Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers
The Minnesota Forest Resources Council (MFRC) was charged under the Sustainable Forest Resources Act of 1995 with coordinating the development of site-level timber harvesting and forest management guidelines. In response to this mandate, the MFRC convened four multi-disciplinary technical teams to develop guidelines for riparian zone management, wildlife habitat, historic/cultural resources and forest soil productivity. The technical team guidelines were developed through consensus over a two-year period and then integrated to produce a single set of guidelines.

Guideline development is an iterative process, where guidelines are modified as new information on the effectiveness of specific guidelines becomes available. Since publication of the original guidelines in February 1999, the MFRC has sponsored three peer reviews and two public reviews of the guidelines. The revisions to the guidelines contained in this guidebook reflect the recommendations agreed to by the MFRC’s various technical committees, the MFRC Ad-Hoc Committee on Guideline Revision, and the full MFRC.

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Reproduction of this guidebook is encouraged. Any modification, however, must first be approved by the Minnesota Forest Resources Council.

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PART 1
THE PURPOSE
OF INTEGRATED GUIDELINES

The Forest

The forest is a diverse and complex community that includes plants, animals, microorganisms and people—along with the surrounding physical environment they inhabit, in which trees are the dominant life form.

Photo courtesy of Minnesota DNR
Sustaining forest resources for future generations depends on balancing a diversity of social, economic and environmental objectives, including:

- Production of timber for wood and paper products
- Providing recreational opportunities
- Protection of cultural resources
- Enhancement of scenic beauty
- Improvement of wildlife habitat
- Conservation of water and soil resources
- Maintaining the viability of rural communities

Photos courtesy of Minnesota DNR (above) and Potlatch Corporation (below)
A Framework of Balance and Stewardship

Forest management can contribute to the long-term sustainability of forested lands in Minnesota. Harvesting timber stands, prescribed burning, the use of pesticides, and the ongoing regeneration of forests contribute to the long-term health, productivity and sustainability of valuable forest resources.

Like many other human activities, from building houses to growing crops to living on a lake, forest management activities also have the potential to adversely affect site-level forest functions and values. As the needs and desires of society impose ever-increasing demands on forest resources, the responsibility to meet those increased demands without compromising the overall sustainability of forest resources becomes more challenging. Within a sound stewardship framework, however, forest management can occur at the site level with no adverse effects on the sustainability of the entire forest ecosystem.
A Diversity of Needs

Sustainability means meeting the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable forestry is a proactive form of management that provides for the multiple uses of the forest by balancing a diversity of both present and future needs. It is a process of informed decision-making that takes into account resource needs, landowner objectives, site capabilities, existing regulations, economics and the best information available at any given time.

Those concerned about forest management have long recognized the challenge of balancing social, economic and environmental objectives and implications. They also recognize the complex relationship between forest management practices and the long-term sustainability of our forests.

The Concept of Integrated Guidelines

Integrated resource management approaches, comprehensive planning, and recommended practices and guidelines are not new ideas. So what is new? Three things:

- The concept of one set of integrated guidelines to support the sustainability of many different resources within forest communities
- The recognition that guidelines should be designed to accommodate a wide range of resource needs, landowner objectives and site conditions
- The idea of a broad-based, collaborative approach to developing user-friendly guidelines applicable to forests throughout Minnesota

To address the concern that some components of the forest are sensitive to the impacts of increasing uses, the Sustainable Forest Resources Act (SFRA) of 1995 directed the Minnesota Forest Resources Council to coordinate development of an integrated set of voluntary site-level timber harvesting and forest management guidelines.
Integrated guidelines recognize the forest as a community of related resources, rather than a collection of separate resources. Photo courtesy of Minnesota Department of Tourism

This concept of integrated guidelines recognizes the forest as a community of related resources, rather than a collection of separate resources. Integrated guidelines reflect the forest ecosystem that they are designed to help sustain. For information about the guideline development process, see Appendix A: How the Guidelines Were Developed.

**Who Will Use the Guidelines**

These forest management guidelines have been developed for use by forest landowners, resource managers, loggers, contractors and equipment operators, who share a concern for balancing forest management activities and the long-term sustainability of forest resources. Although many individuals may participate in managing a particular site, final decisions regarding guideline implementation lie with the landowner.

These guidelines were designed to help landowners, resource managers and loggers determine how to protect the functions and values of forest resources during forest management activities. They do not provide advice on whether to manage or which management activities are needed.
Factors That May Affect Implementation

These guidelines are just that—guidelines. **Voluntary implementation** of these guidelines may be affected by a number of factors, including:

- Federal, state and local regulations
- Economic considerations
- Site characteristics
- Landowner objectives
- Perceived benefits
- Effectiveness of information/education efforts

Recognizing the Need for Flexibility

Because no single set of guidelines can effectively address the concerns of all situations and all areas, guidelines need to be flexible enough to address site-specific conditions. This flexibility also allows guidelines to be modified to balance resource needs, landowner objectives and site capabilities—as long as modified approaches still achieve the same management goals.

Besides being flexible, these guidelines may evolve and change over time. Guideline revisions may occur in the future to reflect new information, new perspectives or new priorities.
What The Guidelines Are...

- The guidelines are designed to be flexible, recognizing that both site conditions and landowner objectives vary. Determining the most appropriate guidelines for implementation on a particular site depends on the informed judgment of the landowner, resource manager or logger responsible for that site.

- It may be possible to implement several guidelines simultaneously in some instances. For example, trees left to protect cultural resources may also satisfy mast guidelines for wildlife, as well as apparent harvest size guidelines for visual quality.

- Implementation of the guidelines is voluntary.

- The guidelines are designed to help forest landowners, resource managers and loggers meet two goals:
  - Conduct forest management activities while addressing the continued long-term sustainability of diverse forest resources.
  - Promote or enhance the functions and values of water and soil resources, riparian areas, wildlife habitat, visual quality and cultural resources.

- The guidelines represent practical and sound practices based on the best available scientific information.

- The guidelines are designed to assist with site-level forest management. They are not designed to provide broad-based landscape direction.
...and What They Are Not

☐ The guidelines are not a substitute for a resource management plan. They are intended to support implementation of a plan once it is in place.

☐ The guidelines are not intended to replace any existing rules or regulations.

☐ The guidelines are not intended as a substitute for obtaining professional assistance as needed to achieve management objectives or meet appropriate engineering standards. They are guidelines, not construction standards or engineering specifications.

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

☐ The guidelines are not intended to address all forest management activities and all forest resources. They address major forest management activities as they relate to selected components of a healthy forest.

☐ The guidelines do not cover all management options related to a particular forest resource. Wildlife guidelines, for example, provide the essentials to address site-level habitat issues, but they do not list all possible techniques for improving forest habitats or for managing particular species.
PART 3

INTEGRATED GUIDELINES

The Purpose of Integrated Guidelines

The purpose of integrated forest management guidelines is to provide consistent, coordinated guidance in sustaining many of the functions and values of our forest resources, including (as outlined in Part 2) cultural resources, forest soil productivity, riparian areas, visual quality, water quality and wetlands, and wildlife habitat.

Forest management includes a broad diversity of activities related to using, maintaining and sustaining Minnesota forests. Major forest management activities, which these integrated guidelines address, include:

- Forest road construction and maintenance
- Timber harvesting
- Site preparation
- Pesticide use
- Reforestation
- Timber stand improvement
- Fire management
- Forest recreation management

These guidelines focus on how to protect the functions and values of forest resources during forest management activities. They do not provide advice on whether to manage or which management activities are needed.
How the Guidelines Will Help Sustain Forest Resources

The following outcomes identify the overall benefits of these integrated forest management guidelines. Addressing six forest resources (cultural resources, forest soil productivity, riparian areas, visual quality, water quality and wetlands, and wildlife habitat), the guidelines for forest management activities provide substantial benefits to the sustainability of forest ecosystems by:

- **Increasing awareness of cultural resources** among forest landowners, resource managers and loggers, and protecting important cultural resources.

- **Maintaining the productive capacity of forest soils**, to favor the regeneration, survival and long-term growth of desired forest vegetation.

- **Maintaining and enhancing vegetation within riparian areas** for the benefit of water quality, fish and wildlife, timber products, recreation and aesthetics.

- **Maintaining and enhancing scenic quality in forested areas** for the enjoyment of tourists, recreational users and local travelers.

- **Maintaining water quality and protecting wetlands.**

- **Encouraging stewardship of wildlife habitat and forest communities**, including all organisms that depend on forests for all or part of their needs.
Two Types of Guidelines: General and Activity-Specific

The guidelines that provide these benefits to forest resource sustainability are divided into two groups: general guidelines, which are common to many forest management activities; and activity-specific guidelines, which apply to specific forest management activities.

The guidelines are supplemented from time to time by “Additional Considerations,” which provide additional guidance to further promote the sustainability of forest resources.

GENERAL GUIDELINES
Common to Many Forest Management Activities

These forest management guidelines are designed to help sustain the following forest resources: cultural resources, forest soil productivity, riparian areas, visual quality, water quality and wetlands, and wildlife habitat. These guidelines are applicable to many forest management activities, including forest road construction and maintenance, timber harvesting, mechanical site preparation, pesticide use, reforestation, timber stand improvement, fire management and forest recreation management.

While many guidelines address only one or two particular forest management activities, a number of the guidelines are applicable to many activities. For example, guidelines for managing fuel and lubricants or maintaining coarse woody debris are not specific to any one forest management activity; they apply to all activities, as do guidelines for goal-setting and conducting a preliminary site inventory.

These general guidelines represent a basic framework for sustaining forest ecosystems, providing a common foundation of “how-to’s” that apply to many different management activities.
ACTIVITY-SPECIFIC GUIDELINES
Applicable to
Particular Forest Management Activities

Beyond the general guidelines, which share a common application to many—if not all—forest management activities, many guidelines apply to particular forest management activities. These activity-specific guidelines are unique to a particular activity. They are designed to work together with the general guidelines to provide a coordinated framework for helping ensure the sustainability of the functions and values of our forest resources.

Within activity-specific guidelines, frequent references back to the general guidelines will make it easy for landowners, resource managers, loggers and others to consider all of the related guidelines—both general and specific—that apply to a particular management activity.
GENERAL GUIDELINES
Common to Many Forest Management Activities

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GENERAL GUIDELINES

Common to Many Forest Management Activities

General guidelines are divided into two sections: Planning and Operational Activities. These two sections suggest that a commitment to sustainability of forest resources is both a planning commitment and an operational commitment:

- The Planning section recognizes that many planning considerations related to resource protection and forest sustainability are common to most forest management activities, and that the commitment to sustainability begins in the early planning stages—long before the actual management activity begins.

- The Operational Activities section focuses on general on-site guidelines that carry out the commitment to sustainability that was begun during the planning phase.
REMEMBER:

Guidelines help with how to manage, not whether to manage.

These guidelines focus on **how** to protect the functions and values of forest resources during forest management activities. They **do not** provide advice on **whether** to manage or **which** management activities are needed.

**Guidelines provide a menu, not a mandate.**

Site-level resource management decisions are based on many different factors, including resource needs, landowner objectives, site capabilities, existing regulations, economics and the best information available at any given time. **No one will apply all of the guidelines** related to a particular activity. Instead, the landowner, resource manager or logger will consider many different factors in determining which combination of guidelines provides the best “fit” for a particular site at a particular time. The intent of having multiple guidelines is to provide decision-makers with as much flexibility—and as much choice—as possible in taking steps to effectively balance forest management needs and resource sustainability.

**Guidelines are supplemented from time to time by “Additional Considerations.”**

The guidelines are supplemented from time to time by “Additional Considerations,” which provide additional guidance to further promote the sustainability of forest resources.
PLANNING

Identifying Goals and Objectives

Getting started requires identifying land ownership goals and objectives, and understanding your soil-site relationships and current forest condition. This first step may require the assistance of professionals. A few considerations related to identifying goals and objectives include the following:

❑ **Planning for the long term is critical** to managing a forest. Why? Because whatever a landowner does (or doesn’t do) will have long-term effects.

❑ **Recognizing landscape-level considerations** in your plan is helpful to understand how your property is linked to the range of goals and directions of other landowners and groups, vegetation, presence of water resources, and land use practices in your area. Landscapes are areas consisting of many ownerships influenced by natural and human processes. Just as you have goals for your property, others—including your neighbors, township board and watershed district—also have goals that guide their activities (Figure GG-1). For additional information on planning groups, see Resource Directory.

❑ **It is important to consider how management activities can influence nearby ownerships or how management on other ownerships may influence your ownership.** Some example landscape-level considerations you should think about in your own planning may include:

  • How management along water bodies on your land may influence water quality (e.g., sediment and temperature) and quantity (e.g., flow) downstream and across the watershed.

  • What wildlife species may be favored by management on your land in relation to available habitat across the landscape.

  • How management on your land may maintain or create resources, forest types, or habitats that are unique in the landscape.
• How management of leave trees adjacent to seasonal ponds may be influenced by how much of the landscape is in young forest and the adjacency of this young forest to seasonal ponds.

• How good stewardship on your land can benefit the ecological health and productivity of the surrounding forest.

• How management on your land may be visible from roads and trails altering the views of users.
• How use of existing road networks to access your land can diminish the need to construct new roads.

• How the existence of cultural resources may alter land use and management.

• How collaborating on creation of or extending trails can benefit recreation, hunting, cross-country skiing and hiking.

**Developing a management plan** will assist the landowner in determining objectives, managing efficiently, avoiding costly errors, making knowledgeable decisions and evaluating progress.

**Identifying ownership goals and objectives** for the property is the first step in planning how to manage a forest.

Begin by identifying the following:

• What resources are most important: trees? soil? water? recreation? wildlife? fish?

• What kind of inventory will have to be taken?

• Are stated goals and objectives for the site in question really possible?

Then ask these three questions:

• **What** does the landowner want from the forest?

• **How much** does the landowner want?

• **When** does the landowner want it?

**Making objectives specific** will make management choices more clear. Professionals may be able to help clarify objectives and make them specific.

**Establishing priorities is an essential step** whenever multiple objectives exist.

**Once goals and objectives are identified**, the next step for a landowner is to determine whether to move forward without professional assistance, or whether the assistance of professionals would be beneficial. For sources of professional assistance, see *Resource Directory*. 
Conducting a Site Inventory

Conducting a site survey involves gathering information, surveying the site firsthand, and then considering a number of factors related to resource needs, landowner objectives and site capabilities. The following planning and design considerations are not all inclusive, but they do identify some of the key factors in making informed forest management decisions.

Gathering Information

✔ Secure aerial photographs, topographic maps, soil surveys, visual sensitivity classification maps and other tools available to provide assistance in evaluating properties and developing plans for forest management activities. Sources of this information include local Soil and Water Conservation District (SWCD) offices, local USDA Natural Resource Conservation Services (NRCS) offices, local Department of Natural Resources (DNR) offices, and county land departments. Many counties have completed soil surveys, and a number of them have also developed visual sensitivity classification maps.

For sources of these information tools, and for a list of counties that have developed visual sensitivity classification maps, see Resource Directory.

✔ Find out whether any special management considerations exist on adjacent properties. For sources of information and assistance, see Resource Directory.

✔ Check existing cultural resource inventories to determine whether any cultural resources are known to be present within the management area. For sources of cultural resource inventories, see Resource Directory.

✔ Assess cultural resource potential. Identification of cultural resources is fundamental for protection of those resources. See Part 2, Cultural Resources: Identifying, Assessing and Managing Cultural Resources and Resource Directory.
Consult a Minnesota DNR wildlife manager, forester or nongame specialist, or Minnesota Natural Heritage staff for information about the occurrence of endangered, threatened or special concern species (ETS species), sensitive communities, or sensitive sites on or near the management area prior to beginning management activities. For additional contact information, see Resource Directory.

Determine whether permits are required from the DNR for crossing of intermittent or perennial streams and open water wetlands. See Appendix H: Types of Work Activities That Do Not Require a DNR Public Waters Work Permit on Public Waters, Public Water Wetlands and Public Watercourses.

Additional Consideration

Consider doing additional research on the history of the project area, especially if existing cultural resource inventories contain no information about the area. Such research efforts may include checking existing maps, air photos and printed historical information, as well as contacting individuals knowledgeable about local history or archaeology. For additional information, see...

Surveying the Site Firsthand

Conduct an on-the-ground evaluation of all land being considered for the forest management activity. It is important to have this firsthand knowledge of the area being considered. Familiarity with soils, terrain and vegetation in the area will assist landowners and resource managers in:

- Making decisions related to operating periods, harvest methods and equipment, tree species suitability, or reforestation strategies
- Choosing appropriate methods of operation
- Affirming (or modifying) forest management objectives
The preliminary site survey evaluates many resources, features and site conditions, including soil characteristics, such as soil texture, which may be determined by hand. *Photo courtesy of Minnesota DNR*

✔ **Evaluate soil conditions** to determine tree species, preferred seasons of operation, site preparation and regeneration techniques, and other information related to forest management decisions.

✔ **Identify resources, features and site conditions** that may require special attention, such as:

- Perennial and intermittent streams, lakes, open water wetlands, non-open water wetlands and seasonal ponds
- Steep slopes, rock outcrops, unstable or poorly drained soils, sinkholes, seeps and springs (See Figure GG-2.)
- Snags and nesting sites
- Cultural resources
- Soil or site conditions that may dictate specific operational timing or methods and equipment to be used, or that may lead to weather-related or seasonal closure of the operations
- Special soil conditions and topographic features that make some areas of the state more sensitive than others to accelerated erosion due to soil disturbance
Factors To Consider in Site Evaluation

After identifying the physical characteristics of the site during an on-the-ground evaluation (as detailed in the previous section), it is also important to identify how these characteristics may affect the planning and design of a particular forest management activity.
Some of these considerations include:

- Soil capabilities and limitations (For information on how to obtain soil interpretations relating to equipment operations, see Resource Directory.)

- Location and width of filter strips and riparian management zones (RMZs)

- Stream crossings

- Visual sensitivity areas

- Evaluating the most efficient use of existing and planned infrastructure (the network of access roads, approaches, trails and landings used to move equipment onto and around a forest management site). Infrastructure considerations include the following:

  - Roads, trails, landings and approaches needed to meet objectives

  - Adequacy of any roads, trails and landings already in existence

  - Assessment of additional roads, trails, landings and approaches needed
Communicating Information

Landowners and resource managers should document their management decisions to help ensure that the resource managers, loggers and operators understand their management objectives and what is required to protect and maintain specific site resources. Landowners should consider the following:

✔ **Create a site map or conduct an on-site review** with the operator to indicate the location of any special concern areas identified during the site survey. Be sure that maps are large enough to adequately depict sensitive areas. See Figure GG-3. The site map or on-site review should clearly identify the location of:

- Streams, lakes, wetlands and seasonal ponds
- Roads and landings on the timber sale
- Approved road and skid trail crossings for the timber harvest. Indicate which of the crossings require a public waters permit.
- Landings used as fueling and maintenance areas
- Reserve islands, boundary lines, corner monuments and other protected items

✔ **Document the width and residual basal area of the RMZ** and the management objective for the RMZ. That management objective (e.g., early successional wildlife habitat, retention or regeneration of long-lived conifer species) may be the same or different from the objective for the general harvest area. Indicate the preferred residual tree species, as well as the distribution of those residual trees within the RMZ (e.g., clumped, scattered).

✔ **Document leave tree clumps or scattered individual leave trees** within the general harvest area and adjacent to the RMZ for even-age management.

✔ **Document the type and spacing of water diversion devices** to be used for roads and skid trails, and especially for all road and skid trail water crossings.
Figure GG-3

Harvest Site Map

- Timber sale boundary
- Temporary road
- Skid trail
- Bridge
- Landing
- Perennial stream
- Intermittent stream
- Filter strip/RMZ
- Filter strip
- Water bar
- Wetland
✔ **Document the soil types (or series)** present and identify the important properties that should be retained.

✔ **Share any information gained** by those conducting the preliminary evaluation among involved landowners, resource managers, loggers and operators. Sharing information helps to assure a common understanding of landowner objectives, existing regulations and site conditions.

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**Incorporating Sustainability into Forest Management Plans**

Forest management activities should follow a well-thought-out plan that defines such factors as the extent and duration of the activity, the most appropriate season and method of operation for the activity, appropriate forest management guidelines to limit site disturbance, and other management objectives related to forest resource sustainability.

The timing of forest management activities or recreational activities can be constrained by pre-existing or seasonal conditions, regulations and limitations, such as seasonal road load limits, seasonal forest access limitations, forest fire hazard conditions, and appropriate times for such activities as herbicide treatments, tree planting and road construction.

---

**Timing and Coordination of Activities**

✔ **Conduct forest management activities** when soil conditions are firm enough to support the type of equipment being used, in order to protect soil productivity and minimize damage to any cultural resources that may be present.
Plan to conduct forest management activities in wetlands when frozen or when firm enough to support equipment being used. Evaluate the site based on weather conditions to ensure adequate support for equipment to prevent or minimize rutting. Examples of weather conditions that could be cause for concern include heavy rain, flooding, significant snow before frost, and three consecutive nights above freezing after frost has been established.

Plan for removal of equipment and cut material from wetland areas prior to thawing at the end of the winter season, or leave it until the next winter.

Plan to conduct activities during the preferred operating periods for site and soil conditions. Preferred operating periods for a site may vary due to local and seasonal climatic conditions, equipment being used and operating techniques.

Combine and integrate forest management activities where appropriate to reduce or eliminate the need for multiple entries by heavy equipment. For example, full-tree skidding may be used for preparation of jack pine seed beds, eliminating the need for additional site preparation.

Protect reserve areas and structural habitat components retained in previous stand treatments.

Winter harvesting is one example of timing forest management activities to protect soil and cultural resources, as well as to avoid periods of peak summer recreational use. Photo courtesy of Minnesota Timber Producers Association
Timing and Coordination of Activities
To Reduce Noise and Visual Impacts

In areas classified as most sensitive:*

✔ Avoid management operations during periods of peak recreational use whenever possible.

✔ Reduce noise in early morning, late evening and other appropriate times whenever possible.

✔ Selectively restrict use of recreational facilities to avoid conflict with management activities.

✔ Temporarily relocate recreation trails away from management activity areas.

✔ Inform and educate recreational users regarding management issues, limitations and timing prior to, during and after management activities.

In areas classified as moderately sensitive:*

✔ Selectively restrict use of recreational facilities to avoid conflict with management activities.

✔ Time management activity with consideration for public use patterns.

✔ Minimize direct conflict with forest recreational users during peak use and special event periods.

✔ Temporarily relocate recreation trails away from management activity areas.

✔ Inform and educate recreational users regarding management issues, limitations and timing prior to, during and after management activities.

In areas classified as less sensitive:*

✔ Limit time constraints to special events or site-specific concerns.

*See Part 2, Visual Quality: Visual Sensitivity Classifications for information related to how classifications are determined and which Minnesota counties have developed visual sensitivity classification maps.
Designing Operations To Fit Site Conditions

✔ **Determine the preferred operating season** for a specific site to help avoid unwanted impacts to the site, as well as the costly process of moving equipment from a site or shutting down operations if negative impacts are occurring.

✔ **Take into account that the preferred operating season may vary** for any one site depending on soil characteristics, local climatic conditions, equipment being used, and operating techniques. The use of low ground pressure (LGP) equipment and such operating techniques as using slash mats to drive on can extend operating seasons on low-strength soils.

✔ **Use caution when operating heavy equipment** on sites whenever adverse soil impacts are likely. Soil susceptibility to compaction and rutting is primarily dependent on soil texture and moisture content. Soils are most susceptible to compaction, rutting and puddling at the following times:

- During spring and early summer months
- Immediately following heavy rains
- During the period between when transpiration ceases in the fall and before freeze-up occurs

Managing and Minimizing Infrastructure

In the context of forest management activities, infrastructure is defined as the network of access roads, approaches, trails and landings used to move equipment onto and around a forest management site.

Any reduction in the total amount of area occupied by such infrastructure reduces the impact on soil productivity, as well as potential impacts to cultural resources, riparian areas and wildlife habitat. For more information on how to obtain soil interpretations relating to equipment operation, see Resource Directory.

✔ **Consider future management activities that may use common infrastructure** for management of adjacent stands or ownerships. Develop or plan infrastructure accordingly.
✔ Examine existing access routes to determine whether they are the best routes to improve. Consider whether relocation would provide a better long-term access route.

✔ Where appropriate, limit direct trafficking of a site to the smallest area necessary when planning such management activities as harvesting and site preparation.

**Equipment, Fuel and Lubricants**

Forest management activities often require the use of a variety of equipment during field operations, as well as the associated use of fuels and lubricants. These operations typically occur at remote locations, with maintenance activities taking place on-site.

Precautions are needed to prevent soil, water and wetland contamination when using fuels, lubricants and other materials associated with heavy equipment operations. Proper planning will help prevent or minimize spills of fuels, lubricants or other materials.

Contamination of soil, water and wetlands can be prevented with proper planning, such as this remote storage tank for waste oil. *Photo courtesy of Minnesota DNR*
✔ **Eliminate or reduce potential contamination arising from spills.** Routine maintenance of equipment, including regular checks of hoses and fittings for leaks or wear, is essential to protecting streams, lakes, wetlands, seasonal ponds, ground water and soils from the impacts of fuel and lubricant spills and leaks.

✔ **Place fueling and maintenance areas,** wherever practical, outside of filter strips or the riparian management zone, whichever is wider.

### Water Quality and Wetlands

✔ **Plan forest management activities to avoid operations in wetlands,** including building landings, skid trails and roads. Where avoidance is not practical, minimize impacts by limiting the extent of wetland activities.

✔ **State and federal wetland regulations provide an exemption** for roads constructed for the primary purpose of providing access for conducting forest management activities. It is not necessary to apply for the forestry exemption; however, you are encouraged to contact local zoning authorities if you have any questions or concerns.

Under the Minnesota Wetland Conservation Act (Minnesota Rules Chapter 8420.0122 Subp. 7), a replacement plan for wetlands is not required for 1) temporary or permanent crossings, or for 2) entering a wetland to perform silvicultural activities, including timber harvesting as part of a forest management activity, so long as the activity:

- Limits the impact on the hydrologic and biologic characteristics of the wetland.

- Does not result in the construction of dikes, drainage ditches, tile lines or buildings.

- Does not result in the drainage of the wetland or public waters.

- Avoids filling whenever possible.
To qualify for an exemption under the Minnesota Wetland Conservation Act (Minnesota Rules Chapter 8420.0115), the primary use of the road must be for forest management activities, and an individual or organization:

- Must use appropriate erosion control measures to prevent sedimentation of water.
- Must not block fish activity in a watercourse.
- Must comply with all other applicable federal, state and local requirements, including water resource protection requirements and water quality Best Management Practices (BMPs), as presented in Protecting Water Quality and Wetlands in Forest Management: Best Management Practices in Minnesota (1995).


Rare or Sensitive Species

✔ Modify management activities to maintain, promote or enhance ETS species (endangered, threatened or of special concern) on the site.

✔ Avoid forest management activities that isolate or eliminate populations of tree species at the edge of their range. Favor these species by promoting natural regeneration, as leave trees, or through other suitable methods to perpetuate them on site. See Part 2, Wildlife Habitat: Sensitive Communities and Sites, and Tree Species at the Edge of Their Range.
Additional Consideration

Consider consulting with the DNR or other forest management experts on ways to maintain or enhance sensitive communities and sites while conducting forest management activities on or near them. For a specific listing of sensitive communities, see Part 2, Wildlife Habitat: Sensitive Communities and Sites, and Tree Species at the Edge of Their Range.

Maintaining Filter Strips

Managing land to control nonpoint source pollution near surface water and wetlands is important. Timber harvesting activities, mechanical site preparation, prescribed burning and road construction increase the potential for sedimentation due to mineral soil exposure.

Planning Considerations

- Maintaining a filter strip between the water body and the forest disturbance can protect surface water. Filter strips are areas adjacent to perennial and intermittent streams, lakes, open water wetlands, non-open water wetlands, seasonal ponds, seeps and springs that help minimize the runoff of sediment, debris, nutrients and pesticides into these water bodies.

Filter strips provide a zone of infiltration that protects surface water by 1) allowing remaining vegetation to remain essentially undisturbed, and 2) allowing the forest floor to trap sediment from adjacent land areas.

- Forest management activities may be conducted in filter strips as long as the integrity of the filter strip is maintained. These activities should produce minimal exposure of mineral soil.
Defining Filter Strips

✔ Apply the following filter strip guidelines to all perennial and intermittent streams, lakes, open water wetlands, non-open water wetlands, seasonal ponds, seeps and springs. Filter strips should border and parallel the edge of all water bodies.

Apply them independently of the width of the riparian management zone, and adhere to them except when the recommended 5% maximum level of mineral soil exposure is unacceptable for the regeneration of certain desired species:

- Limit mineral soil exposure to less than 5%, well distributed throughout the filter strip.
- Avoid concentrating disturbance in the filter strip, to prevent concentration of flows across the filter strip.
- Establish filter strip widths based on percent and length of slope. See Table GG-1, Figure GG-4 and Figure GG-5.

### Filter Strip Width Guide

<table>
<thead>
<tr>
<th>Slope of land between activity and water body</th>
<th>Recommended width of filter strip (slope distance)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10%</td>
<td>50 feet</td>
</tr>
<tr>
<td>11-20%</td>
<td>51-70 feet</td>
</tr>
<tr>
<td>21-40%</td>
<td>71-110 feet</td>
</tr>
<tr>
<td>41-70%</td>
<td>111-150 feet</td>
</tr>
</tbody>
</table>

*For roads, distance is measured from the edge of soil disturbance. For fills, distance is measured from the bottom of the fill slope. Filter strip width increases approximately 2 feet for each percent increase in slope above 10%. For example, the filter strip recommendation for a range in slope values from 11 to 20% is 51 to 70 feet. If the slope is 18%, then the filter strip width is 66 feet.

Table GG-1
Filter Strips and RMZ for Non-Trout Perennial Streams < 3 Feet Wide of Varying Slopes in High Bank and Upland Forests.

Slope <10%

Slope 20%

50’ RMZ

50’ Filter Strip

70’ Filter Strip

Figure GG-4
Filter Strips and RMZ for Designated Trout Streams Where Slope Is < 10%:
Even-Age Management
• Minimize compaction in filter strips while conducting forest management activities on soils susceptible to compaction by:

  — Harvesting under frozen soil conditions; or

  — Using equipment that minimizes the potential for compaction; or

  — Using such operating techniques as slash mats for skid trails and roads.

✔ Consider additional stabilization measures when necessary, such as the use of slash, straw bale barriers, establishment of vegetation by seeding, mulch, and silt fences, including instances when:

• An area of soil is exposed within the filter strip and sedimentation is likely to result.

• Management objectives preclude the use of a filter strip and sedimentation is likely to occur.
Managing Riparian Areas

Riparian management zone (RMZ) guidelines should be determined during the on-the-ground evaluation of the site. They are based on the topography, hydrology and vegetation within the riparian area.

Width, residual basal area and other recommendations are provided based on different types of water bodies, site conditions within the riparian area, and management objectives (even-age or uneven-age management).

The recommended width and basal area guidelines and the flexibility considerations apply within the RMZ. **Outside of the RMZ, normal operations apply,** unless other guidelines further modify those operations.

**Forest management activities may be conducted** within the riparian management zone.

Components of RMZ Guidelines

Riparian management zone guidelines include width and residual basal area recommendations:

- **Recommended widths** are measured along the slope distance from the edge of the water body. Where the edge of the water body is not a straight line, the RMZ width may either parallel that edge or be a straight line (see Figure GG-6). In either case, the width that is applied on the ground represents the average distance from the water’s edge.

- **Basal area** is the cross-sectional area of a live tree 4.5 feet above ground (based on its diameter at breast height, or DBH). Basal area describes the extent to which an area is occupied by trees (a relative index of the density of trees in an area). It is expressed in square feet per tree (ft²/tree) or per acre (ft²/acre). See Appendix E: Determining Basal Area.
Crown closure (the degree to which the forest floor is shaded by tree crowns when the sun is immediately overhead) can also provide an approximation of the extent to which an area is occupied by trees. See Appendix E: Determining Basal Area.

In addition to width and basal area recommendations, there are other riparian guidelines which address other issues within the RMZ. See Incorporating Riparian Guidelines into Plan Design (page 38).
Sample Location of Harvest Activity in Relation to RMZ Boundaries
(Uneven-Age Management Adjacent to a Designated Trout Stream)

On average, the recommended Riparian Management Zone (RMZ) width is 200', and can be straight or irregular in character.
Flexibility Considerations

The variability of site conditions and landowner objectives points to the need for flexibility and professional judgment in making forest management decisions within RMZs. The following flexibility considerations, which are applicable to streams, lakes and open water wetlands, can help landowners, resource managers and loggers make appropriate forest management decisions.

- The width and residual basal area guidelines represent recommendations designed to protect and maintain riparian functions and values. Landowners, resource managers, loggers and contractors should consider the silvicultural needs of the species to be managed, as well as the protection and maintenance of riparian functions and values. Forest management plans within RMZs should consider stream characteristics, as well as goals related to forest regeneration, fisheries and recreation.

- It is acceptable to vary above or below recommended width and residual basal area guidelines, including those situations in which the management objective is to mimic natural processes. Landowner management objectives and management recommendations for the RMZ should be documented during the planning process.

- The slope aspect (direction that the slope faces) should not determine whether the RMZ guidelines should be altered around a water body, since shade is not the sole function of an RMZ.

- The residual basal area within the RMZ should be relatively evenly distributed throughout the RMZ. Gap and clump regeneration patterns may be used. See Figure GG-7.

- Cleared areas within the RMZ should be kept to the minimum size required to meet forest management objectives, while also considering the protection and maintenance of riparian functions and values.

- Consider that many riparian functions and values are best maintained at higher residual basal areas, which will not provide the best regeneration of species managed using even-age management approaches. See Recognizing Tradeoffs, page 35.
Figure GG-7

Residual Distribution Options Within the RMZ

The same RMZ shown with relatively even distribution of residuals (above), and gap and clump distribution of residuals (below).
Best professional judgment should be used to determine the species and distribution of residual trees within the RMZ. Consider:

- Site conditions (such as steep slopes or highly erodible soils)
- Species
- Wildlife habitat needs, especially for cavity-nesting riparian species
- Bunching or clumping of residuals may be desirable to reduce windthrow or promote regeneration of shade-intolerant species
- Favoring tree retention near the bank edge
- Other management objectives

Decisions regarding residual species, as well as individual trees to be retained, should be based on the following considerations:

- Distribution and arrangement within the RMZ
- Regeneration requirements (such as shade tolerance and amount of scarification needed)
- Crown size (for example, maples generally have a larger crown than aspens)
- Windfirmness (including rooting pattern and pre-harvest exposure to wind), longevity, cavity potential, diameter and height. See General Guidelines: Retaining Leave Trees, pages 75-78.
- Stressors in the environment, such as insect and disease threats
- Desirability of retaining or regenerating conifers adjacent to trout water bodies

Application of some wildlife-related guidelines may differ within and outside of the RMZ. For more detail, see Part 2, Wildlife Habitat: Riparian Wildlife Habitat.
Recognizing Tradeoffs

As with many forest management activities and decisions, riparian guidelines may present tradeoffs that need to be considered.

One example of such tradeoffs is the density of residual trees, as measured by residual basal area, when considering even-age management guidelines.

According to management guidelines for aspen (a species commonly managed using even-age management approaches):

“For best aspen sucker regeneration...the parent stand must have a minimum aspen density of 50 trees or 20 square feet basal area per acre. To stimulate suckering, allow heat and light to reach the forest floor by removing as much of the overstory as possible, preferably all trees 2 inches or more DBH (diameter at breast height). As little as 10 to 15 square feet basal area of residual overstory will slow sucker growth by 35 to 40 percent.” (Perala 1979).

In contrast, however:

The protection and maintenance of riparian functions and values (such as inputs of coarse woody debris and fine litter, bank and shoreline stability, shading of the water body, and aesthetics) is enhanced by leaving more residual overstory than is normally recommended to promote the best regeneration of shade-intolerant species such as aspen.

A tradeoff exists. In this case, riparian functions and values are best maintained at residual basal areas that will not provide the best regeneration of shade-intolerant species such as aspen.

(continued on page 36)
Another example of these tradeoffs is the issue of the width of the riparian management zone. Not all riparian functions and values are equally important at all distances from the water’s edge.

While the area closest to the water body is most important for protecting riparian functions and values, that importance decreases and can become very low at a location some distance from the water’s edge.

Tradeoffs can also interact with each other. As an example, regeneration of shade-intolerant species may be sufficient when more residual overstory is retained if the slope, aspect or width of the RMZ allows heat and light from the side to reach the forest floor.

In recognition of these and other tradeoffs, the RMZ guidelines include several recommendations that are intended to provide flexibility for accommodating a range of landowner objectives and site conditions, including forest diversity. Exercise professional judgment when making riparian recommendations. Landowner management objectives and management recommendations for the riparian management zone should be documented during the planning process.

*To obtain management recommendations for other species, contact a forestry professional for assistance. See Resource Directory.*
Defining the Riparian Management Zone

Riparian areas deserve special consideration because they are distinctive habitats important to many fish and wildlife species. The riparian management zone (RMZ) is the area where site conditions and landowner objectives are used to determine management activities that address riparian resource needs. It is the area where riparian guidelines apply. Outside of the RMZ, normal operations apply, unless other guidelines further modify those operations.

Forest management activities may be conducted within the RMZ.

Management of riparian areas focuses on differentiating between various types of water bodies and associated site conditions within the riparian area. Riparian area site conditions include topography, hydrology and vegetation.

**Width and basal area recommendations** are based on the following:

- Type of water body
- Riparian area site condition
- Management objective (even-age or uneven-age management)

The recommendations are divided into two primary groups:

- Designated trout streams (and their designated tributaries) and designated trout lakes
- Non-trout streams, non-trout lakes, and open water wetlands

Recommended guidelines for the second group (e.g., non-trout streams, non-trout lakes) vary depending upon the forest type adjacent to the water body.
Incorporating Riparian Guidelines into Plan Design

In addition to width and basal area recommendations for riparian zone management, the following guidelines address additional issues within the RMZ:

✔ **Review Flexibility Considerations** (pages 32-34) and incorporate into forest management activities as appropriate.

✔ **Manage lands adjacent to water bodies** according to forest type and site conditions, including the option of varying from riparian guidelines where the management objective is to mimic natural processes.

✔ **Maintain a forested condition of varying ages** adjacent to water bodies, generally to the top of the adjacent terrace slope when a terrace slope exists.

✔ **Manage for longer-lived, uneven-age, mixed-species stands** within the RMZ to provide:
  - Shade and moderated microclimate
  - Coarse woody debris
  - Microhabitat diversity
  - Resiliency to natural catastrophes
  - Bank stability
  - Nutrient cycling and carbon and nutrient input

✔ **Manage for long-lived conifers in northern Minnesota** as an option where beaver are to be discouraged near water bodies.

✔ **Consider extended rotation forestry** within the RMZ around all streams, lakes and open water wetlands.

✔ **Leave some super-canopy trees and other long-lived species** in the riparian management zone. If possible, choose trees from the “Excellent” category list. This decision will provide habitat for riparian species that require large super-canopy trees (trees above the existing mature canopy) for hunting perches and nesting sites. See Table GG-7: Leave Tree Preferences for Longevity, Windfirmness and Cavity Potential, page 76.

✔ **When a timber stand is in a deteriorating or declining condition**, appropriate forest management activities may be applied to rejuvenate it within the context of assisting the landowner or resource manager in meeting his or her riparian management goals (see Appendix I).
✔ **Clearly identify the RMZ** so that operators can identify its location on the ground. Options to consider include flagging, paint lines or delineation on a map.

✔ **Distribute the residual basal area within the RMZ** relatively evenly throughout the RMZ where windthrow is not a major concern. Avoid creating large cleared areas within the RMZ.

✔ **Create or retain at least four leave logs per acre** within the RMZ. Use sound forest management where insect and disease concerns exist. See *General Guidelines: Providing Coarse Woody Debris*.

✔ **Minimize compaction in filter strips** while conducting forest management activities on soils susceptible to compaction by:

  - Harvesting under frozen soil conditions
  - Harvesting during dry conditions on the appropriate soil types
  - Using equipment that minimizes the potential for compaction
  - Using such operating techniques as slash mats for skid trails and roads

✔ **Adhere to filter strip guidelines** except when the recommended 5% maximum level of mineral soil exposure is unacceptable for the regeneration of certain desired species. See *General Guidelines: Maintaining Filter Strips*.

✔ **Minimize disturbance to other vegetation** (such as brush or grass) within the RMZ where such vegetation provides primary shading, bank stability and energy input. Keep equipment as far as practical from streambanks and approach at right angles to minimize equipment operation on the most susceptible soils.

✔ **Wherever practical, place fueling and maintenance areas, landings and roads** (except those roads that are needed to cross a stream, lake or open water wetland) outside of filter strips or the RMZ, whichever is wider. See *General Guidelines: Maintaining Filter Strips* and *General Guidelines: Managing Riparian Areas*.

✔ **Use diversion structures on approaches to water crossings** or on roads and trails found within the RMZ to divert water off of the right-of-way before it reaches the water body.
Overview of RMZ Width and Residual Basal Area Recommendations

Designated Trout Streams (and Their Designated Tributaries) and Designated Trout Lakes

(even-age and uneven-age management)
Table GG-2 only
Fig. GG-8 (even-age)
Fig. GG-9 (uneven-age)

Non-Trout Streams, Non-Trout Lakes and Open Water Wetlands

Sedge, Grass, Shrubs and Swamp Forests
(even-age and uneven-age management)
Table GG-3 only
(no figure)

High Bank and Upland Forests
(even-age management)
Table GG-3
(general recommendations)
Fig. GG-14 (streams)
Fig. GG-15 (lakes, open water wetlands)
Table GG-4
(specific recommendations)
Table GG-5 and Fig. GG-16
(management considerations)

High Bank and Upland Forests
(uneven-age management)
Table GG-3
(general recommendations)
Fig. GG-17 (streams)
Fig. GG-18 (lakes, open water wetlands)
Table GG-6
(specific recommendations)

(see next page for locator listing)
## Locator Listing for RMZ Tables and Figures

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Table or figure</th>
<th>Page number</th>
</tr>
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<tbody>
<tr>
<td><strong>DESIGNATED TROUT STREAMS</strong> (and their designated tributaries) and designated trout lakes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Table GG-2</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Fig. GG-8</td>
<td>44</td>
<td></td>
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<tr>
<td>Fig. GG-9</td>
<td>45</td>
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<tr>
<td><strong>NON-TROUT STREAMS,</strong> non-trout lakes and open water wetlands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedge, grass, shrubs and swamp forests*</td>
<td>Table GG-3</td>
<td>48-49</td>
</tr>
<tr>
<td>High bank and upland forests*</td>
<td>Table GG-3</td>
<td>48-49</td>
</tr>
<tr>
<td><em>(even-age management)</em></td>
<td>Table GG-4</td>
<td>56-57</td>
</tr>
<tr>
<td></td>
<td>Fig. GG-14</td>
<td>58</td>
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<tr>
<td></td>
<td>Fig. GG-15</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>Table GG-5</td>
<td>60-61</td>
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<tr>
<td></td>
<td>Fig. GG-16</td>
<td>62</td>
</tr>
<tr>
<td>High bank and upland forests*</td>
<td>Table GG-3</td>
<td>48-49</td>
</tr>
<tr>
<td><em>(uneven-age management)</em></td>
<td>Table GG-6</td>
<td>64-65</td>
</tr>
<tr>
<td></td>
<td>Fig. GG-17</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>Fig. GG-18</td>
<td>67</td>
</tr>
<tr>
<td>*Description of general forest types and illustrations</td>
<td>Fig. GG-10</td>
<td>51-54</td>
</tr>
<tr>
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<td>Fig. GG-11</td>
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</tr>
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<td>Fig. GG-12</td>
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</tr>
<tr>
<td></td>
<td>Fig. GG-13</td>
<td></td>
</tr>
</tbody>
</table>
Certain water bodies are designated through rule-making as trout streams (and their designated tributaries) or trout lakes. If forest management activities occur adjacent to these designated water bodies, refer to the following table and figures for RMZ width and residual basal area recommendations that apply:

- Table GG-2 (even-age and uneven-age management)
- Fig. GG-8 (even-age management)
- Fig. GG-9 (uneven-age management)

**Important Considerations**

Four important considerations relate to these guidelines:

- **Stream width is estimated at the bankfull elevation** at the narrowest portion of a straight channel segment within the management area.

- **RMZ width is measured as slope distance** (the linear distance along the ground), not horizontal distance, **except** when the ground is level, in which case slope distance and horizontal distance are the same.

- **Residual basal area recommendations represent the density of residual trees**, measured in ft²/acre, immediately following any forest management activities that remove trees.

- **No minimum tree diameter is established** when measuring for basal area reserves.
1Forest management may be conducted within the RMZ. Review Flexibility Considerations and Incorporating Riparian Guidelines into Plan Design.

2Filter strip guidelines apply adjacent to all water bodies. See General Guidelines: Maintaining Filter Strips.

3For a listing of current designated trout streams (and their designated tributaries) and designated trout lakes, contact regional DNR fisheries offices (see Resource Directory), local zoning offices or the legislative web site at: www.revisor.leg.state.mn.us/arule/6264

<table>
<thead>
<tr>
<th>Management Objective</th>
<th>Recommended Minimum RMZ Width (slope distance) (in feet)</th>
<th>Recommended Minimum Residual Basal Area (ft²/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Even-Age Management (see Fig. GG-8)</td>
<td>150</td>
<td>60</td>
</tr>
<tr>
<td>Uneven-Age Management (see Fig. GG-9)</td>
<td>200</td>
<td>80</td>
</tr>
</tbody>
</table>

Table GG-2

Designated Trout Streams (and Their Designated Tributaries) and Designated Trout Lakes: RMZ Width and Residual Basal Area Recommendations¹,²,³

¹Forest management may be conducted within the RMZ. Review Flexibility Considerations and Incorporating Riparian Guidelines into Plan Design.

²Filter strip guidelines apply adjacent to all water bodies. See General Guidelines: Maintaining Filter Strips.

³For a listing of current designated trout streams (and their designated tributaries) and designated trout lakes, contact regional DNR fisheries offices (see Resource Directory), local zoning offices or the legislative web site at: www.revisor.leg.state.mn.us/arule/6264
Forest management may be conducted within the RMZ. Review *Flexibility Considerations* and *Incorporating Riparian Guidelines into Plan Design*. 

---

**Even-Age Management Recommendations**

<table>
<thead>
<tr>
<th>Size</th>
<th>Recommended Minimum RMZ Width (slopes distance)</th>
<th>Recommended Minimum Residual Basal Area*</th>
<th>Adjacent Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>all sizes</td>
<td>150'</td>
<td>60 ft.²/acre</td>
<td>5% patch</td>
</tr>
</tbody>
</table>

*Concentrate leave trees adjacent to the RMZ in clumps, varying in size with a minimum size of 1/4 acre. The area of the RMZ cannot be used when calculating the recommended minimum of 5% leave trees.*

---

Designated Trout Streams (and Their Designated Tributaries) and Designated Trout Lakes: 

*Even-Age Management*

**RMZ Width and Residual Basal Area Recommendations**

---

*Concentrate leave trees adjacent to the RMZ in clumps, varying in size with a minimum size of 1/4 acre. The area of the RMZ cannot be used when calculating the recommended minimum of 5% leave trees.*
Designated Trout Streams (and Their Designated Tributaries) and Designated Trout Lakes: Uneven-Age Management

**RMZ Width and Residual Basal Area Recommendations**

<table>
<thead>
<tr>
<th>Size</th>
<th>Recommended Minimum RMZ Width (slope distance)</th>
<th>Recommended Minimum Residual Basal Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>all sizes</td>
<td><strong>200'</strong></td>
<td><strong>80 ft.²/acre</strong></td>
</tr>
</tbody>
</table>

Forest management may be conducted within the RMZ. Review Flexibility Considerations and Incorporating Riparian Guidelines into Plan Design.
Non-Trout Streams, Non-Trout Lakes and Open Water Wetlands

RMZ WIDTH AND RESIDUAL BASAL AREA RECOMMENDATIONS

If forest management activities occur adjacent to a non-trout stream, non-trout lake or open water wetland, begin by referring to the following table, text and figures:

- Table GG-3 (general recommendations; will make reference to specific tables as appropriate)
- Description of General Forest Types (including Figs. GG-10 through GG-13)

Important Considerations

Four important considerations relate to these guidelines:

- Stream width is estimated at the bankfull elevation at the narrowest portion of a straight channel segment within the management area.

- RMZ width is measured as slope distance (the linear distance along the ground), not horizontal distance, except when the ground is level, in which case slope distance and horizontal distance are the same.

- Residual basal area recommendations represent the density of residual trees, measured in ft²/acre, immediately following any forest management activities that remove trees.

- No minimum tree diameter is established when measuring for basal area reserves.
## Non-Trout Streams, Non-Trout Lakes and Open Water Wetlands:  
RMZ Width and Residual Basal Area Recommendations

<table>
<thead>
<tr>
<th>Forest Type</th>
<th>Sedge, Grass, Shrubs</th>
<th>Swamp Forests</th>
<th>Swamp Forests</th>
<th>High Bank Forests</th>
<th>High Bank Forests</th>
<th>Upland Forests</th>
<th>Upland Forests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to Water Table&lt;sup&gt;1&lt;/sup&gt;</td>
<td>&lt; 6&quot;</td>
<td>6&quot; - 18&quot;</td>
<td>&gt; 10 feet</td>
<td>&gt; 10 feet</td>
<td>&gt; 15 feet</td>
<td>&gt; 15 feet</td>
<td></td>
</tr>
<tr>
<td>Soil Moisture Condition</td>
<td>Wet</td>
<td>Wet</td>
<td>Dry-Moist</td>
<td>Moist</td>
<td>Dry-Moist</td>
<td>Moist</td>
<td></td>
</tr>
<tr>
<td>Silvicultural System</td>
<td>Not Applicable</td>
<td>Even-Age</td>
<td>Even-Age</td>
<td>Even-Age</td>
<td>Even-Age</td>
<td>Even-Age</td>
<td></td>
</tr>
<tr>
<td>Representative Species and Forest Cover Types</td>
<td>Alders, willows, sedges, grasses, mosses</td>
<td>Black spruce, tamarack</td>
<td>Northern white cedar, black ash</td>
<td>Aspen, birch, jack pine, red pine, balsam fir, o'Gilead, black oak, white oak, but oak, white pine</td>
<td>Maple, basswood, red oak, white pine, white oak, but oak, balsam fir, ash fir, eastern cottonwood, red maple, white spruce</td>
<td>Maple, basswood, red oak, white pine, white oak, but oak, balsam fir, ash fir, eastern cottonwood, red maple, white spruce</td>
<td></td>
</tr>
</tbody>
</table>

*Table GG-3*

*Table continues on page 49*
Forest management may be conducted within the RMZ. Review *Flexibility Considerations* and *Incorporating Riparian Guidelines into Plan Design*.

Filter strip guidelines apply adjacent to all water bodies. See *General Guidelines: Maintaining Filter Strips*.

Average depth to the water table during the growing season.

<table>
<thead>
<tr>
<th>Forest Type</th>
<th>Sedge, Grass, Shrubs</th>
<th>Swamp Forests</th>
<th>Swamp Forests</th>
<th>High Bank Forests</th>
<th>High Bank Forests</th>
<th>Upland Forests</th>
<th>Upland Forests</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMZ recom-</td>
<td>Leave undisturbed</td>
<td>Use cleanout</td>
<td>Reserve</td>
<td>See Table GG-6</td>
<td>See Table GG-4</td>
<td>See Table GG-6</td>
<td>See Table GG-6</td>
</tr>
<tr>
<td>mendations</td>
<td>or manage with</td>
<td>fire to the</td>
<td>unless</td>
<td>for width and</td>
<td>for width and</td>
<td>for width and</td>
<td>for width and</td>
</tr>
<tr>
<td>and</td>
<td>prescribed fire to</td>
<td>water’s edge</td>
<td>effective</td>
<td>residual basal</td>
<td>residual basal</td>
<td>residual basal</td>
<td>residual basal</td>
</tr>
<tr>
<td>references</td>
<td>mimic natural</td>
<td>to prevent</td>
<td>regeneration</td>
<td>area recommenda-</td>
<td>area recommenda-</td>
<td>area recommenda-</td>
<td>area recommenda-</td>
</tr>
<tr>
<td>to specific</td>
<td>disturbance</td>
<td>high-risk</td>
<td>can be</td>
<td>tions.</td>
<td>tions.</td>
<td>tions.</td>
<td>tions.</td>
</tr>
<tr>
<td>tables.</td>
<td></td>
<td>windthrow.</td>
<td>assured.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Forest management may be conducted within the RMZ. Review *Flexibility Considerations* and *Incorporating Riparian Guidelines into Plan Design*.

2. Filter strip guidelines apply adjacent to all water bodies. See *General Guidelines: Maintaining Filter Strips*.

3. Average depth to the water table during the growing season.
Description of General Forest Types

**Sedge/grass/shrub forest:** An area adjacent to a stream, lake or open water wetland that is covered by grasslike sedges or shrubs and where the soils are wet. The depth to the water table in these areas averages less than 6 inches.

Depending on the site and ecological history, dominant plant species are alders, willows, sedges, grasses or mosses. See Figure GG-10.

**Swamp forest:** An area adjacent to a stream, lake or open water wetland where the depth to the water table is between 6 and 18 inches, and the soils are wet.

Depending on the site and ecological history, dominant tree species are black spruce, tamarack, northern white cedar or black ash. See Figure GG-11.

**High bank forest:** An area immediately adjacent to a stream or lake where the depth to the water table is more than 10 feet, soil moisture ranges from moist to dry, the hillside bank rises steeply above the water, and the water body cuts into the hillside bank, which results in its eroding. Roots from trees growing on the terrace above the water do not reach the water table and therefore do not provide much bank stability.

Depending on the site and ecological history, dominant tree species are aspen, birch, jack pine, red pine, balm o’Gilead, red oak, bur oak, white oak, maple/basswood, balsam fir, ash/elm/cottonwood, red maple or white spruce. See Figure GG-12.

**Upland forest:** An area adjacent to a stream, lake or open water wetland where the depth to the water table is at least 1.5 feet, and soil moisture ranges from moist to dry.

Depending on the site and ecological history, dominant tree species are aspen, birch, jack pine, red pine, balm o’Gilead, red oak, bur oak, white oak, maple/basswood, balsam fir, ash/elm/cottonwood, red maple or white spruce. See Figure GG-13.
Figure GG-10

Profile of a Sedge/Grass/Shrub Forest

Average depth to water table is <6"
Average depth to water table is 6-18".
Average depth to water table is >18"
EVEN-AGE MANAGEMENT
Non-Trout Streams, Non-Trout Lakes
and Open Water Wetlands

RMZ WIDTH AND RESIDUAL BASAL AREA
RECOMMENDATIONS

After consulting Table GG-3 (paged 48-49) and the Description of General Forest Types (pages 51-54), refer to the following tables and figures for specific RMZ width and residual basal area recommendations for even-age management, as well as management considerations that can aid in decision-making:

- Table GG-4 (specific recommendations)
- Table GG-5 (management considerations)
- Fig. GG-16 (management considerations)
- Fig. GG-14 (streams)
- Fig. GG-15 (lakes and open water wetlands)

Important Considerations

Four important considerations relate to these guidelines:

- **Stream width is estimated at the bankfull elevation** at the narrowest portion of a straight channel segment within the management area.

- **RMZ width is measured as slope distance** (the linear distance along the ground), not horizontal distance, except when the ground is level, in which case slope distance and horizontal distance are the same.

- **Residual basal area recommendations represent the density of residual trees**, measured in ft²/acre, immediately following any forest management activities that remove trees.

- **No minimum tree diameter is established** when measuring for basal area reserves.
Non-Trout Streams, Non-Trout Lakes and Open Water Wetlands:
Even-Age Management

RMZ Width and Residual Basal Area Recommendations$^{1,2}$

<table>
<thead>
<tr>
<th>Water Body</th>
<th>Size</th>
<th>RMZ Width (slope distance in feet)</th>
<th>Residual Basal Area (ft$^2$/Acre)</th>
<th>Preferred Leave Tree Strategy for Area Adjacent to the RMZ$^3,4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Trout Streams (see Fig. GG-13)</td>
<td>&gt; 10 feet wide</td>
<td>100</td>
<td>25-80 (see Table GG-5)</td>
<td>5% path</td>
</tr>
<tr>
<td>Non-Trout Streams (see Fig. GG-13)</td>
<td>3-10 feet wide</td>
<td>50</td>
<td>25-80 (see Table GG-5)</td>
<td>5% path</td>
</tr>
<tr>
<td>Non-Trout Streams (Perennial) (see Fig. GG-13)</td>
<td>&lt; 3 feet wide</td>
<td>50</td>
<td>25-80 (see Table GG-5)</td>
<td>5% path</td>
</tr>
</tbody>
</table>

*Table continues on page 57*
Forest management may be conducted within the RMZ. Review *Flexibility Considerations* and *Incorporating Riparian Guidelines into Plan Design*.

Filter strip guidelines apply adjacent to all water bodies. See *General Guidelines: Maintaining Filter Strips*.

Following harvest, concentrate leave trees adjacent to the RMZ in clumps, varying in size with a minimum size of 1/4 acre per clump and occupying a minimum of 5% of the area adjacent to the RMZ. These leave trees add windfirmness to the RMZ, improve water conservation, increase energy inputs to the aquatic system, and enhance the microclimate affecting the aquatic system. The area of the RMZ cannot be used when calculating the recommended minimum of 5% of leave trees retained in clumps.

Refer to county and local zoning ordinances and visual quality guidelines. See *Timber Harvesting: Reducing Visual Impacts of Apparent Harvest Size*.

Where beaver ponds have been created, the width of the RMZ is to be calculated from the edge of the stream channel projected through the beaver pond, rather than from the edge of the flooding caused by the presence of beavers. A filter strip should be established from the edge of the pond.

<table>
<thead>
<tr>
<th>Non-Trout Streams (Intem intent) (see Fig. GG-13)</th>
<th>&lt; 3 feet wide</th>
<th>not applicable</th>
<th>not applicable</th>
<th>not applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Trout Lakes/ Open Water Wetlands (see Fig. GG-14)</td>
<td>≥ 10 acres</td>
<td>100</td>
<td>25-80 (see Table GG-5)</td>
<td>5% patch</td>
</tr>
<tr>
<td>Non-Trout Lakes/ Open Water Wetlands (see Fig. GG-14)</td>
<td>&lt; 10 acres</td>
<td>50</td>
<td>25-80 (see Table GG-5)</td>
<td>5% patch</td>
</tr>
</tbody>
</table>
Perennial and Intermittent Non-Trout Streams 
in High Bank and Upland Forests: 
*Even-Age Management*

**RMZ Width and Residual Basal Area** 
**Recommendations**

<table>
<thead>
<tr>
<th>Size</th>
<th>Recommended Minimum RMZ Width (Slope Distance)</th>
<th>Recommended Minimum Residual Basal Area</th>
<th>Adjacent Area*</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;10' wide</td>
<td>A 100'</td>
<td>25-80 ft.²/acre</td>
<td>5% patch</td>
</tr>
<tr>
<td>3-10' wide</td>
<td>B 50'</td>
<td>25-80 ft.²/acre</td>
<td>5% patch</td>
</tr>
<tr>
<td>&lt;3' wide</td>
<td>C 50'</td>
<td>25-80 ft.²/acre</td>
<td>5% patch</td>
</tr>
<tr>
<td>&lt;3' wide</td>
<td>D not applicable</td>
<td>not applicable</td>
<td>not applicable</td>
</tr>
</tbody>
</table>

*Concentrate leave trees adjacent to the RMZ in clumps, varying in size with a minimum size of 1/4 acre. The area of the RMZ cannot be used when calculating the recommended minimum of 5% leave trees.*

Forest management may be conducted within the RMZ. Review *Flexibility Considerations* and Incorporating *Riparian Guidelines into Plan Design.*
Forest management may be conducted within the RMZ. Review *Flexibility Considerations* and *Incorporating Riparian Guidelines into Plan Design*. 

**Even-Age Management Recommendations**

<table>
<thead>
<tr>
<th>Size</th>
<th>Recommended Minimum RMZ Width (slope distance)</th>
<th>Recommended Minimum Residual Basal Area</th>
<th>Adjacent Area*</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥10 acres</td>
<td>A 100'</td>
<td>25-80 ft.$^3$/acre</td>
<td>5% patch</td>
</tr>
<tr>
<td>&lt;10 acres</td>
<td>B 50'</td>
<td>25-80 ft.$^3$/acre</td>
<td>5% patch</td>
</tr>
</tbody>
</table>

*Concentrate leave trees adjacent to the RMZ in clumps, varying in size with a minimum size of 1/4 acre. The area of the RMZ cannot be used when calculating the recommended minimum of 5% leave trees.*

Non-Trout Lakes and Open Water Wetlands in High Bank and Upland Forests: 

*Even-Age Management*

**RMZ Width and Residual Basal Area Recommendations**
### Table GG-5

**Relative Impact of Residual Basal Area on Accomplishing Landowner Management Objectives...**

<table>
<thead>
<tr>
<th>MANAGEMENT CONSIDERATIONS FOR ALL RMZs</th>
<th>Residual Basal Area$^1$ (ft$^2$/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(low residual basal area)</td>
<td></td>
</tr>
<tr>
<td>☐ Maximum volume removed from timber harvest</td>
<td>25</td>
</tr>
<tr>
<td>☐ Best overall natural regeneration (aspen, birch, jack pine, spruce)</td>
<td></td>
</tr>
<tr>
<td>☐ Facilitates red pine, spruce, jack pine planting</td>
<td></td>
</tr>
<tr>
<td>☐ Wildlife habitat: early successional vegetation</td>
<td></td>
</tr>
<tr>
<td>☐ White pine underplanting</td>
<td>40</td>
</tr>
<tr>
<td>☐ Partial (&lt; 50%) shading of water bodies</td>
<td></td>
</tr>
<tr>
<td>☐ Release conifer understory</td>
<td></td>
</tr>
<tr>
<td>☐ 50% shading of water bodies</td>
<td></td>
</tr>
<tr>
<td>☐ Wildlife habitat: mixed species and age diversity</td>
<td>60</td>
</tr>
<tr>
<td>☐ Cover for wildlife travel corridor</td>
<td></td>
</tr>
<tr>
<td>☐ Selective timber harvest</td>
<td></td>
</tr>
<tr>
<td>☐ Full shading of water bodies</td>
<td></td>
</tr>
<tr>
<td>☐ Nutrient and food input into aquatic system</td>
<td></td>
</tr>
<tr>
<td>☐ Wildlife habitat: contiguous closed canopy</td>
<td></td>
</tr>
<tr>
<td>☐ Aesthetics</td>
<td>80</td>
</tr>
<tr>
<td>(high residual basal area)</td>
<td></td>
</tr>
</tbody>
</table>

$^1$Consider seeking professional assistance when determining appropriate residual basal area silvicultural guidelines for desired even-age species. See Resource Directory.
Table GG-5 (cont’d)

...in High Bank and Upland Forests: Even-Age Management
(Non-Trout Streams, Non-Trout Lakes and Open Water Wetlands)

<table>
<thead>
<tr>
<th>RIPARIAN FUNCTION</th>
<th>Retention of Sediment or Nutrients Associated with Surface or Subsurface Runoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature Moderation (Shading), Coarse Woody Debris and Fine Litter Inputs, and Shoreline/Bank/Channel Stabilization</td>
<td>Retaining ground vegetation and retention of a relatively undisturbed forest floor is important to control sediment and chemical release into aquatic systems. See Maintaining Filter Strips, page 24.</td>
</tr>
</tbody>
</table>

The protection and maintenance of these riparian functions may be reduced at this basal area for a period of time. To increase the protection and maintenance of these functions, landowners may want to consider retaining higher basal areas near (especially within one mature tree length of) the water body. See Recognizing Tradeoffs, page 35.

There should be a reasonable to high level of protection and maintenance of these riparian functions in this basal area range. Leaving this amount of residual basal area, however, may impact natural or artificial regeneration of shade-intolerant species such as aspen or red pine on the site. Consider tradeoffs between the protection and maintenance of riparian functions and other landowner objectives for the site. See Recognizing Tradeoffs, page 35.

See also Figure GG-16, page 62.
Figure GG-16

Relationship of Residual Basal Area to Management Objectives

Curve A depicts objectives attainable with a relatively low Residual Basal Area

Examples
Wildlife habitat: early successional vegetation, maximum volume removed from timber harvest.

Curve B depicts objectives attainable with a relatively high Residual Basal Area

Examples
Wildlife habitat: contiguous closed canopy, aesthetics.

Curve C depicts objectives attainable with a mid-range Residual Basal Area

Example
Wildlife habitat: mixed species and age diversity.
UNEVEN-AGE MANAGEMENT
Non-Trout Streams, Non-Trout Lakes
and Open Water Wetlands

RMZ WIDTH AND RESIDUAL BASAL AREA
RECOMMENDATIONS

After consulting Table GG-3 (page 48-49) and the Description of General Forest Types (pages 51-54), refer to the following table and figures for specific RMZ width and residual basal area recommendations for uneven-age management:

- Table GG-6 (specific recommendations)
- Fig. GG-17 (streams)
- Fig. GG-18 (lakes and open water wetlands)

Important Considerations

Four important considerations relate to these guidelines:

- Stream width is estimated at the bankfull elevation at the narrowest portion of a straight channel segment within the management area.

- RMZ width is measured as slope distance (the linear distance along the ground), not horizontal distance, except when the ground is level, in which case slope distance and horizontal distance are the same.

- Residual basal area recommendations represent the density of residual trees, measured in ft²/acre, immediately following any forest management activities that remove trees.

- No minimum tree diameter is established when measuring for basal area reserves.
## Non-Trout Streams, Non-Trout Lakes and Open Water Wetlands: Uneven-Age Management

**RMZ Width and Residual Basal Area Recommendations**

<table>
<thead>
<tr>
<th>Water Body</th>
<th>Size</th>
<th>Recommended Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>RMZ Width (slope distance in feet)</td>
</tr>
<tr>
<td>Non-Trout Streams (see Fig. GG-17)</td>
<td>&gt; 10 feet wide</td>
<td>200</td>
</tr>
<tr>
<td>Non-Trout Streams (see Fig. GG-17)</td>
<td>3 - 10 feet wide</td>
<td>100</td>
</tr>
<tr>
<td>Non-Trout Streams (Perennial) (see Fig. GG-17)</td>
<td>&lt; 3 feet wide</td>
<td>50</td>
</tr>
<tr>
<td>Non-Trout Streams (Perennial) (see Fig. GG-17)</td>
<td>&lt; 3 feet wide</td>
<td>not applicable</td>
</tr>
</tbody>
</table>

*table continues on page 65*
<table>
<thead>
<tr>
<th>Non-Trout Lakes/ Open Water Wetlands (see Fig. GG-18)</th>
<th>≥10 acres</th>
<th>200</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Trout Lakes/ Open Water Wetlands (see Fig. GG-18)</td>
<td>&lt; 10 acres</td>
<td>50</td>
<td>80</td>
</tr>
</tbody>
</table>

1^Forest management may be conducted within the RMZ. Review Flexibility Considerations and Incorporating Riparian Guidelines into Plan Design.
2^Filter strip guidelines apply adjacent to all water bodies. See General Guidelines: Maintaining Filter Strips.
3^Consider seeking professional assistance when determining appropriate residual basal area silvicultural guidelines for desired uneven-age species. See Resource Directory.
4^Review filter strips recommendations that apply to these smaller wetlands (see Table GG-1, page 25).
Figure GG-17

Perennial and Intermittent Non-Trout Streams in High Bank and Upland Forests:

**Uneven-Age Management**

**RMZ Width and Residual Basal Area Recommendations**

<table>
<thead>
<tr>
<th>Size</th>
<th>Recommended Minimum RMZ Width (slope distance)</th>
<th>Recommended Minimum Residual Basal Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;10' wide</td>
<td><strong>A 200’</strong></td>
<td>80 ft.²/acre</td>
</tr>
<tr>
<td>3-10' wide</td>
<td><strong>B 100’</strong></td>
<td>80 ft.²/acre</td>
</tr>
<tr>
<td>&lt;3’ wide perennial</td>
<td><strong>C 50’</strong></td>
<td>80 ft.²/acre</td>
</tr>
<tr>
<td>&lt;3’ wide intermittent</td>
<td><strong>D not applicable</strong></td>
<td>not applicable</td>
</tr>
</tbody>
</table>

Forest management may be conducted within the RMZ. Review Flexibility Considerations and Incorporating Riparian Guidelines into Plan Design.
Forest management may be conducted within the RMZ. Review Flexibility Considerations and Incorporating Riparian Guidelines into Plan Design.
OPERATIONAL ACTIVITIES

Protecting Cultural Resources

Some types of cultural resources are protected by federal or state law. See Part 2, Cultural Resources: Cultural Resource Management and the Law. For sources of information and assistance, see Resource Directory.

✔ When practical or feasible, avoid management activities within cultural resource areas.

✔ Delineate cultural resource areas using flagging, signs or other appropriate methods. Communicate with loggers and equipment operators to assure clear understanding that there is to be no work in the marked area.

✔ When it is not practical or feasible to avoid cultural resource areas during forest management activities, protect resources by applying one or more of the following procedures:

- Use temporary fencing, barricades or other measures to restrict the movement of heavy equipment and machinery in the cultural resource area.

- Temporarily brace walls and board up windows and doors of historic buildings.

- Prevent potential structural damage or deterioration of historic buildings and structures that might result from heavy equipment operation.

- Avoid felling trees directly onto historic buildings, structures, or surface features of archaeological sites.

- Use temporary protection such as slash, corduroy, tire mats or fill over geotextile.

- Place fill over archaeological sites to prevent soil compaction and erosion.

- Revegetate archaeological sites to prevent erosion.
✔ For cultural resources that cannot be protected from damage, consider data recovery (professional excavation of archaeological sites or documentation of above-ground cultural resources). For sources of information and assistance, see Resource Directory.

✔ If a human burial site is accidentally discovered during operations, cease operations immediately in the vicinity of the discovery. Contact the Office of the State Archaeologist and your local law enforcement agency. For sources of information and assistance, see Resource Directory.

✔ For accidental discovery of other types of cultural resources (such as archaeological artifacts), temporary suspension is not required, but it is recommended. Suspending operations in the immediate vicinity of the cultural resource will allow time to contact a cultural resource professional or develop plans to initiate procedures to avoid or reduce damage to the cultural resource.

✔ When cultural resources are discovered during forest management activities:

- Safeguard the condition of the cultural resource by preventing further damage, loss or deterioration.

- Investigate and document the cultural resource in order to determine its significance and conservation potential. For information on documenting a cultural resource, see Resource Directory.

- Adjust work schedules to allow time for data recovery or other mitigation measures.

✔ Monitor the effectiveness of cultural resource management practices during forest management operations.
Managing Equipment, Fuel and Lubricants

✔ Designate a specified area for draining lubricants from equipment during routine maintenance. The area should allow all waste lubricants to be collected and stored until transported off-site for recycling, reuse or disposal at an approved site.

✔ Provide maintenance vehicles with necessary equipment to collect and store lubricants drained during repair activities. Breakdowns could require that lubricants be drained from equipment at locations away from the designated collection area. It is illegal to burn the residues or drain these materials directly onto the ground (Minn. Rules 7045.0845).

✔ Provide waste containers in maintenance areas or vehicles for collecting solid wastes, such as oil containers, grease tubes, oil filters and other trash.

✔ Recycle or properly dispose of collected solid waste materials at an approved solid waste site. It is illegal to burn these wastes (Minn. Statutes 88.171).

✔ Locate fuel and maintenance areas away from open water, on upland sites whenever practical, and at locations where a potential spill can be contained and properly treated with minimal risk of surface water or ground-water contamination. Whenever practical, place them outside the filter strip or riparian management zone (whichever is wider). When operating on wetland areas, an upland site may also be the preferred location for fueling and maintenance.

✔ Report all petroleum spills of five or more gallons. Direct all reports to the Minnesota Duty Officer. The two 24-hour phone numbers are (651) 649-5451 (Metro Area) and (800) 422-0798 (Greater Minnesota). The Minnesota Duty Officer will contact appropriate state agencies.

✔ Thin-spread any soil contaminated by spills of petroleum products of less than 5 gallons.
Protecting the Normal Flow of Streams and Wetlands

✔ Mark the presence of seeps and springs and avoid damaging their normal flow during management operations. Establish filter strips and employ other wetland protection measures as applicable. See General Guidelines: Maintaining Filter Strips.

✔ Avoid disturbances such as ruts, soil compaction and addition of fill, which can interrupt or redirect the flow of water though a wetland. Such disturbances can also impact the depth of the water table or the extent of flooding or draining that occurs in a wetland, significantly altering the plant and animal community in that wetland.

✔ Keep equipment as far as practical from streambanks to minimize streambank disturbance, and approach at right angles to minimize equipment operation on the most susceptible soils.

✔ Avoid rutting in non-open water wetlands and seasonal ponds. It is important that rutting not bisect wetlands.
Seasonal Ponds

Seasonal ponds are wetland depressions in the soil surface where water pools during wet periods of the year, typically in spring and fall.

- A seasonal pond will have an identifiable edge caused by seasonal inundation and local topography.
- Seasonal ponds are small, typically less than ½ acre in size.
- The edge is best identified during the spring or fall, but it may be identified during dry periods by less forest litter in the depression compared to the upland forest. The wet-dry cycle of seasonally inundated wetlands can result in faster decomposition of plant litter compared to the upland and continuously inundated wetlands.
- Seasonal ponds are typically fishless but are important for amphibians (e.g., frogs, salamanders).
- Other characteristics that may define seasonal ponds include the presence of black ash, the minor presence of shrubs (e.g., alder) along the pond margins, the presence of moss-covered old woody debris, tussocks, and commonly the absence, in many cases, of obligate aquatic plants.
Protecting Non-Open Water Wetlands and Seasonal Ponds

Considerations

Vegetation is important in protecting the functionality of non-open water wetlands and seasonal ponds. The desired amount of leave trees and other vegetation left on a site following a forest management activity will depend on site characteristics and landowner objectives.

Residual vegetation should provide significant shading to prevent excessive warming of soil and water, while also preventing sedimentation due to mineral soil exposure. Residual vegetation should also provide key habitat features, such as coarse woody debris and leaf litter.

For forestland with few seasonal ponds, landowners are encouraged to provide leave trees around these pond bodies, or adjacent to some ponds on sites where they are common.

Targeting application of leave tree guidelines around these water bodies (such as retaining on even-age harvest units a minimum of 5% of the harvest area in clumps and/or 6-12 scattered leave trees per acre) will maintain the shading and structure needed while simultaneously providing habitat for cavity-nesting birds and other wildlife.

The following guidelines are designed to help protect the functionality of small non-open water wetlands and seasonal ponds:

Apply filter strip guidelines to management activities adjacent to non-open water wetlands and seasonal ponds. See General Guidelines: Maintaining Filter Strips.

Avoid disturbances such as ruts, soil compaction, excessive disturbance to litter layer, and addition of fill, which can interrupt or redirect the flow of water into or through a non-open water wetland or seasonal pond. It is important that rutting not bisect wetlands and seasonal ponds. Such disturbances can also impact the depth of the water table or the extent of flooding or draining that occurs in a non-open water wetland or seasonal pond, as well as the integrity of the ground layer, significantly altering its plant and animal community.
Managing Dry Washes in Southeastern Minnesota

The intent of these guidelines is to allow a landowner to capture significantly valued timber while keeping a viable deep root system for bed and bank stability. There are multiple types of dry washes throughout southeastern Minnesota, which vary greatly dependent upon terrain features. These guidelines apply to all dry washes that meet the dry wash definition contained in the glossary.

The two major issues with dry washes are the control of excessive agricultural erosion at the head of the dry wash and stabilization of the banks and bed within the wash. Detention ponds at the top of the hill are the most effective measure in controlling erosion into dry washes, but these are usually on agricultural land, and therefore are beyond the scope of these guidelines. Bank and bed stability are the most significant outcomes related to management and forest practices within these dry washes.

Because deep root systems from trees enhance bank stabilization, selective harvest prescriptions are the preferred option within 25 feet of the dry wash bank. Patch clearcuts for oaks adjacent to this selection strip will still allow enough light penetration to encourage oak regeneration. It is possible to harvest timber to the edge of the dry wash.

Employ one or more of the following practices to protect bank stability:

✔ Employ selective harvest prescriptions within 25 feet of the dry wash bank as it fulfills harvest or landowner requirements, provided sufficient live root system will remain for bank and bed protection.

✔ Select leave trees for wildlife, biased toward areas adjacent to the dry wash.
Other erosion control measures commonly associated with steep slopes and dry washes include:

✔ Design skid trail and road layouts for water control prior to the harvest.

✔ Embed slash in skid trails before concentrated skidding.

✔ Harvest progressively from back to front, with water control structures installed as cutting progresses (see illustration in timber harvesting section, Figure TH-2).

✔ Harvest on frozen ground when feasible.

✔ Minimize roading and soil displacement.

✔ Avoid cabling logs across the wash (bank damage) where feasible.

✔ Use directional felling techniques when possible.

✔ Utilize appropriate equipment to minimize soil impacts.

Retaining Leave Trees (live trees)

✔ Retain leave trees according to the following characteristics related to species, size and condition. Specific recommendations for numbers and distribution of leave trees (such as retaining on clearcuts a minimum of 5% of the harvest area in clumps and/or 6-12 scattered leave trees per acre) can be found in Timber Harvesting: Leave Trees and Timber Stand Improvement: Operational Activities.

Note: Retaining leave trees to benefit one resource may simultaneously fulfill guidelines focused on another resource. For example, leave trees retained to benefit cavity-nesting wildlife may also provide benefits for visual quality, mast, water quality, cultural resources or wetland habitat.
Species: A mix of species is desirable, but preference should be given to particular species for their longevity, windfirmness or cavity potential. TSI (timber stand improvement) operations often favor retention of one or more preferred tree species, but retention of a mix of naturally occurring species is desired. Recognize that all tree species have some value to particular wildlife, and that it is necessary to work with what is available on a particular site.

Table GG-7 characterizes leave trees as excellent, good or fair in terms of longevity, windfirmness and cavity potential. Windfirmness may vary based on site characteristics.

Table GG-7

<table>
<thead>
<tr>
<th>Excellent</th>
<th>Good</th>
<th>Fair</th>
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</thead>
<tbody>
<tr>
<td>white pine</td>
<td>aspens</td>
<td>white birch</td>
</tr>
<tr>
<td>oaks</td>
<td>red pine*</td>
<td>balsam fir*</td>
</tr>
<tr>
<td>elms</td>
<td>tamarack</td>
<td>jack pine*</td>
</tr>
<tr>
<td>ashes</td>
<td>cedar</td>
<td>black spruce*</td>
</tr>
<tr>
<td>sugar maple</td>
<td>red maple</td>
<td>balsam poplar</td>
</tr>
<tr>
<td>yellow birch</td>
<td>white spruce*</td>
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<tr>
<td>basswood</td>
<td>black cherry</td>
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<td>hickories</td>
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<td>box elder</td>
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<td>cottonwood</td>
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<td></td>
<td>walnut</td>
<td></td>
</tr>
<tr>
<td></td>
<td>hackberry</td>
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</tbody>
</table>

*Leaving these species in the overstory imposes a risk of insect and disease infestation to understory regeneration of that same species.
**Size:** Larger-diameter leave trees are generally more valuable to wildlife, but smaller trees have the potential to grow over time and provide habitat as a harvested stand regenerates. Therefore, leave a range of sizes on each managed site as follows:

- Leave trees should be at least 6 inches DBH (diameter at breast height).
- About 50% of leave trees should be greater than 12 inches DBH.
- At least 1-2 trees per clump or per acre should be greater than 18 inches DBH (or the largest size class available).

**Condition:** While trees with some degree of decay or existing cavities have immediate benefits to wildlife, retaining some sound, windfirm trees will provide future snag and cavity needs as a harvested stand regenerates. Therefore, plan to leave trees with a range of conditions on managed sites:

- Include some trees showing signs of decay or trees with cavities.
- Leave some larger, healthy dominants or codominants.
- Leave some smaller, healthy, non-suppressed trees.

Retaining cavity trees enhances the quality of wildlife habitat in forested areas. *Photo courtesy of Minnesota DNR*
✔ **Avoid felling or damaging any canopy individuals** of rare or declining tree species in the state, specifically eastern hemlock, butternut, chinkapin (yellow) oak, honey locust, and Kentucky coffee-tree. Minimize damage to advance regeneration of these species.

✔ **Allow some individuals of longer-lived species** to reach ages of 200–300 years old in managed stands. Such longer-lived species include sugar maple, yellow birch, white pine, red pine, bur oak or red oak. Leave large cull trees standing.

✔ **Exceptions to leave tree guidelines may be made** for a number of reasons, including:

- Operator safety (of loggers, aerial spray applicators and others)

- Public safety (including hazard trees near rights-of-way, recreation sites or airport vicinities)

- Specific silvicultural applications (such as genetic considerations for seed reproduction systems)

- Visual quality

- Surrounding landscape concerns (such as sites adjacent to sharp-tailed grouse management units)

- Forest insects and diseases (such as dwarf mistletoe on black spruce, gypsy moth and pine bark beetles)
Providing Coarse Woody Debris

✔ Avoid having equipment disturb pre-existing large down logs, stumps and uprooted stumps.

✔ If a snag must be dropped, leave it where it falls whenever possible.

✔ Create at least 2 to 5 bark-on down logs greater than 12 inches in diameter per acre, if fewer than this number already exist. In choosing candidates for leave logs, consider the following:

  • Hollow butt sections or other defective lengths of at least 6 feet are preferred.
  
  • Sound logs and 6-inch to 12-inch diameter logs may be used if they represent the best available candidates.

Both aquatic and terrestrial coarse woody debris enhance aquatic and wildlife habitat in forested areas. Photo courtesy of Minnesota DNR
• Hardwood logs have more hollows or cavities and are favored by certain amphibians.

• Conifer logs decay more slowly and thus remain present as structure on a site longer than hardwoods.

• Using pines as down logs, especially in summer, increases the risk of bark beetle damage to adjacent healthy pines.

✔ Scatter leave logs across the site, including a few near wetlands.

✔ If a site includes riparian areas, create 4 leave logs per acre in the riparian management zone, if fewer than this number already exist. The overall average number for the site, however, can remain at a minimum of 2 per acre.

✔ Exceptions to guidelines for providing coarse woody debris may be made for a number of reasons, including:

  • Alignment of skid trails
  • Specific silvicultural applications (such as insect pests)
  • Visual quality issues

Post-Operational Activities and Followup Visits

✔ If a road will provide access to a cultural resource, consider closing the road after the operation is completed.

✔ Remove flagging, signs or other markings that identify a cultural resource when a forest management activity is completed.

✔ If slash, corduroy or fill over geotextile was used for temporary protection of cultural resources, it is preferable in most cases to leave it in place. If tire mats were used, remove them.

✔ Restore watercourses to approximate their natural condition by removing temporary drainage structures and stabilizing the soil along the banks.
✔ **Stabilize bare soil areas and install water diversion devices** and erosion control barriers where appropriate to prevent or minimize erosion and sedimentation from roads, skid trails and landings into surface water and cultural resource areas.

- Seed and fertilize as appropriate.

- Fill in ruts as necessary, weighing the benefits of filling in ruts on skid trails against the potential for additional impact to soil productivity as a result of equipment used to eliminate ruts.

- Inspect erosion control measures periodically and maintain or remove as needed.

✔ **Place traffic barriers where appropriate** to prevent vehicles from disturbing recently stabilized areas. Barriers should be visible and well marked, and they should not present a safety hazard.

✔ **Conduct followup visits** to areas where structures (such as culverts or water bars) or other protection measures (such as seeding of bare areas) are used to minimize impacts on water quality and wetlands. Such followup visits can help assure that the protection measures remain functional.
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REMEMBER:

Guidelines help with how to manage, not whether to manage.

These guidelines focus on **how** to protect the functions and values of forest resources during forest management activities. They **do not** provide advice on **whether** to manage or which management activities are needed.

**Guidelines provide a menu, not a mandate.**

Site-level resource management decisions are based on many different factors, including resource needs, landowner objectives, site capabilities, existing regulations, economics and the best information available at any given time. **No one will apply all of the guidelines** related to a particular activity. Instead, the landowner, resource manager or logger will consider many different factors in determining which combination of guidelines provides the best “fit” for a particular site at a particular time. The intent of having multiple guidelines is to provide decision-makers with as much flexibility—and as much choice—as possible in taking steps to effectively balance forest management needs and resource sustainability.

**General guidelines and activity-specific guidelines are closely related.**

Frequent references from activity-specific guidelines back to the general guidelines will make it easy for landowners, resource managers, loggers and others to consider all of the related guidelines—both general and specific—that apply to a particular management activity.

**Guidelines are supplemented from time to time by “Additional Considerations.”**

The guidelines are supplemented from time to time by “Additional Considerations,” which provide additional guidance to further promote the sustainability of forest resources.
INTRODUCTION

Forest roads connect the most remote parts of the forest to existing township, county and state roads and highways, providing access to forest lands for timber management, fish and wildlife habitat improvement, fire control, hunting and a variety of recreational activities. For the purpose of these guidelines, road construction includes excavation of gravel quarries and borrow pits.

**Permanent roads** are intended for long-term use. They include all-season roads and seasonal roads.

- **All-season roads** are designed for use all year long, though there may be some restrictions on vehicle weight at times during spring breakup or wet periods. There is a great range in design standards and road surfacing in this type of road, depending on the traffic load anticipated.

- **Seasonal roads** are designed for long-term periodic use, such as during dry and frozen periods. These roads are built to lower engineering standards and have minimal material surfacing.

**Temporary roads** are generally minimum-standard roads designed for short-term use during a specific project, such as a timber harvest. Many of these temporary roads are little more than a bladed lane pushed into the harvest site. Use of these roads is typically limited to dry or frozen conditions to minimize rutting and compaction. See Figure ROAD-1.

The Benefits of Guidelines

**Benefits to cultural resources:** Forest road construction guidelines can minimize the potential effects of road building and maintenance activities on cultural resources that can result from removing or altering natural soils that contain cultural deposits, damaging features of archaeological sites or cemeteries, and destabilizing historic buildings and structures.
Guidelines for earth-moving activities, excavation of borrow areas, and practices that cause soil disturbance or erosion can help protect cultural resources, and guidelines for controlling accesses into formerly remote areas can reduce the potential for deliberate vandalism of sensitive sites.

**Benefits to forest soils:** Forest road construction guidelines support the development of a safe and efficient access system that services many acres with as few roads as possible while impacting the smallest percentage of the site necessary. Guidelines address compaction, erosion and indirect impacts to surrounding soils caused by disruption to water flows and sedimentation.

**Benefits to riparian areas:** Forest road construction guidelines can minimize alterations of vegetation within the riparian area. That vegetation is important for providing inputs of coarse woody debris and fine litter to water bodies; retaining nutrients, sediment and energy; bank and shoreline stabilization; maintenance of moderate water temperatures through shading; and wildlife habitat. Guidelines for retaining vegetation can also have a positive impact on aesthetics, wood products and recreation.
**Benefits to visual quality:** Forest road construction guidelines can reduce the visual impacts associated with poor design, construction and maintenance of forest roads. Guidelines can also reduce noise and unsightliness related to gravel pits.

**Benefits to water quality and wetlands:** Forest road construction guidelines can protect water quality and wetlands, particularly in areas having steep slopes with erodible soils, and in areas where forest roads are located near water or wetlands. Guidelines can also help to maintain natural flow patterns across the landscape, avoid concentration of water flows, and minimize sedimentation to water bodies and wetlands. Guidelines for the use of fuels and lubricants can protect water quality and wetlands from the toxic effects of potential spills. Guidelines that address equipment operations and maintenance can help protect water quality.

**Benefits to wildlife habitat:** Forest road construction guidelines suggest management approaches that help protect sensitive sites, rare species, water features and unique habitats in forests. Guidelines for controlling access into remote areas can minimize human activity that may be detrimental to some forest wildlife species.

**Considerations**

A well-planned access system is a sound method of reducing erosion and sedimentation in areas requiring frequent or temporary access. Proper location and construction of roads will provide for safety, longer operating periods, lower maintenance and operating costs, and minimal impacts to forest resources. Servicing as many acres of forest with as few roads as possible is a sound method of reducing impacts to forest resources from road construction.

**Factors in decision-making**

- **The number, size and design of forest access roads** will be influenced by the frequency of access; amount of anticipated traffic; seasons during which access is required; open water wetlands, non-open water wetlands, seasonal ponds, streams and lakes on-site; and safety concerns.

- **Distribution of necessary management activities** will affect the number and location of access roads.
Choices regarding road construction standards and maintenance activities will be influenced by site characteristics and the value of the resources served. Culverts and ditches may be necessary with any road construction technique. See Figure ROAD-2.

Surfacing can be the major cost of low-volume road construction. Alternatives should be evaluated according to expected use and potential impact on sediment load. Where grades make the potential for surface erosion significant, the road should be surfaced with materials that will minimize potential water quality and soil productivity impacts (such as crushed rock, compacted gravel, sod or asphalt).

Visual impacts and the concentration of forest management activities can result from poor design, construction and maintenance of forest access roads. Take into account the following considerations when planning to reduce noise and visual impacts associated with the design and use of forest access roads:

- Noise from traffic, especially large trucks, buses and heavy equipment operating on access roads
- Potential increased costs of building forest access roads to accommodate visual quality concerns, and potential increased costs of using existing roads that require traveling greater distances
• The limited road construction season that generally coincides with the tourist season

• Traffic during wet periods that can increase maintenance needs and create unsightly ruts and mudholes

☐ Visual impacts and noise impacts created by gravel pits are not compatible with recreational user sensitivities. Take into account the following considerations when planning to reduce noise and unsightliness related to gravel pits:

  • Local sources of gravel are necessary for efficient, cost-effective road building and maintenance.

  • Recreational use of gravel pits may cause conflicts.

☐ Site-specific soil, topographic and forest inventory information will assist resource managers or landowners in planning road location and layout. For information and assistance, see Resource Directory.

Minimizing impacts from roads

☐ Because roads take soils out of production, effort should be made to keep the length and width of roads to a minimum without sacrificing safety.

☐ To minimize road mileage and reduce costs, coordination with adjacent landowners may be desirable.

☐ The greatest potential for soil erosion occurs immediately after construction. Disturbed areas should be shaped and stabilized as soon as possible to minimize erosion potential, especially in situations where erosion and sedimentation could impact water quality.

Maintenance needs

☐ The purpose of maintenance procedures is to ensure that measures taken to minimize impacts on forest resources are working and will continue to work for the life of the road. Surfacing materials and the amount of use will determine the level of maintenance required.
Roads that are open for use require more maintenance than roads that are closed to vehicular traffic. Inactive roads (roads currently not in use), whether closed temporarily or permanently, require occasional work to reduce potential impacts on streams, lakes, wetlands and seasonal ponds.

Road layout, construction methods, and erosion and access control all contribute to the longevity, utility, safety and maintenance costs of road systems.

Protecting water quality and water flow

Incorporating guidelines to protect water quality into overall road project design can minimize the potential impact of wetland roads on water quality, as well as alterations to normal water flow patterns.

Effective road construction techniques minimize the disturbance to the natural flow of water over the landscape and ensure the structural integrity of the road embankment.

The goal is to provide a simple road structure of adequate strength to support heavy vehicle traffic and provide drainage structures to pass water at its normal level through the road corridor.

Design Outcomes To Maintain Soil Productivity

To protect soil productivity, the design, construction and maintenance of forest roads should achieve the following beneficial outcomes:

- A well-planned road system that efficiently accesses as many acres as possible with the least amount of site occupied over the long term, with no more than 1-2% of the management area occupied by roads
• A road system built to adequate specifications for the season, duration and level of use

• Proper location and construction of roads that provide for safety, longer operating periods, and lower maintenance and operating costs

• Bare soil areas susceptible to erosion stabilized from future erosion, especially in situations where water quality impacts are possible
Design of Upland Forest Roads

➤ IMPORTANT! Review General Guidelines:

➔ Incorporating Sustainability into Forest Management Plans
➔ Maintaining Filter Strips
➔ Managing Riparian Areas

Landowners may need the services of a forester, engineer or other qualified individual to provide complete design and construction specifications. This professional assistance is particularly important when constructing permanent all-season roads. For sources of professional assistance, see Resource Directory.

Design Considerations

✔ Examine existing access routes to determine whether they are the best routes to improve. Consider whether relocation would provide a better long-term access route.

✔ Consider future management activities that may utilize common roads for adjacent stands or ownerships.

✔ Minimize total road mileage and ground disturbance required to meet landowner objectives.

✔ Plan to limit the area disturbed by roads to less than 1-2% of the management area (defined as the specific site where activities are taking place). Slightly different percentage goals may be appropriate when considering a larger land area, such as a landscape.

✔ Establish and maintain appropriate stabilization, drainage and erosion control measures, and check structures frequently enough to ensure that they are functioning as designed, especially in situations where sedimentation could impact water quality.

✔ Minimize road width consistent with road safety and design considerations.
Alignment and Location

STOP! ✔ Contact Gopher State One Call at (800) 252-1166 or (651) 454-0002 at least one week prior to the start of excavation activities when crossing pipelines or other underground utilities. Or contact Gopher State One Call at www.gopherstateonecall.org

✔ Prior to construction, identify locations of new roads, borrow areas and gravel pits to avoid cultural resources and other sensitive areas.

✔ Reuse previous access roads, landings and skid trails to the extent possible.

✔ Locate roads to minimize the amount of cut-and-fill and the number of water crossings.

✔ Locate roads away from streams, lakes, open water wetlands, non-open water wetlands, seasonal ponds, seeps and springs whenever possible, to provide adequate filter strips.

✔ Wherever practical, locate roads (those that do not cross a stream, lake or open water wetland) outside of filter strips or the riparian management zone (RMZ), whichever is wider. See General Guidelines: Maintaining Filter Strips and General Guidelines: Managing Riparian Areas.

✔ Locate roads to avoid concentrating runoff and reduce the potential for nonpoint source pollution.

Additional Consideration

If road closure is anticipated, consider designing road approaches to facilitate effective closure after completion.
Avoid locating roads below the identifiable high water mark of lakes, open water wetlands, seasonal ponds, and rivers and streams. See Figure ROAD-3. Work in public waters and public water wetlands can proceed only with a permit from DNR Waters, which can be obtained from DNR offices noted in the Resource Directory under Water Crossings.

Avoid locating roads on unstable slopes subject to slumping or creep whenever practical.

Avoid constructing roads with grades in excess of 10%. See Figure ROAD-4.

Minimize down-road flow and ponding by constructing roads with a slight grade of 1% or 2% and with appropriate ditches where practical.
## Reducing Visual Impacts
**Due to Alignment and Location of Roads**

<table>
<thead>
<tr>
<th>In areas classified as most sensitive:*</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔ Minimize the number of roads approaching travel routes or recreation areas.</td>
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</table>

<table>
<thead>
<tr>
<th>In areas classified as most sensitive or moderately sensitive:*</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔ Locate roads and trails to minimize visibility from nearby vantage points, such as scenic overlooks, streams and lakes.</td>
</tr>
<tr>
<td>✔ Reduce visual penetration with appropriate curves in the road alignment.</td>
</tr>
<tr>
<td>✔ Minimize total road mileage and ground disturbance required to meet landowner objectives and anticipated traffic loads.</td>
</tr>
<tr>
<td>✔ Avoid tracking mud onto highways by using appropriate road surface material.</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>In areas classified as less sensitive:*</th>
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<tbody>
<tr>
<td>✔ Consider visual quality to the extent possible.</td>
</tr>
<tr>
<td>✔ Minimize total road mileage and ground disturbance required to meet landowner objectives and anticipated traffic loads.</td>
</tr>
</tbody>
</table>

*See Part 2, Visual Quality: Visual Sensitivity Classifications for information related to how classifications are determined and which Minnesota counties have developed visual sensitivity classification maps.
Reduce visual penetration into clearcuts or landing areas by designing curves in the road alignment. 

*Photo courtesy of Minnesota DNR*
Water Crossings

Water crossings present a high risk to water quality and should be avoided when practical. Bridges or culverts are preferred for road crossings that are used frequently or for extended periods. Low-water fords should be used for infrequent crossings and short-term operations, and should comply with public waters regulations (see Appendix H: Types of Work Activities That Do Not Require a DNR Public Waters Work Permit on Public Waters, Public Water Wetlands and Public Watercourses). Fords should have a firm base installed to minimize potential impacts to water quality or wetlands.

✔ Contact a local SWCD or DNR office, or visit the DNR Web site at www.dnr.state.mn.us/waters/wetlands/pwi/index.html to determine whether a proposed road will cross either a water or wetland noted on Public Waters Inventory maps or a designated trout stream. Regulations on designated trout streams are more restrictive.

Permits for such crossings (Minn. Statutes 103G.245) are obtained from the DNR Waters area hydrologists. DNR regional offices are listed in the Resource Directory. The listing for designated trout lakes and trout streams can also be found at www.revisor.leg.state.mn.us/arule/6264/0050.html See Appendix H: Types of Work Activities That Do Not Require a DNR Public Waters Work Permit on Public Waters, Public Water Wetlands and Public Watercourses.

✔ Minimize the number of water crossings.

✔ Give preference to crossing locations where:

  • Streambed and banks are composed of firm, cohesive soils or rock.
  
  • Approaches to streambanks have low-percent slopes and short slope lengths.
  
  • Construction will disrupt a minimum amount of natural stream channel.

✔ Maintain crossings as close to a 90-degree angle as possible to the streambed.
✔ **Avoid driving equipment over streambanks** for all intermittent and perennial streams regardless of size; instead use improved crossings.

✔ **Construct crossings** so as not to change the cross-sectional area of the stream channel or impede fish migration.

✔ **Construct low-water ford crossings** with materials that will not degrade water quality. These materials include (but are not limited to) concrete, coarse rock, riprap and gabions.

✔ **Minimize construction disturbance** to the natural flow of water.

✔ **Restrict activity in the water** to periods of low flow.

✔ **Design stream culverts and bridges for minimal impact** on water quality. Culvert installations on many streams will require a DNR water crossings permit. In addition, permanent culvert crossings and crossings on streams subject to frequent or flash flooding may require special design considerations. For sources of information on proper sizing of culverts, contact local SWCD offices, local NRCS offices or county highway departments.

✔ **At a minimum, select a stream culvert with a diameter** equal to the narrowest width (top of bank to top of bank) of the stream. Determine this width in a straight section of the stream near the intended stream crossing. Align culverts with the flow of the stream. Extend culvert length to the toe of the fill slope. Use multiple culverts equaling the total stream width for wide streams. If multiple culverts are needed, one should be buried (1/6 of diameter) and others should be about 1 foot higher in order to maintain adequate water depth within one culvert for fish migration during low stream flow.

✔ **Ensure that materials used** for installing stream culverts and bridges within the stream are clean, non-erodible and non-toxic to aquatic life. Such materials include compacted fill, natural rock riprap over geotextile, poured concrete and treated timbers. When using treated timbers below or near the water level, they should be reasonably dry and free of excessive surface oils when installed.

✔ **Anchor temporary structures at one end** to allow the structure to move aside during high water flows.

✔ **Remove temporary fills and structures** to the extent practical when use is complete.
Winter Roads

Winter roads provide access under frozen ground conditions for timber harvesting and other timber management activities. Like all other roads, winter roads need to have provisions for adequate drainage to prevent or minimize erosion and sedimentation into wetlands and open water. With much of the timber harvesting in Minnesota occurring during January, February and March, properly constructed winter roads are an important component of timber management.

✔ **Construct temporary crossings for winter roads** where practical. Examples of preferred temporary crossings include ice bridges, temporarily installed culverts and bridges (including use of native log materials). Soil fill should not be used on these temporary structures. See Figure ROAD-5.

✔ **Construct crossings** to prevent water from backing up.

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**Work Activities That Do Not Require A DNR Public Waters Work Permit**

As long as specific detailed conditions are met (see Appendix H), the following work activities do not require a DNR Public Waters Work Permit:

- Low-water ford crossings (on streams only)
- Temporary bridges (on streams only)
- Water level control structures (on streams only)
- Constructing a bridge or culvert, of filling or excavating the bed of a public water (for streams with a watershed at the mouth of the stream less than 5 square miles only)

Refer to Appendix H for conditions that must be met to conduct these activities without a permit. Remember, if the watercourse is a designated trout stream, the work activities may not be allowed, the timing of the work may be restricted, or a DNR Public Waters Work Permit may be required.
✔ **Consider using culverts or bridges** to cross defined drainages where winter roads are to be used for five years or longer. For information on sizing culverts, contact local SWCD offices, local NRCS offices or county highway departments.

✔ **Anchor temporary structures at one end** to allow the structure to move aside during high water flows.

✔ **Install all temporary structures** that could potentially block water flow in such a manner that they can be easily removed prior to breakup.

Ice bridges are made entirely of packed snow, which melts away in the spring.

Figure ROAD-5
Construction of Upland Forest Roads

➤ IMPORTANT! Review General Guidelines:

➔ Protecting Cultural Resources
➔ Managing Equipment, Fuel and Lubricants
➔ Protecting the Normal Flow of Streams and Wetlands
➔ Protecting Non-Open Water Wetlands and Seasonal Ponds
➔ Retaining Leave Trees
➔ Providing Coarse Woody Debris

✔ Conduct on-site meetings with the logger, landowner and resource manager prior to moving equipment onto a site. Such meetings can help assure common understanding of landowner objectives, road construction standards or specifications, and site conditions.

Clearing

Clearing widths will vary depending on the needs of both the owner and the user of the road. Consideration should be given to the necessity for roadway drying, as well as to the safety, cost and aesthetics of narrow rights-of-way.

✔ Place clearing debris in a manner that will not impede water flow or potentially increase sedimentation of waters.

✔ Provide periodic breaks in the windrows of clearing debris to allow for free movement of water.

✔ Avoid placing clearing debris in filter strips.
Reducing Visual Impacts of Road

<table>
<thead>
<tr>
<th>In areas classified as most sensitive:*</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔ Utilize merchantable timber within road clearings.</td>
</tr>
<tr>
<td>✔ Burn, screen or bury road-clearing debris, such as stumps, rocks and boulders, so that it is not visible from travel routes or recreation areas.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In areas classified as moderately sensitive:*</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔ Utilize merchantable timber within road clearings.</td>
</tr>
<tr>
<td>✔ Move cleared debris outside of the travel route right-of-way so that it is minimally apparent.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In areas classified as less sensitive:*</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔ Encourage utilization of all merchantable right-of-way timber.</td>
</tr>
<tr>
<td>✔ Avoid creating a corridor of debris.</td>
</tr>
<tr>
<td>✔ Do not leave jackstrawed or overturned stumps in immediate foreground.</td>
</tr>
<tr>
<td>✔ Reduce height of dozed clearing debris during road construction.</td>
</tr>
</tbody>
</table>

*See Part 2, Visual Quality: Visual Sensitivity Classifications for information related to how classifications are determined and which Minnesota counties have developed visual sensitivity classification maps.
Excavation

In most cases, material must be brought in to provide an adequate road for even a minimal amount of hauling. Such material should be obtained from the closest available source, which is often the ditch.

During work on new projects, loose exposed mineral soil is the most critical factor affecting siltation of waters.

✔ **Place excavated material** in a manner that will not impede water flow or potentially increase sedimentation of waters.

✔ **Avoid placing excavated material in filter strips.**

✔ **Shape inslopes and backslopes** to promote revegetation and soil stabilization. Slopes of 1.5:1 or flatter are preferred if terrain permits.

✔ **Compact fill material** to reduce entry of water, increase load-carrying capacity and minimize settling.

✔ **Deposit excess material in stable locations** away from streams, lakes, wetlands and seasonal ponds.

✔ **Shape and stabilize borrow pits** and excess material.

✔ **Limit the area excavated** to that which can be properly shaped and compacted within a day, with provisions for storm drainage and sedimentation control.
Reducing Noise and Visual Impacts of Gravel Pits and Borrow Areas

In areas classified as most sensitive or moderately sensitive: *

✔ Locate borrow pits and crushing operations out of the visible corridor as much as possible.

✔ Screen pits from travel routes or recreation areas using existing vegetation or landscape berms.

✔ Reduce noise in early morning, late evening and other appropriate times whenever possible.

✔ Develop gravel or borrow pits from the back to the front of pits (moving toward the predominant view or vantage point). See Figure ROAD-6.

✔ Rehabilitate pits upon completion of use as per guidelines in the Minnesota Department of Natural Resources Handbook for Reclaiming Sand and Gravel Pits in Minnesota (C.G. Buttleman 1992). This publication may be downloaded as a PDF file from the DNR Land and Minerals Web site at www.dnr.state.mn.us/lands_minerals/pubs.html

In areas classified as less sensitive: *

✔ Use methods and applications consistent with integrated resource management principles.

✔ Rehabilitate pits upon completion of use as per guidelines in the Minnesota Department of Natural Resources Handbook for Reclaiming Sand and Gravel Pits in Minnesota (C.G. Buttleman 1992). (See downloading information above.)

*See Part 2, Visual Quality: Visual Sensitivity Classifications for information related to how classifications are determined and which Minnesota counties have developed visual sensitivity classification maps.
Rehabilitate gravel pits upon completion of use. *Photo courtesy of Superior National Forest*

**Figure ROAD-6:** Develop gravel pits from back to front, moving toward predominant viewer or vantage point. In this illustration, Stage 1 has been completed, Stage 2 is in process, and Stages 3 and 4 will follow. Leaving the area adjacent to the road beyond Stage 4 untouched could result in no negative visual impact on the travel route.

**Drainage**

Site drainage and cross-drainage are important for controlling sedimentation. Proper handling of water during construction will minimize potential impacts on water quality.

✔ **Install drainage structures** as construction proceeds.

✔ **Install culverts** at grades 2% more than the ditch grade and angled at least 30 degrees from perpendicular to the flow of water to improve inlet efficiency. See Figure ROAD-7.
Size culverts and other drainage structures large enough to minimize impacts on water quality. Permanently and temporarily installed culverts should be at least 12 inches in diameter for ease of maintenance. Putting in culverts and drainage structures that are too small could result in washing out of the road. For sources of technical assistance, contact local SWCD offices, local NRCS offices or county highway departments.

Compact fill firmly around culverts, paying special attention to the sides and lower portion. Cover the top of culverts with fill to a depth of one-half the pipe diameter of 12 inches, whichever is greater. Culvert lengths should reach to the toe of the fill without changing the sideslopes of the fill. See Figure ROAD-8.
Armor culvert inlets and outlets to reduce bank and channel erosion and sedimentation where appropriate.

Provide adequate drainage for road grades during construction to minimize erosion of unconsolidated materials.

Retain outslope drainage and minimize berms on the outside edge during construction operations, except those intentionally constructed for protection of road grade fills.

Provide temporary cross-drainage structures (such as water bars) during construction where needed. See Cross-Road Drainage, pages 28-31.

Install siltation barriers, such as silt fences and straw bales, during construction in sites where roads and water have close contact for long periods.
Cross-Road Drainage

Water entering onto or adjacent to the road must be diverted away from the road before gaining sufficient flow and velocity to cause significant erosion of the road and ditch.

✔ Control down-road flow of surface water by using a combination of the appropriate road cross-section (see Figure ROAD-9) and appropriate water diversion structures within the roadbed itself, such as broad-based dips (see Figure ROAD-10 and Table ROAD-1) or grade rolls, open-top culverts and water bars (see Figure ROAD-11 and Table ROAD-2).

Figure ROAD-9

Typical Road Profiles for Drainage and Stability

- 2-4% • 2-4%

Crowned fill section for low ground use

- 2-4%

Outslope section for use on moderate slopes for low volume roads and stable soils

- 2-4%

Inslope with ditch section for use on steep hills and areas with fine textured soils

- 2-4% • 2-4%

Crowned and ditched section for high volume roads on steep side hills
Table ROAD-1

Cross-Drain Spacing for Broad-Based Dips and Upland Culverts

<table>
<thead>
<tr>
<th>Grade</th>
<th>Spacing between dips or upland culverts</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2%</td>
<td>500 ft</td>
</tr>
<tr>
<td>3-4%</td>
<td>300 ft</td>
</tr>
<tr>
<td>5-7%</td>
<td>180 ft</td>
</tr>
<tr>
<td>8-10%</td>
<td>150 ft</td>
</tr>
<tr>
<td>11-15%</td>
<td>130 ft</td>
</tr>
<tr>
<td>16%+</td>
<td>110 ft</td>
</tr>
</tbody>
</table>
Water Bar Spacing

<table>
<thead>
<tr>
<th>Grade</th>
<th>Spacing between water bars or water diversion measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>250 ft</td>
</tr>
<tr>
<td>5%</td>
<td>130 ft</td>
</tr>
<tr>
<td>10%</td>
<td>80 ft</td>
</tr>
<tr>
<td>15%</td>
<td>50 ft</td>
</tr>
<tr>
<td>25%+</td>
<td>40 ft</td>
</tr>
</tbody>
</table>

Selecting the correct spacing requires interpolating between the values given. For example, a 4% grade requires a spacing of 170 feet between water diversion structures. A 13% grade requires a spacing of 62 feet between water diversion structures.
✔ **Drain surface water that is diverted from roads** into the filter strip or vegetative area, rather than directly into streams, lakes, open water wetlands, non-open water wetlands or seasonal ponds.

✔ **Use diversion structures** on approaches to water crossings or on roads and trails found within the riparian management zone to divert water off of the right-of-way before it reaches the water body.

✔ **Install cross drains and lead-off ditches** to avoid carrying water long distances in roadside ditches. (See Figure ROAD-12.) Cross drains may include open-top culverts, pipe culverts and bridges.
Protecting Resources

✔ **Stabilize bare soil areas** to reduce erosion. A vegetative cover is recommended along all roadsides. Where necessary, mulch and seed disturbed soil as soon as practical after construction. For sources of recommendations for seed mixes and fertilizer use, see *Resource Directory*.

✔ **Install temporary erosion control devices**, such as straw bales, mulch or woody debris, to help stabilize soils prior to establishment of vegetative cover. See Figure ROAD-13.

✔ **Inspect and repair erosion control measures** on a regular basis to ensure that they remain functional.

✔ **If road construction will take place in the area of a cultural resource**, consider construction when the ground is sufficiently frozen or snow depth is sufficient so that soil disturbance is minimized.

**Figure ROAD-13**
WETLAND FOREST ROADS

Have you identified your goals and objectives?
See Identifying Goals and Objectives in General Guidelines.

Have you conducted a site inventory?
See Conducting a Site Inventory in General Guidelines.

Design of Wetland Forest Roads

IMPORTANT! Review General Guidelines:
- Incorporating Sustainability into Forest Management Plans
- Maintaining Filter Strips
- Managing Riparian Areas

Landowners may need the services of a forester, engineer or other qualified individual to provide complete design and construction specifications. This professional assistance is particularly important when constructing permanent all-season roads. For sources of professional assistance, see Resource Directory.
✔ **Contact an SWCD office or DNR hydrologist** to determine whether the proposed road will cross a water or wetland designated on the Protected Waters Inventory maps. If so, secure the required permit from the DNR Division of Waters to work in public waters (Minn. Statutes 103G.245). For a listing of DNR regional offices, see Resource Directory. See also Appendix H: Work Activities That Do Not Require a DNR Public Waters Work Permit on Public Waters, Public Water Wetlands and Public Watercourses.

✔ **Contact a county planning and zoning office or local SWCD office** to determine whether the local government unit requires a certificate of exemption for forest management activities related to forest road construction. See Resource Directory.

✔ **Wherever practical, place fueling and maintenance areas, landings and roads** (those that do not cross a stream, lake or open water wetland) outside of filter strips or the riparian management zone, whichever is wider. See General Guidelines: Maintaining Filter Strips and General Guidelines: Managing Riparian Areas.

✔ **Avoid crossing wetlands** wherever possible.

✔ **Minimize total wetland road mileage** when wetlands must be crossed, while still meeting landowner objectives.

✔ **Determine the type and depth of wetland subsoils** to ensure proper design and construction.

✔ **Minimize width of roads** consistent with maintaining safety and road design considerations. Provide turnouts, as appropriate, placed at intervals to accommodate two-way traffic. On deep peat wetlands, road fill slopes should be 3:1 or flatter to spread out road loading and minimize failure. (See Figure ROAD-4, page 16.)

✔ **Design upland road approaches** to wetlands so that surface runoff is diverted before entering the wetland.
Construction of Wetland Forest Roads

➤ IMPORTANT! Review General Guidelines:

- Protecting Cultural Resources
- Managing Equipment, Fuel and Lubricants
- Protecting the Normal Flow of Streams and Wetlands
- Protecting Non-Open Water Wetlands and Seasonal Ponds
- Retaining Leave Trees
- Providing Coarse Woody Debris

✔ Conduct on-site meetings with the logger, landowner and resource manager prior to moving equipment onto a site. Such meetings can help assure common understanding of landowner objectives, timber harvesting regulations and site conditions.

Choosing the appropriate road construction technique will depend on a knowledge of water table position, zone of water flow, type of wetland soils, and the strength of wetland soils. With any road construction technique, culverts or ditches (or both) may be necessary.

General Construction Considerations

✔ Prior to construction, identify locations of new roads, borrow areas and gravel pits to avoid cultural resource areas.

✔ Construct all road embankment fills with clean fill or other suitable native materials.

✔ Anchor temporary structures at one end to allow the structure to move aside during high water flows.

✔ Employ sediment control techniques (such as silt curtains) to prevent movement to open water when placing fill during construction.
✔ Provide adequate cross-drainage by employing one or both of the following techniques:

- Use construction methods that allow free water flow throughout the entire roadbed. See Figure ROAD-14.

- Place culverts or other cross-drain structures at each end of each wetland crossing and at intermediate low points. Space culverts or other cross-drain structures at maximum 300-foot intervals to ensure adequate cross-drainage through the roadbed. See Figure ROAD-15.

✔ Shape and stabilize borrow pits and excess material.

✔ Construct ditches in wetland crossings, where necessary, to intercept and carry surface and subsurface water (the top 12 inches) to, through and away from the culverts. Unditched breaks should be left midway between culverts. Additional ditching practices are listed under specific guidelines for various wetland types.

✔ Avoid having ditches create additional outlets that will result in drainage of the wetland or seasonal pond. Additional ditching practices are listed under specific guidelines for various wetland types.

Figure ROAD-14

Road Design for Peat Wetlands with Continuous Cross-Drain-

Drainage layers may be used as an alternative to culverts, or in combination with culverts, to provide adequate cross-drainage.
The following guidelines address four kinds of wetland road construction approaches:

- Crossing mineral soil wetlands
- Crossing shallow peat wetlands
- Crossing deep peat wetlands
- Crossing wetlands in winter

**Crossing Mineral Soil Wetlands**

Wetlands with mineral soils include those wetlands having fine-textured (clay or silt), slowly permeable soils to sandy soils overlaying impervious subsoils or hardpans. Road building across these wetland types employs conventional road construction techniques for road fill and drainage structures.

Weak mineral soils can be excavated and backfilled with clean granular soils, or they can be filled over with clean granular fill and allowed to compress and displace. Additional fill is added to keep the road bed at the desired grade.
Culverts and ditches are installed to minimize disruption of normal water flow across the landscape and transport it through and away from the roadbed.

Fill areas in floodplains should be designed to allow high flows to pass unimpeded.

✔ **Install culverts of sufficient size** to handle hydrologic flows for the site and for long-term maintenance needs. If ditches are needed, construct them immediately adjacent to the toe of the fill slope. For sources of technical assistance, contact local SWCD offices, local NRCS offices or county highway departments.

## Crossing Shallow Peat Wetlands

Wetland crossings of shallow peat less than 4 feet deep may be constructed using conventional road construction methods:

- **The conventional road construction method** consists of excavating the shallow peat and then backfilling with clean granular backfill material. The excavated peat can be used to flatten the roadbed fill slope. Excess peat should be hauled away and disposed of at an approved upland disposal site.

- **Another accepted road construction method** involves placing granular fill material directly onto the peat surface. The weight of the fill material displaces (or pushes aside) the weaker peat until the strength of the subsoils is sufficient to bear the weight of the fill material and vehicle loadings. As final settling occurs, additional fill may be needed to maintain the desired road grade.

With both methods, the installation of culverts and ditches intercepts surface and subsurface water flow, transporting it through and away from the roadbed. (Most subsurface flow occurs in the top 12 inches of the peat).
Follow these guidelines when placing culverts:

✔ **Install culverts that are a minimum of 24 inches in diameter** buried halfway below the soil surface. The upper half will handle surface storm flows and the lower half will handle normal subsurface flows. Failure to bury the lower half of the culvert will cause subsurface water to pond on the upstream side of the road and kill trees. See Figure ROAD-16.

✔ **Place culverts at the low points of the wetland** to pass surface water flows though the road embankments. If ditches are needed, construct them immediately adjacent to the toe of the fill slope. For sources of technical assistance, contact local SWCD offices, local NRCS offices or county highway departments.
Crossing Deep Peat Wetlands

Crossing wetlands with peat soils greater than 4 feet deep can be done using special road construction methods that do not require excavation and backfill. These methods make use of geotextile fabrics, special embankment structures (such as lightweight road fills, extra-wide road bases or log corduroy layers), and the inherent strength of the underlying peat layers to resist slip failure and resultant road failure. (See Figure ROAD-14, page 36.)

Such failures can range from the gradual sinking to the sudden loss of the road into the wetland. When such failures occur, the peat water flow through the wetland is greatly disturbed, which can result in large areas of flooding.

These methods generally specify that a layer of geotextile be placed on the peat surface. Road fill is then placed over the geotextile. To provide additional strength and adequate cross-drainage, special materials such as log corduroy, wood chips or drainage rock may be added in the lower portion of the fill. (See Figure ROAD-14, page 36.)

The specific road structure needed depends on the strength of the peat layers below the road. The determination of shear strength is critical in designing a sound, safe and economical road crossing. The landowner or resource manager is strongly advised to consult a registered civil engineer to accurately determine shear strengths, conduct field testing and provide design specifications.

Some deep peat wetlands with peat layers that are too weak to support a roadbed will require traditional excavation and backfill methods. Because of the high cost of traditional construction methods, as well as environmental effects, it is best to avoid building on these weak peat wetlands.

Cross-drainage through the roadbed in a deep peat wetland is normally slowed or halted as a result of the compression of the peat layers by the road embankment, equipment rutting of the peat surface, or road failure. This can cause flooding on the upslope side of the wetland and drying on the downslope side.
Cross-drainage can be maintained by the proper installation of culvert and drainage layers. In all cases, the construction objective is to provide a stable road surface while maintaining free flow of water through the roadbed.

The following techniques can prevent or minimize impacts to deep peat wetlands:

✔ **Construct road embankments across wetlands** with deep peat subsoils when the peat is frozen. Construction on frozen peat avoids rutting and other damage of the topmost root mat layer, which normally contains considerable shear strength. Such damage can greatly reduce the strength of the upper peat layers and reduce the ability of the wetland subsoils to hold up the weight of the roadbed and vehicle loads.

✔ **Install culverts that are a minimum of 24 inches in diameter** buried halfway below the soil surface. The upper half will handle surface storm flows, and the lower half will handle everyday subsurface flows. Failure to bury the lower half of the culvert will cause subsurface water to pond on the upstream side of the road and kill trees. See Figure ROAD-16, page 39.

✔ **Maintain a separation** between the toe of the embankment fill slope and the ditch when constructing ditches parallel to the roadway. The separation distance should be at least three times the depth of the peat, which will prevent or minimize disturbance of the inherent strength of the top layer of peat containing the root mat. See Figure ROAD-15, page 37.

✔ **Provide ditches to facilitate flow** into and out of culverts.

✔ **Construct ditches using flotation devices** (such as timber mats) or schedule construction to occur during frozen conditions, to prevent or minimize impacts on wetlands and minimize damage to construction equipment.

✔ **Obtain professional engineering advice** on design of cross-drainage ditches for permanent roads across deep peat wetlands.
Specific design techniques for crossing deep peat wetlands

Roadbeds that use geotextile fabrics should be prepared to protect the woody root mat by flush-cutting trees and brush and leaving non-merchantable material in place. The first geotextile fabric should be laid loosely over the cut material. Then proceed with one of the following three wetland road construction techniques:

**Technique #1: Corduroy**

- Place trees parallel to each other, side by side and perpendicular to the roadbed direction
- Cover as needed with clean road fill or gravel.
- If log corduroy is to be used for cross-drainage, apply geotextile both above and below the corduroy. If log corduroy is not to be used for cross-drainage, other cross-drainage structures should be considered. See Figure ROAD-14, page 36.

**Technique #2: Rock drainage layer**

- Place 12 inches of rock (4 inches or less in diameter) over the geotextile, followed by another layer of geotextile. The rock layer will settle into the top 12 inches of the wetland, providing the pore space for water passage through the roadbed.
- Place clean road fill or gravel on top (typically 18 inches deep).

**Technique #3: Lightweight road fills**

Lightweight materials may be incorporated into the core of the road embankment fill to lessen the total weight of the road embankment when constructing on weak peat wetlands.
Lightweight materials include wood chips and sawmill residues, among other materials. Materials with known potential to leach toxic substances (such as construction debris, treated wood, tires, asphalt or other petroleum-laden materials) are not suitable for use.

- Place the lightweight materials over the fabric to form the core of the road embankment fill, followed by another layer of geotextile fabric over the lightweight materials.

- Cover the core with at least 18 inches of granular sand or gravel road fill.

- Install culverts and ditches, if necessary, to pass surface and subsurface waters through the road embankment. See Figure ROAD-15, page 37.

Crossing Wetlands in Winter

Roads across wetlands or seasonal ponds are often designed to take advantage of frozen ground conditions. The following guidelines apply to design of roads across all wetland types.

✔ Plan the layout to maximize operating efficiency and minimize site disturbance.

✔ Select the shortest routes practical that minimize potential problems with drifting snow and the crossing of open water.

✔ Tramp and pack the wetland area wider than needed for the driving and working area if sufficient frost is not present. This additional space will allow for turnouts, snow removal and parking.

✔ Avoid crossing open water or active springs. If unavoidable, temporary crossings are preferred. These can be ice bridges, temporarily installed bridges or culverts, or timber mats.

✔ Avoid using soil fill.

✔ Install all structures that block water flow so that they can be easily removed prior to breakup. If the streams are navigable or require a DNR permit to cross, removal may be necessary at the end of each winter of operation, not just at the end of the timber contract.
✔ Use planking, timber mats or other support alternatives to improve the ability to support heavy traffic where conditions are inadequate to stay within the stated guidelines. If removal would cause more damage than leaving them in place, these areas may be left as permanent sections on frozen roads.

✔ Anchor temporary structures at one end to allow the structure to move aside during high water flows.

✔ Avoid clearing practices that result in berms of soil or organic debris building up on either side of the road clearing. Such berms can disrupt normal water flow.


✔ When rutting exceeds 6 inches in depth for continuous distances greater than 300 feet on any portion of the road, cease equipment operations on that portion of road. Resume operations only when conditions are adequate to support equipment. This practice will minimize blockage of cross-drainage and prevent or minimize down-road channelization. See Figure ROAD-17.

**Figure ROAD-17**

Peat Wetland Surface in Relation to Water Table

The water table (solid line) is near the bottom of the hollows (upper dotted line). Operations should stop when ruts reach 6 inches below the water table or 6 inches below the bottom of the hollows, whichever is lower. Peat is usually still porous 9 inches below the hollows, and ruts will heal in 2 to 3 years. Deep ruts (more than 12 inches below the hollows) will bring up well-decomposed, mucky peat and may take more than 20 years to heal.
MAINTAINING AND CLOSING ALL FOREST ROADS

➤ IMPORTANT! Review General Guidelines:

→ Post-Operational Activities and Followup Visits

Maintenance Measures for All Roads

✔ Clean debris from culverts, ditches, dips and other structures as needed to diminish the danger of clogging and the possibility of washouts. Any debris should be placed away from the watercourse and stabilized, if necessary.

✔ Restrict use of roads during times when the road is especially susceptible to damage, including wet periods and spring breakup.

Maintaining Active Roads

✔ Fill in ruts and holes that develop during road use. Use a suitable material (such as gravel or compacted fill), and fill as soon as possible to reduce the potential for erosion.

✔ Grade road surface periodically to maintain proper surface drainage and eliminate small wheel ruts.

✔ Minimize berms along the edge of the road that will trap water on the road surface. Feather material out on the road surface.

✔ Minimize entry of dust control agents into water. For example, do not apply an excess of chemicals to the road that could potentially be transported to surface water through erosion and surface runoff.

✔ Do not treat roads with calcium chloride as this chemical causes physiological distress for amphibians crossing them.
✔ Implement stabilization methods so that the shape, slope, elevation and contours of archaeological sites and other cultural features are preserved. Stabilization should not alter the historic character of the cultural resource.

✔ Avoid impacting cultural resources within existing road corridors when reconstructing or maintaining forest roads. Management options include the following:

- Limit or eliminate maintenance (including regrading or widening) in or near cultural resource areas.
- Use “fill only” techniques to improve roads that cross subsurface cultural resources.
- Reroute roads that cross cultural resource areas.

Closing Inactive Roads

✔ Remove flagging, signs or other markings in cultural resource areas after road closure, except in those cases where signs are appropriate long-term protection or interpretation tools. These items are indicators that cultural resources are present and may lead to looting.

✔ Remove temporary fill and structures to the extent practical when use is completed.

✔ Close or obliterate temporary forest access roads after management activities are complete if continued access might result in damage to endangered, threatened and special concern species (ETS species), sensitive communities, cultural resources or water features. If temporary roads will be obliterated, earthwork should be confined to the road corridor.

✔ Provide appropriate access control to minimize unauthorized traffic during use and especially after completion of activity.

✔ Ensure that the road surface is in stable condition when the road is closed. When closing the road, there are two particularly important aspects to closure and stabilization for inactive roads.
These are: 1) stabilizing surfaces to minimize erosion and sedimentation to water, and 2) stabilizing and maintaining road surfaces to provide for future access.

Seed and fertilize disturbed surfaces as necessary. To facilitate regeneration, back blade or otherwise scarify roadbeds where appropriate. Use native grass or forb mixes if available. For sources of recommendations for seeding and fertilization, see Resource Directory.
For temporary closure:

✔ **Control access** to minimize maintenance requirements.

✔ **Install appropriate drainage structures** as necessary and maintain in working order.

✔ **Place a barrier to traffic**, and post “Road Closed” signs at the beginning of the road when closing roads.

✔ **Provide periodic inspection and maintenance** of road surfaces as necessary.

For permanent closure:

✔ **Place a barrier to traffic**, such as a berm, and post “Road Closed” signs at the beginning of the road when closing roads. See Figure ROAD-18.

✔ **Place water bars** where necessary. See Figure ROAD-11, page 30.

✔ **Remove structures** that would require continuing maintenance (such as culverts and bridges) even after a road is abandoned.

✔ **Reshape stream crossings** to approximate original channel contour when removing water crossing structures, and stabilize the structure site.

✔ **Provide breaks in extended fills** in flood-prone areas at intervals no greater than 300 feet to accommodate high flows and debris.
Providing appropriate access control eliminates motorized vehicle use (which can lead to erosion) while also encouraging hunters and hikers. Photo courtesy of Itasca County Land Department
Timber Harvesting

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REMEMBER:

Guidelines help with how to manage, not whether to manage.

These guidelines focus on how to protect the functions and values of forest resources during forest management activities. They do not provide advice on whether to manage or which management activities are needed.

Guidelines provide a menu, not a mandate.

Site-level resource management decisions are based on many different factors, including resource needs, landowner objectives, site capabilities, existing regulations, economics and the best information available at any given time. No one will apply all of the guidelines related to a particular activity. Instead, the landowner, resource manager or logger will consider many different factors in determining which combination of guidelines provides the best “fit” for a particular site at a particular time. The intent of having multiple guidelines is to provide decision-makers with as much flexibility—and as much choice—as possible in taking steps to effectively balance forest management needs and resource sustainability.

General guidelines and activity-specific guidelines are closely related.

Frequent references from activity-specific guidelines back to the general guidelines will make it easy for landowners, resource managers, loggers and others to consider all of the related guidelines—both general and specific—that apply to a particular management activity.

Guidelines are supplemented from time to time by "Additional Considerations."

The guidelines are supplemented from time to time by “Additional Considerations,” which provide additional guidance to further promote the sustainability of forest resources.
INTRODUCTION

Timber harvesting involves planning harvest and reforestation; cutting trees and moving them to a landing; processing, sorting and loading; and transporting materials.

The Benefits of Guidelines

Benefits to cultural resources: Timber harvesting guidelines can minimize the potential effects of harvesting activities, such as mixing of surface soils, rutting, compaction and erosion, which can damage certain kinds of cultural resources. Guidelines for construction of roads and landings, felling, skidding and slash management can help to protect cultural resources.

Benefits to forest soils: Timber harvesting guidelines are designed to help protect the physical, chemical and biological properties of forest soils by minimizing the effects of soil compaction and rutting, erosion and nutrient removal that can result from timber harvesting activities. Reducing these potential impacts can maintain root penetration, availability of water, water absorption by plants, availability of oxygen and other gases in the soil, and the degree to which water moves laterally and vertically through the soil. Guidelines can also minimize the need for expensive rehabilitation of highly impacted soils.

Benefits to riparian areas: Timber harvesting guidelines can minimize the alteration of vegetation within the riparian area. That vegetation is important for providing inputs of coarse woody debris and fine litter to water bodies; retaining nutrients, sediment and energy; bank and shoreline stabilization; maintenance of moderate water temperatures through shading; and wildlife habitat. Guidelines for retaining vegetation can also have a positive impact on aesthetics, wood products and recreation.

Benefits to visual quality: Timber harvesting guidelines can moderate the potential adverse visual quality impacts from timber harvesting activities and help reduce the impression of poor harvesting and utilization. Guidelines related to perceived harvest size, slash, landings and snags have the greatest potential to enhance visual quality.
Benefits to water quality and wetlands: Timber harvesting guidelines provide protection to water quality and wetlands by minimizing potential nonpoint source pollution resulting from soil disturbance, disruption of vegetative cover, and timber harvesting activities in close proximity to streams, lakes and wetlands. Guidelines to help maintain vegetative cover can also help riparian areas moderate water temperatures. Guidelines that address equipment operations and maintenance can help protect water quality, and guidelines to minimize rutting in wetlands help maintain normal water flows.

Benefits to wildlife habitat: Timber harvesting guidelines reduce the potential for timber harvesting activities to disturb sensitive sites, rare species, water features and unique habitats. Guidelines related to timber harvesting, especially clearcutting, are aimed at maintaining structural components on a site (including live trees, snags, woody debris, shrubs and ground cover) that are needed by forest wildlife now and as the stand regenerates.

Considerations

Protecting soil and water resources

❒ **Appropriate reforestation goals should be considered** before beginning harvest activity. The plan should include site preparation techniques, if needed, and species selection prior to harvest. It may include natural regeneration of existing species.

❒ **Special soil conditions and topographic features** make some areas of the state more sensitive than others to soil disturbance. Two primary examples of these localized sensitive areas are the blufflands of southeast Minnesota and the Nemadji River Basin south of Duluth.

❒ **When working in areas** with special soil conditions and topographic features that make them more sensitive to disturbance than others, the landowner, resource manager or operator needs to increase the intensity of planning compared to other forested regions of the state. Planning should address long-term development and maintenance needs.

❒ **Soil impacts can be minimized** by limiting the soil area impacted by infrastructure (roads, landings and skid trails), and by careful
consideration of timing, equipment being used, and harvesting methods. Planning considerations include carefully determining appropriate operating seasons for any given soil, as well as using harvest layouts, strategies and equipment that minimize the surface area of a site that is trafficked.

- **Appropriate timber harvesting strategies and practices** can be employed to ensure that timber harvesting practices do not reduce the productive capacity of forest soils through removal of nutrients or disruptions of nutrient cycles. On most Minnesota forest soils, nutrient removal through harvest is not a concern. However, guidelines should be applied in specific situations and site conditions, with the goal of balancing the level of nutrients removed through timber harvest with natural nutrient inputs.

- **Susceptibility to compaction and rutting** on wetlands is dependent on several factors, including level of equipment trafficking, type of equipment used, soil type (mineral soil or peatland), soil water content at the time the silvicultural activity is conducted, and season of activity. In general for mineral soil wetlands, compaction and rutting increase as soil texture becomes finer and soil water content increases. In unfrozen peatland, deep rutting can bring muck to the surface and block normal water flow.

- **Winter alone does not ensure frozen ground.** With sites susceptible to rutting and compaction, specify frozen conditions rather than setting an arbitrary season. Either use the right equipment (e.g., low ground pressure equipment), or use slash mats where there is a sufficient volume of this material.

- **Wetlands are highly productive sites** for a variety of ecologic functions, as well as for the enhancement of water quality. All forest management operations in or adjacent to wetlands should be planned and conducted in a manner that protects these functions.

- **Using appropriate forest management guidelines for harvesting activities** will minimize the potential for sediment, chemical, nutrient and debris movement into streams, lakes, wetlands, seasonal ponds and ground water. Guidelines will also minimize thermal (heating) impacts on surface waters.

- **Employing loggers who have been trained in guideline implementation** can aid in proper and efficient application of site-level timber harvesting guidelines.
Visual impacts

❒ **Travel speed affects the apparent field of vision** and the observation time, which impact the users’ levels of concern. See Figure TH-1.

❒ **Type of harvest** (clearcut vs. partial cut, for example) affects user **perception** of apparent size.

❒ **Stand condition and health** should be considered along with visual impacts.

❒ **Desired future condition of a particular stand** should be considered along with visual impacts.

❒ **Proximity to recreational use areas** results in enhanced user concerns regarding apparent size of harvest.

---

**Figure TH-1:** Travel speed affects apparent field of vision and observation time.
Managing slash

- Slash is unavoidable when timber harvesting.
- Slash treatment has a definite cost.
- Slash near streams, lakes and wetlands is subject to special regulation.
- Slash provides soil nutrients.

Landings

- Size and number of landings are affected by species, products developed, size of sale and timber sale design.
- Topography can limit both placement and number of landings.
- Proximity of harvest to travel routes or use areas can affect placement of landings.
- Proposed future use of landing area (as a parking area along a recreational trail or as a wildlife opening, for example) can affect size and placement of landing.
- Landing treatment practices may result in additional cost, no change in cost, or a savings in cost.

Snags

- Snags represent a potential safety hazard for logging operations.
- Snags can limit effective growth of future plantations by occupying space that could otherwise be used by healthy trees.
- Snags may increase the potential risk of lightning fires.
- Snags enhance the quality of wildlife habitats, providing nesting, denning, feeding and roosting sites, as well as escape areas.
- Snags may increase insect and disease problems for regeneration of a new stand.
Timber harvesting should be designed and conducted to achieve the following beneficial outcomes regarding soil productivity:

- Soil in a condition that favors regeneration and growth of native vegetation and trees
- Majority of soil on site free from any compaction or traffic
- No more than 1-3% of the timber harvest area occupied by roads and landings (Small or irregularly shaped units may result in higher percentages.)
- No more than 10-15% of the timber harvest area occupied by skid trails, with access to the rest of the site (1-2 passes) occupying no more than an additional 20-30% of the area (Small or irregularly shaped units may result in higher percentages.)
- Established skid trails that are managed to retain serviceability so that creation of new trails is not needed
- Soils impacted by equipment traffic limited to an efficiently laid-out system of skid trails that allow access to all areas of the site with a minimum number of trails. Impacts from cross-country travel by equipment (outside of skid trails) limited to the shortest distance between stump and collector trails.
- Minimal rutting in skid trails, roads and landings; and avoidance of rutting in the general harvest area
- Minimal change to the hydrologic condition of the site
- Minimal loss of nutrients on nutrient-sensitive site
- Nutrient removal from timber harvest resulting in no reduction to tree growth or change in vegetative composition of the site
- Bare soil areas and skid trails stabilized from surface erosion
➤ Have you identified your goals and objectives?
See Identifying Goals and Objectives in General Guidelines.

➤ Have you conducted a site inventory?
See Conducting a Site Inventory in General Guidelines.

PLANNING AND DESIGN

➤ IMPORTANT! Review General Guidelines:
- Incorporating Sustainability into Forest Management Plans
- Maintaining Filter Strips
- Managing Riparian Areas
Consider water quality concerns as management objectives are established:

- Include provisions for water protection in the timber sale contract.
- Avoid building landings, skid trails and roads in wetlands.
- Where avoidance is not practical, the resource manager, logger, contractor or landowner should minimize impacts by limiting the extent of wetland activities.

Consider soil or site conditions that may dictate specific timing, harvest methods or equipment to be used, or that may lead to weather-related or seasonal closure of the operation.

When designing timber sales (including layout, size and shape):

- Consider and incorporate forest management goals, harvesting efficiencies and site impacts.
- Use natural features and avoid artificial patterns where possible. These natural features may correspond to changes in topography, soils, wetland interfaces and timber types.

If practical and feasible, protect cultural resource areas:

- Exclude cultural resource areas from timber sale area.
- Keep roads, skid trails and landings away from cultural resource areas.
- If harvest will take place on or near a cultural resource, consider applying guidelines in Timber Harvesting: Protecting Sensitive Areas (page 20).
Plan a progressive harvesting technique that avoids trafficking over pre-cut areas where possible. See Figure TH-2. For example, back-to-front harvesting techniques in frozen and unfrozen conditions can reduce site impacts during harvesting. Advantages of this method include the following:

- Traffic is avoided over newly established regeneration.

- Traffic is focused on a specific set of skid trails by skidding through standing trees, confining soil compaction and rutting to skid trails.

- During the growing season, sites remain dryer and dry out faster after rains because standing trees are actively transpiring moisture.
✔ Mimic natural disturbance by leaving some live trees, snags and reserve patches in clearcut harvest areas. Consider leaving fingers and fire shadow areas next to wetlands in fire-dependent forest types. See Figure TH-3, and see General Guidelines: Retaining Leave Trees.

✔ Create a variety of patch sizes within selection harvests.
✔ For aspen or hardwood cover types on well-drained sandy soils or on shallow soils (8 inches or less) over bedrock, consider one or more of the following guidelines:

- Convert or manage site for tree species that store fewer nutrients in the bole and bark of the tree, such as red pine or jack pine.

- Retain or redistribute slash on the site.

- Avoid full-tree harvesting or full-tree skidding that piles slash, or redistribute slash back onto the site.

- During non-frozen seasons, leave slash in small piles or drags along skid trails or in the skid trails themselves, rather than trafficking off of established trails, because the negative effects of soil trafficking outside of skid trails may outweigh the benefits of redistributing slash.

- Add nutrients to the site, such as municipal sludge, ash or commercial fertilizer. For sources of technical assistance before applying nutrients, see Resource Directory.

- Avoid shortened rotations.

- Consider extending harvest rotation age.
✔ **For organic soils deeper than 24 inches,** consider one or more of the following guidelines:

- Retain or redistribute slash on the site.

- Avoid full-tree harvesting or full-tree skidding that piles slash, or redistribute slash back onto the site.

- Add nutrients to the site, such as municipal sludge, ash or commercial fertilizer. For sources of technical assistance before applying nutrients, see *Resource Directory.*

- Avoid shortened rotations.

- Consider extending harvest rotation age.

### Additional Considerations

☛ **Consider whether a legacy patch is needed.** See *Part 2, Wildlife Habitat: Additional Consideration: Legacy Patches,* for information about legacy patches.

☛ **Consider maintaining the diversity of mast sources** on the site, as well as some level of current production of mast sources. For example, maintain landings as openings or avoid machinery operation in pockets of fruit-producing shrubs.
### In areas classified as most sensitive: *

✔ **Limit apparent harvest size** to 5 acres or less by:

- Leaving patches of trees to break up the harvest area.
- Using one or more of the techniques listed below.

#### In areas classified as moderately sensitive: *

✔ **Limit apparent harvest size** to 5–10 acres by:

- Leaving patches of small unmerchantable species in the harvest area.
- Using one or more of the techniques listed below.

#### In areas classified as less sensitive: *

✔ **Follow standards and guidelines** that best achieve integrated resource management objectives for the area.

**Techniques for limiting apparent harvest area size:**

✔ Create narrow openings into harvest area to limit view from public roads, lakes and rivers, or recreation areas. See Figure TH-4.

✔ Utilize natural terrain. See Figure TH-5.

✔ Shape clearcuts to look more like natural openings where ownership patterns allow. See Figure TH-6.

✔ Adjust contiguous linear feet of harvest frontage along travel routes relative to travel speed.

✔ Consider multiple-stage cuts or other management methods such as shelterwood and selective harvesting. See Figure TH-7.

*See Part 2, *Visual Quality: Visual Sensitivity Classifications* for information related to how classifications are determined and which Minnesota counties have developed visual sensitivity classification maps.*
**Figure TH-4:** The impact of a highly visible harvest (upper left) is reduced by the use of narrow openings into the harvest area (lower right). A vegetative island further blocks the view into the harvest area.

**Figure TH-5:** Using natural terrain to screen clearcuts from view can reduce the apparent size of a harvest area.

**Figure TH-6:** Shaping clearcuts to resemble natural openings (above) is more visually pleasing than geometric clearcut areas (below). The top opening also uses a vegetative island to reduce apparent size from the road.
Figure TH-7: Multiple-stage cutting (right) can reduce apparent harvest area

Vegetative islands (below) provide leave trees for wildlife habitat, serve as legacy patches, and help to reduce the apparent size of this clearcut from the main road (far right). This clearcut has also been shaped to resemble a natural opening. *Photo courtesy of Superior National Forest*

This aerial view of harvest activity in a clearcut area (below) reflects several visual quality management practices, including natural shaping, large vegetative islands and a narrow opening into the area that limits visual penetration from the road (lower left). *Photo courtesy of Chippewa National Forest*
OPERATIONAL ACTIVITIES

➤ IMPORTANT! Review General Guidelines:

➤ Protecting Cultural Resources
➤ Managing Equipment, Fuel and Lubricants
➤ Protecting the Normal Flow of Streams and Wetlands
➤ Protecting Non-Open Water Wetlands and Seasonal Ponds
➤ Retaining Leave Trees
➤ Providing Coarse Woody Debris

Other guidelines that apply:

For activities involving: Refer to these guidelines:

Constructing and maintaining forest roads Forest Road Construction and Maintenance

✔ Conduct on-site meetings with the logger, landowner and resource manager prior to moving equipment onto a site. Such meetings can help assure common understanding of landowner objectives, timber harvest specifications and site conditions.

Protecting Sensitive Areas

✔ Avoid sensitive areas discovered during the actual timber harvest that were not previously identified. Sensitive areas include areas with special soil conditions and topographic features that make them more sensitive to disturbance than others.

✔ Employ harvesting techniques that minimize the need to operate equipment on steep slopes (such as winching logs off steep slopes or cable yarding). Employ appropriate harvesting techniques and equipment when harvesting on steep slopes.
If harvest will take place in the area of a cultural resource, employ measures to reduce soil disturbance, including (but not limited to) hand felling, cable skidding, limited-area feller buncher, low ground pressure (LGP) equipment, cut-to-length systems, and temporary protection such as slash, corduroy, tire mats or fill over geotextile.

Conduct on-site meetings with the logger, landowner and resource manager prior to moving equipment onto a site. Such meetings can help assure common understanding of landowner objectives, timber harvesting regulations, contract specifications and site conditions. Photo courtesy of Minnesota DNR
Landings

✔ Specify the number and location of landings as part of the harvesting agreement.

✔ Size landings to the minimum required for the acres to be harvested, the equipment likely to be used, and the products to be cut.

✔ Plan roads and landings to occupy no more than 1-3% of the timber harvest area. See Figure TH-8.

✔ Locate landings so that they are:
   • On upland areas whenever practical
   • On stable ground
   • Outside of filter strips or the riparian management zone (RMZ), whichever is wider, where practical. (See General Guidelines: Maintaining Filter Strips (pages 24-28) and General Guidelines: Managing Riparian Areas (pages 29-67).
   • Away from areas where a cultural resource is present

✔ Avoid landings in locations that will concentrate runoff from surrounding areas onto the landing. Use an appropriate combination of ditches, water bars and outsloping to keep the landing area dry.

✔ Avoid locating landings and yarding areas on open water wetlands.
Figure TH-8

Sample 20-Acre Timber Sale

An Example of Infrastructure Proportions

1% Road (16 ft wide x 545 ft long)
1% Landing (0.2 acre)
Reducing Visual Impacts of Landings

In areas classified as most sensitive: *

✔ Avoid landings within view of travel routes or recreation areas.
   See Figure TH-9.

In areas classified as moderately sensitive: *

✔ When possible, avoid landings within view of travel routes or recreation areas.

✔ If it is not possible to avoid landings within view of travel routes, screen landings from view as long as possible during logging.

In areas classified as most sensitive or moderately sensitive: *

✔ Keep number of landings to a minimum.

✔ Remove all products promptly when development of visible landings is necessary.

✔ Dispose of grubbed stumps and trees so as not to be visible.

✔ Treat any slash at landings as soon as possible.

✔ Seed, plant and regenerate landings promptly.

✔ Remove all trash from landings upon completion of harvesting.

✔ Plan landings to access future sales.

*See Part 2, Visual Quality: Visual Sensitivity Classifications for information related to how classifications are determined and which Minnesota counties have developed visual sensitivity classification maps.
In areas classified as less sensitive: *

✔ Avoid landings within a travel route right-of-way.

✔ Consider locating landings outside of maintained road right-of-way whenever possible.

✔ Remove all trash from landings upon completion of harvesting.

✔ Locate landings for best economy and reuse on subsequent sales.

**Figure TH-9:** In visually sensitive areas, a recommended practice is to avoid placing landings within view of travel routes or recreational areas. The landing and slash piles above are in full view of travelers and recreational users along the adjacent travel route and waterway. The landing and slash piles below are hidden from the travel route and waterway as a result of the dogleg access road.
Skidding and Skid Trails

✔ **Locate, design, construct and maintain skid trails** to minimize damage to cultural resources or to the residual stand; minimize rutting; maintain surface and subsurface water flows in wetlands; and reduce erosion and sedimentation to protect water quality.

✔ **Lay out skid trails** to minimize the number of skid trails and site disturbance while also achieving necessary operating efficiency.

- If practical and feasible, keep skid trails away from cultural resource areas.

- Avoid locating skid trails in filter strips and riparian management zones (RMZs). See *General Guidelines: Maintaining Filter Strips* and *General Guidelines: Managing Riparian Areas*.

- Avoid construction of skid trails with grades exceeding 35%.

- Limit skid trails to no more than 10-15% of the timber harvest area. Limit equipment traffic off the skid trails to no more than 20-30% of the area with no more than 1-2 passes with heavy equipment. (Small or irregularly shaped units may result in higher percentages of area occupied by infrastructure.) (See *General Guidelines: Designing Operations To Fit Site Conditions*, page 20.)

- Skid low on a slope or across a slope to minimize erosion.

- Minimize long, straight skid trails that channel water. If long stretches cannot be avoided by careful siting, provide adequate drainage to avoid concentration of surface water flow. Divert water by proper shaping of the trail surface and by using broad-based dips, lead-off ditches or water bars. See *Forest Road Construction and Maintenance: Drainage*.

✔ **Use full-tree skidding** rather than tree-length skidding in the vicinity of a cultural resource, if practical and feasible.

✔ **Concentrate equipment traffic on skid trails.** Maximize the area not impacted by traffic by concentrating equipment movements to common trails. Skidders should always use skid trail routes, rather than the shortest distance, to travel to and from landings.
✔ Concentrate skidding to a set of well-developed skid trails for upland sites with mineral soils.

✔ Avoid concentrating well-developed skid trails on shallow and deep organic soils. Operations on organic soils should only occur when soils are adequately frozen.

✔ Prepare skid trails for anticipated traffic needs, to avoid unnecessary maintenance or relocation of trails. Techniques can include packing of snow or ground cover to ensure freezing, placing of slash mats on skid trails prior to skidding, or the use of appropriate wetland road construction methods to provide a stable trail surface.

✔ Maintain skid trails in good repair so that additional skid trails are not required.

✔ Reuse skid trails for thinning operations as trails for future thinnings and final harvest.

✔ If skid trails do not hold up (resulting in excessive rutting or requiring the need to create new skid trails), curtail operations until soils dry out.

Other guidelines that apply:

For activities involving: Skid trails

Refer to these guidelines: Forest Road Construction and Maintenance
Minimizing Rutting

✔ Minimize rutting in skid trails, roads and landings; and avoid rutting in the general harvest area.

✔ If repeated rutting occurs in the general harvest area (outside of skid trails), use alternative operating techniques, such as the following:

• Shifting harvest operations to a stable portion of the harvest area.

• Using low ground pressure (LGP) equipment.

• Using sufficient slash on skid trails as a driving surface.

• Reducing loads carried by logging equipment.

• Packing the snow or ground cover with LGP equipment to enhance freezing and permit off-trail operation of equipment.

✔ If alternative operating techniques fail to eliminate rutting, stop harvesting operations.

Managing Slash

✔ Favor practices that allow for dispersed slash on the site, rather than piling slash, where dispersed slash does not conflict with management objectives or reforestation. When piling slash, piles should be kept away from cultural resources.

✔ If moving slash on-site is desirable, use equipment that minimizes soil disturbance.

✔ Keep logging residue out of all streams, lakes and open water wetlands, except in cases where residue placement is specifically prescribed for fish or wildlife habitat. Make reasonable effort to keep logging residue out of all seasonal ponds and non-open water wetlands.
Reducing Visual Impacts of Slash

In areas classified as most sensitive:*

✔ Encourage full utilization of all species in the harvest area.

✔ Avoid slash piles or windrows visible from travel routes and recreation areas.

✔ Eliminate or minimize slash within the first 50 feet from travel routes or recreation areas.

✔ Limit slash not screened from view beyond 50 feet from travel routes or recreation areas to a maximum height of 2 feet.

In areas classified as moderately sensitive:*

✔ Encourage maximum utilization of all felled trees in the harvest area.

✔ Minimize visual exposure to slash piles and windrows.

✔ Limit slash not screened from view to a maximum height of 2 feet.

In areas classified as less sensitive:*

✔ Avoid obtrusive piles in the foreground of visible areas.

✔ Use appropriate slash disposal to meet silvicultural goals.

✔ Limit slash not screened from view to a reasonable height to avoid a negative visual effect.

*See Part 2, Visual Quality: Visual Sensitivity Classifications for information related to how classifications are determined and which Minnesota counties have developed visual sensitivity classification maps.
✔ Minimize the crossing of intermittent or perennial streams and open water wetlands. On both upland and lowland sites, install bridges, culverts, snow or ice bridges, fords or other means, if necessary, to prevent repeated soil and streambank disturbance where no practical alternative exists to crossing a stream. **IMPORTANT: Such activity may require a permit from the DNR.** See Appendix H: Work Activities That Do Not Require a DNR Public Waters Work Permit on Public Waters, Public Water Wetlands and Public Watercourses.

✔ Approach water crossings at or near right angles to the stream direction, and use measures to minimize streambank disturbances.

✔ Avoid driving equipment over streambanks for all intermittent and perennial streams, regardless of size; instead, use improved crossings.

✔ Minimize channelization of water down long skid trails. If long stretches cannot be avoided by careful siting, provide adequate drainage to avoid concentration of surface water flow. Divert water by proper shaping of the trail surface and by using broad-based dips, lead-off ditches or water bars. See *Forest Road Construction and Maintenance: Drainage.*
✔ **Incorporate water diversion devices** where needed during timber harvest activity (including water bars, tops and branches, ditch blocks and lead-offs). Divert surface flow before it enters landings or a water body. Incorporate water diversion devices during construction rather than as a remedial activity. See *Forest Road Construction and Maintenance: Drainage*.

✔ **To prevent repeated rutting deeper than 6 inches on wetlands**, shift harvest operations to a stable portion of the harvest area or alter operating techniques. Alternative operating techniques include:

- Employing low ground pressure (LGP) equipment
- Using slash on skid trails as a driving surface
- Minimizing the amount of off-trail equipment operation to reduce the area disturbed by heavy equipment
- Waiting for colder weather to freeze down the site, or enhancing freezing of site by packing snow and ground vegetation with LGP equipment.

✔ **If repeated rutting deeper than 6 inches** cannot be avoided with existing or alternative techniques, cease wetland timber harvesting operations. See Figure TH-10.

**Figure TH-10**: The water table (solid line) is near the bottom of the hollows (upper dotted line). Operations should stop when ruts reach 6 inches below the water table or 6 inches below the bottom of the hollows, whichever is lower. Peat is usually still porous 9 inches below the hollows, and ruts will heal in 2 to 3 years. Deep ruts (more than 12 inches below the hollows) will bring up well-decomposed, mucky peat and may take more than 20 years to heal.
Maintaining and Perpetuating Oak

✔ **Use appropriate management methods** (including clearcut, shelterwood and group selection) to perpetuate oak types or oaks within other cover types, while retaining some trees on-site for continued mast production during stand regeneration. If no oaks can be left on a site, ensure that acorn-producing stands occur nearby for wildlife use during regeneration of the cut stand.

✔ **Manage oak stands** and other hard mast-producing trees on extended rotations, growing trees to large diameter to maximize mast production. Maintain oak in well-stocked stands by retaining vigorous trees with dominant crowns, as large crowned trees produce more mast. As older stands become less productive, their regeneration is one approach to long-term mast production.

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**Additional Consideration**

☛ **Consider retaining oak inclusions** when harvesting non-oak cover types.
Snags (standing dead trees)

✓ Leave all snags possible standing in harvest areas.

✓ Exceptions to leaving all snags may be made for reasons related to visual quality. When leaving snags in areas classified as most sensitive or moderately sensitive:

  • Avoid leaving snags in the foreground.

  • Hide scattered snags with vegetative islands, or locate snags around the edge of an opening to allow for camouflage by background trees of similar color and texture.

Leave Trees (live trees)

Leave trees are live trees retained on a site for resource benefits.

Two general options are recommended for retaining leave trees:

  • Retaining leave trees in clumps
  • Retaining scattered individual leave trees
Both options accomplish the management goals of retaining leave trees. Plans for retaining leave trees may utilize one of these options or, when appropriate, they may use the two options in combination. See Appendix E for a table that illustrates trees per acre by diameter class and various basal areas.

✔ OPTION 1: Retain leave trees in clumps occupying a minimum of 5% of each clearcut harvest unit, using the following considerations and guidelines to aid in planning and design:

- With the exclusion of even-age management within riparian management zones (RMZs), trees left to protect cultural resources, visual quality, non-open water wetlands, seasonal ponds, mast or other resources may be counted toward the 5% minimum recommendation. This consideration reflects the concept of overlapping guidelines where, in some instances, applying a guideline to benefit one resource may simultaneously fulfill guidelines focused on another resource.

- For sites with an RMZ that are being managed with an even-age management objective, positioning leave tree clumps adjacent to the RMZ is recommended unless there are other site conditions or management objectives that warrant placement elsewhere in the site.
**Benefits of clumping leave trees include:**

—Potential to meet multiple management objectives simultaneously

—Visual quality

—Equipment maneuverability

—Longevity and durability of leave trees

—Canopy retention and protection of on-site hydrology

—Potential for greater biodiversity within clumps

—Easier application in larger harvest units

—Breakup of harvest area and reduction in apparent harvest size

—Better regeneration of intolerants on the rest of the site, if desired

—Increased animal feeding efficiency and protection from predators

**Clumps should:**

—Be distributed throughout a harvest unit

—Be adjacent to the RMZ for even-age management

—Vary in size, with a minimum of 1/4 acre per clump

—Center around or coincide with such features as:

* Non-open water wetlands and seasonal ponds (see *General Guidelines: Protecting Non-Open Water Wetlands and Seasonal Ponds*)

* One or more large (> 18 inches DBH) active den trees or cavity trees

* Mast trees

* Preferred tree species (such as large white pine)

* Raptor nests or rookeries

* Sensitive communities or sites
Harvesting within clumps is acceptable as long as the function of the clump is retained, key leave trees are not disturbed, and the clump is not doubling as a legacy patch.

* To retain the functionality of the clump, do not reduce the basal area below 80 ft²/acre in trees 6 inches DBH or larger.

* For stands with the basal area below 80 ft²/acre, do not harvest within the leave tree clump.

* Consider retaining representation of all species within the clump.

✔ OPTION 2: As an alternative or supplement to clumps, employ scattered individual leave trees, especially if they are larger, windfirm specimens of preferred species. Scattered leave trees may be easier to apply to small or narrow harvest units than clumps. Use the following guidelines for scattering individual leave trees:

• On most clearcut sites where this method is employed, leave 6-12 trees standing per acre, selecting trees preferentially. For preferred characteristics, see General Guidelines: Retaining Leave Trees.

• On certain clearcut sites, there may be no leave trees or as many as 15 or more leave trees per acre, depending on local conditions or landowner objectives, but the majority (80%) of these sites and their overall harvest acres should retain an average of 6-12 per acre. See Table TH-1.

• On non-clearcut sites (including selection or partial-cut), be sure that the remaining stand includes a minimum of 6 cavity trees, potential cavity trees and/or snags per acre.

• Distribute leave trees throughout the harvested site as much as possible.

✔ Option 1 is the preferred option for leave trees.
Leave trees (clumped or scattered) should be retained until the regenerating stand produces trees of adequate size and degree of decay to provide comparable structural diversity to the original stand.

- Leave tree patches may be prone to windthrow in some single-species stands of jack pine or black spruce on dry, fire-prone or wet sites. When mimicking natural disturbance patterns on these sites, it is appropriate to leave randomly scattered leave tree patches; however, some windthrow of these leave trees should be anticipated. If some level of windthrow is unacceptable to the landowner/resource manager, leave tree patches may be left in small, naturally protected areas within the site.

**Table TH-1**

✔ Leave trees (clumped or scattered) should be retained until the regenerating stand produces trees of adequate size and degree of decay to provide comparable structural diversity to the original stand.

<table>
<thead>
<tr>
<th>Management or Sale Area Size</th>
<th>Approx. number of leave trees per acre</th>
<th>Approx. spacing (in feet) if evenly distributed</th>
<th>Forest Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SMALLER THAN AVERAGE</strong></td>
<td>0</td>
<td>—</td>
<td>OPEN BRUSH</td>
</tr>
<tr>
<td>of harvest units</td>
<td></td>
<td></td>
<td>LOWLAND DECIDUOUS</td>
</tr>
<tr>
<td><strong>AVERAGE</strong></td>
<td>3</td>
<td>120'</td>
<td>LOWLAND CONIFER</td>
</tr>
<tr>
<td>size of harvest units</td>
<td></td>
<td></td>
<td>UPLAND CONIFER</td>
</tr>
<tr>
<td><strong>LARGER THAN AVERAGE</strong></td>
<td>6</td>
<td>85'</td>
<td>UPLAND DECIDUOUS</td>
</tr>
<tr>
<td>of harvest units</td>
<td></td>
<td>80% of clearcuts employing scattered leave trees fall in this range</td>
<td>UPLAND MIXED</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>70'</td>
<td>UPLAND WITH WETLAND INCLUSIONS</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>60'</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15+</td>
<td>54'</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Numbers of vertebrate species using cavity trees varies among habitats. The number of leave trees should reflect the variation among habitats and among site conditions.
During initial harvest entries of seed tree or shelterwood cuts, select ultimate leave trees using the following guidelines:

- Leave a variety of sizes and species of trees, along with the intended seed/shelter trees, to be retained during the final harvest.

- Plan for and protect integrity of reserve tree clumps in initial harvest entries.

- Prevent damage to leave trees in initial and followup harvest entries.

Exceptions to the above leave tree and snag guidelines may be made for a number of reasons, including:

- Operator safety (of loggers, aerial spray applicators and others)

- Public safety (hazard trees near rights-of-way, recreation sites or airport vicinities)
• Specific forest management applications (such as genetic considerations for seed reproduction systems)

• Visual quality

• Alignment of skid trails

• Surrounding landscape concerns (sites adjacent to sharp-tailed grouse management units, for example)

• Forest insects and diseases (such as dwarf mistletoe on black spruce, gypsy moth and pine bark beetles)

✔ **Protect conifer regeneration** (less than 4 inches DBH) when harvesting mixed deciduous coniferous stands. See *Leave Trees* (page 33) and *General Guidelines: Retaining Leave Trees* for guidelines on retention of mature conifer trees. Clumps of conifers are preferable to scattered trees.

✔ **Retain mast trees with bear claw marks** on trunk, which indicate a preferred food source.
Retaining conifer clumps in a clearcut is preferable to leaving scattered trees.

**Additional Considerations**

☛ **Consider providing wildlife security cover and access to food** when designing timber sales in Ecoregions 5 and 6. If the width of a harvest area exceeds 300-400 feet, and/or the size exceeds 40 acres, consider retaining travel lanes where topography does not already provide such cover. Travel lanes should be large enough to economically manage as a stand.

☛ **Consider retaining more than the recommended number** of leave trees in harvest sites of greater than 100 acres. This practice would better mimic natural disturbances, such as fire and windstorm.
Post-Operational Activities

➤ IMPORTANT! Review General Guidelines:
  ➔ Post-Operational Activities and Followup Visits

✔ Evaluate the harvest operation and plan future adaptations at post-harvest conferences with the logger and landowner.

✔ Plan for removal of equipment and cut material from wetland areas at the end of the winter season prior to thawing.

✔ Avoid removing soil from the general harvest area to rehabilitate roads, landings and skid trails. Use already disturbed soil, if needed, rather than disturbing additional soil.

✔ Rehabilitate landings and skid trails when necessary to mitigate soil compaction and reduce erosion.

Additional Consideration

☛ Consider scarifying the soil in the vicinity of conifer seed trees to enhance regeneration of these species.
**Glossary**

**Adsorption:** The inherent ability of a pesticide to bind to surfaces of soil particles. The greater the potential for a pesticide to adsorb to soil particles, the less the potential for the pesticide to move in solution.

**Alignment:** The horizontal route or direction of an access road. It is made up of straight line tangent sections and curves.

**All-season road:** A permanent road designed for use all year long, though there may be some restrictions on vehicle weight at times during spring breakup or wet periods. There is a great range in design standards and road surfacing for this type of road, depending on anticipated traffic load.

**Approach:** A skid trail or road segment leading up to a wetland, open water body or stream and measured from the water body margin to the outer edge of the filter strip or riparian management zone (RMZ). If a topographic break does not occur within the filter strip or RMZ width, whichever is wider, the approach continues to the first topographic break affecting surface flow beyond the filter strip or riparian management zone.

**Archaeology:** The field of science that studies past human culture through the examination of remaining material evidence.

**Archaeological site:** A geographic location where archaeological artifacts, features and other materials are found.

**Artifact:** An object manufactured, modified or used by humans.

**Bankfull elevation:** The height of the streambank at which the stream cannot hold any more water without it beginning to spill out onto the floodplain.

**Barriers:** Obstructions to pedestrian, horse or vehicular traffic intended to restrict traffic.

**Basal area:** The cross-sectional area of a live tree at 4.5 feet above ground. Basal area may be measured in square feet per tree or square feet per acre.
Berm: A low earth fill constructed in the path of flowing water to divert its direction, or constructed to act as a counter-weight beside the road fill to reduce the risk of foundation failure.

Biodiversity: The variety and abundance of species, their genetic composition, and the communities and landscapes in which they occur, including the ecological structures, functions and processes occurring at all of these levels.

Borrow pit: That area from which soil is removed to build up the roadbed, sometimes directly adjacent and parallel to a road.

Broad-based dip: A surface drainage structure specifically designed to drain water from an access road while vehicles maintain normal travel speeds.

Burial mound: An earthwork constructed to cover or enclose one or more human burials. In Minnesota, construction of burial mounds was a common cultural practice between about 2500 and 800 years ago.

Cache pit: A cultural feature, usually excavated into the ground, that was used to store foodstuffs or other items. Cache pits are often found in areas where resources such as maple sap and wild rice have been gathered.

Cavity tree: A live or dead tree that can be excavated or used by wildlife for resting and reproduction.

Ceded lands: Public lands within original reservation boundaries on which American Indian treaty rights can be exercised. See Appendix D: Ceded Lands and Reservation Boundaries.

Cemetery: Any location at which there are one or more human interments. All cemeteries in Minnesota are protected by law, without regard to age, ethnic affiliation or current land ownership.


Coarse woody debris: Stumps and fallen trunks or limbs of more than 6-inch diameter at the large end.

Connectivity: The degree of linkage among similar habitat patches across a landscape.
**Corduroy:** Logs placed over a wetland to reinforce the natural root mat for the purpose of stabilizing the road foundation.

**Crown:** The part of a tree bearing live branches and foliage.

**Crown closure:** The degree to which the forest floor is shaded by tree crowns when the sun is immediately overhead. Complete crown closure occurs when the crowns of trees touch and effectively block sunlight from reaching the forest floor.

**Cull logs:** Logs that do not meet merchantability standards.

**Cultural resource:** An archaeological site, cemetery, historic structure, historic area or traditional use area that is of cultural or scientific value.

**Cultural resource management:** The range of activities aimed at understanding, preserving and providing for the enjoyment of cultural resources. It includes research related to cultural resources, planning for actions affecting them, and stewardship of them.

**Cultural resource management professional:** An individual trained in the principles and methods of cultural resource management.

**Cultural resource potential:** The likelihood that a given location contains one or more cultural resources.

**Culture:** A system of beliefs, values, customs, traditions and other features that are shared by a group of people.

**Culvert:** A metal, wooden, plastic or concrete conduit through which water can flow.

**Cut-and-fill:** Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.

**Data recovery:** The process of collecting data about a cultural resource, in order to preserve the scientific, historical or cultural information that makes the resource significant. For archaeological sites, data recovery usually involves formal excavation.
DBH (diameter at breast height): The diameter, including bark, of a standing tree at breast height (measured at 4.5 feet above ground on the uphill side of the tree).

Dip: An economical, relatively trouble-free structure for providing effective drainage of forest roads. Dips are considerably lower in cost than culverts, so time spent in careful construction is well justified.

Disking: A mechanical method of scarifying the soil to reduce competing vegetation and prepare a site to be seeded or planted. See scarification.

Disturbance regime: Consists of the timing, predictability, frequency and severity of disturbances. Disturbances are relatively discrete events in time that disrupt ecosystem, community or population structure and change resources, or substrate availability of the physical environment.

Ditch: An open channel to conduct water.

Drainage structure: Any device or land form constructed to intercept or aid surface water drainage.

Drift: The movement of pesticides through the air to non-target areas, either as solid or liquid particles, or as vapor.

Dry wash: An incised, often V-shaped gully that receives precipitation directly to help initiate flow, or indirectly as surface runoff from an immediately adjacent agricultural field or grazed slope. Little or no water is contributed by seeps or springs. For a complex series of stream and gully channels, the channel above the uppermost seep or spring along a stream reach is the dry wash, and the segment below is the intermittent stream until there is a reach where it is defined as perennial. Dry washes often have a coarse rubble or bedrock bed.

Earthwork: A cultural feature constructed by excavating or piling soil in a deliberate manner. Burial mounds, cache pits and building berms are examples of earthworks.
Ecological classification system: An approach to categorizing and delineating, at different levels of resolution, areas of land and water having similar characteristic combinations of the physical environment (such as climate, geomorphic processes, geology, soil and hydrologic function) and biological communities (plants, animals, microorganisms and potential natural communities).

Ecoregion: A land area characterized by similar geology, climate, topography, plant communities, soil types and other factors. Minnesota has nine ecoregions.

Endangered species: A species threatened with extinction throughout all or a significant portion of its range.

Erosion: The process by which soil particles are detached and transported by water, wind and gravity and deposited downslope or downstream.

ETS species: Endangered, threatened and special concern species (see individual definitions).

Evaluation (of cultural resources): The process of determining which cultural resources are important. Cultural resource management professionals often use the National Register of Historic Places criteria for evaluating significance because of their flexibility and broad application. See Appendix C: National Register Criteria for Evaluation of Cultural Resources.

Even-age management: A planned sequence of treatments designed to maintain and regenerate a stand with one or two age classes. The range of tree ages is usually less than 20% of the rotation.

Extended rotation: Substantially increasing the rotation age of a forest stand beyond the current optimum economic rotation age. Forest stands where extended rotation is applied are called extended rotation forests (ERFs).

Feature (archaeological): Any non-portable archaeological evidence. Examples include cellar depressions, building berms, foundations or trash heaps.

Felling: The process of severing trees from stumps.

Fill: Any solid material added to or redeposited in a wetland that would alter its cross-section, obstruct flow patterns, change wetland boundaries, or convert the wetland to a non-wetland.
**Filter strip:** An area of land adjacent to a water body that acts to trap and filter out suspended sediment and chemicals attached to sediment before it reaches the surface water. Harvesting and other forest management activities are permitted in a filter strip as long as the integrity of the filter strip is maintained and mineral soil exposure is kept to a minimum.

**Fire retardant:** Any substance that reduces the flammability of combustibles by chemical or physical action.

**Floodplain:** The area adjacent to a watercourse or water basin that has been or may be covered by a regional flood.

**Ford:** A place where a perennial or intermittent stream may be crossed by a vehicle. It may be necessary to reinforce the stream crossing to bear intended traffic.

**Forest community:** All organisms within and dependent on a forest ecosystem for all or part of their needs.

**Forest ecosystem:** A community of plants, animals and microorganisms, and the physical environment they inhabit, in which trees are the dominant life form.

**Forest floor:** All dead vegetation on the mineral soil surface in the forest, including leaf litter and unincorporated humus.

**Forest management:** The multiple-use management of forest resources for sustained yields of wood, water, forage, wildlife and recreation. Multiple use includes timber management, watershed management, range management, wildlife management, fisheries management and recreation management.

**Forest road:** A temporary or permanent road connecting the most remote parts of the forest to existing public roads. Forest roads provide access to forest lands for timber management, fish and wildlife habitat improvement, fire control and a variety of recreational activities.

**Formulation:** The pesticide product as purchased, usually consisting of a mixture of active and inert ingredients.

**Fuel break:** A natural or constructed barrier used to stop the spread of fire by removing fuel or rendering fuel inflammable by use of water or fire retardants. Examples include constructed firelines, wetlines and water barriers.
**Functions:** The physical, chemical and biological processes in a forest, including photosynthesis, decomposition and nutrient cycling.

**Gabion:** A woven wire basket filled with stones of minimum size that will not pass through the openings in the basket. Individual baskets are laid in place like building blocks, and then filled to form retaining walls and erosion-resistant surfaces.

**General harvest area:** That portion of the timber harvest area that is not occupied by landings, roads and skid trails.

**Geotextile:** A product used as a soil reinforcement agent and as a filter medium. Geotextile is made of synthetic fibers manufactured in a woven or loose non-woven manner.

**Grade:** The slope of a road or trail expressed as a percent of change in elevation per unit of distance traveled.

**Ground water:** The subsurface water supply in the saturated zone below the level of the water table.

**Habitat:** The sum total of environmental factors (including food, water and cover) that a species needs to survive and/or reproduce in a given area.

**Half-life:** The time it takes for a pesticide in soil to be degraded so that its concentration decreases by one-half.

**Hard mast:** Nuts and seeds, typically produced by large mature trees (such as oaks and hickories); conifer seeds are also included.

**Harvest unit:** The area where harvesting activities are conducted (harvest area) and adjacent areas that are taken into consideration when determining the actual harvest area.

**Harvesting (timber harvesting):** The felling, skidding, processing, loading and transporting of forest products.
**High bank forest:** An area immediately adjacent to a stream or lake where the depth to the water table is more than 10 feet, soil moisture ranges from moist to dry, the hillside bank rises steeply above the water, and the water body cuts into the hillside bank, which results in its eroding. Roots from trees growing on the terrace above the water do not reach the water table and therefore do not provide much bank stability. Depending on the site and ecological history, dominant tree species are aspen, birch, jack pine, red pine, balm o’Gilead, red oak, bur oak, white oak, maple/basswood, balsam fir, ash/elm/cottonwood, red maple or white spruce.

**Highly erodible soil:** Soil on slopes greater than 35% that is considered to be in the severe category for potential erosion.

**High water mark:** The highest level at which water has remained long enough to leave its mark upon the landscape. Generally, it is the point where the natural vegetation changes from predominantly terrestrial to aquatic.

**Historic area:** An area in which there are features (structures, archaeological sites, or a combination of the two) that reflect historic uses. Examples include roads and trails, formal plantings, parks and building complexes.

**Historic building:** Any complex construction created and used by people to shelter their social, cultural and economic activities. Common types of historic buildings in forested areas include houses, barns, sawmills, churches, hotels and schools. See also historic structure.

**Historic structure:** A functional structure built for a purpose other than providing shelter. Examples include fire towers, rail grades, bridges, dams, silos, kilns and canals. See also historic building.

**Hummock:** A growth habit of *Sphagnum* moss in peatlands that forms a porous, elevated assemblage of the moss above the water table. Common associated species growing amid the *Sphagnum* hummocks include Labrador tea (*Ledum groenlandicum* L.) and Ericaceae shrubs. Hummocks may become 12–36 inches high and 48–72 inches in diameter. The depressions between hummocks are referred to as “hollows,” and the base of the hollow is generally the peatland water table surface.
**Impact:** A change in quantity, quality or biological diversity.

**Inclusion:** A small patch or stand of vegetation situated within a larger patch or stand. Inclusions are distinguishable on aerial photographs or in the field as distinct patches, but are typically too small or insignificant to be practically mapped or managed independently of the surrounding stand. See also *stand*.

**Infiltration:** The process by which water passes through the soil surface.

**Infrastructure:** The network of access roads, approaches, trails and landings used to manage a forest site.

**Integrated pest management (IPM):** Selection, integration and use of management actions based on scientific knowledge of forest systems, including insects and pathogens, in order to achieve desirable economic, ecological and sociological forest management goals.

**Intermittent streams:** Streams with well-defined channels, banks and beds that flow only certain times of the year. They receive water from precipitation and runoff. During dry years, these streams may cease to flow entirely or may be reduced to a series of separate pools supported by seep or spring flows.

**Label:** The information printed on or attached to the pesticide container or wrapper.

**Landing:** A place where trees and logs are gathered in or near the forest for further processing or transport.

**Landscape:** A heterogeneous land area composed of interacting sustainable forest resources that are defined by natural features and socially defined attributes (Minnesota Statutes 89A.01). In general terms, it is a land area defined by natural features, such as a watershed or forest complex, and may include multiple ownerships.

**Leaching:** Downward movement of a pesticide or other soluble material through the soil as a result of water movement.

**Lead-off ditch:** A ditch to remove water from a road or skid trail to a vegetated area.
**Leave log:** All or part of a felled live tree that is deliberately left on a site to provide fresh coarse woody debris. See *coarse woody debris*.

**Leave trees:** Live trees selected to remain on the site to provide present and future benefits, including shelter, resting sites, cavities, perches, nest sites, foraging sites, mast and coarse woody debris.

**Leave tree strip:** An area of land of variable width adjacent to a water body where trees are retained to provide resources benefits.

**Legacy patch:** An area within a managed site that protects soil organic matter and the organisms associated with it, and that will aid in recolonization of the adjacent managed area.

**Local government unit:** A city council, town board, county board of commissioners or watershed management organization.

**Mast:** Nuts, seeds, catkins, flower buds and fruits of woody plants that provide food for wildlife.

**Material Safety Data Sheet (MSDS):** The basic hazard communications tool that provides details on chemical and physical dangers, safety procedures and emergency responses for a particular chemical.

**Midden:** In archaeology, a pile or scatter of debris created as a byproduct of some human activity. Middens often mark old homestead and logging camp locations.

**Minnesota Indian Affairs Council (MIAC):** An organization created by statute to serve as a liaison between the State of Minnesota and the 11 tribal governments within the state. MIAC administers a program designed to protect cultural resources related to American Indian heritage and culture, and it shares authority for treatment of Indian cemeteries with the Office of the State Archaeologist.

**Mulching:** Using organic residues (such as grass, straw or wood fibers) or commercially available alternatives as a covering for exposed forest soil. This mulch covering protects exposed soil, helps control erosion and facilitates revegetation.
**Mycorrhiza (pl. mycorrhizae):** A mutually beneficial association of fungi and roots of plants.

**National Register of Historic Places:** A nationwide program that recognizes sites, structures, objects, buildings and districts that are significant in national, regional, state or local history, architecture or archaeology.

**Natural community:** A group of native plants and animals that interact with each other and their environment in ways not greatly altered by modern human activity.

**Non-open water wetlands:** Non-open water wetlands are Circular 39 (Shaw and Fredine 1956) Type 1 (seasonally flooded basin or flat), Type 2 (wet meadow), Type 6 (shrub swamp), Type 7 (wooded swamp or forested wetland) and Type 8 (bog). Type 1 wetland soils are saturated during variable seasonal periods but may be well-drained during the other periods. Wetland Types 2, 6, 7 and 8 have saturated or waterlogged soils during most of the growing season. Non-open water wetlands may occasionally be inundated with water.

**Nonpoint source pollution:** Diffuse pollution that enters a water body from over the landscape. Nonpoint source pollution reaches streams, lakes, wetlands and ground water through leaching, surface runoff and erosion.

**Nutrient cycling:** The process by which nutrient elements move into, out of, and within an ecosystem.

**Nutrients:** Mineral elements in the forest ecosystem, such as nitrogen, phosphorus or potassium, that are naturally present or may be added to the forest environment by such forest practices as application of fertilizer or fire retardant. Nutrients are necessary for the growth and reproduction of organisms. In water, nutrients are those substances that promote growth of algae and bacteria (chiefly nitrates and phosphates).

**Obligate species:** A species able to survive in only one environment. An osprey is a riparian obligate species, because it requires an environment that includes suitable nesting trees near water bodies containing fish.
**Obliterate:** To unbuild, decommission, deactivate or dismantle a road; to deny use, eliminate travelway functionality, and remove the road from the forest development road system; to return the road corridor to resource production by natural or designed means.

**Old forest:** A forest community distinguished by old trees and related structural features characteristic of later stages of stand and successional development.

**Open water wetland:** Shallow to deep open water generally having readily observable surface water. Water depth varies from a few inches to less than 10 feet. According to the USF&WS wetland classification system, it includes Type 3 (shallow marsh), Type 4 (deep marsh) and Type 5 (shallow open water) wetlands (Shaw and Fredine 1956).

**Office of the State Archaeologist (OSA):** A state office that enforces provisions of law related to private cemeteries and archaeological sites. The office also maintains inventories of recorded archaeological sites and cemeteries in Minnesota.

**Overstory:** That portion of the trees in a forest of more than one story, forming the upper or uppermost canopy.

**Patch:** Unit of land with relatively similar biological and/or physical characteristics.

**Peat:** Unconsolidated material consisting of organic matter accumulated under conditions of excessive moisture.

**Perennial streams:** Streams with well-defined channels, banks and beds that exhibit essentially continuous flow. These streams flow year round, but surface water may not be visible during extreme drought.

**Permanent road:** A forest road intended to be left in place for the long term.

**Persistence:** The time it takes for a pesticide in soil to degrade to the point where it is no longer active.

**Pesticide:** A chemical compound or biological agent used for the control of undesirable plants, animals, insects or diseases.
**Potential cavity tree:** A tree at least 6 inches in diameter showing signs of physical injury or decay and susceptible to excavation by birds.

**Prescribed burning:** The controlled application of fire to wildland fuels in either their natural or modified state, under specified environmental conditions. These conditions allow the fire to be confined to a predetermined area, while at the same time producing the fire intensity and rate of spread required to attain planned resource management objectives.

**Presettlement wetlands:** Wetlands that existed in Minnesota prior to and at the time of European settlement.

**Puddles:** Depressions in the soil surface where water pools during wet periods. A puddle will not have a noticeable difference in forest litter compared to the surrounding area.

**Raking:** A mechanical method of removing stumps, roots and slash from a future planting site.

**Reserve area:** A portion of the management area set aside for a special purpose or use or to protect specific resources.

**Residuals:** Trees selected to remain on the site to provide present and future benefits.

**Rhizome:** A rootlike, usually horizontal stem growing under or along the ground, sending out roots from its lower surface and leaves or shoots from its upper surface.

**Riparian area:** The area of land and water forming a transition from aquatic to terrestrial ecosystems along streams, lakes and open water wetlands.

**Riparian management zone (RMZ):** That portion of the riparian area where site conditions and landowner objectives are used to determine management activities that address riparian resource needs. It is the area where riparian guidelines apply.

**Riprap:** A layer of boulders or rock fragments placed over soil to protect it from the erosive forces of flowing water.

**Rotation age:** The number of years between the formation or regeneration of an individual tree, crop or stand and its final cutting or demise.
**Runoff:** In forest areas, that portion of precipitation that flows across a drainage area on the land surface and in open channels.

**Ruts:** Depressions made by the tires or tracks of such vehicles as skidders, bulldozers, log trucks and pickup trucks. Mixing or smearing of soil often occurs on the sidewalls of ruts, which restricts infiltration of precipitation and disrupts lateral flow of water.

**Rutting:** The creation of depressions made by the tires of such vehicles as skidders, bulldozers, log trucks and pickup trucks. Mixing or smearing of soil often occurs on the sidewalls of ruts, which restricts infiltration of precipitation and disrupts lateral flow of water. Rutting occurs when the soil strength is not sufficient to support the applied loads from vehicle traffic.

**Scarification:** The process of removing the forest floor or mixing it with the mineral soil by mechanical action preparatory to natural or direct seeding or the planting of tree seedlings.

**Seasonal road:** A permanent road designed for long-term periodic use, such as during dry and frozen periods. Seasonal roads are built to lower engineering standards and have minimal material surfacing.

**Seasonal ponds:** Small depressional wetlands where water collects during wet periods of the year, typically in the spring and fall; they may be dry during other periods. These wetlands often exhibit characteristics of Types 1, 3, 6 and 7 wetlands. Seasonal pond characteristics may include: 1) ponded water or evidence of recent standing water; 2) an identifiable edge due to earlier ponded water or local topography; 3) typically less than ½ acre in size; 4) the presence of black ash; 5) minor presence of woody shrubs, such as alder, along the pond edges; 6) the presence of tussocks; 7) the absence in many cases of persistent aquatic plants; and 8) typically fishless.

**Sedge/grass/shrub forest:** An area adjacent to a stream, lake or open water wetland that is covered by grasslike sedges or shrubs and where soils are wet. The depth to the water table in these areas averages less than 6 inches. Depending on the site and ecological history, dominant plant species are alders, willows, sedges, grasses or mosses.
Seeps and seepage wetlands: Small wetlands (often less than an acre or two) that generally occur where ground water comes to the surface. Soils at these sites remain saturated for some portion or all of the growing season and often stay wet throughout the winter.

Sediment: Solid material in suspension, being transported, or moved from its original location by air, water, gravity or ice.

Sensitive communities: Those communities that are sensitive to disturbance, including some kinds of forest management activities. Minimizing levels of disturbance is often critical to their well-being. Sensitivity may be linked to human activity, disruption of water flowage, alteration of stand structure or composition, or some other factor. Sensitive communities include certain native plant communities (sometimes referred to as natural communities), such as seepage swamps and calcareous fens.

Sensitive sites: Those sites that are sensitive to disturbance, including some kinds of forest management activities. Minimizing levels of disturbance is often critical to their well-being. Sensitivity may be linked to human activity, disruption of water flowage, alteration of stand structure or composition, or some other factor. Some examples of sensitive sites include colonial waterbird tree-nesting sites and overwintering cover for rattlesnakes.

Shade tolerance: The capacity of a plant to grow under low light conditions, typically caused by canopy shading.

Shearing: The operation of cutting off trees and brush at ground level by pushing a bulldozer blade along the frozen surface in winter.

State Historic Preservation Office (SHPO): A branch of the Minnesota Historical Society that administers the National Register program for Minnesota, maintains cultural resource inventories, and conducts project reviews required under federal law.

Silt curtain: Filter fabric weighted at the bottom and attached to a flotation device at the top. A silt curtain is used to isolate an active construction area within a lake or wetland and prevent silt-laden water from migrating out of the construction zone.

Silt fence: A temporary barrier made of geotextile and installed to prevent the off-site movement of silt material.
**Silviculture:** The art and science of controlling the establishment, growth, composition, health and quality of forests and woodlands to meet the diverse needs and values of landowners and society on a sustainable basis.

**Site:** An area evaluated as to its capacity to produce a particular forest or other vegetation based on the combination of biological, climatic and soil factors present. For timber harvesting, the area where harvesting activities are conducted (harvest area) plus adjacent areas that are taken into consideration when determining the actual harvest unit.

**Site preparation:** The practice of altering site conditions to favor the establishment, survival and growth of a desired tree species.

**Skid trail:** A temporary pathway over forest soil to haul felled trees or logs to a landing for further processing, loading and transport to a mill.

**Skidding:** The act of moving trees from the site of felling to a loading area or landing.

**Slash:** All residual woody material created by logging or timber stand improvement.

**Slope:** Degree of deviation of a surface from the horizontal, measured as a numerical ratio, as a percentage or in degrees.

**Snag:** A standing dead tree.

**Soft mast:** Fruits, berries, catkins and flower buds produced by a wide variety of early successional species (such as raspberries). In later forest successional stages, soft mast is produced by shade-tolerant understory shrubs.

**Soil compaction:** The increase in soil density resulting from loads applied to the soil surface.

**Soil productivity:** The capacity of soil, in its normal environment, to support plant growth.

**Solubility:** The ability of a pesticide to dissolve in water or other solvents. The greater the solubility in water, the greater the chance that the pesticide will leach to ground water or move in solution to surface water.
**Special concern species:** A species that, although not endangered or threatened, is extremely uncommon in Minnesota or has unique or highly specific habitat requirements. Special concern species may include 1) species on the periphery of their range in Minnesota, but not listed as threatened or endangered; and 2) species that were once threatened or endangered but now have increasing, protected or stable populations.

**Stand:** A community of trees possessing sufficient uniformity in composition, age, arrangement or condition.

**Stream:** Watercourse with a definable bank, including intermittent streams with or without water (even if dry). Stream width is estimated at the bankfull elevation at the narrowest portion of a straight channel segment within the management area.

**Super canopy tree:** Usually a mature or overmature tree, whose crown is at least 25% taller than the majority of the dominant/codominant trees in the stand. *(Dominant tree: A tree whose crown extends above the general level of the main canopy of even-age stands or, in uneven-age stands, above the crowns of the tree’s immediate neighbors and receiving full sunlight from above and partial light from the sides. Codominant tree: A tree whose crown helps to form the general level of the main canopy in even-age stands or, in uneven-age stands, the main canopy of the tree’s immediate neighbors, receiving full sunlight from above and comparatively little from the sides.)*

**Surface soil horizons:** The uppermost part of the soil (typically 3-4 inches) dominated by organic matter accumulation and including the organic “O” horizon and the mineral “A” horizon.

**Sustainability:** Meeting the needs of the present without compromising the ability of future generations to meet their own needs.

**Sustainable forest management:** Development, protection and use of forest resources for achievement of economic and social well-being without damaging the forest resource base or compromising the ability of future generations to meet their own needs.

**Swamp forest:** An area adjacent to a stream, lake or open water wetland where the depth to the water table is between 6 and 18 inches and the soils are wet. Depending on the site and ecological history, dominant tree species are black spruce, tamarack, northern white cedar or black ash.
**Temporary road:** Generally a minimum-standard road designed for short-term use during a specific project, such as a timber harvest. Use of temporary roads is typically limited to dry or frozen conditions to minimize rutting and compaction.

**Threatened species:** A species likely to become endangered in the foreseeable future throughout all or a significant portion of its range.

**Timber harvesting:** The felling, skidding, processing, loading and transporting of forest products, roundwood or logs.

**Timber stand improvement:** Forest management practices intended to either improve growth and form of intended crop trees or manipulate stand composition.

**Toxicity:** A measure of the capacity of a pesticide to cause injury.

**Traditional use area:** A location that has been historically used by one or more groups of people for some type of activity, very often related to the vegetation of the area. Examples include sugar bushes, wild rice beds, and locations where people carry out religious and social activities or gather resources for craftwork or medicinal purposes.

**Trout lakes:** Those lakes that are designated through rule-making. The lakes designated by rule are specified by legal description (township, range and section).

**Trout streams:** Those streams and their associated tributaries that are designated through rule-making. The portions of the streams designated by rule are specified by legal description (township, range and section).

**Turnout:** A widened space in a road that allows vehicles to pass one another and slopes away (downhill) from the road.

**Tussock:** A growth habit of certain perennial grasses and sedges that form compact clumps or tufts of plant roots of relatively solid ground in an otherwise wetland area. Each year, new growth occurs on the accumulated biomass of tillers and increases the height of the tussock. Tussocks may become 12–24 inches in diameter and up to 36 inches high. Common species include tussock sedge (*Carex stricta* Lam.) and tussock cottongrass (*Eriophorum vaginatum* L.)
**Understory:** Any plants growing under the canopy formed by others; particularly, herbaceous and shrub vegetation under a brushwood or tree canopy.

**Uneven-age management:** A planned sequence of treatments designed to maintain and regenerate a stand with three or more age classes. All age classes could be represented.

**Upland forest:** An area adjacent to a stream, lake or open water wetland where the depth to the water table is at least 1.5 feet and soil moisture ranges from moist to dry. Depending on the site and ecological history, dominant tree species are aspen, birch, jack pine, red pine, balm o’Gilead, red oak, bur oak, white oak, maple/basswood, balsam fir, ash(elm)/cottonwood, red maple or white spruce.

**Values:** The characteristics of the forest that are beneficial to society, including protection of functions, public recreation and commercial uses.

**Vertical structure:** The diversity of above-ground vegetative layers in the vertical profile of a stand.

**Visual quality:** A subjective measure of the impact that viewing an object, landscape or activity has on a person’s perception of attractiveness.

**Volatilization:** Conversion of a solid or liquid to a gas.

**Water bar:** A ditch and hump across a trail or road tied into the uphill side for the purpose of carrying water runoff into vegetation, duff, ditch or dispersion area so that it does not gain the velocity and volume that causes soil movement and erosion.

**Watercourse:** Any channel having a definable bed and banks capable of conducting generally confined runoff from adjacent lands. During floods, water may leave the confining beds and banks, but, under low and normal flows, water is confined within the channel. A watercourse may be perennial or intermittent.

**Water quality:** The chemical, physical and biological characteristics of water, usually in respect to its suitability for a particular purpose.

**Water table:** The upper surface of the ground water, generally referred to in terms of linear depth below the soil surface.
Watershed: The surrounding land area that drains into a lake, river or river system.

Wetlands: Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or where the land is covered by shallow water. Wetlands must have the following three attributes:

1) A predominance of hydric soils (soils that result from wet conditions)

2) Inundation or saturation by surface water or ground water at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation (plants adapted to wet conditions)

3) Under normal circumstances, a prevalence of hydrophytic vegetation

Wildfire: Uncontrolled fire occurring in forest land, brushland and grassland.

Wildlife: All forms of life that are wild, including plants, animals and microorganisms.

Windfirm: The ability of a tree to withstand strong winds and resist windthrow (blowdown) and major breakage.

Windrow: Slash, residue and debris raked together into piles or rows.

Windthrow: A tree or trees uprooted by the wind. Also known as blowdown timber.
A. How the Guidelines Were Developed

B. Summary of Cultural Resource Inventory Sources in Minnesota

C. National Register Criteria for Evaluation of Cultural Resources

D. Ceded Lands and Reservation Boundaries

E. Determining Basal Area

F. Regulations, Rules and Ordinances Complementary to Timber Harvesting and Forest Management Guide-line Recommendations

G. Baseline Standards for Development of Best Management Practices To Provide Wetland Protection

H. Work Activities That Do Not Require a DNR Public Waters Work Permit on Public Waters, Public Water Wetlands and Public Watercourses

I. Silvicultural Examples for Riparian Areas

J. Sensitive Native Plant Communities

K. References Cited and Additional Technical Literature
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Appendix I

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Table I-2: Summary of Relative Height Growth of Minnesota Tree Species Under Varying Levels of Shade

Appendix J

Table J-1: Sensitive Native Plant Communities
Appendix A: How the Guidelines Were Developed

Establishing Technical Teams To Develop Guidelines

To develop guidelines as required by the Sustainable Forest Resources Act (SRFA), the Minnesota Forest Resources Council (MFRC) appointed four technical teams for the following topics: riparian management, site-level forest wildlife habitat, forest soil productivity, and cultural resources.

Two additional topics—visual quality, and water quality and wetlands—had already been addressed in previously published guidebooks.

Team members exhibited the following qualifications:

- A basic, if not technical, understanding of the topics to be addressed by the team
- A willingness to devote the time and energy required to contribute in a constructive manner to the team
- A commitment to develop the guidelines in the timeframe established by the MFRC
- A willingness to use a consensus-based process

The technical teams reflected the breadth of interests represented on the MFRC and included representatives from state and federal agencies, county land departments, colleges and universities, forest industry, American Indian tribes, logging interests, recreation interests, conservation groups, landowner groups, private consultants, utility companies and environmental organizations.
Developing Technical Guidelines

The guideline development process focused on three areas:

- Identification of issues
- Development of options to mitigate issues
- Recommendation of a range of practical and sound practices based on the best available scientific information

While the 1994 Generic Environmental Impact Statement Study on Timber Harvesting and Forest Management in Minnesota (GEIS) (Jaakko Pöyry 1994) served as the foundation document for identification of issues and guideline development, the technical teams were not limited to the issues and mitigations identified in the GEIS.

After identifying the scope of the guidelines to be developed for each of the four technical teams, the teams developed proposed guidelines for their assigned topics. This scoping and guideline development process took nearly two years to complete.

The proposed guidelines were submitted for review and evaluation by selected outside peers. Guided by this peer review, each technical team finalized its guidelines and submitted them to the MFRC.

Developing Integrated Guidelines and Determining Economic Effects

Upon completion of the technical guidelines, representatives of each technical team came together to form an integration team. The MFRC forwarded the individual technical team products, along with existing best management practices for visual quality, water quality and wetlands, to the integration team. The purpose of this team was to identify linkages between topics, address conflicting recommendations, and develop finalized, fully integrated guidelines.
The final integrated guidelines are organized by groups of practices commonly associated with timber harvesting and other forest management activities.

The MFRC directed a formal analysis of financial costs and economic effects associated with the application of the guidelines. The goal of the analysis was to identify instances where the application of the guidelines would result in adverse financial costs and economic effects, and then to explore opportunities to offset those adverse effects.

**Guideline Revision**

The MFRC recognized that the timber harvesting and forest management guidelines would periodically need to be revised based on changes in regulations and statutory mandates, new research findings, experience in applying the guidelines, and comments from peer and public reviewers. Since 1999, the MFRC has held two public reviews and three peer reviews of the guidelines.

Many of the comments received focused on the riparian zone management (RMZ) guidelines. The MFRC deferred addressing the RMZ questions to a separate process of review that was initiated in 2004 and is ongoing.

The current revisions to the guidelines consist of additional guidance to key recommendations, clarifications of concepts and language improvements, changes to guideline recommendations based on recent research findings and effectiveness monitoring, and modifications derived from information obtained during the monitoring of the application of the guidelines on public and private forestland in Minnesota.

**For more information**, contact:

Minnesota Forest Resources Council
2003 Upper Buford Circle
St. Paul, Minnesota 55108-6146
Phone: (651) 603-0109
Fax: (651) 603-0110
Web: www.frc.state.mn.us
### Appendix B: Cultural Resource Inventory Sources in Minnesota

<table>
<thead>
<tr>
<th>Source/Contact information</th>
<th>Resource types included/ Geographic coverage</th>
</tr>
</thead>
</table>
| **Minnesota State Historic Preservation Office**  
  Cultural Resource Database | Archaeological sites, cemeteries, standing structures, traditional cultural properties, cultural landscapes  
  *Geographic coverage: Statewide* |
| State Historic Preservation Office  
  Minnesota History Center  
  345 Kellogg Blvd. W.  
  St. Paul, MN 55102-1906  
  Phone: (651) 296-5434  
  Fax: (651) 282-2374 |  |
| **State Archaeological Site File**  
  Office of the State Archaeologist  
  Fort Snelling History Center  
  St. Paul, MN 55111-4061  
  Phone: (612) 725-2411  
  Fax: (612) 725-2427 | Archaeological sites, cemeteries, traditional cultural properties  
  *Geographic coverage: Statewide* |
| **Chippewa National Forest Heritage Sites Database**  
  Chippewa National Forest  
  Route 3, Box 244  
  Cass Lake, MN 56633  
  Phone: (218) 335-8671  
  Fax: (218) 335-8637 | Archaeological sites, cemeteries, standing structures, traditional cultural properties, cultural landscapes  
  *Geographic coverage: Chippewa National Forest* |
<table>
<thead>
<tr>
<th>Source/Contact information</th>
<th>Resource types included/Geographic coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superior National Forest Heritage Sites Database</strong></td>
<td>Archaeological sites, cemeteries, standing structures, traditional cultural properties, cultural landscapes</td>
</tr>
<tr>
<td>Forest Archaeologist</td>
<td></td>
</tr>
<tr>
<td>Superior National Forest</td>
<td></td>
</tr>
<tr>
<td>8901 Grand Ave. Place</td>
<td></td>
</tr>
<tr>
<td>Duluth, MN 55801-1102</td>
<td></td>
</tr>
<tr>
<td>Phone: (218) 626-4320</td>
<td></td>
</tr>
<tr>
<td>Fax: (218) 626-4398</td>
<td></td>
</tr>
<tr>
<td><strong>Geographic coverage</strong></td>
<td>Superior National Forest</td>
</tr>
<tr>
<td><strong>Leech Lake Tribal Cultural Resource Database</strong></td>
<td>American Indian archaeological sites, cemeteries, traditional cultural properties</td>
</tr>
<tr>
<td>Preservation Officer</td>
<td></td>
</tr>
<tr>
<td>Leech Lake Tribal Government</td>
<td></td>
</tr>
<tr>
<td>Route 3, Box 100</td>
<td></td>
</tr>
<tr>
<td>Cass Lake, MN 56633</td>
<td></td>
</tr>
<tr>
<td>Phone: (218) 335-8095</td>
<td></td>
</tr>
<tr>
<td><strong>Geographic coverage</strong></td>
<td>Leech Lake Reservation</td>
</tr>
<tr>
<td><strong>Mille Lacs Tribal Cultural Resource Database</strong></td>
<td>Archaeological sites, cemeteries, traditional cultural properties</td>
</tr>
<tr>
<td>Preservation Officer</td>
<td></td>
</tr>
<tr>
<td>Mille Lacs Tribal Government</td>
<td></td>
</tr>
<tr>
<td>HCR 67, Box 194</td>
<td></td>
</tr>
<tr>
<td>Onamia, MN 56359</td>
<td></td>
</tr>
<tr>
<td>Phone: (320) 532-4181</td>
<td></td>
</tr>
<tr>
<td><strong>Geographic coverage</strong></td>
<td>Mille Lacs Tribal Lands (under development)</td>
</tr>
<tr>
<td><strong>Minnesota DNR Forestry Heritage Resources Database</strong></td>
<td>Archaeological sites, cemeteries</td>
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<tr>
<td>DNR Forestry Archaeologist</td>
<td></td>
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<tr>
<td>Resource Assessment Office</td>
<td></td>
</tr>
<tr>
<td>413 SE 13th Street</td>
<td></td>
</tr>
<tr>
<td>Grand Rapids, MN 55744</td>
<td></td>
</tr>
<tr>
<td>Phone: (218) 327-4449 x 243</td>
<td></td>
</tr>
<tr>
<td>Fax: (218) 327-4517</td>
<td></td>
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<td><strong>Geographic coverage</strong></td>
<td>Non-federal lands statewide</td>
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### Source/Contact information

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<th>Resource types included/Geographic coverage</th>
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<td><strong>Minnesota DNR State Parks Heritage Resources Database</strong></td>
<td>Archaeological sites, cemeteries, structures</td>
</tr>
<tr>
<td>DNR Parks Archaeologist</td>
<td><em>Geographic coverage:</em></td>
</tr>
<tr>
<td>Division of Parks &amp; Recreation</td>
<td>State parks</td>
</tr>
<tr>
<td>Dept. of Natural Resources</td>
<td></td>
</tr>
<tr>
<td>500 Lafayette Road</td>
<td></td>
</tr>
<tr>
<td>St. Paul, MN 55102</td>
<td></td>
</tr>
<tr>
<td>Phone: (651) 297-1153</td>
<td></td>
</tr>
</tbody>
</table>

1Note: This list is not exhaustive, but it identifies locations that actively maintain cultural resource databases and have staff available for assistance. Distribution of data may be restricted under state or federal law. Reliability of information varies.
Appendix C:
National Register Criteria for Evaluation of Cultural Resources

Criteria for Evaluation

The quality of significance in American history, architecture, archaeology, engineering and culture is present in districts, sites, buildings, structures and objects that possess integrity of location, design, setting, materials, workmanship, feeling and association, and:

☐ That are associated with events that have made a significant contribution to the broad patterns of our history; or

☐ That are associated with the lives of persons significant in our past; or

☐ That embody the distinctive characteristics of a type, period or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

☐ That have yielded, or may be likely to yield, information important in prehistory or history.
Appendix D: Ceded Lands and Reservation Boundaries

As used within these guidelines, the term “ceded lands” refers to territories ceded to the United States Government by the Ojibwe under treaties of 1837, 1854, 1866 and 1889.

On public lands within these areas (see Figure D-1), members of the following bands retain the right to pursue traditional practices:

- Mille Lacs Band (Treaty of 1837)
- Fond du Lac and Grand Portage Bands (Treaty of 1854)
- Bois Fort Band (Treaty of 1866)
- Red Lake Band (Treaty of 1889)

When planning forest management activities in these areas, it is advisable to check with tribal representatives to determine whether there are traditional use areas in the vicinity. For sources of information and assistance, see the Resource Directory.
Appendix E: Determining Basal Area

Basal area is useful for a variety of applications, including determining whether enough trees remain within the RMZ (riparian management zone) to maintain and enhance riparian functions and values.

As one example of determining basal area, assume that an acre of RMZ contains 635 trees, varying in size from 1 to 15 inches in diameter as measured at 4.5 feet (DBH). See Table E-1.

For each diameter class, the basal area per acre is determined by multiplying the number of trees per acre by the basal area per tree. For example:

A tree with a 1-inch diameter provides 0.005 ft² of basal area. 168 trees with a 1-inch diameter provide 0.84 ft² of basal area per acre (168 x 0.005 = 0.84).

Similar calculations are made for each tree diameter class found within the RMZ (in this example, from 1 inch to 15 inches).

The total basal area per acre for the RMZ is the sum of the basal area per acre for each diameter class. In this example, the 635 trees on this acre of RMZ represent a total basal area of approximately 80 ft²/acre, which is the recommended basal area within the RMZ for uneven-age management for all water bodies. See Table E-1 on next page.
### Table E-1

**Example of Basal Area Calculations for an RMZ Containing 80 ft² per Acre of Basal Area**

<table>
<thead>
<tr>
<th>DBH (inches)</th>
<th>Number of trees/acre</th>
<th>BASAL AREA ft²/tree</th>
<th>ft²/acre</th>
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<tbody>
<tr>
<td>1</td>
<td>168</td>
<td>0.005</td>
<td>0.840</td>
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<tr>
<td>2</td>
<td>107</td>
<td>0.022</td>
<td>2.354</td>
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<tr>
<td>3</td>
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<td>5</td>
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<td>5</td>
<td>0.922</td>
<td>4.610</td>
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<td>3</td>
<td>1.069</td>
<td>3.207</td>
</tr>
<tr>
<td>15</td>
<td>2</td>
<td>1.227</td>
<td>2.454</td>
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</table>

**Totals**  
635 trees  
80.011 ft²/acre
Using Crown Closure To Approximate Basal Area

While basal area is frequently determined using specialized tools, crown closure can also provide an approximation of the extent to which an area is occupied by trees. (See Table E-2.) Crown closure represents the degree to which the forest floor is shaded by tree crowns when the sun is immediately overhead.

Complete (100%) crown closure occurs when the crowns of trees touch and effectively block sunlight from reaching the forest floor while foliage is on the tree. Table E-2 shows the approximate relationship between crown closure and basal area across a range of species and tree diameters (Verry 1969). Since the relationship between basal area and crown closure varies by both tree species and diameter, crown closure may be different in two areas that have the same residual basal area.

A landowner could approximate basal area by estimating the percentage of crown closure at a particular location. An estimated crown closure of 70%, for example, would mean that about 70% of all sunlight is effectively blocked from reaching the forest floor, which approximates a basal area of 80 ft² per acre.

<table>
<thead>
<tr>
<th>Crown closure</th>
<th>Basal area (per acre)</th>
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<tbody>
<tr>
<td>30%</td>
<td>20 ft²</td>
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<td>35%</td>
<td>25 ft²</td>
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<td>50%</td>
<td>50 ft²</td>
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<tr>
<td>70%</td>
<td>80 ft²</td>
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<td>75%</td>
<td>100 ft²</td>
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<tr>
<td>75%</td>
<td>120 ft²</td>
</tr>
<tr>
<td>80%</td>
<td>140 ft²</td>
</tr>
<tr>
<td>95%</td>
<td>190 ft²</td>
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</table>

Source: Verry 1969
Appendix F: Regulations, Rules and Ordinances
Complementary to Timber Harvesting and
Forest Management Guideline Recommendations

Shipstead-Newton-Nolan Act
United States Code, Title 16, Chapter 3, subchapter 1,
Sections 577–577b

Applies to: Public waters of the United States in parts of Lake, Cook
and St. Louis counties

Resource impacted: Lakes and streams are preserved for their natural
and recreational use.

Contact:
U.S. Forest Service, Forest Supervisor’s Office (Duluth)
(218) 626-4300
r9_superior_NF@fs.fed.us
www.superiornationalforest.org/info/brochures/contact.stm

Public water rules
Minnesota Rules 6115

Applies to: Statewide

Resource impacted: Streams, lakes, public water wetlands

Contact:
DNR Waters (St. Paul)
(651) 296-4800
www.dnr.state.mn.us/waters/watermgmt_section/pwi/index.html

DNR Area Hydrologist
files.dnr.state.mn.us/waters/area_hydrros.pdf  (no www)

¹Note: This list is not exhaustive, but the major regulations, rules and ordi-
nances complement the application of the MFRC’s timber harvesting and forest
management guidelines. Contact local SCWD offices for further information on
local ordinances and contacts.
**Wetland Conservation Act**  
Minnesota Rules 8420

**Applies to:** Statewide  
**Resource impacted:** Non-public water wetlands

**Contact:**  
BWSR (St. Paul)  
(651) 296-3767  
www.bwsr.state.mn.us/aboutbwsr/workareas/index.html  
www.bwsr.state.mn.us/wetlands/wcaforms/index.html

BWSR Board Conservationist  
www.bwsr.state.mn.us/wetlands/wca/fieldstaff.pdf

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**Wild and Scenic Rivers**  
Minnesota Rules 8420

**Applies to:** Designated rivers  
**Resource impacted:** Cannon River (Faribault to the Mississippi River); Kettle River (Pine County); Minnesota River (Lac Qui Parle dam to Franklin); Mississippi River (St. Cloud to Anoka); North Fork Crow River (Meeker County); Rum River (Mille Lacs, Sherburne, Isanti and Anoka counties); St. Croix River

**Contact:**  
DNR Waters (St. Paul)  
(651) 296-4800  
www.dnr.state.mn.us/waters/watermgmt_section/wild_scenic/index.html

DNR Area Hydrologist  
files.dnr.state.mn.us/waters/area_hydros.pdf (no www)
**Land use management ordinances**

**Applies to:** Counties, townships or municipalities

**Resource impacted:** Shorelands, floodplains and zoning on private lands

**Contact:**

DNR Waters (St. Paul)
(651) 296-4800
www.dnr.state.mn.us/waters/watermgmt_section/shoreland/index.html
www.dnr.state.mn.us/shorelandmgmt/guide/index.html

DNR Area Hydrologist
files.dnr.state.mn.us/waters/area_hydros.pdf *(no www)*

County Planning and Zoning
www.bwsr.state.mn.us/directories/WCALGUs_Statewide.pdf

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**North Shore Management Plan**

**Applies to:** Counties, townships or municipalities

**Resource impacted:** Townships adjacent to the North Shore from Duluth northward

**Contact:**

DNR Waters (Grand Rapids)
(281) 327-4416
www.dnr.state.mn.us/waters/lakesuperior/index.html
www.dnr.state.mn.us/waters/lakesuperior/maps.html
**St. Louis-Whiteface-Cloquet Rivers Management Plan**

**Applies to:** Corridor along these three rivers in northeastern Minnesota

**Resource impacted:** St. Louis River, Whiteface River and Cloquet River

**Contact:**
DNR Waters (Grand Rapids)
(218) 327-4416

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**Section 106, National Historic Preservation Act**

**Applies to:** Statewide (when federal funds or permits are involved)

**Resource impacted:** Archaeological sites, cemeteries, historic structures, cultural landscapes, traditional cultural properties

**Contact:**
State Historic Preservation Office
(651) 296-5434

---

**Minnesota Field Archaeology Act**

**Applies to:** Public lands statewide

**Resource impacted:** Archaeological sites

**Contact:**
Office of the State Archaeologist
(612) 725-2411

State Historic Preservation Office
(651) 296-5434
### Minnesota Private Cemeteries Act

**Applies to:** Statewide

**Resource impacted:** Unplatted cemeteries

**Contact:**
Office of the State Archaeologist
(612) 725-2411

### Tribal ordinances

**Applies to:** Within reservation boundaries

**Resource impacted:** Archaeological sites, cemeteries, cultural landscapes, traditional cultural properties

**Contact:**
Minnesota Indian Affairs Council (St. Paul)
(651) 296-0041

Minnesota Indian Affairs Council (Bemidji)
(218) 755-3825
Appendix G: Baseline Standards for Development of Best Management Practices To Provide Wetland Protection

Land use activities in wetlands, which are operating under an exemption in the Minnesota Wetland Conservation Act, should be guided by the following principles to ensure that the activities do not contribute to the loss or diminishment of wetland values and functions. Impacts to wetlands should be avoided if practical alternatives exist.

When impacts cannot be avoided, landowners, managers and operators should implement all practical measures to minimize impacts. Best Management Practices designed to meet these baseline standards will provide the necessary protection while operating in or adjacent to wetland areas and reduce the risk of being in violation of the Minnesota Wetland Conservation Act.

BMPs developed through this process do not supersede federal regulations (33 CFR, Section 323.4 and 7 CFR, Part 12).

1. The activities should minimize impacts to the hydrologic regime of wetlands.

2. The activities should not take or jeopardize the continued existence of state (Minn. Statutes, Chapter 84.0895; Minn. Rules, Chapter 6134) and federal (16, Sections 1531-1544; 50 CFR, Section 17) threatened or endangered species, or adversely modify or destroy the critical habitat of such species.

3. Activities in breeding and nesting areas for migratory waterfowl and spawning areas in wetlands should be avoided if practical alternatives exist.

4. The activities should minimize impacts to species of special concern under Minn. Statutes, Chapter 84.0895 and Minn. Rules, Chapter 6134 where their existence is known within the activity area.
5. In designing, constructing and maintaining roads, vegetative disturbance in wetlands should be kept to a minimum.

6. Permanent roads, temporary access roads and trails in wetlands should be held to the minimum feasible number, width and total length consistent with the management objectives, and local topographic and climatic conditions.

7. All roads, temporary or permanent, should be located sufficiently far from streams or other water bodies (except for portions of such roads which must cross water bodies) and designed to minimize impacts to wetland functions and values.

8. Discharges of dredged or fill material into wetlands to construct a road fill should be made in a manner that minimizes the encroachment of trucks, tractors, bulldozers or other heavy equipment within wetlands that lie outside the lateral boundaries of the fill itself.

9. The design, construction and maintenance of the road crossing should allow the migration or other movement of those species utilizing the wetland.

10. Road fill should be bridged, culverted or otherwise designed to prevent the restriction of everyday surface and subsurface water flows and expected floodwater flows.

11. Fill should be properly stabilized and maintained during and following construction to prevent erosion.

12. Borrow material should be taken from upland sources whenever feasible.

13. All temporary fills should be removed in their entirety and the area restored to its original elevation unless removal will have a greater impact on water quality than leaving in place.

14. Material placed or discharged in wetlands should of suitable material free from toxic pollutants in toxic amounts.
Appendix H: Work Activities That Do Not Require A DNR Public Waters* Work Permit on Public Waters, Public Water Wetlands and Public Watercourses

per Minn. Rules 6115 and 6264
at www.revisor.leg.state.mn.us/arule/a490.html

Low-water ford crossings (on streams only)

No permit is required as long as all of the following conditions are met:

• No special site preparation to bed and bank is necessary.

• Normal summer flow does not exceed 2 feet in depth.

• Normal low flow is not restricted or reduced.

• Crossing conforms to the shape of the natural stream channel.

• Original streambank is no higher than 4 feet.

• Construction is only gravel, natural rock, concrete, steel matting or other durable, inorganic material not more than 1 foot thick.

• Graded finished slope is no steeper than 5:1 (horizontal to vertical).

• Graded banks are seeded or mulched.

• Site is not an officially designated trout stream; trout stream tributary designated by rule; wild, scenic or recreational river; or officially designated canoe and boating route.

*Public waters, public water wetlands and public watercourses are those so designated on Public Waters Inventory maps found at county auditor offices, local SWCD offices, and DNR area and regional offices.
Temporary bridges (on streams only)

No permit is required as long as all of the following conditions are met:

• Streambank can support bridge without pilings, foundations, culverts, excavation or other special site preparations.

• Nothing is placed in the bed of the stream.

• Bridge is capable of removal for maintenance and flood damage prevention.

• Bridge is firmly anchored at one end and can swing away during flooding.

• A minimum 3 feet of clearance exists between lowest portion of bridge and normal summer stream flow.

Water level control structures (on streams only)

No permit is required as long as all of the following conditions are met:

• The contributing watershed above the structure is 300 acres or less.

• The structure is not considered a “dam” under State Dam Safety rules.

• The structure is not on an officially designated trout stream or trout stream tributary designated by rule.
For streams with a watershed less than 5 square miles (3,200 acres)

No permit is required to construct a bridge or culvert, or to fill or excavate the bed of a public watercourse having a total drainage area, at its mouth, of 5 square miles or less, provided that all of the following conditions are met:

- County zoning officials and local SWCD staff are given at least 7 days’ prior notice and determine the project will not result in downstream erosion or sedimentation.
- The project will not divert the water to a different watershed.
- The project will not impound water by damming the watercourse.
- The watercourse is not an officially designated trout stream (or trout stream tributary designated by rule).

Removal of existing structures

No permit is required as long as all of the following conditions are met:

- The original lake, marsh or streambed is restored.
- All parts of the structure, including footings or pilings, are removed.
- The structure is not a water level control device and is not on an officially designated trout stream (or trout stream tributary designated by rule).

Removal of debris

No permit is required to remove loose debris, such as trees, logs, stumps and trash created during timber harvest or other forest management activities, as long as the original alignment, slope or cross-section of the lake, marsh or streambed is not altered.
Appendix I: Silvicultural Examples for Riparian Areas

Forest management in riparian areas is complex and requires the landowner or resource manager to ensure that the harvesting of timber is done in a manner that protects the other critical functions and values of these areas (e.g., water, wildlife, recreational opportunities).

An understanding of how trees grow, reproduce and respond to environmental changes (silvics), combined with the knowledge of techniques to maximize growth, will help to meet the landowner’s objectives (silviculture) and the timber harvesting and forest management guideline recommendations.

It is not possible to provide a comprehensive review of management within the riparian management zone (RMZ). Readers are directed to the references listed at the end of this section and elsewhere to obtain more detailed information and recommendations.

RMZ Management Options

The following examples are not comprehensive, but they provide a starting point to assist in determining an appropriate RMZ management prescription and to illustrate the flexibility of the RMZ site management guidelines.

Maintaining adequate canopy cover is an objective for management within riparian areas to protect resource functions and values. Information is provided below on the relative height growth of established seedlings under various levels of shading. The relative height growth of seedlings is a function of percent shading for the first few years following establishment.

The guidelines are not intended as a substitute for obtaining professional assistance as needed to achieve management objectives or meet appropriate engineering standards.
RMZ Stand Condition: Intact

Forestland that is stocked and in a healthy condition

RMZ Management Goals

Goal 1: Maintain current species composition, using a silvicultural prescription that will maintain the current species composition over the next rotation.

Examples:

- Patch clearcuts in aspen stand with scattered conifers to successfully regenerate aspen while leaving scattered conifers to maintain the conifer component.
- Patch clearcuts in oak.
- Selection harvest (individual or group) in a northern hardwood stand to promote sugar maple, birch and basswood regeneration.

Goal 2: Alter species composition, using a silvicultural prescription to shift the current species composition or introduce a new species.

Examples:

- Shelterwood harvest in a mixed aspen/conifer stand and underplanting white pine.
- Patch clearcuts in a conifer stand with scattered aspen to increase aspen component.

RMZ Stand Condition: Breaking Up

When a timber stand is in a deteriorating or declining condition, apply appropriate forest management activities to rejuvenate it. Mortality may be due to age, insect or disease infestation, flooding, wind damage or other causes. Many of these stands require more intensive management to retain a forested condition.
The RMZ guidelines provide the flexibility necessary to “apply appropriate forest management activities to rejuvenate [the deteriorating stand]” (see *General Guidelines*, page 38). This may include management prescriptions that fall short of the guideline recommendations (e.g., low residual basal area, greater than 5% mineral soil exposure in filter strip).

**RMZ Management Goals**

**Goal 1:** Maintain current species composition, using a silvicultural prescription that will maintain the current species composition over the next rotation.

**Examples:**

- Clearcut with reserves in overmature jack pine stand to successfully regenerate jack pine. Shelterwood harvest is appropriate for vigorous jack pine stands, particularly if there are non-serotinous cones present.

- Clearcut with reserves or patch clearcut salvage harvest in a wind-damaged aspen stand to successfully regenerate aspen.

**Goal 2:** Alter species composition, using a silvicultural prescription to shift the current species composition or introduce a new species.

**Examples:**

- Shelterwood harvest with site preparation and/or white pine underplanting in a mixed white pine/balsam stand hit by spruce budworm to promote an increase in white pine.

- Clearcut with reserves or patch clearcut harvest with site preparation and red pine planting in a mixed balsam and birch stand impacted by budworm and birch decline to introduce red pine.
Residual Canopy Cover and Gap Sizes for Regeneration Establishment and Early Growth

The information presented in Table I-1 is an illustrated summary of silvicultural recommendations from various sources. The shaded or boxed regions in the table represent what is recommended for optimal regeneration and/or early growth or timber quality for each species. Managing for less than optimal growth may be desirable to achieve other goals and objectives for management.

References for Table I-1
(far right column on table)

A. Scoring Tolerance of Forest Trees (Graham 1954)
B. Silviculture and Forest Aesthetics Handbook (Wisconsin DNR 2003)
C. Managing Black Ash Stands
D. Silvicultural Guide for Northern Hardwood Types in the Northeast (revised) 1986
E. Establishing Even-age Northern Hardwood Regeneration by the Shelterwood Method: A Preliminary Guide
F. Natural Regeneration of Northern Hardwoods in the Northern Great Lakes Region
G. Manger’s Handbook for Northern Hardwoods in the North Central States
H. Manager’s Handbook for Aspen in the North Central States
I. Silvicultural Systems for the Major Forest Types of the United States
J. Manager’s Handbook for Balsam Fir in the North Central States
N. A silvicultural guide for the white pine and red pine working groups in Ontario
O. Manager’s Handbook for Jack Pine in the North Central States
P. Regional Silviculture of the United States (1995)
Q. Manager’s Handbook for Oaks in the North Central States
R. A Silvicultural Guide for White Pine in the Northeast
S. Manager’s Handbook for Northern White-Cedar in the North Central States
T. Manager’s Handbook for Black Spruce in the North Central States
U. Regional Silviculture of the United States (1980)
V. Regenerating the Canadian Forest, Principles and Practice for Ontario
Summary of Residual Canopy Cover and Gap Sizes for Recommended Silvicultural Activities

Percent canopy cover (evenly distributed)

<table>
<thead>
<tr>
<th>Species</th>
<th>Shade* Tolerance</th>
<th>0%</th>
<th>5%</th>
<th>20%</th>
<th>40%</th>
<th>60%</th>
<th>80%</th>
<th>100%</th>
<th>Gap Size (acre)</th>
<th>Clearcut Strip Width (ft)</th>
<th>Seed Trees (number per acre)</th>
<th>Ref**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspen</td>
<td>0.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≥ 1.0</td>
<td>200 ft</td>
<td>10</td>
<td>(1, 2)</td>
</tr>
<tr>
<td>Tamarack</td>
<td>0.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 1.0</td>
<td>10</td>
<td>3 - 5</td>
<td>(3, 4)</td>
</tr>
<tr>
<td>Paper Birch</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 1.0</td>
<td>10</td>
<td>6</td>
<td>(5)</td>
</tr>
<tr>
<td>Jack Pine</td>
<td>1.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 1.0</td>
<td>6</td>
<td>(6, 7)</td>
<td>(G)</td>
</tr>
<tr>
<td>Red Pine</td>
<td>2.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 1.0</td>
<td>6</td>
<td>(8, 9)</td>
<td>(H)</td>
</tr>
<tr>
<td>Oak</td>
<td>2.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 1.0</td>
<td>6</td>
<td>(10)</td>
<td>(L, N)</td>
</tr>
<tr>
<td>Black Ash</td>
<td>2.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 1.0</td>
<td>4 - 14</td>
<td>(11, 12)</td>
<td>(F)</td>
</tr>
<tr>
<td>White Pine</td>
<td>4.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 1.0</td>
<td>6</td>
<td>(13)</td>
<td>(C)</td>
</tr>
<tr>
<td>N. White Cedar</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 1.0</td>
<td>6</td>
<td>(14, 15)</td>
<td>(N, R)</td>
</tr>
<tr>
<td>Yellow Birch</td>
<td>6.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 1.0</td>
<td>4 - 14</td>
<td>(16, 17)</td>
<td>(B, S)</td>
</tr>
<tr>
<td>Black Spruce</td>
<td>6.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 1.0</td>
<td>5 - 7</td>
<td>(18, 19)</td>
<td>(D)</td>
</tr>
<tr>
<td>White Spruce</td>
<td>6.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 1.0</td>
<td>6</td>
<td>(10, 20)</td>
<td>(G)</td>
</tr>
<tr>
<td>Sugar Maple / Basswood</td>
<td>9.7 / 8.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 1.0</td>
<td>6</td>
<td>(11, 21)</td>
<td>(H)</td>
</tr>
<tr>
<td>Balsam Fir</td>
<td>9.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 1.0</td>
<td>6</td>
<td>(12, 22)</td>
<td>(I)</td>
</tr>
</tbody>
</table>

- Clearcut and/or Seed Tree Harvest (# of trees/ac in notes)
- Shelterwood (regeneration harvest)
- Single-tree Selection Harvest

*0 = least tolerant, 10 = most tolerant

** References
Silvicultural treatments often result in the change of a seedling’s light regime. Silvicultural prescriptions often attempt to accomplish many different objectives, and treatments do not necessarily result in light conditions that optimize seedling growth.

Other objectives might be seed germination, competition control, promotion of natural pruning, or non-timber values. Table I-2 provides a summary of early height growth of tree regeneration under varying levels of shade.

The numbers in the table relate the amount of shade (%) seedlings receive to their relative height growth (in % of maximum). Relative height growth is an indicator of growth rates of established seedlings within the first three years and reflects the potential trade-off of reduced height growth for other potential benefits.

For ease of interpretation, relative height growth is divided into categories from ideal (i.e., relative height growth is close to its maximum possible height growth) to poor (i.e., less than 50% of potential maximum height growth can be achieved).
Summary of relative height growth of Minnesota tree species under varying levels of shade. The amount of shade (in %) is given for different categories of height growth of young seedlings. As an example, for aspen, relative tree height growth is maximized when shading is 10% or less.

<table>
<thead>
<tr>
<th>Species</th>
<th>Ideal (100-90)</th>
<th>Good (90-75)</th>
<th>Fair (75-50)</th>
<th>Poor (&lt; 50)</th>
<th>References (see below)</th>
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<tbody>
<tr>
<td>Aspen</td>
<td>0-10</td>
<td>10-25</td>
<td>25-50</td>
<td>&gt; 50</td>
<td>(K)</td>
</tr>
<tr>
<td>Tamarack</td>
<td>0-60</td>
<td>60-65</td>
<td>65-85</td>
<td>&gt; 85</td>
<td>(L)</td>
</tr>
<tr>
<td>Paper Birch</td>
<td>35-65</td>
<td>15-35,</td>
<td></td>
<td></td>
<td>(L)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>65-100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jack Pine</td>
<td>0-50</td>
<td>50-65</td>
<td>65-80</td>
<td>&gt; 80</td>
<td>(L)</td>
</tr>
<tr>
<td>Red Pine</td>
<td>0-55</td>
<td>55-75</td>
<td>75-85</td>
<td>&gt; 85</td>
<td>(L)</td>
</tr>
<tr>
<td>Red Oak</td>
<td>0-15</td>
<td>15-45</td>
<td>45-100</td>
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<td>(M)</td>
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<tr>
<td>Black Ash</td>
<td>35-75</td>
<td>15-35,</td>
<td>0-15</td>
<td></td>
<td>(L for white ash)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75-100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Elm</td>
<td>40-60</td>
<td>15-40,</td>
<td>0-15,</td>
<td></td>
<td>(L)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60-75</td>
<td>75-100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Pine</td>
<td>0-60</td>
<td>60-70</td>
<td>70-90</td>
<td>&gt; 90</td>
<td>(L)</td>
</tr>
<tr>
<td>N. White Cedar</td>
<td>0-60</td>
<td>60-75</td>
<td>75-85</td>
<td>&gt; 85</td>
<td>(L)</td>
</tr>
<tr>
<td>Yellow Birch</td>
<td>45-75</td>
<td>10-45,</td>
<td>0-10,</td>
<td></td>
<td>(L)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75-85</td>
<td>85-100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black Spruce</td>
<td>0-35</td>
<td>35-60</td>
<td>60-75</td>
<td>&gt; 75</td>
<td>(L)</td>
</tr>
<tr>
<td>White Spruce</td>
<td>0-55</td>
<td>55-60</td>
<td>60-70</td>
<td>&gt; 70</td>
<td>(L)</td>
</tr>
<tr>
<td>Sugar Maple</td>
<td>40-90</td>
<td>20-40,</td>
<td>0-20</td>
<td></td>
<td>(L)</td>
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<td></td>
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<td>90-100</td>
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<tr>
<td>Basswood</td>
<td>50-85</td>
<td>10-50,</td>
<td>0-10</td>
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<td>(L)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>85-100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balsam Fir</td>
<td>5-60</td>
<td>0-5, 60-70</td>
<td>70-85</td>
<td>&gt; 85</td>
<td>(L)</td>
</tr>
</tbody>
</table>

(K) Regeneration of aspect cutover areas in northern Wisconsin
(L) Growth of tree seedlings as affected by light intensity (Logan 1965-73)
(M) Northern red oak seedling growth varies by light intensity and seed source
References Cited in Tables I-1 and I-2

Letters refer to last columns in Table I-1 (page 5) and Table I-2 (page 7).


Appendix J: Sensitive Native Plant Communities

The rare native plant communities listed in the next two pages are sensitive to timber harvest and other forest management activities. This list of rare communities includes both forest and woodland communities that are dominated by trees and savanna communities that support only scattered trees.

This list of communities follows Minnesota’s Native Plant Community Classification (version 2.0):

- Those communities marked by an asterisk are found in the Laurentian Mixed Forest Province and described in Field Guide to the Native Plant Communities of Minnesota: The Laurentian Mixed Forest (Minnesota Department of Natural Resources 2003).

- Communities without an asterisk are found west and south of the Laurentian Mixed Forest Province; descriptions of these communities are available on the Ecological Services page of the Minnesota DNR Web site at www.dnr.state.mn.us/ecological_services

- Each community name is followed by a unique code used from Minnesota’s Native Plant Community Classification (version 2.0). Note that those communities marked with an “S” have sparse tree cover.
Sensitive Native Plant Communities

* Red Pine - White Pine Woodland (Minnesota Point) FDn32b
* Spruce - Fir Woodland (North Shore) FDn32e
  Jack Pine - Oak Woodland (Sand) FDs27a
  White Pine - Oak Woodland (Sand) FDs27b
  Swamp White Oak Terrace Forest FFs59b
* White Pine - Sugar Maple - Basswood Forest (Cold Slope) MHc38a
* Jack Pine - (Bearberry) Woodland FDe12a
* Jack Pine - (Yarrow) Woodland FDe23a
* Jack Pine - Oak Woodland FDe25a
* Oak - Aspen Woodland FDe25b
* Red Pine - White Pine Forest FDe34a
* Jack Pine Woodland (Sand) FDe12a
* Red Pine Woodland (Sand) FDe12b
* Red Pine - White Pine Woodland (Eastcentral Bedrock) FDe22d
* Black Spruce - Jack Pine Woodland: Jack Pine - Balsam Fir Subtype FDe32c1
* Jack Pine - Black Spruce Woodland (Sand) FDe32d
* Black Spruce Woodland FDe33c
* White Pine - Red Pine Forest FDn43a
  Black Oak - White Oak Woodland (Sand) FDs27c
  Oak - Shagbark Hickory Woodland FDs38b
  Bur Oak - (Prairie Herb) Woodland FDw24a
Sensitive Native Plant Communities (cont’d)

- Elm - Ash - Basswood Terrace Forest FFs59c
- * White Pine - White Spruce - Paper Birch Forest MHn44b
- * White Cedar - Yellow Birch Forest MHn45b
- White Pine - Oak - Sugar Maple Forest MHs38a
- Red Oak - Sugar Maple - Basswood - (Bitternut Hickory) Forest MHs38c
- Sugar Maple - Basswood - Red Oak - (Blue Beech) Forest MHs39b
- Elm - Basswood - Black Ash - (Blue Beech) Forest MHs49b
- Green Ash - Bur Oak - Elm Forest MHw36a
- Black Ash - (Red Maple) Seepage Swamp WFs57a
- Black Ash - Sugar Maple - Basswood - (Blue Beech) Seepage Swamp WFs57b
- S Dry Barrens Jack Pine Savanna (Northern) UPn13a
- S Dry Sand - Gravel Oak Savanna (Northern) UPn13c
- S Dry Hill Oak Savanna (Northern) UPn13d
- S Mesic Oak Savanna (Northern) UPn24a
- S Dry Barrens Oak Savanna (Southern) UPS14a
- S Dry Hill Oak Savanna (Southern) UPS14c
- S Mesic Oak Savanna (Southern) UPS24a
- S Dry Barrens Oak Savanna (Northern) UPn13b
- S Dry Sand - Gravel Oak Savanna (Southern) UPS14b
- S Algific Talus CTs46a
Appendix K: References Cited and Additional Technical Literature


The Minnesota Forest Resources Council (MFRC) has completed development of its biomass harvesting guidelines for forestlands, brushlands and open lands.

These new guidelines are designed to be included in the MFRC’s 2005 forest management guidebook titled Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers. The new biomass guidelines are presented as two additional chapters for the 2005 guidebook:

- Biomass Harvesting on Forest Management Sites
- Woody Biomass Harvesting for Managing Brushlands and Open Lands

Please insert the two enclosed chapters, with tabs, at the back of your 2005 loose-leaf guidebook (directly after the Appendices section). Insert this cover sheet directly before the Table of Contents (to become the fourth sheet in the guidebook).

For the sake of efficiency, and to avoid having to reprint multiple sections of the existing 2005 guidebook, the two new chapters are not integrated into the rest of the guidebook. Instead of updating the existing Rationale, Resource Directory, Glossary and Appendices with biomass harvest information, the two biomass harvest chapters include their own Rationale, Additional Resources, Glossary and Appendices sections.

In addition, the full guidebook Table of Contents, located at the beginning of the guidebook, has not been revised to reflect the two new chapters. Full integration of the new biomass harvest guidelines with the General Guidelines and activity-specific guidelines is expected to occur at the time of the next revision of the entire 2005 guidebook.

(continued on back)
While these new biomass chapters have not been integrated into the rest of the 2005 guidebook, the existing guidelines have been fully integrated into the two new chapters. The biomass harvest chapters include extensive references to both the General Guidelines and the Timber Harvesting guidelines.

As is the case with the rest of the activity-specific forest management guidelines in the guidebook (such as Timber Harvesting and Forest Road Construction and Maintenance), it is essential that the biomass harvest guidelines be considered and implemented in close conjunction with the General Guidelines (the green tabbed section of the guidebook) and, in some instances, the Timber Harvesting guidelines (the light blue tabbed section).

For additional hard copies of these two biomass harvest chapters, as well as copies of the entire 2005 Guidelines, call or email the Minnesota Forest Resources Council (651-603-6761 or mcine017@umn.edu), or visit the MFRC website (www.frc.state.mn.us) to download copies.
Biomass Harvesting on Forest Management Sites

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Biomass Harvesting on Forest Management Sites

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REMEMBER:

**Guidelines help with how to manage, not whether to manage.**

These guidelines focus on how to protect the functions and values of forest resources during woody biomass harvesting management activities. They generally do not provide advice on whether to manage or which management activities are needed. These guidelines do, however, recommend avoiding or modifying biomass harvest of some sites of statewide ecological significance or ecological sensitivity.

**Guidelines provide a menu, not a mandate.**

Site-level resource management decisions are based on many different factors, including resource needs, landowner objectives, site capabilities, existing regulations, economics and the best information available at any given time. No one will apply all of the guidelines related to a particular activity. Instead, the landowner, resource manager or logger will consider many different factors in determining which combination of guidelines provides the best “fit” for a particular site at a particular time. The intent of these guidelines is to provide a menu of site-level management practices that provide for the harvesting of woody biomass while ensuring the sustainability of forest resources in Minnesota.

**General guidelines and activity-specific guidelines are closely related.**

Frequent references from activity-specific guidelines back to the General Guidelines will make it easy for landowners, resource managers, loggers, biomass harvesters and others to consider all of the related guidelines—both general and specific—that apply to a particular management activity.

**Guidelines are supplemented from time to time by “Additional Considerations.”**

The guidelines are supplemented from time to time by “Additional Considerations,” which provide additional guidance to further promote sustainable forest resources.
Interest in biomass energy in Minnesota has increased recently, driven by higher energy prices and state-supported incentives to produce renewable energy. While wood-fired energy facilities have been in operation in the state for quite some time, recent expansion of the energy industry has raised concerns about the impact of increased removal of biomass from the state’s forests.

Examples of new capacity in the renewable fuels industry include such projects as the Laurentian Energy Authority municipal energy project on the Iron Range and the installation of a wood gasifier at the Central Minnesota Ethanol Cooperative in Little Falls. While the benefits of biomass energy are numerous, such as providing jobs locally and reducing use of fossil fuels, increasing removal of biomass from forested sites has the potential to impact long-term site productivity, biodiversity and wildlife populations.

In response to these concerns, the Minnesota State Legislature, as part of its legislation on energy production from woody biomass, directed the Minnesota Forest Resources Council (MFRC) and the Minnesota Department of Natural Resources (DNR) to develop guidelines or best management practices for sustainably managed woody biomass, as per Minnesota Statutes Chapter 216B, Section 2424 (M.S. § 216B.2424).

The legislation specifically states the following: “Guidelines ...must be adopted...for logging slash, using the most recent available scientific information regarding the removal of woody biomass from forest lands, to sustain the management of forest resources as defined by Minnesota Statutes Section 89.001, Subd. 8 and 9, with particular attention to soil productivity, biological diversity as defined by Section 89A.01, Subd. 3, and wildlife habitat.”

*Biological diversity* is defined in Section 89A.01, Subd. 3, as “the variety and abundance of species, their genetic composition, and the communities and landscapes in which they occur, including the ecological structures, functions, and processes occurring at all of these levels.”
For the purposes of these guidelines, **biomass harvesting includes the process of collecting and removing woody biomass from forested sites**. In addition to the utilization of tops and limbs from trees harvested in a roundwood operation, biomass harvest **might** include the utilization of small-diameter trees or stems (which have historically been “non-merchantable”), dead trees (snags), down logs (coarse woody debris), brush and stumps. These guidelines generally recommend retaining coarse woody debris, snags and stumps, as well as some fine woody debris (tops and limbs) and some brush. See Figure BHF-1, page 7.

Biomass harvest removes more woody material from a site than would be removed under typical roundwood harvest. Often biomass harvesting is conducted in addition to roundwood harvesting on the same site, either in conjunction with the roundwood harvest or soon after. In addition, though, biomass harvest is also conducted on sites where a roundwood harvest is not occurring.

**The Benefits of Guidelines**

**Benefits to cultural resources:** Woody biomass harvesting guidelines, in conjunction with General Guidelines, can minimize the potential negative effects of harvesting activities, such as mixing of surface soils, rutting, compaction and erosion, which can damage certain kinds of cultural resources. Guidelines for construction of haul roads and landings, felling, skidding and slash management can help to protect cultural resources.

**Benefits to soils:** Woody biomass harvesting guidelines, in conjunction with General Guidelines, are designed to help protect the physical, chemical and biological properties of soils by minimizing the effects of soil compaction and rutting, erosion and nutrient removal that can result from woody biomass harvesting activities.

**Benefits to riparian areas:** Woody biomass harvesting guidelines, in conjunction with General Guidelines, minimize the alteration of vegetation within the riparian area. That vegetation is important for providing inputs of coarse and fine woody debris to water bodies; retaining nutrients, sediment and energy; stabilizing banks and shorelines; maintaining moderate water temperatures through shading; and providing wildlife habitat.
The definition of biomass includes the following components of a forest stand: snags, tops and limbs, coarse woody debris, stumps, undersized or “non-merchantable” stems, and brush. The guidelines in this chapter generally recommend retaining coarse woody debris, snags and stumps, as well as some fine woody debris (tops and limbs) and some brush. Photos courtesy of Minnesota DNR Forestry
Benefits to water quality, water quantity and wetlands: Woody biomass harvesting guidelines, in conjunction with General Guidelines, are designed to protect water quality by minimizing potential nonpoint source pollution resulting from soil disturbance, disruption of vegetative cover, and biomass harvesting activities in close proximity to streams, lakes and wetlands.

Benefits to wildlife habitat: Woody biomass harvesting guidelines, in conjunction with General Guidelines, reduce the potential for biomass harvesting activities to disturb sensitive sites, rare species, water features and unique habitats. Guidelines are aimed at maintaining structural components of the site (including live trees, snags, fine and coarse woody debris, shrubs and ground cover) that are needed for forest wildlife both now and as the forest stand regenerates.

RATIONALE

Wildlife and Biodiversity

A general premise of forestry that considers wildlife and biodiversity is that silvicultural practices more closely resemble relevant natural disturbance regimes and natural stand development (Hunter 1999; Kohm and Franklin 1997). Furthermore, a greater opportunity exists for sustaining biodiversity when the disparity between managed stands and their natural analogs is reduced.

Biological legacies (see Glossary) are central to the development of silvicultural systems that emulate natural models. Creating and leaving biological legacies maintains critical structural elements of managed stands, thereby sustaining many organisms and ecological processes dependent upon these structures (Kohm and Franklin 1997).

Natural disturbances rarely eliminate all structural elements from the preceding stand, even in the case of extreme or multiple disturbances (Franklin et al. 1995, 2002; Foster et al. 1997). The lack of significant biological legacies is a major difference between traditional even-aged harvesting methods and natural stand replacement disturbances, whether by fire, wind or insects (Lee and Crites 1999).
Most prominent among the legacies lacking from harvested stands is remnant live trees, abundant snags and down trees (with associated pit-and-mound topography) (Franklin et al. 1995). Many roundwood harvesting strategies involve the removal of most large trees from a site, while natural disturbance, even fire, does not. Therefore, recent forest management guidelines, including the MFRC Voluntary Site-Level Forest Management Guidelines, include recommendations to maintain minimum amounts of snags and down logs. Biomass harvesting following roundwood harvest increases the disparity between managed stands and their natural analogs by removing additional coarse woody debris (CWD), as well as slash, thus further challenging natural resource managers to manage sustainably.

These biomass harvesting guidelines, in conjunction with existing forest management guidelines, attempt to incorporate natural disturbance patterns and processes into any harvesting scheme. This effort can be accomplished by 1) maintaining biological legacies through leave tree clumps, and 2) maintaining structural complexity throughout the harvest area by retaining a level of snags, down CWD and slash (or fine woody debris).

**Role of woody debris in maintaining forest biodiversity**

While an abundance of literature demonstrates the importance of standing and down CWD in providing habitat for vertebrate species, small life forms related to fine woody debris (FWD) have not been as well studied—particularly fungi, lichens, bryophytes and arthropods, which are central to the health and productivity of forest ecosystems (Crow 1988, 1990). Woody debris, both CWD and FWD, provides habitat for many of these species (Samuelsson et al. 1994).

Those relatively few studies of the importance of woody debris for invertebrates often reveal an immense diversity of species that require woody debris. For example, one three-year study in the Canadian boreal forest reported that 257 taxa (mostly species) of saproxylic beetles utilized decaying aspen logs (Hammond et al. 2004). Few studies, however, have quantified amounts of woody debris needed to maintain specific populations, much less whole communities.
Harvest of slash and other woody debris for biomass, as part of or following timber harvest, decreases the amount of decaying wood on forest landscapes and changes the chemical and physical environment in clearcuts (Astrom et al. 2005). Astrom also reported that slash harvests in Sweden significantly reduced the species richness of liverworts (with one-third of the species disappearing) but didn’t affect the species richness of vascular plants (Astrom et al. 2005). In Finland, where biomass removals have occurred for a longer time, recommendations are to retain 30% of harvest residue in stands to help maintain biodiversity.

In clearcuts, benefits of slash or FWD include the following:

- It provides shelter, reducing wind velocity and fluctuations in ground surface temperature (Mahendrappa and Kingston 1994; Proe et al. 1994).

- It provides habitat for small mammals (Ecke et al. 2002) and ground-active beetles (Gunnarsson et al. 2004).

- It may shelter plants sensitive to desiccation immediately following clearcuts (cf. McInnis and Roberts 1994; Brakenhielm and Liu 1998).

With the development of a market for woody biomass, much of the CWD and slash (or FWD) that would have remained on site following timber harvest for roundwood is likely to be removed. Although a certain amount of woody debris retention is essential for sustaining biodiversity and wildlife populations, science does not tell us how much woody debris can be sustainably removed from forest harvest sites. (See photos on page 11.)

The science is clear, however, in confirming that natural disturbances create and retain considerably more woody debris than commercial timber harvests do, and that this difference is increased by woody biomass harvest. These guidelines provide a best scientific judgment, tempered by the consensus process among a broad group of forest management interests, related to practices that will sustain a high level of biodiversity.
These two photos demonstrate differing levels of biomass utilization after a timber harvest. The top photo depicts a roundwood harvest area in which all of the slash and CWD has been retained on the site. In contrast, the lower photo depicts a high level of biomass utilization, with most of the slash, CWD, snags and brush removed from the site. Photos courtesy of Minnesota DNR Forestry
Water Quality

The 2005 MFRC Voluntary Site-Level Forest Management Guidelines (2005 Guidelines) focus on retaining water quality by avoiding sediment and nutrient movement into wetlands and water bodies through the use of filter strips and water diversion practices. The 2005 Guidelines also focus on minimizing impacts to wetland form and function by avoiding direct damage to wetlands due to trafficking, drainage or filling.

Re-entry into timber harvest sites increases the potential for sediment movement into wetlands through disturbance of erosion control features and rehabilitated infrastructure. The 2005 Guidelines do not address re-entry into sites for the purpose of recovering biomass. They also do not address the removal of stand components, such as small-diameter trees, CWD and brush within filter strips. Because increased biomass harvest activity in filter strips increases the potential for filter strip disturbance, consideration must be given to how much non-merchantable material and residual CWD should be harvested or retained in filter strips.

Riparian Management Zones

Riparian management zone (RMZ) guidelines included in the 2005 Guidelines deal with most issues related to harvest of biomass in or near RMZs. They do not, however, specifically address removal or disturbance of brush, small trees or CWD in RMZs.

Issues related to biodiversity mentioned in previous sections of this chapter have particular relevance to management within riparian zones. The 2005 Guidelines allow for harvesting of some trees in RMZs, and it seems reasonable to utilize the tops and limbs of these harvested trees. Removal of additional biomass, however, must be balanced with the protection of biodiversity in these special management zones.
Soil Productivity

These guidelines are designed to maintain the productive capacity of forest soils in Minnesota during biomass harvesting activities. Identifying and reducing negative impacts to soil resources should be an essential part of any strategy to achieve sustainable forest management.

In most cases, evidence suggests that, if the current site-level guidelines are followed, biomass harvesting will not create additional or increased physical impacts to soil productivity, as compared to conventional forest harvesting. Where biomass harvesting may create an increased impact, compared to conventional forest harvesting, is with respect to nutrient removals. Removing more biomass from a site inevitably removes more nutrients.

Nevertheless, even in the case of biomass harvesting, where more nutrients are removed than in conventional forest harvesting, new research, resulting in updated nutrient budgets, and the results of long-term studies indicate that, for most mineral soils in Minnesota, the nutrient capital is sufficient to tolerate a large number of such harvest rotations without harmful effects (Grigal 2004).

On deep organic soils (ombrotrophic sites), however, potassium and phosphorus depletion may occur if aggressive biomass removal is practiced over multiple rotations. Very shallow to bedrock mineral soils are also susceptible to nutrient loss. Based on current available information and technology, the guidelines outlined in this chapter will protect the nutrient capital of the average forested site in Minnesota.

The 2005 Guidelines, with respect to nutrient depletion, were developed using information in Minnesota’s Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota (GEIS). The portion of the GEIS dealing with soils was completed in 1992, and nutrient budgets in the report were based on state-of-the-science information available at that time (Grigal and Bates 1992).
Since the GEIS was published, however, an update of the nutrient portion of the GEIS has been completed (Grigal 2004), based on research published since 1992. The 2004 update revisited assumptions used in the original GEIS and modified them based on current knowledge. Major changes included the following:

- Slightly modifying the magnitude of atmospheric inputs.
- Reducing the magnitude of nutrient inputs by weathering (by 2 to 3 times).
- Adding inputs via ground-water flow to organic soils (peatlands).
- Eliminating leaching of nutrients to ground water during the normal silvicultural rotation.
- Increasing the estimated removal of nutrients associated with merchantable bole harvesting and reducing the removal associated with whole-tree harvesting.
- Increasing nutrient capital for mineral soils by assuming uniform nutrient availability to 40 inches depth and by calculating release of nutrients from soil organic matter over 10 years rather than over one year.
- Altering nutrient capital for organic soils and forest floor by calculating release of nutrients from organic matter over 10 years.

Specifically with respect to biomass harvesting, the update assumed that 100% of the logging residue would not be removed following conventional harvest. The material that remains would primarily be high-nutrient small branches and leaves. On average, about 25% of above-ground nutrients in the pre-harvest stand would be retained following residue removal, compared to about 40% retained following conventional harvest.

Future technology, however, may make it possible to remove much more of the woody material from sites, along with nutrients associated with that material. For example, Figure BHF-2 (see page 15) qualitatively compares the increasing removal of biomass and nutrients with the natural nutrient inputs estimated to occur over a rotation. Data are for harvest from the aspen-birch cover type, 50-year rotation, 20 cords-per-acre yield on an average Minnesota forest soil. As biomass removal increases, natural inputs are no longer sufficient to replace nutrients that have been removed, and depletion of the nutrient capital of the site will occur.
This figure correlates relative amounts of nutrients removed with increasing biomass removal compared to natural nutrient inputs. Scenarios are for harvest from the aspen-birch cover type, 50-year rotation, 20 cords-per-acre yield, on an average Minnesota forest soil.

**Scenario A:** Conventional merchantable bole harvest  
**Scenario B:** Whole-tree harvest (not including breakage and loss of tops and limbs that stay on the site)  
**Scenario C:** Whole-tree harvest with an additional 50% of the remaining tops and limbs removed  
**Scenario D:** Whole-tree harvest with removal of all tops and limbs  
**Scenario E:** “D” harvest plus removal of all dead logs on forest floor  
**Scenario F:** “E” harvest plus removal of all standing snags  
**Scenario G:** “F” harvest plus removal of all brush

**NOTE:** Biomass harvesting guidelines in this chapter recommend that approximately one-third of FWD be retained on site, which represents a point close to nutrient removal in Scenario B.

*Figure based on information from Grigal 2004*
The nutrient capital of an average Minnesota forest soil is about 20 times that removed under Scenario G in Figure BHF-2; therefore, even that extreme scenario (G) would be unlikely to affect site productivity over multiple rotations. If the frequency of biomass harvest increases (decreased rotation age), accumulation of natural inputs between harvests will be less. For example, natural inputs over a 25-year period will be roughly half of natural inputs over a 50-year period. Depending on the amount of woody material being removed, the likelihood of negative impacts to site productivity over multiple rotations will increase with decreased rotation ages.

Nutrient storage in coarse-textured (sandy) soils is lower than in an “average” mineral soil. For example, the calcium capital for an average mineral soil in Minnesota is about 15,000 lb/ac, while that for coarse-textured soils is about half that amount, or 7,000 lb/ac. Even on these soils, however, only a small percentage of the system potassium and calcium would be removed in each 50-year rotation, including residue removal.

Some Minnesota soils, however, such as those that are very shallow over bedrock or are deep ombrotrophic peats, have much lower nutrient capital than the average soil. In the case of these soils, high levels of biomass removals are likely to negatively affect their productivity.

Soils provide an environment suitable for a vast array of plant and animal populations, ranging from microscopic bacteria to small mammals. Careful guideline implementation that sustains the physical and chemical characteristics of the soil will, in large part, maintain the biological characteristics of the soil.

Most biological activity in the soil, however, takes place in the surface soil or litter layers. Although surface soil and litter layers are a potential source of biomass, they are also extremely important to maintaining a wide variety of ecosystem functions, such as nutrient supply, erosion control, water retention and rooting medium. Therefore, surface soil and litter layers should not be removed without strong overriding silvicultural reasons. This is true for all sites, not just nutrient-sensitive sites.

Additional trafficking by biomass harvesting or collection equipment may increase physical impacts to the soil. Existing
guidelines—such as keeping equipment on trails and infrastructure, avoidance of rutting, and operating on frozen ground—should be adequate for biomass harvest, as well. Re-entry into the general harvest area of a site, however, to collect forest residue (slash) may be problematic and is therefore discouraged. Re-entry while operating equipment on existing infrastructure (roads and landings) is best. Any re-entry onto a site may impact regeneration and disturb rehabilitated infrastructure. Restoring erosion control features and rehabilitating infrastructure is necessary.

PLANNING, DESIGN AND OPERATIONAL ACTIVITIES

➢ Have you considered the suitability of the site for biomass harvest, based on levels of habitat and species sensitivity?

➢ Have you identified your objectives?
  See Identifying Goals and Objectives in General Guidelines (pages 7-9).

➢ Have you conducted a site inventory?
  See Conducting a Site Inventory in General Guidelines (pages 10-17).
IMPORTANT! For all activities, review and implement General Guidelines.

In addition:

- **For all biomass harvest on forest sites**, review and implement guidelines in *Timber Harvesting*, except where identified or modified in this chapter.

- **If an access road will be constructed or used** on a biomass harvest site, review and implement guidelines in *Forest Road Construction and Maintenance*.

- **For timber stand improvement activities**, follow applicable guidelines in this chapter, as well as guidelines found in *Timber Stand Improvement*.

These guidelines combine planning and design activities with operational activities. This combined approach recognizes a commitment to resource sustainability related to both planning/design and operational considerations:

- **Planning guidelines** recognize that many considerations related to resource protection and sustainability are common to most management activities, and that the commitment to sustainability begins in the early planning stages—long before the actual management activity begins.

- **Operational guidelines** recognize that on-site activities carry out the commitment to sustainability that was begun during the planning phase.
Biomass Harvest on Sensitive Sites

Review existing guidelines: Review General Guidelines and Timber Harvesting guidelines, especially those relating to checking for the presence of known endangered, threatened and special concern species (ETS), sensitive plant communities or cultural resources, including:

General Guidelines:
- Gathering Information (pages 10-11)
- Rare or Sensitive Species (pages 23-24)
- Protecting Cultural Resources (pages 68-69)

Timber Harvesting:
- Protecting Sensitive Areas (pages 20-21)

In addition:

Avoid biomass harvesting in native plant communities listed in Appendix J.

- To determine whether any of these native plant communities are known to occur on the site, consult with local DNR Forestry offices and/or the Minnesota County Biological Survey (MCBS) Native Plant Communities GIS (geographic information system) layers, which may be downloaded from the DNR Data Deli at http://deli.dnr.state.mn.us (GIS software and skills are necessary).

- Biomass harvesting may still be appropriate under the following conditions:
  * If management plans specifically include strategies to maintain habitat for rare species and/or to restore degraded native plant communities.
  * If biomass harvesting is used as a tool to restore degraded native plant communities (e.g., overgrown savanna plant communities). Consult appropriate DNR Ecological Resources regional plant ecologist.
* If biomass harvesting is used as a management tool to assist with ecological management of the native plant community (e.g., creating a fire break as part of burning a fire-dependent native plant community). Consult appropriate DNR wildlife manager and DNR regional plant ecologist.

✔ Avoid biomass harvest within specific sites where plant or animal species listed as endangered or threatened at the state or federal level are known to exist (e.g., sites identified in the DNR Natural Heritage Information System), or where such species are discovered during operations and where biomass harvesting would harm them (unless harvest has been demonstrated to maintain or improve habitat for these species).

• To determine whether these species are known to occur on the site, consult local DNR offices.

• If a bald eagle nest occurs on or near the site, see Recommendations for Avoiding and Minimizing Impacts at http://files.dnr.state.mn.us/natural_resources/animals/birds/eagles/factsheet.pdf

The presence of an eagle’s nest is one example of a sensitive site that should be taken into consideration when planning for and operating on a biomass harvest site. Photo courtesy of Minnesota DNR Parks and Recreation
**Reference M.S. § 216B.2424 (Biomass Power Mandate)** and urge affected utilities to follow the statute as reference.

- M.S. § 216B.2424, Subd. 1a and f, directs that, for utilities specified within this statute, no woody biomass may be harvested from any lands identified by the final or preliminary Minnesota County Biological Survey as having statewide significance as native plant communities, large populations or concentrations of rare species, or critical animal habitat. See *Additional Resources* (page 35) to access complete statute online.

**Managing Water Quality and Riparian Management Zones**

**Review existing guidelines:** Review *General Guidelines* and *Timber Harvesting* guidelines related to water quality and RMZ management, including:

**General Guidelines:**
- Water Quality and Wetlands (pages 22-23)
- Maintaining Filter Strips (pages 24-28)
- Managing Riparian Areas (pages 29-67)
- Protecting the Normal Flow of Streams and Wetlands (pages 71-72)
- Protecting Non-Open Water Wetlands and Seasonal Ponds (page 73)
- Managing Dry Washes in Southeastern Minnesota (pages 74-75)

**Timber Harvesting:**
- Water Quality and Wetlands (pages 30-31)

**In addition:**

**Avoid harvest of additional biomass from within RMZs over and above the tops and limbs of trees** normally removed in a roundwood harvest under existing timber harvesting guidelines.
Avoid additional biomass removal within 25 feet of a dry wash bank except tops and limbs of trees normally removed in a roundwood harvest under existing timber harvesting guidelines, when managing near a dry wash in southeastern Minnesota.

Managing Soil Productivity

Review existing guidelines: Review *General Guidelines* and *Timber Harvesting* guidelines relating to soil productivity, including infrastructure management, nutrient conservation and avoiding impacts to physical properties:

General Guidelines:
- Designing Operations To Fit Site Conditions (page 20)
- Managing and Minimizing Infrastructure (pages 20-21)

Timber Harvesting:
- Design Outcomes To Maintain Soil Productivity (page 10)
- Protecting Sensitive Areas (pages 20-21)
- Minimizing Rutting (page 28)

In addition:

Avoid biomass harvesting (over and above bolewood utilization) on organic soils deeper than 24 inches that are ombrotrophic.

- Ombrotrophic sites typically have more than 90% of the basal area in black spruce, with no alder or willow in the understory. These sites fit the Northern Spruce Bog (APn80) and Northern Poor Conifer Swamp (APn81) native plant communities, as described in *Field Guide to the Native Plant Communities of Minnesota: The Laurentian Mixed Forest Province*, Minnesota DNR, 2003. (See upper photo on page 23.)

Avoid biomass harvesting (over and above bolewood utilization) on aspen or hardwood cover types on shallow soils (8 inches or less) over bedrock. (See lower photo on page 23.)
Do not remove the forest floor, litter layer and/or root systems for utilization as biomass.

- Some silvicultural prescriptions may call for disturbance of the forest floor, but removal of this material or piling should be avoided.

Plan roads, landings and stockpiles to occupy no more than 1-3% of the site.

Avoid additional biomass harvest from erosion-prone sites (e.g., those sites on steep slopes of 35% or more) over and above the tops and limbs of trees normally removed in a roundwood harvest under existing timber harvesting guidelines.

Ensure that landings or on-site areas used to store biomass are in a condition that favors regeneration and growth of native vegetation and trees after use.
Install temporary erosion control devices, such as straw bales, mulch or woody debris, to help stabilize soils prior to establishment of vegetative cover (see Figure ROAD-13 in *Forest Road Construction and Maintenance*, page 32). Take care to avoid introduction of invasive species in bales or mulches.

Encourage native seed mixes and avoid invasive species seed sources when seeding roads and trails to stabilize exposed soils.

**Additional Considerations**

* For soils with 8-20 inches of soil over bedrock and droughty sands, consider that the recommended retention of one-third or more of fine woody debris (FWD) on the site benefits soil productivity as well as biodiversity. FWD should be distributed relatively evenly throughout the site rather than piled. (See also *Managing and Retaining Wildlife Habitat and Structural Diversity*, pages 27-29.)

* Consider that biomass products piled on landings for the majority of one growing season or longer will usually reduce natural regeneration.

**Re-entry into Previously Harvested Sites To Retrieve Biomass**

Residue from timber harvests and other forest management activities often remains piled on site after harvesting activities are completed. The preference is to remove biomass at the time of harvest. If re-entry is necessary, use caution to avoid reducing future forest regeneration and compromising infrastructure rehabilitation efforts.
Avoid re-entry into the general harvest area of a site with a second operation for the purpose of harvesting biomass once regeneration has begun or planting has been completed. (See photo above.)

If re-entry is needed once regeneration has begun or planting has been completed, restrict traffic to existing infrastructure.

Re-establish erosion control measures on roads and landings, including vegetative cover and water diversion devices, after re-entering a site for biomass harvest.

Avoid re-entry of sites across non-frozen wetlands.
**Additional Consideration**

*Retain slash piles that show evidence of use by wildlife.*

Piles left on site for an extended period may be inhabited by species such as Canada lynx, black bears and other wildlife known to den in slash piles. In addition, consider retaining slash piles that are difficult to access. (See photo below.)

This black bear den has been established in a large pile left from a debarking operation. *Photo courtesy of Minnesota DNR Forestry*
Managing and Retaining Wildlife Habitat and Structural Diversity

Review existing guidelines: Review and incorporate leave tree, snag and CWD guidelines in General Guidelines and Timber Harvesting:

General Guidelines:
- Retaining Leave Trees (live trees) (pages 75-78)
- Providing Coarse Woody Debris (pages 79-80)

Timber Harvesting:
- Snags (standing dead trees) (page 33)
- Leave Trees (live trees) (pages 33-40)

The intent of these biomass harvesting guidelines is to leave all pre-existing CWD and snags possible. For exceptions, see General Guidelines and Timber Harvesting guidelines:

General Guidelines:
- Retaining Leave Trees (live trees) (page 78)
- Providing Coarse Woody Debris (page 80)

Timber Harvesting:
- Snags (standing dead trees) (page 33)
- Leave Trees (live trees) (pages 38-39)

Of particular importance are the following General Guidelines:

Leave all snags possible standing in harvest areas.
- Snags cut for safety reasons should be left where they fall.

Retain and limit disturbance to all pre-existing CWD (except in skid trails or landings).
In addition:

- **Retain stumps** and uprooted stumps.

- In filter strips, avoid removal of pre-existing **CWD material** from the forest floor.

- **Avoid biomass harvest in leave tree clumps**, except tops and limbs of trees normally removed in a roundwood harvest under existing *Timber Harvesting* guidelines (see *Timber Harvesting*, pages 33-40).

- **Avoid biomass harvest from within RMZs**, except tops and limbs of trees normally removed in a roundwood harvest under existing *Timber Harvesting* guidelines.

- **Retain and scatter tops and limbs from 20% of trees harvested** in the general harvest area (one “average-sized” tree out of every five trees harvested).

- **Avoid removing FWD resulting from incidental breakage** of tops and limbs in the general harvest area.

- **If harvesting brush and small trees for biomass associated with a timber harvest**, leave 20% of this material on the site. This material may be run over or cut, but it should remain on the site. (See photo on page 29.)
Retaining Fine Woody Debris: The Overall Goal

The overall goal of FWD retention is to retain about one-third of the FWD on a site. This goal is achieved by intentionally retaining 20% of the FWD (tops and limbs from one “average-sized” tree out of every five trees harvested), with an additional 10-15% achieved by incidental breakage during skidding. (Usually, more breakage occurs in winter than in summer.) When implementing FWD retention guidelines, specific operations may vary depending on the type of equipment used. Two examples:

- **When using a cut-to-length system**, tops and branches from one “average-sized” tree out of every five should be processed and left on the site. Tops and limbs from the remaining four trees could be piled for utilization as biomass.

- **When using a full-tree skidding operation**, the tops and limbs from one “average-sized” tree out of every five processed at the landing should be hauled back and redistributed over the general harvest area.

Brush retained on a harvest site may be run over (as seen in the left half of the photo), or it may be left standing (as seen in the right half of the photo). *Photo courtesy of Minnesota DNR Forestry*
Biomass Harvest for Fuel Reduction

Use these guidelines when harvesting understory vegetation for purposes of wildfire fuel reduction. It may be necessary to modify biomass utilization in some cases, such as on sites with excessive fuel loading or urban interface situations.

✔ Retain understory vegetation in several reserve patches that total at least 20% of the harvest area.

- Reserve patches should represent soil moisture conditions within the harvest area. (See Figure BHF-3 on page 31.)

✔ Retain snags greater than 12 inches DBH and down logs where at least one end is greater than 12 inches in diameter and 6 feet in length. Place emphasis on retaining only larger snags and pre-existing CWD, because these larger fuels do not contribute as much to the initial speed and flame length of a wildfire.

✔ Modify management activities to maintain, promote or enhance ETS species (endangered, threatened or special concern) on the site.

POST-OPERATIONAL ACTIVITIES

➤ IMPORTANT! Review General Guidelines: Post Operational Activities and Followup Visits (pages 80-81)

In addition to the General Guidelines:

✔ Evaluate the harvest operation and plan future adaptations at post-harvest conferences with the logger and landowner.

✔ Plan for removal of equipment and cut material from wetland areas at the end of the winter season prior to thawing.

✔ Avoid removing soil from the general harvest area to rehabilitate roads, landings and skid trails. Use already disturbed soil, if needed, rather than disturbing additional soil.

✔ Rehabilitate landings and skid trails, when necessary, to mitigate soil compaction and reduce erosion.
Figure BHF-3

Photos courtesy of Minnesota DNR Forestry

When harvesting biomass for fuel reduction, retain understory vegetation in several patches of at least 20% of the harvest unit.
BIOMASS HARVEST AS A TOOL FOR SILVICULTURE MANAGEMENT

Harvesting of biomass may provide an excellent tool to help accomplish various silvicultural management objectives on many sites. On other sites, however, biomass harvesting may not fit within management strategies or facilitate silvicultural objectives. It may be necessary to modify utilization standards and harvesting techniques to fit site conditions and management objectives.

The following examples demonstrate how biomass harvest may or may not help accomplish management objectives (these are generalized examples intended to stimulate critical thinking; they are not intended to be specific guidelines):

Swamping: Removal of live woody vegetation may temporarily increase the wetness of some sites due to decreased transpiration, which may increase the chances of poor regeneration. When harvesting lowland hardwood stands, consider retaining understory vegetation and non-merchantable stems. Retention of transpiring vegetation reduces the potential for “swamping” of some sites.

Artificial regeneration: If planning for artificial regeneration of a site, consider biomass harvesting as a means of preparing or improving a site for planting. Removal of biomass from a site can reduce the need for some site preparation practices, such as brush raking or shearing.

Browse deterrent: Consider the use of heavy slash or strategically placed slash as a deterrent to browsing by large ungulates (deer and moose). For example, when working in oak stands with the goal of natural oak regeneration, consider leaving heavy oak tops and branches that form a “cage”-type structure when felled to the ground. This technique has been shown to reduce deer browse within the “cage” and increase survival of oak regeneration from seed. Heavy slash loads (even on clearcut sites) can be used as a deterrent to browsing.
Natural regeneration: If planning natural regeneration of conifers from seed (especially serotinous cones), consider modifying biomass harvest by retaining all or some cone-bearing slash to provide a seed source. Timing of harvest, site conditions and species being managed for will influence strategies. In some cases, prior removal of understory brush (such as hazel or balsam fir) may facilitate natural regeneration by removing competition and scarifying the seedbed.

Bark beetles: Biomass harvesting may promote management strategies for insect and disease control. For example, consider the utilization of slash and non-merchantable stems in red pine thinnings to prevent bark beetle buildups. In red pine harvests, biomass removals could benefit nearby and residual pines by preventing or mitigating bark beetle populations. Take care, however, to avoid damage to residual trees by biomass and harvesting machinery that would negate this benefit.

Removal of fresh slash and non-merchantable stems, along with logs from abandoned piles and log decks on harvested sites, will prevent bark beetle buildup during the following season. Complete all removals by June 1. If necessary, during the late spring or summer, directly control bark beetle populations by harvesting the infestation pockets, removing slash and non-merchantable stems on the site, and removing logs from abandoned piles and log decks.

Complete removals within three weeks of initial cutting. Do not permit biomass retrieval at this critical time of year if the activity is likely to cause wounding of red pine stems or root systems.

Thinning stands: Many plantations may benefit from pre-commercial thinning, before individual stems are large enough to provide traditional roundwood products. Consider biomass harvest as a means of marketing early thinnings in these plantations.

For example, some studies show that thinning white spruce plantations at age 25 yields the best growth response in the residual stand, but typically there is not enough pulp volume
at that age to make a commercial sale. Biomass harvesting may provide a commercial avenue to encourage thinning in these stands. Benefits of early thinning of stands include better growth and form of residual crop trees and improved in-stand structure for some wildlife species. Damage to residual stems and root systems should be avoided.

Utilization of biomass in this pine thinning will help prevent bark beetle buildup, as well as provide potential markets for previously non-merchantable stems. *Photo courtesy of Minnesota DNR Forestry*
ADDITIONAL RESOURCES

Minnesota state statutes, laws and rules

General:

www.leg.state.mn.us/leg/statutes.asp
www.revisor.leg.state.mn.us/

Biomass Power Mandate: Go to www.leg.state.mn.us/leg/statutes.asp and enter 216B.2424 under Retrieve a section.

Sustainable Forest Resources Act, Chapter 89A: Go to www.leg.state.mn.us/leg/statutes.asp and search for Chapter 89A in Table of Chapters.

Assessment of the Minnesota Timber Harvesting GEIS

Minnesota Timber Harvesting GEIS: An Assessment of the First 10 Years, August 2005, is available as Paper #182, along with other University of Minnesota staff papers, at http://fr.cfans.umn.edu/publications/staffpapers/

Remaining woody residue after typical timber harvest

Minnesota Logged Area Residue Analysis: This report summarizes the results of data collected on woody logging residue remaining on timber harvest sites across Minnesota. The report includes tables with estimates of average harvest acreage by county and forest type. The report is available at www.dnr.state.mn.us/forestry/um, under Information and Reports on Forest Resources and Wood Use.
Potential markets for woody biomass

*Potential markets,* including a directory of primary and secondary forest products in Minnesota: www.dnr.state.mn.us/forestry/um under *Wood Industry Directories.*

*The MarketPlace Bulletin:* www.dnr.state.mn.us/publications under *Division publications.*

Woody biomass resources and opportunities in the emerging energy industry

For additional information, refer to *Minnesota’s Woody Biomass Resources and Opportunities in the Emerging Energy Industry,* a paper written by Bill Berguson, University of Minnesota, Natural Resources Research Institute, Duluth, Minnesota.

Go to www.blandinfoundation.org. Click on *Public Policy & Engagement;* then click on *Vital Forests/Vital Communities;* then click on *Conferences & Events;* then click on *Seizing Opportunity: Forestry and the BioEconomy;* and then look for *Informing Report: Minnesota’s Woody Biomass Resources and Opportunities in the Emerging Energy Industry.*

Minnesota DNR Ecological Classification System

For additional information, including descriptions of Native Plant Communities (NPCs), visit www.dnr.state.mn.us/ecs
GLOSSARY

**Biological legacy:** Anything handed down or carried over from a predisturbance forest ecosystem, including green trees, patches of undisturbed vegetation, surviving propagules and organisms (e.g., buried seeds, seeds stored in serotinous cones, surviving roots, basal buds, mycorrhizal fungi and other soil microbes, invertebrates and mammals), dead wood, and certain aspects of soil chemistry and structure. (Source: Kohm, K. A., and J. F. Franklin, *Creating a Forestry for the 21st Century: The Science of Ecosystem Management.* Island Press, Washington, D.C.)

**Biomass:** The organic materials produced by plants, such as leaves, roots, seeds and stalks. In some cases, microbial and animal metabolic wastes are also considered biomass. The term *biomass* is intended to refer to materials that do not directly go into foods or consumer products but may have alternative industrial uses. Common sources of biomass are (1) agricultural wastes, such as corn stalks, straw, seed hulls, sugarcane leavings, bagasse, nutshellels, and manure from cattle, poultry and hogs; (2) wood materials, such as wood or bark, sawdust, timber slash and mill scrap; (3) municipal waste, such as waste paper and yard clippings; and (4) energy crops, such as poplars, willows, switchgrass, alfalfa, prairie bluestem, corn (starch) and soybean (oil). (Source: *McGraw-Hill Encyclopedia of Science and Technology*, 5th edition, The McGraw-Hill Companies, Inc.)

**Coarse woody debris (CWD):** Stumps and fallen trunks or limbs of more than 6-inch diameter at the large end.

**Fine woody debris (FWD):** Tops, limbs and woody debris of less than 6-inch diameter at the large end.

**Ombrotrophic:** A condition where minerals and nutrients are received solely from precipitation and dust fall, not from runoff or ground water; characteristic of bogs. (Source: Minnesota DNR *Field Guide to the Native Plant Communities of Minnesota: The Eastern Broadleaf Forest Province*, 2005)
Roundwood harvest: Roundwood harvest refers to a timber harvest where only the main stems of trees are removed from the site. For purposes of this definition, main stem refers to those parts of the tree that meet the utilization standards for pulpwood, posts, bolts or sawtimber, as described in the Minnesota Department of Natural Resources Division of Forestry Timber Sales Manual, 1998, as amended May 1, 2005, and the Minnesota Department of Natural Resources Timber Scaling Manual, 1981, as amended May 1, 2005 (see brief description directly below), except woody material that is intentionally cultivated, harvested and prepared for use, in whole or in part, as a fuel for the generation of electricity or (1) brush, trees and other biomass harvested from within designated utility, railroad and road rights-of-way; (2) upland and lowland brush harvested from lands incorporated into brushland habitat management activities of the Minnesota Department of Natural Resources; and/or (3) upland and lowland brush harvested from lands managed, as per state statute, in accordance with the Minnesota Forest Resources Council’s Woody Biomass Harvesting for Managing Brushlands and Open Lands in Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers.

Description of Utilization Standards from the Minnesota DNR Division of Forestry Timber Sales Manual:

F.3.1 Top Diameters:

Each species/product must be utilized down to a minimum merchantable top diameter outside bark (dob) as follows:

- 3 inches for cordwood material (all species)
- 6 inches for sawtimber (conifers, aspen, balm of Gilead, birch)
- 10 inches for sawtimber (other hardwoods)

Appraisers may apply more restrictive top-diameter standards based on local markets. For example, in areas with hardwood pallet markets, sales with the appropriate quality of wood could be marketed with the statement: “This permit contains hardwoods suitable for processing at sawmills down to a six (6) inch minimum top diameter outside bark.” In this case, the minimum top diameter for hardwood saw logs would be set to 6 inches on the permit appraisal.
Sustainably managed woody biomass: For purposes of biomass guideline development and in accordance with M.S. § 216B.2424 Subd. 1 (d), sustainably managed woody biomass is defined as: (1) brush, trees, and other biomass harvested from within designated utility, railroad, and road rights-of-way [Note: Guidelines will not be developed for this category of biomass]; (2) upland and lowland brush harvested from lands incorporated into brushland habitat management activities of the Minnesota Department of Natural Resources; (3) upland and lowland brush harvested from lands managed in accordance with the Minnesota Forest Resources Council’s *Woody Biomass Harvesting for Managing Brushlands and Open Lands*; (4) logging slash or waste wood that is created by harvest, by pre-commercial timber stand improvement to meet silvicultural objectives, or by fire, disease, or insect control treatments, and that is managed in compliance with the Minnesota Forest Resources Council’s *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers*, as modified by the requirement of this subdivision; and (5) trees or parts of trees that do not meet the utilization standards for pulpwood, posts, bolts, or sawtimber as described in Minnesota Department of Natural Resources Division of Forestry *Timber Sales Manual*, 1998, as amended as of May 1, 2005, and the Minnesota Department of Natural Resources *Timber Scaling Manual*, 1981, as amended as of May 1, 2005, except as provided by M.S. § 216B.2424–Biomass Power Mandate, Subdivision 1, in paragraph (a), clause (1)—“[biomass that] is intentionally cultivated, harvested, and prepared for use, in whole or in part, as a fuel for the generation of electricity”—and this paragraph, clauses (1) to (3).
LITERATURE CITED


Biomass Harvesting Guidelines
for Forestlands, Brushlands and Open Lands
December 2007

The Minnesota Forest Resources Council (MFRC) has completed development of its biomass harvesting guidelines for forestlands, brushlands and open lands.

These new guidelines are designed to be included in the MFRC’s 2005 forest management guidebook titled Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers. The new biomass guidelines are presented as two additional chapters for the 2005 guidebook:

- Biomass Harvesting on Forest Management Sites
- Woody Biomass Harvesting for Managing Brushlands and Open Lands

Please insert the two enclosed chapters, with tabs, at the back of your 2005 loose-leaf guidebook (directly after the Appendices section). Insert this cover sheet directly before the Table of Contents (to become the fourth sheet in the guidebook).

For the sake of efficiency, and to avoid having to reprint multiple sections of the existing 2005 guidebook, the two new chapters are not integrated into the rest of the guidebook. Instead of updating the existing Rationale, Resource Directory, Glossary and Appendices with biomass harvest information, the two biomass harvest chapters include their own Rationale, Additional Resources, Glossary and Appendices sections.

In addition, the full guidebook Table of Contents, located at the beginning of the guidebook, has not been revised to reflect the two new chapters. Full integration of the new biomass harvest guidelines with the General Guidelines and activity-specific guidelines is expected to occur at the time of the next revision of the entire 2005 guidebook.

(continued on back)
While these new biomass chapters have not been integrated into the rest of the 2005 guidebook, the existing guidelines have been fully integrated into the two new chapters. The biomass harvest chapters include extensive references to both the General Guidelines and the Timber Harvesting guidelines.

As is the case with the rest of the activity-specific forest management guidelines in the guidebook (such as Timber Harvesting and Forest Road Construction and Maintenance), it is essential that the biomass harvest guidelines be considered and implemented in close conjunction with the General Guidelines (the green tabbed section of the guidebook) and, in some instances, the Timber Harvesting guidelines (the light blue tabbed section).

For additional hard copies of these two biomass harvest chapters, as well as copies of the entire 2005 Guidelines, call or email the Minnesota Forest Resources Council (651-603-6761 or mcine017@umn.edu), or visit the MFRC website (www.frc.state.mn.us) to download copies.
Woody Biomass Harvesting for Managing Brushlands and Open Lands

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The Minnesota Forest Resources Council wishes to extend its thanks and appreciation to the Laurentian Energy Authority for providing financial support to develop these biomass harvest guidelines, and to the University of Minnesota Initiative for Renewable Energy and the Environment for providing financial support of a worldwide literature review that served as part of the basis for development of these biomass harvest guidelines.

Woody Biomass Harvesting for Managing Brushlands and Open Lands

December 2007
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REMEMBER:

Guidelines help with how to manage, not whether to manage.

These guidelines focus on how to protect the functions and values of brushland and open land resources during woody biomass harvesting management activities. They generally do not provide advice on whether to manage or which management activities are needed. These guidelines do, however, recommend avoiding or modifying biomass harvest of some sites of statewide ecological significance or ecological sensitivity.

Guidelines provide a menu, not a mandate.

Site-level resource management decisions are based on many different factors, including resource needs, landowner objectives, site capabilities, existing regulations, economics and the best information available at any given time. No one will apply all of the guidelines related to a particular activity. Instead, the landowner, resource manager or logger will consider many different factors in determining which combination of guidelines provides the best “fit” for a particular site at a particular time. The intent of these guidelines is to provide a menu of site-level management practices that provide for the harvesting of woody biomass while ensuring the sustainability of brushland and open land habitats in Minnesota.

General guidelines and activity-specific guidelines are closely related.

Frequent references from activity-specific guidelines back to the General Guidelines will make it easy for landowners, resource managers, loggers, biomass harvesters and others to consider all of the related guidelines—both general and specific—that apply to a particular management activity.

Guidelines are supplemented from time to time by “Additional Considerations.”

The guidelines are supplemented from time to time by “Additional Considerations,” which provide additional guidance to further promote sustainable brushland and open land resources.
INTRODUCTION AND RATIONALE

New Opportunities for Managing Minnesota Brushlands

Recent legislation and increased demand for woody biomass as a source of renewable fuel have provided new opportunities for managing Minnesota’s brushlands. Recent expansion of the definition of farm-grown closed-loop biomass, which public utilities seeking to fulfill the state’s biomass mandate must meet, includes the term sustainably managed woody biomass. This term, as defined in Minnesota Statutes Chapter 216B, Section 2424 (M.S. § 216B.2424), includes the following:

- Brush and trees removed from rights-of-way
- Upland and lowland brush harvested as part of brushland habitat management
- Logging slash or residue created by timber harvest, timber stand improvement, fuel management, or insect and disease control or treatments

These guidelines or best management practices (BMPs) for sustainably managing woody biomass have been developed to guide the use of woody biomass harvesting as a tool for “managing and maintaining brushland and open land habitat on public and private lands” (as designated in M.S. § 216B.2424, Subd. 1a, Paragraph h). These guidelines are not intended to apply to agricultural lands actively managed for woody biomass.

For purposes of these guidelines, the term “biomass harvesting” includes the process of cutting, collecting and removing woody biomass from brushland or open land management sites. This woody biomass might include tops and limbs from trees, snags and coarse woody debris (CWD). Primarily, however, it would include woody shrubs (e.g., willow and alder) harvested on lowland or upland brushland sites. Woody biomass may also include other brush species harvested on upland sites. (See photo on page 6.)
Brushland and Open Land Habitats

Brushlands and open land habitats are found throughout Minnesota. Brushlands and open lands are predominantly non-forested habitats dominated by shrubs (i.e., alder, willow), grasses, sedges and herbs.

Brushlands differ from open lands only by the percent cover of trees and shrubs. Open lands are open habitats with less than one-third total cover by trees and shrubs, while brushlands have higher tree and shrub cover. Both habitats are found in the following ecological systems as defined by the Minnesota Department of Natural Resources (DNR) *Field Guides to the Native Plant Communities of Minnesota*: acid peatlands, forested rich peatlands, open rich peatlands, upland prairies, rock outcrops, wet meadow/carrs and wetland prairies.

Some fire-dependent woodlands and wet forests may also be considered brushlands; these habitats are included in the chapter titled *Biomass Harvesting on Forest Management Sites*.
Often, brushlands and open lands are early successional or “young” habitats, which typically require periodic disturbances to maintain themselves. Historically, these habitats tend to be fire dependent. Other brushlands and open lands, however, including most lowland shrub habitats and nutrient-poor peatlands, are relatively stable or “slow-to-change” habitats. For these habitats, management disturbance intervals are much longer than for more fire-dependent communities. Changes in hydrology are more likely to affect succession in such peatlands.

**Wildlife and Brushland/Open Land Habitats**

Many wildlife species use these habitats, and many of these species are rare or declining, especially those dependent on open land habitats. A total of 154 species of vertebrate wildlife are considered dependent on open lands, and 18 species are considered dependent on brushland habitats in Minnesota. Sharp-tailed grouse, moose, woodcock, alder and willow fly-catchers, and golden-winged warblers are examples of species that are dependent upon brushland habitats. See *Appendix 1* for a complete list of brushland- and open land-dependent species.

The woodcock is an example of a species that is dependent on brushlands for habitat. *Photo by Richard Baetsen, U.S. Fish and Wildlife Service Digital Library System*
Open land-dependent species need sites hundreds to thousands of acres in size to sustain their populations. For brushland-dependent species, some require large areas of brushland, while others are equally at home in smaller brushland areas.

**Protecting Soil Resources**

*Appropriate woody biomass harvesting strategies should be employed* to ensure that harvesting does not reduce the primary productivity of brushlands or open lands through inappropriate removal of nutrients or disruptions of nutrient cycles. It is important to maintain an appropriate balance among nutrient capital, rates of nutrient replenishment and rates of nutrient removal associated with harvesting.

On most Minnesota brushland and open land soils, nutrient removal through harvest of biomass is not a concern, since brushland species have relatively high rates of mortality. Therefore, even sites with high nutrient capital do not attain the same levels of above-ground biomass as those of forests:

- Sites with highest biomass—and therefore the greatest rates of nutrient removal associated with harvesting—are also sites with highest levels of nutrient capital and highest rates of nutrient replenishment. As a result, data indicate that nutrients lost during harvest are usually replaced in less than 10 years.

- On less-productive sites, rates of nutrient replenishment are lower. At the same time, though, biomass—and, hence, nutrient removal—is also lower. As a result, nutrients lost during harvest are replaced in less than 10 years. In other words, a site’s inherent productivity influences the rate of nutrient removal and helps maintain the site’s appropriate nutrient balance.

Soils provide an environment suitable for a vast array of plants and animals, ranging from microscopic bacteria to small mammals. Careful guideline implementation that sustains the physical and chemical characteristics of the soil will, in large part, maintain the biological characteristics, as well.

Most biological activity in the soil takes place in the surface soil or litter layers. Organisms that thrive on a site depend on characteristics of the organisms, as well as such soil factors...
as moisture, temperature, aeration, and nutrient and energy supplies. The importance of retaining organic material at the soil surface (including the litter layer) and also retaining root systems cannot be stressed enough. Although these components are a potential source of biomass, they are also extremely important to a wide variety of ecosystem functions, such as nutrient supply, erosion control, water retention and rooting medium, as well as biological aspects of the soil.

The Process of Woody Biomass Harvesting

Woody biomass harvest provides the opportunity to manage brushland and open land habitats, as well as provide a source of renewable products, such as fuel. Generally, woody biomass harvest involves the mechanical removal of most of the woody brush and trees from a managed site.

In recent years, these brushland and open land communities have been managed by shearing, mowing or burning, and did not include the removal of this material from the site. “Shearing” with a bulldozer over frozen ground is often used to regenerate large stands of “stagnant” brushland. Brush and trees are sheared at ground level, after which new growth sprouts vigorously, providing optimum habitat for brushland species for several years. (See Figure BHB-1, page 10.)

Woody biomass harvest of brushlands may involve the following steps:

- Planning for harvest and regeneration
- Cutting woody vegetation (possibly bundling)
- Moving the product to a landing
- Processing the product (chipping or bundling and perhaps drying)
- Loading and transporting the product

These activities involve the operation of heavy equipment, creation of temporary roads for access to sites, and creation of landings. Harvest of brushlands may occur on upland sites; however, the majority of woody biomass harvesting will likely occur in lowland brush communities (wetlands).
Approaches to managing brushlands and open lands may include mowing, burning or shearing. Photos courtesy of Minnesota DNR Wildlife
A Menu of Site-Level Management Practices

Landowners and managers need to make decisions and set goals for site management. The intent of these guidelines is to provide a menu of site-level management practices that provide for the harvesting of woody biomass while ensuring the sustainability of brushland and open land habitats in Minnesota.

The Benefits of Guidelines

Benefits to cultural resources: Woody biomass harvesting guidelines can minimize the potential negative effects of harvesting activities, such as mixing of surface soils, rutting, compaction and erosion, which can damage certain kinds of cultural resources. Guidelines for construction of haul roads and landings, felling, skidding and slash management can help to protect cultural resources.

Benefits to soils: Woody biomass harvesting guidelines are designed to help protect the physical, chemical and biological properties of soils by minimizing the effects of soil compaction and rutting, erosion and nutrient removal that can result from woody biomass harvesting activities.

Benefits to riparian areas: Woody biomass harvesting guidelines are designed to maintain or restore vegetation within the riparian area that is characteristic of the desired condition of the site. Riparian vegetation is important for retaining nutrients, sediment and energy; stabilizing banks and shorelines; maintaining moderate water temperatures; and providing wildlife habitat.

Benefits to water quality, water quantity and wetlands: Woody biomass harvesting guidelines are designed to protect water quality and quantity for all water bodies by minimizing excessive soil disturbance and impacts in close proximity to streams, lakes and wetlands. Guidelines that address equipment operations and maintenance can help protect water bodies from excessive sediment and nutrient loadings by minimizing rutting.
and damage to wetland surface features, such as hummocks. Guidelines that address vegetation management planning can also help maintain normal water flows.

**Benefits to wildlife habitat:** Guidelines related to woody biomass harvesting suggest management activities that resemble relevant natural disturbance regimes and natural stand development processes. They are designed to maintain or improve structural components of the brushland or open land site for the benefit of wildlife.

**Benefits to restoration of native plant communities:** As a result of fire suppression, many brushland and savanna native plant communities have become overgrown with woody vegetation when compared with historical conditions. Woody biomass harvest, if conducted carefully, can be an important tool for restoring these native plant communities.

**Choosing Appropriate Guidelines for Woody Biomass Harvesting**

Specific site-level guidelines may vary depending on both the current condition and the desired future condition of a biomass harvesting site. The user should define the desired future condition as brushland, open land or forest, using the decision key in Figure BHB-2 (see page 14). Keep in mind the following definitions:

- **Forests** are communities of plants, animals and microorganisms, and the physical environment they inhabit, in which trees are the dominant life form.

- **Brushlands and open lands** are predominantly non-forested plant communities dominated by shrubs, grasses or sedges, and herbs. Brushlands and open lands differ from each other only by the percent cover of trees and shrubs:
  - Open lands are plant communities with less than one-third (1/3) total cover by trees and shrubs.
  - Brushlands have higher tree and shrub cover.
Both brushlands and open lands may be found in the following ecological systems: peatlands, upland prairies, rock outcrops, wet meadow/carrs and wetland prairies. These systems are defined in the Minnesota DNR Field Guides to the Native Plant Communities of Minnesota. (For visual examples of these various ecological systems, refer to photos on pages 40-42.)

The decision key in Figure BHB-2 (page 14) is designed to direct the user to the appropriate set of biomass harvest guidelines for these plant communities:

- **Forest biomass harvest:** Follow guidelines in the chapter titled Biomass Harvesting on Forest Management Sites.

- **Brushland woody biomass harvest:** Follow guidelines found in this chapter; however, where specific differences are indicated between brushland habitats and open land habitats, follow recommendations made for structural habitat for brushland habitats (see Table BHB-1, page 38-39).

- **Open land woody biomass harvest:** Follow guidelines found in this chapter; however, where specific differences are indicated between brushland habitats and open land habitats, follow recommendations made for structural habitat for open land habitats (see Table BHB-1, page 38-39).
Open landscape is defined as a portion of land supporting an open to semi-open complex of vegetation consisting of less than two-thirds total cover by trees. (Source: An Assessment of Open Landscapes for Management of Brushland Wildlife Habitat in Northern and Central Minnesota, Minnesota DNR.)

If the landowner objective is to maintain brushland or open land on the site, apply biomass harvesting guidelines for brushlands. If the objective is to reforest the site, apply biomass harvesting guidelines for forests.
Have you identified your objectives?
See Identifying Goals and Objectives in General Guidelines (pages 7-9).

Have you conducted a site inventory?
See Conducting a Site Inventory in General Guidelines (pages 10-17).

PLANNING, DESIGN AND OPERATIONAL ACTIVITIES

Using General Guidelines for biomass harvesting activities

Not all General Guidelines will fit biomass harvesting in brushlands and open lands. For example, retention of leave trees and CWD may not be appropriate for brushland and open land sites. In addition, riparian management zone (RMZ) guidelines in this chapter differ from those in the General Guidelines.

In addition, for many of the General Guidelines, you will need to substitute the existing words “forest management” with the words “brushland and open land management.” With those substitutions, the majority of existing General Guidelines apply to brushland and open land biomass harvesting.
IMPORTANT! For all activities, review and implement General Guidelines, including:

- Incorporating Sustainability into Forest Management Plans (pages 17-24)
- Maintaining Filter Strips (pages 24-28)
- Protecting Cultural Resources (pages 68-69)
- Managing Equipment, Fuel and Lubricants (page 70)
- Protecting the Normal Flow of Streams and Wetlands (pages 71-72)
- Protecting Non-Open Water Wetlands and Seasonal Ponds (page 73)
- Managing Dry Washes in Southeastern Minnesota (pages 74-75)

In addition:

For activities involving constructing and maintaining haul roads, refer to Forest Road Construction and Maintenance guidelines.

These guidelines combine planning and design activities with operational activities. This combined approach recognizes a commitment to resource sustainability related to both planning/design and operational considerations:

- **Planning guidelines** recognize that many considerations related to resource protection and sustainability are common to most management activities, and that the commitment to sustainability begins in the early planning stages—long before the actual management activity begins.

- **Operational guidelines** recognize that on-site activities carry out the commitment to sustainability that was begun during the planning phase.
Designing Operations To Fit a Sustainable Management Plan

Management activities should follow a well-thought-out plan that defines such factors as resource protection, the extent and duration of the activity, the most appropriate season and method of operation for the activity, appropriate biomass harvesting management guidelines to limit site disturbance, and other management objectives related to brushland or open land resource sustainability.

The timing of management activities can be constrained by pre-existing or seasonal conditions, regulations and limitations, such as seasonal road load limits, seasonal access limitations, fire hazard conditions, and appropriate times for such activities as road construction.

**Review existing guidelines**, including:

- General Guidelines:
  - Identifying Goals and Objectives (pages 7-9)
  - Conducting a Site Inventory (pages 10-17)
  - Incorporating Sustainability into Forest Management Plans (pages 17-24)

**In addition:**

☑ **Determine whether the site is appropriate** for biomass harvest.

☑ **Prepare an inventory of important resources** (i.e., trees, shrubs, soil, water, recreation, wildlife, fish).

☑ **Consider and incorporate brushland and open land management goals**, harvesting efficiencies and site impacts.

☑ **Address the practical application of stated goals and objectives** for the site.

☑ **Determine the regeneration goals** and desired vegetative composition for the site.
Determine whether the site includes areas with known occurrence of endangered or threatened species, rare native plant communities or imperiled native plant communities listed in Appendix J and/or Appendix 2 addendum on pages 54-55.

- To determine whether any of these species or native plant communities are known to occur on a site, consult with local DNR offices and/or the Minnesota County Biological Survey (MCBS) Native Plant Communities GIS (geographic information system) layers, which may be downloaded from the DNR Data Deli at http://deli.dnr.state.mn.us (GIS software and skills are necessary).

Document the location of sensitive native plant communities.

Document reserve areas within the general harvest area and adjacent to RMZs.

Employ operators trained in guideline implementation to aid in proper and efficient application of site-level woody biomass harvesting guidelines.

Use natural features and avoid artificial patterns where possible. These natural features may correspond to changes in topography, soils, wetland interfaces, and brushland and open land communities.

Document the filter strip and/or RMZ width and the management objective.

- The RMZ management objective (e.g., brushland or open land habitat) may be the same as or different from the objective for the general harvest area.

- Indicate the preferred residual species, as well as the distribution of those residuals within the RMZ (e.g., clumped, scattered).
✓ **Conduct on-site meetings** with the operator, landowner and resource manager prior to moving equipment onto a site. Such meetings can help assure common understanding of landowner objectives, woody biomass harvest specifications and site conditions.

**Cultural Resource Protection**

- **Review existing guidelines**, including:

  General Guidelines:
  • Protecting Cultural Resources (pages 68-69)

- **In addition:**

  ✓ **Exclude cultural resource areas** from brushland or open land harvest unless protected under frozen conditions.

  ✓ **Keep roads, haul trails and landings away from cultural resource areas.**

  ✓ **If harvest will take place on or near a cultural resource**, consider applying guidelines in *Timber Harvesting: Protecting Sensitive Areas* (pages 20-21).
Sensitive Area and Species Protection

**Review existing guidelines,** including:

General Guidelines:
- Gathering Information (pages 10-11)
- Rare or Sensitive Species (pages 23-24)

**In addition:**

✔ **Avoid or modify management in native plant communities** that are listed in Appendix J, along with Appendix 2 of this chapter.

- To determine whether these native plant communities are known to occur on the site, consult with the local DNR offices and/or the Minnesota County Biological Survey (MCBS) Native Plant Communities GIS (geographic information system) layers, which may be downloaded from the DNR Data Deli at http://deli.dnr.state.mn.us (GIS software and skills are necessary).

- **Biomass harvesting may still be appropriate** under the following conditions:
  
  * If management plans specifically include strategies to maintain habitat for rare species and/or to restore degraded native plant communities.

  * If biomass harvesting is used as a tool to restore degraded native plant communities (e.g., overgrown savanna plant communities). Consult appropriate DNR Ecological Resources regional plant ecologist.

  * If biomass harvesting is used as a management tool to assist with ecological management of the native plant community (e.g., creating a fire break as part of burning a fire-dependent native plant community). Consult appropriate DNR wildlife manager and DNR regional plant ecologist.
Avoid biomass harvest within specific sites where plant or animal species listed as endangered or threatened at the state or federal level are known to exist (e.g., sites identified in the DNR Natural Heritage Information System), or where such species are discovered during operations and where biomass harvest would harm them (unless harvest has been demonstrated to maintain or improve habitat for these species).

- To determine whether these species are known to occur on the site, consult local DNR offices.

- If a bald eagle nest occurs on or near the site, see Recommendations for Avoiding and Minimizing Impacts at http://files.dnr.state.mn.us/natural_resources/animals/birds/eagles/factsheet.pdf

Reference M.S. § 216B.2424 for Biomass Power Mandate and urge affected utilities to follow the statute as reference.

- M.S. § 216B.2424 Subd. 1a and f, directs that, for utilities specified within this statute, no woody biomass may be harvested from any lands identified by the final or preliminary Minnesota County Biological Survey as having statewide significance as native plant communities, large populations or concentrations of rare species, or critical animal habitat. See Additional Resources (page 46) to access complete statute online.

Avoid or modify management activities on sensitive locations (either identified during the planning process or discovered during the actual woody biomass harvest) to maintain, promote or enhance sensitive features.

- Sensitive areas may include known locations of endangered or threatened species, imperiled communities, special soil conditions, lagg areas, topographic features, cultural resources, rare features and other areas that make them more sensitive to disturbance than others. (See photo on page 22.)
Employ harvesting techniques that minimize the need to operate equipment on steep slopes. When harvesting steep slopes is unavoidable, employ appropriate harvesting techniques and equipment.

Prevent tearing of the root mat when crossing lagg areas (see Figure BHB-3 on page 23) by applying such techniques as the use of low ground pressure equipment; not turning equipment while traversing the lagg; and the use of corduroy, slash mats or tire mats when crossing the lagg. Refer to local, state and federal wetland regulations when placing materials in wetlands.
Representation of Lagg Area

- upland forest
- lowland conifer, raised bog
- sedges, alder and willow brush and small areas of open water

lagg area

water table
Maintaining Visual Quality and Reducing Conflicts with Recreational Users

By their very nature, brushland and open land habitats provide broad, open vistas. The concepts of small openings and reduced harvest size are often not applicable with open lands management. At the same time, though, a well-managed site (even a large one) can be managed to improve visual quality. With this understanding in mind, follow the General Guidelines relating to noise and visual quality (page 19).

In all areas:

- Encourage full utilization of all species harvested in the management area.

- Remove biomass products from visible landings as soon as possible (practical).

In areas classified as most or moderately sensitive:

- Avoid landings, when possible, within view of travel routes or recreation areas.

- Keep number of landings to a minimum.

- Treat any products and waste material at landings as soon as possible.

- Seed, plant and regenerate landings promptly.

- Remove all trash from landings upon completion of harvesting.
In areas classified as less sensitive:

✔ Avoid landings within a travel route right-of-way.

✔ Consider locating landings outside of maintained road rights-of-way whenever possible.

✔ Remove all trash from landings upon completion of harvesting.

See Part 2 (yellow section), *Visual Quality: Visual Sensitivity Classifications* (pages 6-9) for information related to how classifications are determined and which Minnesota counties have developed visual sensitivity classification maps.

### Soil Resource Protection

- **Susceptibility to compaction and rutting** on wetlands is dependent on several factors, including frequency of equipment trafficking, type of equipment used, soil type (mineral or organic), soil water content at the time the activity is conducted, and season of activity.

  In general, for mineral soil wetlands, compaction and rutting increase as soil texture becomes finer and soil water content increases. In unfrozen peatland, deep rutting can bring muck to the surface and block normal water flow.

- **Winter alone does not ensure frozen ground.** Often brushlands and open lands are located on hydric soils, causing difficulty in freezing down areas of impact beyond haul roads. With sites susceptible to rutting and compaction, specify frozen conditions rather than setting an arbitrary date or season.

- **Removal of vegetation may increase the wetness of the site** due to reduced transpiration, affecting the vigor, composition, structure and regeneration of the residual vegetation.
Soil impacts can be minimized by limiting the soil area impacted by infrastructure (roads, landings), and by careful consideration of timing, equipment being used and harvesting methods.

Review existing guidelines, including:

General Guidelines:
- Timing and Coordination of Activities (pages 17-18)
- Designing Operations To Fit Site Conditions (page 20)
- Managing and Minimizing Infrastructure (pages 20-21)

In addition:

Retain the soil’s hydrologic condition. Alterations to drainage patterns (especially enhanced flooding) can change the availability of pore space and oxygen levels, which impact soil flora and fauna.

Consider soil or site conditions that may dictate specific timing, harvest methods or equipment to be used, or that may lead to weather-related or seasonal closure of the operation to protect water and cultural resources.

Conduct management operations during preferred operating seasons. The use of low ground pressure equipment, as well as such operating techniques as using slash mats, can extend operating seasons on low-strength soils. (See photo page 27.)

Minimize rutting in primary haul trails, roads and landings.
Avoid rutting in the general harvest area.

- If repeated rutting occurs in the general harvest area (outside of primary haul trails), use alternative operating techniques, such as the following:
  
  * Shifting harvest operations to a stable portion of the harvest area.
  * Using low ground pressure equipment.
  * Using slash on haul trails as a driving surface.
  * Reducing loads carried by harvesting equipment.
  * Packing the snow or ground cover with low ground pressure equipment to enhance freezing and permit off-trail operation of equipment.

If alternative operating techniques fail to eliminate rutting, stop harvesting operations.

Winter harvesting is one example of timing management activities to protect soil and cultural resources. *Photo courtesy of Minnesota DNR Wildlife*
Avoid harvesting in or on sites that are extremely wet, such as water tracks or lagg areas. These sites exhibit conditions that make it unlikely to produce enough frozen material to support heavy equipment. These sites could include the native plant community OPn91–Northern rich fen–water track.

Woody biomass harvesting should be conducted to sustain the productivity of the soil and ensure the survival and long-term growth of desired vegetation on the site. To accomplish this, the following guidelines are recommended:

- **Use a site’s inherent productivity** (as indicated by rate of vegetative regrowth) and management strategy to indicate frequency of biomass harvest. Rapid regrowth allows for more frequent harvest; slow regrowth suggests longer intervals between harvests.

- **Lay out haul trails to minimize site disturbance** while achieving necessary operating efficiency.

- ** Occupy no more than 1-3% of the woody biomass harvest area** by roads and landings (small or irregularly shaped units may result in higher percentages).

- **Stabilize bare soil areas and haul trails** that are susceptible to erosion.

When shearing or harvesting brush:

- **Conduct shearing activities under frozen** soil conditions.

- **Sever stems cleanly** at or just above ground level.

- **Avoid uprooting vegetation**, including brush.

- **Avoid scraping soil material or hummocks into windrows or piles.** Shearing off hummocks reduces the roughness of a wetland’s surface, increasing runoff flows and channeling water. (See Figure BHB-4, page 29.)
Shearing Hummocks

Avoid scraping soil material or hummocks into windrows or piles. Shearing off hummocks reduces the roughness of a wetland’s surface, increases runoff flows, and channels water. Photos courtesy of Minnesota DNR Forestry Brushland Biomass Harvesting.
Water Resource Protection

- **Wetlands are highly productive sites**, which are essential for maintaining and enhancing water quality. All biomass management operations in or adjacent to wetlands should be planned and conducted in a manner that protects water quality.

- **Using appropriate biomass management guidelines for harvesting activities** will minimize the potential for sediment, chemical, nutrient and debris movement into streams, ditches, lakes, wetlands, seasonal ponds and ground water, as well as minimizing thermal (heating) impacts on surface waters.

- **Operations in wetlands are regulated.** The Minnesota Wetland Conservation Act requires that anyone proposing to drain, fill or excavate a wetland contact the local government unit (cities, counties, watershed management organizations, soil and water conservation districts or townships) for the necessary permits.

  ✔ **Contact the appropriate local governmental unit for advice** on federal, state and/or local wetland regulations.

  ✔ **Plan biomass harvesting activities to avoid building landings**, haul trails and roads in wetlands. Where avoidance is not practical, minimize impacts by limiting the extent of these activities in wetlands.

  ✔ **Include provisions for water quality protection** in the biomass sale contract.

  ✔ **Minimize the crossing of intermittent or perennial streams and open water wetlands.** On both upland and lowland sites, install bridges, culverts, snow or ice bridges, fords or other structures, if necessary, to prevent repeated soil and ditch or streambank disturbance where no practical alternative exists to crossing a ditch or stream.

**IMPORTANT:** Such activity may require a permit from the Minnesota DNR. See **Appendix H: Work Activities That Do Not Require a DNR Public Waters Permit on Public Waters, Public Water Wetlands and Public Watercourses.**
Minimize long, straight haul roads that channel water.

- If long stretches cannot be avoided by careful design and location, provide adequate drainage to avoid concentration of surface water flow.

- Divert water by proper shaping of the road surface and by using broad-based dips, lead-off ditches or water bars. See *Forest Road Construction and Maintenance: Drainage* (pages 25-27) and *Cross-Road Drainage* (pages 28-31).

Incorporate water diversion and erosion control practices where needed during woody biomass harvest activity (including water bars, tops and branches, ditch blocks and lead-offs).

- Divert surface flow before it enters landings or a water body.

- Incorporate water diversion devices and erosion control practices during construction rather than as a remedial activity. See *Forest Road Construction and Maintenance: Drainage* (pages 25-27) and *Cross-Road Drainage* (pages 28-31).

Avoid scraping soil material or hummocks into windrows or piles. Shearing off hummocks, tussocks or other surface roughness of wetlands increases runoff flows and channelizes water.

Filter Strips

Managing a filter strip between the water body and the disturbance on site can protect surface water quality and maintain streambank stability. Biomass harvesting activities, prescribed burning and road construction may increase the potential for sedimentation due to soil exposure. Management activities may be conducted in filter strips as long as the integrity of the filter strip is maintained. These activities should produce minimal exposure of mineral soil.

Filter strips are areas adjacent to perennial and intermittent streams, ditches, lakes, open water wetlands, non-open water wetlands, seasonal ponds, seeps and springs. They provide a zone of undisturbed soil to help slow runoff, provide greater infiltration, prevent erosion and trap sediment, debris, nutrients and pesticides from adjacent land areas.
Review existing guidelines, including:

General Guidelines:
• Maintaining Filter Strips (pages 24-28)

In addition:

✔ Apply filter strip guidelines to all perennial and intermittent streams, ditches, lakes, open water wetlands, non-open water wetlands, seasonal ponds, seeps and springs. Filter strips should border and parallel the edge of all water bodies. Apply them independently of the width of the RMZ. (See Figure BHB-5 on page 33.)

✔ Avoid operation of heavy equipment directly adjacent to streambanks or shorelines of water bodies. Utilize hand felling and/or equipment with the ability to reach into this zone (such as boom cutting heads) as a means of managing vegetation.

✔ Consider additional stabilization measures, when necessary (such as the use of slash, mulch and silt fences), including instances when:

  • An area of soil is exposed within the filter strip and sedimentation is likely to result.

  • Management objectives preclude the use of a filter strip and sedimentation is likely to occur.
Filter strip and RMZ width for water bodies with 10% and 20% slopes: Note that the width of the filter strip increases with increased slope (see Table GG-1 on page 25 of *General Guidelines*), while RMZ width remains the same.
Riparian Management Zones

Primarily, riparian management zones (RMZs) help protect riparian functions, such as habitat, water quality, thermal protection for aquatic habitats, and streambank stability. Landowners, resource managers and operators should consider habitat needs of plant and animal species to be managed, as well as the protection and maintenance of supporting riparian functions, such as water temperature, sedimentation and recreation.

When operations occur for woody biomass harvest of brushlands or open lands, water quality and streambank stability functions are protected through the design and use of both filter strips and RMZs. Habitat functions, on the other hand, are protected with the design and inclusion of appropriate reserve areas.

The goal of brushland or open land RMZ guidelines is to provide for functions related to thermal protection and flow detention/retention:

☐ Thermal protection is necessary for cold-water fisheries and other species that require cold waters.

☐ Flow detention/retention is necessary to retain channel stability in the interim between harvest and regrowth.

Loss of plant matter due to harvest operations changes the hydrologic regime by increasing bankfull and flood storage patterns. These alterations may influence the pattern and stability of watercourses by changing meander patterns, increasing bank cuts and inducing higher amounts of sediment deposition.

The following RMZ guidelines apply to sites that occur in large brushland or open land landscapes. For management of RMZs occurring in relatively narrow corridors of lowland or upland brush adjacent to streams and lakes within a forested landscape, refer to the chapter titled Biomass Harvesting on Forest Management Sites. (See photos page 35.)
Brush within an RMZ in a forested landscape: In a brushy riparian zone within a forested setting, use forest biomass harvesting guidelines to determine RMZs. *Photo courtesy of Minnesota DNR Fisheries*

RMZ in a brushland landscape: In a brushland or open land riparian zone, use brushland and open land biomass harvesting guidelines to determine riparian management zones. *Photo courtesy of Minnesota DNR Forestry*
Provide for an RMZ width of 50 feet from the water’s edge for all designated trout waters and Public Water Inventory watercourses, as determined by the DNR or discovered during on-site inspection:

- Contact the local DNR hydrologist or area fisheries supervisor, or check the website at www.dnr.state.mn.us/waters/watermgmt_section/pwi
- RMZ width is measured as slope distance (the linear distance along the ground), not horizontal distance from the streamcourse edge at bankfull width.

Manage vegetation composition within the RMZ (50 feet from the water’s edge) appropriate to native plant community structure (as defined in Table BHB-1, pages 38-39) to protect water temperatures and hydrological functions during regrowth of vegetation:

- Brushland or open land management activities may be conducted within the RMZ while reserving the canopy or shrub cover appropriate for the ecological system as recommended in Table BHB-1.
- Normal operations apply beyond the 50-foot RMZ boundary.
- Removal of trees is acceptable under the condition that RMZ functions are maintained.

Clearly identify the RMZ so that operators can identify its location as they work with large equipment. Options to consider include flagging, paint lines or delineation on a map.

Avoid operation of heavy equipment within the RMZ of streams or shorelines of water bodies. Utilize hand felling or equipment with the ability to reach into this zone (such as boom cutting heads) as a means of managing vegetation.

Distribute residual vegetation within the RMZ relatively evenly, but allow for gap and clump patterns. Avoid creating large cleared areas within the RMZ.
For beaver ponds, determine the width of the RMZ calculated from the edge of the stream channel projected through the beaver pond, rather than from the edge of the flooding caused by the presence of beavers. Determine filter strip width from the edge of the pond.

Reserve Areas

Reserve areas are intended to provide for protection of habitat functions within the brushland and open land site.

Retain 5-10% of the area in reserve areas. Habitats in reserve patches can be dominated by grasses, sedges or brush, but they should be consistent with the composition of the desired ecological system. A minimum patch area of one acre (0.4 hectares) is recommended.

Determine the recommended composition of reserve areas using Table BHB-1 (pages 38-39).

Create a variety of reserve areas within harvest sites:

- Composition of reserve areas should vary depending on the ecological system in which the harvest site occurs.

- Reserve areas of trees and snags may not be appropriate for many brushland and open land ecological systems.

Mimic natural disturbance by leaving some reserve areas within harvest sites.

Table BHB-1 describes desired structural habitat conditions for various habitat classes associated with brushlands or open lands.
### Structural Habitat Components of Reserve Areas and RMZs in Woody Biomass Harvest Sites

<table>
<thead>
<tr>
<th>Habitat Class</th>
<th>Ecological System¹</th>
<th>Open Land Habitat</th>
<th>Brushland Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowland shrub</td>
<td>See definitions on pages 40-42.</td>
<td>Primarily herbaceous. No live trees, shrubs and snags &gt; 2 meters or 6.6 feet tall.</td>
<td>Herbaceous with widely scattered stunted trees and snags (&lt; 10 meters or 33 feet) and sparse tall shrubs.</td>
</tr>
<tr>
<td><strong>Open peatland²</strong></td>
<td></td>
<td>Tall shrub-dominated (&gt; 50% cover). No live trees and snags &gt; 2 meters or 6.6 feet tall.</td>
<td>Apply woody biomass guidelines for forests.</td>
</tr>
<tr>
<td>Forested rich peatland</td>
<td></td>
<td>Variable tall shrub cover. Tall trees (&gt; 10 meters or 33 feet) occasionally present. Leave all snags and down CWD.</td>
<td></td>
</tr>
<tr>
<td>Wet meadow/carr</td>
<td>Primarily herbaceous with sparse (&lt; 25% cover) tall shrubs. No live trees, tree regeneration and snags.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ See definitions on pages 40-42.

² Applies primarily to Northern Alder Swamp.
<table>
<thead>
<tr>
<th><strong>Upland shrub</strong></th>
<th>Primarily herbaceous with sparse low shrubs. No trees, snags, tall shrubs and CWD.</th>
<th>Primarily herbaceous with sparse low shrubs. No trees, snags, tall shrubs and CWD.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upland prairie</strong>³</td>
<td>Primarily herbaceous with variable shrub density. No live trees and snags.</td>
<td>Primarily herbaceous with variable shrub density with widely scattered tall trees and snags. Retain all down CWD.</td>
</tr>
<tr>
<td><strong>Rock outcrop</strong>⁴</td>
<td>Primarily herbaceous. No live trees, shrubs and snags &gt; 2 meters or 6.6 feet tall.</td>
<td>Apply woody biomass guidelines for forests.</td>
</tr>
<tr>
<td><strong>Fire-dependent forest/woodland (cut-over)</strong></td>
<td>Primarily herbaceous. Sparse tall shrubs acceptable. No live trees and snags.</td>
<td>Dependent upon management objectives.</td>
</tr>
<tr>
<td><strong>Old fields</strong>⁵</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>


2. Includes both open rich and acid peatlands

3. When managing for brush prairies and savanna communities, taller shrubs (1.5-2 meters or 4.9-6.6 feet) are appropriate. Additionally, for savannas, scattered trees (typically less than 10 meters or 33 feet tall) are appropriate.

4. This system contains rare native plant communities that are sensitive to woody biomass harvesting. Consult DNR Division of Ecological Resources prior to operating in rock outcrop communities.

5. Old fields, or surrogate grasslands, are those developed as a result of human activities since European settlement; they are typically dominated by non-native, cool-season grasses.

Refer to pages 40-42 for definitions and visual examples of ecological systems.
Open peatland (including open rich peatlands and some acid peatlands): Open rich peatlands are areas of grass and/or sedge or low shrub-dominated wetlands influenced by ground-water flow zones. They often have higher concentrations of minerals and higher species diversity compared to acid peatlands. Acid peatlands are grass and/or sedge or low shrub-dominated wetlands primarily influenced by precipitation. They are extremely low in nutrients and are acidic and separated from ground water. Photos courtesy of Minnesota DNR Ecological Resources

Forested rich peatland: Conifer-dominated or tall shrub-dominated wetlands on deep peat. The water table is normally immediately below peat surface. Photos courtesy of Minnesota DNR Ecological Resources
Wet meadow/carr: Grass and/or sedge and shrub-dominated wetland communities subjected annually to moderate inundation following spring thaw and heavy rains. Willows and dogwoods dominate drier sites. Photos courtesy of Minnesota DNR Ecological Resources (left) and Minnesota DNR Forestry (right).

Wetland prairie: Prairie habitat dominated by native grasses with species-rich component of forbs (herbaceous plants other than grasses or sedges). Big bluestem and prairie cord grass are the major species on wetter sites, which also support a variety of sedge species. Wetland prairies also support dwarf shrubs (e.g., prairie rose) and true shrubs (e.g., red-osier dogwood). Photos courtesy of Minnesota DNR Ecological Resources.

Upland prairie: Prairie areas dominated by native grasses with species-rich component of forbs (herbaceous plants other than grasses or sedges). On upland sites, woody species are limited to dwarf shrubs, such as leadplant and prairie rose. Without fire, trees and shrubs invade prairie areas throughout the state. For purposes of this table, savannas and brush prairies are also included in this system. Photos courtesy of Minnesota DNR Ecological Resources.
**Rock outcrop:** Open or shrub-dominated communities on shallow or exposed bedrock, generally less than 25 acres in size. Shrub communities have a greater accumulation of soil. *Photos courtesy of Minnesota DNR Ecological Resources*

**Fire-dependent forest/woodland:** An ecological system where forest and woodland communities are strongly influenced by wildfires. Fires are a major source of species mortality and strongly influence patterns of plant reproduction and survival. Periodic fires remove much of the litter, duff and other organic material from communities in the system and can have significant effects on nutrient cycling and nutrient availability. Plants and animals characteristic of this system are well adapted to the effects of periodic fires, including removal of organic material. *Photo courtesy of Minnesota DNR Ecological Resources*

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**Additional Consideration**

- Consider retaining oak trees and other hard mast-producing trees and shrubs or perpetuating existing stands as required by the management plan.
Snags

In most situations, snags are not a desirable part of the brushland or open land habitat; they may reduce the quality of the habitat. In some instances, however, such as in forested rich peatlands, snags may enhance the quality of wildlife habitats, providing nesting, denning, feeding and roosting sites.

✔ Refer to Table BHB-1 to determine desired outcomes of snag management (pages 38-39).

Managing the Harvest Site and Infrastructure

✔ Locate windrows and biomass piles so as to:
  • Avoid cultural resources.
  • Minimize interference with natural drainage patterns.
  • Be outside of filter strips, RMZs and leave patches.
  • Follow contours when possible to mitigate the effects of overland flow.

✔ Locate and design haul trails so as to:
  • Minimize damage to cultural resources or leave patches.
  • Minimize rutting.
  • Maintain surface and subsurface water flows in wetlands.
  • Reduce erosion and sedimentation to protect water quality.
  • Minimize site disturbance and the number of haul trails, while also achieving necessary operating efficiency.

✔ Avoid locating haul trails in filter strips and RMZs.
Anticipate traffic needs to avoid unnecessary maintenance or relocation of trails. Techniques include:

- Packing of snow or ground cover to ensure freezing
- Placing of slash mats in high-traffic areas
- Use of appropriate wetland road construction methods to stabilize the trail surface

Maintain haul trails to avoid the need for additional haul trails.

Curtail operations until soils dry out or freeze solid if haul trails do not hold up (resulting in excessive rutting or requiring the need to create new haul trails).

Landings and Stockpile Areas

Specify the number and location of landings as part of the harvesting agreement.

Size landings to the minimum required for the acres to be harvested, the equipment likely to be used and the products to be cut.

Plan roads and landings to occupy no more than 1-3% of the woody biomass harvest area.

Locate landings to be:

- On upland areas whenever practical
- On stable ground
- Outside of filter strips or the RMZs
- Away from areas where a cultural resource is present
Avoid landings in locations that will concentrate runoff from surrounding areas onto the landing. Use an appropriate combination of ditches, waterbars and outsloping to keep the landing area dry.

Avoid locating landings and yarding areas on open water wetlands.

Locate landings for best economy and reuse on subsequent harvests.

POST-OPERATIONAL ACTIVITIES

➤ IMPORTANT! Review General Guidelines:
Post Operational Activities and Followup Visits (pages 80-81)

In addition to the General Guidelines:

Evaluate the harvest operation and plan future alterations during post-harvest conferences with the operator and landowner.

Avoid removing soil from the general harvest area to rehabilitate roads, landings and haul roads. Use already disturbed soil, if needed, rather than disturbing additional soil.

Rehabilitate landings and haul roads, when necessary, to mitigate soil compaction and reduce erosion.

Use seed with native vegetation and fertilize as appropriate when rehabilitating landings and haul roads.
ADDITIONAL RESOURCES

Minnesota state statutes, laws and rules

General:
www.leg.state.mn.us/leg/statutes.asp
www.revisor.leg.state.mn.us/

Biomass Power Mandate: Go to www.leg.state.mn.us/leg/statutes.asp and enter 216B.2424 under Retrieve a section.

Sustainable Forest Resources Act, Chapter 89A: Go to www.leg.state.mn.us/leg/statutes.asp and search for Chapter 89A in Table of Chapters.

Potential markets for woody biomass

Potential markets, including a directory of primary and secondary forest products in Minnesota: www.dnr.state.mn.us/forestry/um under Wood Industry Directories.

The MarketPlace Bulletin: www.dnr.state.mn.us/publications under Division publications.

Managing brushlands for wildlife

A brochure titled Managing Your Brushland for Wildlife is available at www.dnr.state.mn.us/publications/wildlife
Woody biomass resources and opportunities in the emerging energy industry

For additional information, refer to Minnesota’s Woody Biomass Resources and Opportunities in the Emerging Energy Industry, a paper written by Bill Berguson, University of Minnesota, Natural Resources Research Institute, Duluth, Minnesota.

Go to www.blandinfoundation.org. Click on Public Policy & Engagement; then click on Vital Forests/Vital Communities; then click on Conferences & Events; then click on Seizing Opportunity: Forestry and the BioEconomy; and then look for Informing Report: Minnesota’s Woody Biomass Resources and Opportunities in the Emerging Energy Industry.

Minnesota DNR Ecological Classification System

For additional information, including descriptions of Native Plant Communities (NPCs), visit www.dnr.state.mn.us/ecs
**Acid peatlands:** Conifer, low shrub and grass-dominated and/or sedge-dominated wetland communities on *Sphagnum*. Hydrological inputs are dominated by precipitation, not ground water.

**Bagasse:** The biomass remaining after sugarcane stalks are crushed to extract their juice. (Source: en.wikipedia.org/wiki/Bagasse)

**Biomass:** The organic materials produced by plants, such as leaves, roots, seeds and stalks. In some cases, microbial and animal metabolic wastes are also considered biomass. The term *biomass* is intended to refer to materials that do not directly go into foods or consumer products but may have alternative industrial uses. Common sources of biomass are (1) agricultural wastes, such as corn stalks, straw, seed hulls, sugarcane leavings, bagasse, nutshells, and manure from cattle, poultry and hogs; (2) wood materials, such as wood or bark, sawdust, timber slash and mill scrap; (3) municipal waste, such as waste paper and yard clippings; and (4) energy crops, such as poplars, willows, switchgrass, alfalfa, prairie bluestem, corn (starch) and soybean (oil). (Source: McGraw-Hill Encyclopedia of Science and Technology, 5th edition, The McGraw-Hill Companies, Inc.)

**Brushland habitat:** A habitat consisting of a semi-open complex of vegetation with greater than one-third cover by shrubs and/or one-third to two-thirds total cover by trees. These habitats are typically found in the following ecological systems: peatlands, wet forests, upland prairies, rock outcrops, wet meadow/carrs and wetland prairies.

**Carr:** A wetland usually supporting small shrub or thin tree cover.

**Desired future conditions:** The goal of a site’s ecosystem type outlined in a management plan that is designed to move the site toward this self-sustaining or successional ecosystem type.
Ecological system: Groups of native plant communities unified by strong influence from a major ecological process or set of processes, especially nutrient cycling and natural disturbances.

Fire-dependent forest/woodland: An ecological system where forest and woodland communities are strongly influenced by wildfires. Fires are a major source of species mortality and strongly influence patterns of plant reproduction and survival. Periodic fires remove much of the litter, duff and other organic material from communities in the system and can have significant effects on nutrient cycling and nutrient availability. Plants and animals characteristic of this system are well adapted to the effects of periodic fires, including removal of organic material.

Forest ecosystem: A community of plants, animals and microorganisms, and the physical environment they inhabit, in which trees are the dominant life form.

Forested rich peatland: Conifer-dominated or tall shrub-dominated wetlands on deep peat. The water table is normally immediately below peat surface.

Hydric soil: Soil formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions favoring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anerobic soils).

Lagg: A wet, moat-like depression that occurs where a peatland comes in contact with an upland.

Lek: An open area, relatively free of brush and trees, that is used by sharp-tailed grouse and prairie chickens as a display and mating area in the spring.

Lowland shrub: Habitat that occurs in areas with high water tables where broad-leaved shrubs are the dominant plant growth form. This habitat is found in basins, along streams and rivers, and around lakes and ponds.
Old fields: Agricultural fields that have reverted to a non-agricultural condition.

Open lands habitat: Habitat consisting of an open complex of vegetation with less than or equal to one-third total cover by shrubs and/or trees. This habitat is typically found in the following ecological systems: peatlands, upland prairies, rock outcrops, wet meadow/carrs and wetland prairies.

Open landscape: A portion of land supporting an open to semi-open complex of vegetation consisting of less than two-thirds total cover by trees.

Open peatland (including open rich peatlands and some acid peatlands): Open rich peatlands are areas of grass and/or sedge or low shrub-dominated wetlands influenced by ground-water flow zones. They often have higher concentrations of minerals and higher species diversity than acid peatlands. Acid peatlands are grass and/or sedge or low shrub-dominated wetlands primarily influenced by precipitation. They are extremely low in nutrients and are acidic and separated from ground water.

Reserve area: A portion of the management area set aside for a special purpose or use or to protect specific resources.

Rock outcrop: Open or shrub-dominated communities on shallow or exposed bedrock, generally less than 25 acres in size.

Seasonal ponds: A type of wetland not always easily discernible in the field. They are depressions in the soil surface where water pools during wet periods of the year, typically in spring and fall. A seasonal pond will have an identifiable edge caused by seasonal inundation and local topography. Seasonal ponds are small, typically less than 1/2 acre in size. The edge is best identified during the spring or fall.

Seral: A stage of succession in a plant community that is transitional. If left undisturbed, a seral stage will give way to another plant community that represents a further stage of succession. (Source: www.umpqua-watersheds.org/glossary/gloss_s.html)
Shearing: The operation of cutting off trees and brush at ground level by pushing a sharpened bulldozer blade along the frozen surface in winter.

Sustainably managed woody biomass: For purposes of biomass guideline development and in accordance with M.S. § 216B.2424 Subd. 1 (d), sustainably managed woody biomass is defined as: (1) brush, trees, and other biomass harvested from within designated utility, railroad, and road rights-of-way [Note: Guidelines will not be developed for this category of biomass]; (2) upland and lowland brush harvested from lands incorporated into brushland habitat management activities of the Minnesota Department of Natural Resources; (3) upland and lowland brush harvested from lands managed in accordance with the Minnesota Forest Resources Council’s Woody Biomass Harvesting for Managing Brushlands and Open Lands; (4) logging slash or waste wood that is created by harvest, by pre-commercial timber stand improvement to meet silvicultural objectives, or by fire, disease, or insect control treatments, and that is managed in compliance with the Minnesota Forest Resources Council’s Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers, as modified by the requirement of this subdivision; and (5) trees or parts of trees that do not meet the utilization standards for pulpwood, posts, bolts, or sawtimber as described in Minnesota Department of Natural Resources Division of Forestry Timber Sales Manual, 1998, as amended as of May 1, 2005, and the Minnesota Department of Natural Resources Timber Scaling Manual, 1981, as amended as of May 1, 2005, except as provided by M.S. § 216B.2424—Biomass Power Mandate, Subdivision 1, in paragraph (a), clause (1)—“[biomass that] is intentionally cultivated, harvested, and prepared for use, in whole or in part, as a fuel for the generation of electricity”—and this paragraph, clauses (1) to (3).
**Upland prairie:** Prairie habitat dominated by native grasses with species-rich component of forbs (herbaceous plants other than grasses or sedges). On upland sites, woody species are limited to dwarf shrubs, such as leadplant and prairie rose. Without fire, trees and shrubs invade prairie areas throughout the state.

**Upland shrub/woodland:** Habitat that is a combination of (1) savannas and brush prairies, (2) bedrock shrublands, and (3) seral and edge upland shrub areas.

**Wet forest:** Forest communities characterized by muck soils that are saturated in the spring but dry out later in the growing season. They occur in narrow zones along margins of lakes, rivers and peatlands and in depressions. Black ash is often a dominant species.

**Wet meadow/carr:** Grass and/or sedge and shrub-dominated wetland communities subjected annually to moderate inundation following spring thaw and heavy rains. Willows and dogwoods dominate drier sites.

**Wetland prairie:** Prairie habitat dominated by native grasses with species-rich component of forbs (herbaceous plants other than grasses or sedges). Big bluestem and prairie cord grass are the major species on wetter sites, which also support a variety of sedge species. Wetland prairies also support dwarf shrubs (e.g., prairie rose) and true shrubs (e.g., red-osier dogwood).

**Woody biomass:** See *Sustainably managed woody biomass.*
APPENDICES

Appendix 1:
Wildlife Species That Depend on
Brushland Habitats in Minnesota

Moose
Sharp-tailed Grouse
American Woodcock
Alder Flycatcher
Willow Flycatcher
Gray Catbird
Brown Thrasher
Loggerhead Shrike
Blue-winged Warbler
Golden-winged Warbler
Yellow Warbler
Chestnut-sided Warbler
Common Yellowthroat
Yellow-breasted Chat
Clay-colored Sparrow
Song Sparrow
Lincoln’s Sparrow

1 From Appendix A of An Assessment of Open Landscapes for Management of Brushland Wildlife Species in Northern and Central Minnesota, Minnesota Department of Natural Resources. The Appendix also lists the 154 species dependent upon open land habitats.

2 Species in Greatest Conservation Need, Tomorrow’s Habitat for the Wild and Rare, Minnesota Department of Natural Resources

3 Listed on Minnesota Threatened Species List
Appendix 2:  
Additional Sensitive Native Plant Communities

The table on page 55 includes additional non-forested rare native plant communities to supplement Appendix J of *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers*. This list of communities follows Minnesota’s Native Plant Community Classification (Version 2.0).

These communities are described in *Field Guide to the Native Plant Communities of Minnesota: The Laurentian Mixed Forest Province* (Minnesota Department of Natural Resources, 2003), *Field Guide to the Native Plant Communities of Minnesota: The Eastern Broadleaf Forest Province* (Minnesota Department of Natural Resources, 2005), or *Field Guide to the Native Plant Communities of Minnesota: The Prairie Parklands and Tallgrass Aspen Parklands Provinces* (Minnesota Department of Natural Resources, 2005).

Each community name is followed by a unique code from Minnesota’s Native Plant Community Classification (Version 2.0).

**Important note:**

The table in this appendix is *not a stand-alone listing*; it is an addendum to the existing Appendix J. Please refer to both the original Appendix J, as well as this Appendix 2 addendum.
# Sensitive Native Plant Communities

*(addendum to Appendix J, pages 2-3)*

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<th>Type</th>
<th>ECS section</th>
<th>Classification code</th>
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<td>LKu32b</td>
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<td>LKu32d</td>
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<td>Sandstone Outcrop (Northern)</td>
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