Devices To Support Plants and Seedlings

Plant-anchoring devices include mats, carpets, blankets or pallets made of coconut fiber (coir) or jute. They can be used instead of or in combination with wave breakers. They also give plants or seedlings the support and time to become firmly rooted.

These products are staked over a seeded area, or seedlings are planted in the open weave fabric. Some mats can be purchased pre-planted by arrangement with a nursery for quicker establishment of vegetation. Lower-density mats or those with an open weave are preferred, since they allow plants to sprout through the fabric more easily.

Coconut fiber carpet, mat or blanket (also known as coir) is also a useful anchoring material, due to its longevity in the environment. It biodegrades over a period of several years. Mats and blankets are useful on slopes for holding soil in place.

Jute is another material used as an anchoring device or for erosion control. It biodegrades more quickly than coconut fiber. Mats, carpets, pallets and blankets are available in varying thicknesses and densities. Thicker products are sold in mats and pallets; thinner products, such as netting and woven blankets, are sold in rolls.

Maintaining Aquatic Plantings

No long-term maintenance is required for aquatic plantings. If aquatic plants are adequately protected from wave action, they will quickly establish. Be sure to check regularly for invasive non-native species and remove them immediately.

Basic Principles To Avoid Erosion

❒ Do a careful site analysis, so that the development fits the site.

❒ Avoid extensive earthwork in erosion-prone soils.

❒ Preserve native vegetation to the greatest extent possible.

❒ Remove vegetation in small increments as needed.

❒ Install a silt fence wherever earthwork will occur near the water's edge.

❒ Do not leave soil exposed to wind or rain. Seed a quick growing cover crop and mulch immediately.

❒ Construct sediment basins to prevent eroded soil from leaving the site.

❒ Construct temporary dikes (straw bales) to slow runoff velocities and detain sediment.

❒ Maintain temporary control structures until a site is well vegetated.

Things To Remember

✔ Grade conservatively only what is needed to stabilize a site.

✔ Use bio-engineering techniques rather than riprap or other hard armor methods.

✔ Use plant material and seeds that are native to the region.

Stabilization of Riparian Environments at or above the OHWL and on Steep Upland Slopes

Soil erosion occurs when bare soil is exposed to heavy rain, snowmelt or uncontrolled runoff from construction sites or large impervious areas. It is of critical importance to protect the bank or shore of a water body with a silt fence before soil is exposed during the development of a site.

Even soil eroding from unvegetated upland slopes will eventually impact a water body negatively by contributing siltation, increased nutrients, and other pollutants. Water quality and wildlife habitat will be compromised by diminishing natural plant diversity, impacting fish and other organisms, and introducing exotic and invasive plants, which thrive in such disturbed environments.

Expedient temporary and permanent revegetation of open soil sites is equally important. The use of bio-engineering techniques should be given priority over the use of riprap on all relevant Trails and Waterways sites.

Common pussy willow

Benefits of Bio-engineering Installations

❒ They effectively stop erosion and build on the regenerative force of vegetation to protect and naturalize eroded shorelands, streambanks and upland slopes.

❒ They provide enough stability to a disturbed slope that natural invasion and colonization of native plants can take place and eventually take over the stabilizing role.

❒ They generally require minimal access for equipment and therefore cause relatively minor site disturbance.

Suitable Plant Material

Stakes and bundles of fast-rooting trees and shrubs are particularly suited to reinforcing soil with roots and drawing excess water from the soil through evapotranspiration, thereby minimizing downslope movement of earth masses. (See "Native Plant Species Recommended for Stabilizing Slopes," page 25.)

Selected plant material should:

- Root easily
- Be long, straight, and flexible
- Be in plentiful supply near the project site

When installed properly, this fast-rooting material:

- Stabilizes the surface layer from wind, and gravitational and hydraulic forces
- Slows the movement of water and soil particles down the slope
- Traps sediment in the live brush and promotes infiltration of water
- Allows seeds to establish in the moister sediment, thereby allowing natural succession to take place

Peachleaf willow

Shaping the Bank, Shore or Slope

Any shaping of a disturbed slope should be done very conservatively and only to stabilize it so that plants can take hold. Any unnecessary grading may also forgo the potential for natural recolonization of native plants.

Selected Bio-engineering Techniques

The following bio-engineering techniques are recommended to help stabilize erosion-prone environments along shores and banks, as well as on upland slopes.

Erosion Control Fabrics

When to use: On slopes when soil needs to be held in place until plants establish from seed.

Method: Jute, coir, straw and wood fiber blankets are staked over a seeded area. Seedlings may be planted through slits in the fabric. Erosion control fabrics are also useful in combination with other methods, such as the installation of stakes, branch packing, fascines and brush layering.

Live Stakes

When to use: In areas of minor erosion or shallow sliding. Live stakes can also be used in combination with erosion control fabrics.

Method: To stabilize a slope, any bank overhang must first be removed, shaping the bank so it is stable. Live stakes are cut and planted on the site during the dormant season. Willows and cottonwood work well. For additional suitable plant materials, see “Native Plant Species Recommended for Stabilizing Slopes,” page 25.

Stakes should be 2 to 3 feet long with a minimum diameter of 1/2 inch: The larger the diameter, the greater the food reserves. Side branches need to be cut off clean, and bark needs to be intact.

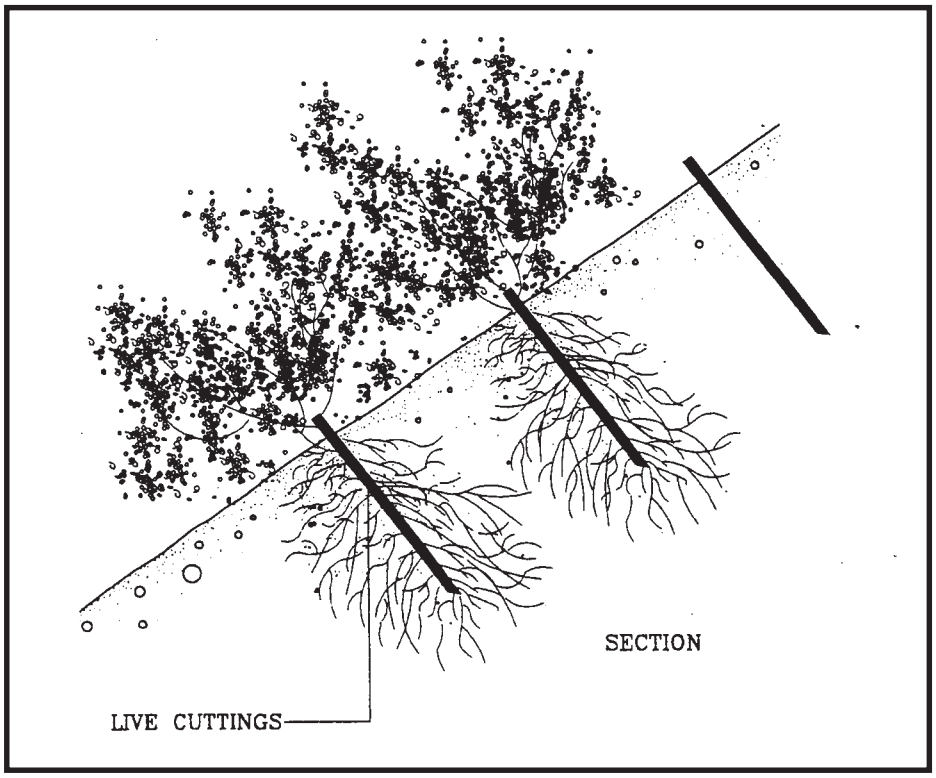


Figure 4: Schematic diagram of an established, growing live stake installation.
From *Biotechnical and Soil Bioengineering Slope Stabilization, A Practical Guide for Erosion Control,* by Donald H. Gray and Robbin B. Sotir, John Wiley & Sons, 1996. Reprinted by permission of John Wiley & Sons, Inc.

Tamp the live stake into the ground at right angles to the slope, using a mallet to avoid splitting the stake. At least two buds should be above the ground after planting, and 80% of the stake should be in the ground. The butt of the stake should be cut diagonally, for easier insertion. Soil must be firmly tamped around the stake. Install the stakes 2-3 feet apart, using triangular spacing. There should be 2-4 stakes per square yard. (See Figure 4.)

Cottonwood

Branch Packing

When to use: On small areas that have been scoured out or have slumped, leaving a void.

Method: Once the problem has been identified and corrected, alternate layers of live branches and backfill are installed, which will rapidly vegetate the scour. Slump areas should not exceed 4 feet in depth or width. For suitable plant materials, see "Native Plant Species Recommended for Stabilizing Slopes," page 25.

Live branch cuttings can range from 1/2 inch to 2 inches in diameter. They should be long enough to reach the undisturbed bank and should protrude slightly beyond the rebuilt slope face. Depending on the size of the scour/slump, wooden stakes should be 5-8 feet long, made from 3-inch to 4-inch diameter poles.

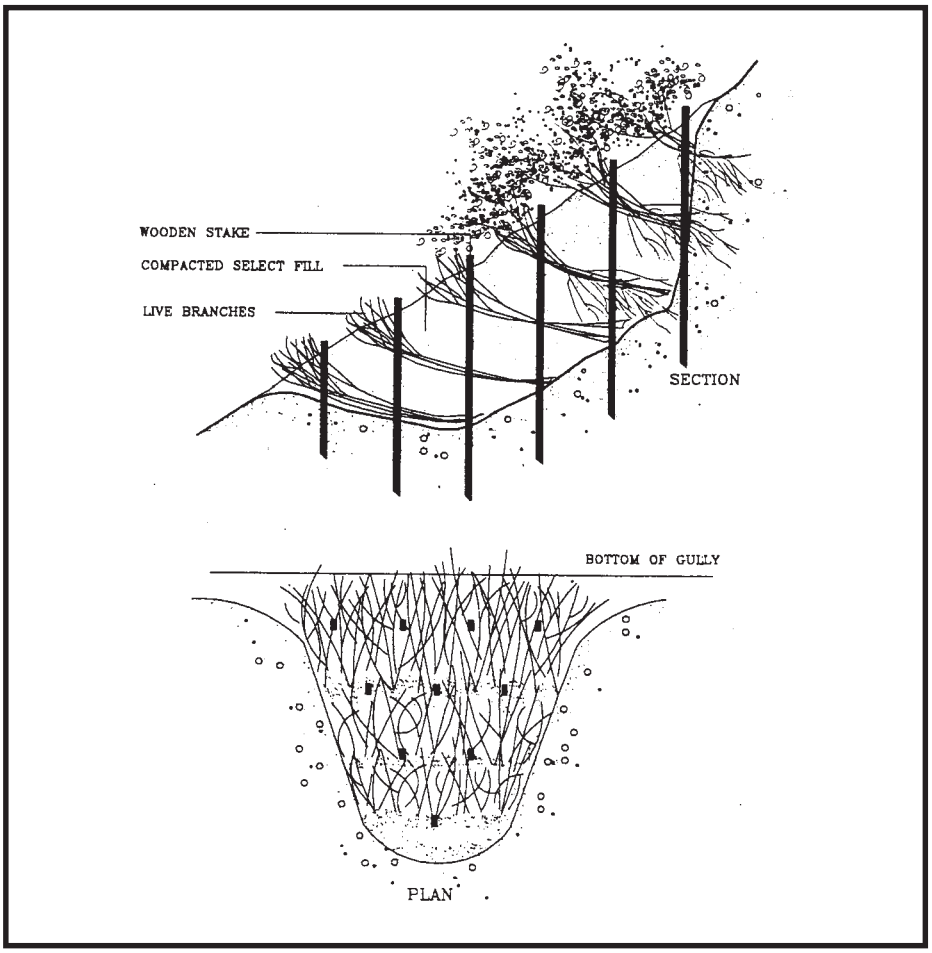


Figure 5: Schematic diagram of an established, growing branchpacking installation.
From *Biotechnical and Soil Bioengineering Slope Stabilization, A Practical Guide for Erosion Control,* by Donald H. Gray and Robbin B. Sotir, John Wiley & Sons, 1996. Reprinted by permission of John Wiley & Sons, Inc.

Starting at the lowest point, the stakes are driven 3 feet into the ground, 1 to 1 1/2 feet apart. A layer of live branches 4 to 6 feet thick is placed in the bottom between the stakes, with basal ends lower than growing tips. Each layer of branches is covered by a layer of soil, which is lightly compacted to ensure good soil contact. The final installation should match the existing slope profile, with growing tips protruding slightly. (See Figure 5.)

Live Fascines (Wattles)

When to use: Where minimum site disturbance is crucial, providing excellent protection against surficial erosion.

Method: Fascines are bundles (wattles) of dormant rootable plant material placed in shallow trenches on contour. Suitable plant material is listed in Table 1 on page 25. The bundles consist of live twigs of plant species that root easily. Dead material can be mixed in if there is a shortage of live twigs.

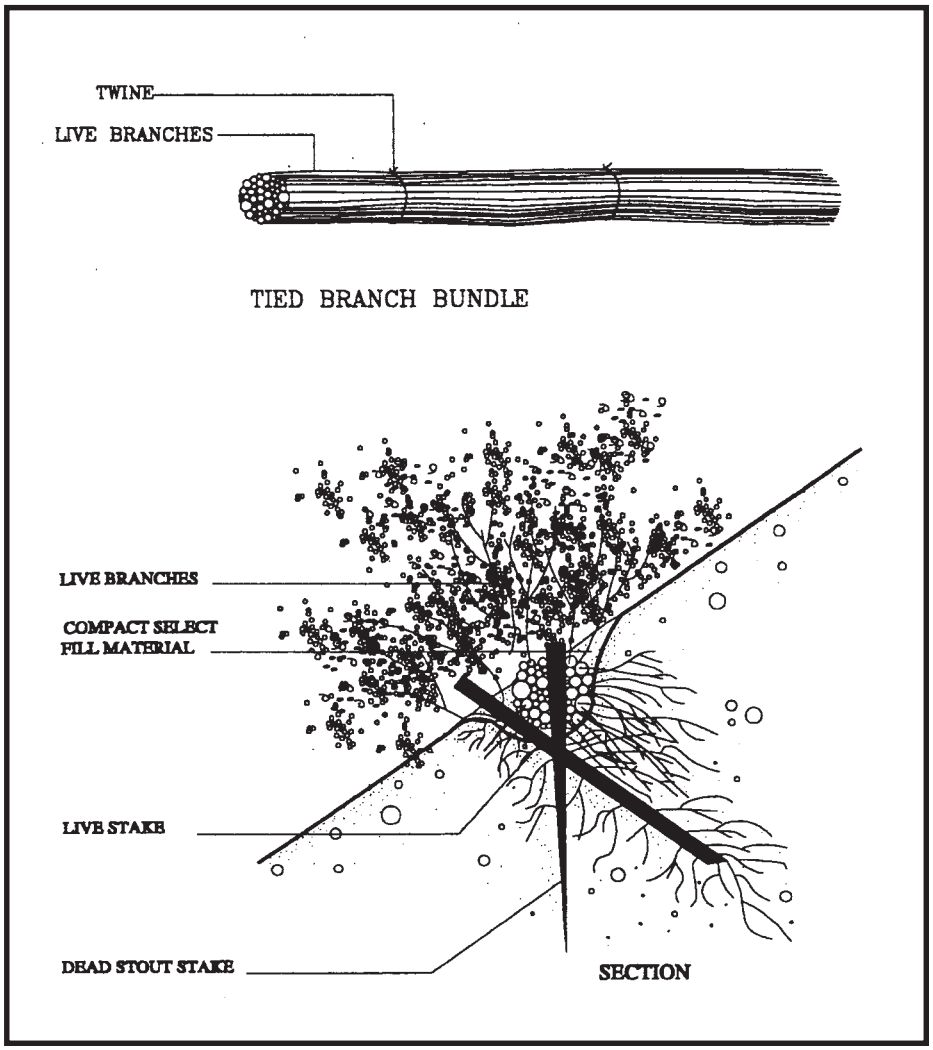


Figure 6: Schematic diagram of an established, growing live fascine installation, showing live fascine bundles (above) and method of placement in a slope (below). From *Biotechnical and Soil Bioengineering Slope Stabilization, A Practical Guide for Erosion Control,* by Donald H. Gray and Robbin B. Sotir, John Wiley & Sons, 1996. Reprinted by permission of John Wiley & Sons, Inc.

❒ While fascines may be installed in the fall, early spring may be better, when soil moisture is high and the growing season is ahead. Suitable material (see Table 1, page 25), consisting of twigs and branches 1 1/2 inches in diameter or less, is made into bundles 5-10 feet long. These bundles should be 6 to 8 inches in diameter, with all growing tips pointing in the same direction. The bundles are tied tightly with twine or wire. (See Figure 6.)

❒ Bundles should not be prepared more than 1 or 2 days before placing, and they should be stored covered and kept moist in a shady place. They should not be laid out on the slope exposed to sun and wind.

❒ Proper staking (using live stakes or tapered construction stakes) is essential to secure the bundles. Using live stakes of the same species as the bundles has the advantage that they will root and add to the plant cover.

❒ Work proceeds from the bottom of the slope to the top on contour. Vertical spacing of rows can range from 3 feet when working with a slope of maximum steepness of 2:1 (2 horizontal lengths to 1 vertical height) up to 10 feet, depending on the steepness of the slope and soil characteristics.

❒ Trenching should be done just prior to the laying of the bundles to minimize drying of the soil. The trench should be shallow, just slightly less than the diameter of the bundles.

❒ Bundles are placed into the trench. Bundles will be held in place by inert or live stakes driven through the bundles, about 2-3 feet on center. Extra stakes should be used at the connection points of the bundles.

❒ Bundles are covered with soil, leaving 10% of their surface exposed. Walking on the finished fascines will help work the soil in between the bundles for better soil contact for maximum root development.

❒ A completed fascine should resemble a slight terrace with a windrow of twigs protruding from the lower edge. If properly constructed, the bundles are neither so exposed as to encourage undercutting by runoff, nor so completely buried as to be overrun by water and silt. After fascine installation, planting and seeding of permanent vegetation can occur. On flatter slopes, use long straw for mulch between fascines; on steep slopes, use anchored jute or coir netting. Mulch effectively prevents raindrops from eroding bare soil.

Brush-Layering

When to use: Where deeper reinforcement of the soil is needed on upland slopes.

Method: Contour brush-layering is related to fascines on contour. But there are some differences:

❒ Branches are laid perpendicular to the slope on benches, with developing roots reaching deeper into the slope, and tips of branches protruding beyond the face of the slope. Protruding tips slow runoff velocity and filter sediment.

❒ Brush-layering can be used in fill slopes and cut slopes. Branches are not bundled but are spread out across the bench.

Installation of fill slopes

During embankment construction from the sole of the slope up, regular grading equipment can be used to haul and install the brush. Each layer of brush is covered with a layer of soil and then lightly compacted. These branches root along their length and act as immediate horizontal slope drains. (See Figure 7.)

Mulch should be placed between rows. Jute, coir or hold-down netting should be used on steeper slopes for better protection.

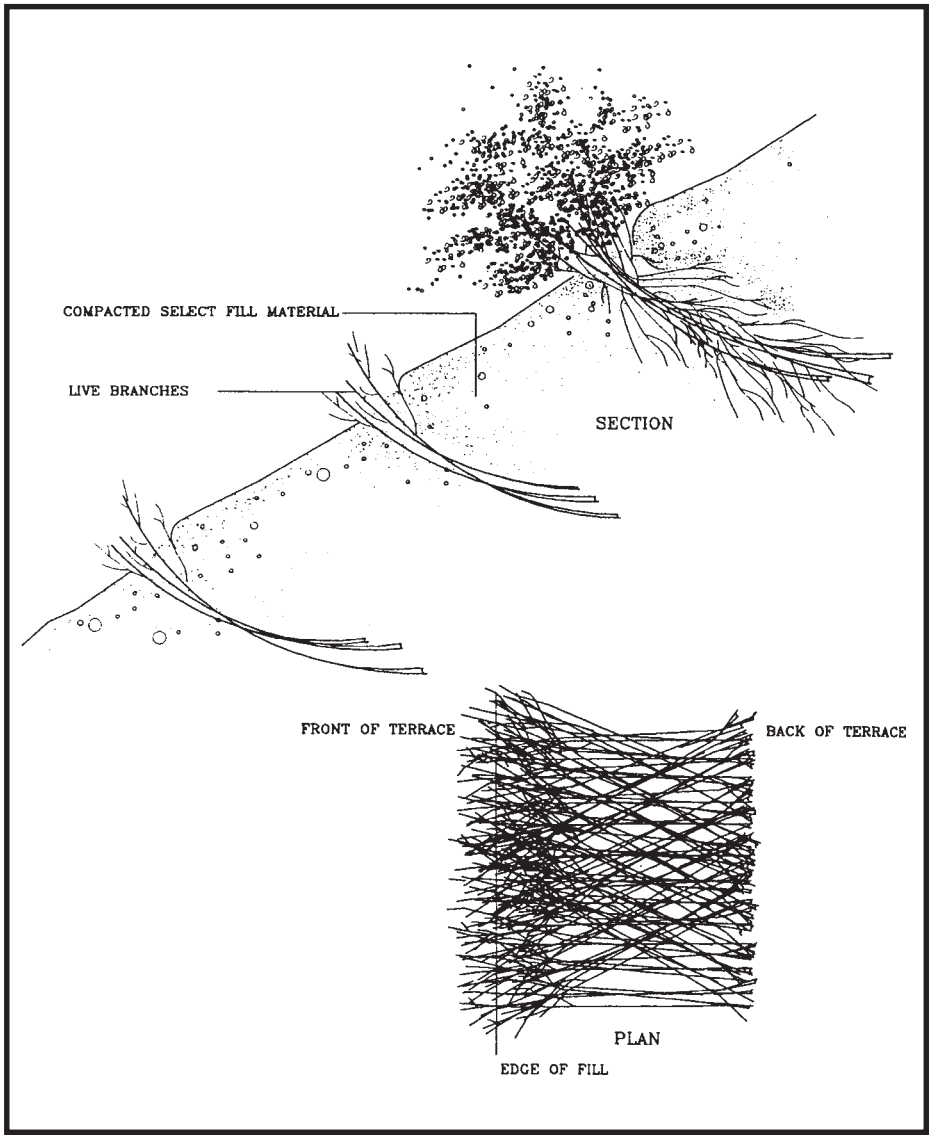


Figure 7: Schematic diagram of an established, growing fill slope brush layer installation, showing alternating layers of live cut brush inserted between lifts of soil. From *Biotechnical and Soil Bioengineering Slope Stabilization, A Practical Guide for Erosion Control,* by Donald H. Gray and Robbin B. Sotir, John Wiley & Sons, 1996. Reprinted by permission of John Wiley & Sons, Inc.

Installation of cut slopes

For remedial treatment of existing slopes, small benches are excavated. The branches are inserted into the slope perpendicular rather than parallel, which provides reinforcement that is better oriented and better able to resist shallow shearing.

The width of the benches ranges from 2-3 feet. Benches are angled back into the slope slightly. Live brush is placed on the bench, followed by backfilling and compacting soil.

Brush is cut into 3- to 4-foot lengths with stems of 3/4 inch to 2 inches in diameter. Brush should protrude to filter sediment from runoff and hold it on the slope. The slope should not be steeper than 2:1, with a spacing 3 to 5 feet between benches as steepness of slope decreases, depending on soil and site condition. (See Figure 8.)

Mulch should be placed between rows, as with fill slopes. Jute, coir or hold-down netting should be used on steeper slopes for better protection.

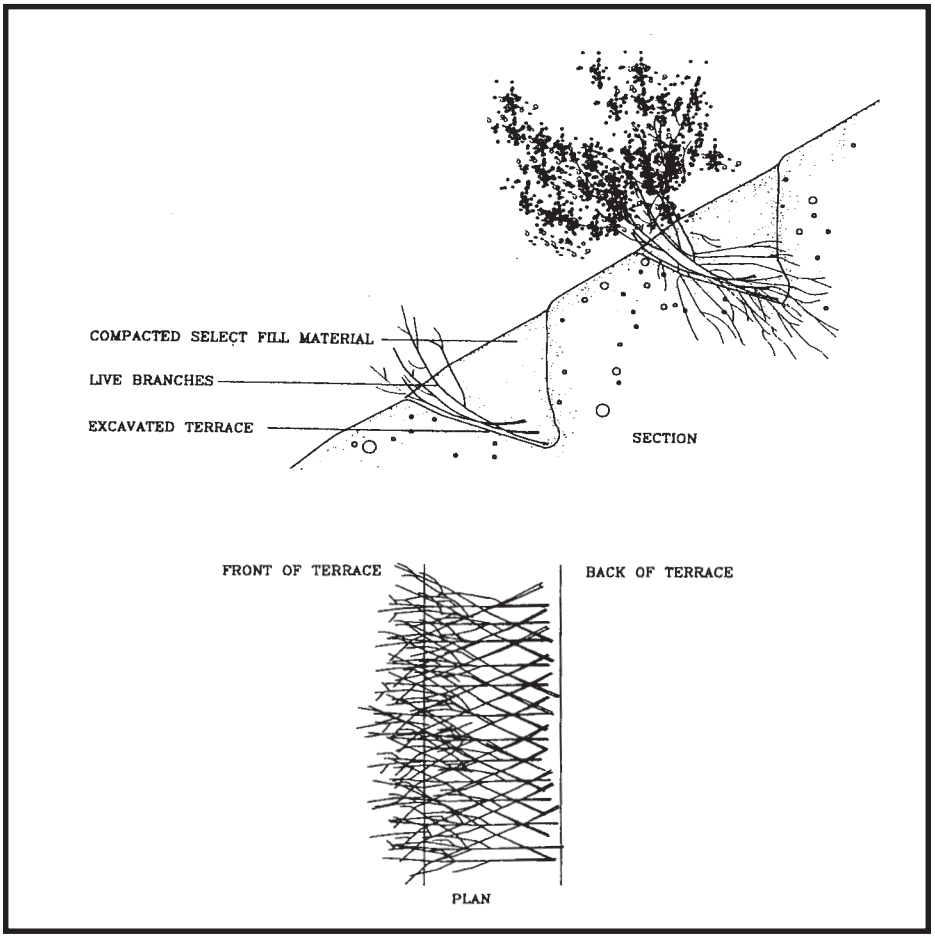


Figure 8: Schematic diagram of an established, growing cut slope brush layer installation, showing alternating layers of live cut brush placed on narrow benches or terraces excavated in the slope. From *Biotechnical and Soil Bioengineering Slope Stabilization, A Practical Guide for Erosion Control,* by Donald H. Gray and Robbin B. Sotir, John Wiley & Sons, 1996. Reprinted by permission of John Wiley & Sons, Inc.

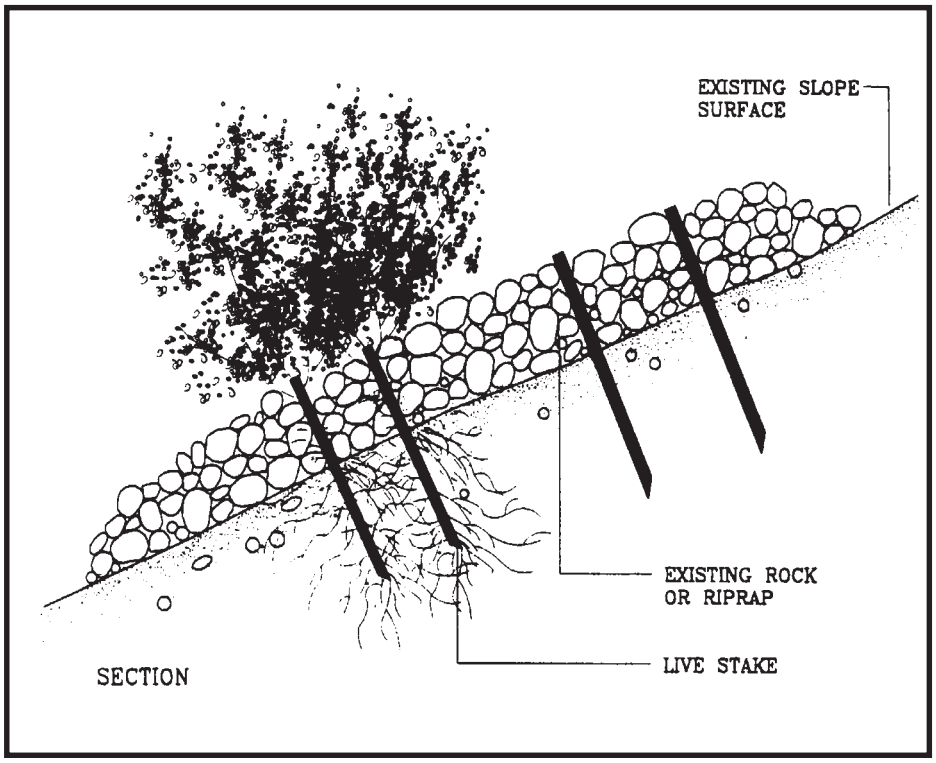


Figure 9: Schematic diagram of an established, growing vegetated riprap joint planting. From *Biotechnical and Soil Bioengineering Slope Stabilization, A Practical Guide for Erosion Control,* by Donald H. Gray and Robbin B. Sotir, John Wiley & Sons, 1996. Reprinted by permission of John Wiley & Sons, Inc.

Joint Plantings

When to use: Where plants can enhance existing or needed rock riprap.

Method: Live stakes are tamped into joints or openings between the rocks. Root systems provide a mat beneath the rock that holds soil in place. Survival rate of stakes can be low if stakes don't have good soil contact, and they are easily damaged as they are driven in between the rocks. (See Figure 9.)

Additional Bio-engineering Techniques

Additional bio-engineering techniques exist beyond those presented in this section. Local soil and water conservation district staff and DNR staff with experience in bio-engineering can provide assistance in the use of appropriate stabilization techniques for individual sites.

Treatment and Use of Plant Material Suitable for Bio-engineering Techniques

Trees and shrubs used for cuttings in bio-engineering construction techniques are pioneer species (early successional species). Pioneer species improve the conditions of disturbed sites, stabilizing and improving soil and microclimate. Given time and stable conditions, the improved soil and microclimatic conditions help long-lived plant species to establish on their own. Planting is also an option if a natural seed source is nonexistent.

Pioneer species improve the conditions of disturbed sites, stabilizing and improving soil and microclimate. Given time and stable conditions, the improved soil and microclimatic conditions help long-lived plant species to establish on their own.

For instance, several species of willows will temporarily grow from cuttings in much less favorable soils, such as denuded lands and road fills. Although most willows naturally grow along moist/wet streamsides and meadows or swales, they will grow for a few years in these less favorable environments, stabilizing the site before they die out.

Speckled alder

Harvesting, Handling and Installation of Cuttings

❒ Cuttings used in bio-engineering construction must be native to the region and cut from local stock.

❒ Install cuttings only during the dormant season between September and April.

❒ Cut branches at the harvest site at 8-10 inches above the ground to assure healthy regeneration.

❒ Select healthy branches that are reasonably straight, and bind them into bundles.

❒ Make clean cuts. Avoid tearing and split ends. The butt ends should be cut to a point for ease of installation.

❒ Install cuttings preferably the same day they are cut and when the temperature is above 50 degrees Fahrenheit.

❒ If cuttings cannot be installed the same day they are cut, keep the branches moist (heeled in or in water), out of the wind and in the shade. Use within 2 days after cutting.

❒ Do not install cuttings that have already broken bud.

❒ Use onsite stockpiled soil as the planting medium if its quality is capable of supporting plant growth.

❒ Ensure that cuttings have a terminal bud scar within 1-2 inches of the top, and that at least two buds are above the ground after installation. Cuttings put out their greatest concentration of shoots and their strongest ones just below the terminal bud scar.

Native Plant Species Recommended for Stabilizing Slopes

Table 1 lists native species recommended for stabilizing slopes and provides useful information related to native regions, size and form, habitat value, root type and rooting ability. (See Minnesota ECS section map, below.)

Name	Minnesota ECS sections	Size /Form	Habitat value	Root type	Rooting ability
Boxelder *Acer negundo*	All	Large understory, 35-50' irregular	Excellent	Moderately deep and spreading laterals	Poor-fair
Speckled alder *Alnus inc. ssp. rugosa*	1-8	Small tree, 20-35' globular	Excellent	Shallow, narrow spreading	Fair
Silky dogwood *Cornus amomum*	5-9	Mid-height shrub, 6-12' globular,	Very good	Shallow lateral, fibrous	Very good
Gray dogwood *Cornus racemosa*	1, 3-9	Mid-height shrub, 6-12', obovoid	Very good	Shallow lateral, fibrous, suckering	Good
Redosier dogwood *Cornus sericea*	All	Mid-height shrub, 6-12', globular	Very good	Shallow lateral, fibrous, stoloniferous	Very good
Common ninebark *Physocarpus opulifolius*	1, 7	Mid-height shrub, 6-12' mound	Good	Shallow lateral, fibrous	Fair-good
Balsam poplar *Populus balsamifera*	1-8	Large canopy, 50-75'	Good	Shallow, fibrous	Very good
Cottonwood *Populus deltoides*	2-9	Large canopy, 75-100' obovoid	Good	Shallow, fibrous	Very good
Quaking aspen *Populus tremuloides*	All	Large understory, 35-50', columnar	Good	Shallow, fibrous, prolific sprouting	Fair
Allegheny blackberry *Rubus allegheniensis*	1, 2, 5-8	Small shrub, 3-6' mound	Very good	Shallow, fibrous, suckering	Good
Red raspberry *Rubus strigosus*	1-8	Small shrub, 3-6' mound	Very good	Shallow, fibrous, stoloniferous	Good
Sandbar willow *Salix exigua*	All	Mid-height shrub, 6-12'	Good	Shallow, fibrous, suckering	Fair-good
Peachleaf willow *Salix amygdaloides*	3-9	Large understory, 35-50', columnar	Good	Shallow, fibrous, extensive	Very good
Pussy willow *Salix discolor*	All	Small tree, 20-35' columnar	Good	Shallow, fibrous, extensive	Very good
Prairie willow *Salix humilis*	All	Medium shrub, 6-12' globular	Good	Shallow, fibrous	Good
Shining willow *Salix lucida*	1, 2, 5, 6	Large shrub, 12-20' globular	Good	Shallow lateral	Very good
Black willow *Salix nigra*	2, 5-9	Large understory, 35-50', columnar	Good	Shallow, divided into multitude of rootlets	Excellent
American elderberry *Sambucus canadensis*	3, 5-9	Medium shrub, 6-12' obovoid	Very good	Shallow lateral, stoloniferous, suckers	Good
Scarlet elder *Sambucus pubens*	1, 2, 5-9	Medium shrub, 6-12' obovoid	Very good	Deep laterals, fibrous	Fair-good
Meadowsweet spirea *Spirea alba*	All	Small shrub, 3-6' mound	Good	Shallow lateral, fibrous, suckering	Fairgood
Hardhack spirea *Spirea tomentosa*	5, 6, 8	Small shrub, 3-6' mound	Good	Shallow, fibrous, suckering	Fair
Wolfberry *Symphoricarpus occidentalis*	All	Small shrub, 3-4' mound	Good	Shallow, fibrous, colony forming	Good
Downy arrowwood *Viburnum rafinesquianum*	All	Small shrub, 3-6' obovoid to globular	Very good	Shallow lateral, fibrous	Fair-good
Nannyberry *Viburnum lentago*	All	Small tree, 20-35' obovoid	Good	Shallow, fibrous	Fair-good

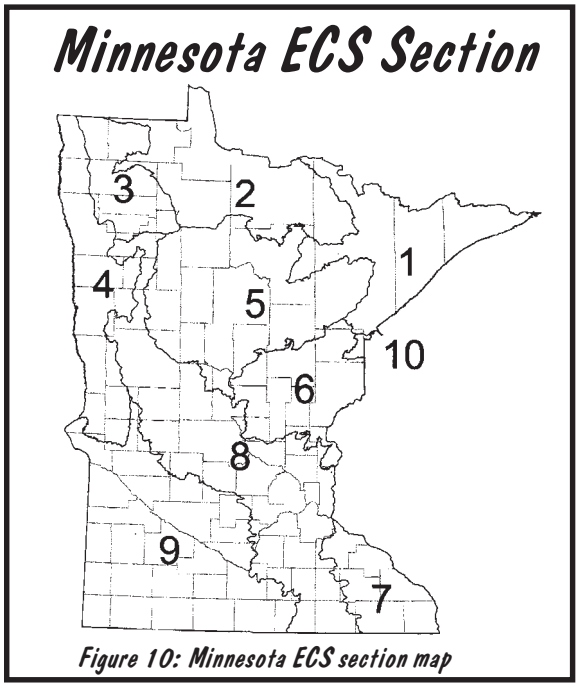


Figure 10: Minnesota ECS section map

Alphabetical by scientific name

Note: Some willow species—and balsam poplar in particular—should not be used in areas in close proximity to the trail tread. These species have stoloniferous roots and grow through the asphalt. This makes a trail unsafe for some uses and creates a maintenance problem.

1 Northern Superior Uplands
2 Northern Minnesota & Ontario Peatlands
3 Lake Agassiz, Aspen Parklands
4 Red River Valley
5 Northern Minnesota Drift & Lake Plains
6 Western Superior Uplands
7 Paleozoic Plateau
8 Minnesota & NE Iowa Morainal
9 North Central Glaciated Plains
10 Southern Superior Uplands

Monitoring of Restoration Sites

It is critical to monitor these sites, so that we can learn how natural systems respond and change over time. We need to use ecological knowledge, statistical inference and informed intuition to interpret these responses and changes. Our goal must be to design and implement a monitoring program that will best help us track our progress in striving for ecological functionality and increased diversity of species on these sites.

The following basic steps will help us get started:

- ❒ Inspect the site regularly.
- ❒ Control exotic species.
- ❒ Prune to reduce competition and stimulate new growth.
- ❒ Assure that temporary wave-breaking devices are in working order.
- ❒ Replace dead unrooted branches.
- ❒ Record and evaluate changes to each site annually.
- ❒ Adjust management activities as needed.

Plant Sources for Aquatic Forbs and Grasses

Look for nurseries that specialize in plants that grow in aquatic environments. Be sure to ask for source identification when purchasing seeds, propagules and plants. Some nurseries also offer contract growing plants for specific projects, from seeds collected from a nearby site.

For Suppliers of Native Seeds and Plants, go to:

http://www.dnr.state.mn.us/gardens/nativeplants/suppliers.html

Speckled alder

For Further Information

Biotechnical and Soil Bioengineering Slope Stabilization, A Practical Guide for Erosion Control, by Donald H. Gray and Robbin B. Sotir. John Wiley & Sons, New York, 1996.

Healthy Rivers: A Water Course, this CD ROM is an interactive tool to understand the ecology and management of river systems; produced by the Department of Natural Resources, 2004.

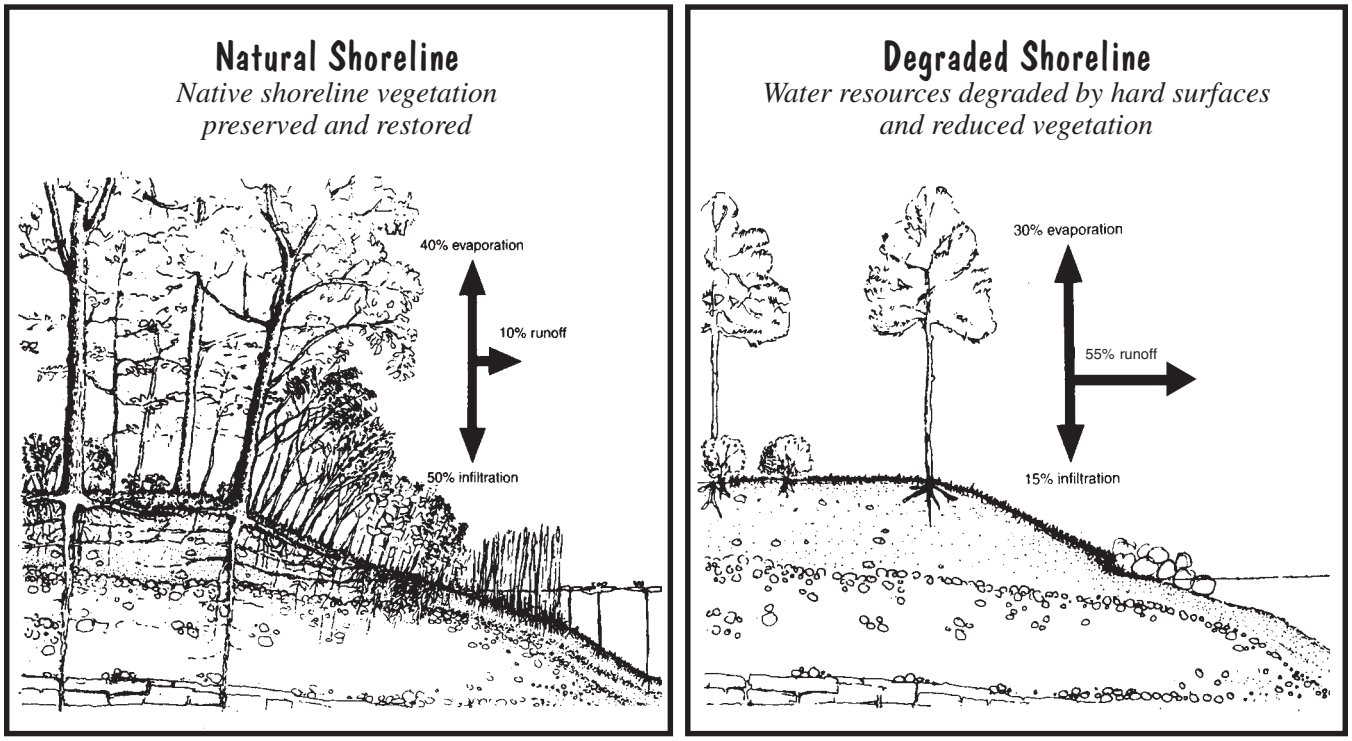
Lakescaping for Wildlife and Water Quality, by Carrol L. Henderson, Carolyn J. Dindorf and Fred J. Rozumalski. Nongame Wildlife Program Section of Wildlife, Minnesota Department of Natural Resources, St. Paul, Minnesota, 1999.

"Soil Bioengineering for Upland Slope Protection and Erosion Reduction," Chapter 18, *Engineering Field Handbook.* USDA Soil Conservation Service, 1992.

Stream Corridor Restoration: Principles, Processes and Practices. An interagency document produced in cooperation with 15 federal government agencies, 1998.

Wetland Plants and Plant Communities of Minnesota and Wisconsin, by Steve D. Eggers and Donald M. Reed. U.S. Army Corps of Engineers, St. Paul, Minnesota, Second Edition, 1997.

Restore Your Shore, CD ROM by the Minnesota Department ofNatural Resources. Copies are available through the Minnesota Bookstore; call 1-800-657-3757 for information 2001.



CHAPTER 5

Controlling Exotic Species

CONTENTS

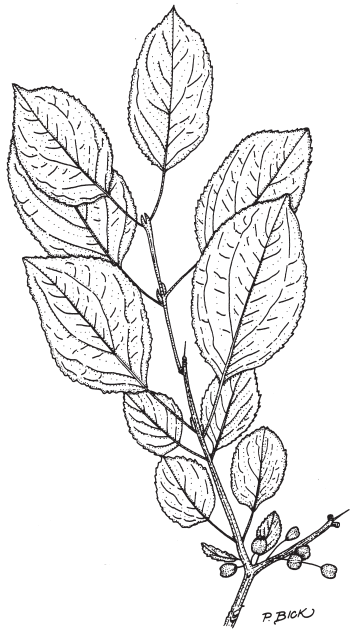
White sweet clover

CHAPTER 5

Controlling Exotic Species

We are in a period of the world's history when the mingling of thousands of kinds of organisms from different parts of the world is setting up terrific dislocations in nature.

Charles S. Elton



Common buckthorn

Reasons for Concern

Exotic (non-native) species are foreign invasive plants and animals that are slowly infiltrating and changing our nation's ecological balance and posing increasing threats to our lakes, streams, prairies and woodlands.

Exotic species are considered to be those species that have been intentionally or accidentally introduced to North America since European settlement in Minnesota (around 1800). Human actions—either intentional or accidental—are the main source of introductions. Well-known examples of intentional introductions that were intended to be beneficial but went awry include the English sparrow, purple loosestrife and European carp.

According to a 1996 report by The Nature Conservancy, invasive species have contributed to the population decline of 42% of threatened and endangered species in the United States. Many of these invasive species also pose a threat to agricultural areas, lakes and streams, parks, trails and roadsides.

Pioneers and Colonizers

Exotic invasive species are ecological pioneers and colonizers. Once introduced, they quickly establish themselves in ecologically disturbed or weakened communities.

These species typically displace native flora because they grow faster, have efficient seed dispersal methods and tolerate a wider range of conditions. Exotic species almost always lack the natural predators and diseases that control these same populations in their native environments. As the diversity and population of the native plants decrease, so does the variety of habitats for wildlife.

Opportunistic species are a second group of invasive species that are native. These species are also colonizers that can dominate certain disturbed natural communities and decrease species diversity.

Human-induced disturbances create conditions that allow pioneering species, such as exotics and certain native species, to invade an area. In a healthy ecosystem, natural disturbances, such as fire or flooding, generally keep exotic species in check, allowing disturbance-adapted native species to thrive.

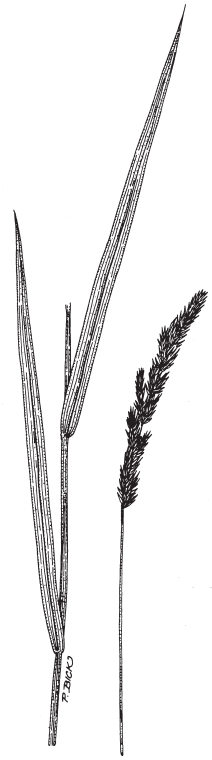
Ecological and Economic Impacts

While only a small percentage of the 4,000 estimated exotic plant species cause problems, just 79 exotic plant and animal species have already cost the U.S. economy an estimated $79 billion.

More than 4,000 exotic species exist in the United States. In Minnesota, 20% of all noncultivated plant species are exotics. While only a relatively small percentage of the 4,000 estimated exotic plant species cause problems, just 79 exotic plant and animal species have already cost the U.S. economy an estimated $79 billion.

Invasive exotic species generate huge ecological costs by:

- ❒ Outcompeting existing native vegetation
- ❒ Diminishing biodiversity
- ❒ Threatening rare species through habitat elimination
- ❒ Reducing food and cover for native fish and wildlife
- ❒ Impoverishing native grasslands and woodlands



Reed canary grass

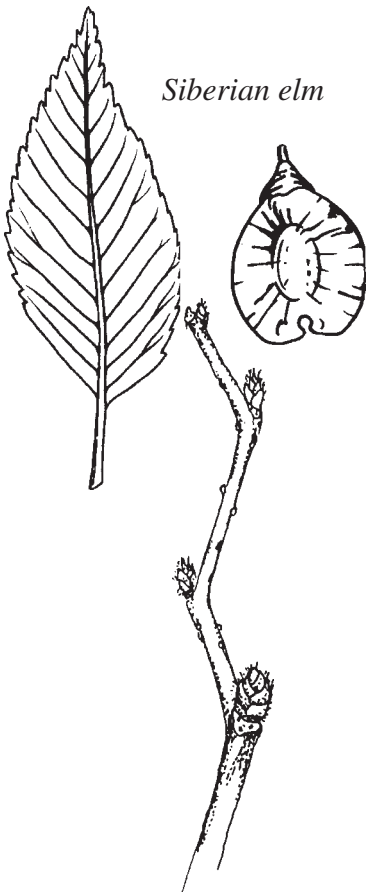
Guiding Principle

To make control of exotic species a management priority, with the long-term goal of restoring ecological balance to natural plant communities along state trails, canoeing and boating routes, and water access sites, thereby increasing the quality of the recreational experience and fostering user awareness and appreciation.

This principle can be achieved by:

- ❒ **Understanding the origin and biological behavior** of exotic plants.
- ❒ **Identifying and ranking the extent of exotic plant invasion.**
- ❒ **Focusing control efforts** on those plant communities that still have high ecological diversity to encourage natural regeneration of native plants.
- ❒ **Monitoring treated sites** regularly and thoroughly to keep exotic species under control.

Guidelines for Controlling Exotic Species



Siberian elm

The Minnesota Interagency Exotic Species Task Force prepared a report and recommendation for the Minnesota Legislature in 1991. The report identified those species that are potentially harmful to the integrity of Minnesota's remaining natural areas. The report also recommended a set of statewide policies to control these invasive species.

The Task Force limited its review and discussion of exotic species to plants and animals, including birds, mammals, fish, reptiles, amphibians, insects, mollusks and crustaceans. Genetically engineered native organisms were also considered exotic species. (Bacteria, fungi and other microorganisms were not covered by this report.)

Of the exotic species that already exist in Minnesota, the Task Force identified 38 species as posing a severe threat; 42 species as posing a moderate threat; and 33 species as posing a minimal threat at the time of the report. An additional 40 species have been identified as potentionally harmful if introduced in Minnesota.

Listing of Harmful Exotic Plants

Table 1 and Table 2 on pages 4 and 5 list exotic plants that are identified as presenting a moderate to severe threat to natural plant communities:

- ❒ Table 1 lists harmful exotic woody plants (page 4).
- ❒ Table 2 lists harmful exotic perennial and annual herbaceous plants and grasses (pages 4-5).

Exotic honeysuckle

Table 1: Harmful exotic woody plants

Common name	Scientific name (alphabetical)	Environmental impact	Current degree of threat
Amur maple	*Acer ginnala*	Shades out herbaceus plants in savannas and open woods and stump sprouts.	Moderate
Norway maple	*Acer platanoides*	Invades native forests, out-competes sugar maple and shades out ground layer plants.	Moderate
Japanese barberry	*Berberis thunbergii*	Out-competes native shrubs in woodlands and oak savannas.	Moderate
Russian olive	*Eleagnus angustifolia*	Displaces native vegetation; grows on most soils in full sun.	Moderate
Exotic honeysuckles	*Lonicera tartarica* *Lonicera morrowii* *Lonicera x bella*	Displaces native species in woodlands and forest edges; can dominate the understory of oak woods.	Severe
European buckthorn Alder buckthorn	*Rhamnus cathartica* *Rhamnus frangula*	Displaces native understory shrubs, primarily in southern oak, maple-basswood, and riparian woodlands; also invades prairies and wetlands. **Restricted noxious weed.**	Severe
Black locust	*Robinia pseudoacacia*	Outcompetes native species; is persistent and monotypic; prefers upland woods and grasslands.	Moderate
Siberian elm	*Ulmus pumila*	Invades dry and mesic grassland; is very hardy.	Moderate

Table 2. Harmful exotic perennial and annual herbaceous plants and grasses

Common name	Scientific name (alphabetical)	Environmental impact	Current degree of threat
Quackgrass	*Agropyron repens*	Rapidly invades native prairie; extremely hard to eradicate.	Severe
Garlic mustard	*Alliaria petiolata*	Invades rich moist upland forests and wooded streambanks; displaces native ground layer. See Fact Sheet Series. **Prohibited noxious weed.**	Severe
Hoary alyssum	*Berteroa incana*	Displaces native species, particularly in dry prairies and sand blowouts.	Moderate
Smooth brome grass	*Bromus inermis*	Cool-season exotic; can successfully invade native prairie.	Severe
Flowering rush	*Butomus umbellatus*	Competes with native shoreline vegetation, can out-compete willows and cattails. **Prohibited noxious weed.**	Severe
Plumeless thistle	*Carduus acanthoides*	Aggressive biennial; dominates within three years; difficult to control.	Moderate
Musk thistle	*Carduus nutans*	Invades disturbed areas, especially grazed prairie. **Prohibited noxious weed.**	Moderate

Table 2. Harmful exotic perennial and annual herbaceous plants and grasses *(continued)*

Common name	Scientific name (alphabetical)	Environmental impact	Current degree of threat
Spotted knapweed	*Centaurea maculosa*	Aggressive allelopathic species; difficult to control; displaces natives in dry grasslands.	Severe
Ox-eye daisy	*Chrysanthemum leucanthemum*	May displace native species; difficult to control.	Severe
Canada thistle	*Cirsium arvense*	Invades native prairie and woodlands. Difficult to control. **Prohibited noxious weed.**	Moderate
Bull thistle	*Cirsium vulgare*	Invades native prairie and woodlands. Difficult to control. **Prohibited noxious weed.**	Moderate
Crown vetch	*Coronilla varia*	Beginning to spread from the roadsides where it was planted; will outcompete most native plants.	Severe
Queen Anne's lace	*Daucus carota*	Can become a dense roadside forb; invades low quality or disturbed prairies and old pastures.	Moderate
Grecian foxglove	*Digitalis lanata*	Occurs primarily in Washington County. Forms single species stands, toxic.	Moderate
Leafy spurge	*Euphorbia esula*	Aggressively displaces native species; very difficult to control. **Prohibited exotic species.**	Moderate
Creeping Charlie	*Glechoma hederacea*	Chokes out forbs and grasses. Not a threat to healthy native communities.	Moderate
Orange hawkweed	*Hieracium aurantiacum*	Invades northern pastures and forest edges, roadsides, colonizes.	Moderate
Yellow iris	*Iris pseudacorus*	Competes with native shoreline vegetation.	Moderate
Butter and eggs	*Linaria vulgaris*	Colonizes abandoned pastures, croplands and along roadsides.	Moderate
Bird's foot trefoil	*Lotus corniculatus*	Aggressive; monotypic; forms a dense mat; crowding out native plants.	Moderate
Purple loosestrife	*Lythrum salicaria*	Aggressively crowds out emergent wetland vegetation; invades wet prairies. **Prohibited exotic species.**	Severe
White sweet clover	*Melilotus alba*	Aggressive biennial; invades native grasslands.	Moderate
Yellow sweet clover	*Melilotus officinalis*	Aggressive biennial; invades native grasslands. See Fact Sheet Series.	Moderate
Amur silver grass	*Miscanthus sacchariflorus*	Invades disturbed sunny to semi-shaded environments, aggressive colonizer.	Moderate
Wild parsnip	*Pastinaca sativa*	Invades in most moisture regimes; dry to wet-mesic; spreads rapidly; causes phytophoto-dermatitis to human skin.	Severe in southeast Minnesota
Reed canary grass	*Phalaris arundinacea*	Very aggressive; forms monotypic stands; prefers fertile organic soils but also grows on uplands and spoil piles; difficult to eradicate.	Severe
Kentucky bluegrass	*Poa pratensis*	Displaces native warm-season species.	Severe
Japanese knotweed	*Polygonum cuspidatum*	Spreads vegetatively forming dense thickets especially along disturbed stream banks and lakes.	Moderate
Perennial sow thistle	*Sonchus arvensis*	Colonizes disturbed sites. **Prohibited noxious weed.**	Moderate
Common tansy	*Tanacetum vulgare*	Widespread in northern Minnesota. Competes with native prairies, savannas.	Moderate
Hairy vetch	*Vicia villosa*	Aggressive climber crowds out native species in sandy soils.	Moderate

Control Methods

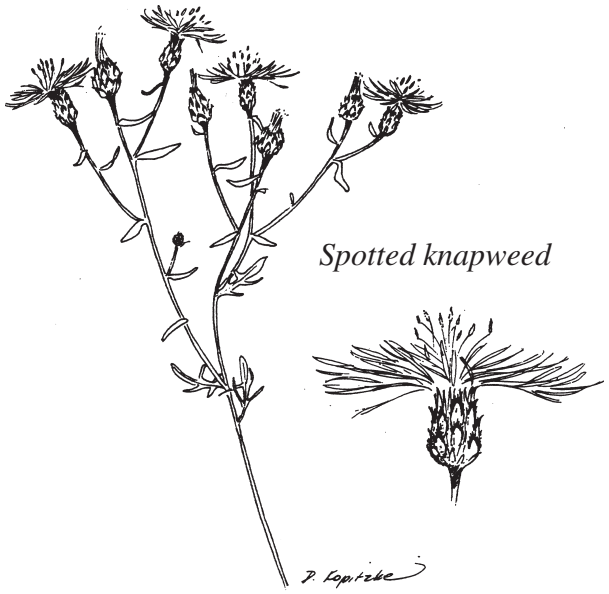
Methods for control of exotic species fall into four categories: mechanical removal, prescribed burning, use of herbicides, and biological control.

❒ **Mechanical removal:** Pull and remove plants from the site before they go to seed; girdle trees.

❒ **Prescribed burning:** Apply a burning regime that weakens exotic plants and gives native plants a chance to compete.

❒ **Use of herbicides:** Apply foliar sprays to small plants; cut and treat stumps to discourage resprouting on large woody plants (see Figure 1, page 7). Follow Operational Order #59: Use of Pesticides in DNR Natural Resource Management Activities, 1977; revised 2004.

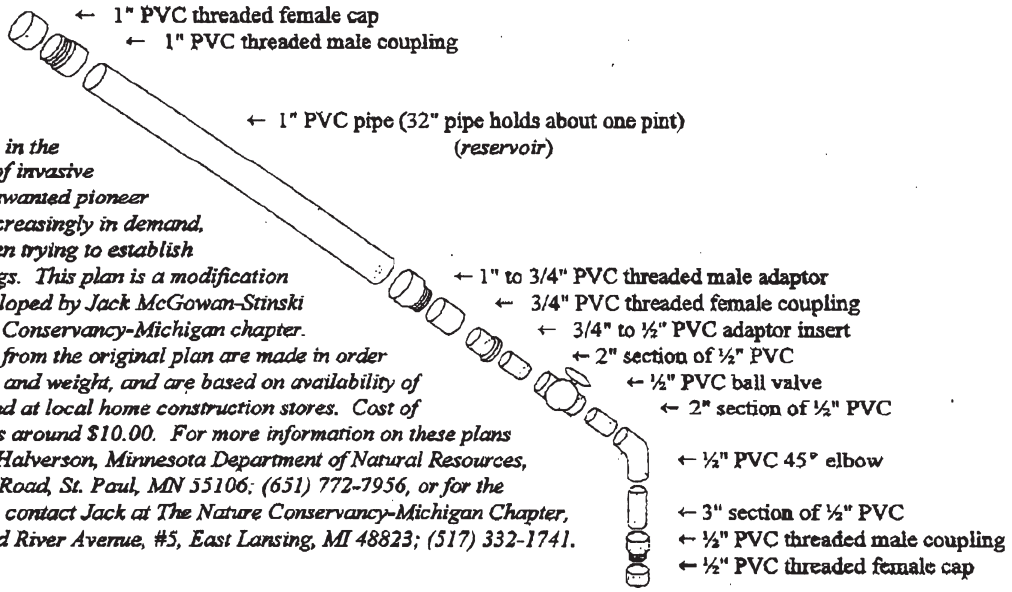
❒ **Biological control:** The U.S. Department of Agriculture (USDA)
is conducting a major biological control program that involves importing, propagating and distributing the natural enemies of exotic plants. Extensive and careful research precedes the introduction of biological control agents. The USDA is the permitting agency. Biological control is used in Minnesota for the following plants: purple loosestrife, leafy spurge and spotted knapweed.



Spotted knapweed

Cut Stump or Small Plant Herbicide Applicator

Components and instructions for assembly and use



Tools to assist in the management of invasive exotics and unwanted pioneer species are increasingly in demand, especially when trying to establish native plantings. This plan is a modification of a plan developed by Jack McGowan-Stinski of The Nature Conservancy-Michigan chapter. Modifications from the original plan are made in order to reduce cost and weight, and are based on availability of materials found at local home construction stores. Cost of construction is around $10.00. For more information on these plans contact Mike Halverson, Minnesota Department of Natural Resources, 1200 Warner Road, St. Paul, MN 55106; (651) 772-7956, or for the original plans contact Jack at The Nature Conservancy-Michigan Chapter, 2840 E. Grand River Avenue, #5, East Lansing, MI 48823; (517) 332-1741.

Assembly Instructions: Cement all non-threaded parts together using PVC pipe cement. To prevent leakage, be sure to use Teflon plumbing tape on all of the threaded parts. Before attaching the ½" PVC threaded female cap, drill two 1/16" drip holes near the center of the cap. More holes can be added later if you feel additional flow is needed.

A variety of sponge materials can be used at the end, but remember that larger sponges will require more herbicide before becoming saturated. I found that a small (approximately 4" by 4") terry covered sponge (staining pad) works well. When centered on the drip cap it can be wrapped across the tip and tied above the cap. A terry cloth protected sponge is more durable than sponge alone. In order to suit your specific needs, you can experiment with different kinds of applicator ends and sponges.

To use: With the ball valve in the "OFF" or "CLOSED" position, pour herbicide mix in reservoir and close with threaded female cap (at top of applicator). Open ball valve to allow herbicide to reach sponge (you may have to loosen cap at top of applicator to allow air to enter reservoir). When the sponge begins to saturate, close ball valve and re-tighten reservoir cap. Once the sponge is saturated only a light touch on target plant or stump is needed. Open ball valve when more herbicide is needed.

Helpful Hints:

- In order to make cleaning easier, there are three places where threaded parts are used.
- Always clear drip holes of residue before re-using applicator (a paper clip works well).
- A plastic bag should be secured around the sponge tip when moving from one location to another (do not store this way for a long period of time).
- Do not allow left-over herbicide mix to remain in reservoir during freezing or very hot conditions.
- Be sure to correctly identify plants before you treat them.
- Always follow herbicide label directions.
- Be sure to check whether state or local permits are needed before you apply herbicides, especially near water.

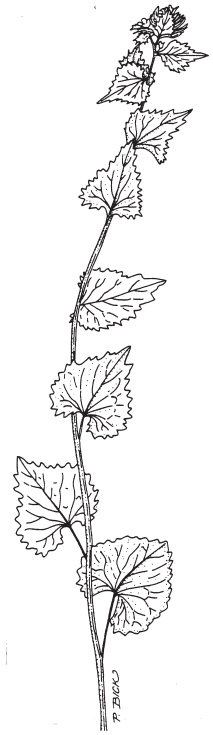
Figure 1: Cut stump or small plant herbicide applicator

For Further Information

Biology and Management of Noxious Rangeland Weeds edited by Roger L. Sheley & Janet K. Petroff, Oregon State University Press, Corvallis, 1999.

Invasive Weeds of Wisconsin, a video produced by the Park People, P.O. Box 17513, Milwaukee, Wisconsin 53217. Phone: 414-273-7257. www.theparkpeople-milwaukee.org

Minnesota invasive non-native terrestrial plants, an identification guide for resource managers. Minnesota Department of Natural Resources, Trails and Waterways Division, 2003 edition.
This publication is available at Minnesota's Bookstore, order online at www.minnesotasbookstore.com or call 1.800.657.3757.
Also available at:
http://www.dnr.state.mn.us/terrestrialplants/index.html



Garlic mustard

Report and Recommendations of the Minnesota Interagency Exotic Species Task Force, July 1991. Minnesota Department of Natural Resources, St. Paul, Minnesota.

The Tallgrass Restoration Handbook, Stephen Packard and Cornelia F. Mutel. Island Press, Washington, D.C., 1997.

Wisconsin Manual of Control Recommendations for Ecologically Invasive Plants. Bureau of Endangered Resources, Wisconsin Department of Natural Resources, Madison, Wisconsin, May 1997.

Businesses Providing Exotic Species Control and Management Services

Go to: http://www.dnr.state.mn.us/gardens/nativeplants/suppliers.html

CHAPTER 6

Planting and Pruning of Woody Plants Protecting Existing Trees from Construction

CONTENTS

(continued)

CHAPTER 6

Planting and Pruning of Woody Plants Protection Existing Trees from Construction

Introduction

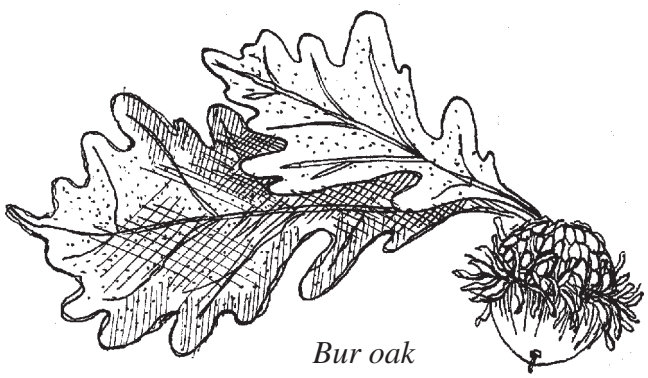
This section of the guide addresses general practices for planting and pruning of woody vegetation.

Planting of woody vegetation is primarily done for the following reasons:

- ❒ To serve as a windbreak
- ❒ To act as privacy plantings upon request from adjoining landowners
- ❒ To landscape newly constructed trail and water access sites and rest areas

Pruning of woody vegetation focuses primarily on the following objectives:

- ❒ Keeping trees and shrubs from encroaching into the path of travel
- ❒ Pruning selectively for aesthetic reasons to enhance scenic diversity
- ❒ Providing a safe user experience by removing hazard trees (Hazard tree removal is addressed in Operational Order #97.)



Bur oak

Guiding Principle

To plant and prune and protect woody vegetation along state trails and on water access sites as needed to provide a safe, enjoyable and aesthetically pleasing recreational experience.

This guiding principle can be achieved by:

❒ **Planting woody plants that are landscape appropriate and native** to Minnesota.

❒ **Choosing species whose mature form and size will be suitable** for the available space, to avoid extensive pruning later.

❒ **Treating plant material with care** before and after planting to assure the greatest rate of survival and future enjoyment for recreational users.

❒ **Pruning trees and shrubs to provide safe user experiences.**

❒ **Pruning trees and shrubs to enhance their health and beauty.**

❒ **Protect existing native trees from construction impact.** whenever possible.

❒ **Providing necessary training** for field personnel involved in planting and pruning.

❒ **Providing appropriate tools,** so that needed care can be done efficiently and without damage to vegetation.

Conducting a Comprehensive Site Analysis

A site analysis must precede the planting of any given site and should include the following steps:

❒ **Analyze soil types and characteristics.**

- Refer to *Soil Surveys by County: NRCS in Cooperation with Minnesota Agricultural Experiment Station,* from the U.S. Department of Agriculture.
- Conduct a soil sampling onsite.
- Determine soil compaction or disturbance.
- Determine content of organic matter and nutrient levels.
- Determine pH factor.

❒ **Determine soil moisture** gauged on a gradient from dry to mesic to wet.

- Determine drainage patterns. For example, sandy soils and hilltops are dry; depressions and clay soils hold water and therefore are more moist.

❒ **Consider topographic features,** such as slope and aspect.

- Determine whether the site is hilly or level; identify degree of exposure to the sun (south, north, east or west).

❒ **Consider the microclimatic conditions** of the site, within the regional context.

❒ **Select the appropriate plant species** according to site conditions and the specific landscape unit.

- Consult *Vascular Plants of Minnesota,* by G.B. Ownbey and T. Morley (1991).
- Consult the County Biological Survey database.
- Consult *Restore Your Shore* CD Rom (includes an encyclopedia of 400 native plants).

Planting

Site Preparation and Weed Control

A thorough site preparation will assure healthy growing conditions for trees and shrubs, allowing plants to compete for nutrients in the soil. Complete site preparation consists of eliminating weed competition over the entire planting site.

❒ If undesirable vegetation is present, the site should be tilled 8-10 inches deep and disked in the fall before planting the following spring. A non-selective herbicide should also be applied prior to tilling if rhizomatous plants, like quackgrass and reed canary, exist on the site.

❒ In areas where site disturbance has to be restricted, such as erodible slopes, strip site preparation is the preferred method:

• Mow identified 4-foot to 6-foot planting strips in the fall; treat emerging undesirable vegetation with a non-selective herbicide, such as glyphosate; then till the strip.

• Plant seedlings the following spring in the center of the tilled strips. Vegetation left between planted rows serves three purposes:

—It acts as a screen to prevent the soil from drying out during hot summer winds.

—It helps to lower soil temperatures.

—It increases the relative humidity level near the seedlings.

IMPORTANT!

Be sure to locate all buried utility lines before preparing a site by calling:

GOPHER STATE ONE CALL
800-252-1166 or
651-454-0002

Planting Methods

General Guidelines

When planting bare-root plants, it is very important not to let roots be exposed to air and sun. Roots should always be covered with soil (heeled in) or tarps, or they should be submersed in water (tubs or pails) until they are planted. (See Figure 1, page 5.)

❒ **Planting methods** depend on the size of the root mass of the bare-root plant:

• Bar-slit planting works well for small bare-root plants with little to moderate root mass.

• Hole-planting applies for all other bare-root plants, including containerized plants, as well as balled and burlapped plants.

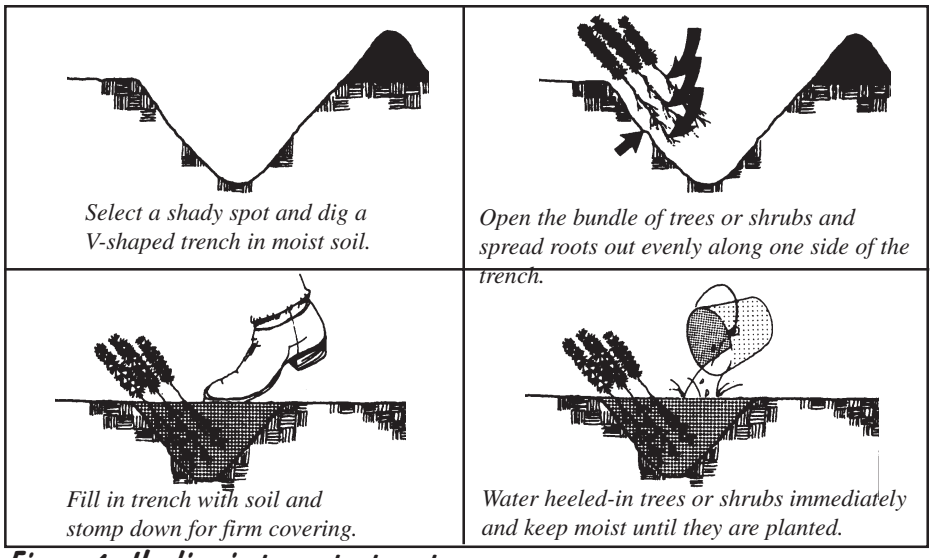


Figure 1: Heeling in to protect roots

❒ **Planting in the spring** gives the best results, because plants will have the entire season to take root. Planting may be started as soon as the ground is free of frost and can continue as long as the bare-root plants have not started new growth.

❒ **Plant bare-root plants within 24 hours of receiving** except plants that need to be sweated. If this is not possible, place packaged plants under refrigeration. The ideal temperature is 40-50 degrees Fahrenheit. If you must postpone your planting operations for a week or more, it's best to heel in the bare-root plants, which means spreading plant roots out in a trench, so that soil can filter down through and be in contact with all roots. Be sure to keep bare-root plants well-covered with soil and water thoroughly.

❒ **Sweating nursery stock.** Buds on birch, hackberry, oaks, hawthorn and ironwood become very dormant during winter storage (in the nursery plants are dug in the fall and put in cold-storage). They need high humidity and warm temperatures to break bud. This is best accomplished by placing the plants in a building or in the shade outside for a few days, and covering them with wet straw and a sheet of plastic. Buds will swell in a few days at temperatures between between 45 and 75 degrees. Plants should then be planted around the mid to end of May when temperatures remain above freezing.

❒ **Protect bare-root plants** at the planting site. Exposing roots to sunlight and drying winds for 3 to 5 minutes can cause plant mortality.

❒ **Planting depth is one important aspect** for the future health of a tree or shrub. A properly planted or established tree or shrub will have its root collar flare at or slightly below (less than 1 inch) the soil or mulch level. This transition area between the stemwood and first main order roots has to be visible or be only slightly covered with mulch.

Tree roots need oxygen and water in order to survive and grow. When main order roots are buried too deep, they will move upward toward the soil surface and, in the process, often girdle the buried stem. As roots and stem (trunk) grow, they compress each other, creating weak points, and the exchange of water and nutrients will be compromised.

Bar-Slit Planting

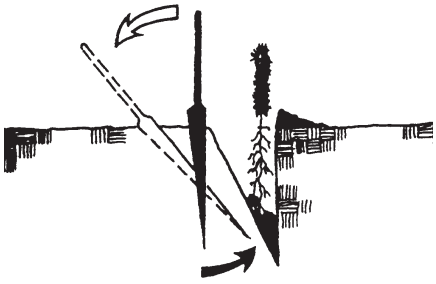
❒ Using a planting bar or spade, make a slit in the soil, deep and wide enough to accommodate the roots loosely. (See Figure 2.)

❒ Insert the bar behind the plant, and push the bar back and forth to push soil around the plant.

❒ Use your heel to close the second hole, firming soil around the plant.

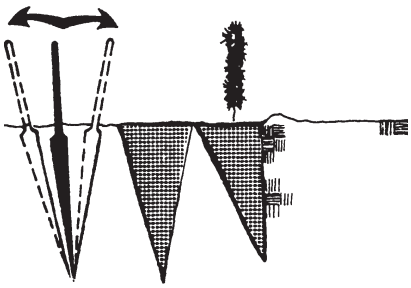
Plunge bar in soil at an angle (as shown); then push forward to upright position.

Place seedling against flat side of planting hole.

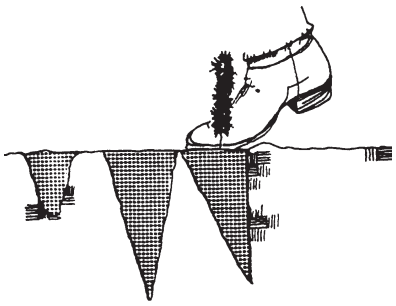


Plunge bar into ground 3 inches from seedling. Pull bar back to pack dirt at bottom of roots.

Next, push handle of bar forward to pack soil at top of roots. To close hole, plunge bar into ground 3 inches from last hole.



Work it forward, then pull backward, filling hole.

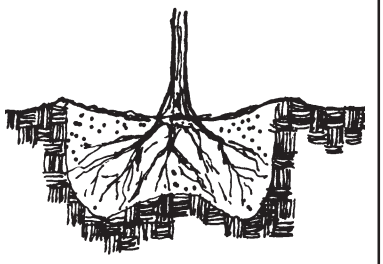


Last hole can be filled by tamping in loose soil with heel. Carefully tamp loose earth around seedling with your foot to prevent air pockets.

Figure 2: Using a planting bar

Hole-Planting Bare-Root Plants

❒ Dig the hole slightly deeper than the size of the root system, to allow backfill with enough soil to hold the plant slightly higher than the depth it was grown in the nursery. The planting hole should be wider than the size of the root system. Make sure that the root collar flare is visible at soil level or slightly below. (See Figure 3.)



Place bare-root tree or shrub at appropriate depth. Root collar flare should be visible at soil level.

Figure 3: Planting bare-root trees and shrubs

❒ In poorly drained soils, plants should be placed higher, with soil mounded to cover the top roots, which will improve oxygen availability to the roots. Another method in poorly drained soils is to modify the planting hole, creating a pedestal for the plant to rest on, allowing water to collect below the root mass.

❒ Examine the roots before planting, cutting away diseased, damaged or girdling roots.

❒ Straighten roots and spread evenly; then cover with soil and tamp it.

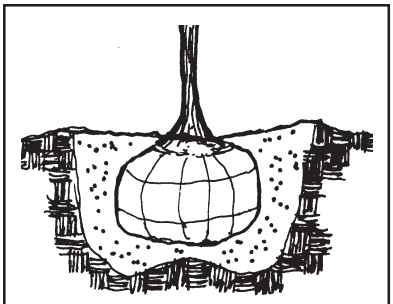
❒ Always use original soil from the site for backfill. In general, soil amendments need not be used; instead, choose the appropriate plant species for the site.

❒ Eliminate air pockets as much as possible by gently raising and lowering the plant while adding soil and tamping it.

❒ Finish filling the hole with soil, creating a depression around the plant as you tamp down. Then water thoroughly. Water will also help fill air pockets with soil.

Hole-Planting Balled and Burlapped or Containerized Trees and Shrubs

❒ Make sure that the root collar flare is visible on containerized and balled and burlapped trees and shrubs, and plant them with the root collar flare visible at soil level or slightly below. (See Figure 4.)



Pull burlap or wire basket away from trunk and cut all twine.

Figure 4: Planting balled and bur-lapped trees and shrubs

❒ In poorly drained soils, plants should be placed higher, with soil mounded to cover the top roots, which will improve oxygen availability to the roots. Another method in poorly drained soils is to modify the planting hole, creating a pedestal for the plant to rest on, allowing water to collect below the root mass.

❒ Remove all twine, and pull burlap or wire basket away from the trunk. No burlap should show above soil surface, as it could act as a wick and draw moisture away from the root ball.

❒ Container-grown plants may be rootbound. If so, separate or sever roots to avoid strangling.

❒ Always use original soil from the site for backfill. Soil amendments need not be used; instead, choose the appropriate plant species for the site.

❒ Create a depression around the plant as you tamp down.

For Evergreens Only: When and Where To Plant

It is best to plant evergreens only where they naturally occur, primarily in the northeastern part of the state. Most evergreens planted in the non-forested landscape will suffer winter browning caused by exposure to wind and sun.

Fall planting of evergreens should not be later than October, as roots will not become established.

It is best to plant evergreens only where they naturally occur, primarily in the northeastern and northcentral part of the state. Most evergreens planted in the non-forested landscape will suffer winter browning caused by exposure to wind and sun.

White spruce

Mulching

All plants, including shrubs and trees, will benefit greatly from a 3- to 6-inch layer of organic mulch: 3 inches when using fine-textured mulch, 6 inches when using coarse-textured mulch.

All plants, including shrubs and trees, will benefit greatly from a 3- to 6-inch layer of organic mulch.

Mulch is beneficial because it:

- ❒ Holds soil moisture, allowing better infiltration of water.
- ❒ Moderates soil temperature. (Roots like cool, moist soil.)
- ❒ Suppresses weed growth. Grasses especially compete more strongly for water and nutrients than broadleaf weeds.
- ❒ Provides added protection from mowers and weed whips.

On level ground, organic mulch works best. On slopes, landscape fabric may be the better choice. On small sites, cardboard or several layers of newspaper weighted down will suppress weed growth for 2 to 3 years, giving small seedlings an advantage.

Using Landscape Fabric

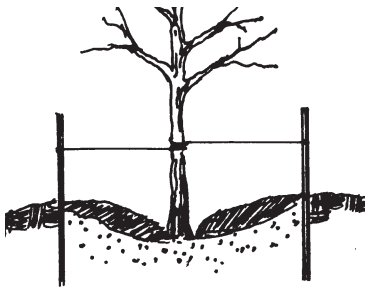
Landscape fabric is available in rolls 2 to 8 feet wide or in mats 3 feet by 3 feet. Fabric should be breathable and photo-degradable, and it should provide at least 3 years of weed control.

Method:

❒ Stake the fabric down with metal or plastic stakes, so that it will not wash downslope in heavy rains.

❒ Be sure to remove weeds before installing fabric.

❒ Make a compound slit (X-shaped) in the fabric for the trunk, and sufficiently secure the mat or roll.



Stake larger trees with two metal stakes, 4-ply hoses and #14 wire for guying. Spread 4-6 inches of mulch; keep mulch away from trunk.

Figure 5: Staking and mulching trees

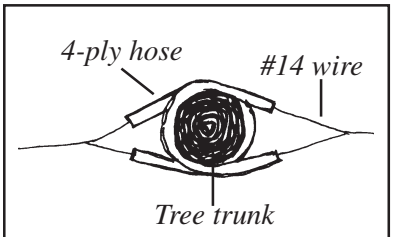


Figure 6: Guying detail

Mulching Around Trees

❒ Spread mulch out to a minimum 18-inch radius from the base of the tree.

❒ Keep mulch away from the trunk, to aid plants in winter hardening and reduce damage by rodents. Keeping mulch away from the trunk is also important because a constant wet environment around bark promotes disease. (See Figures 5 and 6.)

❒ Replenish mulch regularly to maintain a 4-inch depth, which will keep competing weeds to a minimum.

Watering

Routine watering is necessary during the first growing season. Weather and soil makeup determine the need for watering.

A thorough watering just before the soil freezes is especially important, so that newly planted trees and shrubs can withstand dry winter winds.

Avoid short and frequent watering, because it promotes development of a shallow root system and makes plants much more vulnerable to environmental stress situations.

Water supplied to the drip line of a tree will be the most beneficial, because the majority of water intake occurs there.

Keeping trees well watered for at least 2 years is the single most effective treatment for helping them recover from planting shock.

Protection of New Plantings

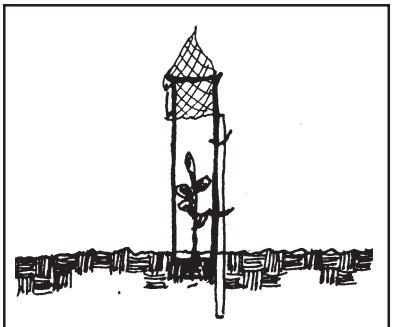
Preventing animal damage: Animal damage can be severe in new plantings, depending on the availability of other food and the severity of the winter. The following methods exist for protecting new plantings from animal damage:

❒ **Tree shelters:** To protect seedlings from being girdled by mice at ground/snow level and being browsed by rabbits and deer, place a tree shelter (cylindrical plastic tubing) around the trunk. (See Figure 7, page 10.) Tree shelter design has been perfected over the years to give optimum protection to newly planted tree and shrub seedlings.

Besides giving protection against animal damage, these shelters capture moisture by protecting from drying winds. Shelters create a greenhouse effect, which enhances faster growth.

Trees in shelters may be more susceptible, however, to frost damage, because the slightly warmer temperature inside the shelters delays the hardening-off period before winter.

Set the cylinder firmly into the ground, without damaging the roots, so rodents cannot girdle the trunk at ground level. The cylinder should be at least 4-5 feet high to also protect seedlings from deer and rabbit browsing.



Tree shelters are used for deciduous trees to protect seedlings from being girdled by mice or browsed by rabbits and deer.

Figure 7: Tree shelters

❒ **Budcapping:** Budcapping of tree seedlings is one method to protect the terminal bud from wildlife.This procedure is done each fall after leaf drop for the first couple of years, until the seedlings have grown above the animals' reach.

❒ **Wildlife deterrent**: Tree Guard™ with Bitrex™ or Plantskyd™ are browse deterrents that are sprayed on leaves, needles and stems. Both products form a protective layer that resists dew, snow and rain for 4-6 months. If applied in the fall, it will protect plants through winter, when browsing damage is most severe.

Temporary fencing: Young plantings can be destroyed in one winter season. Small seedlings are difficult to see, especially by fast-traveling motorized recreation vehicles. Temporary highly visible fencing may be a solution during the winter months.

Monitoring

A newly planted site needs to be inspected on a regular basis:

A newly planted site needs to be inspected on a regular basis.

❒ Check rate of plant survival and replace dead plants.

❒ Water thoroughly and regularly, especially during drought conditions.

❒ Add organic mulch to keep weeds suppressed.

❒ Re-apply browse deterrent in the fall.

Pruning

Proper pruning of trees and shrubs is as important as keeping a site mowed or litter free. It is an aesthetic treatment, as well as an essential necessity to the health of woody vegetation. Incorrect pruning work reflects poorly on resource management and presents an unprofessional image to the public.

Every tree or shrub is a living organism and has a unique natural shape. It is essential to first understand its growth habit before attempting to prune.

Pruning Tools

- ❒ Pruning shears (Felco)
- ❒ Pole pruners
- ❒ Lopping shears
- ❒ Hedge shears (mechanical or motorized)
- ❒ Pruning saws, "pull-stroke" with tempered metal blade
- ❒ Chainsaw (to be operated only by qualified individuals, with required safety precautions)

All tools must be maintained in good working condition. They should be sharpened and regularly sanitized to prevent the spread of disease.

The Purpose for Pruning Deciduous Trees and Shrubs

Pruning work consists primarily of:

- ❒ Pruning to provide proper clearance
- ❒ Creating space around leaning trees to prevent further leaning. Providing sunlight from above will eliminate the need for these trees to continue to lean into the trail to reach sunlight. (See Figure 8.)
- ❒ Removing hazardous trees
- ❒ Thinning and corrective pruning of individual trees and shrubs as needed
- ❒ Pruning of damaged trees and shrubs during and after construction
- ❒ Controlling shrub willows, and balsam poplar in particular, within 6 feet of the trail treadway. Suckers growing through asphalt create a hazard to trail users (rollerbladers in particular).

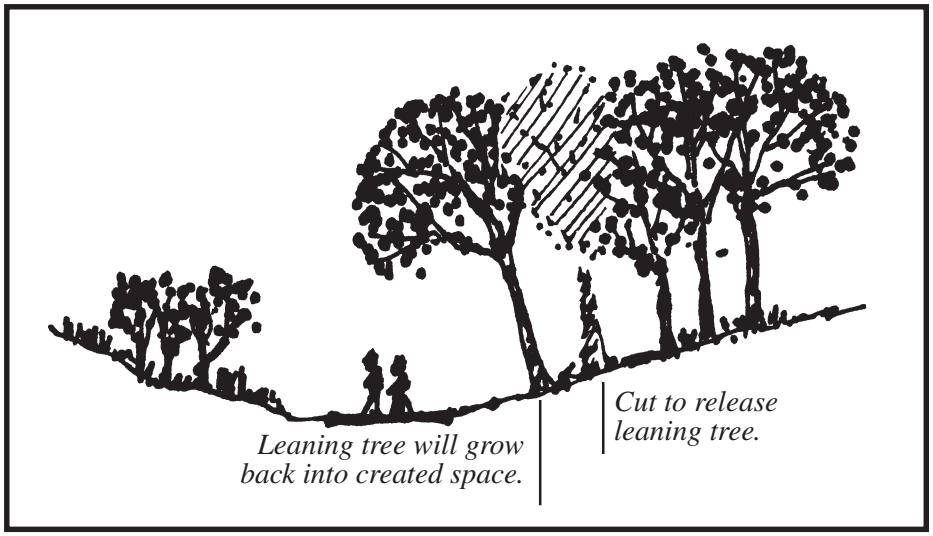
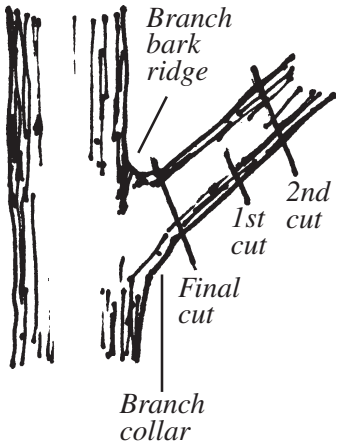


Figure 8: Creating a space to prevent further leaning



For branches that are larger than you can get your hand around, use a 3-step cut.

Figure 9: Cutting of larger branches

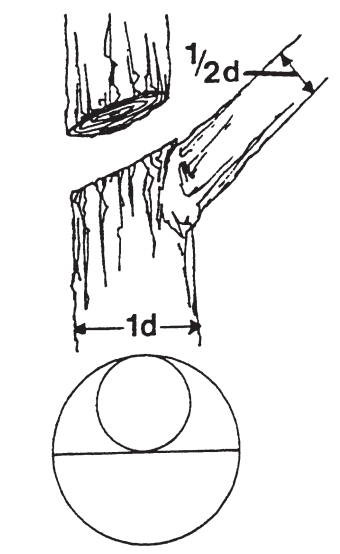


Figure 11: Selective heading

How To Prune Deciduous Trees and Shrubs

A tree or shrub should never be topped; instead, it should be thinned. Thinning retains and promotes the natural shape of a woody plant, while radical heading or topping destroys it. Topping will stimulate a lot of thick regrowth at the tips of branches and is not an appropriate way to control size. To remove a tree, cut as close to the ground as possible.

Methodic thinning includes the following steps:

- ❒ Remove dead wood and stubs first.
- ❒ Then remove deformed, old or crossing branches.
- ❒ If small branches need to be cut back, cut near a bud, to avoid creating dead stubs. Larger branches should be removed as shown in Figure 9.
- ❒ Branches with U-shaped angles of attachment should be retained. These are strong, healthy attachments. (See Figure 10).

Codominant branches with a narrow V-shaped angle are prone to split. On young trees, removing lateral branches of one of the codominants will weaken it enough to allow the other branch to dominate. (See Figure 10.)

Selective heading reduces height while maintaining the natural shape of a tree. This method involves heading a branch or leader back to another smaller branch below (but no smaller than 1/2 of the diameter of the wood that is cut). This reduces height while maintaing the natural shape of a tree. (See Figure 11.)

Figure 10: Types of branch unions
U-shaped strong union (left) and V-shaped weak union (right)

When To Prune Deciduous Trees and Shrubs

When to prune depends to a large extent on what results are expected. It also depends on the susceptibility of plants to disease at certain times during the growing season.

Light pruning and the removal of dead wood can be done anytime, except for species requiring special attention as listed below.

Pruning should not be done in wet weather, which promotes fungal and bacterial growth. Cankers and rots are easily introduced at this time.

Summer: Pruning for Clearance Only

Pruning in June and July, after seasonal growth is complete, is most advantageous in this situation. Reducing the total leaf surface reduces the amount of food manufactured and sent down to the roots to be stored for next year's growth. Although this time is stressful for trees in particular, it helps to retard growth and therefore reduces the need for frequent pruning, because plants will not grow back as fast as they would after a winter or spring pruning.

Pruning during dormancy is the most common practice, especially for trees. It results in vigorous growth in the spring.

Pruning in summer with leaves still on the plants also helps to identify species. Exotic species should be eliminated first before cutting any native species.

Late Fall and Winter

Pruning during dormancy is the most common practice, especially for trees. It results in vigorous growth in the spring. Start winter pruning in November and finish by April 1. Some species of trees, such as maple, walnut, butternut, birch and ironwood, may "bleed," because sap begins to flow early and profusely in these trees. This is not harmful to the tree and will cease when the tree leafs out.

Corrective pruning during the dormant season is most advantageous for most trees and shrubs, because:

- ❒ Dead, cracked or broken branches, weak forks and other structural defects are easy to see when trees are without leaves.
- ❒ Woody plants can adapt to the loss of branches by adjusting size or number of leaves the following spring.
- ❒ Callus tissue develops much faster around cuts during the spring growth spurt.
- ❒ Infectious diseases don't spread as easily in winter, because pathogens are dormant.
- ❒ The use of heavier equipment is less damaging to frozen soil.
- ❒ Leafless branches, when chipped, make a high-quality mulch.

Fall and Early Spring

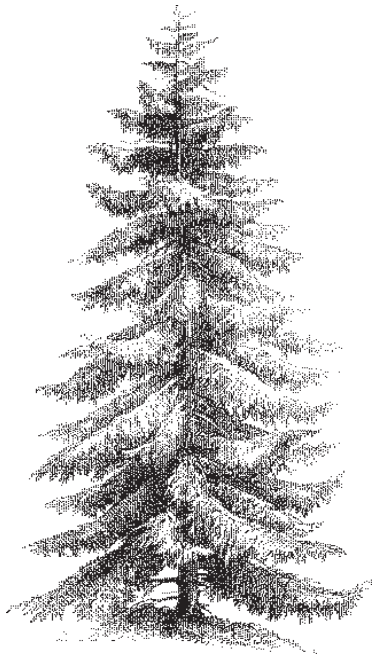
Avoid pruning live wood from trees when leaves are falling or forming. During those times, the tree is either storing starch and growing new roots or growing spring wood and new leaves. Less energy is available to respond to pruning wounds than during other times of the year.

Early Summer

Early summer is the best time to radically reduce hedges. New growth will come back fastest and produce a healthy-looking hedge. Any other pruning at that time may not be effective and useful.

Special Precautions

❒ Elms and Oaks are two species that should only be pruned at certain times of the year namely from September 1 to April 1. Both trees are susceptible to fatal diseases which have killed many trees in Minnesota. Dutch-elm-disease and Oak wilt are caused by two different fungii which move from affected trees via grafted root systems or via insects during the growing season.



❒ The Dutch-elm-disease carrier of the fungus is primarily the European elm bark beetle which feeds on young twig crotches of living elms. Beetles also burrow into the bark of dying or dead elmwood to lay their eggs creating a vicious cycle. Overwintering larvae emerge as adults about the time elms break dormancy in the spring. Spring and early summer feeding by beetles spreads the fungus into springwood vessels of the tree.

Proper disposal of diseased elmwood consists of either stripping the bark off immediately after cutting and using it for firewood, or chipping for mulch.

❒ The oak wilt disease carriers are various sap beetles which feed on the spore mats of the fungus between bark and wood of oak wilt-killed trees. These mats are produced between April and late June on red oaks that wilted during the previous summer. That time of the year red oaks produce large springwood vessels and are very susceptible to infection. The same beetles are attracted to fresh wounds on healthy oaks in the spring.

Because the natural form of an evergreen is usually the most desirable, limit pruning to correcting growth defects only.

Pruning Evergreens

Because the natural form of an evergreen is usually the most desirable, limit pruning to correcting growth defects only. As with deciduous trees, pruning should not be done in wet weather, which promotes fungal and bacterial growth. Cankers and rots are easily introduced at this time.

Fly honeysuckle

When To Prune

Red cedar, white cedar, yew and hemlock: These evergreens grow continuously through the growing season and may be pruned at any time, but early in the growing season is usually best.

Spruce and fir: The time for pruning is not critical, although they do not grow continuously. Best time for pruning is late winter, before growth starts.

Pines: Pines put on a single flush of growth per year and then stop. They must be pruned at the candle stage of growth, before the new candles become woody. Pruning at other times will cause dead stubs.

Up to two-thirds of the new growth can be removed. Pruning should not go into last year's growth. Along trails, there may be a need to take off whole lower limbs at the trunk for clearance, rather than candle-stage pruning. Generally, there is no need to do candle-stage pruning. Candle-stage pruning is done in the horticulture business to make pines look like "Christmas trees" (spruce or fir trees).

Protecting Existing Trees from Construction Impact

Mark construction zone boundaries

With contruction plans at hand mark all structures determined for the site. Determine cut and fill areas and where heavy equipment will be used.

Inventory the site and determine which trees should be saved

Record location, size and health of each tree to be saved. Mark trees that need to be pruned to make room for building and construction equipment.

Select the healthiest trees. Young trees survive disturbance better than mature trees. Improve tree survival by saving groups of trees rather than indivudual trees. Smaller trees may be saved by transplanting.

Protect the trees that are to be saved.

Install orange fencing around the Protected Root Zone (PRZ) and post "off limit". Have builders and contractors sign a landscape protection contract.

Soil compaction is the largest killer of trees, grade changes within the PRZ are detrimental as well, especially if the fill is more than 24". Cutting soil away destroys feeder roots and nutrient-rich topsoil**.** Excavation or trenching should take place outside the PRZ. Tunneling under the tree may be the choice if the trench has to be close to the tree. Healthy trees are an asset and enhance the health and aesthetic quality of a site.

For Further Information

Forest Pest Diagnosis Sheets. Minnesota Department of Natural Resources, Division of Forestry, St. Paul, Minnesota.

How to Detect, Assess and Correct Hazard Trees in Recreational Areas. Minnesota Department of Natural Resources, St. Paul, Minnesota, 1993.

How To Prune Trees. NA-FR-01-95, *USDA Forest Service.*

Minnesota Shade Tree Advocate (quarterly newsletter). Minnesota Shade Tree Advisory Committee, Jan Hoppe, 1151 Green Hall, 1530 Cleveland Avenue North, University of Minnesota, St. Paul, Minnesota 55108.

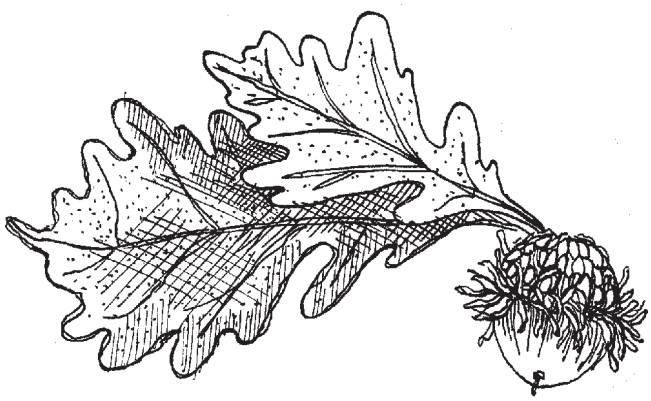
Preventing Stem Girdling Roots. A video presented by the Minnesota Society of Arboriculture.

Protecting Trees from Construction Damage, by Nancy L. Miller, David M. Rathke and Gary R. Johnson. University of Minnesota Extension Service, St. Paul, Minnesota, NR-FO-6135-S, 1993.

Pruning Trees and Shrubs, by Mervin C. Eisel. University of Minnesota, AG-FO-0628, Revised 1989.

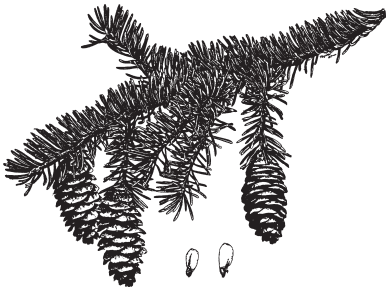
Tree City USA Bulletin, Bulletin #1, James R. Fazio (editor).

Tree Owner's Manual, AG-MI-3898, University of Minnesota, St. Paul, Minnesota.



Bur oak

Glossary



White spruce

Allelopathy: The inhibitory or stimulatory effects of released organic chemicals by one plant on the germination, growth and metabolism of a different plant (The Dictionary of Forestry, Society of American Foresters, 1998).

Amorphous: Without definite form.

Aspect: A position facing a compass direction, such as south, north, east and west.

Association: A plant community of some particular kind or grade. An association may have several dominants, either mixed together or occurring in different places (The Dictionary of Forestry, Society of American Foresters, 1998).

Awn: A slender, bristle-like terminal extension of the flowering part of many grasses.

Biome: A community of living organisms of a single major ecological region.

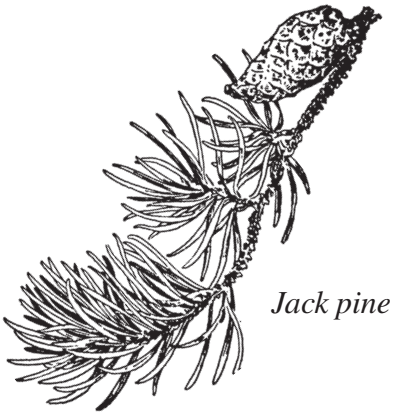
Boreal forest: The northern hemisphere, circumpolar tundra forest type, consisting primarily of black spruce and white spruce with balsam fir, birch and aspen. The boreal forest is the most extensive forest type in the world (The Dictionary of Forestry, Society of American Foresters, 1998).

Browse: To forage or graze on the buds, stems and leaves of woody vegetation by wildlife, primarily hoofed animals (The Dictionary of Forestry, Society of American Foresters, 1998).

Budcapping: A method of protecting the terminal bud from browsing by wildlife, by stapling a plain white piece of paper around the terminal bud of a seedling.

Bulb scales: Thick scales that can easily be rubbed off of a lily bulb. When planted 1/2 to 1 inch deep, they produce a single leaf in the first year, while seeds take 2 years to germinate.

Callus tissue: A growth of large, undifferentiated, homogeneous cells produced by the cambial zone of woody plants that seals off a wound, eventually covering it (The Dictionary of Forestry, Society of American Foresters, 1998).



Jack pine

Canopy: The foliar cover in a forest stand, consisting of its upper layers (The Dictionary of Forestry, Society of American Foresters, 1998).

Climax forest: An ecological community that presents the culminating stage of a natural forest succession for its locality (The Dictionary of Forestry, Society of American Foresters, 1998).

Codominant branches: Branches that are of equal size arising from the same position, competing for dominance.

Coniferous: Cone-bearing; refers to cone-bearing trees.

Connectivity: A measure of how connected or spatially continuous a corridor is or should be to ensure continuous habitat for wild plants and animals for breeding, feeding or movement. Connectivity is the primary measure of corridor structure (The Dictionary of Forestry, Society of American Foresters, 1998).

Conservative species: Species that thrive best in a relatively stable (successionally advanced) community with its original processes intact. A conservative species is the opposite of an early successional species, which grows best in disturbed open soil.

Cultivar: A plant that has been selectively bred for certain desirable characteristics and is generally more or less genetically uniform. Such a cultivated plant is given an additional non-Latin name or is designated *variety* or *var.* (The Dictionary of Forestry, Society of American Foresters, 1998).

Cuticle: The protective outer covering of a seed, which is often very hard.

Cut slope: An earthen slope that is cut; for example, a road built lower than the existing terrain would result in a cut slope.

Deciduous forest: A forest whose vegetation is made up of tree and shrub species that shed foliage simultaneously in the fall.

De-bearding: Part of the seed-cleaning process. Awns or excessive hair on some native grasses (Canada wild rye) need to be removed for easier seeding.

Designed plantings: An assemblage of plants selected and arranged for a specific purpose.

Diameter at breast height (dbh): Measurement norm (4.5 feet from the ground) for determining the diameter of a tree trunk.

Drip line: The line extending vertically from the exterior edge of a tree's live crown to the ground.(The Dictionary of Forestry, Society of American Foresters, 1998).

Exotic sweet clover

Drumlin fields: An accumulation of elongated hills composed of glacial drift (any rock material, sorted or unsorted, deposited as a result of glaciation).

Ecological classification: A multifactor approach to categorizing and delineating, at different levels of resolution, areas of land and water having similar characteristic combinations of physical environment (such as topography, climate, geology, soil and hydrology), biological communities (such as plants, animals and microorganisms), and human influences (such as social, economic and cultural factors).

Ecological pioneer: A plant capable of invading disturbed bare sites and colonizing rapidly over considerable areas.

Ecosystem: A spatially explicit, relatively homogenous unit of the earth that includes all interacting organisms and components of the biotic environment within its boundaries. An ecosystem can be of any size, such as a log, pond, field, forest or the earth's biosphere.(The Dictionary of Forestry, Society of American Foresters, 1998).

Ecotype: A genetically differentiated subpopulation that is restricted or adapted to a specific habitat; plants adapted to a localized environment, such as climate, soils or aspect.(The Dictionary of Forestry, Society of American Foresters, 1998).

Emergent: Emergent vegetation, stems and flowers extending out of the water.

Endangered, threatened and special concern species: These species have special status under Minnesota Rules, Chapter 6134.

End moraine: See *moraine.*

Exotic species: A plant introduced from another country or geographic region outside its natural range.

Fascines: Stems and branches of rootable plant material (willow, dogwood and alder, for example) that are tied together in long bundles, placed in shallow trenches on contour, and staked down to stabilize erodible slopes.

Filler: Used in the process of broadcasting seeds by hand. Seeds mixed with a filler of moistened sawdust or vermiculite will provide a more even distribution of seeds as they adhere to the filler and are less likely to be blown away by wind.

Fill slope: An artificial earthen slope that is being built up; for example, when a road is built higher than the existing terrain.

Flora: Plants collectively, especially the plants of a particular region or time.

White trillium

Forb: A non-woody, broad-leaved, herbaceous plant other than those in the grass, sedge and rush families.

Geomorphology: The geologic study of the configuration and evolution of land forms.

Girdle (mechanical): To remove a broad band of bark around a living stem, without damaging the sapwood that is directly beneath the bark. Girdling kills a tree slowing (over a full growing season), thereby avoiding resprouting.(The Dictionary of Forestry, Society of American Foresters, 1998).

Girdling roots: Roots that are intertwined to the point of restricting optimum growth of a plant. Container-grown plants are most susceptible.

Ground moraine: See *moraine.*

Herbaceous: Non-woody plants made up of grasses, forbs (broad-leaf perennials) and ferns.

Hydrology: The scientific study of the properties, distribution and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Hydroseeding: A seeding method for use on steep slopes where other methods are not possible. A seed-water-mulch mixture is sprayed as a slurry evenly onto the slope.

Interseeding: The dispersing of seed into an established vegetation cover where desirable species still exist.

Lateral branches: The branches that grow out from the trunk or stem of a tree. Ideally they should be evenly spaced.

Laurentian Divide: The ridge of low rugged hills meandering through Northern Minnesota that separates the headwaters of streams which flow north into Hudson Bay and south into Lake Superior. The Laurentian Divide at this location is only a remnant of a once-gigantic mountain range formed more than one billion years ago.

Legumes: Herbacous or woody plants in the bean family. Because these plants are able to fix atmospheric nitrogen in the soil, they are known for their soil-improving quality.

Ligule: A papery, hairy or scar-like structure at the inner juncture of the leaf blade and leaf sheath; primarily in grasses.

Listed species: Species of plants and animals that are identified (listed) as endangered, threatened or of special concern.

Litter: The uppermost layer of decaying organic matter in any plant community.

Management unit: A subdivision of a management area.

Mesic: Sites characterized by intermediate soil moisture conditions, neither decidedly wet nor dry.(The Dictionary of Forestry, Society of American Foresters, 1998).

Monoculture: A stand of a single species, generally even-aged.

Moraine: An irregular accumulation of glacial drift (any rock material, sorted or unsorted, deposited as a result of glaciation), with an initial topographic expression of its own, built chiefly by the direct action of glacial ice. There are many kinds of moraines, including end moraines or terminal moraines, ground moraines and moraine complexes.(The Dictionary of Forestry, Society of American Foresters, 1998).

Mulch: Any loose covering on the surface of the soil to conserve moisture, control weeds and build soil. This may be organic material on site in the form of leaves and twigs, but is most often it is deliberately applied organic material, such as cut grass, straw, bark or sawdust.(The Dictionary of Forestry, Society of American Foresters, 1998).

Native species: An indigenous species (a basic unit of taxonomy) that is normally found as part of a particular ecosystem; a species that was present in a particular area at the time of the Public Land Survey (1847-1907).(The Dictionary of Forestry, Society of American Foresters, 1998).

Tall sunflower

Natural areas: A physical and biological area in nearly natural condition that exemplifies an ecological community with its biotic, geologic and hydrologic features. A natural area is allowed to go through natural physical and biological processes, with human intervention only to the extent of prescribed burning or fire suppression.(The Dictionary of Forestry, Society of American Foresters, 1998)

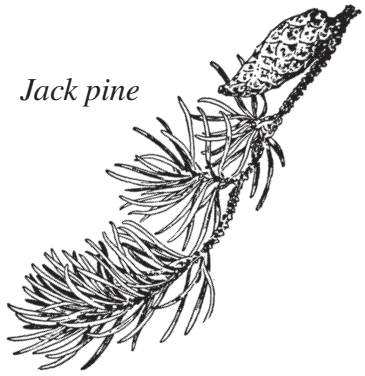
Natural colonization: Natural regeneration from seed that naturally falls on the ground and finds the right conditions to grow.(The Dictionary of Forestry, Society of American Foresters, 1998).

Natural community: Complex assembly of species as they have evolved in their environments over long periods of time.

Natural community management plan: A plan that identifies management priorities and strategies to enhance and preserve natural plant communities native to Minnesota.

Natural system: See *ecosystem.*

Nutrient level: The amount of nourishing ingredients in the soil that are available to plants.



Jack pine

Openings: Grassy openings in a forested or woodland environment.

Opportunistic species: Plant species that take advantage of certain conditions to establish and thrive, often to the disadvantage of other plants; exotic species, for example, are opportunistic.

Organic matter: The top layers of the soil where plant matter is in various stages of decomposition; for example, various layers of decomposing leaves on the forest floor.

Outwash plain: A level plain consisting of stratified sands and gravels laid down by glacial meltwater streams.

Phytophotodermatitis: A painful rash that develops when people with sensitive skin come in contact with plant sap of wild parsnip in the presence of sunlight. Wild parsnip (*Pastinaca sativa*) is a non-native plant that occurs frequently in the southeastern part of the state.

Pine barrens: A form of savanna (see *savanna)* that occurs in the north-central part of the state on very sandy soils. Dominant plants include: Jack pine, northern pin oak, American hazel, blueberry, sweet fern, spreading dogbane and wild strawberry.

Prairie: A fire-dependent natural plant community, dominated by grasses and with few or no trees.

Propagule: A part of a plant, such as a bud, tuber, root, shoot or spore, that can multiply vegetatively rather than through seed.(The Dictionary of Forestry, Society of American Foresters, 1998).

Remnant community: A plant community with all or part of its natural composition intact as it was recorded at the time of the Public Land Survey (1847-1907).

Rhizomatous plants: Plants that have modified stems that grow below ground and produce roots, scale leaves, and suckers irregularly along its length and not just at nodes, such as quackgrass and sumac.(The Dictionary of Forestry, Society of American Foresters, 1998).

Riparian: Pertaining to the bank or shore of a natural waterbody, the bank of a river, the edge of a lake or wetland.

Root collar: Transition area between stem wood and the point where the first main-order roots flare out.

Savanna: A more or less open woodland having an undergrowth mainly of grasses; trees are of moderate height and generally deciduous or evergreen.

Scarify: To apply chemical, mechanical, heat or moisture treatment to seeds to make the seed coat permeable and thereby improve germination.

Scouring: Soil erosion through the force of moving water.

Slope: An inclined surface.

Slumping: Soil sliding down suddenly, as it relates to the instability of an earthen slope.

Soil amendment: An improvement of the existing soil of a site by adding organic matter.

Soil fauna: Organisms that assist in the decomposing of leaf litter, eventually turning it into nutrient-rich soil.

Spring ephemerals: A forest groundlayer herbaceous species that produces leaves and flowers before trees leaf out, and then dies back soon after. These species are most numerous in moist hardwood forests.

spp: Several species of the same genus.

ssp: Subspecies.

Stoloniferous: Having a stem or branch that grows along the ground surface (stolon) and takes root at its nodes; strawberries are one example.(The Dictionary of Forestry, Society of American Foresters, 1998).

Fly honeysuckle

Submerged: Vegetation growing under water.

Succession: A dynamic phenomenon in natural communities whereby one group of plant species is supplanted by another over time.

Swale: A moist or marshy elongated depression in the landscape.

Target community: A plant community determined to be the most appropriate for a specific site. This determination requires indepth knowledge of the site and its history.

Terminal bud: The bud on the end of a shoot or twig.

Terminal bud scar: A mark at the end of a stem or branch, indicating the former attachment of a leaf and indicating where a new leaf or stem will grow again.

Thatch: Herbaceous plant material that has accumulated over several years, forming a thick layer of partially decomposed organic material that delays soil warmup in the spring and may suppress the growth of some species.

Topography: The physical features of a place or region.

Topping: Reducing the height of a tree or shrub by pruning indiscriminately across the top. Topping destroys the natural shape of a tree or shrub.

Trash ripper: Part of an inter-seeder drill that will slice through the vegetative layer and make a furrow in which the seed is placed.

Treadway: The surfaced or otherwise designated portion of a trail right-of-way where trail activities take place.

Understory: All forest vegetation growing under the canopy or upper layers of forest vegetation.

Upland site: A site that is most likely dry and more exposed to climatic variations; opposite of lowland.

Vermiculite: A neutral substrate of layered silicates that is commonly used for starting plant seeds and cuttings.

Weed trees: Species of trees, native and non-native, that aggressively invade a site when natural processes are disrupted.

Wildlands: Ecologically healthy lands that are not dedicated for such uses as agriculture, urban development, mining or recreation.

Wild-type seed: Seed that is directly derived from native wild stock, including seed that was collected from the wild and then put into production. Wild-type seed has not undergone a selection process.

Windthrow: Trees felled or broken off by wind; also called blowdown.

Woodland: A plant community in which, in contrast to a typical forest, trees form an open canopy, with the understory being occupied by shrubs, grasses and forbs.

Wild geranium