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Best Practices Handbook ON ROADSIDE VEGETATION MANAGEMENT

handbook

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Maintaining roadsides for safety and aesthetics is an important issue for all levels of government throughout Minnesota. Vegetation is one important element of roadside maintenance. This handbook provides guidelines for effective management of roadside vegetation for local agencies, and highlights seven best management practices that were identified through research, surveys, and discussion with industry experts.

The seven best management practices for roadside vegetation fall into these seven categories:

1. Develop an integrated roadside vegetation management plan
2. Develop a public relations plan
3. Develop a mowing policy and improved procedures
4. Establish sustainable vegetation
5. Control noxious weeds
6. Manage living snow fences
7. Use integrated construction and maintenance practices

The main conclusion from the handbook is that successful roadside vegetation management depends on an integrated approach. This includes a wide variety of best management practices to address the many issues involved. This integrated approach includes an assessment of the existing conditions and determination of the type of roadside environment desired. Other construction operations, including proper seeding techniques, selection of the correct plant in the right area, selection of salt-tolerant seed species where needed, and erosion control, will greatly affect the roadside condition. Use of integrated construction and maintenance practices is one of the most important best management practices identified in the handbook.

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Executive Summary

Maintaining roadsides for safety and aesthetics is an important issue for all levels of government throughout Minnesota. Vegetation is one important element of roadside maintenance. A healthy roadside environment reduces maintenance needs and costs, preserves the roadside surface, provides safety for vehicles and travelers, limits liability for the governing agency, maintains good public relations, and improves the overall driving experience. This handbook was written to provide guidelines for effective management of roadside vegetation for local agencies, and highlights seven best management practices (BMPs) that were identified through research, surveys, and discussion with industry experts.

The seven best management practices for roadside vegetation fall into these seven categories:

1. Develop an integrated roadside vegetation management plan
2. Develop a public relations plan
3. Develop a mowing policy and improved procedures
4. Establish sustainable vegetation
5. Control noxious weeds
6. Manage living snow fences
7. Use integrated construction and maintenance practices

Appropriate management techniques for vegetation along a specific roadway depend on many factors, including:

- the type of vegetation desired
- the desired appearance of the roadside
- soil conditions
- roadway traffic
- roadway use and visibility
- adjacent land use
- roadway location
- topography

Additional management constraints include available staff, resources, equipment, environmental constraints, adjacent land use, and many others. When developing a plan for roadside vegetation management, all of the above are to be considered. This handbook offers suggestions for doing so, and for developing an integrated plan that optimizes available resources and desired results.

This handbook also reviews local government roadside vegetation management practices in Minnesota. It highlights some of the practices that the state, counties, and cities have found to be effective or efficient. The material should be useful to local governments that are interested in how others agencies with similar concerns manage their roadside environments.

The main conclusion from the handbook is that successful roadside vegetation management depends on an integrated approach. This includes a wide variety of best management practices to address the many issues involved. This integrated approach includes an assessment of the existing conditions and determination of the type of roadside environment desired. Other construction operations, including proper seeding techniques, selection of the correct plant in the right area, selection of salt-tolerant seed species where needed, and erosion control, will greatly affect the roadside condition. Use of integrated construction and maintenance practices is one of the most important best management practices identified in the handbook.

Introduction

Throughout Minnesota, all levels of government are concerned with the issue of maintaining their roadsides—for both safety and aesthetic reasons. A healthy roadside environment reduces maintenance needs and costs, aids in preserving the roadside surface, provides safety for vehicles and travelers, limits liability for the governing agency, maintains good public relations, and improves the overall driving experience.

This handbook strives to provide assistance to local agencies in roadside vegetation management operations by sharing information obtained from the many years of experience of those working in the field, and by highlighting new technology that is improving operations. This handbook also highlights seven best management practices (BMPs) identified through research, surveys, and discussion with industry experts.

REVIEW OF ROADSIDE VEGETATION MANAGEMENT PRACTICES

One vital element of roadside maintenance is vegetation. Roadside vegetation management is a critical, expensive, and time-consuming operation for many local agencies. Reduced resources, whether monetary or staffing, have created the need for better management of roadside maintenance activities. Additionally, legislation that requires the control of noxious weeds, restriction of mowing times and areas, and protection of groundwater imposes additional responsibilities.

Effective management requires an integrated approach incorporating the needs of local communities and users with a broad knowledge of plant ecology and natural processes, design, construction, and maintenance; monitoring and evaluation procedures; government statutes and regulations; and technology. All of these factors must be considered when developing a plan to economically manage roadsides for safety, environmental health, and visual quality.

To obtain information about current practices, three surveys were distributed to a variety of city and county recipients in Minnesota as well as in Wisconsin, Nebraska, North Dakota, South Dakota, and Iowa. A Technical Advisory Panel composed of industry experts evaluated the survey responses, followed up with telephone interviews, and then developed the list of seven best management practices highlighted in this handbook. See Appendix A for more about this process.

The Technical Advisory Panel identified seven recommended general actions for effective roadside vegetation management, based on the findings of three surveys, discussions with practitioners, and current research. Each site is unique, possessing its own criteria, needs, and circumstances. Depending on the type of roadside environment being managed, one or all of the following management tools may apply.

Seven Best Management Practices for Roadside Vegetation:

1. Develop an Integrated Roadside Vegetation Management Plan
2. Develop a Public Relations Plan
3. Develop a Mowing Policy and Improved Procedures
4. Establish Sustainable Vegetation
5. Control Noxious Weeds
6. Manage Living Snow Fences
7. Use Integrated Construction and Maintenance Practices

HOW THIS HANDBOOK IS ORGANIZED

This handbook has eight chapters and seven appendices.

Chapters 1–7 discuss each of the seven best management practices identified by the Technical Advisory Panel and offer ways to incorporate these practices into a roadside vegetation management plan. Chapter 8 gives specific examples of where and how these techniques are being used.

Appendix A presents the survey methodology, results, and responses. Appendix B gives detailed soil information. Appendix C lists vegetation characteristics, while Appendix D lists use of herbicides. Appendix E describes common Minnesota noxious weeds, and Appendix F lists Mn/DOT's technical memorandum No. 89-8-ME-6, pertaining to the withholding of funds for incomplete grading operation.

Chapter 1
Best Management Practice No. 1:
Develop an Integrated Roadside Vegetation Management Plan

WHY HAVE AN INTEGRATED ROADSIDE VEGETATION MANAGEMENT PLAN

An Integrated Roadside Vegetation Management (IRVM) Plan is a decision-making and quality-management process for maintaining roadside vegetation. It integrates many elements with cultural, biological, mechanical, and chemical pest control methods to economically manage roadsides for safety, environmental health, and visual quality.

The challenges government agencies face in managing roadside vegetation drive the need for effective IRVM programs. Those challenges include:

- increasing legal requirements, such as laws regarding water quality, mowing, and noxious weed control
- incentives for quality improvements and cost savings
- the need for the proper use of pesticides and herbicides
- increased public demands and customer expectations
- increased liability concerns
- mandates by governing agencies

An integrated plan will greatly assist in meeting the diverse expectations and requirements listed above as well as the requirements of the Groundwater Act of 1989. This act dictates, under "State Uses of Pesticides and Nutrients," that "The state shall use integrated pest management techniques in its management of public lands, including roadside rights-of-way, parks, and forests; and shall use planting regimes that minimize the need for pesticides and added nutrients" (Chapter 326, Article 5, 18B.063).

In addition to the Groundwater Act of 1989, the 1994 amendment to it (Chapter 558, Section 26)

required the Commissioner of the Department of Natural Resources (DNR) to prepare a plan for the optimum use of sustainable agriculture and integrated pest management techniques on land owned by the state. A report published in March of 1996 provides the framework for the development of local IRVM plans, which are outlined in Chapter 8.

Benefits of implementing an integrated management plan

SAFETY
Creation of adequate sight distances and hazard-free zones
Minimized effects of rain, blowing and drifting snow, and ice formation
Reduced hazardous conditions for maintenance staff

ECONOMIC
Increased productivity from planning work versus reacting to work problems
Economical and environmentally sustainable outcomes
Extended life of pavement
Use of optimum weed and pest control measures
Improved cost-effectiveness of construction activities

FLEXIBILITY
More efficient use of staff, time, and equipment through planning
A variety of management tools and techniques from which to choose at any given time

ENVIRONMENTAL
Improved water quality
Improved overall air quality
Protected soil
Increased biodiversity and desirable native plant communities
Reduced number of invasive plants and weeds
Improved safety for wildlife
Newly created habitat
Reduced impact of roadway projects

AESTHETIC
More healthy vegetation appropriate for the area
Creation of a diverse plant community without noxious weeds and undesirable vegetation
Use of plants for screening
Improved appearance of roadway due to native grasses and wildflowers
Pleasant experience for travelers

PUBLIC RELATIONS
Establishment of partnerships, teamwork
Shared expertise between agencies
Increased public awareness of maintenance activities

DEVELOPING AN IRVM PLAN

When developing an IRVM plan, consider the needs of local communities and users; plant ecology and natural processes; design, construction, and maintenance processes; monitoring and evaluation procedures; government statutes and regulations; and technology. The five steps for developing a plan are:

1. Promoting an IRVM Philosophy

Convincing maintenance staff and decision makers to adopt an integrated approach to roadside vegetation management may be difficult, and full implementation of an agency-wide IRVM program may take a long time. Five focus areas are given below, along with considerations for promoting an IRVM philosophy.

Public Involvement
- Educate the public on why and how roadsides are managed. This education should include the reasons for roadside vegetation management in relation to functional roadway objectives, surrounding land use, the overall ecosystem, natural processes, and applied technologies.
- Communicate an appreciation for the beauty of self-sustaining, low-maintenance roadsides.
- Communicate the cost-savings realized through lower life cycle maintenance costs, less negative environmental impact, and efficient use of tax dollars.

Legislative Considerations
- Communicate to the legislature that IRVM is a worthwhile investment that will result in lower maintenance life cycle costs. To do so, initial costs must be presented clearly in relation to long-term savings with innovative technologies.
- Maintenance funding must be dedicated at a reasonable base level for accomplishment of all critical maintenance and some preventive maintenance activities.

Upper Management
- Communicate the role that IRVM can play as a problem-solving tool for roadsides.
- Provide the necessary links with design and construction personnel when constructing the roadway.

Maintenance Supervisors
- Recognize that these people are the primary resources for motivation, coordination, guidance, training and follow-through on an IRVM program.
- Develop a management system that includes necessary record-keeping and cost-tracking components for measurement and evaluation.
- Require these staff members to develop and implement relevant technology and computer applications for the implementation and practice of the IRVM program.

Maintenance Staff
- Hire, train, and dedicate crews for roadside maintenance.
- Inspire crew members and motivate them to learn and continuously improve the quality of roadsides in their care.
- Recognize those individuals and crews that succeed in improving their roadside environment.

IRVM provides a way to support ongoing improvement through a continuous evaluation of how roadsides are managed. The most important factor is participation from those parties listed above.

2. Preliminary Planning

Each roadway is unique, and one plan for all roads in a jurisdiction may not be appropriate. The next step in moving towards integrated roadside vegetation management is to evaluate the roadways for which an agency is responsible, and assign them to categories for which a plan can be developed.

A local plan adapted to fit local culture, political concerns, and climate and environmental conditions is best. Developing a plan requires a team effort, with input from those people having expertise in landscape architecture, maintenance, design, construction, biology, horticulture, utilities, and public relations as well as from general citizens. A steering committee responsible for developing the plan, providing guidance on how it is run, and reviewing the annual work plan and progress may also be created.

All roadsides should receive the same type of management (mowing, brushing, etc.) that results in a safe roadway for those using it. However, prior to plan development, the agency should identify the roadways they are responsible for maintaining and prioritize them according to the level of management they will receive. The amount and type of vegetative maintenance done on each roadside will depend on the category to which it is assigned.

Suggested categories include:

- Location — Urban or rural
- Zoning — Industrial, commercial, residential, and agricultural
- Level of use — High or low traffic
- Roadway type — Interstate, primary, or secondary road

While developing the plan and considering maintenance strategies, keep the following guidelines in mind:

- Timing is an important factor for all control and maintenance methods.
- Programs should be kept flexible to allow for changes as needed.
- A combination of several control methods is usually more effective than any single treatment.
- Maintenance costs are lowest when programs are planned and carried out on schedule.

Also, identify the desired outcome for a given feature. For example, is the objective to have low maintenance, return the roadside to prairie grasses, maintain golf course-like sod, or reestablish a wetland? Once you have identified the desired outcome, you can develop a plan to achieve it.

3. Assessing Existing Conditions

Assess existing conditions to assign and prioritize management strategies for an area. Three factors that will steer management techniques are soil, topography, and vegetation.

SOIL

Understanding the type of soils present and their physical characteristics is important when outlining a plan for roadside vegetation management. Soil type and texture determine vegetation selection, herbicide application rates, fertilization needs, and erosion potential. Once known, target management techniques to those conditions.

The ideal surface soil is composed of 5 percent organic matter, 25 percent air, 45 percent mineral material, and 25 percent water. The organic material provides fertility and water-holding capacity and supports microbial life. Oxygen is required for all root growth. Along roadsides, soil is typically stripped of its nutrients and compacted such that little air remains in the soil, leaving a very hostile environment for vegetation to flourish. When trouble-shooting to determine causes of vegetation problems, assessing the soils in an area may explain excessive weed growth or resistance to chemical control methods.

Field Determination of Soil Texture

Conducting laboratory tests to determine soil texture and type is not always practical or possible, so it is useful to have methods of classifying soil in the field. You can do this by feeling the soil and by making judgments based on its appearance.

To make a field determination, break the soil in your hand. How easily it breaks is one indicator of the soil type. Next, moisten the soil and form it into a cast. Press or rub the moist sample between your thumb and index finger to create a thin ribbon until it breaks. You will be able to "ribbon" the soil if it is moist enough to be worked with the fingers but provides some resistance. Ribbons of soil should be about 1/2-inch wide and about 1/8-inch thick for best results. Classifying soils using these methods may prove difficult at times, but with practice and experience, it is possible to become reasonably proficient.

The descriptions of the soil classes in Table 1-1 are for field use. The main soil classes are described as well as likely variations.

Appendix B contains additional detailed information about soil weathering, formation, and texture.

Table 1-1. *Field Classification of Soils*

Soil Classification	**Description**
Gravel (G)	A combination of soil particles between 2 mm and 3" in size. Fine gravel has a predominance of particles between 2 mm and 3/8". Gravel is easily identified by visual inspection.
Sand (S)	All particles are smaller than 2 mm (No. 10 sieve). Contains less than 10% silt and clay. Appearance is loose and granular, and individual particles can be readily seen and felt. Non-plastic, and therefore can't be pressed into soil ribbons. If squeezed into a cast in the hand when dry, it will fall apart when pressure is released. Squeezed when moist, it will form a cast that holds its shape when the pressure is released, but will crumble when touched. Variations include -Coarse sand (Cr S): main particle size is 425 mm (No. 40)–2 mm (No. 10) -Fine sand (FS): main particle size is 75 mm (No. 200)–425 mm (No. 40) -Very fine sand (VFS): almost all particles are close to 75 mm (No. 200 sieve). It may be difficult to distinguish between very fine sand and silt. -Sand (S): applied when the sample is well graded, and contains approximately the same amount of coarse and fine sand.
Sand and Gravel (S & G)	A mixture of sand and gravel. Very well graded, identified by visual inspection. Variations include -Sand and Fine Gravel (S & FG) -Coarse Sand and Gravel (Cr S & G) -Coarse Sand and Fine Gravel (Cr S & FG)
Loamy Sand (LS)	All material is smaller than 2 mm (No. 10 sieve). Contains 10–20% fine-grained silt and clay combined. Loose and granular, with individual soil particles that may be easily seen and felt. Appears dirty when compared with sand, due to higher silt and clay content. Non-plastic, and therefore can't be pressed into soil ribbons. Squeezed into a cast in the hand when moist, it will form a cast that holds its shape when the pressure is released. The cast will withstand careful handling and some jarring without crumbling; this stability differentiates loamy sand from clean sand. Loamy Sand can be further classified as coarse, fine, or very fine, depending on the proportions of different sizes of sand particles present. The term Loamy Sand (LS) is used when the material is well graded, containing approximately equal proportions of coarse and fine sand.
Sandy Loam (SL)	Contains 20–50% silt and clay combined, but less than 20% clay. May contain 0–50% silt and 0–20% clay, but must always contain at least 50% sand grains. Plastic, so when moist can be pressed into thin ribbons between the thumb and index finger. Individual sand grains seen and felt. Other soils fitting into this category include -Slightly Plastic Sandy Loam (sl pl SL) -Plastic Sandy Loam (pl SL) -Slightly Plastic Coarse Sandy Loam (sl pl Cr SL) -Plastic Fine Sandy Loam (pl FSL) -Plastic Very Fine Sandy Loam (pl VFSL)

Table 1-1. *Field Classification of Soils* (cont'd)

Soil Classification	Description
Loam (L)	(The term "loam" generally means a combination of sand, silt, and clay; this soil contains more than 50% silt and clay combined.) Contains 30–50% sand, 30–50% silt, and 0–20% clay. Somewhat gritty, but feels smoother than sandy loam. When moist, it will form a ribbon 1/4-1" in length, but somewhat thinner and stronger than can be formed with sandy loam. The word "loam" is commonly used in agricultural fields to describe topsoil, which contains black organic material.
Silt Loam (L)	Contains 50–100% silt, 0–50% sand, and 0–20% clay, and must always contain at least 50% silt particles. When dry, may appear cloddy, but the lumps are easily broken. When pulverized, feels soft and fluffy. When moist and pressed between the thumb and index finger, offers little resistance to pressure and feels smooth or slippery. Non-plastic and will not press into a continuous ribbon, but rather into shorter, crumbly, dull sections. Sticks together when moist, in a manner similar to flour with water added to it, because of its fine-grained structure. In its natural state in the ground, may be very wet, due to the capillary affinity for water.
Clay Loam (CL)	Contains 20–30% clay, 20–50% silt, and 20–50% sand. Fine-textured and will form a ribbon 1–2" long before breaking. Does not offer as much resistance to pressure as clay loam and has a dull appearance, but is slippery.
Sandy Clay Loam (SiCL)	Contains 20–30% clay, 20–50% silt, and 20–50% sand. Fine-textured soil, which will form a 1–2" ribbon without breaking. Does not offer as much resistance to pressure as clay loam and has a dull appearance, but is slippery.
Sandy Clay Loam (SCL)	Contains 20–30% clay, 50–80% sand, and 0–30% silt. Has a gritty feel compared to the more slippery feel of clay loam. Will form a 1–2" ribbon.
Clay (C)	Contains 30–100% clay, 50% silt, and 0–50% sand. Smooth and shiny. Will form a long, thin flexible ribbon 2" or more in length.
Silty Clay (SiC)	Contains 30–50% clay, 50–70% silt, and 0–20% sand. Very plastic, but feels smooth and slippery ("buttery"). Will form a ribbon 2" or more in length.
Sandy Clay (SC)	Contains 30–50% clay, 50–70% sand, and 0–20% silt. Very plastic, but feels gritty. Will form a long, thin ribbon 2" or more in length.

Soil Health

Healthy soil is a critical element for establishing a healthy roadside environment. Even the most appropriate and useful tools for managing roadside vegetation may not work if the soil lacks enough nutrients to support the targeted vegetation. To improve unhealthy soil, try measures such as the use of a fertilizer, aeration, or deep scarification to incorporate oxygen into the soil. If improving soil health is not possible, choose appropriate vegetation (that does not need high nutrient soils to flourish) for establishment in that area.

The first step is determining the health of the soil. A soil quality task force established by the Soil Science Society of America defines soil quality as "the capacity of a specific kind of soil to function, within natural or managed ecosystems, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation."

A 1993 study interviewed 28 farmers from southeastern Wisconsin about their methods for recognizing a healthy soil. From the farmers' perspective, a soil's health can be seen in the plants that grow from it, animals that live nearby, and water (ground and surface) that flows over or through it. The study verified that the appearance of the vegetation growing in a soil is a main indicator of the soil's health.

The farmers also said the presence of weeds indicated unhealthy soil (see Table 1-2).

***Table 1-2. F**armers' Indicators of Healthy and Unhealthy Soils*

Soil Property	Healthy Soils	Unhealthy Soils
Organic matter	High as possible	Lacking in organic matter
Vegetation appearance	Green, healthy, uniform, lush, dense stand, tall, large leaves	Stunted or small, poor color
Erosion potential	Will not erode from water or wind	Blows or washes away sooner
Earthworms	Worms abundant, seen after rain, evidence of holes and castings	Few worms, if any, present
Drainage	Good drainage without ponding	Tight or waterlogged, drains too fast, may pond
Tillage	Readily breaks up, crumbles	Needs more disking, lumpy
Soil structure	Won't roll out of hand, crumbly, loose, granular	Hard, lumpy, compacted
pH	6.2–7.0	<6.0 or >7.0
Compaction	Doesn't pack down, stays loose	Compacted, hardpan
Infiltration	No standing water, rapid absorption into soil	Water runs off soil or sits on top
Soil color	Dark, black	Orange, light brown, bleached, sandy or mottled color
Water retention	Holds moisture	Takes too much moisture, or doesn't hold any
Roots	Large, deep, spread out	Undeveloped, shallow, short

The farmers recommended several ways to maintain and improve the health of the soil, such as adding manure and compost, planting cover cropping, applying lime, and avoiding working the soil when it is wet.

The Wisconsin Soil Health Scorecard was developed from the results of the survey. The scorecard, a tool for assessing and monitoring soil quality and health, allows for a holistic evaluation of soil, plant, animal, and water properties by asking several questions. Each question measures a soil health property along a 0–4 point scale, with 0 representing an unhealthy soil, 2, an impaired soil, and 4, a healthy soil. Once a final score is totaled for each soil, it can be used as an initial assessment and as a reference for future health after implementing a management plan.

Another way to assess the health of the soil is to send a sample to the University of Minnesota Extension Service Office. For a small fee, the service will analyze the nutrient content of the soil sample and recommend the appropriate type and application rate for any necessary fertilizer.

Soil Considerations for Herbicide Use

Herbicide application rates vary according to soil type. When determining a method to control weeds, evaluating the soil type may explain a specific weed growth or resistance to treatment in an area.

Guidelines for Herbicide Application

1. Use lower application rates for coarse-grained soils and higher rates for fine-grained soils or soils high in organic material.
2. Learn the potential for herbicide runoff before using it.
3. Do not spray in these areas if rain is likely since steeper slopes increase runoff.

Soils can be categorized as coarse or light, medium- or fine-grained, with the following properties and resulting considerations for herbicide application (Table 1-3).

Table 1-3. *Soil Types and Properties*

Grain Size	Description	Properties	Herbicide Considerations
Coarse or light	Dry: breaks easily, crumbles into loose soil Moist: feels gritty, forms ribbons ≤1/2" long	Sandy soil contains more than 50% sand and is well drained, doesn't hold nutrients well or cause chemicals to break down quickly	Low rates of application
Medium	Dry: resists moderate pressure before breaking. With high silt content, soil will pop apart suddenly in a burst of floury soil; soil feels soft and floury with some grit Moist: forms 1" ribbon and leaves dull fingerprint marks	Loamy soils have low sand clay content but high silt, are chemically inactive, and do not absorb or tie up chemicals	Normal rates of application
Fine or heavy	Dry: hard to break clods of soil Moist: makes very firm casts, forms ribbons > 1" long, and leaves shiny fingerprint marks	Chemically active particles have surfaces that attract and hold onto water, minerals, and chemical herbicide particles	Higher rates of application

Erosion/Runoff Potential

Erosion and runoff can be a serious problem along roadsides, both during and after construction. Erosion is caused when the land surface is washed away by wind or water; sediment is the byproduct. In addition to the loss of valuable soil resources, erosion results in an unhealthy environment for growing vegetation, waterways polluted with sediment, and costly maintenance activities to repair damage. Damage at the site may include rilled and gullied slopes, washed-out ditches, damage to pavements and drainage structures, clogged pipes, and flooding. Water bodies are damaged when they become filled with polluting sediment, making them susceptible to flooding and stream bank erosion.

Vegetation retards erosion. A recent study showed that, in a given rainfall episode, bare soil can lose up to 100 pounds of sediment, mulched soil loses up to 20 pounds, and well-vegetated soil loses only up to one pound. The presence of well-established vegetation, or even a mulch cover, will preserve the soil and reduce the effects of erosion in an area.

The five types of erosion are listed in Table 1-4.

Significant erosion problems can occur during construction before new turf is established.

Table 1-4. *Types of Erosion*

Type of Erosion	Description	Minimization Technique
Raindrop splash	The impact of the raindrop dislodges soil, causing bare soil to be splashed into the air. The effect of the splash also increases compaction and destroys open soil structure.	Stabilize the soil to prevent erosion.
Sheet erosion	The transporting mechanism of soil is loosened by raindrop splash, resulting in the removal of soil from sloping land in thin layers. A function of soil type, depth, and velocity of flow.	Minimize by diverting flow away from the slope.
Rill erosion	The sheetflow becomes concentrated in small, defined channels a few centimeters deep. The form of erosion in which most rainfall erosion occurs.	Prevent by slope stabilization and diverting flow. Repair immediately with disking or tilling.
Gully erosion	The effect of concentrated flow in unrepaired rills.	Requires extensive repair.
Channel erosion	Erosion occurring at bends and in constrictive areas.	Smooth bends, add riprap.

Sandy or gravelly soils may be excessively drained, and are typically light brown with a red or orange tint. Herbicides applied to these soils may leach through quickly when their application is followed by a heavy rain, polluting the water layer. Herbicides may also be transported laterally underground, affecting non-targeted regions.

According to the new Natural Resource Conservation Services, there are four major soil groups, based on infiltration rate.

Type A: Sands and gravels, with low runoff potential and high infiltration rates.
Type B: Average to medium coarse-textured soils, with average runoff potential and moderate infiltration rates.
Type C: Moderate- to fine-grained soils, with high runoff potential and slow infiltration rates.
Type D: Clay soils, with very high runoff potential and very low infiltration rates.

Generally, the permeability and water-holding capacity of a soil increases with its organic content, soil structure, and fertility.

TOPOGRAPHY

Topography also affects roadside conditions. Slope aspect, exposure, and configuration affect vegetation establishment and sustainability and interact with vegetation to modify microclimates. Runoff and erosion potential are increased in areas with high topographic relief. Flat, low spots will hold water, allowing for sediment to settle and remain on site. Therefore, keep topography in mind when evaluating vegetation, erosion control needs, herbicide types, and mowing strategies.

In areas with high slopes and rough terrain, regrading may significantly reduce erosion problems. To reduce erosion, preserve as much natural vegetation as feasible during regrading. Also, make slopes as flat as possible, with adequate rounding at the top and bottom. The degree of slope affects the roadside appearance, safety, and maintainability, with flatter slopes allowing for easier mowing, spraying, and other maintenance activities.

Some tips for reducing erosion are:
- Slow water velocity.
- Divide runoff into smaller quantities.
- Allow for water infiltration.
- Provide mechanical or structural retention methods.

A combination of adequate drainage, protective lines, and desirable vegetation offers the best means for conserving soil.

VEGETATION

Native Vegetation

Native plants, and the benefits of establishing them along roadsides, have been given much attention recently. The term "native" refers to a plant species' place of origin, and in this case refers to a plant that was present in this region prior to European settlement. Native plants form naturally diverse plant communities that are well adapted to Minnesota's soils, wildlife, and extreme climate. However, a plant that is native to Minnesota may not be native to the specific area in which it is being planted. Prior to developing a plan for a roadside, consider which types of plants are native to that specific area.

Non-native plants have been introduced to this state from other continents by settlers, by gardeners, or by accident. They often displace native plants when their natural checks and balances do not work in the new environment. Non-native species also often form much less diverse plant communities that provide poor habitat for native wildlife. Today, Minnesota has about 1,800 species of flowering plants, of which as many as 20 percent are introduced or non-native species.

There are three main reasons for preserving native plants:

Environmental: There are no substitutes for the original wild species of Minnesota. Once lost, their genetic material can never be re-created. Also, native wildlife often depend on native vegetation for survival.

Economic: Native plant communities are relatively stable and require little maintenance. These natural communities provide good erosion control and are less susceptible to weed invasions.

Aesthetic: Native wildflowers and grasses provide seasonal color changes along roadsides, a natural beautification. They also screen undesirable views and objects if planted strategically.

Currently, 75 species of plants are endangered or threatened with extinction in Minnesota. Habitat loss due to land use changes frequently threatens the existence of these rare plants. The best way to save them is to preserve their natural habitats now.

Minnesota contains three vegetation zones, each with the following native vegetation:

- Northern Conifer Forests
  Extensive pine and spruce forests, peat bogs, and muskegs give the feeling of "wilderness" to the northeastern third of the state. Areas also contain members of the heath family, such as blueberry, swamp laurel, and Labrador tea, along with other forest plants such as twinflower, Canada mayflower, bunchberry, star flower, and blue-bead lily. Roadside wildflowers include fireweed, joe-pye weed, evening primrose, prickly wild rose, and wild columbine.

- Eastern Deciduous Forests
  Ranging from oak savannas to maple-basswood forests of the "Big Woods," the eastern deciduous forests have a different variety of wildflowers. Wildflowers in these areas include trillium, jack-in-the-pulpit, hepatica, bloodroot, violets, and wild geranium.

- Western Tallgrass Prairies
  Fertile soils created by native prairie grasses originally drew the European settlers into southern and western Minnesota. Rare prairie remnants are occasionally found along railroad and highway rights-of-way and in old cemeteries, on land that was never used for agriculture. Prairie wildflowers include hoary puccoon, butterfly weed, bergamot, blazing star, and New England aster. Prairie grasses include big bluestem, little bluestem, and Indian grass.

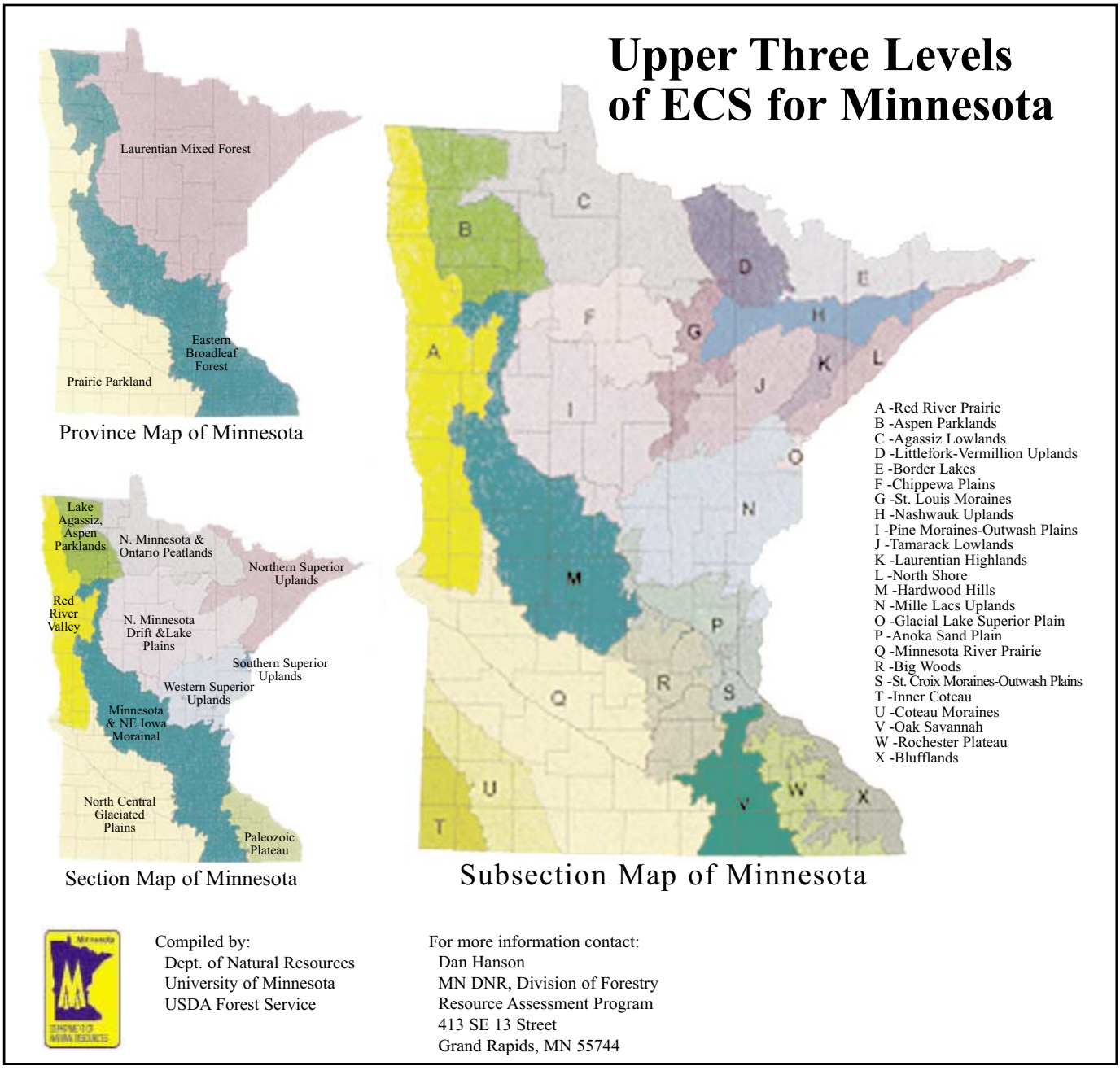


Figure 1-1. *Ecological Classification System Maps of Minnesota*

Very few areas of undisturbed native vegetation remain in Minnesota. Although at one time tall grass prairies covered a third of the state, they are now very rare, covering only one percent of their original acreage. Figure 1-1 shows presettlement vegetation types in Minnesota.

Plant Types

Plants may be grouped according to their physical characteristics or according to their life cycles (Table 1-5). Note their classification when determining a control strategy, as a plant's reaction to treatment depends on these characteristics. Understanding the life cycle of a plant will help you determine the correct timing for control methods.

Table 1-5. *Plant Types*

Plant Groups	Description
	Plant Groups According to Physical Characteristics
Grass	Plants have a single seedleaf. Leaves are narrow and upright; roots are fibrous and part of either a simple, shallow annual system or an extensive, winter-hardy perennial system that spreads laterally over many feet.
Broadleaf	Plants have two seed leaves. Leaves are generally broad with net-like vein patterns; roots are part of a coarse root system. Plants may be winter or summer annuals, biennials, or perennials.
Woody	Plants are perennials with woody stems, which do not die over winter. Examples are low-growing brush, shrubs, perennial vines, and trees.
	Plant Groups According to Life Cycle
Annuals	Plants that complete their life cycle in one year. Summer annuals germinate in the spring, grow in the summer, and die in the fall. Control is most effective in the spring when they are seedlings. Winter annuals germinate in the fall, begin growing in the winter, and flower in early spring. Seeds are also produced in spring, and plants die by summer. Control is most effective in the fall or early spring.
Biennials	Plants that need two years to complete their life cycle; they produce a low-growing plant in the first year and a flower stalk in the second. Plants then die after the seeds have matured in the second year. Control is most effective during the first year of growth.
Perennials	Plants that live indefinitely and reproduce by seed. They also reproduce vegetatively by rhizomes, tubers, or root sections. Control is difficult because of their extensive root systems, but is most effective with the use of systemic herbicides when plants are seedlings. For established perennials, adapt control methods to the yearly life cycle of the plant. Herbicides applied to foliage during the early part of summer are not very effective because of plant characteristics. Once flowering begins, foliar applications of herbicides are most effective (during bud-to-flower stage and especially just before flowering). Chemical herbicides are also effective right after plants are cut (on woody plants) and new growth occurs (on herbaceous plants). Application in the fall, prior to plants going dormant, is also effective. Foliar herbicides are most effective on woody plants when applied in mid- to late summer. Treatment with dormant sprays is possible during the winter as well.

4. Developing a Plan

After the steering committee or appropriate personnel have been assembled and roadside areas have been categorized, the IRVM Plan may be written. Steps to writing the long-range plan are listed below.

1. Develop a vision or mission statement.
   A vision statement is a picture of your road 10 to 20 years in the future. It includes your highest aspirations for what the roadside can become and serves as a source of motivation for all those involved in the process. A mission statement is broad and outlines the ultimate reason for the program's existence.

2. Collect pertinent data, such as costs, vegetation (existing and desired), available personnel, and resources.
   This step includes reviewing records of current maintenance operations and taking an inventory of current roadside vegetation conditions.

3. Establish goals and objectives.
   When doing so, consider the following basic principles:
   -Safety for the traveling public and maintenance staff
   -Maintenance of the infrastructure and highway integrity
   -Cost-effective use of public resources
   -Environmentally sound decision-making
   -Needs and concerns of adjacent landowners and the traveling public

4. Analyze and prioritize goals and objectives.
   Identify which goals are most important. This allows problem areas to be dealt with first, making other goals and objectives easier to reach.

5. Assign duties and responsibilities for each program participant.
   With input from those staff members who will be responsible for plan implementation, assign duties and responsibilities.

6. Plan for budget considerations.
   Identify costs connected with implementing each plan element, as well as ways to deal with budget constraints. This may include planning for equipment purchases and staff needs and increasing the efficiency of existing operations.

7. Provide an opportunity for research and innovation.
   Note research opportunities that may result in innovations for improving quality, reducing costs, and improving working conditions for maintenance staff.

8. Provide evaluation criteria
   This may be the most important element of the IRVM plan. It is critical that some benchmark be developed to measure program success. Meet and document short-term goals and objectives. Maintain records of implementation activities over time to evaluate overall direction and accomplishments. Periodically evaluate the plan to determine if it is advancing and if it has reasonable and attainable goals and objectives. Make changes as needed.

5. Implementing the Plan

Take the following steps to implement the IRVM plan:

1. Identify appropriate methods and application for control.
   For each maintenance activity, identify the appropriate control method. This could include mechanical methods, such as mowing and aeration; biological or natural processes; cultural methods, such as appropriate seed selection, planting and mulching, or burning; chemical methods, such as the use of herbicides and pesticides; a hands-off approach; or preservation and conservation.

2. Train.
   Train all staff responsible for implementing each element of the IRVM Plan regarding the plan components and their responsibilities. This is especially important for those staff members who will be completing the actual maintenance activities.

3. Keep records.
   Keep records of maintenance activities. This includes information about the type of control used, conditions under which it was applied, and general management information. Information about the control method includes weather, application area limits, time of application, concentration and quantity of any chemicals applied, and other information as needed. For general management purposes, hours, personnel, equipment, and costs are needed to set priorities, evaluate cost-effectiveness, and budget time and money for future activities. A complete and continuously updated location map, indicating control activities and dates of application, is recommended. This can be integrated with a Geographic Information System (GIS) to automate the record-keeping process.

4. Evaluate the program.
   Regularly evaluate in order to measure the success of an IRVM Plan. This may include tracking the number of citizen complaints received before and after plan implementation, cost reductions for certain maintenance activities, and allocation of staff time. Evaluate the effectiveness and success of plan elements and make changes as necessary. Evaluation is an ongoing process, as are changes and improvements.

ADDITIONAL RESOURCES

How to Develop and Implement an Integrated Roadside Vegetation Management Program, available from the National Roadside Vegetation Management Association at 218 Rhett Drive Adams Run, Newark, Delaware 19702.

The Vegetation Management Association of Minnesota. Contact Paul Walvatne or Bob Jacobson at Mn/DOT Environmental Services, 888-345-2537, for additional information.

Chapter 2
Best Management Practice No. 2:
Develop a Public Relations Plan

When asked to identify the most challenging aspect of roadside vegetation management, improving public relations was the issue listed most often by survey respondents. Effective public relations include dealing with a variety of audiences, such as homeowners and adjacent right-of-way owners; media relations; complaint handling; and crisis management. The most cost-effective integrated vegetation management program will include a public relations plan. Such a plan can efficiently resolve complaints and manage crises, protect the program from budget cuts by selling its advantages to the public, and increase the public's general approval of herbicide use or other management strategies. Each agency should have a plan for media relations, complaint resolution, and crisis management.

Effective public relations depend on the following elements:

- *User awareness*: Users of the vegetation management plan must thoroughly understand the program, its intent, and its goals. Maintenance staff stands at the forefront when dealing with the public while conducting maintenance activities. However, all staff members, as well as other agency personnel responsible for dealing with the public, should be trained regarding the purpose of the activities and the rules and regulations considered in developing the plan. Agency staff should be cooperative and knowledgeable about the policies and procedures being implemented.

- *Public awareness*: Notify the public prior to conducting controversial roadside vegetation management activities, such as herbicide application. Coordinate control operations with adjacent property owners, whether they are homeowners, other agencies, utilities, or companies. Communicate specifics of the plan to property owners and address any concerns or oppositions prior to beginning work.

- *Media relations*: Use the media to make the public aware of spraying operations, as well as to assist in achieving public understanding and acceptance of roadside vegetation management policies, plans, and programs. Communications, whether issued before or after work is performed, should be clear, honest, and helpful.

- *Response to complaints*: Responses to complaints should be complete and professional. When a complaint is made, assign an appropriate staff person to respond to it, recording evidence with color photographs and consulting the manufacturer of a specific product if needed. Develop a standard procedure, preferably in writing, to ensure that all complaints are received and resolved in the same objective manner.

- *Crisis management*: A crisis is most easily managed in its early stages. Implementing a crisis plan as part of roadside vegetation management will make that quick response possible.

Chapter 3
Best Management Practice No. 3:
Develop a Mowing Policy and Improved Procedures

Since mowed areas are so visible to the public, mowing may be the single most important part of a vegetation maintenance operation. A mowing policy makes for better use of maintenance staff time, assists in the prioritization of areas to be mowed and not mowed, increases safety for the mowing staff, and improves public relations.

Mowing roadsides is very expensive in terms of personnel hours, equipment hours, and fuel consumption. Its purpose is to provide sight distance and room for a vehicle to pull off the road, so mowing the entire roadside is unnecessary. If done improperly, mowing can cause additional maintenance problems and adverse effects to soils, roadside habitat, and nesting birds. Improper mowing height and too frequent or poorly timed mowing can reduce root mass, plant vigor, and overall plant production potential. Operating heavy equipment on roadside slopes can destroy vegetation, weakening the plant community and making roadsides more susceptible to weeds and erosion. Having a plan, and educating staff regarding proper mowing procedures, will prevent some of these problems.

Areas that require periodic mowing to maintain a safe right-of-way are intersections, bridges, sharp curves, and farm and field entrances. Everywhere else, allowing—or introducing—native grasses provides an acceptable alternative. The use of native grasses is outlined in Chapter 4.

DEVELOPING A MOWING POLICY

When developing a mowing policy, an agency should consider 1) safe operating practices, 2) the prioritization of mowed and unmowed areas, 3) the use of noxious weed formula, and 4) the expected or required cost reductions.

A good mowing policy will identify the following:

- objective of mowing
- impacts if mowing is reduced
- a communication plan between mower operators and weed sprayer operators
- areas that could be left unmowed with little negative effect
- ways to blend areas that are left unmowed with areas that are mowed
- treatment of those areas left unmowed
- mower operator training needs
- other maintenance activities that could be done if less time is spent on mowing
- magnitude of slopes to be mowed and not mowed
- person or persons who will determine the areas to mow and not mow
- best time to mow certain vegetation types, based on growth, time of year, or height
- alternative vegetation that could be planted that does not have to be mowed
- nesting times for local wildlife
- location of saturated soils

Obtaining input from all mowing staff will result in a mowing policy that addresses safety concerns, identifies communication issues and procedures, and establishes the criteria for which areas are to be mowed and to what extent. Agreement on these issues and inclusion in a written

plan results in all staff working towards the same goal. Reducing the amount of mowing and the extent to which areas are mowed gives workers more time to complete other activities and increases the efficiency of all maintenance operations.

STATE MOWING POLICY

The mowing policy developed by Mn/DOT is described in chapter five of the Mn/DOT Maintenance Manual. This policy states that the primary purpose of maintaining vegetative cover is to prevent erosion. Roadsides are to be generally maintained in conformance with adjacent land use, and spot mowing is to be used to control noxious weeds.

A mowing law regulates mowing outside the metro area. This law lists the following requirements:

- The first eight feet from the roadway surface may be mowed.
- The entire right-of-way may be mowed from July 31 to August 31 for any reason. The rest of the year, the entire right-of-way may be mowed only for safety reasons, and only to a minimum height of 12 inches.
- The entire right-of-way may be mowed to maintain sight distance.
- The entire right-of-way may be mowed, burned, or tilled for establishment of permanent vegetative cover or for prairie vegetation management.

Permissible grass heights, from chapter five of the Mn/DOT Maintenance Manual, are listed in Table 3-1.

Table 3-1. *Permissible Grass Heights*

	Urban Height (mm)		**Rural Height (mm)**	
	Minimum	**Minimum**	**Minimum**	**Minimum**
Shoulder sod: gravel or paved	100	150	100	300
	Vegetation growing on gravel shoulders will be controlled by blading. Vegetation growing in cracks in bituminous shoulders should be destroyed by herbicides, soil sterilants, or other acceptable methods.			
Shoulder inslope top 2 swaths	100	300	100	450
Ditches and backslopes below top 2 swaths	100	300	Terminal	Terminal
Steep slopes steeper than 1:3	Terminal	Terminal	Terminal	Terminal
Medians				
less than 17 m	100	300	100	450
greater than 17 m	100	300	Terminal	Terminal
Interchanges	100	300	100	450

Mn/DOT Requirements for All Mowing Widths

Mow all grass to a minimum height of 100 mm. You should mow:

- all of the shoulder
- two swaths of the mower on all inslopes
- all of the median for those less than 17 m wide, and for medians greater than 17 m wide, mow two-swath widths
- a smooth transition when blending between mowed and unmowed areas

For safety reasons, Mn/DOT mowing policy recommends that operators avoid slopes greater than 3:1, be alert and slow down in high grasses, avoid traffic, and wear all approved safety equipment.

To control noxious weeds, Mn/DOT mowing policy requires operators to mow heavily infested patches of Canada thistle when the patch area exceeds 50 square feet, to communicate with other maintenance staff to avoid mowing areas soon after or just before spraying, and to avoid mowing areas of leafy spurge.

Other Guidelines from the Mn/DOT Policy

- Keep signs clear and their approaches mowed from approximately 150 m.
- Keep vegetation around guardrails controlled for approximately 0.5 m on either side to reduce the effects of trapping sand, snow, and dirt.
- Maintain sight distance at at-grade intersections, interchanges, and curves.

AN ACT

Relating to transportation: restricting mowing of highway right-of-way outside of cities; amending Minnesota Statutes 1984, section 160.02, by adding a subdivision; proposing coding for new law in Minnesota Statutes, chapter 160.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF MINNESOTA;

Section 1. Minnesota Statutes 1984, section 160.02, is amended by adding a subdivision to read:

Subd. 4. [NOXIOUS WEEDS] "Noxious weeds" has the meaning given in section 18.171, subdivision 5.

Sec. 2. [160.232] [MOWING DITCHES OUTSIDE CITIES.]

Road authorities may not mow or till the right-of-way of a highway located outside of a home rule charter or statutory city except as allowed in this section and section 160.23.

On any highway, the first 8 feet away from the road surface, or shoulder if one exists, may be mowed at any time.

An entire right-of-way may be mowed after July 31. From August 31 to the following July 31, the entire right-of-way may only be mowed if necessary for safety reasons, and may not be mowed to a height of less than 12 inches.

A right-of-way may be mowed as necessary to maintain sight distance for safety and may be mowed at other times under rules of the commissioner, or by resolution of a local road authority.

A right-of-way may be mowed, burned, or tilled to prepare the right-of-way for the establishment of permanent vegetative cover or for prairie vegetation management.

Effective 5/17/85

Note: 1986 amendments are underlined.

Figure 3-1. *Minnesota Mowing Law*

Chapter 4
Best Management Practice No. 4:
Establish Sustainable Vegetation

Planting and establishing sustainable vegetation along roadsides is very important, since trying to establish plants and trees that are not suited to an area or condition is a waste of time and resources. Sustainable vegetation requires less maintenance and thrives where it is planted. The keys to a sustainable roadside environment include:

1. Using native grasses and wildflowers
2. Using salt tolerant species
3. Staging planting
4. Controlling erosion
5. Selecting appropriate shrubs and trees for a given area
6. Strategically managing woody vegetation and trees

USING NATIVE GRASSES AND WILDFLOWERS

Two primary objectives of roadside maintenance, weed prevention and erosion control, can be accomplished through the use of native grasses and wildflowers. The establishment of native plants in an area results in a diverse and strong plant community adapted to local conditions—including a wide range of soil types, moisture levels, and climactic conditions. Since most prairie grasses and wildflowers grow best during hot, dry summer months, they provide excellent erosion control during the fall and spring. Deep roots also prevent the invasion of noxious weeds and reduce the number of undesirable and competing shrubs and trees.

Additionally, including wildflowers with native grasses creates a more stable and colorful environment throughout the growing season and adds color, texture, and beauty to the roadside.

Other benefits of using native grasses and wildflowers include:

- Less money spent on herbicides, fertilizers, and maintenance. Because native plants are self-sustaining, they require less maintenance, and their dense roots force out competing plants, so the area requires less herbicide use.
- More effective application of herbicide through better use of equipment and spot spraying only the weeds. Using the best products at the right time optimizes chemical use.
- Soil stabilization through the use of native prairie grasses. The dense and deep root systems (typically 6–8 feet, but potentially 12–14 feet deep) for these grasses prevent erosion and slope failure.
- Roadside beautification and enhanced wildlife habitat (such as food and nesting cover for birds) through restoration of a piece of Minnesota's natural heritage—living prairie grasses and wildflowers.
- Improved traffic safety, as vegetation screens headlight glare in curved median areas and delineates the roadway for drivers.
- Creation of an inexpensive and low-maintenance snow fence.
- The ecological benefits of a more diverse, self-sustaining planting without chemicals or mowing.
- A dramatic reduction in mowing and spraying needs.
- Aesthetic improvements to the road and travel experience, which can help reduce driver fatigue and boredom.

- Reduced environmental impacts from maintenance operations.
- Improved water and air quality.

These benefits can be achieved by integrating several management techniques into a system that encourages desirable vegetation and prevents undesirable vegetation from establishing.

Native grasses that can be grown in Minnesota include:

- Blue-joint grass
- Big and little bluestem
- Fringed brome
- Kalm's brome
- Buffalo grass
- Prairie cord grass
- Prairie dropseed
- Sand dropseed
- Tall dropseed
- Blue grama
- Indian grass
- June grass
- Sand lovegrass
- Green needle grass
- Switchgrass
- Slender wheatgrass
- Western wheatgrass
- Canadian wild rye

Blazing Star

A complete list of Minnesota-hardy grasses, as well as appropriate wildflowers and their substitutes, is on the Mn/DOT Office of Environmental Services Web site at www.dot.state.mn.us/environment. Wildflowers are listed for each of four areas in Minnesota, as well as for wetland areas.

According to the Mn/DOT specification, all native grass and wildflower seed shall be of current production seed or have been harvested from the previous two growing seasons. All wild-type native grass and forb seed shall have a source of origin within Minnesota, eastern North or South Dakota, northern Iowa, or western Wisconsin. Wild-type seed is defined as that which is derived directly from native wild stock, including seed that was collected in the wild and placed into production or that which has been harvested directly from native stands—regional or local ecotypes that have not undergone a selection process. Wild-type refers to all native seed referred to as "common" in the industry.

A Survey of Existing Native Plants

To identify existing native plant stands in your jurisdiction, conduct a preliminary survey. Once existing native plants are identified, develop and implement appropriate management guidelines. The survey should include:

- Specialized management techniques, such as prescribed burns, reduced mowing, and reduced herbicide/pesticide spraying, which are required for high-quality native plant communities.
- The location of rare plants, so that spraying, construction, and other disturbances can be avoided.
- Potential sources for native seed for future roadside plantings.

- Management guidelines for different areas.
- A plan to contact railroad companies and utilities to coordinate appropriate maintenance practices.
- Identification of areas for future research opportunities on the use of tall grasses for snow-drift control.
- Identification of areas for future research opportunities on roadside wildlife preservation.
- Coordination and communication with the DNR and National Rails to Trails Conservancy (RTC) concerning potential recreational/educational uses of abandoned railroad rights-of-way.
- Identification of problem weeds and locations so that appropriate maintenance practices can be outlined and priorities for brush control set.

Seed Sources and Harvesting

Native grass and wildflower seed is expensive, costing approximately $50–100 more per acre than varietal turf grass seed. One way to reduce this expense is to harvest seed from stands of established native grasses. Harvest the seed in the fall, either by hand, perhaps using volunteer organizations, or with farming equipment. Some weedwhipper-style equipment is effective; combines and flail vacs are practical for larger areas.

Several books provide information on harvesting dates, seed storage, and propagation. It is important to obtain permission before collecting seed on state and county preserves, private land, and state right-of-way and to leave at least 80 percent of the seed for regeneration.

Use seed that has adapted to local climate and environmental conditions. Through natural selection, genetic variants within species have developed to adapt to local conditions. These variants, known as ecotypes, are suited to local climate, soil type, diseases, and pests. To date, the Midwest has relied heavily on western varieties for prairie plantings. These varieties, typically selected from a limited gene pool, were developed as vigorous forage plants and can overtake less aggressive local populations. In addition, due to their limited gene pool, these western varieties may also lack resistance to local diseases, pests, and weather, making them short-lived. They may also bring in new diseases that threaten local populations.

A list of sources to obtain local ecotype seed is on the Mn/DOT Office of Environmental Services Web site at www.dot.state.mn.us/environment.

Recently, most of the effort by seed producers has been put towards producing native prairie seed. Seed for natives from other vegetative zones, such as woodland edges, is also being developed and should be available within the next few years.

How to Start a Prairie Planting

When planting wildflowers, use hardy drought-resistant flowers and plants indigenous to the area. To determine what types of flowers will grow in an area, visit local natural areas that have similar topography. Match plants to sun or shade and drainage needs.

STEPS TO A PRAIRIE PLANTING

- Visualize what the planting is to accomplish, whether providing erosion control, wildlife habitat, beautification, or reduced maintenance.

- Survey the site and consider drainage requirements, soil type, existing vegetation, sun and wind exposure, and adjacent land uses and management impacts.

- Clear the existing vegetation by using a broad-spectrum herbicide, such as glyphosate

(Roundup). Allow a week for the herbicide to work effectively, then mow or burn to remove the dead plant material. After that, drill or rake seed into the stubble.

- If timing permits, an alternative to using herbicides is cultivation, or sequences of till, fallow, and till. Plow or harrow the soil several times prior to planting to destroy existing vegetation and eliminate germinating weeds. The last two cultivations before seeding should be just deep enough to remove any remaining weed seedlings.

- Plant a native mix that includes fast cover and permanent establishment species, using as many species as are affordable (this adds to the beauty and diversity of the roadside). Achieving good seed-to-soil contact is the best insurance for successful establishment. For larger areas, use a native grass drill if available. If broadcasting seed, lightly rake, drag, or disk the seed to a depth of 1/4–1/2 inch. Roll or cultipack to firm the seedbed.

- Unchecked weeds can shade out prairie seedlings during the first year. To prevent this, mow weeds at a height of 4–6 inches the first year, on approximately June 1, July 15, and September 1. The second year, mow at a height of 7–9 inches in May and 12–14 inches in June, if needed. These mowing heights will help prevent damage to emerging prairie plants. Additional spot mowing or hand weeding may also help control invasive weeds.

- Burn as soon as enough leaf litter accumulates to carry a fire (usually the second or third year after planting). This helps destroy weedy species and stimulate prairie vegetation. Burning every three to five years should be sufficient. If woody vegetation becomes a problem, burn more often. Burn in sections and at different times of the year to reduce adverse effects to any one prairie species. If burning is not possible, remove plant litter by some other means, such as raking or mowing. Note that most of the growth in the first two years occurs below ground, and it may be three to four years before the growth above ground is well established.

How to plant prairie grasses and wildflowers in your own ditch

1. Start small. Keep the size manageable by only planting a few patches.
2. Inventory your plantings.
3. Plant in late fall (November) or by mid-June in the spring.
4. Order seed from a local supplier.
5. Burn off the existing vegetation or cut it as low as possible with a mower or weedwhipper.
6. Spray the area with a broad-spectrum herbicide (such as Roundup) prior to burning or cutting to reduce competition.
7. Avoid deep tillage, which invites erosion and weeds. Rake lightly to loosen the soil and improve establishment.
8. Scatter the seed by hand. Mix seed with sand to allow more even distribution.
9. Work the seed into the soil by raking the area to a depth of 1/4 inch.
10. Firm the seedbed.
11. Post a sign so that the area is not sprayed.
12. When weeds reach a height of 10 inches, mow to a height of about 5 inches several times during the first growing season. This stimulates warm season plant growth.

Maintenance Needs

Burning and haying are the two primary management techniques for use with prairie vegetation.

Burning offers the following benefits:

- Stimulate the growth of many native prairie plants
- Control weeds and woody invaders

- Remove thatch
- Recycle nutrients
- Warm the soil and give warm-season plants an earlier start

Consider traffic safety, weather conditions, equipment, and staffing before burning. Timing is important; burning is most beneficial from mid-April to early May for warm-season grasses. As with spraying growing weeds, burning earlier is better for wildflowers, and waiting does more harm than good. Any burning plan must include smoke management provisions for safety purposes.

Additional information regarding proper burning procedures can be obtained from the Fire Management and Research Program at The Nature Conservancy (850-668-0827), the DNR Division of Forestry (651-296-4491), or the county fire marshall.

USING SALT-RESISTANT VEGETATION

Road salt and deicers can greatly damage roadside vegetation. Although these damaging effects are most severe within 50 feet of the pavement, they may extend hundreds of feet depending on the volume and speed of traffic traveling on, and wind direction near, a particular road. Accumulated salt in a soil can also affect its drainage capabilities. Because salt or deicer use on pavement is required for safe winter travel in Minnesota, the use of salt-resistant vegetation is vital for sustaining vegetation along the road.

A 1989 study conducted by the Wisconsin Department of Transportation found that local geology affects the impact of a roadway deicer. The relative impact is related to the chemical load of the surface and ground water. Traffic volumes and local topography also affect the deicer's impact; a deicer is diffused further from the roadway in high traffic and in high fill sections. The amount of salt that a soil retains is related to its clay content. In addition, the study found that chlorine accumulates in both deciduous and coniferous trees at a rate of 40 to 100 times the amount retained in the soil.

To alleviate the effects of roadway salt on adjacent soil and vegetation, treat the soil with gypsum, which reverses the effects of salt and sodium accumulation, and plant a salt-resistant or alkali grass. Mn/DOT has developed a new low-maintenance turf seed mix, 60A (Modified 60B), for use in areas with high salt, the composition of which is shown below. This grass reaches a height of about 12 inches. The application rate is 100 pounds per acre.

Common Name	Botanical Name	Percent of Mix
Fescue, creeping-red "Cindy"	Festuca rubra	10.0
Rye-grass, perennial "Elf"	Lolium perene	14.0
Bluegrass, Canada "Reubens"	Poa compressa	12.0
Bluegrass, fowl	Poa palustris	10.0
Bluegrass, common "98/85"	Poa pratensis	12.0
Bluegrass, Kentucky "Park"	Poa pratensis	12.0
Bluegrass, Kentucky "Caliber"	Poa pratensis	10.0
Alkali grass, "Salty"	Puccinella distans	19.0
White clover	Trifolium repens	1.0
	Total	**100.0**

The following natives or wildflowers can also be used with success in areas where salt is an issue:

Native grasses: Canadian wild rye, Indian grass, little bluestem, blue grama, side oats grama
Wildflowers: Black-eyed Susan, purple prairie clover, yarrow, bush clover

A report titled *Establishment, Protection, and Reestablishment of Urban Roadside Vegetation Against Salt and Ice* is available through Mn/DOT's Office of Research Services. The report outlines many maintenance and construction activities to use in Minnesota.

STAGED PLANTING

Staged planting involves planning for the continuous maintenance and improvement of roadside areas. This could include:

- Replacement of trees and vegetation that dies out
- Addition of vegetation as funds become available
- Filling in gaps from killed noxious weeds
- Temporary seeding during construction
- Seeding in stages during construction, as each area is completed
- Special projects and experimentation

CONTROLLING AND PREVENTING EROSION

Use silt fence and hay bales to slow water velocity.

Erosion control is required to maintain a healthy roadside environment, since the structure and contents of soil must be preserved if vegetation is to thrive. Actions that help control erosion include:

- Incorporating good design methods that reduce flow velocity
- Using native grasses
- Using structural methods, such as sediment basins and check dams
- Using vegetative methods, such as blankets and mulches

Mulching protects the soil, reduces flow velocity, and retains moisture. Good mulch materials are hay and straw (either wheat or oats). Both types of mulches should be free of weeds. Use hay where new weeds will not be a problem. After mulch is applied, drive over the area with a disc to anchor the mulch to the ground, then cover it with liquid tack. Wood chips make for good mulch around trees.

Mulch within 14 days of seeding. During construction, temporarily seed stockpiles. Seed all completed and final-graded areas as soon as possible.

CHOOSING THE RIGHT TREE OR SHRUB FOR A GIVEN AREA

As with plants and grasses, placing a tree or bush in an area where it will not thrive causes maintenance problems that could have easily been avoided. When selecting a specific type of vegetation, consider the vegetative zone of the area, local soils, temperatures, precipitation and runoff, slope, and sunlight exposure to better the chances for survival.

The Mn/DOT Prairies to Forests Program, which encourages the extensive seeding and planting of grassland, savanna, and woodland species where appropriate, can help you select the correct plant for a given area and provide ideas for revegetating weed-infested areas. The program recommends using a combination of the trees and shrubs listed in Table 4-1, along with a review of natural plant communities surrounding your planting area and a consultation with a Mn/DOT or DNR forester to determine species and quantities.

Tree and Shrub Seedling Mixes

In past years, Mn/DOT relied heavily on using red pine along roadways. In some cases, it was planted outside of its native range and in areas not suited to the requirements of the tree. A better practice is to note native plant communities in the area and then select a suitable tree or shrub. Table 4-2 outlines appropriate selections for Minnesota planting zones (see Figure 4-1). A 50-50 mix of trees and shrubs planted at an average spacing of five feet apart will provide a diverse and adaptable plant community. Five to twenty plant species will also ensure plant diversity, but in some cases, planting all of the same species may be desirable.

Table 4-1. *Trees and Shrubs in Minnesota*

Trees	**Shrubs**
Statewide Upland	
American elm	American elder
American linden	American plum
Big tooth aspen	Common chokecherry
Box elder	Downy arrowwood
Bur oak	Gray dogwood
Common hackberry	Nannyberry
Eastern cottonwood	Red-berried elder
Green ash	Smooth sumac
Ironwood	Smooth wild rose
Northern pin oak	Oldfield juniper (Juniperus communis)
Statewide Lowland	
American elm	Highbush cranberry
Black ash	Pussy willow
Eastern cottonwood	Red-osier dogwood
Green ash	Sandbar willow
	Tamarack (except SW)

Table 4-2. *Trees and Shrubs for Minnesota Zones*

Species	**Minnesota Planting Zone**					
	1	2	3	4	5	6
Trees						
Mixed Conifer/Hardwoods						
Bur oak (1)	x	x	x			
Northern pin oak (1)	x	x	x			
Northern red oak (1)	x	x	x			
Red maple (1)	x	x	x			
White pine (1)	x	x	x			
White spruce (1)	x	x	x			
Mixed Conifer						
Red pine (1)	x	x	x			
Jack pine (1)	x	x	x			
White pine (1)	x	x	x			
White spruce (1)	x	x	x			
Balsam fir (1)	x	x	x			
Other						
Kentucky coffee tree (1)	x					x
Northern red oak (1)	x	x	x	x		x
Red maple (1)	x	x	x	x		
River birch (1 and 2)	x					
Showy mountain ash (1)	x	x	x	x		
Silver maple (1 and 2)	x	x	x	x		x
Sugar maple (1)	x	x	x	x		
White ash (1)	x	x				
Yellow birch (1)	x	x	x	x		
Shrubs						
American hazelnut (1)	x	x	x	x	x	
Beaked hazelnut (1)	x	x	x	x	x	
Dwarf bush honeysuckle (1)	x	x	x	x		
Staghorn sumac (1)			x	x	x	
Winterberry (winter holly) (1)	x	x	x	x		

(1) upland areas (2) lowland areas

Note that white pine may be used in zones 1, 2 and 3, but deserves special consideration due to the low percentage (approximately 1 percent) of Minnesota land covered by this tree. Since white pine tolerates some shade, it can be planted in the understory of deteriorating stands of pioneer hardwoods like aspen and birch. The tree should not be planted where deicing salt is used.

Consult a Mn/DOT forester or other specialist to determine species and quantities. Another good resource, Mn/DOT's *Woody and Herbaceous Plants for Minnesota Landscapes and Roadsides* expert system for plant selection, can be obtained by the public or external agencies from the DNR Division of Forestry or the Minnesota State Horticultural Society.

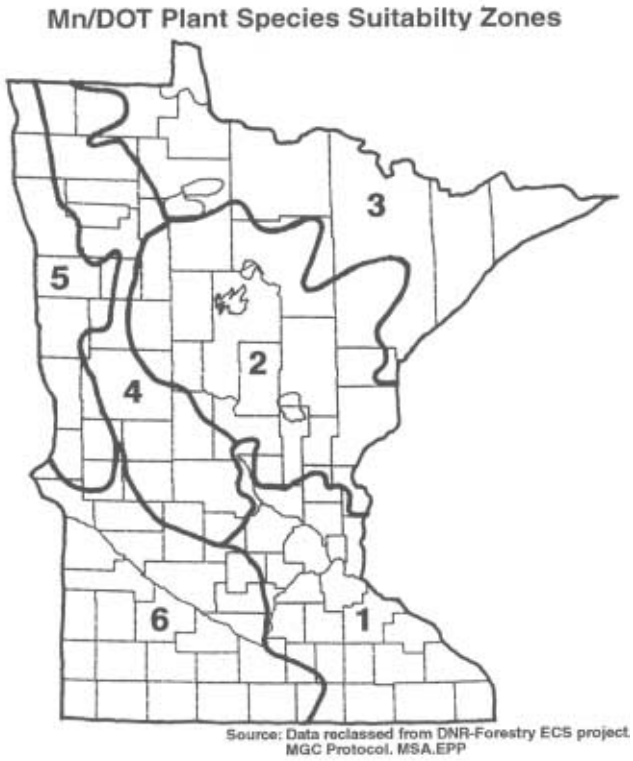


Figure 4-1. *Minnesota Plant Hardiness Zones*

Site Preparation

Minimizing competition from grasses and weeds requires site preparation. The amount of preparation depends on the soil type: loamy sands require little or no preparation, whereas heavier sandy loam to clay loam areas require more preparation. Appropriate levels of site preparation are listed in Table 4-3.

Seedling Storage and Handling

Store plants in a cool place at 35–45ºF and plant within three to five days. Keep the root system cool and moist and protected from the drying effects of the sun and wind. Prior to planting hardwoods, you may choose to soak roots for one hour, but inspect the roots first to ensure they are disease-free, as soaking may spread the disease. Do not soak evergreens.

Planting Dates

The optimal planting time is in the spring, from frost to May 15.

Table 4-3. *Levels of Site Preparation*

Area	**Site Preparation Required**
Areas traversable with tractor and tree planter	1. Spray the planting area with Roundup, preferably during late summer prior to spring planting. Till with a spading machine, machine plant, and mass mulch the area with wood chip mulch. Prior soil loosening can be eliminated if "Whitfield Planter" is used when planting through sod. 2. Spray the planting area with Roundup, preferably during late summer prior to spring planting. Machine plant into killed area, and apply surflan for control of germinating weeds. 3. In light soils plant into existing vegetation without site preparation.
Steep slopes not traversable mechanized equipment	1. Spray 3’ diameter areas for each plant, hand plant, and with apply weed fabric and/or wood chip mulch to the sprayed area. 2. In light soils, plant into existing vegetation without site preparation. Applying a 3’ diameter circle of wood chip mulch will reduce evaporation and evapotranspiration.
Another option	Dramatic results and accelerated growth have been documented in Ottawa roadside reforestation trials by tilling in compost and planting through perforated black poly. The poly is cut and pulled out after 3–4 years, assuming crown closure and full leaf litter are achieved to control competition.

Seedling Installation

Machine planting: Drive the tractor slowly to ensure that seedlings are planted straight and to prevent J-root formation. Hold the seedling's root flare with index finger and thumb, and make sure the root flare is even with the groundline. An individual should walk behind the tree planter and perform a "tug test" to ensure that soil is firmly packed around the root system. Seedlings should not give when they are gently pulled at their base.

Planting machines are available from Mn/DOT, the DNR, and the Soil and Water Conservation Districts. Mn/DOT's machines, designed to plant through a sod layer, are available at Duluth District 1A and Mankato District 7A. A seed/acorn planter is available in the Metro Division. The DNR has over 200 machines throughout the state available for loan or rental. The Soil and Water Conservation District's machines, most suited to planting in tilled planting sites, are available for a minimal fee on a first-come, first-served basis.

Seedling Sources

The DNR has a good selection of native trees and shrubs from local seed sources.
They may be contacted at:

General Andrews Nursery
Box 95
Willow River, MN 55795
Phone: 218-372-3183
Fax: 218-372-3091

If purchasing from a private nursery, make sure seedlings have been grown from Midwest- or Minnesota-origin seed, or from other propagation material such as softwood cuttings. The Minnesota Crop Improvement Association (MCIA) should certify the source of plants or seed. The proof of certification, usually in the form of a tag affixed to the box or other shipping container, indicates where the product was collected.

Direct Seeding

Several tree and shrub species may be established from seed; those that are good candidates are listed below.

Trees	Box elder, green ash, American elm, hackberry, silver maple, bur oak, red oak, northern pin oak, Kentucky coffee tree
Shrubs	Red-osier dogwood, gray dogwood, American plum, red-berried elder, and staghorn and smooth sumac. (Note: both types of sumac require pretreatment, which consists of placing the seeds in boiling water, turning off the heat, and letting them soak in this same water for 24 hours. Sumac seed treated this way must be planted in the spring.)

Site Preparation: Spray existing vegetation with Roundup, preferably in late summer for fall or spring seedings. Apply 1–2 inches of wood chip mulch over either tilled or untilled ground after planting the woody plants. Tilling prior to seed scattering provides a better seedbed for woody seeds; however, more weeds will emerge from tilled soil.

Timing: The best time for seeding most species is in the fall (September 15–November 1), which gives the seeds a period to winter and naturally stratify in preparation for spring germination and eliminates the need to store seeds over winter in refrigerators. If storing seeds in refrigerators, put

them in closed containers to prevent drying out. Some seeds will take one to two growing seasons to germinate, in spite of fall seeding. A 1- to 2-inch layer of wood chip mulch or straw layer over the seeds will reduce rodent and bird predation and provide some weed control and moisture retention.

Rates: Allow 3- to 10-foot spacing between surviving trees and shrubs. Direct seeding rates for tree and shrub propagation are listed in Table 4-4. Seeding associations determine the total seeds necessary to achieve this spacing, assuming an average 7.5 percent survival rate, based on information in the table.

Table 4-4. *Direct Seeding Rates for Tree and Shrub Propagation*

Species	**Ave. Number of Seeds/Pound**	**Pounds per Acre***	
		Monoculture*	Association*
Trees			
Box elder	13,400	0.5–1	0.2
Green ash	17,260	0.4–1	0.2
American elm	70,900	0.2–0.5	0.1
Hackberry	43,000	0.3–0.5	0.1
Bur oak	75	100–150	30
Red oak	125	50–100	20
Northern pin oak	245	25–50	10
Kentucky coffee tree	230	25–50	10
Shrubs			
Red-berried elder	286,000	NA	0.01–0.1
Gray dogwood	13,000	NA	0.5–1.0
Red-osier dogwood	18,500	NA	0.5–1.0

* Monoculture refers to planting only one species and Association, to planting two or more species.

MANAGING WOODY VEGETATION AND TREES

To manage woody vegetation along a roadway, it may be necessary to divide the right-of-way into zones, as shown in Figure 4-2, and assign a management strategy to each. For example:

Zone 1 – shoulders
Zone 2 – clear zone
Zone 3 – brush

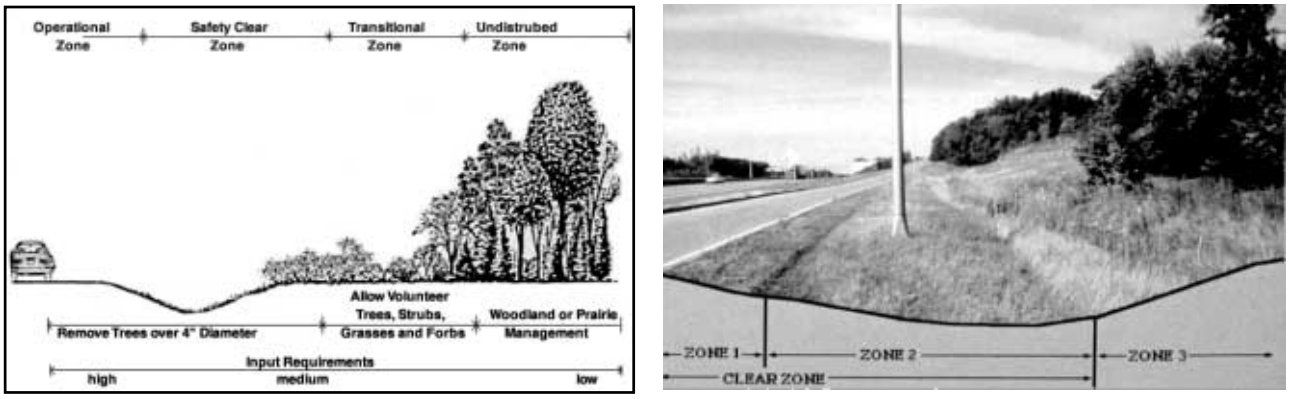


Figure 4-2. *Roadway Zones*

General Best Management Practices for Woody Vegetation

BRUSH CONTROL GUIDELINES

- Don't spray big brush; rather, chop it down. The extreme color change from spraying may cause public concern.
- Spray when trees and shrubs are small (less than 6 feet tall).
- Mow smaller brush before spraying.
- Spray elm when it is small enough to absorb the herbicide. Spray in the fall, because the color of the dead foliage will look like natural fall color.

TREE CARE AND PRUNING GUIDELINES

- Remove trees greater than 4 inches in diameter from zone 2.
- When spraying, keep an adequate distance from desirable woody plants.
- Prune every two years on young trees and every five years on trees in intensively managed areas.
- Don't ignore the mid-size tree.
- Follow safety and OSHA standards.

Pruning

Trees are pruned along the roadside primarily for:

Safety: Removing branches that could fall and cause injury or damage property, trimming branches that interfere with the sight lines, and removing branches that grow into utility lines. Selecting species that will not grow beyond the available space and have strength and form characteristics appropriate for use along roadsides can reduce the need for safety pruning.

Health: Removing diseased or insect-infested wood, thinning the crown to increase airflow and reduce pest problems, and removing crossing and rubbing branches. Pruning can be used to encourage trees to develop a strong structure and reduce the likelihood of damage during severe weather. Removing broken or damaged limbs encourages wound closure.

Aesthetics: Enhancing the natural form and character of trees or stimulating flower production. Pruning for form is especially important on open-grown trees that do very little self-pruning.

The emphasis when pruning young trees should be on producing strong structure. As trees grow, shift the emphasis to maintaining the tree structure, form, health, and appearance.

The common types of pruning are:

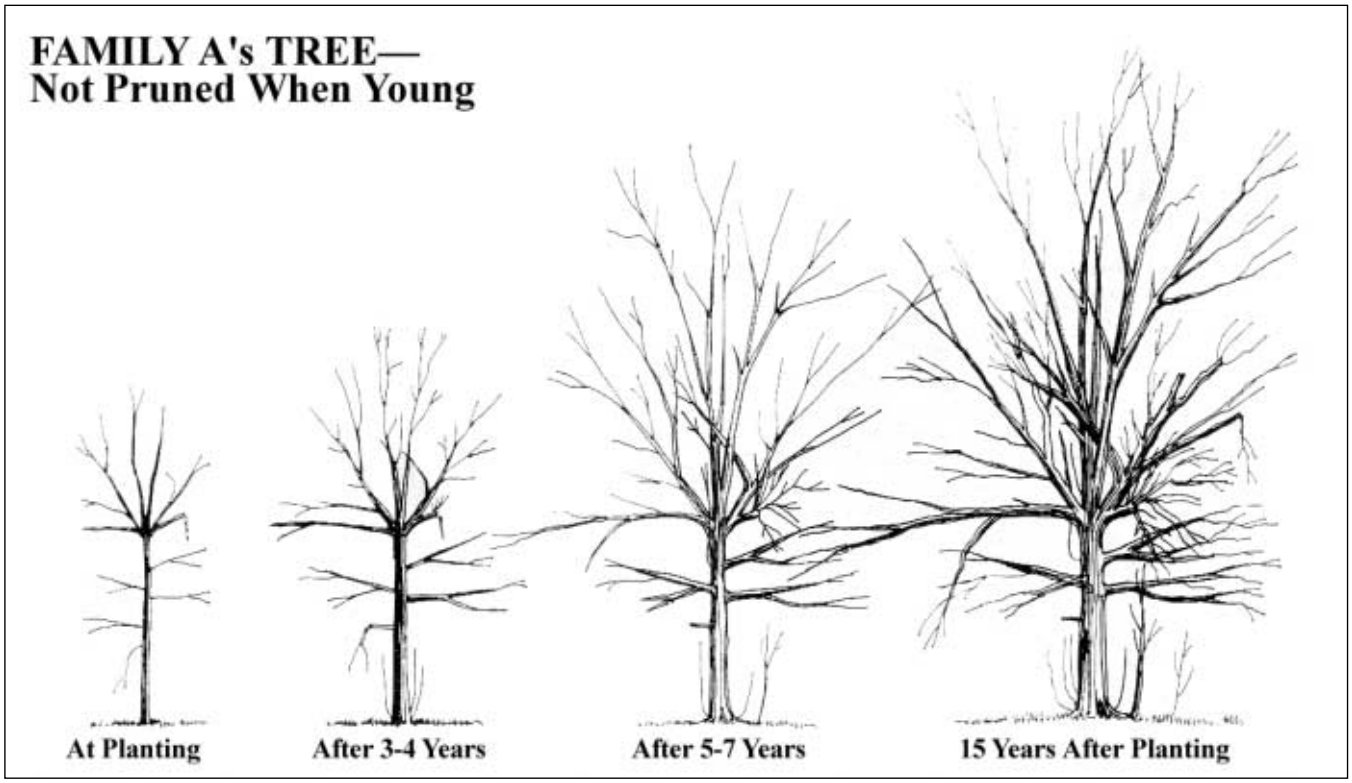
Crown thinning: The selective removal of branches to increase light penetration and air movement throughout the tree crown. The intent is to maintain or develop a tree's structure and form. No more than one-quarter of the living crown should be removed at a time. This technique is primarily used on hardwoods.

Branches with strong U-shaped angles of attachment should be retained. Branches with narrow, V-shaped angles often form included bark, and should be removed. Included bark forms when two branches grow at sharply acute angles to another, producing a wedge of inward-rolled bark between them. This prevents strong attachment of branches and may cause a crack at the point below where the branches meet. Co-dominant stems that are about the same size and that arise from the same position often form included bark, so remove some of the lateral branches from a co-dominant stem.

Crown raising: The practice of removing branches from the bottom of the crown of a tree to provide clearance for vehicles or line of sight. After pruning, the ratio of living crown to total tree height should be at least two-thirds. On young trees, temporary branches may be retained along the stem to encourage taper and protect trees from vandalism and sunscald. Less vigorous shoots, about 6 to 8 inches apart along the stem, should be selected as temporary branches. Prune these annually to slow their growth, eventually removing them altogether.

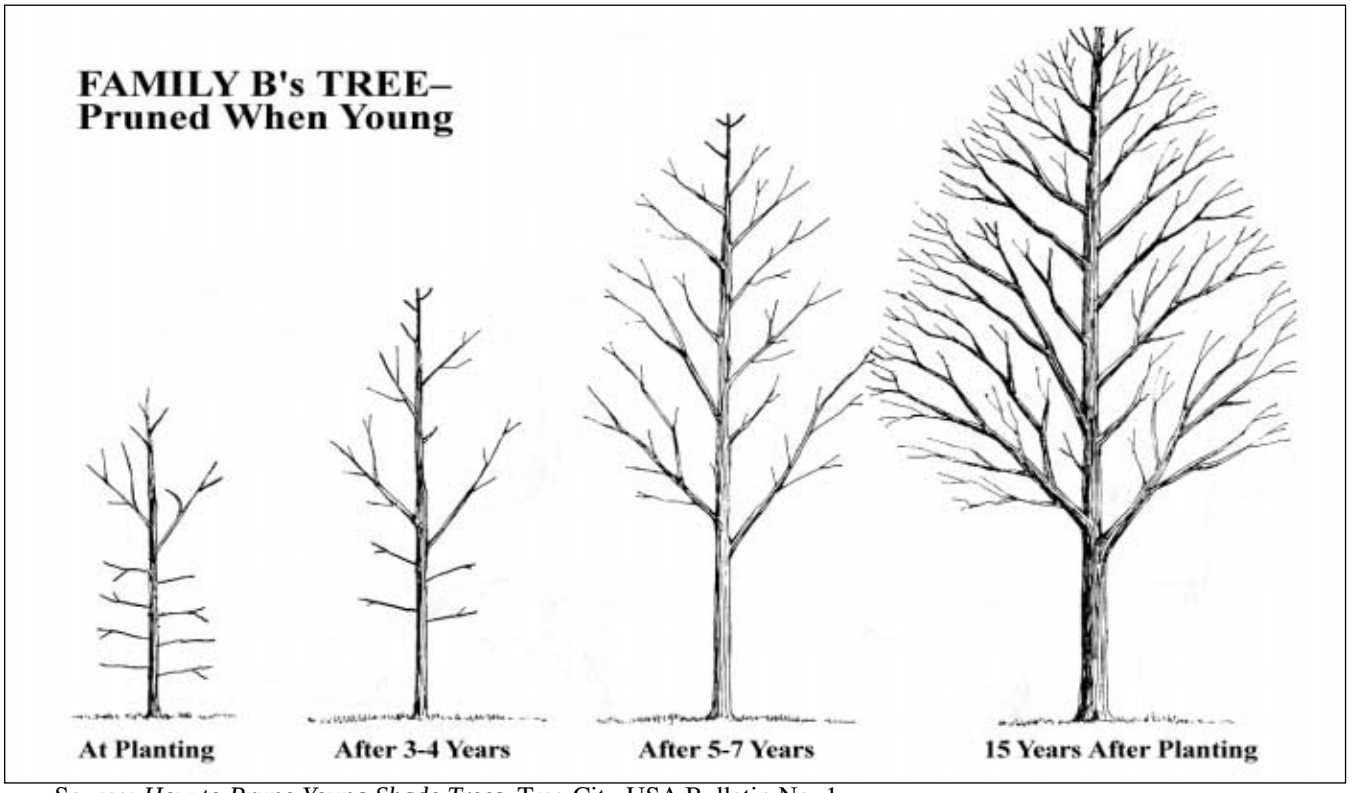
Crown reduction: Also called drop crotch pruning; used most often when a tree has grown too large for its permitted space (such as beneath a utility line). This method is preferable to topping because it results in a more natural appearance, increases the time between prunings, and minimizes stress to the tree. However, this technique often results in large stem wounds that may lead to decay; it should never be used on a tree with a pyramidal growth form. A better long-term solution is to remove the tree and replace it with one that will not grow beyond its available space.

The importance of proper tree pruning is illustrated in Figures 4-3 and 4-4.



Source: *How to Prune Young Shade Trees,* Tree City USA Bulletin No. 1.
Figure 4-3. *Improper Pruning Techniques*

At planting, tree B was pruned correctly. Both the broken branch and the competing branch were removed close to the trunk. Another branch, swollen from an insect laying eggs, was also removed. After three or four years, all root suckers and sprouts in the crown and excessive branches were removed to reduce competition for light, water, and nutrients. A co-dominant leader branch was removed as well, as were several of the lowest limbs.



Source: *How to Prune Young Shade Trees,* Tree City USA Bulletin No. 1.
Figure 4-4. *Proper Pruning Techniques*

At five to seven years, the lower limbs were pruned off to raise the bottom of the crown out of the way of human heads. The lowest limbs will now be the permanent lowest limbs. Note that branches do not move upward as a tree grows taller.
The center of a branch at 5 feet will always be at 5 feet.


Bad pruning results in too many co-dominant branches.

Keys to Good Pruning

- Prune early in a tree's life so that pruning wounds are small and growth occurs at the best location.
- Begin with a visual inspection at the top of the tree and work downward.
- Identify the best leader and lateral branches before pruning, and remove defective parts before pruning for form.
- Aside from protecting against oak wilt, pruning cuts need not be protected if they are done properly. For aesthetics, you may feel better painting larger wounds with neutral color tree paint, but evidence shows that it does not prevent or reduce decay.
- Keep tools sharp. One-hand bypass or scissors cut (not anvil-type) pruning shears with curved blades work best on young trees.
- Make safety a number one priority. For high branches, use a pole pruner. Some, like the one shown in Figure 4-5, have both a saw and a shears on the same tool.
- When you prune back to the trunk for a larger limb, branches too small to have formed a collar (the swollen area at the base) should be cut close. (Note in the figure of the pruning shears that the cutting blade is cutting upward for less effort and a close cut.) Otherwise, fol-

low the rules of good pruning of larger limbs by cutting just outside the branch ridge and collar, at a slight down and outward angle, so as not to injure the collar. Do not leave a protruding stub.

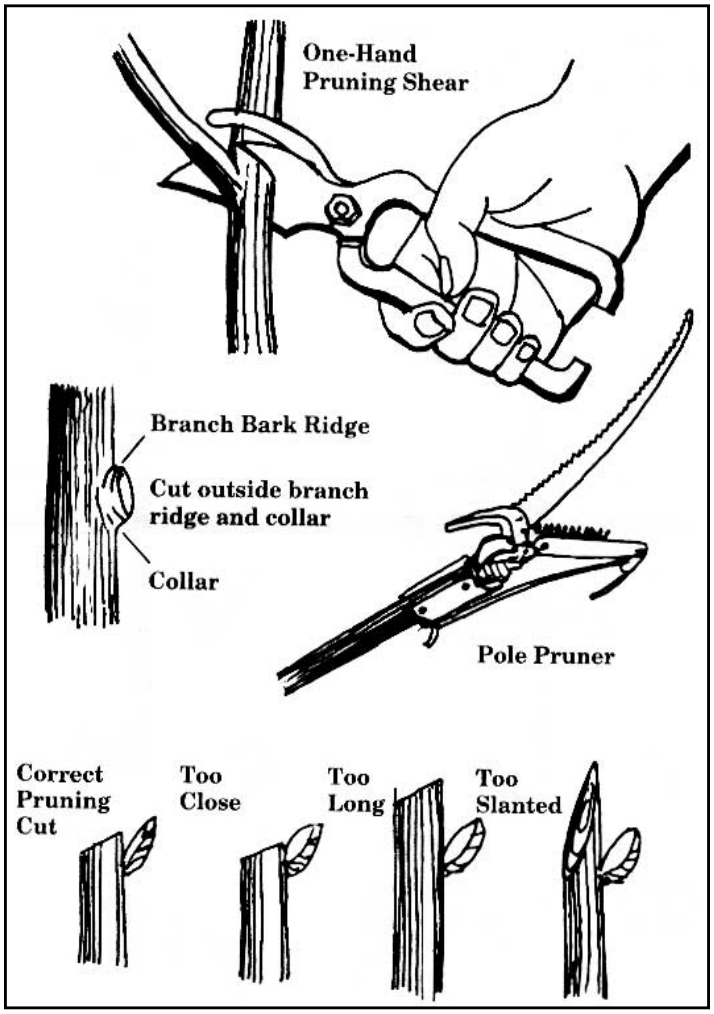
- When simply shortening a small branch, make the cut at a lateral bud or another lateral branch. Favor a bud that will produce a branch that will grow in a desired direction (usually outward). The cut should be sharp and clean, and made at a slight angle, about 1/4 inch beyond the bud.

The optimal time to prune depends on the reason for pruning. Light pruning and the removal of dead wood, with the exception of oaks, can be done at any time in dry conditions. Some guidelines are given below.

Winter: Pruning during dormancy is the most common practice. This results in a vigorous burst of new growth in the spring, so use this method if that is the desired effect. Preferably, wait until the coldest part of winter has passed.

Summer: To direct growth by slowing unwanted branches, or to slow or dwarf the development of a tree or branch, pruning soon after seasonal growth is complete. The slowing effect results from the reduction of total leaf surface, which thereby reduces the amount of food manufactured and sent to the roots for their development and next year's growth of the crown. Pruning in the summer can also be done for corrective purposes, since defective limbs, or limbs that hang down too far under the weight of leaves, can be seen more easily.

Fall: Because decay fungi spread their spores profusely and cut wounds heal more slowly in the fall, this is a good time to leave your pruning tools in storage.



Source: *Tree Care: A Manual for Public Trees,* City of Chesterton, Ind.

Figure 4-5*. Keys to Good Pruning*

Flowering Trees: If the purpose for pruning is to enhance flowering:

- For trees that bloom in the summer or the fall on current year's growth, prune in the winter.
- For trees that bloom in the spring from buds on one-year-old wood, prune when the flowers fade.

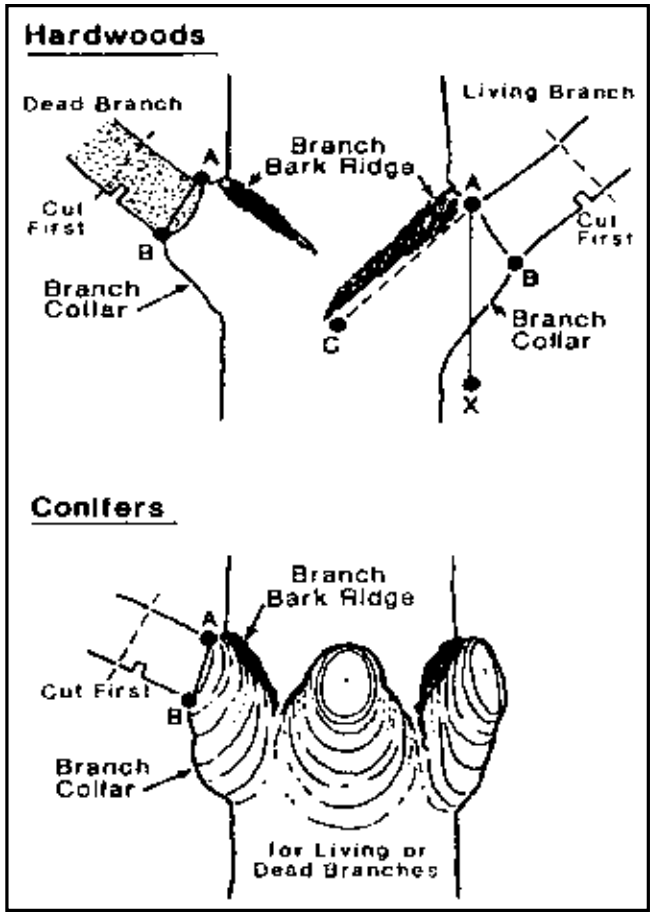


Figure 4-6. *Proper Pruning Principles*

Urban foresters and arborists suggest including the following tips into a tree maintenance program:

- Prune minimally immediately after transplanting; within three years, prune for strength and form; every three years thereafter, prune to lift the canopy of street trees.
- Provide initial training and annual refresher training for pruning crews.
- Stress tool sharpness and, if necessary, disinfection methods.
- Develop an up-to-date inventory of all maintenance operations, including pruning, and note future needs.
- Monitor on an annual basis.

Additional Care Guidelines for Trees

- Remove all dead branches as well as branches that cross or rub.
- To prevent the spread of infectious diseases, disinfect all pruning tools before using them on a new tree.
- Prune all large, established lower branches as needed for traffic or pedestrian clearance under the tree. For street clearance, allow 15 feet and for sidewalk clearance, allow 8 feet.
- Use proper pruning techniques (listed below). Make all cuts with a sharp saw or pruner and only at the nodes or crotches.
- Avoid using wound dressings.

Natural Target Pruning

1. Locate the branch bark ridge (BBR).
2. Find target A—outside BBR.
3. Find target B—where branch meets the collar.
4. If B cannot be found, drop an imaginary line at AX. Angle XAC equals CAB.
5. Stub cut the branch.
6. Make final cut at line AB. (With power saws, make final cut on upstroke.)

Do not:

- Make flush cuts behind the BBR.
- Leave living or dead stubs.
- Injure or remove the branch collar.
- Paint cuts.

Pruning Practices that Harm Trees

Topping: Pruning large upright branches between nodes, sometimes done to reduce the height of a tree.

Tipping: Cutting lateral branches between nodes to reduce crown width. Both tipping and topping result in the development of epicormic sprouts, or in the death of the cut branch back

Young tree in need of pruning

to the next lateral branch below. The epicormic sprouts are weakly attached to the stem and eventually will be supported by a decaying branch.

Stub cutting: An action that delays wound closure and possibly provides entry to canker fungi that kill the cambium, which delays or prevents woundwood formation.

Tree Removals

Safety along a roadside is the main issue when determining which trees should be removed. All trees and branches that endanger the public should be removed as soon as possible. Remove the stumps of trees to a depth of at least 6 inches below ground level, fill the cavity with soil, and level it off.

Factors to consider when dealing with problem trees are:

- Contribution of the tree to the land use character, the roadway, and the surrounding area.
- Functional classification of the roadway now and in the future.
- Traffic volume and speed.
- Roadway geometrics, such as horizontal and vertical alignment, width, and cross-section.
- Position of the tree relative to the actual traveled way that a driver unfamiliar with the street would expect to follow if the tree were not in place.
- Effects of the tree on the environment: Does it reduce sight distance, or block signals or signs?
- Effects of the roots on underground utilities and pavement integrity.

Remove hazard trees when young.

ADDITIONAL RESOURCES

Establishment, *Protection and Reestablishment of Boulevard Turf Against Salt and Ice* is available through the Minnesota Local Road Research Board. Contact the Mn/DOT Office of Research Services at 651-282-2275.

For information on proper burning procedures, contact the Fire Management and Research Program at The Nature Conservancy (850-668-0827), the DNR Division of Forestry, or the county fire marshall.

For extensive information about best management practices for erosion control and soil preservation, see Chapter 6 of the publication *Best Management Practices for Erosion Control*, published by the Minnesota Pollution Control Agency.

For information on plant selection, see Mn/DOT's *Woody and Herbaceous Plants for Minnesota Landscapes and Roadsides* expert system for plant selection, available from the DNR Division of Forestry or the Minnesota State Horticultural Society.

The Mn/DOT Prairies to Forests Program provides guidance for obtaining funds within Mn/DOT and from other agencies, help in choosing plant materials best suited for their intended use, project coordination and equipment needs, and technical assistance on planting and maintenance. It was designed to complement Mn/DOT's programmed roadside landscaping and turf establishment project during highway construction, the Landscape Partnership Program, urban forestry programs, and the National Tree Trusts' America's Treeways Program (800-846-8733).

The DNR has a good selection of native trees and shrubs from local seed sources. Contact General Andrews Nursery, Box 95, Willow River, MN 55795. Phone: 218-372-3183; fax: 218-372-3091

Chapter 5
Best Management Practice No. 5:
Control Noxious Weeds

According to Minnesota's noxious weed law, all agencies shall control all noxious weeds on the roadside or right-of-way at a time and in a manner ordered by the Commissioner of Agriculture or local weed inspector. It is unlawful to neglect, fail, or refuse to comply with a notice to control noxious weeds. Plants identified as "noxious," either by the state of Minnesota or by individual counties, are listed in Table 5-1. Note that the list of noxious weeds changes yearly, so obtain a current list for control purposes. Descriptions and drawings of the 10 noxious weeds for Minnesota are given in Appendix E. Biological characteristics of common weeds and their noxious classifications are listed in Table 5-2.

Table 5-1. *Undesirable Plants*

Type of Plant	Description	Examples
Noxious weeds	Plants that have been characterized as noxious by legislation and whose control is mandated by law.	Field bindweed, hemp, purple loosestrife, poison ivy, leafy spurge, perennial sow thistle, bull thistle, Canada thistle, musk thistle, and plumeless thistle. Mn/DOT adds buckthorn, garlic mustard, birdsfoot trefoil, crown vetch, and reed canary grass.
Secondary weeds	Plants that may be added by a county to its noxious weed list.	Hoary alyssum, Jerusalem artichoke, wild buckwheat, buffalobur, burdock, tall butter cup, bracken, wild carrot, nightflowering catchfly, white cockle, common cocklebur, oxeye daisy, curly dock, flixweed, giant fox tail, gumweed, narrowleaf, hawkweed, and Russian thistle. Mn/DOT adds spotted knapweed.
Offensive weeds	Undesirable for reasons that are insufficient to result in their classification as noxious, but warrant control for other reasons.	Poisonous plants: sumac or oak and stinging nettle. Prickly weeds: sandbur and cocklebur. Allergy producing plants: ragweed. Messy plants Herbicide-resistant weeds

Canada Thistle

Purple Loosestrife

Canada Thistle infected with Pseudomonas syringae pv. tagetis (PST), a native bacteria

Table 5-2. *Biological Characteristics of Weeds*

Type	Name	Class	Location	Noxious Classification	
				State	County
Grasses	Giant foxtail	summer annual	T	No	Becker, Benton, Clay, Douglas, Mahnomen, Mille Lacs, Todd, Wadena, Wilkin
	Wild oat	winter annual	T	No	Clay
	Quack grass	creeping perennial	T	No	Clay
Broadleaves	Field bindweed	perennial	All	Yes	All
	Hemp	annual	All	Yes	All
	Purple loosestrife	creeping perennial	All	Yes	All
	Kochia	summer perennial	T	No	Becker, Clay, Otter Tail, Wilkin
	Leafy spurge	creeping perennial	P and T	Yes	All
	Sow thistle	creeping perennial	All	Yes	All
	Bull thistle	biennial	All	Yes	All
	Canada thistle	creeping perennial	T and W	Yes	All
	Musk thistle	biennial	All	Yes	All
	Plumeless thistle	biennial	All	Yes	All
	Ragweed	summer annual	T and W	No	Cass, Todd
	Sunflower	summer annual	P and T	No	Mn/DOT Districts 4, 7 (less Waseca), and 8; Dodge, Dakota, Mower, Rice, Scott, Stearns, and Wright
	Tansy	biennial	W	No	Beltrami, Cass, Itasca, Koochiching
Woody plants	Poison ivy	creeping perennial	W and T	Yes	All
Sedges	Yellow nut sedge	bulbous perennial	P	No	Jackson, Rice

P = Prairie areas
W = Woodlands and forest areas
T = Transition areas

CONTROLLING WEEDS

Among the variety of ways of containing weeds are biological, cultural, physical, and chemical control methods.

Biological Weed Control

Biological weed control includes the use of insects or pathogens. The U.S. Department of Agriculture (USDA) is conducting a major biological control program that involves importing, propagating, and distributing weeds' natural enemies. These feeding insects inhibit the growth and reproduction of weeds, reducing their ability to compete with desirable native range plants. In general, these insects are best used in areas of large infestation. Smaller infestations are better treated with herbicides.

Five beetles are also available for use with leafy spurge. *Aphthona flava* feeds on the leaves and flowers, which reduces photosynthesis. Others feed on the stems and roots of the plants.

"Thistle Yellows" bacterium will be available soon to be used against Canada thistle infestations. A leaf-eating beetle is also available for use on purple loosestrife. Spotted and diffuse knapweeds can be controlled using one of 12 insect species cleared by the USDA for use in the United States. These insects are either root-borers (*Agapeta zoegana, Cyphocleaonus achates, Pterolonche inspersa, Sphenoptera jugoslavica)* or seedhead agents *(Metzneria paucipunctella, Bengasternus fausti, Chaetorellia acrolophi, Larinus minutus, Larinus Obtusus, Terellia virens, Urophora affinis, Urophora quadrifasciata*).

Cultural Control of Noxious Weeds

Cultural control of weeds includes planting native grasses or competing plant species to force out noxious weeds. This information is included in the section on Use of Native Grasses in Chapter 4.

Physical Control of Noxious Weeds

This includes tilling, mowing, and burning areas to control weeds. Mowing policies are given in Chapter 3.

Mowing Canada thistle at the wrong time will distribute seed and spread weed infestation.

Chemical Control of Noxious Weeds

Chemical weed control includes the use of herbicides.

APPLYING HERBICIDES

Minnesota law requires that herbicides be applied in accordance with the product label and in a manner that will not cause unreasonable adverse effects on the environment, endanger humans, or damage agricultural products, food, livestock, fish, or wildlife. Herbicides may not be applied onto property beyond the boundaries of the target site, nor directly on a human by overspray. Workers in an immediately adjacent property may not be exposed. Spray drift should be minimized; most herbicide labels indicate methods for reducing spray. The treated area must be posted if the labels indicate a specific time delay before safe human reentry or if the area is treated through irrigation systems.

Except for those herbicides that are cleared for use in aquatic environments, herbicides must be introduced into the application equipment after it is filled with water.

Proper coverage is important for effective control, especially when using systemic herbicides. The following tips will help ensure good coverage.

- Use the correct amount of oil or water as carrier. Too much water will cause the mixture to drip off the plants and will render the remaining solution too diluted to be effective. Too little water will result in incomplete coverage.
- Use a surfactant when spraying to increase chemical effectiveness. Some target plants include:
  wild onion, garlic
  purslane
  Johnson grass
  yellow nut sedge
- Spray the undersides of leaves whenever possible to improve penetration.
- Since leaves with hairs or bristles prevent absorption, use a wetting agent to improve effectiveness when spraying the following plants:
  large crabgrass
  common mullein
  various mallows
  velvetleaf

Spot spraying minimizes drift.

Three Things to Remember When Using Herbicides

1. Spot spraying
   Herbicides should be spot sprayed, rather than blanket sprayed over an entire area, since blanket spraying may cover desirable plants and may weaken existing vegetation (thus increasing weed infestation). Applying herbicides using nozzles and low pressure will reduce drift. Also, certain additives will increase droplet size.

Maintain adequate separation between desirable vegetation and weeds when spraying.

2. Appropriate timing
   Table D-2 in Appendix D outlines the appropriate time to spray a specific weed in order for spraying to be most effective. Herbicides work better when used at higher temperatures. Foliar herbicides must be applied during a rain-free period to be effective, and herbicides that are absorbed through the roots need rain directly after application to work best. Under all circumstances, herbicides should be sprayed when it is not windy in order to minimize drift.

3. Knowing how herbicides work
   Tables 5-3 and 5-4 provide information for better understanding herbicide formulations and applications. Knowing the appropriate herbicide to use for a given situation will optimize its use.

Table 5-3. *How Herbicides Work*

Type	Description	Important Notes	Examples
Classification by their effect on plants			
Translocated "systemic"	Products are absorbed through the leaves and stems (foliar absorbed) or roots (root absorbed) of plant. Foliar-absorbed products move downward to the roots and are usually non-residual, becoming inactive by contact with soil. Root-absorbed products move upward to foliage. May be selective (affecting only grasses or broadleaf plants) or non-selective (affecting all plants).	Need time to work. Avoid mowing soon after application to provide time for products to reach roots. Use caution when mixing foliar-absorbed products with water, as soil particles in muddy water may reduce effectiveness.	
Act through growth regulation	Products upset normal growth by causing plants to grow very rapidly and decrease photosynthesis. Roots lose ability to absorb soil nutrients, and stems and leaves lose ability to move food throughout the plant.		2,4-D MCPP 2,4-DP dicamba MCPA picloram triclopy
Photosynthesis inhibitors	Products upset food-producing system, destroying needed chlorophyll.	Usually more effective on seedlings than on established weeds.	Atrazine cyanazine (Bladex) simazine (Princep) prometone (Pramitol) bromacil (Hyvar x) diuron (Karmex) fluometuron
Soil sterilants	Non-selective herbicides make the soil nonproductive for any vegetation. Chemicals must be carried by water through the soil, and may move only as far as the first rainfall takes them; others may continue to leach.	Overapplication increases the danger of water contamination and damage to other plants.	Karmex Krovar Oust Spike Arsenal
Growth inhibitors	Products cause abnormal cell development or prevent cell division for developing plant.		chlorpropham EPTC vernolate butylate profluralin penoxalin benefin dinitramine butralin dalapon
Contact herbicides	Products use non-selective killing or injuring of all types of plants. Kill or injure only plant tissue that they touch.		paraquat dinoseb

Table 5-3. *How Herbicides Work* (cont'd)

Type	Description	Important Notes	Examples
Classification by Method of Application			
Broadcast	Liquid spray or granules are applied evenly over an entire area.	Proper equipment calibration required to ensure correct application rates.	
Band	Liquid spray or granules are applied in narrow, parallel strips several feet apart.	On sloped areas, strips should run across the slope.	
Directed	Narrow stream of liquid is applied at the base of an undesirable plant.		
Spot treatment	Liquid spray or granules are applied to individual weeds or clumps of weeds.		
Basal bark	Liquid solution in water or oil applied to cover the lower 8–10" of woody brush or individual tree trunks.		
Dormant stem	Liquid solution in water or oil applied to tree stumps and woody stems in winter.		
Cut stump	Liquid solution in water or oil applied to brush and tree stumps immediately after cutting to prevent sprouting.		
Classification by Timing of Application			
Preplant	Application before a crop is planted; most often used during establishment of new turf.		
Pre-emergence	Application before weed seeds germinate; does not control any established weeds, but may be applied along with post-emergence products to prevent sprouting of seedlings.		
Post-emergence	Application to growing weeds; timing varies with target weed and environmental conditions.		
Adjuvants, Additives, and Surfactants			
Wetting agent "spreaders"	Reduce surface tension of spray droplets, enabling the droplets to spread out and cover greater leaf surface area. Also improve the penetration of water in heavy, compacted soils, limiting runoff.	Use only when recommended because they increase the toxicity of some herbicides. Can increase runoff when high volumes are used.	Surf-Side Aqua-Mate Hydro-Wet Bio-Film Sea-Wet X-77
Foam suppressants	Prevent the foaming that can occur when mixing a spray solution.		Defoamer Hopkins Defoamer ZAP Anti- Foaming Agent Agway Defoamer Helena Defoamer
Compatibility agents	Allow products to mix that would otherwise separate. Deflocculators prevent wettable powders from binding to each other and settling out of the mixture. Emulsifiers maintain the stability of an emulsion.		Comp-Ad Compliment EZ Mix

Table 5-3. *How Herbicides Work* (cont'd)

Type	Description	Important Notes	Examples
Penetrating agents	Speed up the absorption process by dissolving either the waxy cuticle or cuticle cell membranes.		Foliar penetrants Surfactant WK Cide-Kick Clean-Cut Clean-Cut Plus Pine Booster Plus Pine Arborchem Basal Oil diesel oil
Drift control agents	Increase the size of spray droplets, reducing the hazard of damage to desirable vegetation.		Lo-Drift Poly Control II Triton B Drift Proof
pH adjusters	Used when mixing water is too acidic or too alkaline.		Buffer X Spray-Aide (acidifier)
Marking agents	Dyes added to the tank mix to indicate coverage; helpful for inspection.		Bull's Eye Tracker Blazon Agro-Mark Doggett Blue/Green Dye

Table 5-4. *Partial List of Pest Situations and Possible Pesticide/Control Products*

Situation	Possible Products	Mix Ratios	Comments
Pavement cracks	Roundup Pro	2 gal/100 gal	Kills emerged vegetation.
	Roundup Pro/Surflan	1gal/1gal/100 gal	Kills emerged vegetation and prevents annual weeds for one growing season; more expensive.
	Roundup Pro/Pendulum	1gal/5 qt/100 gal	Kills emerged vegetation and prevents annual weeds for one growing season; less expensive.
	Roundup Pro/Endurance	1 gal/2 lb/ 100 gal	Kills emerged vegetation and prevents annual weeds for one growing season; very effective/safe mixture; non-staining.
	Hot water	Only water at 230º F	Kills top but not roots.
Guardrails	Roundup Pro/Surflan	1gal/1gal/100 gal	Kills existing vegetation and prevents annual weed germination for one season; safe on slopes; treat early post-emergence; no risk to adjacent woodies.
	Roundup Pro/Pendulum	1gal/1gal/100 gal	Same comments as for Roundup Pro/Surflan mix.
	Roundup Pro/Simazine	1 gal/10 lb/100 gal	Less expensive; lasts one to two seasons.
	Sahara DG	10 lb/acre	Trial use; watch for runoff into landscaping; more movement risk under severe rainfall conditions.
	Endurance	2 lb/acre	Non-staining pre-emergence control, longer lasting; add Roundup Pro if treating post-emergence
Canada thistle	Todon 101	1–1.5 gal/100 gal	Effective, restricted use; do not use near land scaping (10' from dripline)
	Transline	1 qt/100 gal	Very effective, general use; good for sensitive areas.
	Transline & Telar	2 qt/1 oz/100 gal	Extends the window of control into bloom stage.
	Pseudomonas bacteria	Research	Mow infested Canada thistle plants when moist in order to promote spread of this natural bacterium (Pseudomonas syringae).
Leafy spurge	Todon 101	1–2 gal/100 gal	Best chemical control available; restricted use; do not use near landscaping (10' from dripline).
	Transline	1 qt/100 gal	Invert system; restricted use; do not use near landscaping.
	Plateau	4–12 oz/acre	Trial use only; may be easier on adjacent land-scape plantings; use with methylated seed oil (1.5–2 pt/acre) and nitrogen (2 pt/acre).
	Krenite S	6 qt/acre	Effective when spurge is in bloom, especially following prescribed burns; use in sensitive areas.
	Flea beetles	500–1000 insects	Effective but takes time for flea beetle populations to build up; long-term solution.
Purple loosestrife	See 2,4-D	1 gal/100 gal	An aquatic 2,4-D formulation; aquatic label expires in 1998.
	Rodeo (glyphosate)	2 qt/100 gal	Aquatically labeled, non-selective.
	Garlon 3A	2 qt/100 gal	Non-aquatically approved; selective, experimental use for wetlands will not be available after 1998.
	2,4-D Dimethylamine	6 pt/100 gal	Aquatically labeled, 2,4-D amine formulation; label supported for 1999 and beyond.

Table 5-4. *Partial List of Pest Situations and Possible Pesticide/Control Products* (cont'd)

Situation	Possible Products	Mix Ratios	Comments
	Parasite insects/beetles	500–1000 insects	Preferred alternative in extensive, heavily infested areas. Contact Luke Skinner, DNR at 651-297-3763 for details on how to raise leaf-eating beetles.
Foliar brush	Garlon 4 or Garlon 3A	1 gal/100 gal 5 qt/100 gal	Premier brush control products. Use Garlon 3A (amine formulation) when temperatures are above 85oF.
	Krenite	6 qt/100 gal	Mid- to late summer for sensitive areas; plants go into normal fall coloration; can weaken/kill grass stands.
Basal brush	Garlon 4/Androc Oil	20%/80%	Premier brush control method; low profile dormant stem treatment.
Cut stumps	Pathway (Tordon)	Ready to use	Not restricted use; do not use in landscape beds or within the dripline of desirable trees or shrubs.
	Pathfinder II (Garlon)	Ready to use	Labeled for floodplains; does not hold up in freezing temperatures.
	Garlon/Diluent	20%/80%	Good for winter, dormant basal or cut stem.
Landscape Plantings			
Pre-emergent			
Mulch beds	Dyclomec	Read label	Overdose kills or injures woody plants—not much room for error.
Bare ground, rock	Surflan	Read label	Good safety factor; questionable in wood chip mulch beds.
Bare ground	Goal	Read label	Can injure leafed-out deciduous plants; poor on grasses.
	Ronstar	2.25–42 lb/1000 sq ft	Reported to be effective before mulch placement or on top of wood chip mulch.
	Pendulum	2.4 oz/1000 sq ft	
	Endurance	1–2.3 lb/acre	Trial only; longest residual of the pre-emergents; requires tank agitation.
Post-emergent			
Before-bed prep	Roundup Pro	1–4 qt/acre	Broadcast spray over proposed planting/seeding area. Rates for blue grass are 1–2 qt/acre. Rates for brome grass are 3–4 qt/acre. May till up and plant in five days.
Weeds in beds	Roundup Pro	20%, 80% water	Wiper or wick applicator; many absorbing woody roots in mulch.
Grass in beds	Fusilade	Read label	Can injure juniper and potentilla when sprayed over the top. Timing is critical.
	Transline conventional	1 qt/100 gal	Spot spray only.
	Transline in backpack	1 fl. oz/3 gal	Spot spray only.
	Roundup Pro	20% , 80% water	Wick applicator.
	Pseudomonas bacteria		Effective for long-term control of thistles and ragweed, etc., in high-density wildflower plantings.

Table 5-4. *Partial List of Pest Situations and Possible Pesticide/Control Products* (cont'd)

Situation	Possible Products	Mix Rates	Comments
Site prep—wildflowers	Transline	1 qt/100 gal	Broadcast spray in fall to clean up thistle, trefoil, and broadleaf plants.
	Roundup Pro	2–4 qt/acre	Site prep treatment in spring; can interseed in five days.
Thistles in wildflowers	Transline conventional	1 qt/100 gal	Spot spray only.
	Transline in backpack	1 fl. oz/3 gal	Spot spray only.
	Roundup Pro	Read label	Wick applicator.
	Pseudomonas bacteria		Effective for long-term control of thistles and ragweed, etc., in high-density wildflower plantings.
Dandelions in turf	2,4-D	Read label	Amine formulation to prevent volatilization.
	Confront	Read label	Trial use, this is a mix of Garlon and Transline; causes severe leaf curl on basswood and other lindens, no damage to most other woodies.
Poison ivy	Garlon 4	1 gal/100 gal	Volatility can be a problem when temperatures exceed 80oF.
	Garlon 3A	1 gal/100 gal	Amine; low risk to adjacent plants.
	BK 800 (Trimec)	1 gal/100 gal	Ester; volatility can be a problem when temperatures exceed 80oF.
Pocket gopher	Strychnine	Read label	Restricted use.
	Anticoagulants	Read label	Restricted use.
	Prairie seeding		Poor habitat for gophers.
	Cultural		Eliminate/reduce legumes from site or seed mixes.
	Fenceline woody plantings		Encourages predators like kestrel, other hawks, and badgers.
Yellow-headed spruce sawfly	Sevin	Read label	Spray sawfly larvae when in 1st through 3rd instars (less than 1/2" in length); spraying later instars kills beneficial predatory insects; notify beekeepers if spraying extensive areas.
Adjuvants			
	Activate Plus	5 oz/10 gal	Surfactant; less expensive.
	Silkin	8–16 oz/100 gal	Increases the effectiveness of applications; highly effective wetting agent and penetrant; improves rainfastness.
	Nu-Film IR		Trial; increases effectiveness of applications; improves rainfastness.
	Windbrake	1–3 pt/100 gal	Drift control-mixes easier in low agitation.
	Corsair	6–12 oz/100 gal	Drift control; concentrated; use with good agitation.

Tables 5-3 and 5-4 were prepared by Paul Walvatne and Leo Holm, both of Mn/DOT, with review and input by Mark Croswell, Terra Vegetation Management, April 1998 (revised April 9, 1998).

Note: No matter what product is used, always read the label. Additional information on herbicide formulations and uses of herbicides for noxious weed control is included in Appendix D.

HANDLING HERBICIDES

Safety is the most important factor in herbicide use. It's important not only to protect workers, but also to protect the environment.

All herbicides have a warning label that contains one of the signal words—DANGER, WARNING, or CAUTION—that denotes the toxicity level of the product. Materials with the word DANGER on their label are at least 10 times more toxic than those with the word WARNING and 100 times more toxic than those with the word CAUTION.

The hazard potential of a herbicide depends on two primary variables: toxicity and exposure. Toxicity is the capacity of a substance to produce injury or death; exposure refers to the contact with the untargeted species. Therefore, a product may be extremely toxic but present little hazard to the applicator or others when used:

- in a very diluted formulation;
- in a formulation not readily absorbed through the skin or readily inhaled;
- only occasionally and under conditions to which humans are not exposed; and
- only by experienced applicators that are properly equipped to handle the material safely.

On the other hand, a product may have relatively low toxicity but present a hazard if used in concentrated form which is readily absorbed or inhaled.

To reduce the human hazards posed by the application of herbicides, always:

- Read, study, and follow the labeling instructions and precautions.
- Avoid spilling the material on human skin and clothing, and wear adequate protective clothing as indicated on the label. If a spill occurs, wash immediately with soap and water.
- DO NOT SMOKE while mixing or using.
- Wash thoroughly and change clothes after spraying.
- Store herbicides in original containers only.
- Prevent drift by slowing down, reducing pressure, or adding adjuvants.
- Be alert and keep your mind on the job.

Get medical attention quickly if you or a coworker experience any unusual or unexplained symptoms while applying herbicides.

HERBICIDE SPILLS

A herbicide spill is potentially hazardous and should be cleaned immediately. Exercise extreme care when using materials and read and follow all labeling information.

To prevent possible spills:

- Prevent bags and cardboard containers from getting wet.
- Prevent or correct leaks in herbicide containers and application equipment.
- Keep drift to a minimum by the proper use of spray adjuvants, nozzle selection, pressure, and sprayer speed.
- Avoid volatilization by using only amine formulations. Ester formulations may be used with caution for dormant stem treatments.
- Dispose of all empty containers as required by law.
- When transporting herbicides, tie down or secure the containers in order to prevent them falling off the vehicle. Follow all state requirements for transporting.

If a spill occurs:

- Rinse all skin that has been exposed to the material and remove all contaminated clothing.
- Contain the spill as well as possible. Do not spread the spill by washing it down. Prevent the spill from contaminating any water sources.
- Clean the spill by removing the contaminated soil or by neutralizing the chemical with an application of activated charcoal, or both.

- If the spill is large and help is needed, contact the Minnesota State Patrol or Minnesota Department of Agriculture.
- Wash spills off sprayer and dispose of the contaminated rinse water in accordance with state regulations.

HERBICIDE RECORDS

The applicator must maintain a record of herbicides used on each site for a minimum of five years. Records must include the following information:

- application date
- name/address of customer
- brand name
- site location
- license number of applicator
- dosage of herbicide used
- temperature
- number of units treated
- completion time
- name/signature of applicator
- US/EPA registration number
- wind speed/direction
- name/address of applicator company

Chapter 6
Best Management Practice No. 6:
Manage Living Snow Fences

Highway segments with wide, open stretches are vulnerable to blowing snow accumulation on the surface and reduced visibility for roadway users. Living snow fences include rows of trees and shrubs that, if planted in the right location, can cause snow to accumulate in a more convenient area and can also improve visibility during and after snowstorms. In Minnesota, prevailing winds are out of the northwest.

Traditional snow fences are designed to permit 40–60 percent airflow, slowing the wind and piling the snow safely downwind.

SNOW FENCE PLACEMENT AND DESIGN

To improve visibility and/or prevent drift accumulation on highway sections in areas where there is 10,000 feet of "fetch distance" (open distance perpendicular to the centerline), a living snow fence should be planted 250 feet from the centerline. Note that normal rights-of-way are typically 75–100 feet from the centerline, but that planting on existing rights-of-way may extend drift formation onto the road surface. In these situations, additional right-of-way should be purchased, or easements obtained, to plant the snow fence.

In areas where the "fetch distance" is only a few thousand feet, a living snow fence planted 100 feet from centerline will still be effective.

A strip of tall grasses 12 feet wide will actually trap the snow and hold it. Native grasses are an attractive addition to farmsteads and field borders because they remain upright during the winter and provide wildlife with excellent cover for the winter and nesting habitat in the spring.

Proper design of a living snow fence involves three key elements: height, density, and length.

Height: This affects the snowdrift length and depth. Snow storage capacity increases by more than four times when the height is doubled. Typically, vegetative barriers should be set back from the area to be protected 10–15 times the mature height of the vegetation.

Density: This affects both windward and leeward snowdrift lengths and heights. The species, number of rows, and plant spacing determine density. Winter density of deciduous trees must also be considered. Density should be uniform with no openings and gaps.

Length: This determines the maximum length of the area that can be protected. Less snow is stored at the ends of barriers, so the snow fence must extend 100 feet beyond the area to be protected.

SELECTING PLANTS FOR A LIVING SNOW FENCE

Use plants that are adapted to site conditions such as soil pH, soil moisture extremes, and soil texture. Most plants have characteristics that make them susceptible to one or more problems, such as insects, disease, and storms. Although in most cases pest- and weather-related problems

are minor concerns, selecting a variety of plants with similar growth and site requirements can minimize the risk of a single problem destroying the snow fence planting.

Avoid plants for which a major insect or disease is known to cause problems with establishment and long-term survival. Honeysuckles that are susceptible to "witches broom" aphids are one example. A potential pest of concern is the gypsy moth, a non-native leaf-eating insect that has been expanding westward from its original introduction on the East Coast in 1869. Although it's unknown when this pest will become established in Minnesota to the point of affecting tree health, to be safe, avoid species that are the preferred hosts of gypsy moth (listed in Table 6-1).

Table 6-1. *Tree Species Preference Rankings for Gypsy Moth*

Preferred	**Intermediate**	**Avoided**
Apple	Beech	Arborvitae
Aspen	Cherry	Ash
Basswood	Elm (American, rock, Siberian)	Balsam fir
Birch (gray, paper, and river)	Hemlock	Black walnut
Hawthorn	Hickory	Buckeye
Larch	Ironwood	Butternut
Oak	Maple	Catalpa
Poplar	Pine	Dogwood
Sumac	Serviceberry	Slippery elm
Willow	Spruce	Hackberry
		Kentucky coffee tree
		Locust (honey and black)
		Red cedar
		Yew

Source: *Catch the Snow with Living Snow Fences*, Mn/DOT 1999.

The Minnesota Interagency Living Snow Fence Task Force developed "winning combinations" for snow fences, based on observations made during the winter of 1996–1997, site visits, past experience, and recent work understanding snow transport. The required fence height and set-back for any of these combinations is based on the principal of snow transport. Design criteria can be obtained from the 1999 publication titled *Catch the Snow with Living Snow Fences*, published by Mn/DOT Office of Environmental Services.

The five winning combinations for use as a living snow fence are:

- Twin row tall grass native prairie snow catch
- Twin shrub row
- Deciduous tree windbreak
- Vertical side community shelterbelt
- Structural snow fence

Living snow fence effectively keeping roadway clear.

Chapter 7
Best Management Practice No. 7:
Use Integrated Construction and Maintenance Practices

A Mn/DOT study showed that five major items, listed below, are significant in the establishment of good vegetative cover.

- Control of water flow
- Preparation of slope and topsoil
- Seeding and fertilizing
- Use of mulch and erosion control products
- Mowing

Of those five items, three are affected during construction. The goal of the turf establishment process is the quick establishment of self-perpetuating plants that stabilize the soil, protect road structure, and enhance the value of the road.

Sediment created by erosion is the single greatest pollutant by volume in our waters. It creates an unhealthy environment for fish, destroys the balanced biological conditions required for a healthy aquatic environment, increases flood crest, and decreases the capacity of drainage channels. Minimizing erosion controls sediment.

During construction, the disturbed soil is especially subject to erosion. Conservation of the soil, and the need for soil of adequate depth with the required nutrients for establishing vegetative cover, is extremely important. Make efforts to retain the soil on site to establish a good vegetative cover later, since poor soils or inadequate soil depth will allow for the establishment of undesirable vegetation.

When designing and specifying requirements for a project, consider roadside vegetation through provisions for soil conservation, erosion control, topography, and aesthetics. Specify required soil type and depths, which will greatly influence the health of the roadside environment. Implement a control plan for controlling erosion and sediment that incorporates the use of silt fences, sediment basins, and temporary seeding and mulching prior to beginning the earthwork. Unless elements of roadside vegetation management are considered in design, maintenance staff will encounter difficulties in implementing the plan, especially as it relates to erosion control and the establishment of desirable vegetation

INTEGRATED CONSTRUCTION AND MAINTENANCE PRACTICES

Erosion Control

The following techniques can help to reduce or control erosion during construction:

1. Minimize the area exposed at any one time, as well as the duration of the exposure. Develop a staging plan that specifies temporary seeding as an area of construction is completed.
2. Minimize the area disturbed for the project. Clear only within the construction limits or as required for safety or clear zones.
3. Apply erosion control practices throughout construction. For example, keep soil covered, roughen the slope on the contour, and track the area with a cleaned dozer.

4. Use perimeter control practices, such as dikes, filters, and sediment basins.
5. Keep runoff velocity low, and retain runoff on-site by flattening, reducing slopes, and preserving the natural vegetative cover.
6. Place gravel-based materials immediately after the subcut is completed.
7. Strip existing topsoil and store for use later. Seed stockpiles while waiting to reuse.
8. Follow up work with periodic inspections.

Topsoil Placement and Grading Operations

Place topsoil on subsoil that is loose, scarified, or bulldozer-tracked perpendicular to slope contours so that a bond occurs, thus preventing slippage during rain. Use mulch to establish vegetation by stabilizing the soil surface, protect against wind and water, hold the seeds in place, protect seeds from rapid changes in temperature, and reduce evaporation. In most cases, do not finely grade slopes. Moderately rough surfaces help trap seeds and moisture, and so will result in more successful vegetation establishment.

Temporary Seeding

Use temporary seeding to prevent disturbed soil from lying unprotected until the entire project is completed. If one area of a project is completed, seed it as soon as possible. Stockpiles and temporary structures can also be seeded temporarily. Be sure to properly prepare the seedbed to a depth of at least three inches and use quality seed. Fast-growing annual seed, such as recommended in section 3876 of the Mn/DOT Standard Specifications for Construction, provides temporary cover quickly.

Only fertilize if needed. Apply seed evenly to 1-1/2-inch maximum depth for grain and less than 1/2-inch depth for grasses. Complete with a mulch cover.

Permanent Seeding

Select an appropriate seed mixture based on the area, soil, and climate. The appropriate fertilizer and application rate is also important. As with temporary seeding, soil should be prepared to a depth of at least three inches. Apply mulch uniformly to a depth of 1/4 to 1/2 inch to protect the seed and minimize soil erosion. Note the seeding dates as listed in the Mn/DOT Standard Specifications: do not seed between September 1 and October 15 in northern Minnesota or between September 15 and November 1 in southern Minnesota.

Tree Protection

Trees are subject to damage and destruction during construction and must be protected. Table 7-1 outlines some ways to do this.

Mn/DOT Standard Specification 2572, Protection and Restoration of Vegetation, is included in Chapter 8. This specification, describing the protection and preservation of vegetation from damage and the corrective action to use when damage occurs, should be followed during construction. Vegetation in this respect includes but is not limited to trees, brush, roots, woody vines, and perennial forbs and grasses.

Table 7-1. *Tree Protection during Design and Construction*

Impact to Tree	Construction Activity	Methods/Treatments to Minimize Damage
Branch and trunk damage	Injury from equipment	Fence trees to enclose low branches and protect trunk. Report all damage promptly so an arborist can treat appropriately.
	Pruning for vertical clearance for building, traffic, and construction equipment	Prune to minimum height required prior to construction. Consider minimum height requirements of construction equipment and emergency vehicles over roads. Have a trained person perform all pruning.
	Felling trees in construction area	Require that trees being removed be felled away from tree protection zones.
Root damage or loss	Stripping site of organic surface soil	Restrict stripping of topsoil around trees. Any woody vegetation to be removed adjacent to trees to remain should be cut at ground level by hand rather than pulled out by equipment, since the latter will result in root injury to the remaining trees.
	Digging into topsoil layer and killing roots while loading piles of soil, sand, gravel	Store materials outside fenced protection zones and away from root zones. Place plastic tarp, straw, plywood, or geotextile material beneath pile.
	Lowering grade, scarifying, preparing subgrade for fills, structures	Use retaining walls with discontinuous foots to maintain natural grade as far as possible from trees. Excavate to finished grade and cut exposed roots with a saw to avoid root wrenching and shattering by equipment, or cut with root pruning equipment. Soil below cut face can be removed with equipment sitting outside the tree's dripline.
	Subgrade preparation for pavement	Use paving materials requiring a minimum amount of excavation. Design traffic patterns to avoid heavy loads adjacent to trees (heavy loads require thicker pavement structures). Specify minimum subgrade compaction under pavement within root zone. Install aeration pipes if necessary.
	Excavation for footings, walls, foundations	Design walls and structures with discontinuous foots and pier foundations. Excavate by hand near major roots. Avoid slab foundations and instead use post-and-beam footings.
	Trenching for utilities, drainage	Coordinate utility trench locations with installation contractors. Consolidate utility trenches and try to have them placed next to driveways and walks. Excavate trenches by hand in areas with roots larger than 1" in diameter. Tunnel under woody roots rather than cutting them. Curve trenches rather than using straight lines.
	Fill dirt over roots	Avoid adding soil over root zone. If unavoidable, insert aeration pipes.
Unfavorable conditions for root growth; chronic stress from reduced root systems	Compacted soils	Fence trees to keep traffic and storage out of root area. In areas of engineered fills, specify minimum compaction if fill will not support a structure. Provide storage yard and traffic areas for construction activity well away from trees. Protect soil surface from traffic compaction with 12" to 14" of wood chip mulch. Following construction, vertical mulch compacted areas and install aeration vents.

Table 7-1. *Tree Protection during Design and Construction* (cont'd)

Impact to Tree	Construction Activity	Methods/Treatments to Minimize Damage
	Spills, waste disposal (e.g., paint, oil, fuel)	Post notices on fences prohibiting the dumping and disposal of waste around trees. Require immediate cleanup of accidental spills.
	Concrete washout and waste dumping Soil sterilants (herbicides) applied under pavement Impervious surface over soil surface	Designate washout areas. Dig pit and remove after construction, if necessary. Use herbicides safe for use around existing vegetation and follow label directions. Utilize pervious pavement material where possible. Install aeration vents in impervious paving.
Inadequate soil moisture	Rechannelization of stream flow; redirecting runoff; lowering water table; lower grade	In some cases, it may be possible to design systems to allow low flows through normal stream alignments and provide bypass into storm drains for peak flow conditions. Provide supplemental irrigation in similar volumes and seasonal distribution as would normally occur.
Excess soil moisture	Underground flow backup; raising water table	Fills placed across drainage courses must have culverts placed at the bottom of the low flow so that water is not backed up before rising to the elevation of the culvert. Study the geotechnical report for ground water characteristics to see that walls and fills will not intercept underground flow.
	Lack of surface drainage away from tree	Where surface grades are to be modified, make sure that water will flow away from the trunk, i.e., that the trunk is not at the lowest point. If the tree is placed in a well, drainage must be provided from the bottom of the well.
	Irrigation of exotic landscapes	Some species cannot tolerate frequent irrigation required to maintain lawns, flowers, and other shallow-rooted plants. Use free-form mulch areas, avoid landscaping under those trees, or utilize plants that do not require irrigation.
Increased exposure	Thinning stands, removal	Save groups or clusters of trees when working with species that perform poorly in the open or as single trees. Maintain the natural undergrowth.
	Excessive pruning	Prune sparingly, especially in stands of shade-tolerant species. Leaves manufacture the food needed for root growth and recovery from shock.

Source: Tree City USA Bulletin No. 20, The National Arbor Day Foundation.

Chapter 8
Examples of Best Management Practices

This chapter highlights examples of cities, counties, state districts, and neighboring states that are using the best management practices identified in this handbook.

BMP #1: DEVELOP AN INTEGRATED ROADSIDE VEGETATION MANAGEMENT PLAN

Examples of Integrated Roadside Vegetation Management Plans from the following agencies are highlighted below:

- Iowa Roadside Vegetation Management Program
- Mn/DOT Maintenance Area 3B IRVM Plan
- Mn/DOT Metro Division IRVM Plan
- Visual Quality Best Management Practices for Forest Management in Minnesota

Table 8-1 outlines a summary of the first three plans.

Table 8-1. *Elements of Roadside Vegetation Management Plans*

Best Management Practice	**Iowa RVMP**	**Mn/DOT Area 3B**	**Mn/DOT Metro**
Establishment of Sustainable Vegetation	Control topsoil erosion from surface runoff and wind. Use conservation tillage.	Use appropriate vegetation type to control erosion.	Use interseeding in areas where turf is sparse or weed-infested.
Mowing Operations	Mow less; mow only in areas to improve safety and sight distance.	Mow less; mow based on type of roadway. Leave many areas unmowed.	Mow less; leave many areas unmowed.
Control Noxious Weeds	Use native grasses and wildflowers. Use herbicides as a second choice.	Use cultural (native grasses) and biological (insects) control. Spot spray with herbicides.	Spot spray. Use biological control.
Use of Woody Vegetation and Brush Control	Conduct these operations during winter when staff is available.	Spray brush less than 6' high. Remove other brush and hazard trees. Allow naturalization of brush beyond the ditch lines.	Spray brush less than 6' high. Remove other brush and hazard trees. Allow naturalization of brush beyond the ditch lines. Control Dutch elm and oak wilt diseases.
Use of Native Grasses	Strongly urge use of native grasses to control noxious weeds and to create a more diverse landscape.	Use prescribed burning, where safety and traffic permit. Harvest native grass seed from existing stands.	Use controlled burning; attempt to coordinate with burning of adjacent land. Establish stands of prairie grasses.

Iowa Roadside Vegetation Management Program

The Office for Integrated Roadside Vegetation Management at the University of Northern Iowa has published its roadside vegetation management plan in *The Roadside Almanac IRVM,* elements of which are outlined below.

ESTABLISHING SUSTAINABLE VEGETATION

One plan objective is to control topsoil erosion from surface runoff and wind blowing across bare fields. Adjacent farmers are encouraged to employ conservation tillage that lets crop residue protect the soil surface and reduces soil movement. The IRVM acknowledges that since eroded soil deposited on the roadside can bury roadside vegetation and increase maintenance work, it implements measures to prevent it.

CONTROL OF NOXIOUS WEEDS THROUGH USE OF NATIVE GRASSES

Iowa controls annual and biennial weeds through the use of native grasses and wildflowers. Its IRVM recognizes that most of the plants growing on the roadside are harmless and may be native wildflowers. A diverse plant community will result in a continuous bloom of flowers throughout the growing season.

Iowa has identified maintaining a healthy stand of native grasses as the best way to control invasive weeds. These grasses have extensive roots that offer the toughest competition to Canada thistle. In addition, plant diversity along the roadsides creates a strong plant community. Prairie plants can adapt to a wide range of soil types, moisture levels, and climactic condition. Most prairie grasses and wildflowers grow best during hot, dry summer months, providing excellent erosion control during the fall and spring. Deep roots also prevent the invasion of noxious weeds and reduce the numbers of shrubs and trees.

If natives are not used, Iowa's second choice for controlling noxious weeds is herbicides. Spot spraying is recommended, as blanket spraying applies herbicide on the entire roadside plant community, weakening existing vegetation, killing wildflowers, and allowing more weed invasion.

Annual and biennial weeds typically produce many seeds and complete their life cycle in one or two years. The top layer of soil is loaded with weed seed, and with heavy rainfall, almost all seeds germinate, establish roots, and grow. The question of whether to mow or spray these weeds is important. These weeds die after flowering, and it may take a year or two of average rainfall for a group of small weed patches to be established. If prairie plants are nearby, in time they will eventually reclaim the disturbed area. In order to determine the correct response (if any) for managing individual weeds, one must understand their life cycle.

MOWING PRACTICES

Mowing roadsides is very expensive in terms of personnel hours, equipment hours, and fuel consumption. If the purpose of mowing is to provide sight distance and room for a vehicle to pull off the road, mowing the entire roadside is unnecessary. Improper mowing height and too frequent or poorly timed mowing can reduce root mass, plant vigor, and overall production potential. Operating heavy equipment on roadside slopes can tear up vegetation, weakening the plant community and making the roadside more susceptible to weeds and erosion. Because of this, Iowa's plan calls for reduced mowing, and the mowing of only those areas where it is needed for sight distance and safety.

Some areas do require periodic mowing to maintain a safe right-of-way. They include:

- intersections
- bridges
- sharp curves
- farm and field entrances

Everywhere else, Iowa is learning to appreciate the flowing beauty of the tall grasses that do not require mowing.

WINTER PLANNING

During winter months, equipment is maintained, seed and herbicide supplies are inventoried, and plans are made for the warmer months' roadside vegetation management activities. Other winter activities include:

- renewing landowner contacts
- controlling brush (on milder days)
- removing trees and brush to provide a safe recovery area for vehicles
- removing trees from foreslope and ditch bottoms
- treating stumps to prevent resprouting
- removing brush and trees on the backslope as required by local practices

Integrated Roadside Vegetation Management Plan for Mn/DOT Maintenance Area 3B – St. Cloud

Mn/DOT's Maintenance Area 3B developed its integrated roadside vegetation management (IRVM) plan as a proactive way to address roadside management and respond to the following legislation:

- Groundwater Act of 1989 (Chapter 326, Article 5, Section 18B.063) under STATE USES OF PESTICIDES AND NUTRIENTS: The state shall use integrated pest management techniques in its management of public lands, including roadside rights-of-way, parks, and forests; and shall use planting regimes that minimize the need for pesticides and added nutrients.

- 1994 Amendment to the Groundwater Act of 1989 (Chapter 558, Section 26). The legislature required the Commissioner of the Department of Natural Resources (DNR) to prepare a plan for the optimum use of sustainable agriculture and integrated pest management techniques on land owned by the state. A report published in March of 1996, *Sustainable Agriculture and Integrated Pest Management Plan for State-Owned Lands,* provides the framework for the development of local plans such as the 3B effort.

Mn/DOT's plan represents planning at the local effort, with a core committee composed of Mn/DOT maintenance and technical advisory personnel, Minnesota Department of Agriculture regulatory personnel, and county agricultural inspectors. The plan supplements the roadside section of the Maintenance Operations Manual, as well as pertinent sections of Mn/DOT's design manual and the "vegetation height control" and "noxious weed control" standards developed as part of the Mn/DOT area maintenance engineer's planning process.

The plan includes the general elements that follow.

MISSION STATEMENT

Manage roadsides with environmental stewardship, using economical methods, for public safety and visual quality.

PRINCIPLES

1. Promote a safe environment for the traveling public, services employees, and wildlife.
2. Protect, respect, and encourage the natural, native environment.
3. Be receptive and respectful of inputs from other entities.
4. Set a respectable example for all that use, benefit from, maintain, or adjoin the right-of-way.
5. Search for and/or develop methods that will reduce operating costs.

GOALS

1. Reduce roadside hazards.
2. Reduce state and county listed noxious weeds.
3. Reduce mowing.
4. Improve the catalog and record-keeping system.
5. Increase and preserve native vegetation.
6. Increase public awareness and enhance Mn/DOT's image.

Specific objectives are listed for each sub-area to meet the above goals. For example, some of the objectives for one sub-area are listed below:

1. Inventory and remove 50 percent of hazard trees on two-lane roads and 100 percent on I-94, with 100 percent removal in five years.
2. Maintain 100 percent of all sight corners to appropriate safety standards.
3. Control 75 percent of noxious weeds and encroaching bush with a 15 percent reduction of herbicide use per year for the next three years; increase control to 90 percent in five years.
4. Further reduce mowing by timely and appropriate use of herbicides and staying with "top cut" only in all appropriate areas.
5. Maintain areas of native prairie with controlled burning of 20 percent of burnable sights every year.

General requirements for the IRVM Program are also listed. Components of the IRVM plan include:

- mowing
- brush control
- herbicide application
- biological control methods
- prescribed burning
- planting
- tree trimming and cutting
- rodent and insect control
- mulching and fertilizing
- erosion control
- native seed harvesting

Each of these operations will be conducted as an integral part of an overall program, so that personnel performing each activity will know that they are part of this overall goal-oriented program. In addition, customers (such as the public) will be informed that there is a program with goals in place.

The plan also outlines a strategy for categorizing roadsides. Roadsides in Area 3B fall into three different types based on the management practices needed to keep them safe and aesthetically pleasing. The three types are listed below.

Type	Description	Examples
1	Minimal mowing, no full-width mowing, natural vegetation height shoulder cuts only	TH94/10, TH 65 Bypass
2	50/50 mowing, areas next to at-grade businesses and homes mowed, many areas left unmowed	TH 15 in St. Cloud
3	High frequency mowing, parkways, boulevards, blue grass turf; many business areas also left unmowed	TH 15 St. Cloud

The plan includes a mapping and communication plan that states that roadsides of each type will be indicated on maps so that all maintenance personnel and the public are informed. The roadside category will dictate the amount and type of each of the IRVM practices conducted and will form

the basis for the long-term goals for each of the roadside types. The maps will also include current-year noxious weed control, landscape partnership projects, ongoing vegetation research projects, and prairie restoration projects.

IRVM guidelines are included in the plan. The roadside is divided into several roadside management zones, as shown in Figure 8-1.

Those guidelines include:

- Following a mowing effort that allows mature vegetation height where appropriate and also addresses safety and aesthetic issues. Mowing will also be used to control annual weeds and to knock down perennial weeds prior to spraying. Quality, not quantity, is the goal.
- Using brush control where needed and where brush is taller than 6 feet. Control brush in accordance with Figure 8-1. Allow naturalization of woody plants beyond the ditch line (except where the clear zone goes beyond the ditch line).
- Following a herbicide application effort that controls noxious weeds. Unwanted brush less than 6 feet in height may also be sprayed in accordance with Figure 8-1.
- Working with other agencies on attempting biological control of noxious weed and insect pests in selected areas. Areas will be located on maps.
- Working with prescribed burning of native vegetation for enhancement and weed control, where safety and traffic permit.
- Incorporating a planting effort for visual aesthetics, and in places where the turf is sparse and/or in weed-infested areas.
- Trimming and/or cutting hazard trees (defective trees with a target such as people, cars, and other property) in rest areas and other roadside areas.
- Using appropriate methods of rodent/insect control when infestations become a problem.
- Mulching/fertilizing specifically in landscape plantings, higher visibility and maintenance areas such as rest areas, etc.
- Integrating the use of appropriate types of vegetation by seeding or planting in areas where erosion control is needed.
- Continuing to expand the native seed harvesting of existing stands of native prairie in order to make future new seeding in the area more economical.

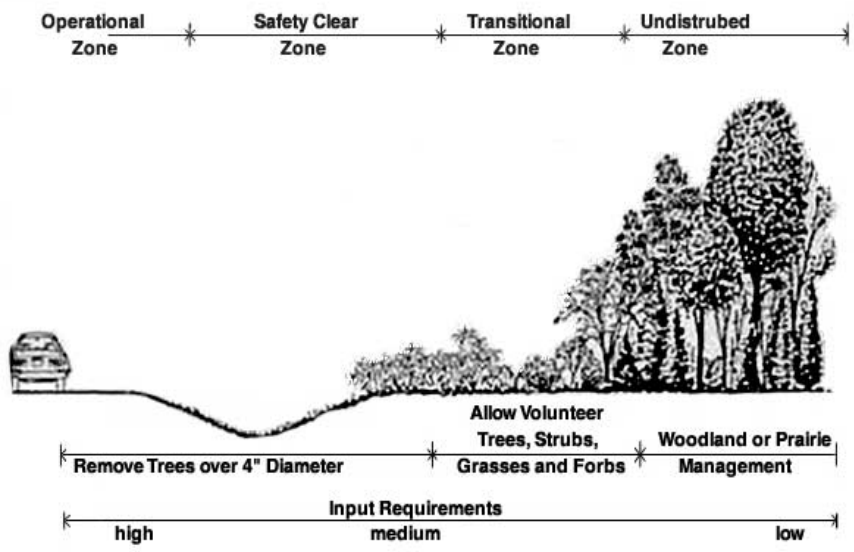


Figure 8-1. *Roadway Management Zones*

Ongoing program requirements include:

- budgeting
- conducting resource inventories
- establishing lines of authority
- providing employee training
- encouraging employee input
- interacting with technical experts
- reviewing and determining equipment needs
- determining how state resources are to be used
- reviewing and evaluating the program

RESPONSIBILITY FOR THE PLAN

The plan also outlines who is responsible for the IRVM program. A core committee is identified whose responsibility is to provide direction and guidance on how the program is run. The committee comprises maintenance personnel as well as vegetation management experts. The committee is to meet yearly and develop goals for the upcoming season, as well as develop a summarized activity report for the year. In addition, the plan lists resource experts who are responsible for the various plan elements.

IMPLEMENTATION SUMMARY

Reduction of Roadside Hazards

Prior to plan implementation, there was confusion as to what constitutes a roadside hazard, especially because of the concept of reduced mowing together with the idea of leaving naturally growing vegetation on the backslopes. The plan includes specific documentation regarding clear recovery zones and sight safety corner requirements, along with a copy of indicators for vegetation height control and a speed chart for sight intersections. Roadside hazards, especially at sight corners, were always a priority for the area, but now with the appropriate uniform information for all workers, these issues are addressed much more confidently and efficiently.

Efficiently Reducing Mowing

In the first year of plan implementation, right-of-way mowing was reduced by an average of 30 percent. The policy states that areas are to be "mowed top cut only, with exceptions." Exceptions for the year included the center median of Interstate 94, which was mowed at the request of the State Patrol to improve the effectiveness of radar equipment. Other exceptions were made to provide sight distances, clear thistles and deer crossing areas, help prevent drifting snow, and improve aesthetics within some city limits. Experimenting with different rental tractor and mower setups helped identify much faster and more efficient ways to mow top cut throughout an entire area. A successful spring training and information meeting on reduced mowing was held, but more information will be provided to workers in the future. Mowing can and should be further reduced.

Reduction of Noxious Weeds with Herbicides

Maintenance workers who were licensed pesticide applicators were given the title of Intermittent Supervisor and allowed to work on vegetation management full time during the season. Since they could purchase needed herbicides and equipment, they could apply herbicides on a timely basis without interference. Meanwhile, part-time summer help was hired to fill in for those workers. In the first year of the program implementation, noxious weed spraying increased overall by 50 to 75 percent, but this was due to decreased mowing, which was previously used to control weeds. Noxious weed populations and herbicide use are both expected to drop in the future.

Burning Native Prairie Areas

Maintenance Area 3B incorporated burning into its maintenance program in order to restore native prairies and control weeds. During the first year, almost 30 acres of prairie were burned, but most of the focus of the program was on training and acquiring equipment. Significant gains were made in training; after one year, the area had a full complement of trained workers, experienced, equipped, and prepared for burning on a larger scale. Additional burns have been successfully completed since.

Implementation of a Uniform Maintenance Area Mapping System

Implementation of a mapping system is an element of the IRVM Plan for Maintenance Area 3B. To accomplish this, CAD maps were obtained from Mn/DOT and plat books obtained from the county. The maps that were developed include established areas of noxious weed infestations, hazard trees, native seeding, and other important elements of the management plan. These maps are updated and assist in program planning, record keeping, and assessment.

Increase Areas of Native Vegetation

The IRVM Plan notes that increasing native vegetation will lead to better weed control, reduced mowing, and protection of the environment. One problem that Maintenance Area 3B encountered was the high cost and short supply of native seed. To make seed more available, it initiated a program to harvest existing stands of native seed within the maintenance area. In 1995, Mn/DOT and the DNR together harvested 400 pounds of native grass seed, which was shared between the two departments. Maintenance used the seed for 40 acres of right-of-way. In addition, a large construction project was planted with native species, from which additional seed can be harvested.

Integrated Roadside Vegetation Management Plan for Mn/DOT Metro Division

Mn/DOT's Metro Division developed its integrated roadside vegetation management (IRVM) plan as a proactive way to address roadside management and as a response to the same legislation as referenced in Maintenance Area 3B's plan. The Metro Division's plan includes the general elements that follow.

MISSION STATEMENT

We are committed to managing Metro Division roadsides to ensure the safety, well being, and enjoyment of travelers and adjacent neighbors while using cost-effective and environmentally appropriate vegetation management methods.

GOALS

In conjunction with the plan, goals were identified for the following areas:

- prairie seedings
- leafy spurge beetle release sites
- brush control and selective trimming
- landscape maintenance and plantings
- mapping and inventory
- training, communication, and education

CHARACTERIZATION OF MANAGEMENT PRACTICES

Roadsides are categorized based on management practices needed to keep them safe and aesthetically pleasing. They range from high-maintenance turf and landscaped areas requiring frequent mowing and fertilizing to low-maintenance areas where a natural or wild appearance is acceptable and desired. The three categories for the plan are the same as those identified in the plan for Maintenance Area 3B.

MAPPING/COMMUNICATION

Roadsides of each type are indicated on maps so that the public and all maintenance personnel are informed. The roadside category dictates the amount and type of maintenance performed and forms the basis for the long-term goals of each roadside type. The maps will also include current-year landscape partnership projects and programmed landscape projects, ongoing vegetation research projects, and prairie restoration projects.

IRVM PROGRAM COMPONENTS

- mowing
- brush mowing and cutting
- spraying chemicals and biologicals
- planting and interseeding
- biological control
- care of landscaping
- fertilizing
- mulching

- hazard tree control
- Dutch elm and oak wilt control
- washout repair
- prescribed burning

Each operation is conducted as though it is an integral part of an overall program. By doing so, personnel performing roadside maintenance activities will be aware that there is a program in place and that they are working within an overall program. In addition, the public and others will be aware that a program with goals is in place.

IRVM GUIDELINES

Guidelines for the Metro Plan are given below. Note the similarities with the program for Maintenance Area 3B. Both groups were given similar objectives but each developed different guidelines.

1. Follow a mowing effort that allows mature vegetation height where appropriate and also addresses safety and aesthetic issues. Mow to control annual weeds and to knock down perennial weeds prior to spraying. Quality, not quantity, is the goal.

2. Use brush mowing and cutting where brush needs to be controlled and is over 6 feet in height. Mow from the edge of the shoulder to just beyond the bottom of the ditch on a four-year cycle to control brush and to reveal washouts in this zone. Contact the herbicide coordinator for follow-up herbicide treatments on brush regrowth following mowing. Control brush in accordance with Figure 8-1 (see Maintenance Area 3B). Allow naturalization of woody plants beyond the ditch line (except where the clear zone goes beyond the ditch line).

3. Follow a spot spraying effort that controls noxious weeds. Unwanted brush less than 6 feet in height may also be sprayed in accordance with Figure 8-1.

4. Work with other agencies on attempting biological control of noxious weed and insect pests in selected areas. Areas will be located on the map.

5. On an initial limited basis, work with controlled burning of native vegetation where safety and traffic permit. Where possible, use controlled burns in conjunction with adjacent burns.

6. Fertilize areas where the turf may be weak or depleted, especially in the highly maintained type 3 roadsides, such as the I-35E Parkway and the Mall of America.

7. Incorporate interseeding efforts in places where the turf is sparse and/or in weed-infested areas.

8. Identify and treat hazard trees (defective trees with a target such as people, cars, and other property) in rest areas and other roadside areas.

9. Control Dutch elm and oak wilt disease along state roadsides in communities with active control programs.

10. Integrate reforestation and prairie establishment efforts in appropriate areas.

ONGOING PROGRAM REQUIREMENTS

Like the Maintenance Area 3B Program, the Metro IRVM Plan identified several ongoing requirements that must be met to conduct a successful program. They are:

- Budgeting
- Having established line of authority
- Providing employee training

- encouraging employee input
- communicating
- interacting with technical experts
- reviewing and determining equipment needs
- determining ratios of, type, and amount of contract work
- reviewing and evaluating the program
- determining how state forces are to be used

Many of the above requirements were already in place prior to the plan's development. Yearly goals were established for each of the above to ensure continuation.

STEERING COMMITTEE

A steering committee was assembled to provide input to the process and ongoing program requirements. It provides for input from employees and other agencies. At a minimum, the steering committee will be made up of six members, five from Mn/DOT and one from the Minnesota Department of Agriculture. Mn/DOT members must include management, front-line workers, and central office technical experts.

Yearly goals will be established by the steering committee based on a review of the previous year's accomplishments. The yearly goals will be established by February 15 and will form the basis for the upcoming season. Each year the steering committee will develop a report of accomplishments. This report, to be completed by January 15, will be distributed to maintenance workers as well as staff.

RESPONSIBILITY, REPORTABILITY, NETWORK OF TECHNICAL EXPERTISE

The plan assigns one person with overall responsibility for implementation. In addition, technical experts are identified to assist in plan implementation. They include representatives from Mn/DOT Environmental Services, the Minnesota Department of Agriculture, and county ag inspectors.

Visual Quality Best Management Practices for Forest Management in Minnesota

This handbook, developed in May 1994, is a cooperative project involving many government and industry agencies. The best management practices guidelines were designed to provide forest managers and loggers with the tools to voluntarily implement visual quality BMPs into an overall integrated resource management approach to forest management operations. The handbook is divided into the following five parts:

Part I "Laying the Groundwork" explains the concerns and the process that led to the cooperative development of these practices.
Part II "Visual Management Planning" describes the concept of visual management planning.
Part III "Classifying Sensitive Visual Management Areas" outlines the factors used in determining classifications, the three classifications themselves, and the classification process.
Part IV "Recommended Visual Quality BMPs for Forest Management" describes 11 forest management activities and offers recommendations for enhancing visual quality for each of the three sensitivity levels.
Part V "Training, Implementation, and Monitoring" explains the factors that will determine the long-term success of this effort.

This small, spiral-bound handbook, designed for use in the field, contains many photos along with explanations of best management practices. Copies can be obtained from the U.S. Forest Service.

BMP #2: DEVELOP A PUBLIC RELATIONS PLAN

Figure 8-2 gives an example of a letter Wright County staff sent to all adjacent property owners to indicate that work would be done near their property. Property owners are allowed the option of maintaining the right-of-way between their land and the roadway, but must indicate to the county that they are choosing to do so. They must sign a notice stating their choice and post signs telling the maintenance crews not to spray. If property owners do not eliminate noxious weeds by the date indicated on the form, the county will remove the weeds without the property owner's consent. Figure 8-3 gives an example of the statement property owners must sign.

Beginning in May, the Wright County Highway Department, as part of its vegetation management program, will be scheduling some roadside vegetation work along all Wright County highways. The unwanted brush will be cut and/or treated with herbicide. We're notifying you about this work since your land may be adjacent to the roadside scheduled for treatment.

Our goals are to eliminate the brush and to promote grass cover along the roadside. Brush along the road reduces driving visibility, obstructs road signs, and reduces driver reaction time to crossing wildlife. Brush presents maintenance problems by retaining water along the roadbed, obstructing ditches, and damaging equipment.

To meet these goals, we use selective herbicides that control the brush and noxious weeds but allow the grasses to grow unharmed. All herbicides we use have been fully tested and are approved by the U.S. Environmental Protection Agency and the Minnesota Department of Agriculture.

During spray operation, we'll take care to avoid sensitive areas adjacent to the right-of-way such as tree plantations, ornamental plantings, crops, gardens, front yards, lakes, and streams.

If you would like to maintain the right-of-way adjacent to your land in some other fashion, such as mowing, please follow these instructions:

1. Stop by (prior to May 1, 2000) at the Wright County Public Works Building (located along State Highway 25 at the Jct. of CR. 138 on the north side of Buffalo) and fill out the proper form including the property description.
2. Post the "DO NOT SPRAY" signs that you will be given.
3. Remove the brush and/or noxious weeds within that site by May 15, and continue to maintain it. If the brush and/or noxious weeds are not removed, then we must treat the area as part of our vegetation management program.

If you have any questions please call the Wright County Highway Department at 1-800-362-3667, extension 7383 or 682-7383.

Figure 8-2. *Example of a Letter to Property Owners*

SPRAYING FORM

I _____, being the owner or occupant of the following described land, do hereby state that I do not wish to have weed or brush spraying done adjacent to my property on Wright County Highway number _____ and I further agree that I will control the weeds and brush along this area of road right-of-way prior to May 15, 2000.

I understand that if the weeds/brush are not cut or sprayed by this date that the County will spray these areas, even if the signs are in place.

Property Description: _____
(address) _____

Township: _____

_____
Owner/Occupant Signature

_____
Highway Dept. Witness

Figure 8-3. *Example of a Spraying Form*

BMP #3: DEVELOP A MOWING POLICY AND IMPROVED PROCEDURES

Nebraska Department of Roads

The Nebraska Department of Roads' mowing policy states that limited mowing frees workers to do more important maintenance. They recognize the benefits of allowing vegetation along the roadside to grow tall, since it provides a home for animals and a living snow fence.

Nebraska's policy allows for mowing only those slopes less than 3:1. Areas with slopes greater than 3:1 are marked with a sign, and all mowers have a slope indicator in them to provide additional information. Mowing steeper slopes is not safe. Also, the state mows to a minimum of 5-inch cut height. Its first mow is by Memorial Day. The width of the mowed area depends on the type of highway, whether the area is a median or shoulder, and whether or not decorative flowers are present.

Type of Highway	Area	Mow width
Interstate	Median	5-8' if flowers present
		5-15' if no flowers present
	Outside	15' maximum
Other highways	Outside	5-15' w/surfaced shoulders
		15' w/turfed shoulders

Nebraska performs a second mow sometime during the summer to provide sight distance. The final mowing is done after Labor Day, as needed to provide snow control and to finish total mowing. It does not use mowing to control brush, which is controlled with chemical application.

To ensure that agencies have an equal understanding of its mowing policy, the Nebraska Department of Roads issued a memo of understanding with the state game and parks commission. This memo specifies frequency of mowing, mowing widths, and safety standards.

Wisconsin Department of Transportation

The Wisconsin Department of Transportation's policy is to maintain a clear zone, free of woody vegetation within 25–30 feet of the roadway edge. Mowing in the clear zone beyond the shoulder cut is permitted every two to three years, and is only allowed from mid-July to the end of March to allow nesting birds to hatch. The grass is mowed to a minimum height of 6 inches and a width of 15 feet on the outside of the road and 5 feet on the inside. For safety reasons, no mowing is allowed where the slope is greater than 3:1. Mowing is allowed in the first few years after construction to control weeds.

This policy has resulted in:

- more attractive roadsides
- clear vision at intersections
- safe pull-off areas
- clear recovery zones
- lower maintenance costs
- smooth visual transition from roadway to vegetation beyond
- preserved native vegetation
- natural regrowth
- improved wildlife habitat

Mn/DOT Mowing Policy

The Metro Area mows with an emphasis on quality, not quantity, and follows these principles:.

MOWING FOR SAFETY

- Sight corners at same grade intersections of township, county, and state highways.
  Vegetation that obstructs the vision above a 30-inch sight line to crossing traffic should be mowed or cut within the boundaries of the right-of-way markers.

- Sight lines at interchange entrance ramps.
  Vegetation that obstructs the vision above a 30-inch sight line to mainline traffic should be mowed out within 300 feet of where the mainline and the merging lane join.

- One- to two-swath perimeter mowing.
  Vegetation not to exceed 18 inches, and optimally 12 inches.

MOWING FOR NOXIOUS WEED CONTROL

- Mow heavily infested thistle patches over 50 square feet before the plants go to seed. Minimize scattered mowing patterns.

- Communication between mower operators and Mn/DOT or contract herbicide applicators is extremely important to prevent mowing right after spraying or mowing out areas to be sprayed in the future.

- Do not mow leafy spurge.

AESTHETIC CONSIDERATIONS WHEN MOWING

- Make attractive flowing mow lines that blend with features such as guardrails, delineator posts, traffic signs, light standards, retaining walls, etc.

- When a one- to two-swath cut results in mowing out over half the width of a narrow right-of-way strip, mow the entire strip to the retaining wall, noise wall, or other feature.

- Mow to the break in the slope on fill slopes even if it means mowing less than the capacity of the mower. It may even take mowing one instead of two swaths.

- When mowing out noxious weed paths, drive to the patch with the mower off and raised up unless a blending cut makes sense off the one- to two-swath cut.

- Conduct fall mowing/cleanup mowing before winter.

The Posi-Track offers excellent mobility for mowing and brush control.

BMP #4: ESTABLISH SUSTAINABLE VEGETATION

Use of Native Grasses

WRIGHT COUNTY PILOT HARVEST PROJECT

Wright County has begun a pilot project to harvest seed from stands of native grasses in county parklands. Partnering with the Department of Transportation, the county will use Mn/DOT's equipment to harvest the seed, then will return half of the seed harvested to Mn/DOT. After seed has been harvested, it is sifted manually and prepared for storage and later use.

IOWA NATIVE GRASS SEED HARVESTING

Some Iowa counties plant locally harvested seed in nursery plots, establishing a seed source for future years.

Prairie Restoration Project on Interstate 90

TH56–MOWER COUNTY NATIVE GRASS STANDS

Trunk Highway 56 in Mower County runs parallel to an abandoned railroad line and contains prairie remnants that have not been disturbed since the railroad was built. Mn/DOT determined that this site was important for the preservation of prairie grasses and added the right-of way from LeRoy to about two miles northwest of Rose Creek to the Mn/DNR Natural Heritage Registry in 1982. Mn/DOT also developed a resource management plan for the site, based on a plan initiated by K. Bolin of the DNR. The plan incorporated planned burning on TH56.

Mn/DOT management of the corridor discourages the following:

- the introduction or removal of plant or animal species
- the use of motor vehicles off of the graded shoulder
- the use of herbicides, pesticides, or mowing for vegetation control

Mn/DOT district maintenance personnel continue to use burning as an effective tool for this area of right-of-way. These burns have shown to be very easy to implement, inexpensive, and effective in encouraging the proliferation of native plants.

However, management of the railroad right-of-way along TH56 has not been as successful. The DNR has been trying to acquire the abandoned railroad right-of-way in order to designate the entire corridor as a scientific and natural area. Several portions of the right-of-way were sold to other parties, and in 1986, a portion of the land was acquired by a utility. In 1990, the highest quality prairie along the corridor was plowed after being sold to a private owner. Experience from this parcel shows that identification of native vegetation remnants is not enough to protect them. Once they are identified, these remnants must be managed and monitored if they are to be preserved.

PRESCRIBED BURNS FOR NATIVE GRASS MANAGEMENT IN SHERBURNE NATIONAL WILDLIFE REFUGE

Sherburne National Wildlife Refuge conducts a series of prescribed burns every year as part of its habitat management program. Refuge staff trained and certified in fire fighting conducts these burns, but local fire departments, law enforcement agencies, and state natural resource offices are informed of the burn and remain on stand-by.

The prescribed burn is a managed fire conducted under a special set of guidelines for weather and safety. Most burning is done in April and May, but can also be done in the fall, on days when conditions meet the required set of guidelines. Factors considered are humidity level, wind speed, and wind direction.

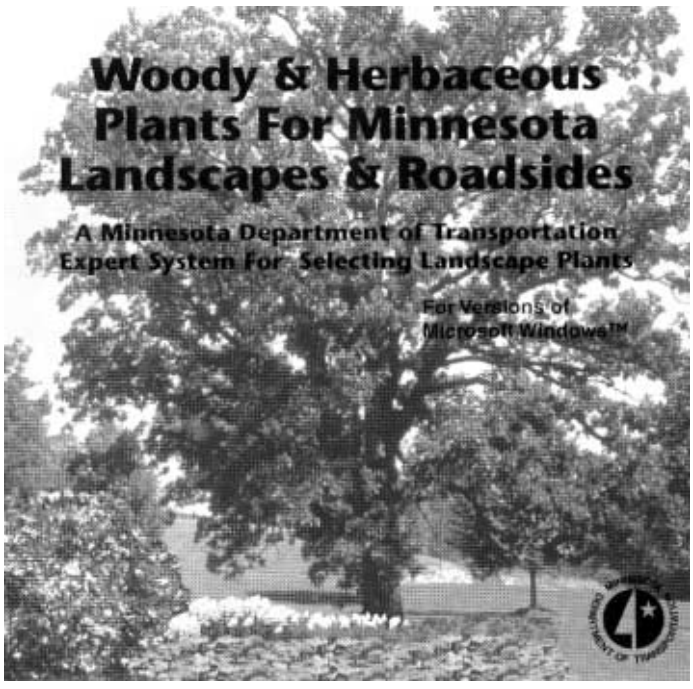
Every year, several areas on the refuge are selected for burning. Each unit is bordered by plowed breaks, waterways, or roads that allow the fire to be contained. In 1998, 12,281 acres were burned during four burn days. The burn area is ignited by hand using a drip torch, and refuge fire engines with trained firefighters are on-site to ensure that the fire remains under control.

Burning helps restore and maintain many plant habitats by removing dry, dead plant matter that has built up over the years, opening up space for new plant growth and providing better cover and food for wildlife. The burn allows nutrients locked-up in dried plants to be returned to the soil for use by new plants. Burning also enables the restoration of the ecosystem that existed in the area prior to European settlement. The plans and wildlife are adapted to fire and depend on periodic burning for their continued existence. Their deep root system allows them to resprout quickly after a fire passes.

Use of the Right Plants in the Right Areas

MN/DOT INTERACTIVE PROGRAMS

A challenging element of roadway design and maintenance is selecting the appropriate vegetation to plant in the project right-of-way. The wrong selection can lead to expensive removal and replacement of dead plants. Mn/DOT's Office of Environmental Services has recognized the need to provide assistance in making these selections and has developed an excellent tool in response, an interactive, easy-to-use program titled *Woody & Herbaceous Plants for Minnesota Landscapes & Roadsides.* Its purpose is to improve the quality of roadside plant selection and management in Minnesota by offering expert assistance in selection, thereby increasing the likelihood that plants will be placed in locations and under conditions in which they are likely to survive, if not flourish.



For a given area, the user is provided a list of existing growing conditions. The program then quickly and accurately determines the most appropriate plant(s), based on the location, site conditions, and expected functions for landscape design, restoration, and management.

This program has been used by district maintenance staff, external agency staff, consultants, and community landscaping professionals to select appropriate herbaceous grasses, sedges, ferns, perennial flowers, trees, shrubs, groundcovers, and vines for any combinations of desired characteristics and existing site conditions. It is totally comprehensive and applicable for

all vegetation types and conditions applicable to transportation and general landscape development, restoration, and management in Minnesota.

A copy of this Mn/DOT program on CD-ROM may be obtained by the public or external agencies from the DNR Division of Forestry or the Minnesota State Horticultural Society.

MN/DOT PRAIRIES TO FORESTS PROGRAM

The Mn/DOT Prairies to Forests Program was developed to encourage the seeding and planting of prairies, savanna, and woodland species in appropriate areas along state roadsides. The program gives guidance for obtaining funds within the DOT and from other agencies, assists in choosing plant materials that are best suited for their intended use, offers project coordination and equipment, and provides technical assistance on planting and maintenance. It also assists with integrated vegetation management programs by providing a means to revegetate weed-invested areas. The program will be implemented by Mn/DOT Maintenance staff with technical assistance from the Office of Environmental Services.

The program's benefits include:

- Revegetation that reduces mowing and the use of herbicides
- Restored native plant communities for erosion control and wildlife enhancement
- The use of living snow fences to reduce drift formation and increase visibility
- The use of vegetation screens to provide windbreaks, noise abatement, and improved roadside visual quality
- Improved roadside aesthetics through seasonal colors and forms
- Reduced carbon dioxide levels

The program goal is to develop a sustainable planting program for herbaceous and woody vegetation on extensive areas of state and interstate roadsides in order to reduce maintenance problems and improve environmental quality.

The program's objectives are to:

- Plant 50,000 tree/shrub seedlings per year on state roadsides
- Seed 500 acres per year with native grassland species
- Reestablish native plant communities where appropriate by combining woodland, savanna, and grassland species
- Create a consistent demand for a wide selection of native species to include deciduous and evergreen trees, shrubs, vines, grasses, wildflowers, sedges, and rushes
- Develop improved and cost-effective methods of establishing and maintaining woody plants from small plant stock and by direct seeding
- Work with other agencies and the private sector to develop a certification program for "Source Certified" plant material in Minnesota
- Implement new technologies and research results, such as using salt-adapted species and various soil additions with plantings
- Develop plant lists that are predicated on the use of natural plant associations compatible with the Minnesota DNR ecological classification system and included on Mn/DOT's expert system software for plant selection

Erosion Control

Design of blankets and stabilizers that limit erosion in Minnesota has been difficult because current design criteria are based on biased personal field observations or on data from studies conducted in other states. In 1996, representatives from the Mn/DOT Office of Environmental Services and the University of Minnesota initiated a project to test the interaction between native seed mixes used across the state and erosion control products used on construction projects. They created an erosion control test site in Eden Prairie to study all elements of erosion control.

Manufacturers were invited to test their erosion control products at a designated large sedimentation basin. The entire basin was planted and covered with 24 different erosion control products. Private industry donated thousands of dollars worth of equipment, supplies, and labor to ensure the project's success.

This site is unique because it's the first large-scale, side-by-side comparison of multiple biodegradable erosion control products. Research from this project is already affecting the regional industry. Improved experimental erosion control mats in development will use Minnesota-derived materials of peat and post-processed alfalfa stems.

The research is also affecting the public sector. Mn/DOT is developing guidelines that, based on the research findings, will recommend specifically how and when certain erosion control products will be used in the future on all Mn/DOT construction projects. Several hydraulically applied products also will be specified for the first time for use along roadsides, including plant germination enhancers, a new concept that will enhance germination in nutrient-poor roadside soils.

Mn/DOT and the University created an erosion control test site to test and compare products.

Mulch protects seed and soil from erosion until vegetation can be established.

BMP #5: CONTROL NOXIOUS WEEDS

Cultural Control

Many agencies are using native grasses to control noxious weeds, since their dense, deep root systems inhibit weed growth. Both Wright County and Mn/DOT Maintenance Area 3B have found success in controlling noxious weeds, specifically Canada thistle, using native grass stands.

Biological Control

The Mn/DOT Office of Environmental Services uses beetles to control noxious weeds, such as leafy spurge, in several sites. Beetle use can also effectively control purple loosestrife. For example, in June 1993, two beetle species were released at a site in southern Ontario that was covered with purple loosestrife. Over the last five years, the insect populations there have exploded, completely suppressing seed output and reducing the purple loosestrife infestation by over 90 percent, while native plants such as cattails were flourishing. Purple loosestrife is severely damaged through the entire area, and beetles have spread for miles from the site. The reductions in purple loosestrife over large areas and the return of native cattails show the potential of biological weed control as a management tool.

For more information on this project, contact:

Luke Skinner
Coordinator, Purple Loosestrife Program
Minnesota DNR
DNR Building Box 25
500 Lafayette Road
St. Paul, MN 55155-4025
Phone: 651-297-3763
E-mail: luke.skinnner@dnr.state.mn.us

The U.S. Department of Agriculture (USDA) has a similar program to eliminate spotted knapweed infestations through the release of beetles. Twelve beneficial insect species from Europe have been cleared by the USDA for release in the United States, and most of them attack both species of knapweed. The insects work together by feeding on the seeds or in the roots of the weeds. Each attack reduces the knapweeds' defenses by inhibiting seed production, either from direct destruction of seeds or by stunting overall growth and strength of the plant. In some cases, when the insect larvae burrow into the root, they allow naturally occurring soil components such as fungi and bacteria to enter the plant's system, further weakening the plant.

For more information, contact your local ag inspector or the Mn/DOT Office of Environmental Services.

Spot Spraying Techniques

Herbicides may be applied more effectively through better use of equipment and by spot spraying only the weeds. Using the best products at the right time may optimize chemical use. Appendix D contains information about correct timing for herbicide applications. The figures below show the correct timing for control of one noxious weed, Canada thistle. Figure 8-4 shows Canada thistle just after mowing, which is the best time to spray with herbicides. Figure 8-5 shows another time to spray Canada thistle, which is just prior to seed release. This is the worst time to mow, as mowing will aid in seed distribution. Figure 8-6 shows Canada thistle after it has been sprayed.

Figure 8-4. *Canada Thistle After Mowing*

Figure 8-5. *Canada Thistle Just Prior to Seed Release*

Figure 8-6. *Canada Thistle After Spraying*

Figure 8-7. *Spraying too close killed vines on fence.*

Figure 8-8. *Milkweed is desirable along roadsides and should not be sprayed.*

It is also important to maintain adequate distance between desirable and undesirable vegetation. Figure 8-7 shows spraying too close to the vines on the fence. This killed the vines as well as the targeted weeds. Adequate distance depends on wind, herbicide used, and other conditions

Note that some vegetation, such as milkweed, is desirable and should not be sprayed. Since milkweed is often mistaken for an undesirable weed, refer to Figure 8-8 for help in identifying this plant.

BMP #6: MANAGE LIVING SNOW FENCES

Interagency Living Snow Fence Task Force

An Interagency Living Snow Fence Task Force has been formed to provide more information about planting living snow fences. Members include representatives from the Kandiyohi Soil and Water Conservation District, Minnesota Association of Soil and Water Conservation Districts, Minnesota Board of Soil and Water Resources, Minnesota Department of Agriculture, Minnesota DNR, Minnesota Division of Emergency Management, Mn/DOT, University of Minnesota, and U.S. Department of Agriculture.

The task force has developed a guidebook titled *Catch the Snow with Living Snow Fences* to help practitioners effectively design living snow fences. It is available through Mn/DOT's Office of Research Services.

Use in Minnesota

In Minnesota, living snow fences have been used since the 1930s, when Mn/DOT planted 12 million trees and shrubs along 600 miles of highway to control snow. These rows of trees were installed 75 feet from the highway centerline, which has since been proven too close, actually making the problem worse. In the winter of 1996-1997, Mn/DOT hired an international snow control consultant to review 18 problem drifting areas in the southern part of the state. Based on estimates of snow transport during an average winter and maximizing the benefit/cost ratio, the consultant concluded that a 10-foot tall fence is required to provide adequate storage over an average winter. Using more conservative guidelines, a 12-foot fence would provide sufficient capacity 95 years out of 100.

Springfield, Minnesota

In Springfield, Minnesota, an 8-foot tall structural fence installed 275 feet back from the centerline held 11,424 tons of snow during the winter of 1996-1997. This resulted in an estimated savings of $34,272 based on a typical removal cost of $3/ton of snow.

Snow drift on rural roadways can be dangerous.

BMP #7: USE INTEGRATED CONSTRUCTION AND MAINTENANCE PRACTICES

Contract Enforcement

One way to enforce the requirements of the seeding contract is to withhold funds for an incomplete grading operation on a per acre level. Mn/DOT Technical Memorandum Number 85-4-RD-1 allows for $700 to $2,000 per acre to be withheld from the contract when grading and turf establishment requirements are not met. A copy of the Technical Memorandum is attached in Appendix F.

Scarifying the soil during construction significantly improves the chances of any vegetation establishment.

Protecting trees during construction

Specifications

Another way to ensure that trees, brush, flowers, and grasses are not damaged during construction is to enforce the requirements of Specification 2572, Protection and Restoration of Vegetation. This specification promotes the protection and preservation of vegetation from damage and the use of corrective action when damage does occur. Vegetation includes, but it not limited to, trees, brush, roots, woody vines, and perennial forbs and grasses.

Elements of section 2572.3 CONSTRUCTION REQUIREMENTS include:

A. Protecting and Preserving

The Contractor shall protect and preserve:

(1) Specimen trees.
(2) Threatened and endangered plants, as listed on the federal and state threatened and endangered species list.

(3) Vegetation designated in the Contract to be preserved.
(4) Trees, brush, and natural scenic elements within the right-of-way and outside the actual limits of clearing and grubbing consistent with section 2101.3.
(5) Other vegetation the Engineer identifies for protection and preservation.

The Contractor shall not place temporary structures, store material, or conduct unnecessary construction activities within a distance of 25 feet outside of the dripline of trees designated to be preserved without approval from the Engineer.

The Contractor shall not place temporary structures or store material (including common borrow and topsoil) outside of the construction limits in areas designated in the Contract to be preserved.

A1 Temporary Fence

The Contractor shall place temporary fences to protect vegetation before starting construction. The Contractor shall place temporary fence at the construction limits and at other locations adjacent to vegetation designated to be preserved when specified in the Contract, directed by the Engineer, or allowed by the Engineer. The Contractor shall not remove the fence until all work is completed or until removal is allowed by the Engineer.

The fence shall prevent traffic movement and the placement of temporary facilities, equipment, stockpiles, and supplies from harming the vegetation.

A2 Clean Root Cutting

The Contractor shall cleanly cut all tree roots at the construction limits when specified in the Contract or directed by the Engineer.

The Contractor shall immediately and cleanly cut damaged and exposed roots of trees designated for protection back to sound healthy tissue and shall immediately place topsoil over the exposed roots. The Contractor shall limit cutting to a minimum depth necessary for construction and shall use a vibratory plow or other approved root cutter prior to excavation. The Contractor shall immediately cover root ends that are exposed by excavation activities to within 6 inches of topsoil as measured outward from root ends.

A8 Destroyed or Disfigured Vegetation

If the Contractor destroys or disfigures vegetation designated to be preserved, the Contractor shall, at no expense to the Department, restore the damaged vegetation to a condition equal to what existed before the damage was done. The Engineer may assess damages against the Contractor on vegetation where an equal level of restoration is not accomplished. The Engineer will assess damages to trees and landscaping at not less than the appraisal damages as determined by the International Society of Arboriculture appraisal guide. The Engineer will determine and assess damages to other vegetation.

A10 Other Vegetation Protection Measures

The Contractor shall provide other vegetation protection measures, including root system bridging, compaction reduction, aeration, and retaining walls, as specified in the Contract or as directed by the Engineer.

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Appendix A
Survey Methodology and Results

SURVEY METHODOLOGY

As part of this study, three surveys were distributed to a variety of audiences. The first survey, sent to all cities with populations over 5,000 and all counties in Minnesota, consisted of a short questionnaire asking recipients to provide general program information and to rate their agency's roadside vegetation program. Those who indicated that they had some sort of roadside vegetation management program in place were sent a second, more detailed survey. This second survey was also given to state agencies in Wisconsin, Nebraska, North Dakota, South Dakota, and Iowa, as well as to people attending a maintenance workshop sponsored by the Minnesota Technology Transfer/Local Technical Assistance Program (T^2/LTAP). The third survey was distributed to attendees of the Vegetation Management Association of Minnesota conference in July of 1998.

FIRST SURVEY

The first survey consisted of a brief questionnaire requesting general information about the roadside vegetation management program in each jurisdiction. The survey attempted to identify those cities and counties that have developed formal roadside vegetation management programs or that are working to create best management practices for managing their roadsides.

Respondents were asked to indicate areas of interest relating to roadside vegetation management. The questionnaire also asked respondents for information about new seeding methods (seed application and staged seeding, seed certification and interseeding, native seed harvesting), pesticide use, mowing operations, and equipment.

This first survey was sent to 200 agency engineers, and 49 (24.5 percent) responded. Respondents were first asked to rate the roadside vegetation management plan for their jurisdiction on a scale of 1 to 5, with 1 the lowest, indicating that they have no management plan, and 5 the highest, indicating that their plan is totally integrated. The survey results indicated that most agencies do not have a formal roadside vegetation management plan.

Respondents gave a variety of brief descriptions for the roadside vegetation management plan for their jurisdiction, some of which are summarized below. Several agencies have a formal or informal rotation system in place to mow or spray a given portion of their area each year. Most agencies concentrate their efforts on mowing (either all or designated portions of their roadsides), noxious weed control, and brush control. Noxious weeds and brush are controlled most often by spraying. A few respondents indicated that they were beginning to use native grasses and wildflowers.

Respondents noted the following as areas of interest in plan development:
- economic factors, including maintenance costs
- planting sustainable vegetation
- the use of native grasses
- the use of seeds and trees adapted to roadside soils
- protection and better use of topsoil
- construction issues relating to erosion control and monitoring of topsoil

The questionnaire also requested information about new seeding methods, including seed application and staged seeding, seed certification, and interseeding and native seed harvesting. Information on the use of pesticides, mowing operations, and equipment was also requested. Those cities and counties responding that they are implementing some element of roadside vegetation management were asked to identify a contact person for their jurisdiction. A more detailed survey was then sent to that person, asking for much more relevant information. Survey responses are listed below.

Survey Responses

Surveys were sent to 200 agency engineers; 49 (24.5 percent) responded.

1. Please rate the roadside vegetation management plan for your jurisdiction, with 1 being the lowest rating, indicating that you have no management plan, and 5 being the highest rating, indicating that your plan is totally integrated.

Rating:	
no rating:	3 (6.2 percent)
1:	9 (18.3 percent)
2:	12 (24.5 percent)
3:	17 (34.7 percent)
4:	6 (12.2 percent)
5:	2 (4.0 percent)

2. Briefly describe the roadside vegetation management plan for your jurisdiction.

Examples of roadside vegetation program activities identified by the first survey respondents:

MOWING

- "At present, we make two shoulder cuts and full ditch cuts on one-quarter of the county right-of-way. We spot spray various weeds, and saw cut brush that gets too large for the mowers to remove. The highway department does have some native plantings in place."

- "We have a combination mechanical/chemical program, and are trying to move to a full chemical application program. We have worked from a 100 percent contract writing program to currently a 50 percent contract/50 percent county forces program."

- "At this time, our management plan is mostly mechanical cutting and mowing. The maintenance forces complete the roadside mowing and cut small/light trees and brush. We typically let a contract to cut the larger trees. Spraying is done as needed to control noxious weeds."

- "We mow medians and some boulevards along undeveloped property. We do some weed spray mixed with a growth retardant—primarily in medians. Mowing is only about two times a year, except in high visibility median areas 'downtown,' then approximately four times per year."

- "Our department mows roadside ditches after June 30 to allow wildlife nesting to hatch. After this, we try to mow the approximately 12 miles of ditches/roadsides once a month until September."

BRUSH AND TREE CONTROL

- "Boulevard tree trimming program was started seven–eight years ago, and includes trimming and shaping one-fifth of the boulevard trees every winter. We also have a small pro-

gram for mowing the boulevard and right-of-way (ROW) ditches, which includes 20 miles: mow three–four times a summer."

- "Our maintenance crews spray brush to ensure sight distances and to alleviate potential problems. We contract mow all CSAH and county road ROW from the shoulder to the backslopes. Noxious weeds are also controlled by spraying."

NOXIOUS WEED CONTROL

- "We spot spray noxious weeds May 15 to July 1. Brush control this same period plus full application approximately two weeks. Mow one-third of county road right-of-way complete each year."

- "Mowing two SHCO cuts twice a year, spot spraying ROW springs, summer, and fall. Brushing winter and brush hog fall and winter. Also growth regulator, guardrail treatment."

- "We mow and brush cut the entire right-of-way on a three-year rotation. We spray for Canada thistle and leafy spurge wherever and whenever we find it."

OTHER

- "Roadside vegetation management is a very minor activity for our city. We do have a very strong landscape maintenance and flower garden program with a newly instituted integrated pest management (IPM) plan."

- "Spot spray two-thirds of the county and continuous spray one-third; rotate every year."

- "In rural areas (non-developments) seeding is allowed. In urban areas (new development) seeding is allowed until new home is constructed, then sodding boulevard is required along with the construction of existing roads: We generally resod boulevard where needed, and repair isolated areas. We generally topsoil and reseed."

- "Scheduled mowing, noxious weed control, brush/tree removal."

- "We mow yearly, combined with noxious weed spraying. Mowing is done at least three times during the summer (top cut only). Complete ROW mowing done about once every five years. No wildflower and controlled burning done."

- "Shoulder mowing twice/year; herbicide applied to thistles and trees as needed."

- "We spot spray for weeds and mow the entire ROW every other year."

- "We spot spray for weeds; top cut all county roads; mow entire ROW every four years (one-quarter of county each year)."

- "Top cut mowing June, July, August; spray noxious weeds as required; when possible during September, October, November, and December we cut brush and trees and treat them with chemical treatment; we are trying to start three-year burn cycle with private groups and forest service; some native grass seeding by contract."

- "Beginning to experiment with salt-resistant seed along roadsides. Standard erosion control implemented on construction projects. Maintenance includes mowing schedule, trimming, weed management."

- "All miles driven, and we spray as required. A minimal second pass is sprayed on trouble spots. All miles top cut, 50 percent ROW to ROW every year minimal, then sprayed and covered. We also spray with Telar and HiDep, mow, and conduct brush control."

- "Hennepin County's roadside vegetation management plan consists of controlling noxious weeds by weed spraying and roadside mowing. Contracted roadside mowing was done in the western MTCE district. This was our first attempt at contracted roadside mowing and it worked well for us."

- "Brushcutting, clearing, spraying on an annual basis; mowing on an annual basis."

- "New road construction has defined criteria to follow regarding establishment of turf, and erosion protection of all slopes, ditches, etc. For maintenance, roadside mowing and brushing is done seasonally."

- "It is addressed primarily through road reconstruction when turf is established. On the opposite end of the spectrum, we are starting a pilot program for roadside spraying to control excessive brush."

- "Biweekly mowing of nonresidential boulevards by staff; contractual mowing of rural sections."

- "We do a fall spray using Tordon K, Garlon 4, SEE 2, 4-D. Lately we are on a four-year rotation mowing to fence line on all county roads, which has had a big impact on our brush problem. Also have planted some native grasses on new construction."

- "We do some spot spraying, we also do some roadside mowing, but we need to implement a better plan for the future."

SECOND SURVEY

Those cities and counties that indicated on the first survey that they were implementing some element of roadside vegetation management were asked to identify a contact person for their jurisdiction. The second, more detailed survey was then sent to that contact person. Because so few respondents from the first survey indicated that they had a vegetation plan in place, only 21 follow-up surveys were sent out; of those, 14 were returned (66.7 percent). This second survey was also sent to state agencies in Wisconsin, Nebraska, Iowa, North Dakota, and South Dakota. Some of the information returned in the state agency survey is highlighted in Chapter 8, under specific examples of Best Management Practices. This survey asked much more detailed questions about a variety of topics, including equipment, herbicides, mowing, seeding, and erosion control. Best Management Practices identified in those areas are as follows:

SEEDING

- interseeding with native grasses
- staged seeding during construction
- use of hydromulches and other mulches

EROSION CONTROL

- use of silt fence and fabric
- use of mulch, ditch blocks, blankets
- use of crown vetch and tree planting
- staked netting or bales used with sodding and riprap

MOWING

- full cut every three years on a three-year rotation, beginning August 1
- mow 6–12 feet width twice yearly; spot spray for noxious weeds

- spray medians and sidewalks in high visibility areas once a year
- mow top cut 100 percent of system, and mow to right-of-way over 50 percent of system each year
- mow as much roadside as possible, but not on steep slopes; first cut ASAP, cut to right-of-way to control brush; avoid use of chemicals

BIGGEST CHALLENGES

- getting the work done with weather and time constraints
- getting out public information on herbicides, and overcoming controversy (mentioned by four)
- noxious weed and tree and brush control (mentioned by two)
- satisfying conflicting public expectations regarding weed control, mowing, and expenditures
- controlling leafy spurge and purple loosestrife
- keeping farmers happy
- getting contractors to take the time it takes to do a good and timely job of turf establishment and erosion control

INNOVATIVE PRACTICES

- establishment of native grass stands
- management of roadsides using natives and wildflowers
- fall spraying, change from mowing to spraying
- biological and weed control using insects

THIRD SURVEY

One more survey was distributed, this one at the Vegetation Management Association of Minnesota (VMAM) annual meeting in July of 1998. At the time this survey was conducted, the TAP had identified most of the best management practices. However, this conference was attended by a wide variety of vegetation and environmental industry representatives and their perspective and input was sought. The attendees at the VMAM were asked to identify best and worst management practices. In addition, they were asked to give specific examples of where the best management practices already identified by the TAP were being used.

Perhaps the most important piece of information obtained from performing all three surveys was that there were few best practices being implemented locally in Minnesota. So the TAP looked to successful programs in other states and results of current research to identify Best Management Practices for roadside vegetation. In addition, individual responses for all surveys were evaluated, and follow-up phone calls were made to those respondents who had identified an innovative or cost-saving practice in their jurisdiction.

BEST MANAGEMENT PRACTICES SELECTED BY SURVEY RESPONDENTS

The wide variety of responses obtained from the three surveys is summarized below. Note that "best management practices" identified by survey respondents are not necessarily the same practices that this manual's Advisory Panel would select.

GENERAL

- effective partnerships with adjacent landowners to fully accomplish BMP objectives
- the development of partnerships with other agencies for roadside management
- an integrated approach to roadside vegetation management
- practices that encourage diversity along the roadside environment
- biological control of invasive species

- prescribed burning
- use of living snow fences
- elimination of the use of invasive (but not noxious) weed species, such as crown vetch, birdsfoot trefoil, and reed canary grass
- fall spraying after most farmers have cut ditches and some regrowth has taken place

SEEDING

- interseeding with native grasses
- staged seeding during construction
- use of hydromulches and other mulches
- use of quality seed, with good seed-to-soil contact
- seed drilling

EROSION CONTROL

- use of silt fence and fabric
- use of mulch, ditch blocks, blankets
- use of staked netting or bales with sodding and riprap
- use of staged grading during construction and establishing vegetative cover early
- early coordination with the DNR on construction projects
- requirement of an erosion control plan in all grading contracts
- contractor responsibility for implementing the erosion control plan during construction
- establishment of vegetation early; use of mulch, erosion control blankets, hydromulches, bales, silt fences, rock check dams, and sediment basins during and after construction, and conducting these activities as soon as possible after grading is completed

MOWING

- reduced mowing
- interagency coordination for mowing
- full cutting every three years on a three-year rotation, beginning August 1
- twice-yearly mowing of a 6- to 12-foot width and a spot spraying for noxious weeds
- spraying of medians and sidewalks in high visibility areas once a year
- top cutting of 100 percent of system and mowing to right-of-way over 50 percent of system each year
- mowing of as much roadside as possible, but not on steep slopes; a first cut ASAP to right-of-way to control brush; avoidance of chemical use
- mowing after the general plant height in the area reaches 12 inches, with that mowing to a minimum height of 6 inches
- rotational mowing

WORST MANAGEMENT PRACTICES IDENTIFIED BY SURVEY RESPONDENTS

- broadcast herbicide spraying
- mowing entire right-of-way
- inadequate erosion control
- excessive salt use
- planting high maintenance vegetation
- mowing during nesting season
- mowing when the ground is wet, causing ruts and tearing up slopes

GREATEST CHALLENGES

- completing work with weather and time constraints
- communicating to the public about on herbicides, and overcoming controversy
- controlling noxious weeds
- satisfying conflicting public expectations regarding weed control, mowing, and expenditures

- controlling leafy spurge and purple loosestrife
- keeping farmers happy
- getting contractors to do a good and timely job of turf establishment and erosion control
- obtaining adequate funding, given competing department needs
- accomplishing goals with limited staff and funding
- establishing vegetation after construction
- maintaining quality vegetation without adequate water
- establishing native grasses and wildflowers
- educating maintenance personnel about management policies
- practicing tree and brush control
- dealing with the effects of salt, sand, and ice
- controlling erosion
- carrying out public relations
- ensuring the safety of workers
- accomplishing the work without enough time and funding

INNOVATIVE PRACTICES

- establishing native grass stands
- managing roadsides using native grasses and wildflowers
- spraying in the fall
- changing focus from mowing to spraying
- controlling weeds using insects (biocontrols)
- integrating planning, design, and construction into construction plans
- bidding items in order to pay contractors for each care cycle they perform satisfactorily (expecting a minimum of two years on plantings)
- following policies and paying attention to stand establishment
- allowing farmers to plant alfalfa in ditches, which eliminates the need for weed control and reduces the amount of wildlife living along roadsides
- allowing roadsides to return to the natural environment and be maintained only for safety and drainage
- using living snow fences
- spot spraying for noxious weeds and brush

Appendix B
Soils Information

BASIC SOILS INFORMATION

Weathering

A soil's characteristics depend on the material from which it evolved, called the parent material, and the method by which it formed. Soil results from the weathering of rock or the decomposition of organic materials. Weathering can be achieved mechanically, by temperature changes, frost action, rain, wind, ice or other physical means, or chemically, from the reaction of rock minerals with oxygen, water, acids, or salts. The type of soil produced by rock weathering depends on the rock type. Granites weather to form silty sand or sandy silts. Basalt weathers into clayey soils, and sandstone weathers into sandy soils.

Soils produced by weathering are categorized by their location relative to the parent rock. Soils that remain over the rock from which they came are called residual soils, and those soils that are transported from their place of origin and deposited elsewhere are called transported soils.

The particle size, shapes, and composition of residual soils may vary widely, depending on the amount and type of weathering. The depth of a residual soil layer depends on the rate at which the rock weathering occurred. Transported soils are commonly moved by gravity, water, glaciers, and wind. Gravity deposits, typically located close to the parent material, are generally loosely compacted. Soils moved by water, or alluvial deposits, are often found in the vicinity of moving water. They tend to be loose and compressible soils. Glacial deposits are made up of soil and rock mixed together. Wind deposits may be fine or coarse in texture.

Soil Profile

The soil profile is a natural succession of zones below the ground surface and represents the alterations to the original soil brought about by the weathering process. In general, there are four distinct zones in a natural soil profile:

O horizon	Leaves, vegetation, and organic debris
A horizon	Sometimes called the topsoil layer, the layer rich in humus and organic plant material, frequently darker in color than the underlying soils due to the accumulation of organic matter
B horizon	The subsoil immediately below the topsoil layer; often contains more clay soils
C horizon	The soil beneath the A and B horizons from which they were derived; also known as the parent material

Soil Texture

The soil texture refers to the relative size of the mineral particles. It is an important characteristic, as it limits and defines the soil's uses. Most natural soil types are composed of a combination of many particle sizes, the distribution of which gives the soil a distinctive appearance. This appearance—texture—is the term most often used to identify a soil.

There are three main textural classes: coarse- or light-grained, medium-grained, and fine- or heavy-textured soils. These may also be characterized as gravels, sands, and silts or

clays. According to the Mn/DOT *Grading and Base Manual,* grain size ranges for these soil sizes are as shown in Table B-1.

Table B-1. *Grain Size Distribution Ranges*

		Corresponding US Standard Sieve Sizes	
Particle Size	Diameter (mm)	Passing	Retained On
Gravel	76 (3") to 2.0	3"	No. 10
Coarse Sand	2.0 to 0.42	No. 10	No. 40
Fine Sand	0.42 to 0.074	No. 40	No. 200
Silt	0.074 to 0.002	Cannot be separated by sieving.	
Clay	< 0.002	Determined by settling velocity in soil-water suspension.	
*Colloidal Clay	< 0.001		

*Colloidal Clay is usually included in the clay size of fraction and is the smallest size clay particle. In addition to their physical characteristics, colloidal clay particles possess marked chemical factors and frequently have electrical charges present on their surface.

Laboratory Determination of Soil Texture

To separate the soil particles by size, conduct a gradation analysis in which the soil sample is run through a series of sieves. The portion passing or retained on each sieve is measured and expressed as a percentage. The percentages of smaller size particles that pass the No. 200 sieve are determined by hydrometer analysis, which determines the soil size based on its settling velocity.

Once the percentage of each particle size in the sample is known, the soil can be assigned a definite textural classification dependent upon the amounts of sand, clay, and silt present. Use the triaxial chart shown in Figure B-1 to classify a soil. Stone and gravel particles larger than the sand size (No. 10 sieve) do not have much effect on the basic soil classification. Soils containing more than 25 percent gravel particles are generally termed gravelly or stony soils.

The textural names of the soils obtained from the chart are designed to tell as much as possible about the soil in one to three words. Once the textural classification is known, approximations and estimates of many soil properties can be made, such as its strength, water-holding capacity, frost heave potential, maximum dry density, and optimum moisture content.

The triaxial chart places soil textures into three main groups based on clay content. Those three groups are then subdivided further, as follows:

Soils containing less than 20 percent clay:

- Sand
- Loamy sand
- Sandy loam
- Loam
- Silt loam

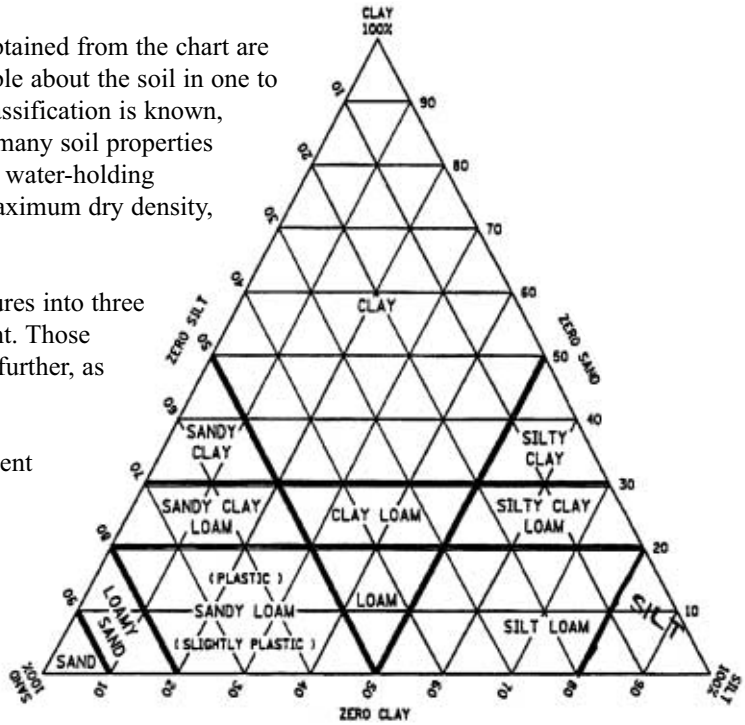


Figure B-1. *Soil Classification*

Soils containing 20–30 percent clay:

- Sandy clay loam
- Clay loam
- Silty clay loam

Soils containing more than 30 percent clay:

- Sandy clay
- Clay
- Silty clay

Table B-2, from the *Mn/DOT Grading and Base Manual*, lists soil textures with their gradation limits determined by laboratory mechanical analysis.

Table B-2. *Gradation Limit of Textural Soils Groups*

Soil Class	**% Gravel**	**% Coarse Sand**	**% Fine Sand**	**% Silt and Clay**	**% Silt**	**% Clay**
Group 1						
Gravel	90–100			0–10		0–10
Sand and Gravel	25–90			0–10		0–10
Coarse Sand	0–25	50–100		0–10		0–10
Sand	0–25	0–50	0–50	0–10		0–10
Fine Sand	0–25		50–100	0–10		0–10
Loamy Sand and Gravel	25–50	0–50	0–50	10–20		0–20
Loamy Coarse Sand	0–25	50–90		10–20		0–20
Loamy Sand	0–25	0–50	0–50	10–20		0–20
Loamy Fine Sand	0–25		50–90	10–20		0–20
Gravelly Sandy Loam	25–50	25–50	0–50	20–50		0–20
Coarse Sandy Loam	0–25	50–80		20–50		0–20
Sandy Loam	0–25	0–50	0–50	20–50		0–20
Fine Sandy Loam	0–25		50–80	20–50		0–20
Gravelly Loam	25–50			50–70	30–50	0–20
Loam	0–25	0–50	0–50	50–70	30–50	0–20
Silt Loam			0–50	50–100	50–100	0–20
Group 2						
Gravelly Sandy Clay Loam	25–80	0–80	0–80	20–50	0–30	20–30
Gravelly Clay Loam	25–50	0–50	0–50	50–80	20–50	20–30
Sandy Clay Loam	0–25	0–80	0–80	20–50	0–30	20–30
Clay Loam	0–25	0–50	0–50	50–80	20–50	20–30
Silty Clay Loam	0–25	0–30	0–30	70–100	50–80	20–30
Group 3						
Sandy Clay	0–25	0–70	0–70	30–50	0–20	30–50
Clay			0–50	50–100	0–50	30–100
Silty Clay			0–20	80–100	50–70	30–50

Appendix C
Vegetation Characteristics

Table C-1. *Characteristics of Commonly Selected Grasses*

Common Name	Life Cycle	Season	pH Range	Germination Time (days)	Optimal Germination Temp.	Winter Hardines	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seeds per Pound	Maintenance Requirements	Remarks
Tall fescue	P	C	5.5–6.2	10–14	60–85	F	F	M	SPD	225K	Low when used for erosion control; high when used in lawn.	Better suited for erosion control and rough turf application.
Tall fescues (Improved)	P	C	5.5–6.2	10–14	60–85	F	G	M	SPD	220K	Responds well to high maintenance.	Excellent for lawn and fine turf.
Kentucky bluegrass	P	C	6.0–6.5	14	60–75	G	P	M	SPD	2.2 m	Needs fertile soil, favorable moisture. Requires several years to become well established.	Excellent for fine turfs —takes traffic, mowing. Poor drought and heat tolerance.
Perennial ryegrass	P	C	5.8–6.2	7–10	60–75	F	F	M–H	SPD	227K	Will tolerate traffic.	May be added to mixes. Improved varieties will perform well all year.
Fine fescues Hard fescue	P	C	5.0–6.2	10–14	60–80	VG	G	L	MWD	400K	Grows well in shade and will tolerate infertile soils; improved disease resistance.	Exceeds all fine fescues in most tests. Excellent for low-maintenance situations.
Chewings fescue	P	C	5.0–6.2	10–14	60–80	VG	G	L	MWD	400K	Tolerates shade, dry infertile soils.	Poor traffic tolerance, less thatch than other fine fescues.

Table C-1. *Characteristics of Commonly Selected Grasses* (cont'd)

Common Name	Life Cycle	Season	pH Range	Germination Time (days)	Optimal Germination Temp.	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seeds per Pound	Maintenance Requirements	Remarks
Red fescue	P	C	5.0–6.2	10–14	60–80	VG	G	L	MWD	400K	Low to medium fertility requirements. Requires well-drained soils.	Spreads by rhizomes, tillers and stolons. Will not take traffic; very shade tolerant.
Redtop	P	C	5.8–6.2	10	65–85	G	F	L	PD	5 m	Will tolerate poor, infertile soils; deep rooted.	Does well in erosion control use; not for lawns.
Weeping lovegrass	P	W	4.5–6.2	14	65–85	F–P	G	L–M	SPD	1.5 m	Low fertility requirements; excellent drought tolerance.	Fast growing, warm season bunch grass. Excellent cover for erosion control.
Orchard grass	P	C	5.8–6.2	18	60–75	F	F	M	SPD	625K	Does best on well drained, loamy soil.	Good pasture selection, may be grazed.
Annual ryegrass	A	C	5.8–6.2	7	60–70	G	P	M–H	SPD	227K	Do not use in fine-turf areas.	May be added into mixes or established alone as temporary cover in spring and fall.
Rye	A	C	5.8–6.2	7	55–70	VG	G	L–M	SPD	18K	Do not use in fine-turf areas.	May be added into mixes or established alone as temporary cover in spring and fall.
Foxtail millet	A	W	5.8–6.2	10	65–85	VP	G	M	MWD	220K	Establishes well during summer. Very low moisture needs.	May be added to erosion-control mixes or established alone.

Table C-1. *Characteristics of Commonly Selected Grasses* (cont'd)

Common Name	Life Cycle	Season	pH Range	Germination Time (days)	Optimal Germination Temp.	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seeds per Pound	Maintenance Requirements	Remarks
Sericea lespedeza	P	W	5.8–6.2	21–28	70–75	F	VG	L	MWD	335K	Grows in most well-drained soils. Low fertility requirements. Inoculation is essential.	Use hulled seed in spring; unhulled in fall. Very deep-rooted legume.
Flatpea	P	C	5.0–7.0	14–28	65–75	G	G	L	PD	15K	Needs lime and high phosphorus. Good shade tolerance.	Tolerates acidic and water soils better than other legumes.
Annual lespedezas	A	W	5.8–6.2	14	70–85	F	VG	L	MWD	200K	Will grow on almost any well-drained soil.	Survives with very little nitrogen.
Red clover	P	C	6.0–6.5	7–14	70	G	F	M	SPD	275K	Needs high levels of phosphorous and potassium.	Acts as a biennial. Can be added to low-maintenance mixes.
White clover	P	C	6.0–6.5	10	70	G	P	M	PD	700K	Requires favorable moisture, fertile soils, and high pH.	Spreads by soil surface stolons, white flowers.

Key:
A = Annual P = Perennial C = Cool Season Plant W = Warm Season Plant
G = Good F = Fair P = Poor VP = Very Poor
H = High M = Medium L = Low
SPD = Somewhat Poorly Drained MPD = Moderately Poorly Drained
PD = Poorly Drained VPD = Very Poorly Drained

Source: *Best Management Practices for Erosion and Sediment Control,* Brian C. Robers, 1995.

Appendix D
Use of Herbicides

Table D-1. *Herbicide Formulations*

Type of Formulation	Description	Advantages	Disadvantages
Emulsifiable concentrate	Liquid formulations with the active ingredient dissolved in one or more emulsifiers so that material will mix readily with water. Solutions contain 2–8 lb. of active ingredient/gal.	Easy to measure and mix; not abrasive and will not plug screens and nozzles.	High concentrations of active ingredients pose hazards to people if skin comes in contact with product. Cannot freeze, are highly flammable; compatibility with other herbicides may be a problem. Can cause deterioration of rubber hoses, gaskets, and pump parts.
Flowables	Finely ground solid particles suspended in a liquid. Flowables contain 4 lb. or more of active ingredient/gal. (mg/l)	Can be readily mixed with water and won't clog nozzles. Need only moderate agitation to remain in suspension.	Hazardous when handling and storing undiluted concentrated materials. Cannot freeze, highly flammable; compatibility with other herbicides may be a problem. Can cause deterioration of rubber hoses, gaskets, and pump parts.
Granules and pellets	Dry, ready-to-use materials containing 2–15% active ingredient. Most granules are prepared by applying the active ingredient as a liquid to a coarse, porous solid material such as corncobs or clay. Applied directly to the soil or over the plants.	Ready to use as purchased and require no further mixing. Do not normally present a drift hazard; can be applied with relatively inexpensive equipment such as seeders and fertilizers.	More expensive than many other formulations. Granular formulations cannot be used for treating foliage because they won't stick to plants.
Solutions	Designed to be used without further dilution, or to be diluted with specially refined oil or other petroleum solvents. Some can be mixed with water to form true solutions. Contain 2–8 lb. or more of active ingredients/gal. Many are formulated with spreader and sticker chemicals.		
Water dispersible granules	Dry, granular materials to be mixed with water.	Easy to handle; less respiratory hazard with absence of dust-like particles.	Hazardous when handling and storing undiluted concentrated materials.
Wettable powders and soluble powders	Dry powdered formulations, usually containing 25–80% active ingredient. Wettable powders are mixed with water to form suspensions; soluble powders dissolve in water to form solutions. Wetting agent often added to keep suspended particles uniformly dispersed.	Safer to use on foliage, usually not absorbed through the skin as quickly as other liquid solutions. Generally easy to transport, store, and mix; relatively low cost.	Dust-like particles may be hazardous to the applicator if breathed in during mixing. Wettable powder suspensions must be agitated constantly to avoid settling of particles; will cause problems by clogging sprayer screens and nozzles; very abrasive to spray nozzles and pumps. Very hard alkaline water may be difficult to use with wettable powders.

Source: *Roadside Vegetation Management Manual,* Pensylvania Dept. of Transportation Report No. 85-08, 1987.

Table D-2. Uses of Herbicides for Noxious Weed Control Table

Weeds	Stage	Herbicides	Mix Ratio (gal/100 gal H2O)	Rate		Time
				Broadcast (lb ai/a)	Spot (%)	
Bull thistle	Rosette	Weedar 64	2.5–5	1.9–3.8	0.6	South: 5/1–6/15 8/25–major frost North: 5/20–6/25 8/15–major frost
Canada thistle	4" rosette to 15" or bud	Tordon 101* Tordon K* Transline	1 0.25 0.25	1 1 .5	1 0.1-1 0.5	South: 5/1–6/15 8/25–major frost North: 5/25–6/25 8/15–major frost
Cocklebur Field bindweed	Actively growing and young Actively growing at or beyond full bloom	Weedar 64 Rodeo Garlon 3A	2.5–5 3–5 0.5–1.5	1.9–3.8 3–4 4.5	0.6 1.5 1–5	Late summer or fall Late summer or fall
Giant foxtail Hemp	Germinating Close to maturity	Stomp 3.3 EC Weedar 64 Visko-Rhap 2D/oil	1 2.5 3/3	1.8–3.6 2 4	1 0.6 6	Spring Earlier in the season
Hoary alyssum	Actively growing 3"–8" tall	Weedar 64	2.6	2	6	South: 4/10–5/20 8/25–major frost North: 4/20–6/10 8/15–major frost
Leafy spurge	6" to full bloom	Tordon K* Weedar 64 Tordon 101*	1 2.5-5 1	1 1.9-3.8 1-5	1 0.6 1	South: 4/15–5/25 North: 4/30–6/10 Summer or fall months before major frost
Loosestrife	Actively growing at or beyond the bloom	Visko-Rhap 2D/oil Rodeo Garlon 3A	3/3 0.5 0.5	4 2 4.5	6 1 1.5	
Musk thistle	Rosette to bud	Tordon K* Transline	1 0.5	0.25 0.5	0.25 0.5	South: 5/1–6/15 8/25–major frost North: 5/25–6/25 8/15–major frost
Plumeless thistle	Rosette	Visko-Rhap 2D/oil Weedar 64	3/3 2.5-5	4 1.9-3.8	6 0.6	Late summer or fall
Poison ivy	Any stage	Envert 171/oil Arsenal	3/3 0.5	6 1	30 2	Any time
Ragweed	Actively growing 2"–10" tall	Weedar 64	2.6	2	0.6	South: 6/10–8/10 North: 6/15–7/25

D-2. *Uses of Herbicides for Noxious Weed Control* (cont'd)

Weeds	Stage	Herbicides	Mix Ratio (gal/100 gal H2O)	Rate		Time
				Broadcast (lb ai/a)	Spot (%)	
Sow thistle	Rosette to bud	Weedar 64	2.5–5	1.9–3.8	0.6	South: 5/1–6/15 8/25–major frost North: 5/25–6/25 8/15–major frost
Velvetleaf	Actively growing less than 6" tall	Roundup	1	1	1	Late spring or summer
Wild sunflower	Actively growing less than 6" tall	Transline	0.5	0.5	0.25–0.75	Late spring or summer

Source: *Roadside Vegetation Management Manual,* Pennsylvania Dept. of Transportation Report No. 85-08, 1987.

Table D-3. *Use of Herbicides for Specific Situations*

Use	Situation	Herbicides	Medium	Rate (%)	Application System	Equipment	Coverage	Results
Nonselective	Ditches	Rodeo/Surefact (2:1)	Water	1.5	conventional	backpack	weed foliage	kill, safe in water
	Inlets	Visko-Rhap 2D	Oil	30	invert	sprayer		kill
	Fence line	Hyvar XL	Water	2	conventional	handgun	3–6" wide on each side	gradual kill
	Sign posts	Roundup	Water	1	conventional	handgun		kill
	Guardrails	Roundup/Surflan (1:1)	Water	2	conventional	mixer		kill, extend control, safe on slope
		Precep 4L	Asphalt	.2	conventional	hand hose	18" wide	extend control
		Chopper	Asphalt	0.05	conventional	spray bar w/ 2 or 3 V nozzles	each side	extend control
		Krovar I DF	Asphalt	1 lb	conventional			extend control
	Median barrier islands	Stomp 3.3 EC	Water	1	conventional	truck or backpack sprayer	whole facility	prevent seeding
		Roundup	Water	1	conventional			kill
	Pavement cracks	Roundup	Water	2	conventional	sprayer		kill
		Roundup/Surflan (1:1)	Water	2	conventional	single conical nozzle	6" wide	kill, prevent seeding
		Roundup/Pricep 4L (1:1)	Water	2	conventional			kill, extend control
	Shoulders	Spike 80W	Water	Varies	conventional	truck sprayer	whole area	gradual kill
		Roundup	Water	1	conventional			kill

Table D-3. *Use of Herbicides for Specific Situations* (cont'd)

Use	Situation	Herbicides	Medium	Rate (%)	Application System	Equipment	Coverage	Results
Selective	Basal Brush	Garlon 4	Oil	20	conventional	backpack sprayer	lower 12–24" stem bark	premier control
		Pathfinder	None	RTU	conventional			kill
	Cut Stubble	Tordon K*	Water	2–4	conventional	truck or backpack sprayer	fresh top cut	prevent resprout, extend kill
		Rodeo	Water	1–1.5	conventional			prevent resprout
	Cut Stumps	Pathway	None	RTU	conventional	backpack or hand sprayer	cambium	kill, prevent sprouting
		Weedone CB	None	RTU	conventional			safe on slopes
	Foliar Brush	Garlon 4	Water	1	conventional	hose sprayer handgun	all leaves, stems, roots	premier control
		Envert 171	Oil	100	invert			kill
	Landscape Beds	Surflan A.S.	Water	1.5	conventional	backpack sprayer	weed top or soil	prevent seed from germinating
		Casaron 4G	None	Varies	spread			
	Soil Brush	Spike 80W	Water	Varies	conventional	sprayer handgun	soil surface	gradual kill
		Hyvar XL	Water	17	conventional			control
	Tree Injection	Chopper	Water	7	conventional	hatchet hand sprayer	1" cuts spaced 1–2" wide	control
		Garlon 3A	Water	50	conventional			kill
Growth Regulator	Roadside Turf	Oust	Water	0.4 lb	conventional	ground sprayer	weed foliage soil surface	suppress seedhead
		Roundup	Water	1.5	conventional			suppress growth
	Tree Implant	Cutless	None	Varies	insertion	driller squirt bottle	above buttress root	reduce terminal growth
		Profile 2SC	None	Varies	soil injection	graduated pitcher	6" below soil surface	pruning volume

* Restricted use herbicides

Source: *Roadside Vegetation Management Manual,* Pennsylvania Dept. of Transportation Report No. 85-08, 1987

Appendix E
Minnesota Noxious Weeds

All ten noxious weeds for Minnesota are described and illustrated below. Source: Mn/DOT Office of Environmental Services.

HEMP (MARIJUANA)

Description: An annual plant with a branched taproot that reproduces only by seed. It grows 2–10 feet tall, has coarse, somewhat grooved, rough, hairy stems. Plants will become large and bushy unless crowded. Hairs on the upper parts of the plant exude a sticky resin with a characteristic odor. Leaves are alternate or opposite, petiolate, and divided into 5–11 hairy leaflets with notched edges. Male and female flowers are on separate plants. The male flower is green without petals. The male plant, which produces the pollen, turns yellow and dies soon after pollen is shed. The female plant produces flowers in the axil of the upper leaves and remains green and vigorous until frost. Flowering occurs from July to September and seed production, from August until frost. Seeds are yellowish-tan to mottled brown, 1/8-inch long, and oval-shaped.

Distribution: Hemp prefers rich, low, wet areas, but can be found in waste areas near farm fields and buildings. Hemp is found throughout the southern half of Minnesota.

Drawing:

Hemp *Cannabis sativa*

BULL THISTLE

Description: Bull thistle grows most often as a biennial, reproducing only by seed. During the first year of growth, a large basal rosette with a large taproot is formed. During the second year of growth, an erect flowering stem grows 2–4 feet tall. The stem is large, branched, and covered with dense hair. Leaf bases extend down the stem,

giving it a winged appearance. The leaves are alternate, dark green, and coarsely lobed, with 3–4 points per lobe, each ending in a long sharp spine. The upper surface of the leaf is covered with short, stiff hairs and spines, and the underside of the leaf is covered with dense, woolly, gray hair. The flower heads are compact, 1–2 inches in diameter, and spine-tipped bracts surround each reddish-purple flower. Flowering occurs from late June through August and the seed matures from July through September. Seeds are 1/8-inch long, oblong, flattened and curved, and light brown with dark brown stripes.

Distribution: Bull thistle is primarily found in pastures, waste areas, and along roadsides throughout Minnesota in a variety of soil types.

Drawing:

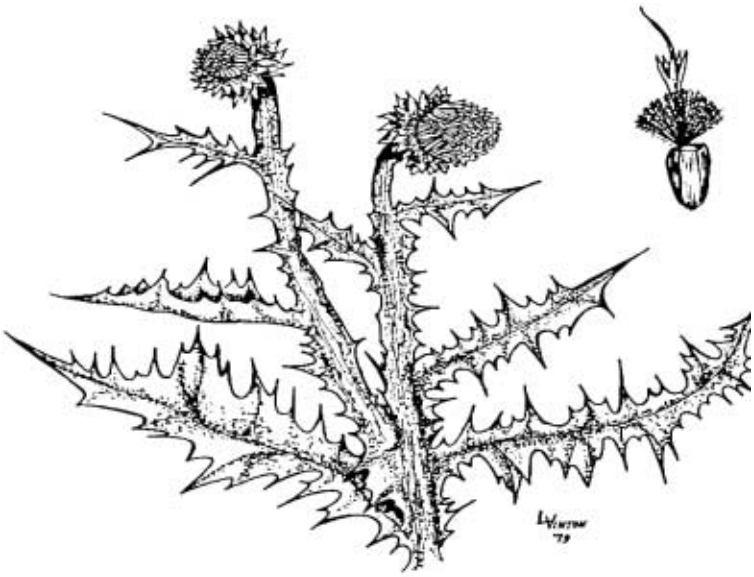
Bull Thistle *Cirisium vulgare*

MUSK THISTLE

Description: This plant, also called nodding thistle, reproduces only by seed and grows most often as a biennial, although it can occasionally grow as a winter annual or annual. During the first year of growth, a large basal rosette with a large taproot is formed. During the second year of growth, an erect flowering stem grows to a height of 3–6 feet. The stem is branched with spiny leaves extending down the stem to give it a winged appearance. The wings are lobed and wavy with each lobe ending in a spine. The leaves are bluish-green with light green midribs and a white margin. They are alternate, smooth, coarsely lobed with 3–5 points per lobe, and slightly wavy. Each lobe ends in a prominent hair on either surface. The flower heads are large—up to 2 inches across—and frequently droop on the ends of long spineless stems. The flowers are deep rose to violet in color and are surrounded by large spiny bracts. Flowering occurs from late June through August, and the seed matures from July through September. The seeds are yellowish-brown, oblong, and 3/16-inch long with a protrusion at the place where they were attached to the pappus.

Distribution: Musk thistle is primarily found in pastures, waste areas, and along roadsides throughout southern Minnesota, with the most severe infestations in southeastern Minnesota. Although it prefers moist alluvial soils, it can grow in many different ones.

Drawing:



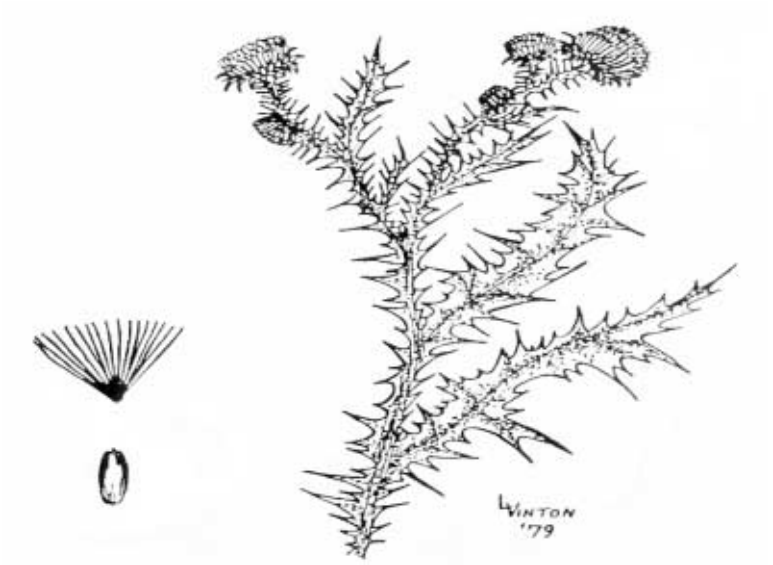
Musk Thistle *Carduus nutans*

PLUMELESS THISTLE

Description: Plumeless thistle reproduces only by seed, growing most often as a biennial, but occasionally as a winter annual or annual. During the first year of growth, it forms a large basal rosette with a large taproot. During the second year, it grows an erect, branched flowering stem 3–6 feet tall with spiny wings. The leaves are alternate, narrow, and deeply lobed with scattered hair on the upper leaf surface and dense white hair on the lower surface, especially along the midrib. Lobes on the leaves and stem end in white to yellowish spines. The flower heads are globe-shaped, erect, and single or loosely clustered with spiny bracts at the base of each. Flowers are reddish-purple and 1/2–1 inch in diameter. Flowering occurs from June through August, with seeds maturing 5–12 days after full bloom. The seeds are straw-colored with brown striations to the collar where the pappus is attached, 1/16-inch long, and usually linear but occasionally curved.

Distribution: Plumeless thistle is primarily found in pastures, waste areas, and along roadsides throughout Minnesota. It prefers sandy, well-drained soils.

Drawing:



Plumeless Thistle *Cardiis acamtjpodes*

CANADA THISTLE

Description: Canada thistle is a perennial that reproduces by seeds and underground roots. Roots extend several feet deep and some distance horizontally, often forming dense patches. The mature plant reaches a height of 2–5 feet. Upright stems are grooved, branched at the top, and slightly hairy when young and increasingly hairy as they mature. The leaves are alternate and somewhat lobed, with crinkled edges and spiny margins. The flower heads are numerous, compact, and 3/4-inch or less in diameter. Flowers are reddish-purple to purple and are surrounded by bracts with spiny tips. Male and female flowers are usually borne on separate plants. Flowering occurs from June through September, with seeds maturing 8–12 days after full bloom. Seeds are gray to brown, smooth, slightly tapered, and 3/16-inch long with a ridge around the blossom end.

Distribution: Canada thistle can be found in all crops, pastures, waste areas, and along roadsides throughout Minnesota. It is the most prevalent and persistent broadleaf weed in the state.

Drawing:

FIELD BINDWEED

Description: Field bindweed, also called creeping Jenny or morning glory, is a perennial that reproduces by seeds and underground roots. The root system is very extensive and may penetrate the soil to a depth of 20–30 feet. The plant grows prostrate or climbs on any nearby object. The spreading stems are smooth, slender, usually twining, and 2–7 feet long on a mature plant. The arrow-shaped leaves are alternate with smooth margins and two basal lobes. The flowers are white to pink, approximately 1 inch in diameter, funnel shaped, and borne singly on long stalks in the axil of the leaf. The flower stalk has two bracts located 1/2–2 inches below the flower, which helps distinguish this weed from hedge bindweed. Flowering occurs from May to September. Seeds are borne in egg-shaped seedpods, each containing four seeds. The dark brownish-gray seeds are 1/8-inch long with a rough surface and one rounded and two flattened sides.

Distribution: Field bindweed will grow in most cultivated fields, gardens, lawns, waste areas, and along roadsides throughout Minnesota, with the heaviest infestations found in the western half of the state.

Drawings:

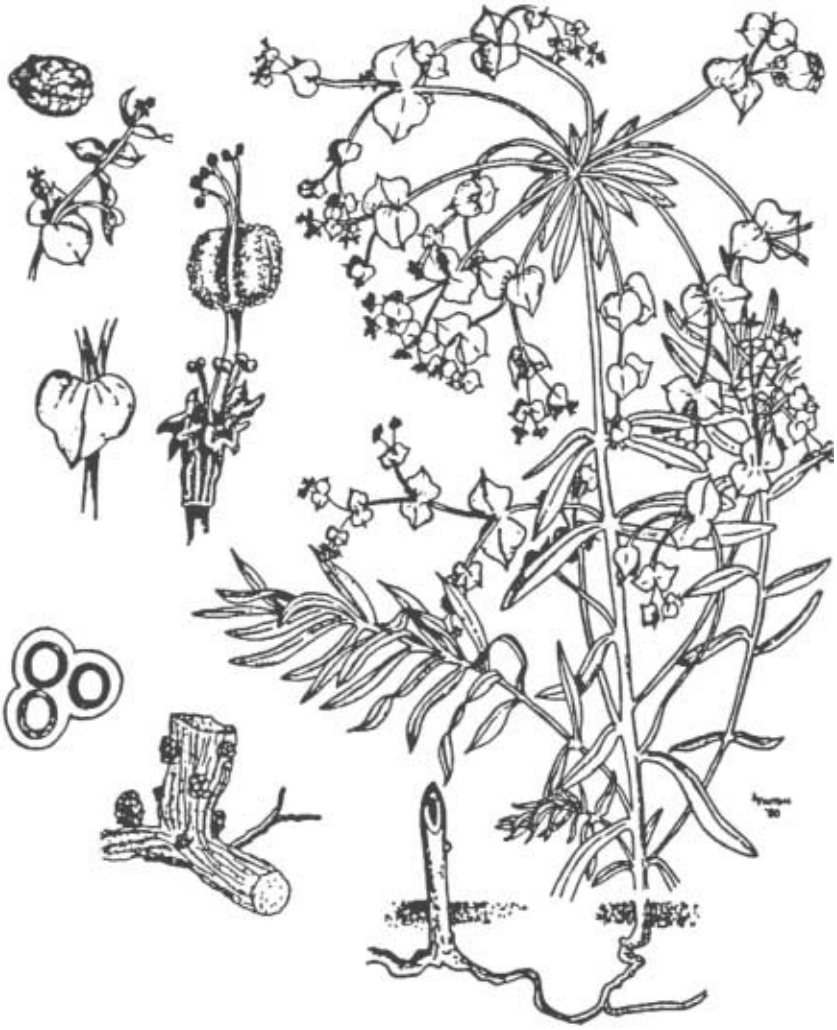
Field Bindweed *Convolvulus arvensis*

LEAFY SPURGE

Description: Leafy spurge is a perennial that reproduces from both seeds and underground roots. The root system is extensive and consists of numerous coarse and fine roots that occupy a large volume of soil. Roots are most abundant in the upper foot of soil; however, some roots can extend to a depth of 15 feet or more. The mature plant will reach a height of 2–3 feet. Stems are smooth, branched at the top, and filled with a milky juice. The linear-shaped leaves are alternate, bluish-green, and narrow (1/4-inch wide) with smooth margins. Leafy spurge produces a flat-topped cluster of yellowish-green flower-like structures, called bracts, on which the true flowers are produced. Flowering occurs from June through August and seeds are produced from July to September. Seeds are borne in three-lobed pods that contain three seeds each. The smooth, 1/8-inch long seeds are gray-white to gray-brown, usually mottled or flecked with brown, and marked on one side by a faint dark seam running the length of the seed.

Distribution: Leafy spurge grows primarily in pastures, waste areas, and along roadsides throughout Minnesota. The heaviest infestations are found in the western half of the state and along most of the roadsides in Minnesota's metropolitan areas.

Drawings:



Leafy Spurge *Euphorbia esula*

PERENNIAL SOW THISTLE

Description: Perennial sow thistle is a perennial that reproduces by seed and underground roots. Roots can penetrate the soil to a depth of several feet. Mature plants reach a height of 3–7 feet. The smooth upright stems, either with or without hair, contain a milky juice. Leaves are variable in shape and size. Basal leaves are narrow and deeply lobed, and leaves along the stem are 4–8 inches long, alternate, attached directly to the stem, irregularly toothed, and lobed with spiny edges. Flower heads are approximately 1-1/2 inches in diameter, produced in bright yellow clusters, and attached to terminal branches at the top of the plant. Flowering occurs from June through August and seeds mature July through September. The reddish-brown seeds with small cross wrinkles are 1/8-inch long, slightly flattened, and longitudinally ribbed with 5–7 ribs.

Distribution: Sow thistle will grow in cultivated fields, pastures, waste areas, and along roadsides throughout Minnesota, with the heaviest infestations found in the western and northern half of the state.

Drawings:

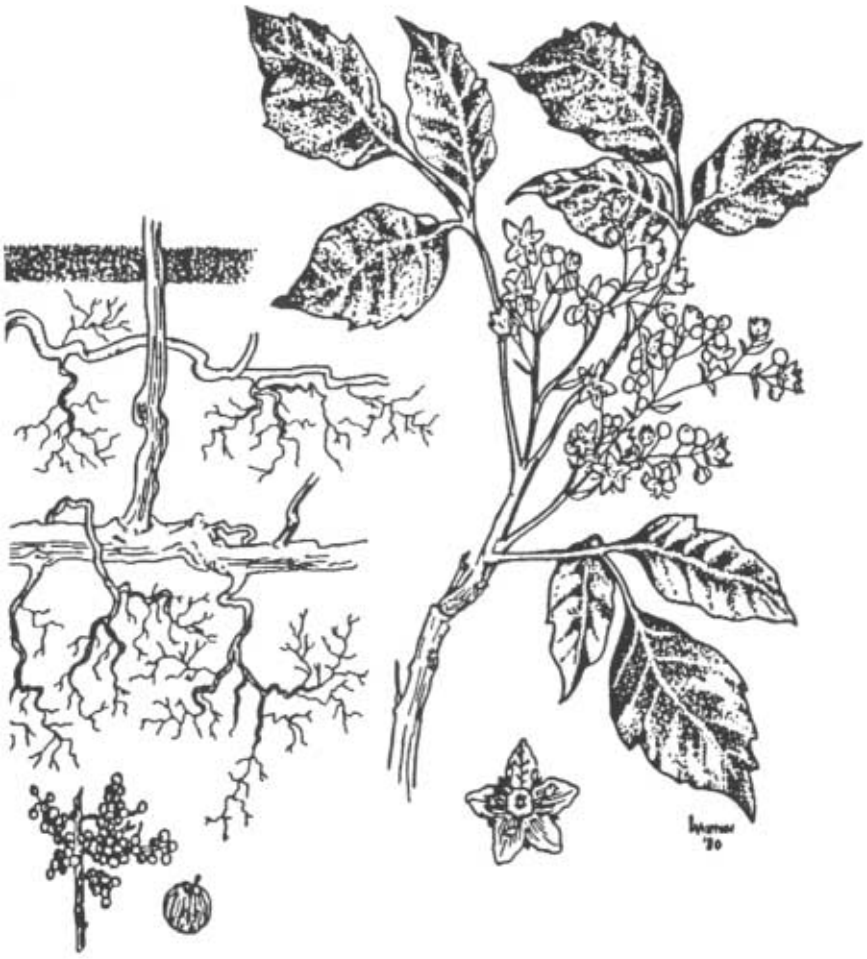
Perennial Sow Thistle *Sonchus Arvensis*

POISON IVY

Description: Poison ivy is a native perennial woody species that reproduces by both seeds and underground roots. It primarily grows as a woody vine; however, when growing in full sunlight it may become a shrub up to several feet tall. As a vine, poison ivy will climb fence posts, shrubs, and trees. Older vines may exceed 2 inches in diameter and reach 75 feet in length. Leaves are alternate and consist of three leaflets that can vary greatly in shape. Most often, leaflets are 2–4 inches long, pointed at the tip, and shiny with notched or smooth edges. Leaves are petiolate, and often the terminal leaflet has the longest stem. The small, five-petaled flowers are yellowish-green and borne in a cluster 1–3 inches long. Flowering occurs from August through September, although not all plants will flower or bear fruit. Seeds are produced inside a fruit that grows in clusters on slender stems in the axil of the leaves. The fruit is grayish-white to yellow, 3/16-inch in diameter, and marked with distinct lines on the outer surface, somewhat like a peeled orange. Seeds are grayish striped and approximately 1/8-inch in diameter. All parts of this plant contain a poisonous material that causes blistering of the skin.

Distribution: Poison ivy grows along stream banks and the edges of paths, roadsides, and fences, in woodlands, and in other noncultivated areas throughout Minnesota. The heaviest infestations are found in wooded areas of the state. It prefers moist, shaded locations.

Drawings:



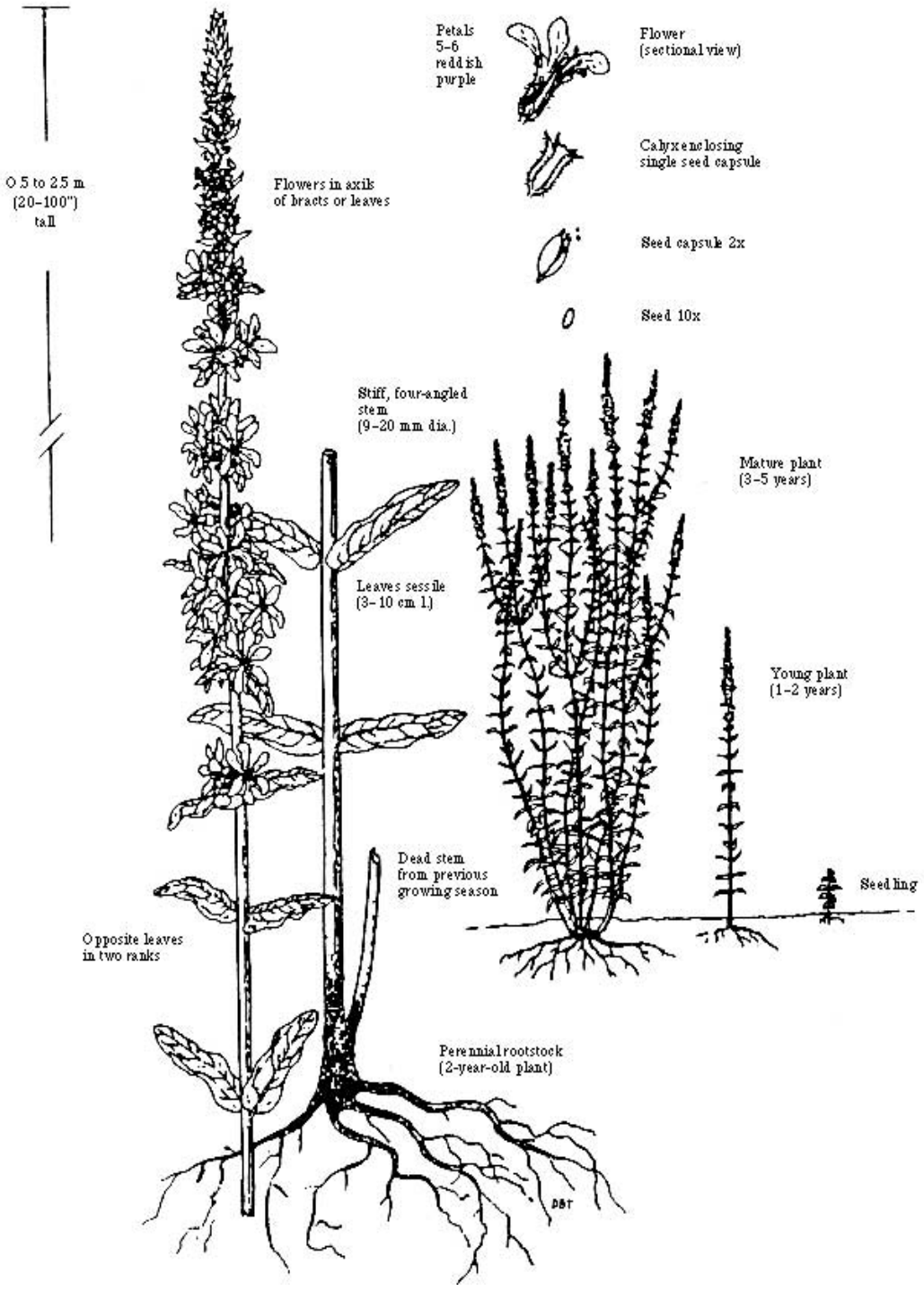
Poison Ivy *Rhus radicans*

PURPLE LOOSESTRIFE

Description: This is an aquatic perennial that reproduces by seed or underground roots and can spread by sprouting from pieces broken off the plant. It has a woody taproot and a fibrous root system that forms a dense mat. The erect stems of a mature plant can reach 7 feet in height. The branched stems are somewhat square and covered with fine hairs. The leaves are opposite or whorled, linear-shaped with smooth edges, hairy, and attached directly to the stem. Purple or magenta flowers form in dense terminal spikes at the top of the plant with 5–7 petals. Flowering begins in June and continues through early September. The pods contain many seeds that are flat, light tan to golden brown, and very tiny, about the size of a pin.

Distribution: Purple loosestrife is an aquatic plant that grows in moist soils in wet meadows, pasture wetlands, cattail marshes, streams and riverbanks, lakeshores, and ditches. Infestations are increasing in the state, with more than 75 percent of Minnesota counties infested.

Drawing:



Purple Loosestrife *Lythum salicaria* or *virgatum*

Appendix F

Technical Memorandum No. 89-8-ME-6

MINNESOTA DEPARTMENT OF TRANSPORTATION
TECHNICAL SERVICES DIVISION

Technical Memorandum No. 89-8-ME-6

February 17, 1989

TO: Distribution 57 I & J

FROM: E. E. Ofstead, Assistant Commissioner
Technical Services Division
L. F. McNamara, Assistant Commissioner
Operations Division

SUBJECT: Withholding of Funds for
Incomplete Grading Operation
Specification 2105.5
"Per Acre Value"

This is a revision and reissuance of Technical Memorandum No. 85-4-RD-1.

Specification 2105.5 provides that a portion of partial payments will be withheld on all areas within the grading construction limits, exclusive of roadbed areas, on which construction activities have disturbed the natural vegetation leaving the areas exposed to probable erosion. The purpose of deferring payment is to encourage contractors to complete the grading and reestablish the turf on a balance by balance basis. When the turf establishment work is completed, the funds are released. The amount withheld is to be based on the probability of significant erosion occurring and the potential for damage caused by such erosion.

The probability of significant erosion varies, depending upon the amount of disturbed area, duration of the project, steepness of inslopes and backslopes, the steepness of ditch grades, soil types and temporary erosion control measures provided.

If the erosion all takes place within the R/W and the eroded soil is contained with the R/W, the contractor can normally repair the damage without significant problems. If the eroded soil is deposited on adjacent property, significant problems in repairing the damage could develop. If the eroded soil is deposited in streams, lakes or wetlands, repairing the damage is virtually impossible.

Various projects should have different per acre values, and most projects should be subdivided into areas with different per acre values. Specification 2105.5 provides that unless the Plans or Special Provisions establish a different amount, $700 per acre shall be withheld for incomplete grading operations. For average conditions on most projects, $700 per acre is the appropriate amount to be withheld.

However, on minor widening projects where the grading is confined to the inslopes with no disturbance of vegetation in the ditches and backslopes, there is little likelihood of significant erosion. Additionally, the sequence of construction activities results in topsoil being replaced on the inslopes after the shoulder construction is

completed. Therefore, except for areas immediately adjacent to streams, lakes, and wetlands, funds should not be withheld for incomplete grading operations on minor widening projects.

As a general guide to designers, the following per acre values should be used:

1.	Minor widening projects with no disturbance of vegetation in ditches or backslopes.	
	a. Immediately adjacent to streams, lakes, wetlands.	$700/Acre
	b. Other areas.	$0/Acre
2.	General construction projects.	
	a. With 4:1 or flatter slopes and ditch grades generally less than 2%.	$700/Acre
	b. With 3:1 or steeper slopes and ditch grades frequently 4% or steeper.	$1500/Acre
	c. Areas immediately adjacent to or draining directly to streams, lakes, or wetlands.	$2000/Acre
3.	Bridge replacement projects.	
	a. Over rivers and streams.	$2000/Acre
	b. Other areas.	$700/Acre

When final plans and special provision recommendations are submitted to the Design Engineering Section, the designer shall include recommendations on the amounts to be withheld for incomplete grading operations. On projects where the designer determines that $700 per acre throughout the project length is the appropriate amount to be withheld, the submittal should include a statement so saying.

FACT SHEET: MINNESOTA NOXIOUS WEED PROGRAM

This program has one major function and it is to prevent the harmful effects that undesireable plants can have on the state's citizens. The Minnesota Noxious Weed Law and Rules have been in existence since 1929 and are designed to be a cooperative effort between state, county, and local governments. Each level has a separate and distinct role in this effort.

REGULATORY AUTHORITY:

Minnesota Statutes, sections 18.75 to 18.88 and Minnesota Rules, parts 1505.0730 to 1505.0760.

STAFF:

- 8 state personnel who spend approximately 40% of their time in this program.
- Agricultural Inspectors in each of 87 counties spending 30% time on noxious weed law enforcement duties.
- 8,000 Local Weed Inspectors in cities and townships (% of time unavailable).
- Between state and county staff, about 30 full-time field staff involved in noxious weed law enforcement.

PROGRAM DIMENSIONS:

- 20 million acres of cultivated land and 32 million acres of other land that is subject to infestation by noxious weeds.
- Land divided among 87 counties and over 2,600 townships and cities as separate political subdivisions.
- 10 species are on the primary noxious weed list to be controlled on all land in the state and 51 species on the secondary list that can be petitioned as a primary noxious weed on an individual county basis.
- In 1993, over 13,500 contacts made with landowners to voluntarily control noxious weeds. In about 900 cases, a formal or individual notice was served and in about 110 of these cases, the inspector had to carry out the control measures. These figures indicate over 99% compliance rate.

PERMITS:

- "Permit to Transport Noxious Weed Propagating Parts in Infested Material or Equipment"
- This permit is issued by local weed inspectors or county agricultural inspectors (number issued unavailable)
- Condition of Permit Issuance:
  - Prevention of spread during transport of noxious weed propagating parts in material or equipment.
  - Propagating parts must be controlled or destroyed at destination to prevent spread.
- Duration; Revocation:
  - Permit valid for up to 1 (one) year after date issued.
  - Permit revoked if the inspector determines noncompliance by permit holder.

For additional information about the enforcement of the Minnesota Noxious Weed Law contact
Minnesota Department of Agriculture
Agronomy Services Division/ Noxious Weed Section
90 West Plato Boulevard, St. Paul MN 55107-2094
Telephone: (612) 296-8309 FAX: (612) 297-2271

Appendix G
Glossary of Terms

Absorption:	Entrance of pesticide into plant, animal, or soil.
Activate:	To cause a herbicide to have a toxic effect on plants, usually by moving the herbicide into contact with the roots.
Active ingredient:	The portion of a pesticide that works toward killing or controlling a pest. Expressed as a percentage (dry materials) or pounds per gallon (liquids).
Adjuvant:	A product added to sprayed materials to improve their ability to contact or penetrate the plant.
Adsorption:	The attraction of particles of one substance to the surface of a solid.
Adventitious roots:	Roots that originate from an unusual location on a plant such as along the stem.
Aerial application:	Application by helicopter or airplane.
Aerosol:	A very fine mist of solid or liquid particles suspended in air.
Agitation:	Constantly stirring or mixing spray material in the tank.
Amine salt:	An organic (carbon-based) compound containing hydrogen derived from ammonia. A water soluble herbicide formulation with low volatility.
Annual:	A plant that completes its life cycle, from seed to flowering and seed production, in one year, then dies.
Antagonism:	Loss of chemical activity of a herbicide by exposure to another chemical. A situation in which the mixing of two herbicides results in the reduced effectiveness of both.
Antidote:	A treatment administered to nullify or reverse the effect of a poisonous material taken internally.
Aquatic:	A plant or animal that grows and lives in water.
Aqueous:	A solution that contains water.
Aromatics:	Chemical compounds derived from hydrocarbon benzene.
Aspect:	The direction from which sunlight strikes a slope.
Backslope:	The side of the ditch furthest from the road.
Band application:	Placing a chemical herbicide in strips on the ground.
Bare ground treatment:	Herbicide application with the objective of keeping soil clear of all vegetation.
Bark:	The woody tissue outside of the vascular cambium layer of a woody plant.
Basal treatment:	Applying a herbicide to stems at ground line, root collar, and exposed roots.
Biennial:	A herbaceous plant that completes its life cycle in two years by germinating during one growing season, overwintering, then producing flowers and seeds during the second growing season before dying.
Biological diversity:	Refers to the variety and variability of living organisms (plants or animals) in a given area.
Biological integrity:	A state of being in which an area contains only those species that are native to the area, unpolluted by the introduction of undesirable or alien species.
Boot stage:	The growth stage of grass when the seed head has formed but has not yet emerged from the sheath.
Broadleaf weeds:	Dicotyledonous plants that are not grasslike, but rather have broad net-veined leaves.

Broadcast application:	Spreading a spray or dust over an entire area.
Brush:	Woody plants.
Bunchgrass:	A grass that produces many side shoots and thus grows in a clump.
Carrier:	Liquid or solid material to which a chemical is added to facilitate application.
Chemical:	A synthetic compound that, when applied properly to target vegetation or other pests, will kill any part or all of that pest.
Chemical trimming:	The use of contact herbicides to selectively control encroaching plant growth.
Chlorinated hydrocarbon:	A synthetic organic pesticide compound containing chlorine, hydrogen, and carbon.
Companion crop:	Often necessary for plantings on highly erodible sites. It usually consists of oats planted at the rate of 1/2 or 1-1/2 bushels per acre to hold the soil until the permanent seeding gets established.
Compatibility:	When two or more materials can be successfully mixed and used together, they are said to be compatible.
Concentration:	The amount of active ingredient in a given volume of liquid or dry material.
Conifer:	A tree, usually an evergreen, that produces its seeds in cones and has needle-like leaves.
Contact herbicide:	A herbicide that kills only the part of a plant that it touches directly rather than by translocation.
Contaminate:	To pollute.
Cool season:	Plants, mostly grasses, that grow during the fall and spring and are more or less dormant during the summer.
Corrosion:	To wear away by chemical means.
Crown:	That part of the plant where stem and roots join.
Cuticle:	A waxy layer that forms on the outer surface of plant foliage.
Deciduous:	A plant that loses its leaves seasonally.
Decreaser:	Range plants that decrease under heavy grazing. Some plants can be decreasers or increasers depending on soil and moisture conditions.
Degradation:	The process by which a chemical is broken down into simpler forms.
Delayed action:	Herbicidal activity that does not show effects immediately after application, but whose response occurs after a time.
Desiccant:	A material or herbicide that causes plant tissues to become dehydrated.
Diluent:	Any material, liquid or dry, that dilutes or carries an active ingredient.
Directed application:	Applying a pesticide to a specific area of a plant rather than as an overall broadcast application (spot spraying).
Dormancy:	A necessary period of rest that most perennial plants undergo during which visible growth is temporarily suspended. May result from the season or from stress.
Dormant seeding:	Seeding made in late fall just prior to freezing. Use the regular seeding rate if the seed is incorporated into the soil.
Dormant spray:	Applied to woody plants during their dormant period.
Dosage:	The amount of active ingredient applied per acre.
Drift:	Small particles of spray solution that are carried off target by air.
Ecosystem:	An ecological community together with its physical environment; considered as a unit.
Ecosystem-based management:	An approach that considers the whole system, not just the parts, and brings people together to work for the health of the land and the communities it supports.
Ecotype:	In a species having a wide geographical distribution, a subgroup that has developed specific adaptations to local conditions such as temperature, light, and humidity.

Emergence:	The time during the growth of a plant when the seedling shoot first breaks through the soil.
Emulsifiable:	A formulation in which the active ingredient is dissolved in an organic solvent. The concentrate then can be diluted in water or oil for application.
Emulsifier:	A chemical that facilitates the suspension of one liquid in another. An additive that improves the mixing properties of two liquids.
Encroachment:	Practices on land adjacent to roadsides resulting in negative impacts to roadside vegetation.
Erosion:	The physical removal of surface material, either rock or soil, by water or wind.
Ester:	A relatively volatile formulation in which an inorganic acid such as 2,4-D is mixed with alcohol.
Fertilizer:	Any material added to soil to supply nutrients for plant growth.
Fibrous root system:	A root system in which all roots are about the same length and diameter.
Field border:	A narrow strip of grass planted between field and roadside that protects roadside vegetation from cropland activities and runoff.
Foliage:	The leaves of a plant.
Foliar application:	Herbicide applied to leaves or needles of a plant.
Foreslope:	The side of the ditch closest to the road.
Formulation:	The physical form in which a herbicide is used. It may be 1) water solution, 2) oil solution, 3) liquid emulsions, 4) suspensions, or 5) dry (granules, dusts, or pellets).
Frilling:	Cutting slits through tree bark and filling them with chemicals.
Frost seeding:	A seeding made in late February or March on seedbeds prepared in the fall. Seed is sown on the surface that has been made friable by freezing and thawing. The soil surface is usually honeycombed with small cracks.
Germination:	The beginning of growth from a seed.
GPA:	Gallons per acre.
GPM:	Gallons per minute.
Granules:	Pesticide formulation in which small particles of clay or organic matter are impregnated with the active ingredient.
Grasses:	Monocotyledonous plants that have narrow leaves, parallel venation, and leaves composed of blade, sheath and liqule.
Ground application:	Spray application made by equipment carried by hand or mounted on trucks or other ground equipment.
Ground cover:	Any low-growing vegetation that protects soil from erosion.
Growing season:	The period of time between the last killing frost in spring until the first killing frost in fall, and during which time plants are actively growing.
Growth regulator:	A hormone-like chemical, either natural or synthetic, that speeds up or slows down the growth rate of plants. Commonly used to slow down the growth of grasses.
Herbaceous:	Non-woody vegetation.
Herbicide:	Chemical materials, natural or artificial, used to kill or control plants.
Hormone:	A synthetic or naturally existing plant growth regulator.
Humidity:	The amount of moisture air is holding at a certain temperature. Herbicides are more effective under conditions of moderate humidity.
Impermeable:	Cannot be penetrated.
Increaser:	Range plants that increase in number as the decreaser plants are weakened and die.
Inhibit:	To slow down or stop an activity.
Introduced:	Plants that have been brought in from outside North America and are not in the original vegetation.

Invert emulsion:	A mixture in which water is dispersed in oil.
kg/ha:	Kilograms per hectare.
Label:	Printed material attached to a pesticide container. The label is a legal document providing explicit instructions for use.
Lateral encroachment:	Vegetation that grows and extends into areas where it is not wanted.
Lb/A:	Pounds per acre.
Leaching:	Downward movement of material through soil while dissolved or suspended in water.
Miscible:	Two or more liquids that can be mixed together and remain mixed.
Mission statement:	Answers the question "why do we exist?" from a customer's perspective. It usually describes products, services, and the customers who use them.
Monocotyledon:	A plant that has a single leaf; includes grasses.
Mulch:	A layer of material placed on the ground to retain moisture, to control soil temperature, or to inhibit the growth of weeds.
Native:	Plants that are native to the North American continent.
Native plant:	A plant species that occurs naturally in a particular area without human cause or influence. Known to exist in an area prior to European settlement.
Native plant community:	A diverse group of native plants that grow together in the same general place and have mutual interactions.
Nonselective herbicide:	A chemical formulation that destroys any type of plant.
Noxious weed:	A weed defined by law as being objectionable enough to warrant a law requiring its control.
Orifice:	The opening of a spray nozzle through which the liquid is sprayed.
Overall treatment:	A chemical applied uniformly over an entire area.
Pelleted:	A type of herbicide formulated for dry application in which the active ingredient is carried by particles of inert material or formed into small pellets.
Perennial:	A plant that normally lives three or more years.
Pesticide:	A chemical used to kill or inhibit a pest, whether vegetation, insect, animals, or fungus.
Phloem:	The living conductive tissue in plants that carries food manufactured by the leaves down into the plant roots.
Photodecomposition:	Destroyed or broken down by light.
Photosynthesis:	A process by which green plants manufacture their own food by combining carbon dioxide and water in the presence of light.
Phytotoxic:	Damaging to plant leaves.
Pollutant:	Contamination of water, soil, or air by harmful substances.
Postemergence:	Herbicide applied after weeds have begun active growth.
Prevention control:	Preventing the initial establishment of weeds.
Pure live seed (PLS):	The percent of seed germination times the percent of seed purity of each species.
Rate of application:	The amount of chemical material applied per acre.
Rate of distribution:	The amount of spray solution (chemical material plus water or other carrier) applied per acre.
Registered use:	Date, timing, and application of pesticides as determined by the EPA.
Regrowth:	Sprouts from roots or suckers from stumps of partially killed plants.
Residual:	The length of time that a pesticide remains active, usually in soil.
Resistance:	The ability of an organism to avoid damaging effects of a material by some internal mechanism.
Rhizome:	A perennial underground stem that can produce new plants.
Root collar:	The portion of a woody plant where the stem meets the root.
Root kill:	Root system completely dead, usually by application of systemic herbicide to a perennial plant.

Root suckering:	Sprouts that arise from roots that are still alive although the top of the plant may be dead.
Sensitive:	The inability to withstand injury from a herbicide.
Soil persistence:	The length of time that a soil-applied chemical remains phytotoxic in soil.
Soluble:	A material made by dissolving a material in a liquid, usually water. A true solution tends to remain stable, whereas emulsions and suspensions tend to settle out.
Solvent:	A liquid that will dissolve a substance.
Species:	In the system of binomial classification of plants and animal, a species is a subdivision of a genus.
Spot treatment:	Herbicide application limited to a small area or to individual plants.
Spreader:	A chemical additive that increases the ability of a herbicide spray to adhere to the surface of the target plant. Often used with wettable powder formulations.
Stolon:	The above ground horizontal stem of a perennial plant. Capable of developing roots, thereby spreading the plant by vegetative reproduction.
Suckering:	Sprouts arising from roots or underground stems.
Summer annual:	A plant that grows from seed, produces flowers, and dies within a single year.
Surfactant:	A surface active agent added to a herbicide mix to improve contact with the plant.
Susceptible:	Capable of being affected or injured, as when a plant is susceptible to the effects of a particular herbicide.
Suspension:	A mixture in which very fine particles of a solid are suspended in a liquid, rather than dissolved.
Sward:	Portion of ground that is covered with grass.
Synergism:	Cooperative action between two pesticides where the results are greater than the sum effect of both pesticides used alone.
Systemic:	A pesticide that is applied to one part of a plant, absorbed, and translocated throughout the plant.
Taproot:	A main root that grows downward and has only a few fibrous lateral roots.
Tolerance:	The ability to resist injury from pesticides or other adverse condition, or the amount of pesticide allowable in or on form products at the time of sale.
Top kill:	When leaves and stems are killed to the ground line.
Toxicity:	The degree to which a material is poisonous.
Translocation:	To be moved from one part of a plant to another by the plant's own vascular system.
Transpiration:	Evaporation of water from within a plant through its foliage.
Turf:	A mat formed on soil surface by grass, including root system.
Vapor drift:	The movement of herbicide vapor through the air away from the area of application.
Vapor pressure:	A chemical property that causes liquids to evaporate. The lower the vapor pressure, the faster a liquid evaporates.
Vines:	Woody or succulent plants that climb by tendrils or by twining, or that trail along the ground.
Viscosity:	The resistance of a liquid to flow readily. Viscosity usually decreases as temperature increases.
Volatile:	A substance that evaporates or vaporizes at ordinary temperature when exposed to air.
Warm season:	Grasses that reach their peak growth in midsummer. They have deep roots that allow them to have lush, green growth during July and August when cool season grasses are dying out.

Weed:	Any plant growing where it is not wanted.
Wettable powder:	A powder applied as a spray by mixing with water, forming a suspension rather than a solution.
Wetting agent:	A chemical added to a liquid spray mix to improve contact when the liquid is applied to plants.
Wildflower route:	A highway or system of highways that has been identified as having significant native or planted population of wildflowers available for viewing by travelers.
Winter annual:	A plant that germinates in fall, overwinters as a rosette, and produces seed during the second growing season.
Woody plants:	Plants that develop woody tissue above ground.
Xylem:	Plant tissue that primarily conducts water upward within the plant. In woody plants, the xylem exists throughout the heartwood.

From *Roadside Almanac; Roadside Vegetation Management Manual,* PennDOT; Mn/DOT spec book, and *How to Develop and Implement an Integrated Roadside Vegetation Management Plan*