

Voluntary Site-Level Forest Management Guidelines

Sustaining Minnesota Forest Resources



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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 which was first published in 1999.

Guideline development is an iterative process, where guidelines are modified in response to new information, changing technology, and evolving issues. Since the original publication the guidelines have been revised four times as required in statute; a comprehensive assessment completed in 2005 and again in 2007 when biomass harvesting guidelines were added. The MFRC initiated a third revision in 2010 to address riparian area guidelines in response to the findings of the Riparian Science Technical Committee which was convened to provide information and guidance to the Council on riparian-related issues. Other topical areas were also evaluated for revision, and the entire revision process was completed in late 2012. The fourth revision was initiated in 2020 and completed in 2024 using a multi-pronged approach.

Different facets of the most recent revision process included: 1) A stakeholder survey related to perceived effectiveness of FMGs, 2) A review of implementation rates and effectiveness for FMGs monitored by the Guideline Monitoring Program, 3) A scientific literature review, 4) Peer review focus group engagement, and 5) A public comment period followed by additional refinement of FMG language. More information related to the revision process is available on the MFRC website.

Guideline Editions

- 1999
- 2005
- 2007
- 2012
- 2025

Summary of 2025 FMG Update Process

A multi-pronged process to review and identify potential updates to the FMGs began in mid-2020 with a stakeholder survey that gathered feedback on users' experiences with and perceptions of Minnesota's voluntary site-level FMGs. The MFRC's Site-Level Committee (SLC) used results from the survey, information from the Minnesota Department of Natural Resources' Guideline Monitoring Program, and a thorough scientific literature review, to inform their examination of the FMGs for potential updates.

Stakeholder Survey

Survey respondents included public and private landowners and managers, loggers and technical service providers, scientific researchers and educators, MFRC members and partners, and the general public. This comprehensive survey aimed to identify and assess any potential opportunities for FMG updates, and gain insight into FMG training and usage across stakeholder groups. The survey results indicated that users of the FMGs generally felt the guidelines are not in need of significant changes; however, there were indications that some guidelines may not be well understood or consistently used.

Guideline Monitoring Program Review

Survey findings were supported by Guideline Monitoring Program reports that further indicated some inconsistencies with FMG interpretation and the need for minor clarifications. The Guideline Monitoring Program reports also suggested that insufficient training/education, not the content of the FMGs, contributes to lower implementation of and compliance with some FMGs. In particular, the reports identified a need to re-emphasize opportunities for education and field training on FMG implementation to practicing foresters whenever possible.

Scientific Literature Review

A scientific literature review was conducted to identify recent advances in relevant peer-reviewed scientific research related to the FMGs since their last update. The literature review findings showed that research supports the fundamental practices outlined in current FMGs and highlighted the need for updates to FMGs informational reference material and listings such as those for endangered, threatened, and special concern species.

FMG Review Process Findings

The SLC's multi-pronged approach to review the FMGs for potential updates concluded that no sections of the FMGs were identified as needing major modifications. The review findings identified potential clarifications and minor edits to improve communication and interpretation of the FMGs by users. The review findings also identified three FMGs topical areas requiring further investigation and peer review consultation involving specialists with substantial knowledge and experience in the topical areas, which are discussed below.

Peer Review Focus Group Engagement

Peer review focus groups were convened in 2023 to engage diverse and expert perspectives on FMGs topical areas identified as needing further investigation. These topics included riparian management zones/leave trees, climate change considerations, and invasive species. The SLC used input from these peer review focus groups to guide proposed updates and inform recommended updates to invasive species guidance and the development of climate change guidance.

Summary of 2025 FMG Updates

Updates to the FMGs are modest but strategic and important to ensure the guidelines remain relevant and reflective of current science and management concerns. These recommended updates include new invasive plant species guidance, climate change considerations, and clarification or additional considerations related to riparian management zones, leave tree retention, erosion control, and other topics to guide and support the sustainability of our forestry operations. These updates are important to the credibility and relevance of the FMGs. They also are designed to provide operators and resource managers the flexibility they need to apply guidelines to site-specific conditions. This flexibility has been foundational to the FMGs since their inception.

In addition to the adoption of recommended changes, the MFRC recognizes the need for renewed training, outreach, and education efforts to support consistent application of the updated FMGs. The comprehensive nature and complexity of the FMGs further supports the need for education on the long-term intent and function of guideline practices.

Although the recommended updates address concerns of today, ongoing periodic review is essential for maintaining the FMGs' relevancy to forestry and forest conditions in Minnesota.

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- Associated Contract Loggers
- Beltrami County Land Department
- Birchem Logging
- Blandin Paper Company (UPM–Kymmene)
- Boise Cascade Corporation
- Bois Forte Band (Nett Lake Reservation)
    - Department of Natural Resources
- Bureau of Indian Affairs, Red Lake Agency
- Cass County Land Department
- Duluth Audubon Society/Minnesota Audubon Council
- Institute for Minnesota Archaeology
- Itasca Community College
- Izaak Walton League
- Lake County Land Department
- Minnesota Board of Water and Soil Resources
- Minnesota Center for Environmental Advocacy
- Minnesota Deer Hunters Association
- Minnesota Department of Natural Resources
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- North Shore Forest Products, Inc.

- Office of the Minnesota State Archaeologist
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- USDA Forest Service
    - Chippewa National Forest
    - North Central Research Station
    - Superior National Forest
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        - Department of Forest Resources
    - College of Agriculture, Food and Environmental Sciences
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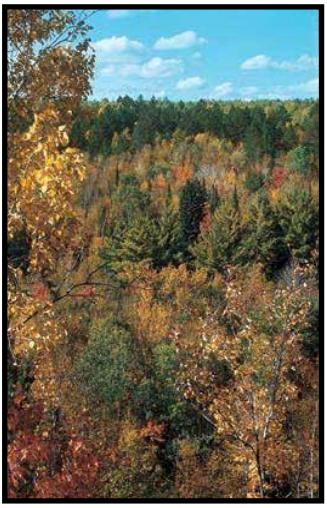
The Minnesota Forest Resources Council and the members of its Integration team would like to thank Mike Phillips for his tireless commitment, leadership and unfailing humor throughout the guideline development and integration process.

"*So let it be written; so let it be done.*"

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.



The forest is a diverse and complex community, 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





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. Photos courtesy of Minnesota DNR (above) and Potlatch Corporation (below)



Harvesting timber stands can contribute to the long-term health, productivity and sustainability of valuable forest resources. Photo courtesy of Minnesota DNR

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 Pollution Control Agency





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 Affecting 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.

Climate Change and Minnesota's Forests



There is great concern about how climate change impacts Minnesota forest ecosystems. Minnesota's forests provide a variety of ecological, economic, and social benefits, but the productivity and functioning of Minnesota forests may be affected by climate change. The effects of climate change in Minnesota are projected to include warming temperatures,

more frequent severe precipitation events, increased wind events, and increased periods of drought stress. These changes will be likely to impact the composition of Minnesota's forests, the operability of forest soils, disturbance patterns, etc., all of which have major implications for the ecological, economic, and social benefits that these forests provide.

Managing forests in the face of climate change requires consideration of these changes in climate and the risks associated with these future changes. On-site application of some guidelines may be impacted by climate change. Managers and operators should consider these potential climate change impacts when planning and implementing these forest management guidelines.

Some guidelines are especially relevant when considering long-term climate change impacts on Minnesota's forests and forest management. These guidelines are indicated by a "Climate Consideration" logo. When this logo is present, please consider consulting the following resources for specific climate change guidance for your site:

- Northern Institute of Applied Climate Science
- "Climate Change and Minnesota Forests" – 2020 MFRC Report
- "Minnesota Forest Ecosystem Vulnerability Assessment and Synthesis" – 2014 USDA Forest Service Report
- Minnesota Department of Natural Resources

Part 2: Selected Components of a Sustainable Forest – Rationale and Management Considerations

A forest ecosystem reflects the dynamic interaction between people—landowners, resource managers, loggers, tourists and recreational users—and many different forest resources, including, among others, cultural resources, forest soil productivity, riparian areas, visual quality, water quality and wetlands, and wildlife habitat.

Part 2 introduces and defines these six forest resources, providing the rationale for their role in the overall sustainability of forested lands in Minnesota.

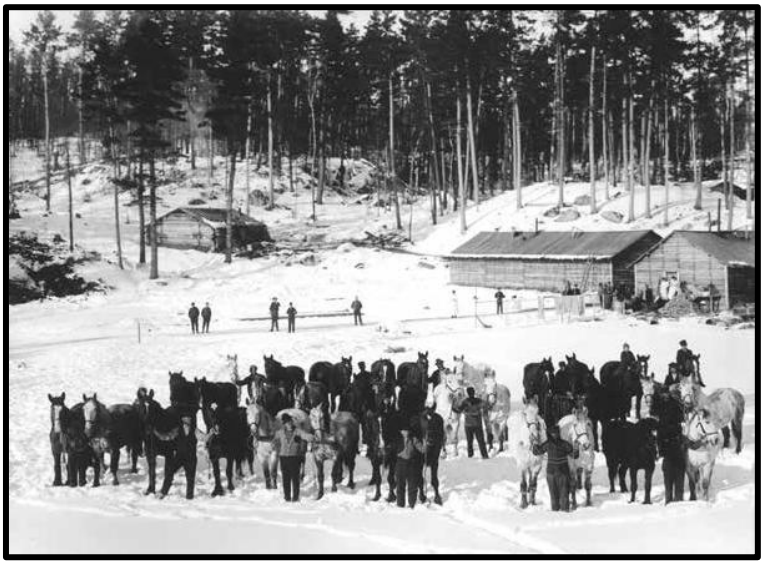
- Cultural Resources
- Forest Soil Productivity
- Riparian Areas
- Visual Quality
- Water Quality and Wetlands
- Wildlife Habitat

Cultural Resources

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The location of this historic northern Minnesota logging camp (circa 1915) is today a valuable cultural resource: an archaeological site representing an important chapter in the history of the region. Photo courtesy of Minnesota Historical Society (William F. Roleff)

The Value of Cultural Resources

What Cultural Resources Are

In these guidelines, **cultural resource** means any site, building, structure, object or area that has value in American history, archaeology, architecture, engineering or culture. A cultural resource may be the archaeological remains of a 2,000-year-old Indian village, an abandoned logging camp, a portage trail or a pioneer homestead. It may be of value to the nation or state as a whole or important only to the local community. In order to be considered important, generally a cultural resource has to be at least 50 years old.

The people of Minnesota are heirs to a unique legacy of cultural resources, many of which occur within the state's public and private forest lands. Generally, these cultural resources fall into five broad categories: historic structures, archaeological sites, cemeteries, traditional use areas and historic areas.



Burial mounds are a cultural resource that can be found in Minnesota today. This burial mound is located in Houston County. Photo courtesy of Minnesota DNR Forestry Heritage Resources Program

The following list provides an overview of the most common types of cultural resources within these categories:

Historic Structures

- Buildings constructed to shelter human activities, such as:
    - Houses, barns, outbuildings
    - Schools, churches, government buildings
    - Mills, factories, stores
- Other industrial and engineering constructions, such as:
    - Roads, bridges, dams

    - Fire lookout towers
    - Logging camps, haul roads, sluices
- Structures that have historic significance, such as:
    - Notable examples of architectural styles or construction methods
    - Buildings that are associated with important people, events or trends
    - Sole or rare survivors of important types or styles of construction
- Vegetation that is part of a historic site, such as:
    - Plantations
    - Formal gardens or plantings

Cemeteries

- Any deliberate human burial, including:
    - Platted burial grounds
    - Unmarked graves
    - Abandoned township or church burial grounds
    - Family plots or “pioneer” cemeteries
    - Burial mounds
- Markers, such as wooden or stone monuments, spirit houses, rock outlines
- Associated vegetation, such as flowers, trees and shrubbery

Archaeological Sites

- Locations that contain important scientific information about 10,000 years of human occupation in Minnesota
- Locations that contain surface or below-ground artifacts (objects) and features (local modifications of natural terrain) reflecting human activity, such as:
    - Campsites and villages
    - Hunting and fishing camps
    - Food-gathering sites
    - Quarries

- Trading posts
- Logging camps
- Homesteads
- CCC camps
- Ruins of structures, such as mills, factories, farmsteads



"Traditional use areas" were the site of a particular activity (such as food-gathering) by a group of people over a period of years. This Ojibwe hut (1920) stored tools and food containers, which the Ojibwe used for food-gathering. Photo courtesy of Minnesota Historical Society (Frances Densmore)

Historic Areas

- Groups of associated structures, features and sites; examples include:
  - Transportation networks made up of roads, trails, rail grades, portages
  - Clusters of related structures and features, such as a farmhouse, barn, outbuildings, roads and fields
- Designed landscapes, such as parks, gardens, recreation areas
- Areas shaped by historical land uses, such as agriculture, mining, logging

Traditional Use Areas

- Specific geographic locations traditionally used by one or more groups of people for a community activity, such as:
    - Locations where plants important for medicinal or ceremonial use are gathered
    - Locations where food plants are gathered
    - Locations where traditional craft materials are gathered
    - Locations associated with traditional beliefs and practices
- Shrines and ceremonial sites

Historical Context

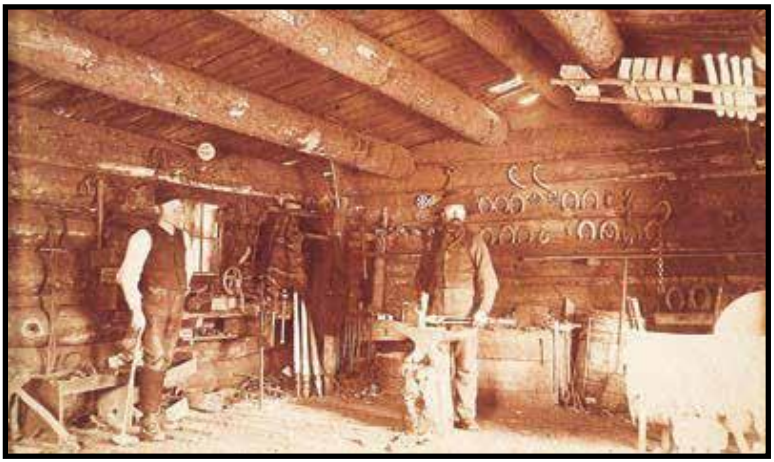
Cultural resources reflect roughly 10,000 years of human occupation in Minnesota, from the earliest appearance of people at the end of the last Ice Age to the 20th century. Cultural resource management professionals commonly divide the state's history into three time periods:

- **The Pre-Contact Period** begins approximately 10,000 years ago and covers Minnesota history through about A.D. 1650. Several successive Native American cultural traditions existed here during this long period of time, as native peoples adapted to a wide range of conditions in all of the state's ecosystems. Ancient Native American settlement and subsistence in Minnesota generally reflect the hunting and gathering pattern of the Eastern Woodlands, but there were also societies characterized by agriculture and village life.
- **The Contact Period** groups together the events and cultural trends characterized by the interaction of Native American and Europeans during the period from about 1650, when the first explorers reached Lake Superior, to 1837, the date of the first treaties ceding

tribal lands in Minnesota to the United States. Cultural resources from this period are most often linked to the themes of exploration and discovery, the fur trade, acculturation of tribal societies, and initial Euro-American settlement.

- **The Post-Contact Period** covers the years between 1837 and the end of the Second World War. Cultural resources from this period are particularly abundant and reflect both broad historical themes and more narrow, localized topics:
    - **Broad historical themes** include Native American reservation communities, logging, agriculture, mining, transportation, industry and urban development.
    - **More narrow, localized topics** include ethnic settlements, folk architecture, state parks and pioneer farmsteads.

In special circumstances, cultural resources from the post-1945 era may also be considered significant.



The site of this blacksmith shop at an 1885 lumber camp would today provide important information to help archaeologists (and others) better understand daily life in a logging camp more than 100 years ago. Photo courtesy of Minnesota Historical Society

Assumptions and Desired Outcomes

Six primary assumptions provided the foundation for the development of cultural resource guidelines:

- Cultural resources are scarce and nonrenewable.
- Voluntary guidelines should enable forest land managers, landowners and cultural resource managers to avoid unnecessary conflicts.
- Natural environments that have been shaped by historical processes of land use may also have cultural resource value.
- Long-range planning is the key to successful cultural resource management.
- Good forest land management is compatible with good cultural resource management practices.
- Education and partnerships will be the keys to successful guideline implementation.

These guidelines were developed to provide landowners, loggers and resource managers with information about cultural resources and recommendations on how to take them into consideration during forest management activities.

The purpose of the guidelines is to achieve two major outcomes related to all forest management practices:

- **Increased awareness of cultural resources** among forest landowners, loggers and resource managers
- **Protection of important cultural resources** during forest management activities

Potential Impacts to Cultural Resources

In general, cultural resources are fragile. Threats range from natural forces (erosion, flooding, weathering and fire) to human action (logging, agriculture, mining, land development and vandalism). Lack of awareness of the existence of a cultural resource is the main cause of damage. Use of these guidelines will encourage implementation of practices that will minimize unintentional damage to cultural resources.

Potential damaging effects to cultural resources resulting from forest land management activities include:

- Soil disturbance
- Soil compaction
- Rutting
- Changes in public access
- Changes in vegetation which is part of a cultural resource
- Damage to above-ground features

Cultural resources are susceptible to the effects of soil erosion, compaction and rutting. These forces can disturb

archaeological sites and destabilize historic structures. Traditional use areas may be impacted by timber harvesting, fire management and herbicide use.

While changes in site access created by forest roads make some cultural resources susceptible to looting and vandalism, they may also enable opportunities for on-site education, interpretation and tourism—which may, in turn, lead to new threats to the integrity of the resource.

The Benefits of Cultural Resource Management

The underlying reason for including cultural resource management (CRM) as part of forest management is the growing **recognition that cultural resources have value and should be wisely managed.** Cultural resources represent parts of an inheritance shared by all people. This heritage is of fundamental value to modern-day societies and is truly a gift from the past. Cultural resources are valued in a variety of ways. They often possess spiritual, scientific and other values that are weighed differently by different cultures.

The benefits of CRM are both tangible and intangible. Today CRM is increasingly seen as a necessary component of land stewardship. Forest managers and landowners should use CRM as a tool to minimize conflicts between stewardship and economics, and to treat cultural resources as assets rather than liabilities. **Cultural resource management is about people, not things**, and its orientation is toward the future, not the past.

While the intangible benefits of cultural resource management cannot always be easily defined, they are nevertheless important:

- As scarce, nonrenewable parts of the environment, cultural resources by their very nature provide physical

links to the past, along with a sense of national, community and personal identity.
- Historic structures, historic areas, traditional use areas and other above-ground cultural resources provide environmental diversity, while some structures and artifacts have intrinsic value as works of art.
- Perhaps most importantly, the conservation of cultural resources contributes to an understanding of history, fosters an appreciation for heritage, and stimulates learning at all education levels.
- Lastly, resources that connect the present with the past fulfill important nostalgic and spiritual instincts shared by large segments of modern society.

The Economics of Cultural Resource Management

Economically, CRM will not usually pay for itself, but some forest landowners will discover that preserved and protected cultural resources can be financial assets that do provide opportunities for development:

- Indirectly, cultural resource conservation efforts often contribute to soil, water and wildlife habitat conservation measures.
- Some kinds of cultural resources, including archaeological sites and historic structures, have value as heritage tourism sites and may be used to help stimulate outdoor recreational development.
- The return on investment in the preservation, rehabilitation and adaptive reuse of above-ground cultural resources is often reflected in increased resale values, and, although “quality of life” benefits are sometimes difficult to accurately measure, CRM may be used as an effective tool for developing a sense of corporate or community identity that increases

economic productivity and encourages new investment.

- Finally, a growing number of federal and state laws provide financial incentives for preserving and protecting cultural resources. For example, landowners may qualify for a federal income tax deduction, and/or a reduction in estate tax, by donating conservation easements at particularly important cultural resources to non-profit conservancy groups.

Federal investment tax credits are also available for rehabilitating and reusing historically significant buildings and structures. (Unlike some neighboring states, Minnesota does not have property tax abatement for cultural resource properties.) For current information on tax incentives, contact the State Historic Preservation Office. See *Resource Directory.*

Cultural Resource Management and the Law

Although these guidelines are designed to be voluntary, forest managers will need to know something of the non-voluntary, regulatory side of CRM. The legal basis for CRM is deeply rooted in federal and state legislation concerned with natural resource conservation and environmental protection going back to the early 1900s.

The National Historic Preservation Act (NHPA) of 1966, as amended, is the centerpiece of the national historic preservation program and has become an important component of state and local CRM programs in Minnesota. NHPA establishes the National Register of Historic Places and provides for State and Tribal Historic Preservation Officers to implement the national preservation program. Section 106 of NHPA requires that federal agencies consider the effects of their activities on cultural resources.

The State of Minnesota has also adopted laws designed to ensure that both natural and cultural resources are considered in government decision-making. These laws include state environmental policy and environmental rights acts. Virtually all environmental legislation currently on the books applies to CRM issues.

Cultural resource laws in general are intended to ensure that **significant resources will be taken into consideration** when activities are planned that might damage their scientific or cultural values. Both federal and state laws protect cultural resources. In some cases, one or more of these laws might apply on private property as well.

Human burials are given special consideration under federal law, tribal ordinance and state law. The Minnesota Private Cemeteries Act (MS 307.08) protects all human burials in the state from disturbance, regardless of age, ethnic affiliation or land ownership. Similar protections apply to burials on lands under federal and tribal control.



Many graves in pioneer cemeteries do not have markers, making identification and protection more difficult. This headstone, found in a pioneer cemetery in Aitkin County, was on the only one of eight graves with an easily recognizable marker. Photo courtesy of Minnesota DNR Forestry Heritage Resources Program

For cultural resources other than cemeteries, how a law applies is determined by three factors:

- Land ownership
- The source of funding being used for the activity
- Any permitting authority that might be involved

Federal law applies whenever activity takes place on federal land **or** will use federal funds **or** will require a permit issued pursuant to federal authority. State law applies whenever the activity is on non-federal public land **or** will use non-federal public funds. If human burials are known or suspected to be present, state law applies regardless of ownership.

Although administration and enforcement of environmental protection laws vary, forest managers would do well to assume that, whenever a government permit or license is required, some kind of CRM review and compliance may also be required.

Federal and state laws, for example, require public land forest managers to consider the effects of their projects on cultural resources. When a cultural resource eligible for inclusion on the National Register must be destroyed or damaged by forest management activities on public land, public funds may be used to recover important historical, archaeological or cultural data that would otherwise be lost.

Burial sites are a special category of cultural resources. Under the Minnesota Private Cemeteries Act, all human burials are afforded the same legal protection as platted cemeteries, regardless of land ownership.

Including Cultural Resource Management in Strategic Planning

For forest landowners with large tracts of ownership, a comprehensive cultural resource management plan may be the most effective way to integrate protection of cultural and historical resources with forest management. Comprehensive planning would assist forest land managers to identify both known cultural resources and areas with potential to contain unrecorded cultural resources. For small landowners and operators, stewardship plans should establish priorities for dealing with cultural resources within the framework of site conservation planning.

Identifying, Assessing and Managing Cultural Resources

Checking Cultural Resource Inventories

Information is available that may help landowners and forest managers in identifying cultural resources. Cultural resource surveys and their resulting inventories form an important basis for forest management decisions that affect cultural resources.

The first step in cultural resource management (CRM) planning is to check existing cultural resource inventories to determine whether any important cultural resources are known to be present within a given area. (*See Appendix B: Cultural Resource Inventory Sources in Minnesota.*) In particular, landowners and forest managers are encouraged to check for recorded burial sites in management areas.

While other inventories exist (such as those maintained by local units of government and county historical societies), the inventories listed in the Appendix provide the most comprehensive databases, as well as professional staff to provide assistance.

Most of the statewide cultural resource inventories maintain “hard copy” site maps that show specific cultural resource locations, as well as areas that have been surveyed for cultural resources. A formal written request is not necessary. Requests may be made by phone, and requested information is most often available within a few days.

Conducting a Pre-Field Review

If no surveys of a forest management site have been previously completed, landowners and operators may want to conduct their own assessment of the project area’s cultural resource potential. This process may entail checking existing maps, air photos and printed historical information, as well as contacting individuals knowledgeable about local history or archaeology.

Documentary information that may be of assistance includes:

- Township, county, regional or state histories
- Historical maps, atlases and plats
- Government land surveyor field notes
- Information about local Indian communities
- Industry and business records
- Air photos
- Reports of previous cultural resource surveys
- Interviews with historians, archaeologists and other knowledgeable individuals

These materials are available in libraries and special historical research collections in larger cities; at colleges and universities; and in local public libraries, county courthouses and museums. Public agencies, large private landowners and corporations may have records or histories of their operations.

Assessing Cultural Resource Potential

Some locations are more likely than others to contain cultural resources. The following kinds of features may be expected to have high potential for cultural resources:

- Current shorelines or “terraces” adjacent to a permanent lake, river or stream
- Former shorelines, including glacial lakes (such as Agassiz, Upham, Duluth or others), abandoned river channels, solid dry land around large marshes and bogs, and abandoned high-water shorelines on lakes
- Junctions of water bodies, including stream inlets and outlets to lakes, and river junctions
- Good places to camp, including areas where people camp now
- Islands
- Peninsulas or points of land along a shoreline
- Areas adjacent to fish spawning beds, good fishing spots and wild rice beds
- Transportation routes, such as old trails, roads, portages and railroads (Many modern roads follow old trails and wagon roads.)
- Areas near community centers, such as towns and villages, especially in combination with transportation routes
- Depression-era tree plantings (often near old homesteads)

Field Identification of Cultural Resources

A walk-over inspection of the management area may reveal unrecorded cultural resources. Forest managers, landowners and others following these guidelines can undertake a preliminary assessment of a site's cultural resource potential. A walk-over inspection can be done at the same time as other field activities, such as timber inventory or timber sale preparation. Background information gathered during the cultural resource assessment process (see above) may provide some clues as to what kinds of cultural resources might be present and where to look for them.

Here are some things to look for:

- High spots offering a panoramic view
- Unusual natural features
- "Surface" artifacts (anything manmade)
    - Check bare spots, eroded areas, tree tipups and cut banks. Look for broken clay pottery and stone tools ("arrowheads"), as well as manufactured items.
- Vegetation that grows in disturbed soils (including poison ivy, ragweed, chenopods, amaranthus and nettles)
- Surface features:
    - Cellar and well holes
    - Cement or asphalt slabs
    - Fieldstone foundations and other structures
    - Retaining walls
    - Miscellaneous building materials (bricks, roofing materials, plaster and stucco)
    - Metal pipes (such as well pipes)
    - Earthen berms and trenches
    - Shallow depressions (such as graves or ricing pits)

Note: Such features could indicate possible burial sites. Contact the Office of the State Archaeologist or a cultural resource professional. For sources of information and assistance, see *Resource Directory.*



A traditional Ojibwe burial practice, spirit houses are found throughout forested areas of Minnesota. One example is this spirit house in Cass County, photographed in 1995. Photo courtesy of Minnesota DNR Forestry Heritage Resources Program

- Milled lumber (such as boards suitable for use in burial crosses, spirit houses or building construction)
    - Note: Burial crosses or spirit houses could indicate possible burial sites. Contact the Office of the State Archaeologist or a cultural resource professional. For sources of information and assistance, see *Resource Directory.*
- Domestic or exotic plant species (including lilac bushes, fruit trees and daisies)
- Areas with traditional resources, especially where gathering is known to occur or evidence exists that the area is used (for example: wild rice, maple “sugar

bush," birch bark, boughs, and such wild foods as berries, mushrooms, roots and herbs)
- Fence materials (wood or metal posts, or wire)
- Old roads, trails and portages (especially the junction areas where two come together or are associated with a clearing)
- Trash dumps containing antique items or jumbo-sized tin cans
- Clearings in the woods
- Objects in or attached to trees; blazed trees
- Standing structures and buildings. Ask these questions:
    - How old is it?
    - Who owned it? Who designed it? Who built it?
    - What condition is it in?
    - Is it associated with an important person or event?
    - Is it an unusual architectural style?
    - How much has it been altered from the original?

Assessing Management Alternatives

(see Figure CR-1)

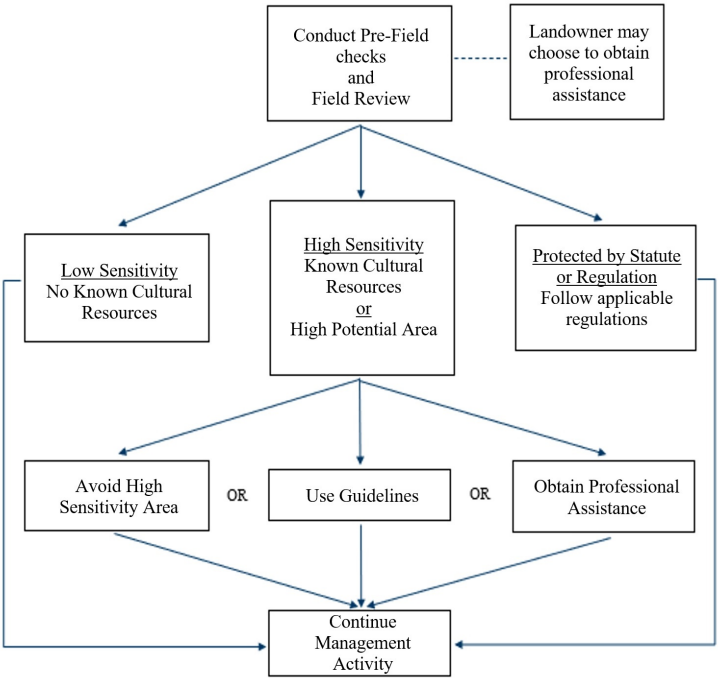
- **Protection by law:** If the pre-field review indicates that the project area contains a site protected by law (such as a burial site), further action will be determined by statute or regulations.
- **Identification as a low-sensitivity site:** If no cultural resources have been recorded and the pre-field review and walk-over inspection yielded no indications of important cultural resources, the site would have low sensitivity, which means there are probably no important cultural resources located there. Proceed with the management activity.
- **Identification as a high-sensitivity site:** If cultural resources are known to exist, or if the pre-field review

and walk-over inspection indicate their presence, or if any of the features listed in the section *Assessing Cultural Resource Potential* are present, the site has high sensitivity. In this case, the forest manager has several alternatives to consider, of which the following are recommended:

- Avoid the highly sensitive areas identified within the project area.
- Protect the cultural resource by means of the treatment and mitigation practices described in *General Guidelines: Protecting Cultural Resources* and applicable sections of the activity-specific guidelines.
- Bring in a cultural resource management professional to carry out a survey for archaeological and above-ground cultural resources. Doing so may incur additional costs. For sources of information and assistance, see *Resource Directory.*

Recommended Procedure for Identifying, Assessing, and Managing Cultural Resources

Figure CR-1



When Accidental Discovery Occurs

Unrecorded cultural resources may be discovered during operations. Guidelines for proceeding depend upon the nature of the discovery:

- In the case of human burials, if such discovery occurs, **temporary suspension of operations in the vicinity of the discovery is required.** If a human burial site is accidentally discovered, contact the Office of the State Archaeologist and the local law enforcement agency.

For sources of information and assistance, see *Resource Directory.*

- For 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 provide time to contact a cultural resource professional or develop plans to apply appropriate guidelines to avoid or mitigate potential effects to the cultural resource.

Take the following steps when important 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.
- **Adjust work schedules** to allow time for data recovery or other mitigation measures, including following appropriate cultural resource guidelines.

Evaluation and Documentation

Evaluation uses the information generated during cultural resource identification to determine whether a particular cultural resource meets defined criteria. The most widely used standard for evaluating the significance of cultural resources is the National Register of Historic Places (NRHP). See *Appendix C: National Register Criteria for Evaluation of Cultural Resources.*

In most cases, the importance (or the cultural resource value) of any one archaeological site, building or area cannot be fully evaluated without comparing it to other cultural resources. As a general rule, CRM professionals (including state or tribal preservation office staff, college

and university faculty, or consulting archaeologists and historians) are in the best position to recognize the qualities in a cultural resource that make it worth protecting.

Formal evaluations by cultural resource professionals are usually not necessary within the context of forest management activities. If the landowner thinks the cultural resource is important enough to follow the guidelines, no formal evaluation is necessary.

Documentation of cultural resources discovered during forest management activities is not required. However, landowners and operators are encouraged to make a written record of their discoveries and share that information with the Office of the State Archaeologist (OSA) or the State Historic Preservation Office (SHPO), as well as tribal authorities when appropriate.

The most important fact to document is the location of the cultural resource. See *Resource Directory* for information about cultural resource inventories, as well as sources of information and assistance.

The Limitations of Mitigation

Cultural resources cannot always be preserved in place, even with the best CRM planning and treatment measures. There will be times when forest management requirements cannot be accommodated by avoidance or protective treatments. Sometimes, steps can be taken to mitigate adverse impacts. For example:

- Archaeological sites can be subjected to data recovery (salvage excavation) that extracts and preserves useful data that would otherwise be destroyed.
- Old buildings can be relocated to new sites or salvaged for curation in a museum.

- Historic structures and cultural features can be documented in the form of maps, photographs and written data, so that their informational value can be preserved.

The Value of Cultural Resource Education and Training

Cultural resource management is about people, not things. These guidelines have been designed to serve as both an information source and a stimulus to increase involvement by forest land managers in the conservation of Minnesota's cultural resources. Therefore, education will be the key to successful guideline implementation.

The use of landowners, foresters, loggers and other forest workers to carry out CRM practices is important because it will help ensure support for forest heritage conservation and reduce costs. Indeed, some of the specific skills applying to CRM that forest workers can demonstrate include first-hand knowledge of local resources, operation of heavy equipment, geographic information systems and photography.

While the amount of CRM training necessary will depend on the aspect of CRM in which those being trained will participate, all landowners and foresters will need at least a brief orientation to the specific challenges and opportunities of CRM, as well as the appropriate CRM terminology, planning methods, treatment and mitigation practices.

Logger education should emphasize the need for consistency in all aspects of CRM, especially cultural resource identification and treatment. Specific training should be made available to operators to enable them to identify and describe cultural resources in the field.

Selected Resources for Additional Information

The American Mosaic: Preserving a Nation's Heritage. 1987. Edited by Robert E. Stipe and Antoinette J. Lee. United States Committee/International Committee on Monuments and Sites (US/ICOMOS). The Preservation Press of the National Trust for Historic Preservation, Washington, D.C. *A one-volume primer on cultural resource management issues, providing an overview of the preservation movement in the United States today. Includes essays on how the national preservation program works, new directions in the preservation movement, private sector cultural resource management, and the place of archaeology in preservation.*

Guidelines for Evaluating and Documenting Rural Historic Landscapes. National Register Bulletin 30. Linda Flint McClelland, J. Timothy Keller, Genevieve P. Keller and Robert Z. Melnick. U.S. Department of the Interior, National Park Service, Interagency Resources Division, Washington, D.C. *This bulletin offers technical guidance for identifying and evaluating cultural resource values embodied in areas shaped by historical processes of land use, such as logging, agriculture, mining and transportation.*

Guidelines for Local Surveys: A Basis for Preservation Planning. 1985. Anne Derry, H. Ward Jandl, Carol D. Shull and Jan Thorman; revised by Patricia L. Parker. Published as National Register Bulletin 24 by the National Park Service. Washington, D.C. In order to plan for the protection and enhancement of cultural resources, it is necessary to determine what sites and buildings make up that resource. *This bulletin provides a wide range of*

information on identifying, evaluating and protecting cultural resources on both private and public land.

Nearby History: Exploring the Past Around You. 1982. David E. Kyvig and Myron A. Marty. Published by the American Association for State and Local History. Nashville, Tennessee. *How to search for historic buildings and sites, how to recognize important cultural resources, and how to determine the best strategies for protection.*

The Prehistoric Peoples of Minnesota. Third Edition. 1983. Elden Johnson. Minnesota Historical Society, St. Paul, Minnesota. *This publication provides a general introduction to the first 10,000 years of human history in Minnesota and explains the methods and goals of modern archaeology.*

Protecting Archeological Sites on Private Lands. 1993. Susan L. Henry, with contributions from Geoffrey M. Gyrisco, Thomas H. Veech, Stephen A. Morris, Patricia L. Parker and Jonathan P. Rak. Published by the National Park Service. Washington, D.C. *A useful handbook for private landowners interested in protecting archaeological sites, providing information on a wide range of techniques for managing archaeological resources. Includes a general overview of regulatory and non-regulatory strategies for land use planning and archaeological site stewardship.*

Unique Historical and Cultural Resources. 1992. Prepared for Minnesota Environmental Quality Board by Jaakko Pöyry Consulting. *This technical paper was prepared as part of the GEIS Study on Timber Harvesting and Forest Management in Minnesota. Defines cultural resources and describes potential impacts to them under various harvesting scenarios.*

Forest Soil Productivity

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The Value of Forest Soil Productivity

Sustainable Soil Productivity

Soil productivity is defined as the capacity of soil, in its normal environment, to support plant growth. Soil productivity is reflected in the growth of forest vegetation or the volume of organic matter produced on a site. In forest management, soil productivity is most often measured in volume of trees produced; however, other methods of determining productivity exist, including forest community assessments.



Minnesota's forest soils are a fundamental resource on which rests the ability of our forests to provide a wide variety of benefits."

Jaakko Pöyry 1992

The goal of these guidelines is to maintain the productive capacity of forest soils in Minnesota. A decrease in soil productivity could affect the level of timber harvesting the forest can sustain, as well as other forest values, such as wildlife habitat and biodiversity. Identifying and reducing impacts to this resource should be an essential part of any strategy to achieve sustainable forest management.

A certain amount of soil impact is inevitable when conducting some forest management activities. Many of the recommended practices are aimed at keeping this

impact to a minimum level and affecting only a small percentage of a forest site.

Benefits of Forest Soil Productivity

Soil is the fundamental resource of the forest. Without it or its productive capacity, the other resources of the forest are diminished. Primary benefits of soil productivity include the following:

- Maintaining soil productivity is an important consideration in determining the level of timber harvesting the forest can sustain, as well as other forest values, such as wildlife habitat and biodiversity.
- Maintaining soil productivity sustains forest soils in a condition that favors regeneration, survival and long-term growth of desired forest vegetation.
- Maintaining soil productivity is key to sustainable forest management.
- Maintaining forest soil productivity is less costly than correction or mitigation, such as trying to fix damaged soils after the fact.
- Soil productivity influences what plants can grow on a site (or in the forest) and how well they grow.
- Maintaining the sustainability of forest soils is key to meeting society's need for forest products and other amenities of the forest.

Using Guidelines to Maintain Soil Productivity

Desired Overall Outcomes

These guidelines have been designed to lead to the following outcomes for all forest management activities:

- Increasing awareness and understanding of soil impacts caused as a result of forest management

activities among forest landowner, resource managers, loggers, equipment operators and others involved in forest management.
- Maintaining forest soil conditions to favor regeneration, survival and long-term growth of desired forest vegetation.
- Minimizing the forest area occupied by roads, landings and skid trails.
- Encouraging the use of alternate equipment and operating techniques that avoid or reduce impacts to soils, so that forest management activities can be conducted with little or no reduction in soil productivity.

Soil Productivity and Sustainable Forest Management

Soil plays an important role in forest growth and management. It provides moisture and nutrients for tree growth, serves as a medium for root growth, and physically supports the equipment used in harvesting, yarding and other operations.



Maintaining soil productivity is critical to sustainable forest management. A decrease in soil productivity could affect the level of harvesting the forest can sustain, as well as other forest values, such as wildlife habitat and populations, and biodiversity.

Disturbances initiated by intensive forest management can have diverse impacts on the physical, chemical and

biological characteristics of soils, which can, in turn, impact long-term productivity. For example:

- Features such as access roads, landings and skid trails result in significant reduction of the productive capacity of the soils directly beneath them.
- Severe nutrient depletion reduces soil fertility, directly affecting vegetation growth.
- Soil compaction and associated disturbances reduce and disrupt soil porosity, thereby restricting water and air movement into and through the soil. This results in poor soil aeration, which negatively affects root growth and the activity of soil organisms involved in nutrient cycling and other processes.
- Soil compaction decreases the rate of water infiltration into the soil, increases overland flow, and increases the potential for soil erosion.
- Compaction also increases soil resistance to root penetration, thus limiting the volume of soil available for root exploitation.
- Accelerated soil erosion leads to the removal of surface soil material and increased sedimentation of surface waters.



Some of these impacts (such as the development of roads, landings and skid trails) are an unavoidable consequence of forest access and utilization. These guidelines are intended to minimize negative impacts to soil productivity and ensure the continued sustainability of forest management in Minnesota.

When planning forest management activities, prevention of negative impacts is more desirable than correcting impacts after they have occurred. Mitigation of impacts to the soil after they have occurred can be costly and may not be very effective. It is more effective to prevent impacts from occurring than to resort to such mitigation measures as deep subsoiling, constructing erosion control devices, fertilization or filling in ruts.

Pre-planning and on-site soil investigations are good tools for avoiding negative soil impacts. Soil conditions should be evaluated to determine suitable species, preferred seasons of operations, and preferred site preparation and regeneration techniques.

For example, soils susceptible to severe compaction or rutting under expected climatic conditions should be identified as requiring harvest under frozen ground conditions or with specialized equipment.



Consider how climate change impacts may influence forest soil productivity and operability.

Predicting the operability of a site will help protect the site, as well as save operators from the costly process of moving equipment off a site after discovering that negative impacts are occurring. If unique weather conditions occur or specialized equipment is available, these soils may be operable under non-frozen conditions.

Applying Guidelines to Varying Site Conditions

Forests in Minnesota grow on a wide variety of soils and site conditions:

- **Hundreds of different "soil types" have been identified** in the forested portions of Minnesota. These soils include deep organic soils in peatlands; shallow

soils over bedrock; dry sandy soils formed in outwash or beach deposits; deep moist loamy and clayey soils formed in rolling glacial till; and poorly drained fine loamy and clayey soils formed in level lake plains.
- **Topography also varies greatly** in Minnesota forest regions, from steep long valley slopes in the southeast to nearly flat lake plains or short steep irregular slopes of the northern forests. Each site presents unique conditions and opportunities.

Because of the great variety of soils and site conditions in Minnesota's forested areas, it is impossible to develop guidelines that cover every situation. These guidelines are intended as a set of general recommendations to be applied to forest management in Minnesota.

Because site conditions vary, it is very important that individuals making forest management decisions evaluate the soil conditions on the site they are considering. Specific soil conditions will allow the manager to develop specific prescriptions for a given site that will ensure that the productive capacity of a site is not reduced due to forest management.

Soil Characteristics and Potential Impacts

Three Related Groups of Soil Characteristics

These guidelines refer to physical, chemical and biological aspects of soils. These three characteristics are closely interrelated, and impacts on one aspect may influence others:

- The physical properties of soil include such factors as soil texture, structure, porosity, soil density, drainage and surface hydrology.

- The chemical properties of soil include nutrient status (inputs and outputs) and pH.
- The biological properties of soil include the multitude of organisms that thrive in soil, such as mycorrhizae, other fungi, bacteria and worms.

Because of the nature of forest management activities in Minnesota, the risk or significance of impacts to soil properties appears to be highest for physical properties, followed by chemical properties, and finally by biological properties.

For example, in Minnesota, forest management sites with reduced growth because of nutrient loss due to timber harvesting are relatively uncommon, while sites that have suffered due to physical impacts are more common. Impacts to physical characteristics also appear to be more long lasting.

In addition, it appears that, if care is taken not to negatively impact the physical and chemical properties of the soil, then the biological aspects take care of themselves. However, if a soil is severely compacted, then forest plants cannot utilize nutrients because of the poor physical rooting environment, and the soil organisms responsible for nutrient cycling are limited as well.

Physical Characteristics of Soil and Potential Impacts

Soil physical properties include soil texture, structure, porosity, soil density, drainage and surface hydrology. These properties are very important in influencing what plants can grow on a site and how well they grow.

The physical soil properties determine the ease of root penetration, the availability of water and the ease of water absorption by plants, the amount of oxygen and other

gases in the soil, and the degree to which water moves both laterally and vertically through the soil.

Soil Compaction

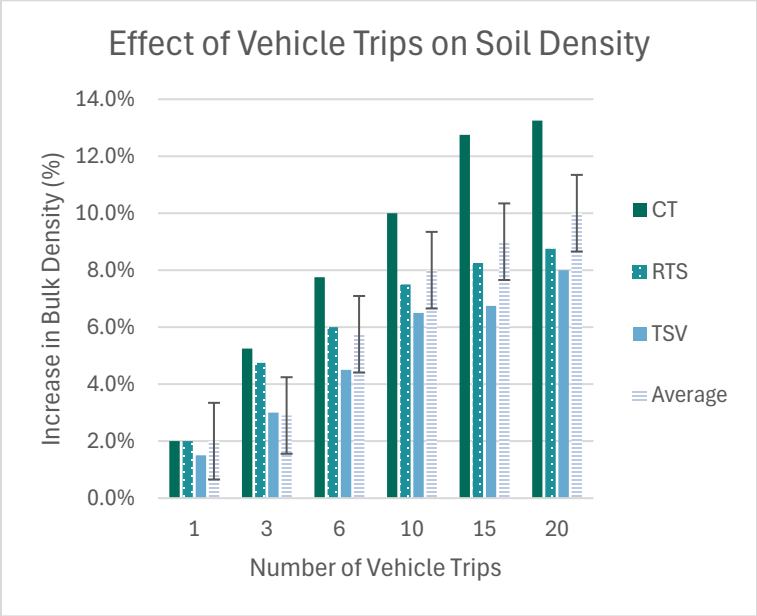
According to Jaakko Pöyry (1992), “Soil compaction is one of several types of closely related physical soil disturbances that can occur during timber harvesting and forest management activities. The other types of physical soil disturbance include puddling, rutting and scarification. These disturbances often occur simultaneously and are almost exclusively caused by:

1. Trafficking by heavy equipment during felling, forwarding, skidding and site preparation operations
2. The dragging action of logs as they are moved from the stump to the landing
3. Slash disposal and the creation of planting or seeding sites during site preparation

“It is difficult to distinguish between each type of disturbance in terms of their effect on site properties, and all of these disturbances are often referred to generically as soil compaction.

“Soil compaction is the increase in soil density resulting from loads applied to the soil surface. During the compaction process, soil volume is decreased primarily through the elimination of macropores (pores > 0.002 inches in diameter). Pore volume and pore size are key properties that govern gas and water relations in the soil. Because of their relatively large diameter, macropores are particularly important in regulating the rates of water and gas movement.”

Figure S-1



Effect of vehicle trips on soil density (adapted from Froehlich et al., 1980). Values provided relate to the impact of successive trips by various logging vehicles (CT = crawler tractor, RTS = rubber-tired skidder, TSV = torsion suspension

The first few trips (with heavy equipment) over the soil surface produce the greatest increase in soil density. A large percentage of the increase in soil density occurs during the first six trips on some soils (Froehlich et al 1980). (See Figure S-1.) Machine vibration may also contribute to compaction.

Recovery of compacted soil is variable depending on the severity of the compaction and local conditions. Most studies, however, indicate that recovery from compaction and its effects is long term rather than short term.

Severely compacted soils may require up to 40 years or more to recover naturally, according to Hatchell and

Ralston (1971). Froehlich and McNabb (1984) state that "...the effects of soil compaction should be assumed to persist for several decades on forest sites."

Even in cold climates, where the action of freezing and thawing presumably loosens soils quickly, the density of compacted soils decreases slowly (Voorhees 1983 and Corns 1988). In an ongoing study in Minnesota and the Lake States (Stone and Elioff 1998), no reduction in soil density has been measured 5 years after intentional compaction.

"Soil compaction affects site quality and tree growth through its effect on the rooting environment. Reduced aeration significantly decreases the respiratory activity of plant roots and their capacity to supply the plant with adequate moisture and nutrients" (Jaakko Pöyry 1992).

"Compaction also increases soil strength, which reduces root growth by increasing soil resistance to root penetration. The decrease in porosity associated with compaction also reduces soil infiltration capacity or the rate of water movement in the soil. In addition to reducing the amount of soil water available for plant growth, slower infiltration capacities result in increased amounts of over-land flow, which can lead to increased erosion rates" (Jaakko Pöyry 1992).

Rutting



Rutting is the creation of depressions made by the tires of vehicles such as skidders, log trucks and pickup trucks, usually under wet conditions. Rutting occurs when the soil strength is not sufficient to support the applied load from vehicle traffic. The risks of rutting occurring may increase due to climate change, specifically changes in precipitation

patterns and freeze-thaw cycles. A few examples of the effects of rutting:

- Rutting affects the surface hydrology of a site as well as the rooting environment. The process of rutting physically severs roots and reduces the aeration and infiltration of the soil in the rut itself, thereby degrading the rooting environment.
- Rutting also disrupts natural surface water hydrology by damming surface water flows, creating increased soil saturation up-gradient from ruts, or by diverting and concentrating water flows, creating accelerated erosion.
- Soil rutting is also an important indication that other physical soil impacts may be occurring on a site.

Protecting Soil Resources

Timing of forest management activities, development of infrastructure, and selection of equipment and operating techniques are all critical components contributing to the effectiveness of forest management activities, as well as the protection of the soil resource. It is important to avoid operating heavy equipment on a site when adverse soil impacts are likely, and to limit direct trafficking of a site to the smallest area possible.

The susceptibility of soil to compaction and rutting is primarily dependent on soil texture and moisture content. Soils are most susceptible to compaction, puddling and rutting during spring/early summer months, immediately following heavy rains, and in the fall after transpiration has ceased and before freeze-up.

Soils most susceptible to compaction and rutting include fine-textured soils (silty clay, sandy clay and clay) and medium-textured soils (fine sandy loam, very fine sandy loam, loam, silt loam, silt, silty clay loam, clay loam, and sandy clay loam). Poorly and very poorly drained soils of



any texture are susceptible to compaction and rutting during most years when not frozen.

The preferred operating season for any one site may vary depending on local climatic conditions, equipment being used and operating techniques. The use of low ground pressure (LGP) equipment and such operating techniques as the use of slash mats to drive on can extend operating seasons on low-strength soils. Infrastructure, such as roads, landings and skid trails, directly impacts the soils that it is developed on; therefore any reduction in the area occupied by infrastructure reduces the impact to soil productivity. For more information on how to obtain soil interpretations relating to equipment operation, see *Resource Directory.*

Peatland Timber Harvests

Peatlands are a unique ecosystem producing valuable wood products. These soils pose specific management concerns and harvesting issues, including low soil strength and low nutrient status.

Typically, these sites are harvested when soils are frozen. New technologies and equipment allow harvesting on these sites under non-frozen conditions with minimal impact. LGP equipment, including eight-wheeled tracked forwarders, portable artificial mats, natural slash mats and cable logging systems, are all options for completing

harvesting with an impact on soil productivity that is similar to conventional winter harvest methods.

These technologies are especially suitable for shallow organic soils adjacent to high land (likely to a maximum of 500 feet) and on pockets of organic soils within highland soils. Timber harvesting on deep peat soils under non-frozen conditions in large peatlands is not practical because of low soil strength and lack of truck access.

Soil Erosion

Soil erosion is another type of physical soil impact that can occur as a result of soil disturbance during timber harvesting, site preparation and other forest management activities. Soil erosion is the process by which soil particles are detached and transported by water, wind and gravity to some downslope or downstream point. Erosion is a natural process. Increased erosion that occurs due to human activity is considered to be accelerated erosion.

Almost all accelerated erosion on forested lands in Minnesota follows major disturbances that increase the exposure of soil to water (Patric and Brink 1977, as cited in Jaakko Pöyry 1992). Several factors can influence the rate of soil erosion on a site: rainfall intensity and duration, slope steepness and slope length, erodibility of the soil on the site, and soil cover (overstory and surface cover) (Dissmeyer and Foster 1980).

When all other factors are held constant, surface erosion rates increase with increasing rainfall intensity, increasing slope steepness, and increasing slope length (Jaakko Pöyry 1992). Perhaps the greatest factor controlling surface erosion in forests is the amount of vegetative cover and forest litter protecting the soil surface (Megahan 1990, as cited in Jaakko Pöyry 1992).

Soils with the highest inherent erodibility contain high proportions of fine sand and silt, low amounts of soil organic matter, and slow permeability. Table S-1 shows the relative erodibility hazard for different soil textures. Extra care should be taken on silt, silt loam, loam, very fine sandy loam, sandy clay loam, silty clay loam and clay loam soils, as these soils tend to erode easily when disturbed or exposed, especially on long slopes or slopes greater than 10%.

According to the 1994 Generic Environmental Impact Statement Study on Timber Harvesting and Forest Management in Minnesota (GEIS), the greatest erosion rates in Minnesota were estimated to occur in southeastern Minnesota. The potential for erosion in this part of the state is approximately two to three times the estimated rates of the rest of the state. This landscape has the steepest slopes (averaging 45% in many areas), and the southern portion of the state also has the highest rainfall intensity (Jaakko Pöyry 1994).

Table S-1

Soil Erosion Susceptibility of Texture Classes

Surface Soil Texture	Susceptibility to Erosion
Silt, silt loam, loam, very fine sandy loam	1 (highest)
Sandy clay loam, Silty clay loam, clay loam	2
Clay, silty clay, sandy clay, very fine loamy sand, fine sand loam	3
Sandy loams	4
Loamy sands, sands	5 (lowest)

Dry washes are created by erosion and are commonly found in southeastern Minnesota. They are generally found on bluffland slopes too steep to farm. These blufflands are characteristically forested, often containing valued timber species (e.g., oak species, black cherry). Dry washes are generally described as ephemeral streams that exhibit a bank and bed with an incised, often V-shaped gully having a coarse rubble or bedrock bed. The dry wash receives precipitation directly to help initiate flow or indirectly as surface runoff from an immediately adjacent agricultural field or grazed slope. Water flows only for short durations with little to no water contributed by springs or seeps. The two major issues with dry washes are the control of excessive agricultural runoff at the head of the dry wash and stabilization of the banks and bed within the wash.

Soil erosion impacts the long-term productivity of a soil by removing nutrients and surface soils (which contain a high percentage of nutrients and water-holding capacity of soil). This eroded material (sediment) is then deposited on top of downslope soils, covering up richer surface soils with less productive material.

Erosion on skid trails and roads reduces the ability of the soils in the trail or road to revegetate. It also tends to create a poor transportation system that encourages the creation of more trails and roads to replace the eroded ones.

Accelerated erosion is caused by forest management activities that result in the following:

- Removal of vegetation and litter, or disturbance of surface soil, which exposes mineral soil to rain and water
- Soil compaction, which decreases the rate of water infiltration into the soil
- Concentration of surface runoff (Jaakko Pöyry 1992); areas of soil disturbance, such as roads, landings, skid trails, fire lines and site prep areas, can all create soil erosion problems

For timber harvest areas, the GEIS suggests that mitigation strategies be concentrated around forest roads, skid trails and landings. If the guidelines for reducing compaction and related disturbances are followed, erosion will be reduced. Soil compaction, puddling, rutting and scarification decrease the rate of water movement into the soil, which increases overland flow, channels and concentrated runoff, and reduces protective surface cover (Jaakko Pöyry 1992).

One of the most effective means of reducing erosion is to reduce the volume, velocity or distance of travel that water flows down a road, landing or skid trail. Information on water diversion devices for reducing volume, velocity and direction of flow is available in the Forest Roads section of the FMGs.

Chemical Characteristics of Soil and Potential Impacts

Soil chemical properties include nutrient status of a soil and soil pH. Soil chemical characteristics are influenced by many things, including soil origin, soil texture and drainage, degree of soil weathering and development, and organic matter type and content. These characteristics vary widely in Minnesota's soils. Forest management affects the nutrient status of a soil/site through 1) removal of nutrients in forest products and 2) disturbance of surface soils through harvesting and site preparation activities.

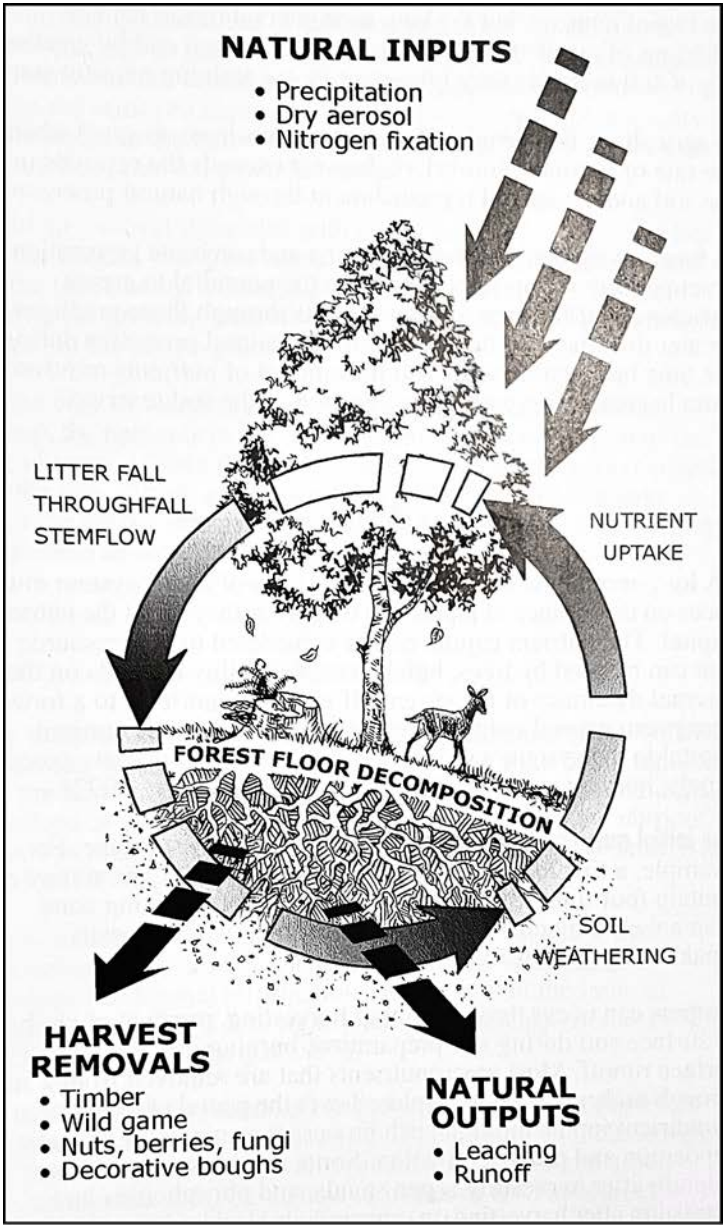
Nutrient Cycling

Nutrient cycling is the process by which nutrient elements move into, out of, and within an ecosystem. The forested ecosystem in Minnesota receives natural inputs of nutrients through atmospheric deposition and geologic weathering. See Figure S-2.

Through the life of a stand, these inputs can be significant. Outputs of nutrients occur through timber harvesting or other practices (such as site preparation) and through soil leaching and surface runoff (Jaakko Pöyry 1992).

In Minnesota and adjoining areas, nutrients that are of primary concern for forest growth are nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg). Complete understanding of nutrient use and sustainability requires not only knowledge of the amount of nutrients removed during the harvest (or through poor site preparation techniques), but also knowledge of the nutrient capital of the soil and the rates of natural additions and losses of these nutrients.

Figure S-2 Nutrient Cycling



In contrast to the annual harvests associated with agriculture, forest harvest—and hence nutrient removal—typically occurs only once per rotation or every 40 to 120 years. This not only reduces the rate of removal, but the long-time interval makes natural additions of nutrients by atmospheric deposition and by weathering of soil minerals very important in maintaining nutrient status.

In agriculture, deficiencies of macronutrients have occurred when the rate of nutrient removal via harvest exceeds the reserves in the soil and the annual replenishment through natural processes.

In forest ecosystems, timber harvesting and some site preparation practices remove nutrients and have the potential to create deficiencies if the removal of nutrients through these practices is greater than the replenishment through natural processes during the time between harvests and the amount of nutrients removed from harvest represents a large portion of the soil reserves.

The Balance of Inputs and Outputs

“A long-term view of forest nutrient status of an ecosystem must focus on the balance of inputs and outputs as they affect the nutrient capital. The nutrient capital can be considered to be a resource that can be used by trees, but whose availability depends on the internal dynamics of the system. If inputs of nutrients to a forest ecosystem exceed outputs from that system, then the nutrient capital in the system will increase. Conversely, if outputs exceed inputs, nutrient capital will decrease” (Jaakko Pöyry 1992).

The initial nutrient capital of a site varies widely by soil type. For example, a fine loamy soil formed in lacustrine sediment may contain four times the amount of calcium in the rooting zone than a well-drained sandy soil formed in outwash deposits (Jaakko Pöyry 1992).

Outputs can occur through timber harvesting, removal of slash or surface soil during site preparation, burning, leaching or surface runoff. Most macronutrients that are removed from a site through timber harvest are replaced over the period of the rotation by nutrient inputs through such processes as precipitation, dust deposition and nitrogen fixation. Some notable exceptions are calcium after harvesting aspen stands, and phosphorous and potassium after harvesting on organic soils (Jaakko Pöyry 1992).

Different nutrients are stored in different parts of a tree, and different tree species store the nutrients in different relative abundances throughout the tree. For example, aspen utilizes a relatively high amount of calcium and stores roughly 50% of the calcium in the bole-wood and bark of the tree. Because nutrients that are contained within the harvested portion of a tree are removed from a site, species that store high amounts of nutrients in the bole-wood and bark result in higher amounts of nutrient removed when harvested.

Nutrient removal associated with timber harvest is very dependent on the species being harvested and on the components, or parts of the trees, being removed. For example, a full-tree harvest during the growing season will remove virtually all the nutrients stored in the above-ground part of the trees.

In the case of merchantable bole harvest, with limbing at the stump, the nutrients in the crown and in the upper portion of the woody stem (above the merchantable top diameter) are retained on the site. If trees are skidded to a landing before limbing, then the nutrients in the crown are removed from the actual site of growth as well (Jaakko Pöyry 1992).

Mineral Soils

An analysis of data that were available at the time of the GEIS indicated that, on some sites, some nutrients were being removed by the harvest at a greater rate than the rate of natural additions (defined as mining by the GEIS). On mineral soils, the nutrient that was most often of concern was calcium; other nutrients were seldom lost at greater rates than additions.

This caused concern about the relationship of calcium loss to sustainability of forest production. Recent studies have produced additional information indicating that the issue of calcium depletion is less significant than indicated in the 1992 GEIS (Wilson and Grigal 1995).

In summary, the mineral soil sites for which nutrient depletion may become a concern after two or three rotations include aspen (or other hardwoods) on well-drained sandy soils and aspen (or other hardwoods) on shallow (8 inches or less) to bedrock soils.

Aspen grow poorly on these soils, and are often termed “off-site aspen.” A rational management strategy for these sites is conversion to pine (red or jack pine) where appropriate. Both pines are more productive on these sites, and they demand much less calcium. On other upland sites, nutrient depletion is usually not an acute problem, but one that can be further studied and dealt with in the future without affecting sustainability.

Other nutrient-retention strategies for these sites include the following:

- Retaining or redistributing slash on the site
- Avoiding full-tree harvesting or full-tree skidding that piles slash without redistributing it
- Addition of nutrients to the site
- Avoiding shortened rotations

Many modern harvesting systems require full-tree skidding for efficiency of the operation. In these situations, slash can be redistributed out to the site from the landing. Caution should be exercised during non-frozen seasons to avoid trafficking additional areas while redistributing slash. The negative effects of soil compaction due to increased trafficking could outweigh the positive benefits of redistributing slash. It may be advantageous to leave clumps of slash (drags left along skid trails) or leave slash in the skid trails.

Organic Soils

Most deep organic soils in Minnesota (soils with greater than 24 inches of organic surface) contain a relatively low amount of phosphorus (P) and potassium (K) in the rooting zone of the organic soil surface. Deep organic soils do not have a nutrient input of mineral weathering to replenish nutrients; instead, these soils depend solely on atmospheric deposition.

Black spruce is the major species harvested on peatland soils, and many harvesting techniques remove the full tree from the site, including branches and needles. In the case of organic soils, available evidence indicates that this removal of the full tree leads to removal of a large proportion of the potassium and a relatively large proportion of the phosphorus from the site.

Rates of replenishment for P and K are low; about 100 years are required to rebuild K reserves to their original level after harvest.

Removal of only the woody bole and associated bark does not lead to these large losses of potassium and phosphorus. Thus, full-tree harvest may be inappropriate without corrective measures such as fertilization. Site preparation techniques that pile or windrow slash result in a similar removal of nutrients from the general area of a

site. These practices have an effect similar to full-tree harvesting.

Mechanical Site Preparation

Many mechanical site preparation techniques involve the disturbance, redistribution and possibly the removal of surface soils. The surface horizons of most forest soils are very important to the productivity of the soil. These horizons are rich in organic matter; they contain the bulk of the soil's nutrient and moisture-holding capacity; and they provide a source of mychorrizae. Surface horizons also cushion soil from traffic and buffer extremes in temperature. Severe treatments that remove or displace the surface organic and mineral soil layer may result in nutrient removal and other site degradation, such as soil erosion and compaction.



It is important to remove the surface soil as little as possible from the immediate area of the seedling. Practices that remove surface soil from the general vicinity of a seedling (such as dozing soil into windrows) should be avoided, as these practices remove the many benefits of surface soil from the area utilized by a seedling.

The removal of surface soil is exaggerated with extremes of soil types. In other words, coarse dry soils and wet fine soils, or soil shallow to bedrock, are most likely to be severely impacted from surface soil removal. "Extremely shallow soils have a limited store of nutrients and are sensitive to disturbance, as are coarse-textured, excessively well-drained soils, whose limited nutrient

reserves resides principally in the surface organic layer and in logging debris. Any treatment of such sites should retain as much of the organic layer and any logging debris as possible or mix the organic and mineral layers together" (Sutherland and Foreman 1995).

Slash provides shelter that mediates climatic extremes and contributes organic matter (nutrients and water-holding capacity) to forest soils. Although slash may create some hardship when planting a site, windrowing or piling of slash should be avoided, and **scattering of slash should be encouraged.** This is particularly important on coarse droughty soils.

According to the forest soils technical paper of the GEIS (Jaakko Pöyry 1992): "There is virtually no justification, from the standpoint of nutrient status, for use of any site preparation technique that displaces material. Site preparation techniques that incorporate materials (such as disking) or only displace materials short distances (such as the Brakke scarifier) do not have negative impacts on nutrients."

Prescribed fire is used to reduce slash for ease of planting, setting back or killing competing vegetation, or exposing mineral soil for seeding. "Hot" slash burns on dry sandy soils have the potential to reduce soil productivity by consuming the forest floor, which reduces the water-holding capacity of these sites, volatilizes some nutrients, and makes nutrients rapidly available to plant uptake, runoff or leaching.

Biological Characteristics of Soil and Potential Impacts

Biological characteristics of soil include the population of plants and animals that thrive in a particular soil, including microflora (fungi, bacteria, algae) and microfauna (worms,

arthropods, protozoa). Forest soils contain a multitude of microorganisms that perform many complex tasks relating to soil formation, slash and litter disposal, nutrient availability and recycling, and tree metabolism and growth. Generally the number of organisms are greatest in the forest floor and the area directly associated with plant roots (Pritchett 1979).

The population of soil organisms (both density and composition) and how well that population thrives is dependent on many soil factors, including moisture, aeration, temperature, organic matter, acidity and nutrient supply (Pritchett 1979).

These physical and chemical soil characteristics are influenced by forest management as previously indicated. Impacts to these soil properties may directly impact the soil biology, thereby impacting the functions of the organisms, many of which are beneficial to plant growth. Implementation of practices that protect the physical and chemical properties of the soil, also protect the “habitat” of the soil organisms and result in sustaining these populations.



Enhancement of Soil Productivity

In addition to guidelines to mitigate against potential negative impacts to soil productivity, opportunities exist to enhance soil productivity. In these guidelines, the term enhancement is defined as improving the current

productive potential of a site or fully expressing the productive capacity of a site.

To sustainably meet society's need for forest products and other amenities of the forest, intensive management of a portion of the forest resource may be necessary. The following section describes some of the available options to improve productivity.

Fertilization

Fertilization is often used in agriculture to improve outputs of a particular crop and maintain productivity. In forestry, opportunities exist to increase fiber outputs through fertilization.

Limited research has been done on fertilization of species common in Minnesota. Recommendations for forest fertilization need to be better refined in order to understand situations in which this practice is biologically beneficial and economically effective.

Generally speaking, returns on investment in forestry are greater when made on sites closer to markets, due to transportation costs. Fertilization treatments made later in the rotation have the benefit of reducing carrying costs of money and increasing growth when trees are adding merchantable volume.

Detailed nutrient analysis of the soil and fertilizer should be done before application. Water quality guidelines related to pesticides use should be followed when applying fertilizers.

Genetic Improvement

Capturing a site's potential can often be improved by using improved genetic material. In Minnesota, seed orchards have been developed through concentrated cooperative breeding efforts over the past 20 years. These efforts have

been focused on improving growth, tree form and insect and disease resistance.

Seedlings grown from improved seed are available commercially. Currently the most widely planted species in forested environments are Norway (red) pine, jack pine and white spruce. These species have different opportunities for improved growth. For example, Norway (red) pine has a narrow genetic variability, whereas jack pine has a wide genetic variability.

Shortened Rotation

On those sites where nutrient depletion is not a concern, it may be possible to increase fiber production by reducing rotation age. Given the age distribution of Minnesota's forest resources, capturing production of a portion of these stands may be useful to stabilize the flow of available timber in the future. Feasibility of reducing rotation age will depend on several factors, including end-product, harvesting equipment and nutritional status of the site. Research is needed to better understand the ramifications of reduced rotation on other site factors and to develop guidelines for identifying sites on which reduced rotations could be implemented.

Preventing Flooding

In some cases, increases in tree growth are possible through maintenance of proper drainage. Maintaining proper drainage may include controlling beaver populations to prevent flooding of forested areas and maintaining natural drainage, where consistent with landowner and landscape objectives.

Bedding, mounding and other site preparation methods that modify microsite conditions for tree establishment may also be beneficial for tree growth on saturated soils. These techniques are effective in improving aeration in the root

zone immediately after planting, thereby improving early tree growth and survival. It is important on these sites to plant and manage species suitable to the poorly drained conditions.

Competition Control

Controlling competing vegetation has significant positive effects on survival and growth of trees. Various methods, including herbicide use, should be used to control competing vegetation early in the rotation to achieve maximum fiber productivity.

Thinning/Timber Stand Improvement

Commercial and pre-commercial thinning may be useful to capture the productive capacity of a stand. Thinning concentrates growth on fewer stems, thereby increasing the recovery of usable fiber. In addition, thinning can have the effect of shortening rotations by increasing the growth rate of individual trees, thus producing larger trees at an earlier age.

Thinning also allows selection of the most desirable trees in a stand on which to concentrate volume growth. This technique has the effect of increasing the overall value of the stand and presenting the opportunity to provide higher economic returns to landowners by increased product value at an earlier age.

Species/Site Matching

Matching the appropriate species to specific site conditions has the ability to increase forest productivity. For example, aspen growing on coarse-textured soils (“off-site”) may decrease the nutrient capital of these sites over time and produce lower yields compared to other species. To increase productivity on these sites, pine species will

generally be a more efficient species, both from the perspective of fiber production and nutrient conservation.

Riparian Areas

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The Value of Riparian Areas

A Transition from Aquatic to Terrestrial Ecosystems

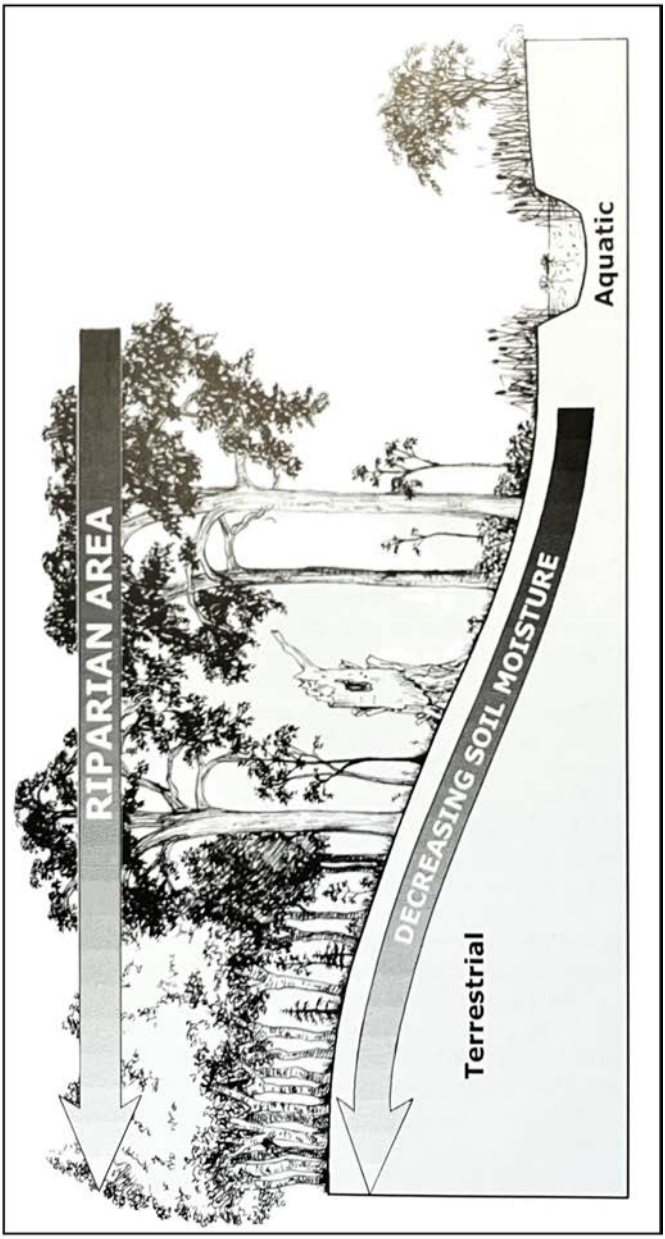
A **riparian area** is the area of land and water forming a transition from aquatic to terrestrial ecosystems along streams, lakes and open water wetlands. See Figure RMZ-1.

Riparian areas are among the most important and diverse parts of forest ecosystems. They support high soil moisture and a diversity of associated vegetation and wildlife, and they perform important ecological functions that link aquatic and terrestrial ecosystems:

- Riparian areas maintain streambank, channel and shoreline stability, stream temperature and water quality.
- Riparian areas provide water storage and conservation, nutrient and food input to the aquatic system, instream structure of coarse woody debris, and a moderated micro-climate.
- Riparian areas also provide important habitat for many species of fish, mammals, birds, reptiles, amphibians and insects.
- Riparian areas are also important for recreation, tourism, forest products, hunting, fishing, biological diversity and other human values they provide.

To protect the functions and values of riparian areas, riparian guidelines recommend specific riparian management zones (RMZs) for streams, lakes and open water wetlands. These RMZs are applied in the portion of the riparian area where site conditions and landowner objectives are used to determine management activities that address riparian resource needs.

Figure RMZ-1: Terrestrial Habitat in a Riparian Area



Protecting Riparian Functions and Values

The purpose of these voluntary guidelines is to protect riparian functions and values by minimizing the potential adverse impacts of forest management. These functions and values include:

- Timber production
- Moderation of riparian microclimates caused by canopy shade (including water temperature and soil temperature)
- Bank, channel and shoreline stability
- Recruitment of coarse woody debris
- Biological diversity and important habitat features essential to maintaining biological diversity
- Resiliency to natural catastrophes

Impacts that may occur during forest management activities can affect the functions associated with riparian areas. Some of the issues and concerns associated with conducting forest management activities within forested riparian areas have been summarized (Laursen 1996).

For example, timber removal may increase water and sediment yields, leading to stream channel destabilization and loss of aquatic habitat. It may also decrease woody instream cover, destabilize streambanks, reduce shading, increase water temperatures, reduce inputs of fine litter to the water body, and reduce the diversity of plants and animals in the area. Destabilized and damaged banks are important sources of sediment input that reduce water quality and fish habitat. Also, road crossings may add sediment and cause bank failures.

From a landscape perspective, managing a greater proportion of the riparian area for uneven-age mixed stands of longer-lived species suitable to the site can help protect riparian functions and values.

Forested riparian areas perform important ecological functions that link aquatic and terrestrial ecosystems. They are also highly valued by humans because of the wide array of products and services they provide. These beneficial functions and values include the following:

- Maintaining soil, channel and streambank stability, stream temperature and water quality
- Providing water storage and conservation
- Providing nutrient and food input to the aquatic system
- Providing instream structure of coarse woody debris
- Providing a moderated microclimate
- Providing diverse and productive habitat for aquatic and terrestrial wildlife, habitat continuity and travel corridors for wildlife, and support of unique habitats and communities
- Providing for recreation, tourism, forest products, hunting, fishing, biological diversity and other human values

The Importance of Riparian Areas

Retaining vegetation, including trees, within riparian areas is key to maintaining functional linkages between the terrestrial and aquatic ecosystems, including the following:

Retaining Nutrients and Sediment and Maintaining Water Quality

Riparian vegetation plays a very important role in retaining nutrients, sediment and organic matter. Intact riparian vegetation also acts as a very effective filter to maintain or improve water quality.

Within the riparian area, the vegetation traps suspended material and slows the water velocity, allowing sediment to settle out. It also slows downslope movement of leaves and branches, providing time for their decomposition and the recapture of nutrients before they reach the water

body. Plants that are near the water's edge absorb nutrients directly from the water.

Wildlife Habitat

Riparian areas have high plant diversity, both horizontally and vertically from the water's edge, which contributes to the high diversity of plants and animals that live in these areas. Frequently the most species-rich habitats to be found in a landscape, riparian areas provide critical corridors linking favored wildlife habitats.

The species that are of most concern in riparian areas are "obligate" species, which require both the water and surrounding forests as habitat. In Minnesota, obligate riparian species include 32 reptile/amphibian species, 20 bird species and 15 mammal species. Numerous plant and invertebrate species (such as salamanders) are also strongly associated with these habitats. Those species are found only in these areas or spend critical portions of their life cycle there.

Inputs of Coarse Woody Debris and Fine Litter

Coarse woody debris helps to create and maintain pools, reduces stream velocities, forms eddies where food organisms are concentrated, supplies protection from predators, provides shelter during winter runoff, and traps and stores small debris from the forest. It also traps smaller debris, which then traps fine debris, sediment and organic matter and can lead to natural levee formation.

The fine litter formed by the breakdown of decomposing plants, leaves and animals serves as the energy base for the aquatic food chain. Future sources of decay-resistant coarse woody debris can be maintained by actively managing for large-diameter conifers.

Maintaining Moderate Temperatures through Shading

Small increases in air and water temperatures may lead to changes in the composition and growth of fish, aquatic insect and riparian species. Riparian vegetation, particularly the vegetation overhanging or shading the water's surface, regulates water temperature. Shading away from the water's edge helps to minimize the warming of overland surface water flows before they reach the water body.

Bank, Channel and Shoreline Stabilization

Roots and rhizomes of riparian vegetation stabilize and reinforce the banks and shorelines of streams, lakes and open water wetlands. Roots proliferate into fresh sediment deposits, helping to stabilize them. In addition, root systems allow the formation of overhanging banks, which provide excellent habitat for aquatic organisms.

Riparian Area Importance

Riparian areas were important to society's prehistoric ancestors and are no less so to modern society, if for somewhat different reasons. Because hunting and gathering cultures of the past used riparian areas extensively as places to live and obtain food, cultural resources are often located there.

Today, the water's edge is recognized as an important resource for a variety of reasons, including spiritual values, aesthetics, wood products and recreation.

Variability of Riparian Functions

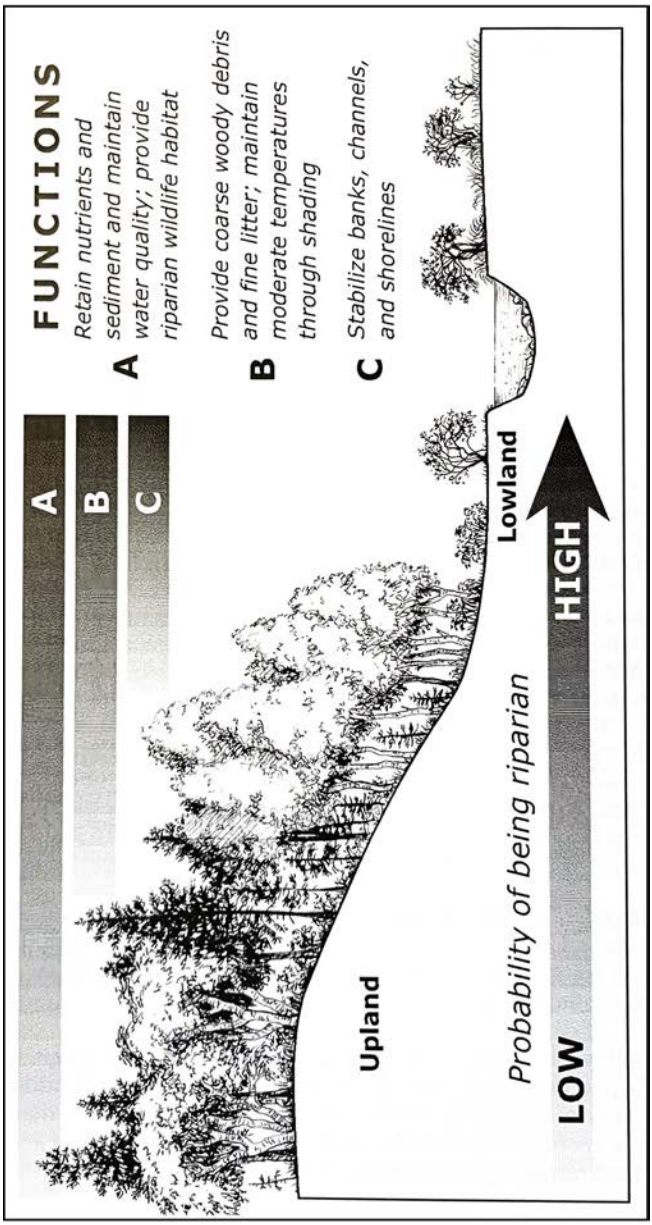
The functional importance of riparian areas varies in type and degree due to their variability in hydrological, topographical and vegetational condition. For example, the

riparian area of a lowland black spruce or black ash forest is very different from that of an upland aspen or northern hardwood forest. Similarly, the riparian area associated with a wide swampy floodplain is very different from the riparian area of a stream that has a steep bank adjacent to it.

For this reason, it is difficult to arrive at definitive numerical widths to define the riparian management zone (RMZ), as each riparian area is unique and the management zone chosen will vary in width depending on site conditions and landowner objectives.

It may also be difficult to know where some riparian functional linkages cease to exist, such as the movement of soil in water to a stream or the extent of terrestrial wildlife habitat. Not all riparian functions are equally important at all distances from the water. **The probability of a forest serving a riparian function decreases as the distance from the water's edge increases.** At some distance from the water's edge, the likelihood of a location having any riparian function at all is very low. See Figure RMZ-2.

Figure RMZ-2: Relationship of Riparian Function and Distance from Water's Edge



The Riparian Management Zone: Minimizing Adverse Impacts on Riparian Areas

Riparian management zones (RMZs) are areas of special concern along streams, lakes and open water wetlands. They are intended to retain relatively continuous forest cover for the protection and maintenance of aquatic and wildlife habitat, aesthetics, recreation and forest products. Within the RMZ, management activities should be modified through RMZ guidelines to minimize potential adverse impacts.

For example, it is important to keep slash out of intermittent streams where flash flooding will move the excess debris downstream. Additionally, an RMZ should be designed to minimize blowdown of residual trees. This requires consideration of site characteristics (such as exposure to wind, species and soil moisture) as well as the width and residual basal area.

The recommended minimum RMZ widths in *General Guidelines* Table GG-2 provide general guidance for most water quality, aquatic and wildlife habitat protection, and aesthetic objectives.

Landowner interest in increasing the functional effectiveness of riparian areas or considering larger landscape implications of their management actions may result in wider RMZs than those recommended in the guidelines. Consultation with a natural resource professional may help in making these decisions

The Need for Monitoring and Research

There is a need to intensively monitor and to carry out research to determine the effectiveness of riparian management zone guidelines and their ability to accomplish their intended objectives.

While the guidelines are based on the best available scientific information and compromise, most of the research studies that form the basis for discussion were conducted in other regions of the country. Considerable research in Minnesota is needed on riparian areas due to the lack of data specific to landforms, water bodies and forest cover types found within the state.

The types of site-specific research that would be beneficial for Minnesota's conditions include assessments of the following:

- **How leaving varying amounts of residual basal area** after timber harvesting within riparian forests may affect such factors as the composition, growth and productivity of the residual forest and biological diversity
- **How leaving large dead trees on the ground** after timber harvesting within riparian forests may affect such factors as the composition, growth and productivity of the residual forest and biological diversity
- **How varying levels of riparian forest reserves** (including residual basal area, crown closure and width of the riparian management zone) may, over time, affect such factors as bank stability; reduction in overland flow of sediment; ability to remove chemicals (including nitrogen and phosphorus) from overland flow; maintenance of moderate water temperatures

through shading; provision of coarse woody debris; and the production of fine litter

Other Considerations

- Guidelines for skid trails established as part of water quality and wetland guidelines are appropriate for use when operating within the RMZ. See *Timber Harvesting: Skidding and Skid Trails, and Timber Harvesting: Water Quality and Wetlands.*
- The term “shade strip” (as referenced in *Protecting Water Quality and Wetlands in Forest Management*) is not used in this integrated guidebook. Instead, the term “riparian management zone (RMZ)” should address all of the functions and values (including water temperature) that were formerly associated with shade strips.
- Leaving some super-canopy trees and other long-lived species in the RMZ should be a consideration. If possible, choose trees from the “Excellent” category of Table GG-3: Leave Tree Preferences for Longevity, Windfirmness and Cavity Potential in *General Guidelines: Retaining Leave Trees*.

This approach will provide habitat for riparian species that require large super-canopy trees (trees above the existing mature canopy) for hunting perches and nesting sites. (The “excellent” species recommended are white pine, oaks, elms, ashes, sugar maple, yellow birch and basswood.)

Selected Resources for Additional Information

At the Water’s Edge: The Science of Riparian Forestry. Conference Proceedings. 1996. S. B. Laursen (ed.) Minnesota Extension Service, St. Paul, Minnesota. 160 pages.

Biodiversity: A Background Paper for a Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota. 1992. Jaakko Pöyry Consulting, Inc., Tarrytown, New York. 109 pages.

Final Generic Environmental Impact Statement Study on Timber Harvesting and Forest Management in Minnesota. 1994. Jaakko Pöyry Consulting, Inc., Tarrytown, New York.

Forest Wildlife: A Background Paper for a Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota. 1992. Jaakko Pöyry Consulting, Inc., Tarrytown, New York. 283 pages.

Maintaining Productivity and Forest Resources Base: A Background Paper for a Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota. 1992. Jaakko Pöyry Consulting, Inc., Tarrytown, New York. 302 pages.

Northeast Region Plan; Forest, Fish and Wildlife Management Program Appendix: Biodiversity Guidelines. 1994. Minnesota Department of Natural Resources, Division of Forestry, St. Paul, Minnesota. 40 pages.

Protecting Water Quality and Wetlands in Forest Management: Best Management Practices in Minnesota. 1995. St. Paul, Minnesota. 140 pages.

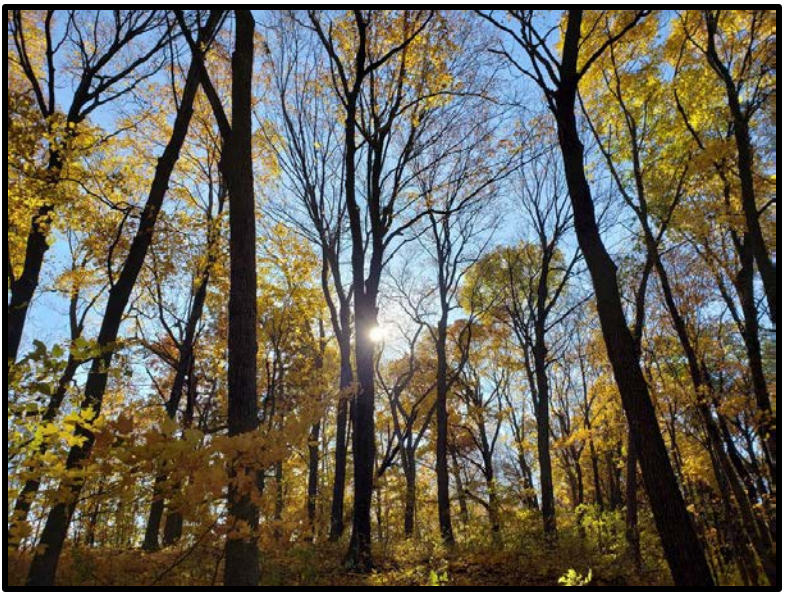
Riparian Vegetation Effectiveness. National Council of the Paper Industry for Air and Stream Improvement, Inc., Research Triangle Park, North Carolina. 26 pages. (Unpublished)

Visual Quality Best Management Practices for Forest Management in Minnesota. 1994. St. Paul, Minnesota. 78 pages.

Visual Quality

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Scenic quality is one of the primary reasons people choose to spend their recreation time in or near forested areas. Photo courtesy of David Miller (MN DNR).

The Value of Visual Quality

A Concern for Aesthetic Quality

Minnesotans are concerned about the aesthetic quality of forested lands throughout the state, which are a great source of pride for Minnesota citizens. Scenic beauty—or "visual quality"—is one of the primary reasons people choose to spend their recreation and vacation time in or near forested areas.

They are also attracted by the peace and quiet of the outdoors, the serenity, the solitude, and a host of other emotional, spiritual and sensory responses that make up the richly aesthetic and deeply personal experience that is so closely tied to time spent in or near our forests.





Minnesota forests are particularly vital to the health of two industries: tourism and forest products.

Minnesota forests are particularly vital to the health of two industries: tourism and forest products. While many of the demands on the forests from these two industries are compatible and even complementary, concern about the specific impacts of various forest management practices on visual aesthetics led to the development of a guidebook titled *Visual Quality Best Management Practices for Forest Management in Minnesota.*

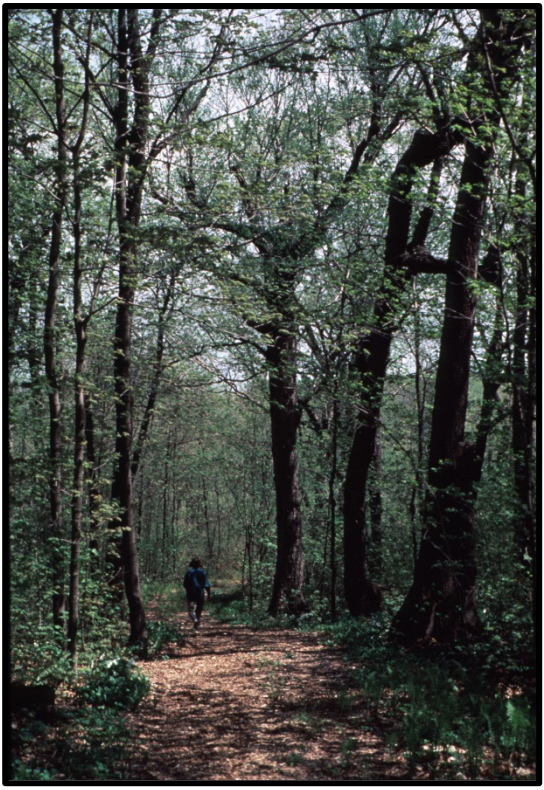
Published in 1994, this guidebook provided the source of the visual quality guidelines that have been integrated into this larger guidebook.

Benefits of Visual Quality Management

Visual quality is one important aspect of the broad, multi-faceted concept of integrated forest resource management. Visual quality management can:

- Enhance visual quality of forested lands for recreational users, resulting in a healthy tourism economy

- Reduce conflicts with and negative perceptions of the timber industry, therefore helping to sustain a healthy timber economy
- Minimize visual and audible impacts of forest management activities on tourists and recreational users
- Minimize visibility of harvest areas by limiting apparent size of harvest
- Minimize visual impact of slash
- Minimize the impact of landing operations on recreational viewers and users
- Minimize visual contrast created by snags and broken or leaning trees



Minnesotans are concerned about the aesthetic quality of their forest areas, which are a source of pride for citizens of the state. Photo courtesy of Minnesota DNR

- Reduce visual impacts associated with the design and use of forest access roads
- Reduce the visual impact of site preparation practices and reduce the time that the effects of these practices are visible
- Promote more natural-appearing stands
- Enhance the aesthetics of visual management areas by minimizing visual impacts of TSI activities
- Reduce visual impacts of treated vegetation
- Reduce noise and unsightliness related to gravel pits

Visual Sensitivity Classifications

Recognizing Different Levels of Visual Sensitivity

In 16 of the most heavily forested counties in Minnesota, county visual quality committees have classified all roads, designated recreation trails, and lakes and rivers into one of three visual sensitivity categories.

Three factors were used in determining classifications:

- The perceived degree of sensitivity of users of that travel route or recreation area concerning landscape aesthetics
- The volume and type of use the travel route or recreation area receives
- The speed of travel within the route or area



Large unbroken clearcuts are generally perceived by the public as unsightly, at least until the newly established regeneration begins to restore the natural beauty of the site. Photo courtesy of David Wilson (MFRC)

Visual Sensitivity Categories

Three visual sensitivity classifications reflect different levels of concern on the part of typical users:

Most Sensitive

Applies to travel routes and areas where **significant public use occurs** and where **visual quality is of high concern** to typical users. Examples of such routes may include public highways, local roads, recreational lakes and rivers, and designated recreational trails and areas that provide a high level of scenic quality.

Moderately Sensitive

Applies to travel routes or recreation areas, not identified as “most sensitive,” **where visual quality is of moderate**

concern to typical users. Examples of these routes and areas may include public highways and local roads, recreational lakes and rivers, and designated recreational trails that provide **moderate to high scenic quality but less significant public use**.

Less Sensitive

Applies to travel routes or recreation areas, not identified as “most sensitive” or “moderately sensitive,” where visual quality is of less concern to typical users. Examples of these routes may include public highways and low-volume local forest roads, non-designated trails, and non-recreational lakes and rivers.

An example: In areas classified as “most sensitive,” landings should be avoided within view of travel routes or recreation areas. However, in areas classified as “less sensitive,” landings may be visible, but placing landings in the travel route right-of-way should be avoided.

The Value of Visual Sensitivity Classifications

Visual sensitivity classifications help the landowner, resource manager and logger choose visual quality guidelines that help fulfill the expectations of the county visual quality committees. Visual quality guidelines used in an area classified as “most sensitive” would be different than guidelines used in an area classified as “less sensitive.”

An example: In areas classified as “most sensitive,” landings should be avoided within view of travel routes or recreation areas. However, in areas classified as “less sensitive,” landings may be visible, but placing landings in the travel route right-of-way should be avoided.



The “most sensitive” classification applies to those travel routes or areas where significant public use occurs and where the visual quality is of high concern to typical users. Photo courtesy of Explore Minnesota

Determining Classifications for a Particular Site

The 16 counties where visual sensitivity classifications have been completed include Aitkin, Becker, Beltrami, Carlton, Cass, Clearwater, Cook, Crow Wing, Hubbard, Itasca, Koochiching, Lake, Lake of the Woods, Mille Lacs, Pine and St. Louis counties.

County visual sensitivity classification maps may be viewed by contacting county land departments or local DNR Forestry offices within the counties. See *Resource Directory*.

In counties where there are no formal visual sensitivity classifications, landowners, resource managers and loggers should use their knowledge and experience to classify the visual sensitivity of the area where they are working. Based on their determinations of the area’s visual

sensitivity, they should follow the appropriate guidelines for that sensitivity classification.

Water Quality and Wetlands

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The Value of Water Quality, the Threat of Nonpoint Source Pollution

An Abundance of Clean Water

An abundance of clean water is one of Minnesota's greatest resources. Much of this water originates in forested watersheds and feeds our lakes, streams and rivers. When carrying out any forest management activity, care is needed to prevent or minimize nonpoint source pollution impacts on water quality and wetlands, as well as impacts on normal water flow in wetlands.

In addition to water, these forested areas provide many other valuable resources and support a variety of human activities. Landowners, resource managers, loggers and contractors attempt to balance a variety of objectives when planning and conducting forest management activities. These activities include the production of timber, the support of recreational uses, the enhancement of scenic beauty, the improvement of wildlife habitat, and the protection of forest ecosystems.

Potential Impacts of Nonpoint Source Pollution

Nonpoint source (NPS) pollution is diffuse pollution that originates from over the landscape. While the amount from any one particular location may seem insignificant, the combined effects of NPS pollution from throughout a watershed can impact water quality and wetlands.

NPS pollution reaches streams, lakes, wetlands and ground water through leaching, surface runoff and erosion. While some NPS pollution does occur naturally, such as when soil is carried in runoff to surface water, human activity can dramatically increase the potential for NPS

pollution. Many forest activities have the potential to contribute NPS pollution to streams, lakes, wetlands and ground water.

Types of water pollutants that can be generated from forest activities include:

- Sediment
- Nutrients
- Pesticides
- Fuels and lubricants
- Organic matter
- Thermal impacts

NPS pollution from forest activities is not severe in most areas of Minnesota, due to the state's topography, soils and forest locations. Forest management activities with the greatest potential for creating NPS pollution include:

- Forest road development
- Timber harvesting activities
- Mechanical site preparation
- Pesticide application
- Prescribed burning and fireline clearing

Of these activities, the building and maintenance of forest roads is generally considered to have the greatest potential to impact water quality and wetlands. This impact is due to the concentration of activity, the extent of area affected, the amount of disturbed and exposed soil, and the relative permanence of a forest road. These effects are of particular concern when activities are close to water.

Benefits of Guidelines

Guidelines for water quality and wetlands provide a number of important benefits. These guidelines:

- Prevent or minimize nonpoint source pollution from forest management activities.
- Prevent or minimize erosion and subsequent sedimentation of water bodies.
- Prevent or minimize the movement of pesticides, fuel, lubricants and other chemicals to surface water, wetlands and ground water.
- Maintain water temperatures within their normal range.
- Maintain normal hydrologic flows in wetlands.

How Guidelines Can Protect Water Quality and Wetlands

NPS pollution cannot be eliminated entirely, but guidelines for water quality and wetlands can prevent or minimize the impact of forest management activities on streams, lakes, wetlands and ground water. Recommended guidelines (implemented individually or in combination) provide landowners, resource managers, loggers and contractors with the tools to either prevent NPS pollution or ensure that the amount of NPS pollution is kept to a level compatible with state water quality and wetland protection goals.

In addition to protecting water quality, guidelines for wetlands provide the tools to maintain the functions and values of wetlands by protecting normal water flow in wetlands.



Guidelines for water quality and wetlands can prevent or minimize the impact of forest management activities on streams, lakes, wetlands and ground water. Photo courtesy of Minnesota DNR

Water Quality and Wetland Protection in Minnesota

A Regulatory Umbrella

Statutes and regulations currently exist for local, state and federal agencies to control water pollution and protect wetlands on both public and private forestlands:

- **At the local level**, this “regulatory umbrella” includes comprehensive local water plans (Minn. Rules 8410), local zoning ordinances and shoreland management regulations.
- **At the state level**, regulatory involvement includes the Minnesota Groundwater Protection Act, the Minnesota

Wetland Conservation Act (Minn. Rules 8420), the Minnesota Pollution Control Agency Water Quality Standard Rules (Minn. Rules 7050), and the Minnesota Department of Natural Resources Protected Waters Permit Program (Minn. Rules 6115).

- **At the federal level**, regulations include the National Environmental Policy Act; the National Forest Management Act; the Federal Clean Water Act; the Coastal Zone Management Act; and the Food, Agriculture, Conservation and Trade Act.

Providing Exemptions and Flexibility

Wetlands are highly productive sites for a variety of ecologic functions, as well as for the enhancement of water quality.

All management operations in or adjacent to wetlands should be planned and conducted in a manner that protects them.

State and federal wetland regulations provide an exemption for silvicultural activities in wetlands. To qualify for an exemption for silvicultural activities in a wetland under the Minnesota Wetland Conservation Act, 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 Best Management Practices and water resource protection requirements

The wetland guidelines were developed to meet the intent of federal regulations (33 Code of Federal Regulations [CFR], Section 323.4, and 7 CFR, Part 12). These sections were 1) modified to allow flexibility of implementation

where appropriate, and 2) broadened to cover the activities listed in the Wetland Conservation Act. The federal criteria that served as the standard for much of the original BMP development are listed in *Appendix G: Baseline Standards for Development of Best Management Practices to Provide Wetland Protection*.

Because one single set of practices cannot 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 individual guidelines to be modified to balance water quality and wetland protection with other forest values and management considerations, such as promoting biodiversity and enhancing wildlife and aquatic habitat. **Modified approaches may be used as long as the alternate practices achieve the same level of protection for water quality and wetlands**.

A Cooperative Response to Water Quality Concerns

Effective protection of water quality and wetlands depends in great part on the attitude toward—and acceptance of—water quality and wetland protection measures by individual landowners, resource managers, loggers and contractors.

Broad-based recognition of the need for guidelines to protect water quality and wetlands led to a gathering of a diverse working group of individuals representing many of Minnesota's public and private organizations.

This group developed a guidebook titled *Protecting Water Quality and Wetlands in Forest Management: Best Management Practices in Minnesota*. Published in 1989 and updated in 1995, this stand-alone publication serves

as the source document when Best Management Practices for water quality protection (BMPs) are referenced in statute.

The goal of these guidelines (termed BMPs in the guidebook) was to accomplish the following:

- **Heighten awareness** of nonpoint source pollution
- **Provide tools** to landowners, resource managers, loggers and contractors for protecting water quality and wetlands in forested watersheds in a manner consistent with the intent of federal and state water quality and wetland protection mandates
- **Provide sufficient information and guidance** to assist these individuals in making informed and appropriate management decisions on a site-by-site basis

Protecting Water Quality and Wetlands in Forest Management provided the source of the guidelines for water quality and wetlands that have been integrated into this larger guidebook.



Wildlife Habitat

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Developing Wildlife Habitat Guidelines

Parameters and Considerations

Wildlife defined: For purposes of these guidelines, wildlife is defined as all forms of life that are wild (including plants, animals and microorganisms). These guidelines consider only forest-dependent terrestrial and amphibious forms of wildlife in the recommendations.

Habitat defined: The sum total of environmental factors (including food, water and cover) that a species needs to survive and/or reproduce in a given area.

Ten wildlife-related topics were considered in these guidelines:

- Leave trees and snags
- Coarse woody debris and slash
- Conifer retention and regeneration
- Mast
- Patterns of cutting
- Endangered, threatened and special concern (ETS) species
- Sensitive communities and sites, and tree species at the edge of their range
- Seasonal ponds
- Riparian wildlife habitat
- Additional consideration: Legacy patches

Other interrelated issues were considered during guideline development, including:

- Vertical structure of vegetation
- Variation of silvicultural systems
- Mimicking natural disturbance
- Old forest characteristics

- Lowland conifer communities
- Exotics and hybrids
- Forest type conversion

The original scoping process focused on mitigating wildlife impacts projected in the 1994 Generic Environmental Impact Statement Study on Timber Harvesting and Forest Management in Minnesota (GEIS). Additional issues beyond those covered in the GEIS were also considered. The intention is to provide practical, science-based (to the extent possible) voluntary guidelines to address significant issues and projected impacts, at least minimally, and to mitigate these impacts or prevent them from occurring.

Integration of wildlife guidelines with other guidelines addressing cultural resources, forest soils, riparian areas, visual quality, and water quality and wetlands helped resolve any differences in applicability among them. Other dimensions of forest management, such as forest health or recreation, were given less consideration during the development of wildlife habitat guidelines.

Limitations and Assumptions

"Essential" guidelines, rather than comprehensive: Certainly, much more can be done to enhance wildlife habitat or individual species than what is recommended within these guidelines. Furthermore, each management practice, including the option to do nothing on a site, will at once favor some species and disfavor other species. As a result, it is not practical to provide a comprehensive set of guidelines covering all possibilities for improving habitat in Minnesota forests. Instead, these guidelines cover the essentials for addressing site-level issues while deferring to other existing guidelines, publications or professional managers to provide direction to those whose objectives focus on wildlife management.

Guidelines and "additional considerations": Some of the recommendations are based on less clear or emerging issues that may change with time. Such recommendations are included as "additional considerations," such as legacy patches, which provide direction to landowners wishing to improve wildlife habitat. Thus, two classes of recommendations are provided: "guidelines" and "additional considerations." Although both are voluntary in nature, the guidelines have higher priority and will also be more important to monitor over time.

Site-level guidelines with "landscape implications": Wildlife habitat guidelines were drafted assuming that a practice has been selected for a particular site and that the guidelines should provide direction for someone applying that practice. Throughout the process, however, it was difficult to separate landscape-level and site-level issues. While many issues clearly fit into one level or the other, some fall into a gray area.

For wildlife, more than for other forest resources, what occurs on a site influences the surrounding landscape, and vice versa. While the guidelines focused on the site level as much as possible, some of the more important overlaps have been included as "landscape implications." Landscape-level wildlife needs should be addressed through professional planning for individual properties and through cooperation among landowners and agencies within a landscape.

Overlapping benefits: Many of the wildlife habitat guidelines can be applied simultaneously. For example, leave tree clumps in clearcuts might also serve as rare species buffers or legacy patches, or they may provide mast production. These overlapping benefits may extend to other forest resources as well, such as for cultural resource protection.

Recognizing practicality issues: In implementing the wildlife habitat guidelines, users should be mindful of the practicality of guidelines, recognizing the additional cost and effort needed to implement them. For example:

- Application of guidelines may result in increased time for design, administration or execution of forest management activities.
- Trees may be withdrawn from harvest availability for the short or long term, decreasing potential revenue.
- Retention of various structural habitat components (such as snags and down logs) may reduce expected tree regeneration or lead to increased mortality or pest damage in some cases.

Guidelines and additional considerations have been developed for 10 topics, which have been integrated into the overall forest management activity guidelines in *Part 3*. The benefits and rationale for these guidelines follow for each of the 10 wildlife-related topics.

Benefits of Wildlife Habitat Guidelines

Benefits apply mainly to the wildlife habitat on a site, but improved habitat may indirectly lead to a better-functioning ecosystem and therefore improved overall productivity of the site in the long run. Implementation of guidelines for wildlife habitat:

- **Provides for wildlife requiring perches**, tree cavities and bark foraging sites through retention of suitable leave trees and snags on a site during forest harvesting and timber stand improvement
- **Provides cover, food or growing sites** for certain amphibians, reptiles, mammals, birds, invertebrates, fungi and green plants through retention or creation of coarse woody debris and slash during forest management

- **Ensures diversity of wildlife habitat** through the retention and regeneration of conifers for food, nesting and cover in mixed deciduous/coniferous stands
- **Provides for adequate mast production** from trees and shrubs as food for wildlife
- **Provides site-level wildlife habitat requirements** by using a variety of sizes and shapes of harvest areas
- **Increases awareness of endangered, threatened and special concern species** and manages forests to maintain or enhance existing populations of these species
- **Increases awareness of sensitive communities** and sites and maintains or enhances them where they are found
- **Provides for perpetuation of most of the genetic diversity within tree species**, as well as maximization of the potential for tree species to shift their geographic ranges in response to possible rapid climatic changes
- **Provides site-level wildlife habitat features** for terrestrial species associated with wetlands and seasonal ponds within forests
- **Provides site-level wildlife habitat features** for riparian obligate terrestrial species
- **Maintains the biological integrity** of a harvested site

Rationale for Guidelines in Each Topic Area

Leave Trees and Snags

Purpose: To provide for wildlife requiring perches, tree cavities and bark-foraging sites through retention of suitable leave trees and snags on a site during forest harvesting and timber stand improvement.

Rationale, Background and Benefits

In Minnesota, some 40 birds, 29 mammals, and several reptiles and amphibians use snags because they provide specialized substrates for nesting and/or foraging for birds and other species. The major issue for cavity-dependent wildlife and timber harvesting is whether some suitable trees and nest cavities remain for these species following logging or timber stand improvement.

Retention of leave trees and snags during timber harvesting provides habitat for wildlife requiring perches, tree cavities and bark-foraging sites as the surrounding forest regenerates, by mimicking natural disturbances to some degree. Leave trees and snags may also provide unique niches and microsites for a variety of plants, especially within retained clumps or as individuals fall over with time and begin to decay. Soil conditions will also benefit.

The fundamental idea is to retain some structure for snag- and cavity-dependent species on a site or maintain the potential to produce such structure as a stand grows and develops.

Ecoregion Applicability

One issue indirectly tied to ecoregions is openland/ brushland management. For prairie and parkland landscapes or portions of forested landscapes with openland/brushland management desired future conditions, minimizing or eliminating the leave tree/snag tree guideline may be appropriate. It may also be appropriate to harvest timber in these landscapes at younger-than-normal rotation ages.



Both snags (standing dead trees) and leave trees (live trees retained on a site) provide for wildlife requiring perches, tree cavities and bark-foraging sites. Photo courtesy of Potlatch Corporation

Another issue in agriculture/forest interfaces is nest parasitism by cowbirds. Timber harvests in forests adjacent to agricultural areas may require clear-felling of all stems along edges.

Regarding a preferred mitigation strategy to retain more trees with cavities, the GEIS states: “This mitigation should be applied over all Minnesota ecoregions, but for mammals it may be especially critical within the range of the gray squirrel, projected to be heavily impacted under all harvest scenarios.”

Landscape Implications

Although these guidelines address site-level recommendations for snags and leave trees, the contribution of an individual site should be considered in the context of the surrounding landscape. Many of the cavity-dependent species being addressed have home ranges larger than the typical harvest unit, so planning for their needs requires a broader look, both spatially and temporally, at the larger forest community.

If suitable habitat exists surrounding a given harvest site to maintain populations of these species, then leave trees may not be as critical on that site. However, if harvests are likely in the adjacent habitats, then the trees left on the initially harvested sites become more important as the surrounding forest regenerates. Consideration must be given to the time it takes for a regenerating stand to produce trees of adequate size and degree of decay to provide suitable structure.

Consider reducing leave tree and snag requirements on harvest sites adjacent to agricultural lands (especially pastures) to reduce nest parasitism by cowbirds and nest predation. Note also that not all forest communities naturally provide snags; therefore, across a given landscape, not all sites must be managed for leave trees and snags.

Coordination among neighboring landowners may result in varying numbers of leave trees on a site if adjacent lands exceed or fall short of the recommendations. Managers of larger landholdings may be able to plan for sufficient cavity-dependent wildlife habitat on portions of their property (such as riparian reserves) and reduce leave tree/snag requirements on other portions.



Leave trees provide sites for nesting, such as this goshawk nest. Photo courtesy of Potlatch Corporation



Coarse woody debris provides cover, food, habitat structure and growing sites for many different animals and plants. Photo courtesy of Potlatch Corporation

Coarse Woody Debris and Slash

Purpose: To provide cover, food or growing sites for certain amphibians, reptiles, mammals, birds, invertebrates, fungi and green plants through retention or creation of coarse woody debris and slash during forest management.

Rationale, Background and Benefits

Salamanders, snakes, small mammals and birds will benefit most from coarse woody debris and slash. Small mammals dependent on slash and coarse woody debris in turn provide food for mammalian carnivores and forest raptors (such as the pine marten and the northern goshawk).

A variety of invertebrates, soil microorganisms and plants will also benefit from the niches created by down logs. Regeneration of yellow birch, white cedar and eastern hemlock will be enhanced. Many sites already provide the number of down logs (or more) called for in the guidelines. Coarse woody debris may need to be created in some plantations.

Ecoregion Applicability

When choosing leave logs, note that species at the edge of the range will differ depending on ecoregion. (See *Sensitive Communities and Sites, and Tree Species at the Edge of Their Range)*. Coarse woody debris decays more rapidly in the southeast, where consideration should be given to making leave logs with as large a diameter as possible. When selecting candidate leave logs, a mix of tree species is desirable.

Landscape Implications

Although the coarse woody debris (CWD) guidelines focus on the managed site and its resident reptiles and

amphibians, CWD may also be benefiting reptiles and amphibians that breed elsewhere (in seasonal ponds) and then move to or disperse through the site being managed. Therefore, consider the proximity of off-site seasonal ponds when making decisions on CWD.

Conifer Retention and Regeneration

Purpose: To ensure diversity of wildlife habitat through the retention and regeneration of conifers for food, nesting and cover in mixed deciduous/coniferous stands. Conifers should continue to be a significant structural component in appropriate habitats and landscapes.

Rationale, Background and Benefits

A concern for wildlife in northern Minnesota is extensive conversion of mixed aspen/birch-conifer forests to early successional aspen-birch. Retaining young conifers, including isolated trees and scattered clumps, can provide habitat and food needed for many different wildlife species and can increase the probability that conifers will later regenerate on harvested areas.

Various animal species, including the great gray owl, bald eagle, pine warbler, white-tailed deer, moose, pine marten, lynx, snowshoe hare and red-backed vole, depend on coniferous stands for structural attributes. Others—including spruce grouse, red-breasted nuthatch, red squirrel, porcupine and moose—depend on food that coniferous stands provide. Conifers provide thermal cover from both heat and cold. Reduced snow depth and surface crusting benefit both deer and moose. Some conifer-associated species of birds will only remain in clearcut areas if conifer patches of sufficient size are left.

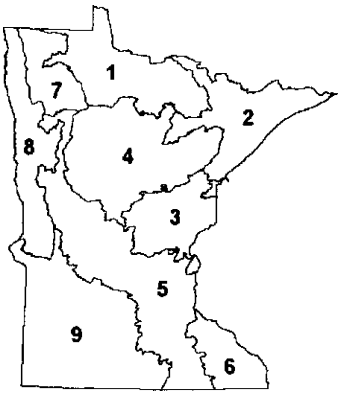
Encouragement of coniferous regeneration in mixed deciduous-coniferous forests in the northeast will help lessen the impact on those reptiles and amphibians

associated with mixed forests, such as the wood turtle, ringneck snake and red-backed salamander. Retaining clumps of conifers will also protect soil characteristics and associated ground flora.

Conifers should be left for the many important habitat characteristics that these trees provide to a large portion of Minnesota's vertebrate fauna. Conifer stands, inclusions of conifers within mixed-species stands, and conifer understories in mature aspen and birch stands are all important components of wildlife habitats in Minnesota.

When retaining conifers, clumps are preferable to scattered trees. Clumped conifers are more windfirm; are better potential seed sources because of improved pollination; can withstand snow and ice loads more successfully; and can provide better cover. See Table WH-1.

Ecoregion Applicability



These guidelines are applicable to Ecoregions 2, 3 and 4 and possibly Ecoregions 1, 5 and 6.

Landscape Implications

Application of these guidelines may have implications where landscape connectivity or riparian corridors are a concern.

Table WH-1

Conifer Species and Examples of Use by Wildlife

Conifer Species	Examples of Use by Wildlife
Red pine	Mature trees may be used by raptors for perches or nest trees. Seeds are important mast for winter songbirds and red squirrels.
White pine*	When young, provides good escape and severe weather cover for many species. High calorie, large seeds eaten by many small mammals and winter songbirds. Mature trees are important for cavity-dependent wildlife, preferred bald eagle next trees, and escape trees from bears. Roosting trees for wild turkeys.
Jack pine	Very good cover when trees are young. Used as browse. Buds and needles are important spruce grouse food. Seeds eaten by red squirrels. Persistent cones provide a year-round food source.
Balsam fir	Important winter and summer cover for deer, moose, and many species of birds. Birds eat seeds and use trees for nesting. Winter browse for moose.
Black spruce	Important escape and severe winter cover. Birds eat seeds and use trees for nesting. Buds and needles are important spruce grouse food.
Tamarack	Mature stands provide excellent habitat for owls. Snags are used as hunting and singing perches.
White cedar	Mast is important food source for winter songbirds. Very important winter

	cover for deer. Important for browse during severe winters. Provides cover and cooling effect near water.
White spruce	Important seed source for winter finches. Summer nest cover for songbirds. Black-backed woodpeckers forage under bark for insects.
Eastern red cedar	Important winter cover. Berries used by birds for food.
Hemlock	Mature trees provide important owl roosting sites. Very limited range in Minnesota (special concern species).

*See also *Minnesota's White Pine: Now and for the Future.* 1996. White Pine Regeneration Strategies Group, Minnesota DNR, St. Paul, Minnesota.

Mast

Purpose: To provide for adequate mast production from trees and shrubs as food for wildlife.

Rationale, Background and Benefits

High levels of fat, protein and carbohydrates in mast contribute to energy stores critical for migration or hibernation, and for survival of newly independent young. Some birds and mammals depend heavily on mast during peak production periods in late summer and early fall. During winter, some sources remain available on trees and shrubs, under snow or stored in caches.

Mast production is generally favored by increased crown exposure to light, crown size, maturity of trees or shrubs, increased soil nutrients, tempered microclimates (especially during flowering) and adequate soil moisture. Production on a site tends to vary considerably from year to year.

Other considerations:

- Mast-producing species often depend on animals for their dispersal and reproduction.
- Riparian edges often contain a higher concentration and richness of mast-producing species.
- Most shrub species will regenerate well and produce mast after cutting, burning or soil disturbance.

Although the GEIS points out concerns for oak and other dominant tree species, especially in relation to game species (such as deer or gray squirrels), trends in other mast species were not modeled.

As a result, recommendations for oak and other dominant tree species are presented as “guidelines,” while recommendations for other mast-producing species are presented as “additional considerations.” See Table WH-2.

Table WH-2

Examples of Mast-Producing Plants That Benefit Wildlife in Minnesota

Mast Species	Example of Use by Wildlife
Oaks (acorns) and hazel nuts	Deer, bear, wild turkeys, woodpeckers, blue jay, wood duck, squirrels
Maple and ash seeds	Small mammals, evening and pine grosbeaks
Aspen, birch, and hazel buds	Ruffed grouse
Yellow and white birch seeds	Common redpoll, pine siskin, and American goldfinch
Conifer cones and seeds (such as white cedar, balsam fir, black spruce, white pine, common juniper, red cedar, Canada yew)	Red squirrels, white-winged and red crossbills, pine siskins, red breasted nuthatch, and pine grosbeak
Late summer mast (juneberries, blueberries, cherries, dogwoods, and elderberries)	Important to wide diversity of birds and mammals as they prepare for migration and winter.
Soft mast retained in fall and through winter (such as mountain ash, highbush cranberry, nannyberry, and winterberry)	Waxwings, pine grosbeaks, and other diverse bird and mammal species.
Vines (such as wild grape)	Diversity of birds and mammals

Ecoregion Applicability

Retention of mast and other key food-producing tree types should be prioritized in accordance with the local abundance of each tree species. In areas of least abundance, greatest attention should be applied to retention. For oaks, the northern range limit is most critical in assuring that the range of producing trees is not diminished. Mountain ash berries are an important food source for birds during harsh winters. This species occurs commonly in three northeastern counties (Cook, Lake and St. Louis).

Landscape Implications

Land managers in regions with low mast availability have opportunities to enhance wildlife habitat characteristics by careful management of mast species on their land. Some wildlife species may travel significant distances to obtain mast. The black bear, for example, may travel 10 miles to obtain mast.

Patterns of Cutting

Purpose: To provide site-level wildlife habitat requirements by using a variety of sizes and shapes of harvest areas.

Rationale, Background and Benefits

Because there is such a great variety in the home range territory of various organisms, it is important that forests be managed at a variety of scales. This management objective will involve making silvicultural decisions on a landscape basis. Ideally the management regime should range from the very fine-scale management represented by selection cutting to the coarse-scale management affected by sizable clearcuts. Size of clearcuts should be determined by considering issues such as size of the management unit, the home range requirements of large animals, aesthetics and natural disturbance regimes.

Size and shape of both cut and uncut areas should meet habitat needs of wildlife. To benefit wildlife in managed forests of Minnesota, a variety of cut sizes—from as small as one acre to larger than 100 acres—is recommended. Larger patch sizes have historically occurred under natural disturbance regimes on even-aged, fire-dependent types, such as jack pine. Smaller patches are appropriate in more heterogeneous forest types, such as deciduous forests on moraines.



Ecoregion Applicability

It is easier to maintain and create larger patches of older forest in northern Minnesota than in the fragmented forests in southeastern Minnesota. Creating large patch sizes in landscapes where land ownership is dominated by smaller holdings is problematic. In such areas landowners and managers are encouraged to seek opportunities to collaborate with neighboring owner/managers in creating larger patches where they may be rare.

Landscape Implications

In areas dominated by agricultural land use practices (in south-central and southeast regions), where riparian forests represent the majority of the forest in the area, consider only uneven-age management.

On large clearcuts, consider harvesting in segments over several years. This will provide both early successional diversity and, over the long term, a large, mature forest

patch. Try to coordinate with adjacent landowners when natural patch boundaries cross property lines.

Endangered, Threatened and Special Concern Species

Purpose: To increase awareness of endangered, threatened and special concern species (ETS species) and manage forests to maintain or enhance existing populations of these species. See Table WH-3).

Rationale, Background and Benefits

Minnesota is home to more than 2,500 plant species, several hundred vertebrate species, and numerous invertebrates. The Minnesota Department of Natural Resources (DNR) has designated 594 of these plants and animals as endangered, threatened, or species of special concern, with nearly 30%—245 species—further identified as species that may be affected by forest management activities. Twelve of these are also federally listed as threatened or endangered.

All species are part of the natural forest ecosystem and contribute to its healthy functioning. Additional values of diversity include the following:

- Conservation of genetic strains of plants or animals that are adapted to local climate and site conditions
- Conservation of local populations with natural resistance to disease
- Conservation of species that may produce new economically valuable products
- Conservation of rare species that may play critical but unknown roles in ecosystem function
- Conservation of aesthetic and recreational values
- Usefulness for scientific and educational purposes

Knowledge of the occurrence of rare plants and animals in Minnesota is incomplete. The best information on occurrences of rare species is being gathered by the Minnesota County Biological Survey, initially in the more critical prairie, metropolitan and southeastern counties.

As of January 2004, surveys have been completed in 57 counties, and surveys are under way in an additional eight counties. As each county is surveyed, a more complete basis for identifying sensitive species and areas will be available (see Table WH-3). Because this survey is not an exhaustive inventory, locations of rare species will remain unknown at the conclusion of the project.

Relatively little is known about the impacts of timber harvesting or other forest management activities in Minnesota on many rare species or their habitat. Several recent studies in other parts of the country suggest that long-lived, slowly dispersing understory plants, especially those in late-successional forests, are negatively affected by timber harvest. Biologists and forest landowners need to work together so that informed decisions can be made to protect rare plants and animals.

It is important to gather information and contact individuals or agencies with knowledge of ETS species, and sensitive communities and sites while planning management in upland and riparian areas. Consult experts if ETS species and sensitive communities are suspected to occur on site. Timber harvest activities should be scheduled or designed to avoid disturbing ETS or sensitive species.

Endangered and threatened species are protected in Minnesota by one or both of the following laws: the Federal Endangered Species Act of 1973 (Public Law 100-478) and “Protection of Threatened and Endangered Species” (Minnesota Statutes 84.0895). Species of special concern are not protected by either state or federal laws.

Native birds and certain wildflowers (lady's slippers, other orchids, trilliums, gentians, arbutus and lotus) are protected by other state and federal laws, including the Conservation of Certain Wildflowers statute, the Migratory Bird Treaty Act, and the Bald Eagle Protection Act.

Table WH-3

Minnesota - ETS Species to Be Concerned About When Conducting Forest Management Activities

*END = Endangered, THR = Threatened, SPC = Special Concern

X = species is present

Status*	Scientific Name	Common Name	Ecoregion (ECS Section)**								
			1	2	3	4	5	6	7	8	9
SPC	Accipiter atricapillus	American Goshawk	X	X	X	X	X				
THR	Achillea alpina	Siberian Yarrow	X	X					X		
END	Acris blanchardi	Blanchard's Cricket Frog			X		X	X			X
SPC	Adlumia fungosa	Allegheny Vine		X		X					
SPC	Aegolius funereus	Boreal Owl		X		X					
END	Agalinis gattingeri	Round-stemmed False Foxglove						X			
END	Agrostis hyemalis	Winter Bentgrass						X			
SPC	Ahtiana aurescens	Eastern Candlewax Lichen	X	X		X					
SPC	Allium cernuum	Nodding Wild Onion					X	X			
THR	Allocetraria oakesiana	Yellow Ribbon Lichen		X							
SPC	Ambystoma maculatum	Spotted Salamander			X						

Status*	Scientific Name	Common Name	Ecoregion (ECS Section)**								
SPC	Antennaria parvifolia	Small-leaved Pussytoes	X		X		X		X	X	X
SPC	Aphanorrhegma serratum	Lidded Earth Moss					X				
SPC	Arisaema dracontium	Green Dragon					X	X			X
THR	Aristida tuberculosa	Seaside Three-awn			X		X	X			
THR	Arnoglossum reniforme	Great Indian Plantain					X	X			
SPC	Arrhenopterum heterostichum	Differential Branched Crease Capsule Moss						X			
THR	Arthrorhaphis citrinella	Golden Dot-lichen		X							
THR	Asclepias amplexicaulis	Clasping Milkweed					X	X			
SPC	Asio flammeus	Short-eared Owl	X		X	X	X		X	X	X
SPC	Asplenium platyneuron	Ebony Spleenwort					X	X			
END	Astragalus alpinus var. alpinus	Alpine Milkvetch		X							
SPC	Atrichum tenellum	Little Saw Moss		X	X			X			
THR	Aureolaria pedicularia	Fernleaf False Foxglove					X	X			
SPC	Baptisia lactea var. lactea	White Wild Indigo					X	X			X
SPC	Baptisia leucophaea	Plains Wild Indigo					X	X			
END	Bartonia virginica	Yellow Bartonia					X				
THR	Boechera collinsii	Collins' Rock Cress		X					X		
SPC	Boletus subcaerulescens	A Porcini Mushroom		X	X						

Status*	Scientific Name	Common Name	Ecoregion (ECS Section)**								
SPC	Borodinia laevigata	Smooth Rock Cress					X	X			
THR	Botrychium angustisegmentum	Narrow Triangle Moonwort		X	X	X					
END	Botrychium ascendens	Upswept Moonwort	X	X		X			X		
END	Botrychium	Slender Prairie Moonwort		X		X			X		
SPC	Botrychium minganense	Mingan Moonwort	X	X	X	X			X	X	
THR	Botrychium mormo	Goblin Fern	X	X	X	X	X				
THR	Botrychium neolunaria	New World Moonwort	X	X		X			X		
SPC	Botrychium pallidum	Pale Moonwort	X	X	X	X	X		X		
SPC	Botrychium simplex	Least Moonwort	X	X	X	X	X		X	X	X
END	Botrychium spathulatum	Spatulate Moonwort		X		X			X		
SPC	Bryoria fuscescens	Pale-footed Horsehair Lichen		X		X					
SPC	Buteo lineatus	Red-shouldered Hawk	X	X	X	X	X	X		X	X
SPC	Buxbaumia aphylla	Bug-on-a-stick Moss		X				X			
END	Caloplaca parvula	A Species of Lichen		X							
THR	Cardamine pratensis	Cuckoo Flower	X	X		X	X				
SPC	Carex annectens	Yellow-fruit Sedge					X	X			X
END	Carex careyana	Carey's Sedge						X			
THR	Carex conjuncta	Jointed Sedge					X				

Status*	Scientific Name	Common Name	Ecoregion (ECS Section)**								
THR	Carex davisii	Davis' Sedge					X	X			X
END	Carex formosa	Handsome Sedge					X	X	X		
SPC	Carex grayi	Gray's Sedge			X		X	X			X
SPC	Carex hookerana	Hooker's Sedge				X		X	X		
THR	Carex jamesii	James' Sedge					X	X			
THR	Carex laevivaginata	Smooth-sheathed Sedge					X	X			
SPC	Carex michauxiana	Michaux's Sedge		X							
SPC	Carex muskingumensis	Muskingum Sedge				X	X	X			
THR	Carex novae-angliae	New England Sedge		X							
SPC	Carex obtusata	Blunt Sedge			X	X	X		X	X	
SPC	Carex ormostachya	Necklace Sedge		X	X	X					
END	Carex pallescens	Pale Sedge	X	X		X	X				
END	Carex plantaginea	Plantain-leaved Sedge					X	X			
SPC	Carex typhina	Cattail Sedge			X		X	X			
SPC	Carex xerantica	Dry Sedge		X					X	X	
THR	Chilostigma itascae	Headwaters Chilostigman Caddisfly		X		X					
SPC	Chondestes grammacus	Lark Sparrow			X	X	X	X	X	X	X
SPC	Cicindela denikei	Laurentian Tiger Beetle	X	X							

Status*	Scientific Name	Common Name	Ecoregion (ECS Section)**								
THR	Cicindela lepida	Ghost Tiger Beetle					X	X		X	X
END	Cicindela limbata nympha	Sandy Tiger Beetle					X				
SPC	Cicindela patruela patruela	Northern Barrens Tiger Beetle			X	X	X	X			
SPC	Cicindela splendida	Splendid Tiger Beetle						X			
THR	Cirriphyllum piliferum	Hair-pointed Feather Moss					X	X			
SPC	Cirsium pumilum var. hillii	Hill's Thistle			X	X	X	X			X
SPC	Coluber constrictor	North American Racer					X	X			
END	Commelina erecta	Slender Dayflower						X			
SPC	Crataegus calpodendron	Late Hawthorn			X		X	X			X
SPC	Crataegus douglasii	Black Hawthorn		X							
SPC	Crocanthemum canadense	Canada Frostweed			X	X	X	X			
SPC	Crotalaria	Rattlebox					X	X			
THR	Crotalus horridus	Timber Rattlesnake					X	X			
THR	Cypripedium arietinum	Ram's Head Orchid	X	X	X	X	X		X		
SPC	Cyrto-hypnum pygmaeum	Pygmy Plume Moss						X			
SPC	Deparia acrostichoides	Silvery Spleenwort						X			
THR	Deschampsia flexuosa	Slender Hair Grass		X							
THR	Desmodium cuspidatum	Big Tick Trefoil					X	X			

Status*	Scientific Name	Common Name	Ecoregion (ECS Section)**								
END	Diarrhena obovata	Obovate Beakgrain					X	X			
SPC	Dicentra canadensis	Squirrel Corn					X	X			
SPC	Dryopteris goldieana	Goldie's Woodfern				X	X	X			X
END	Dryopteris marginalis	Marginal Shield Fern						X			
END	Eleocharis wolfii	Wolf's Spikerush					X				X
SPC	Empidonax virescens	Acadian Flycatcher			X		X	X	X		X
THR	Emydoidea blandingii	Blanding's Turtle		X	X	X	X	X			X
SPC	Eptesicus fuscus	Big Brown Bat		X	X	X	X	X			X
SPC	Erebia mancinus	Taiga Alpine		X							
END	Erigeron	Bitter Fleabane		X							
END	Erynnis persius persius	Persius Dusky Wing						X			
END	Erythronium propullans	Dwarf Trout Lily					X	X			
THR	Eupatorium sessilifolium	Upland Boneset						X			
THR	Floerkea proserpinacoides	False Mermaid			X		X	X			
SPC	Frullania selwyniana	Selwyn's Ear-leaf Liverwort		X							
THR	Gaylussacia baccata	Black Huckleberry			X		X	X			
THR	Glyptemys insculpta	Wood Turtle		X	X	X	X	X			
SPC	Gymnocarpium robertianum	Scented Oak Fern	X	X		X		X			

Status*	Scientific Name	Common Name	Ecoregion (ECS Section)**								
SPC	Gymnocladus dioicus	Kentucky Coffee Tree					X	X			X
SPC	Habronattus calcaratus maddisoni	A Jumping Spider		X							
THR	Hamamelis virginiana	Witch-hazel			X		X	X			
SPC	Hemidactylium scutatum	Four-toed Salamander		X	X	X					
SPC	Hesperia leonardus	Leonard's Skipper	X			X	X	X		X	X
SPC	Hesperia leonardus leonardus	Leonard's Skipper	X			X	X	X			
SPC	Hesperia leonardus pawnee	Pawnee Skipper					X			X	X
END	Hesperia uncas	Uncas Skipper					X				
SPC	Heterodermia obscurata	Orange-tinted Fringe Lichen				X					
SPC	Heterodon nasicus	Plains Hog-nosed Snake			X		X	X		X	X
THR	Homalosorus pycnocarpos	Narrow-leaved Glade Fern						X			
THR	Hudsonia tomentosa	Beach Heather		X	X	X	X	X	X	X	
END	Hybanthus concolor	Eastern Green-violet						X			
END	Hydrastis canadensis	Goldenseal					X	X			
SPC	Hydrocotyle americana	American Water-pennywort		X	X		X				
THR	Hylodesmum nudiflorum	Stemless Tick Trefoil			X		X	X			
END	Iodanthus pinnatifidus	Purple Rocket					X	X			
SPC	Jeffersonia diphylla	Twinleaf						X			

Status*	Scientific Name	Common Name	Ecoregion (ECS Section)**								
END	Juglans cinerea	Butternut		X	X	X	X	X			X
PC	Juniperus horizontalis	Creeping Juniper	X	X			X	X	X	X	X
SPC	Laccaria trullisata	Sand-loving Laccaria		X		X	X				
SPC	Lactarius fuliginellus	A Species of Fungus					X				
END	Lechea tenuifolia	Narrow-leaved Pinweed					X	X			
THR	Leersia lenticularis	Catchfly Grass						X			
THR	Lescuraea saxicola	Lustrous Bow Moss		X							
END	Listera auriculata	Auricled Twayblade		X							
SPC	Listera convallarioides	Broad-leaved Twayblade		X							
END	Lobaria scrobiculata	Textured Lungwort		X							
THR	Luzula parviflora	Small-flowered Woodrush		X							
SPC	Lynx canadensis	Canada Lynx		X							
SPC	Lysimachia quadrifolia	Whorled Loosestrife			X						
SPC	Malaxis	White Adder's Mouth	X	X	X	X	X		X		
END	Malaxis paludosa	Bog Adder's Mouth		X		X					
SPC	Meesia uliginosa	Swan Moss	X								
SPC	Melanohalea subolivacea	Brown-eyed Camouflage Lichen		X		X					
THR	Melica nitens	Three-flowered Melic						X			

Status*	Scientific Name	Common Name	Ecoregion (ECS Section)**								
SPC	Menegazzia terebrata	Port-hole Lichen		X							
SPC	Microtus ochrogaster	Prairie Vole				X	X	X	X	X	X
SPC	Microtus pinetorum	Woodland Vole						X			
THR	Minuartia dawsonensis	Rock Sandwort	X				X	X	X		
THR	Moehringia macrophylla	Large-leaved Sandwort		X							
SPC	Mustela nivalis	Least Weasel	X				X		X	X	X
SPC	Myotis lucifugus	Little Brown Myotis	X	X	X	X	X	X	X		
SPC	Myotis septentrionalis	Northern Long-eared Bat	X	X	X	X	X	X			X
THR	Napaea dioica	Glade Mallow					X	X			
SPC	Nuttallanthus canadensis	Old Field Toadflax			X		X	X			
THR	Oarisma garita	Garita Skipperling							X	X	
SPC	Ochrolechia androgyna	Powdery Saucer Lichen		X		X					
SPC	Oenothera rhombipetala	Rhombic Evening Primrose			X		X	X			
SPC	Ophiogomphus anomalus	Extra-striped Snaketail		X		X					
THR	Ophiogomphus susbehcha	St. Croix Snaketail			X		X				
THR	Orobanche fasciculata	Clustered Broomrape					X	X	X	X	X
THR	Orobanche ludoviciana	Louisiana Broomrape					X		X	X	X
THR	Orobanche uniflora	One-flowered Broomrape			X	X	X	X	X	X	X

Status*	Scientific Name	Common Name	Ecoregion (ECS Section)**								
END	Osmorhiza berteroi	Chilean Sweet Cicely		X							
SPC	Osmorhiza depauperata	Blunt-fruited Sweet Cicely		X							
SPC	Panax quinquefolius	American Ginseng			X	X	X	X			X
THR	Pantherophis obsoletus	Western Ratsnake						X			
SPC	Parkesia motacilla	Louisiana Waterthrush			X		X	X			X
THR	Parmelia stuppea	Powder-edged Ruffle Lichen			X						
END	Paronychia canadensis	Canada Forked Chickweed						X			
END	Paronychia	Forked Chickweed					X				
END	Parthenium integrifolium	Wild Quinine					X	X			
SPC	Peltigera venosa	Fan Lichen		X							
SPC	Perimyotis subflavus	Tricolored Bat		X			X	X			X
SPC	Perognathus flavescens	Plains Pocket Mouse					X	X		X	X
THR	Phacelia franklinii	Franklin's Phacelia		X		X					
END	Phegopteris hexagonoptera	Broad Beech Fern						X			
THR	Phemeranthus rugospermus	Rough-seeded Fameflower					X	X			
SPC	Phenacomys ungava	Eastern Heather Vole		X							
THR	Piptatherum canadense	Canadian Ricegrass		X					X		
SPC	Pituophis catenifer	Gophersnake			X		X	X	X		X

Status*	Scientific Name	Common Name	Ecoregion (ECS Section)**								
SPC	Planogyra asteriscus	Eastern Flat-whorl		X							
SPC	Platanthera clavellata	Small Green Wood Orchid	X	X	X	X	X				
THR	Platanthera flava var. herbiola	Tubercled Rein Orchid		X	X	X	X	X			
SPC	Plebejus idas nabokovi	Nabokov's Blue		X							
END	Plebejus samuelis	Karner Blue					X	X			
SPC	Plestiodon fasciatus	Common Five-lined Skink			X			X			X
THR	Poa paludigena	Bog Bluegrass			X	X	X	X			
END	Polanisia jamesii	James' Polanisia					X	X			
END	Polemonium lacustre	Great Lakes Jacob's-ladder	X	X		X					
END	Polystichum acrostichoides	Christmas Fern						X			
THR	Polystichum braunii	Braun's Holly Fern		X							
END	Prosartes trachycarpa	Rough-fruited Fairybells		X							
THR	Protopannaria pezizoides	Brown-gray Moss-shingle Lichen		X							
END	Psathyrella cystidiosa	A Species of Fungus					X				
END	Psathyrella rhodospora	A Species of Fungus					X				
END	Pseudocyphellaria holarctica	Yellow Specklebelly Lichen		X		X					
SPC	Pyrola minor	Small Shinleaf		X		X					
SPC	Quercus bicolor	Swamp White Oak					X	X			

Status*	Scientific Name	Common Name	Ecoregion (ECS Section)**							
SPC	Ramalina thrausta	Angel's Hair Lichen		X						
SPC	Ranunculus lapponicus	Lapland Buttercup	X	X		X			X		
SPC	Rorippa sessiliflora	Sessile-flowered Yellow Cress					X	X			X
THR	Rubus chamaemorus	Cloudberry		X							
SPC	Rubus multifer	Kinnickinnick Dewberry					X				
THR	Rubus semisetosus	Swamp Blackberry		X	X	X	X				
SPC	Rubus vermontanus	Vermont Bristle-berry		X	X	X	X				
THR	Rudbeckia triloba var. triloba	Three-leaved Coneflower					X	X			X
SPC	Ruellia humilis	Wild Petunia					X	X			
SPC	Salix pseudomonticola	False Mountain Willow							X		
SPC	Sanicula trifoliata	Beaked Snakeroot					X	X			
SPC	Sarcosoma globosum	A Cup Fungus		X							
SPC	Sassacus papenhoei	A Jumping Spider						X			
THR	Sceptridium oneidense	Blunt-lobed Grapefern		X	X	X	X	X			
SPC	Sceptridium rugulosum	St. Lawrence Grapefern	X	X	X	X	X				
SPC	Schinia indiana	Phlox Moth									X
SPC	Schinia lucens	Leadplant Flower Moth					X	X	X	X	X
END	Scleria triglomerata	Tall Nutrush					X				

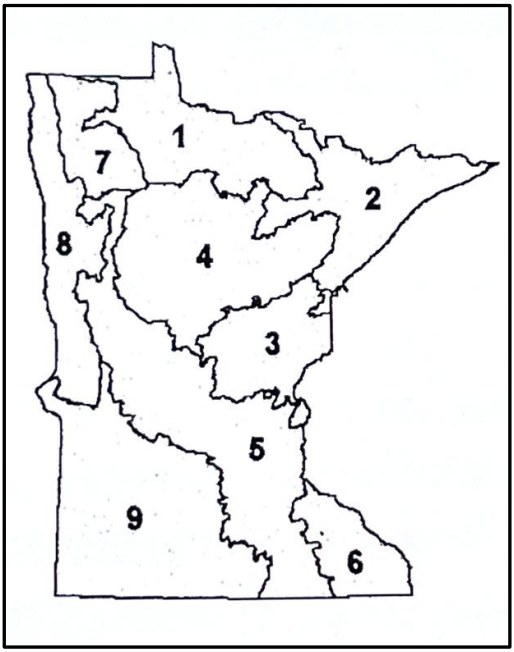
Status*	Scientific Name	Common Name	Ecoregion (ECS Section)**								
THR	Scutellaria ovata var. versicolor	Ovate-leaved Skullcap					X	X			
SPC	Setophaga cerulea	Cerulean Warbler			X	X	X	X			X
SPC	Setophaga citrina	Hooded Warbler				X	X	X			
SPC	Shepherdia canadensis	Soapberry		X					X		
SPC	Silene	Drummond's Campion			X	X	X		X	X	
THR	Silene nivea	Snowy Campion					X	X			
SPC	Somatochlora forcipata	Forcipate Emerald	X	X	X	X					
SPC	Sorex fumeus	Smoky Shrew		X							
THR	Sphagnum compactum	Cushion Peat Moss		X							
THR	Spilogale interrupta	Eastern Spotted Skunk				X	X		X		X
THR	Spiranthes casei var. casei	Case's Ladies' Tresses		X		X					
END	Splachnum rubrum	Red Parasol Moss		X							
SPC	Sticta fuliginosa	Peppered Moon Lichen	X	X		X					
SPC	Striatura ferrea	Black Striate		X							
END	Suillus weaverae	A Species of Fungus				X	X				
SPC	Symphyotrichum shortii	Short's Aster						X			
SPC	Synaptomys borealis	Northern Bog Lemming	X	X		X					
THR	Synthyris bullii	Kitten-tails			X		X	X			X

Status*	Scientific Name	Common Name	Ecoregion (ECS Section)**								
SPC	Taenidia integerrima	Yellow Pimpernel					X	X			
SPC	Tephrosia virginiana	Goat's Rue						X			
SPC	Thaspium barbinode	Hairy-jointed Meadow-parsnip					X				X
SPC	Thelia hirtella	Nipple Moss		X		X					
SPC	Thelocarpon epibolum	A Lichen	X	X							
THR	Trichocolea tomentella	A Species of Liverwort	X	X	X	X					
THR	Trichophorum clintonii	Clinton's Bulrush		X		X	X	X	X		
SPC	Trillium nivale	Snow Trillium					X	X			X
SPC	Triplasis	Purple Sandgrass					X	X		X	
SPC	Tropidoclonion lineatum	Lined Snake									X
END	Tsuga canadensis	Eastern Hemlock	X	X	X	X					
THR	Tutelina formicaria	A Jumping Spider					X				
SPC	Usnea longissima	Methuselah's Beard Lichen		X							
SPC	Usnea rubicunda	Red Beard Lichen			X	X	X	X			
THR	Vitis aestivalis	Silverleaf Grape						X			
SPC	Waldsteinia fragarioides	Barren Strawberry		X	X	X					

Table WH-3 Continued

**Ecoregion (ECS Section)

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



Source: Minnesota DNR. Rare Species Guide, Based on Minnesota's List of Endangered, Threatened and Special Concern Species, 2013.

Other laws, both state and federal, may apply to the protection of plants and animals in the state. For specific information on ETS species occurrences, the laws protecting them, and recommended management practices (including buffers), contact either the Minnesota Natural Heritage and Nongame Research Program or a DNR regional nongame specialist. See *Resource Directory*.

Field Survey Consultants and Other Resources

Consult with DNR wildlife managers, nongame specialists or Minnesota Natural Heritage and Nongame Research staff. See *Resource Directory.*

Other Survey Consultants and Sources of Information

- Local wildlife biologists, foresters, park managers or naturalists
- Nature centers, environmental learning centers, colleges, universities and University of Minnesota Extension offices
- Ecologists, botanists, natural resource consultants or forest stewardship plan preparers
- ETS source books, including:

  Coffin B. and L. Pfannmuller. 1988. *Minnesota's Endangered Flora and Fauna. 473 pp. University of Minnesota Press. Illustrated book covering some 300 species, ranging from mosses and lichens to vascular plants, birds, mammals, reptiles, amphibians, fish, butterflies, mollusks and tiger beetles. Individual species accounts, state distribution maps, illustrations and habitat. (Note that the status of many species has changed since this book was published.)*

  Chippewa National Forest, Minnesota Department of Natural Resources, Leech Lake Reservation. 1996.

Rare Plants Field Guide: *Chippewa National Forest and Cass County Unpaginated. Loose-leaf in ring binder. 36 species. Color photo, description and habitat information for each species, line drawings for some species.*

Shubat, Deborah, and Gary Walton. 1997. Rare Plants of Minnesota's Arrowhead. Olga Lakela Herbarium, University of Minnesota, Duluth. *Pocket-size field guide to 56 species of non-grasslike plants from the 1996 Minnesota DNR ETS list that have records in Carlton, Cook, Lake or St. Louis counties. Color photo, distribution map, description and habitat information for each species.*

Minnesota Department of Natural Resources (2003). *Field Guide to the Native Plant Communities of Minnesota: The Laurentian Mixed Forest Province*. Ecological Land Classification Program, Minnesota County Biological Survey, and Natural Heritage and Nongame Research Program. Minnesota Department of Natural Resources, St. Paul, Minnesota.

Ecoregion Applicability

Applies to all ecoregions.

Landscape Implications

Some area-sensitive ETS species will benefit most from large, unfragmented habitat blocks.

Sensitive Native Plant Communities and Sites, and Tree Species at the Edge of Their Range

Purpose: To increase awareness of sensitive native plant communities and sites and maintain or enhance these

where they are found; and to provide for perpetuation of most of the genetic diversity within tree species, as well as maximization of the potential for tree species to shift their geographic ranges in response to possible rapid climatic changes.

Rationale, Background and Benefits

Sensitive native plant communities and sites represent only a very small portion of the total forested area of the state. Even where they do occur, they often occupy only a limited part of a managed parcel of land. Adjoining properties may share these features in some cases.

The best information on occurrences of sensitive native plant sites and communities is being gathered by the Minnesota County Biological Survey, initially in the more critical prairie, metropolitan and southeastern counties. As each county is surveyed, a more complete basis for identifying sensitive areas will be available. Even when this project is complete, however, many sensitive native plant communities and sites will remain unknown, especially in forest areas of northern Minnesota.

Identifying sensitive sites and communities in the field can be challenging and may require expert evaluation.

Some sensitive sites and communities are best managed by avoidance, while other sites can either be maintained or enhanced by the use of appropriate silvicultural or harvesting procedures.

For the most part, sensitive native plant communities and sites are not protected by statutes. One exception is calcareous fens, a particular kind of treeless wetland community, which is protected by Minnesota Statutes 103G.223.

Most tree species in Minnesota reach the limit of their geographic range somewhere within the boundaries of

the forested portion of the state. There is a need to maintain genetic diversity within tree species and maximize the potential for tree species to shift their geographic ranges if rapid climatic changes occur. For additional information on current and future tree ranges, visit Tree Atlas - Climate Change Atlas - Northern Research Station, USDA Forest Service (https://www.fs.usda.gov/nrs/atlas/tree/)

Sensitive Native Plant Communities

Native plant communities are associations of native plants that interact with each other and with their environment in ways not greatly altered by modern human activities or by introduced organisms. These associations form recognizable units (e.g., white cedar-yellow birch forest, black spruce woodland) that reoccur over space and time. For a current list of sensitive native plants communities see *Appendix J: Sensitive Native Plant Communities.*

Field Survey Consultants and Other Resources

The following resources can assist in a field survey to identify sensitive sites or communities:

- DNR wildlife managers, nongame specialists or Minnesota Natural Heritage and Nongame Research staff. For information and assistance, see *Resource Directory*.
- Local wildlife biologists, foresters, park managers or naturalists.
- Source publications, including:
    - *Minnesota's Native Vegetation: A Key to Natural Communities*
    - *Natural Vegetation of Minnesota at the Time of the Public Land Survey*

- *Minnesota's St. Croix River Valley and Anoka Sandplain: A Guide to Native Habitats*
- *Minnesota's Natural Heritage: An Ecological Perspective*

Ecoregion Applicability

Applies to all ecoregions.

Landscape Implications

Forest prairie transition zones typically will have different management options than forest zones. Cooperative management with neighbors is possible when sensitive sites or communities extend over several ownerships.

Seasonal Ponds

Characteristics of 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 1/2 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 and tussocks, and commonly the absence, in many cases, of obligate aquatic plants.

Seasonal Pond Guidance

Purpose: To provide site-level wildlife habitat features for terrestrial and amphibious species associated with seasonal ponds within forests.

Rationale, Background, and Benefits

Minnesota has a variety and abundance of seasonal ponds. The mixture of land and water features across the landscape provides an important dimension to the habitats of many wildlife species.

Seasonal ponds are different from puddles. Seasonal ponds retain water for longer periods and support populations of invertebrates that consume forest litter that falls into the depressions. These invertebrates provide food for birds and other species.

With a lack of fish and other predators, these waters can be prime breeding habitat for amphibians. Seasonal ponds are also important spring food sources for breeding waterfowl.

Seasonal ponds are best identified in spring when full of water. Frog calling in spring, vegetation type or topography might provide additional clues to their location. Amphibians and reptiles will benefit the most from application of wetland-related guidelines. The GEIS projected no significant negative impacts to species or communities. However, there were four species of reptiles and amphibians not modeled in the GEIS because of a lack of ecological data. Of these four, two are especially linked to these pond resources: the gray tree frog and the blue-spotted salamander:

- The gray tree frog requires ponds within forests surrounded by abundant riparian vegetation. The extent to which wetland protection guidelines will maintain shading, litter depth, water quality and plant cover around seasonal ponds in forests will closely parallel the degree to which these frogs are protected from impacts.
- The blue-spotted salamander requires semi-permanent ponds surrounded by hardwood forests, preferably maple basswood, which have abundant woody debris on the ground. This species will be impacted by short rotations where there is a loss of debris and by the degradation of seasonal ponds.

Applying guidelines for water quality, leave trees and snags, coarse woody debris and slash during forest management activities can retain and create key habitat features (including woody debris, litter depth and plant cover) in these areas, while preventing siltation or excessive warming of seasonal ponds.

The Need for Research and Monitoring

The ecological importance of seasonal ponds in the forest is well recognized. However, existing inventories, such as the National Wetland Inventory, are incomplete with regard to the number and location of these wetlands in Minnesota's forests. These two factors indicate the need to document their occurrence and further research their ecological role in forests in Minnesota.

Preliminary research in Minnesota indicates that seasonal ponds may recover to approximate pre-harvest conditions for such factors as hydroperiod, abundance of amphibian larvae, macroinvertebrate abundance and diversity, macroinvertebrate population sizes, coarse woody debris loadings, and water chemistry within 10 years after harvest. Slower recoveries were found for such factors as

canopy cover and inputs of coarse particulate organic matter.

When considering potential management impacts to seasonal ponds, it is important to consider the portion of the landscape that may be in young forest (e.g., <10 years) and the adjacency of this forest to seasonal ponds. For more information regarding seasonal ponds, see *Technical Literature on Forested Wetlands and Seasonal Ponds.*

Riparian Wildlife Habitat

Purpose: To provide site-level wildlife habitat features for terrestrial riparian-obligate species.

Rationale, Background and Benefits

Riparian areas are among the most important parts of forest ecosystems. These areas have high plant diversity, both horizontally and vertically from the water's edge, which contributes to the high diversity of animals that live in these areas.

Up to 134 vertebrate species occur in riparian forests in this region, but many of these species will also use non-riparian forest habitat.

The species that are of most concern in riparian areas are "obligate" species, which require both the water and surrounding forests as habitat. In Minnesota, 32 reptile/amphibian, 20 bird and 15 mammal species are considered obligate riparian species. Numerous plant and invertebrate species are also strongly associated with these habitats.

Different animals are associated with different stream sizes. In general, larger animals are associated with larger streams and smaller species with smaller streams. A reverse pattern is found in some salamanders.

Some degree of mature forest cover is desirable along many riparian areas given long-term disturbance regimes. The amount or percentage of mature forest in a riparian area is an important management consideration at both the landscape and site levels. Riparian forests usually have a higher proportion of long-lived species and larger diameter, older and taller trees of all species than occur outside the riparian area.

Forest streams come in many sizes, growing from spring-fed trickles to large rivers as they move downhill and converge with one another to drain larger and larger watersheds. Along this gradient, the ecological characteristics of a riparian area change in a gradual continuum. Because of these characteristics, management guidelines for riparian areas in general should be considered on a landscape level.

Landscape issues are not addressed in these guidelines. Application of some wildlife-related site-level guidelines may differ within and outside the riparian management zone (RMZ), as described in Table WH-4.

Riparian Habitat Priorities

It is important to keep in mind the following wildlife-related concerns for riparian habitats:

Leave Trees and Snags

- Many riparian species are cavity dependent.
- Some riparian species require large super-canopy trees (trees whose crowns are found above the general forest canopy) for perches and nesting sites.
- Shade is essential for maintaining microhabitat conditions for some riparian animals.

Coarse Woody Debris and Slash

- Several riparian animal species require downed logs for cover.

Mast

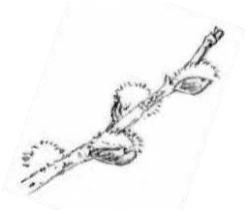
- Riparian edges often contain a higher concentration and richness of unique mast species, especially shrubs, than adjacent upland areas.

ETS Species

- Some ETS species occur in riparian areas.

Sensitive Communities and Sites

- Some sensitive communities occur in riparian situations.
- Many riparian species are sensitive to disturbance during the breeding season



Ecoregion Applicability

These guidelines are applicable to all forested ecoregions. In the southeast, consider limitations of harvest on adjacent slopes and the requirement of wider no-harvest strips adjacent to streams and rivers.

Landscape Implications

In areas dominated by agricultural land use practices (in south-central and southeast regions), where riparian forests represent the majority of the forests in the area, consider only uneven-age management.

Table WH-4

Differences in Application of Guidelines Within and Outside the Riparian Management Zone (RMZ)

Wildlife-Related Topic	Applying Guidelines Within the RMZ	Applying Guidelines Outside the RMZ
Leave trees and snags	• See RMZ recommendations for numbers and distribution of leave trees • Emphasize leave trees from excellent category when possible. See *General Guidelines: Retaining Leave Trees*. • Leave some bigger conifers and other long-lived tree species.	• Leave trees in 1/4-acre-plus clumps over 5% or more of the clearcuts (preferred), and/or 0-15 scattered leave trees per acre. • OK to choose all species (see mast below). Leave a variety of tree sizes and conditions (See *General Guidelines*.)
Coarse woody debris and slash	• Leave or create at least 4 bark-on downed logs per acre (overall site average, including non-RMZ, may still be a minimum of 2 per acre). Avoid disturbing down logs and uprooted stumps in the RMZ. If practical, leave (i.e., fell) one tree into a stream if coarse woody debris is not already in the stream in order to add structural diversity to the stream.	• Leave or create at least 2 bark-on downed logs per acre

Wildlife-Related Topic	Applying Guidelines Within the RMZ	Applying Guidelines Outside the RMZ
Conifer retention	• Leave undisturbed as many immature and mature conifer trees in the RMZ as possible.	• Maintain conifers as a significant structural component within mixed hardwood/ coniferous stands. (See *Timber Harvesting*, and *Wildlife Habitat Rationale*.)
Mast	• Leave undisturbed as many mast-producing trees and shrubs in the RMZ as possible. • Plan management activities to avoid removing or trampling mast-producing trees and shrubs.	• Give mast-producing trees preference as leave trees.
Patterns of cutting	• In harvests > 100 acres with an RMZ, consider leaving a forested travel corridor for animals along the RMZ. • Consider alternative management (other than clearcuts with leave trees) in stands currently comprised of mainly shade-tolerant species.	• Place legacy patch in representative habitats throughout the site.
Legacy patches	• In a stand that has an RMZ whose vegetation is similar to the surrounding upland, and for which a legacy patch is needed or desired, place the legacy patch in the RMZ.	• Place legacy patch in representative habitats throughout the site.

Additional Consideration: Legacy Patches

Purpose: To maintain the biological continuity of a harvested site having less than 30 ft^2/acre residual basal area.

Rationale, Background and Benefits

Biological continuity of a harvest site is the perpetuation of the full complement of organisms (including fungi, soil invertebrates, ground layer plants, reptiles, amphibians and small mammals) that have been successful in occupying the area in recent generations.

By avoiding soil compaction of the entire harvest site, removal of the natural litter layer and alteration of the hydrology of a reserve patch, additional source areas may be provided for recolonization, gene pool maintenance and establishment of microhabitats for organisms that can persist in small patches of mature forest.

Site sensitivity, and therefore the need for legacy patches, is dependent upon soil compressibility, soil drainage and time of year of harvest. In practice, a legacy patch provides additional protection to a leave tree clump (see *General Guidelines: Retaining Leave Trees*), in that a legacy patch:

- Is not disturbed with regard to soil compaction, litter removal and alteration of hydrology
- Does not need to be considered on all sites
- Is representative of the site

In practice, a leave tree clump may also serve as a legacy patch if a legacy patch is determined to be necessary on the site (Table WH-5, WH).

Assessing the Need for Legacy Patches

Consider whether a legacy patch is necessary by consulting Table WH-5. Even if the table indicates a need,

however, a legacy patch may not be needed if the desired results can be achieved through normal operating procedures that provide the same benefits as a legacy patch (such as a 1/4 acre leave tree clump left on frozen ground, or the use of low-impact harvesting equipment that minimizes disturbance on a site).

In harvests where less than 30 ft^2/acre basal area remains and Table WH-5 indicates a need, the following characteristics are preferred:

- A patch should be undisturbed in terms of soil compaction, natural litter layer and hydrology.
- Patches should vary in size, with a minimum of 1/4 acre per patch.
- For harvest units at least 15 acres in size, leave a minimum of 5% of the unit undisturbed.
- Randomly locate the patch (or patches) within a harvest unit to represent well the community type being harvested, including, if possible, some high-quality trees.
- The duration of a legacy patch is through one rotation. Location of the patch may vary during subsequent rotations. If a legacy patch is left in an intensively managed area (such as a plantation), it would be most beneficial to keep the patch in the same location over several rotations.

Table WH- 5

Decision Matrix for Legacy Patches on Mineral Soil Uplands with Less Than 6 Inches of Peat

Drainage[1]	Texture[2]	Depth to Restricting Layer[3]	5% Legacy Patch Requirement		
			Growing Season	Dormant Season	
			Any Soil	Unfrozen Soil	Frozen Soil[4]
Excessive & Somewhat Excessive	Coarse	>2 ft.	No	No	No
		<2 ft.	No	Yes	No
Well & Moderately Well	Coarse	>2 ft.	No	No	No
		<2 ft.	No	Yes	No
	Medium	>4 ft.	No	Yes	No
		<4 ft.	Yes	Yes	No
	Fine	>3 ft.	No	Yes	No
		<3 ft.	Yes	Yes	No
Somewhat Poor	Coarse	>3 ft.	No	Yes	No
		<3 ft.	Yes	Yes	No
	Medium & Fine	not applicable	Yes	Yes	No
Poor	All	not applicable	Yes	Yes	No

Footnotes to Table WH-5

1. **Soil Drainage Classes**
   - **Excessively and somewhat excessively drained:** Water drains very rapidly. Soils are commonly shallow, very porous, steep, or a combination of these conditions. No gray mottles occur within 60 inches of the surface.

- **Well-drained and moderately well-drained:** Water drains quickly enough in the upper 20 to 40 inches to prevent the formation of gray mottles. Gray mottles may form within 20 to 40 inches (moderately well) of the surface if downward water movement is retarded by a clay layer or if a regional water table is present for part of the growing season.
- **Somewhat poorly drained:** Water drains slowly. Saturation occurs long enough to form gray colors (mottles or dominant matrix) within 10 to 20 inches of the surface. Soils generally have a layer that retards downward water movement or a high water table for part of the growing season.
- **Poorly drained:** Water drains very slowly. Saturation occurs long enough to form gray colors (mottles or dominant matrix) within 10 inches of the surface. Soils generally have a layer for part of the growing season.

2. **Soil textures** are groups of standard classes as defined by the Natural Resources Conservation Service, 1975. Soil Taxonomy. USDA Agric. Handbook 436. pp. 469-472.
   - **Coarse:** sand, loamy sand, sandy loam
   - **Medium:** fine sandy loam, very fine sandy loam, loam, silt loam, silt, silty clay loam, clay loam, sandy clay loam
   - **Fine:** silty clay, sandy clay, clay
3. **Any feature that retards downward water movement**, such as hardpans, soil horizons greater than 6 inches thick with silty clay loam, clay loam, sandy clay loam, silty clay, sandy clay, or clay textures; bedrock; or frost, during spring breakup.
4. **Soil should be sufficiently frozen** to avoid disturbing the surface layer. Determining when soil is frozen may vary depending on location. One rule of thumb: “If there

is 14 inches of snow by the third week of December, there will be no frost in the soil. Likewise, following winter, if there are three consecutive nights above freezing, the frost will be gone."

Note: Drainage, texture and depth to restricting layer may be obtained from site visits or a county soils atlas map (available from local NRCS offices). See *Resource Directory*.

Species and Communities Affected

Late successional species and those that do poorly on disturbed soils will benefit the most. Many soil microorganisms helpful in plant regeneration and other important processes will help in the regeneration of the harvested site.

Ecoregion Applicability

This guideline is applicable to all ecoregions where soil conditions indicate a need, harvests are initiated on unfrozen ground, and routine harvesting practices do not meet the guideline recommendations.

Landscape Implications

Larger designated reserve areas, such as those found in state parks and Scientific and Natural Areas, can fill a role on the landscape level similar to that provided by legacy patches on the site level.

Selected Resources for Additional Information

Accommodating birds in managed forests of North America: A review of bird-forestry relationships. R. Sallabanks, E. Arnett,

T.B. Wigley, L. Irwin. 2001. Tech. Bull. 822. National Council For Air and Stream Improvement, Inc., Research Triangle Park, North Carolina.

Amphibians and Reptiles of Minnesota. 1994. B. Oldfield and J. J. Moriarty. University of Minnesota Press, Minneapolis, Minnesota. 237 pages. *This volume describes each of Minnesota's reptiles and amphibians, noting distribution, habitat and life history of each species.*

Biodiversity: A Technical Paper for a Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota. 1992. Jaakko Pöyry Consulting, Inc. Raleigh, North Carolina: 111 pages. *This technical paper provides background on GEIS modeling results for biodiversity, including information on projected impacts of increased timber harvest, suggested mitigations and detailed information on plants and plant communities. This paper was a primary source for development of site-level wildlife habitat guidelines.*

Birds and Forests: A Management and Conservation Guide. 1995. J. C. Green. Minnesota Department of Natural Resources, St. Paul, Minnesota. 182 pages. *This book provides a wealth of information on habitat needs of and management recommendations for Minnesota's diverse bird populations. Both stand-level and landscape-level recommendations are included.*

County Biological Survey of Minnesota. Minnesota Department of Natural Resources, St. Paul, Minnesota. This program began in 1987 as a systematic survey of rare biological features. *The goal of the survey is to identify significant natural areas and to collect and interpret data on the distribution and ecology of rare plants, rare animals and natural communities. Published maps display the results for 17 of 33 counties surveyed through January 1998. Surveys are under way for 18 additional counties*.

Creating a Forestry for the 21st Century: The Science of Ecosystem Management. 1997. K. A. Kohm and J. F. Franklin (eds.) Island Press, Washington, D.C. 475 pages. *This compilation of papers looks at various aspects of forest ecosystem management, including a summary of various wildlife topics, including economic concerns.*

Field Guide to the Native Plant Communities of Minnesota: The Laurentian Mixed Forest Province. Minnesota Department of Natural Resources. 2003. Ecological Land Classification Program, Minnesota County Biological Survey, and Natural Heritage and Nongame Research Program. Minnesota Department of Natural Resources, St. Paul, Minnesota.

Final Generic Environmental Impact Statement Study on Timber Harvesting and Forest Management in Minnesota. 1994. Jaakko Pöyry Consulting, Inc. Tarrytown, New York. 496 pages plus an executive summary and appendix. *This GEIS study was the main impetus for the development of forest management guidelines by the Minnesota Forest Resource Council's technical teams. This paper was a primary source for development of site-level wildlife habitat guidelines. It includes projections of significant impacts to various forest resources based on three projected levels of timber harvest in the state*.

Forest Wildlife: A Technical Paper for a Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota. 1992. Jaakko Pöyry Consulting, Inc. Raleigh, North Carolina. 283 pages plus an appendix. *This technical paper provides background on GEIS modeling results for wildlife, including a host of information on projected impacts of increased timber harvest, suggested mitigations and individual species life histories. This paper was a primary source for development of site-level wildlife habitat guidelines.*

The Mammals of Minnesota. 1982. E. B. Hazard. University of Minnesota Press, Minneapolis, Minnesota. 280 pages. *This book is an excellent source for ranges, habitats and natural histories of Minnesota's mammals.*

Minnesota's Endangered Flora and Fauna. 1988. B. Coffin and L. Pfannmuller (eds.) University of Minnesota Press, Minneapolis, Minnesota. 473 pages. *Although slightly dated because of the changing status of individual species, this book remains a key information source on the status, habitat and identification of endangered, threatened and special concern species in the state.*

Minnesota's Native Vegetation: A Key to Natural Communities (v. 1.5). 1993. Natural Heritage Program, Minnesota Department of Natural Resources, St. Paul, Minnesota. 110 pages. *Descriptions and keys to identification of natural communities are included in this technical manual. Characteristic plant species are listed for each community. Future updates may include successional pathways and clearer ties to the Ecological Classification System and commonly recognized cover types.*

The Patterned Peatlands of Minnesota. 1992. H.E. Wright, Jr.,B.A. Coffin, and N.E. Aaseng. (eds.) University of Minnesota Press. Minneapolis, Minnesota.

Report on the Scientific Roundtable on Biological Diversity Convened by the Chequamegon and Nicolet National Forests. 1994. T. R. Crow, A. Haney and D. M. Waller. North Central Forest Experiment Station, USDA Forest Service, St. Paul, Minnesota. General Technical Report #NC-166. 55 pages. *This report gives consensus-based alternative management strategies for Great Lakes forests by this group of natural resource professionals.*

Saving Nature's Legacy: Protecting and Restoring Biodiversity. 1994. R. F. Noss and A. Y. Cooperrider. Island Press, Washington, D.C. 416 pages.

Vascular Plants of Minnesota: A Checklist and Atlas. 1991. G. B. Ownbey and T. Morley. University of Minnesota Press, Minneapolis, Minnesota. 307 pages. *More than 2,000 vascular plants found in Minnesota are listed in this reference book. Maps of collected specimens of each species depict their ranges within the state. This book was a key resource for developing maps of tree species at the edge of their range in Minnesota*.

Wildlife, Forests, and Forestry: Principles of Managing Forests for Biological Diversity. 1990. M. L. Hunter, Jr. Prentice Hall, Inc,. Englewood Cliffs, New Jersey. 370 pages. *This text reviews the many facets of wildlife in the managed forest, providing a balanced approach to modern forest wildlife management.*

Wildlife Habitats in Managed Forests: the Blue Mountains of Oregon and Washington. 1979. J. W. Thomas (ed.) USDA.Forest Service Agricultural Handbook No. 553. US Government Printing Office, Washington, D.C. 512 pages. *Although this handbook focuses on western wildlife species and their habitats, much of the background information and principles are applicable throughout the forests of the United States and represent accepted management practices of many wildlife management agencies.*

Woodland Stewardship Plan Manual. 1991 (periodically updated). Division of Forestry, Minnesota Department of Natural Resources, St. Paul. *Tabbed three-ring binder including numerous brochures, fact sheets and individual management plans for non-industrial private forest (NIPF) landowners. This document is a primary source for NIPF landowners enrolled in the Forest Stewardship program. The information in the stewardship manual should complement and expand on the site-level wildlife habitat guidelines in this document, providing comprehensive planning information for a specific parcel of land*.

Technical Literature on Forested Wetlands and Seasonal Ponds

Ash, A.N., and R. C. Bruce. 1994. Impacts of timber harvesting on salamanders. *Conserv. Biol.* 8:300-301.

Blaustein, A. J., and D. B. Wake. 1995. The puzzle of declining amphibian populations. *Scientific American*. Vol. 272: 52-57.

Brooks, R. T., and M. Hayashi. 2002. Depth-area-volume and hydroperiod relationships of ephemeral (vernal) forest pools in southern New England. *Wetlands* 22:247-255.

Brown, A. V., Y. Aguila, K. B. Brown and W. P. Fowler. 1997. Responses of benthic macroinvertebrates in small intermittent streams to silvicultural practices. *Hydrobiologia* 347:119-125.

Cox, R. R., and M. A. Hanson, C. R. Roy, N. E. Euliss, Jr., D. H. Johnson and M. G. Butler. 1998. Mallard duckling growth and survival in relation to aquatic invertebrates. *Journal of Wildlife Management* 62:124-133.

de Maynadier, P. G., and M. L. Hunter. 1995. Relationships between forest management and amphibians. *Environmental Review-Dossiers Environment* 3:233-261.

Dube, S., and A. P. Plamondon. 1995. Watering up after clear-cutting on forested wetlands of the St. Lawrence lowland. *Water Resources Research* 31:1741-1750.

Gleason, R. A., N. H. Euliss, Jr., D. E. Hubbard, and W. G. Duffy. 2003. Effects of sediment load on emergence of aquatic invertebrates and plants from wetland soil egg and seed banks. *Wetlands* 23: 26-34.

Hanson, M. A., J. C. Church, A. T. Miller, and B. Palik. 2002. Testing the efficacy of harvest buffers on seasonal wetlands in forested landscapes. In: DonCarlos, M. W. et al. (eds.) *Summary of Wildlife Research Findings 2002*. Minnesota Department of Natural Resources, St. Paul, Minnesota.

Johnston, C. A., and P. Meysembourg. 2002. Comparison of the Wisconsin and National Wetlands Inventories. *Wetlands* 22:386-404.

Johnston, C. A. 1994. Cumulative impacts to wetlands. *Wetlands* 14:49-55.

Kenney, L. P. 1995. Wicked big puddles: a guide to the study and certification of vernal pools. U. S. Government Printing Office.

Lannoo, M. J. (ed.) 1998. *Status and Conservation of Midwestern Amphibians*. University of Iowa Press, Iowa City, Iowa.

Lockaby, B.G., A.L. Murphy, and G.L. Somers. 1996. Hydroperiod influences on nutrient dynamics in decomposing litter within a floodplain forest. *Soil Science Society of America Journal* 60:1267-1272.

Lugo, Areil E., Sandra Brown and Mark Brinson. 1990. *Ecosystems of the World: Forested Wetlands*. Vol. 15. Elsevier Science Publishers B. V. New York, New York.

Mitsch, W. J., and J. G. Gosselink. 1993. *Wetlands*. Van Nostrand Reinhold. New York, New York. 722 pages.

Murkin, H. R., and D. J. Batt. 1987. The interactions of vertebrates and vertebrates in peatlands and marshes. *Memoirs of the Entomological Society of Canada* 140:15-30.

Ossman, F. J., and M. A. Hanson. 2002. Northern forest wetlands: Characteristics and influences of forest age-structure. In: DonCarlos, M. W. et al. (eds.) *Summary of Wildlife Research Findings 2002*. Minnesota Department of Natural Resources, St. Paul, Minnesota.

Palik, B., D. P. Batzer, R. Buech, D. Nichols, K. Cease, L. Egeland, and D. E. Streblow. 2001. Seasonal pond characteristics across a chronosequence of adjacent forest ages in northern Minnesota, USA. *Wetlands* 21:532-542.

Palik, B., R. Buech, L. Egeland. 2003. Using an Ecological Land Hierarchy to Predict the Abundance of Seasonal Wetlands in Northern Minnesota Forests. Ecological Applications 13 (4): 1153-1163.

Roble, S. M., and D. B. Kittredge, Jr. 1991. Protection of vernal pools during timber harvesting. *The Northern Logger and Timber Processor*. May: 6-7.

Roy, V., J. K. Jeglum, and A. P. Plamondon. 1997. Water table fluctuations following clearcutting and thinning on Wally Creek wetlands. P. 239-251 In: Trettin, C.C. et al. (eds.) *Northern Forested Wetlands: Ecology and Management*. CRC Press Inc., Lewis Publishers, New York, New York.

Shepard, J. P. 1994. Effects of forest management on surface water quality in wetland forests. *Wetlands* 14:18-26.

Shure, D. J., M. R. Gottschalk, and K. A. Parsons. 1986. Litter decomposition in a floodplain forest. *American Midland Naturalist* 116:314-327.

Stewart, R. E., and H. A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. U.S. *Fish and Wildlife Service Resource Publication 92*. U.S. Government Printing Office, Washington, D.C.

Thorpe, J. H., and A. P. Covich. 1991. Ecology and Classification of North American *Freshwater Invertebrates*. Academic Press, Inc. San Diego, California. 911 pages.

Trettin, C. C. (ed.) et al. 1997. *Northern Forested Wetlands: Ecology and Management*. Lewis Publishers, New York, New York.

Wellborn, G. A., D. K. Skelly, and E. E. Werner. 1996. Mechanisms creating community structure across a freshwater habitat gradient. *Annual Review of Ecological Systems* 27:337-363.

Welsch, D. J., D. L. Smart, J. N. Boyer, P. Minkin, H. C. Smith and T.L. McCandless. 1995. Forested wetlands: functions, benefits and the use of best management practices. Northeastern Area, USDA Forest Service, Radnor, Pennsylvania. 62 pages.

Wiggins, G. B., R. J. Mackay and I. M. Smith. 1980. Evolutionary and ecological strategies of animals in annual temporary pools. *Archiv für Hydrobiologie Supplement* 58:97-206.

Zedler, P. H. 2003. Vernal pools and the concept of "isolated wetlands." *Wetlands* 23: 597-607.

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.

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General Guidelines: An Introduction

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. "Additional considerations" and the term "consider" are included as a supplement to the guidelines to provide for careful thought in reaching suitable resource management decisions. These terms are intended to provide as much flexibility and choice as possible in

effectively balancing forest management needs and resource sustainability.

Planning

Identifying Goals and Objectives

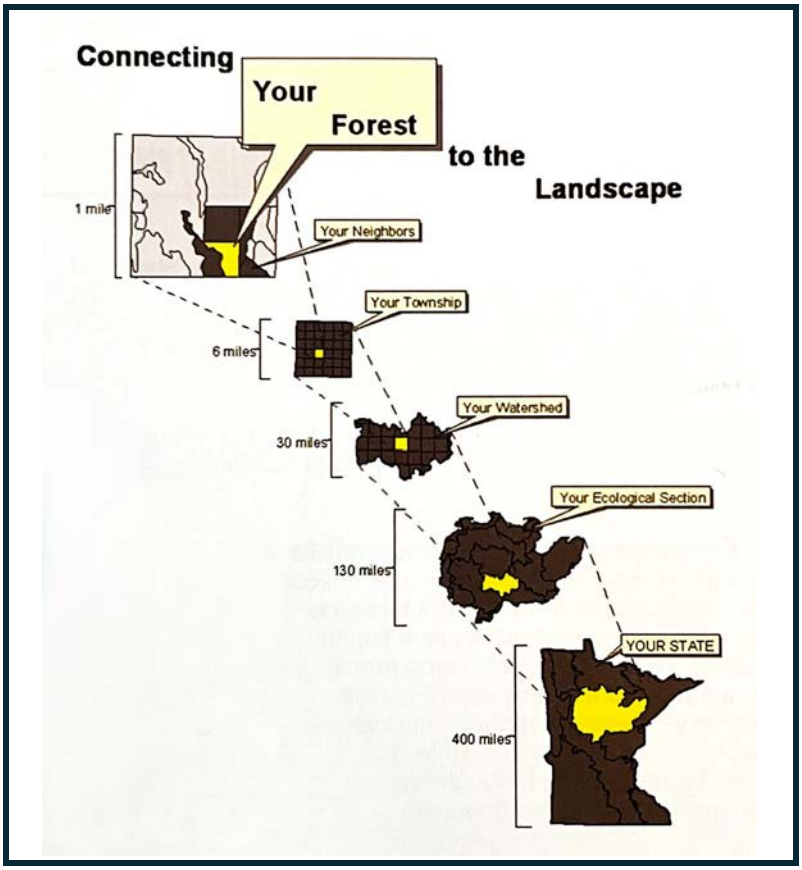
Getting started requires identifying land ownership goals and objectives, and understanding your soil-site relationships and current forest condition. This first step may require the assistance of professionals. A few considerations related to identifying goals and objectives include the following:

- **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.

Figure GG-1



- **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*.
- **When developing a management plan** for your site, consider the overall condition of your watershed, the likelihood of your plans to cause detriment to water quality and habitat in the watershed, and your ability to address any impacts including consideration of the total area of the watershed that you manage. If management activities are likely to impact watershed habitat or water quality, modify your plan such that impacts are minimized. The following resources will assist you in evaluating your watersheds condition.

Resources

Minnesota Department of Natural Resources Watershed Health Assessment Framework webpage
https://www.dnr.state.mn.us/whaf/index.html

Minnesota Pollution Control Agency Watershed Approach to Water Quality webpage
https://www.pca.state.mn.us/air-water-land-climate/watershed-approach-to-water-quality

United States Environmental Protection Agency Water Topics webpage
http://water.epa.gov/type/watersheds/index.cfm

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, National Wetlands Inventory (NWI), 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 *Part 2: Cultural Resources and Resource Directory*.

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
- Consider visiting the site during snow free conditions when these resources, features and site conditions may be most visible.

Figure GG-2 Seep in a Forested Area



Additional Consideration

Consider conducting additional field survey work prior to forest management activities to determine whether endangered, threatened or special concern species (ETS species), rare tree species, or sensitive communities or sites are present. See *Part 2, Wildlife Habitat: Endangered, Threatened and Special Concern Species and Sensitive Communities and Sites, and Tree Species at the Edge of Their Range*.

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:

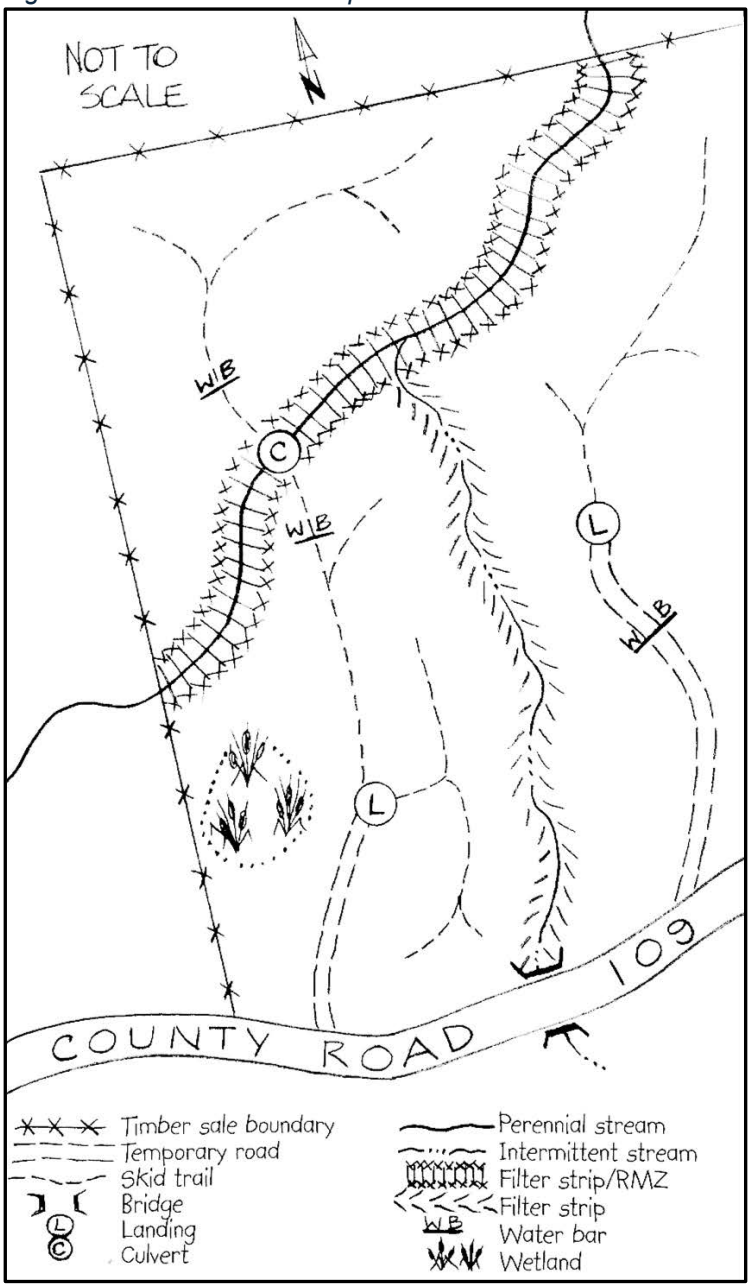
✓ **Create a site map or conduct an on-site review** with the operator to indicate the location of any special concern areas identified during the site survey. Be sure that maps are large enough to adequately depict sensitive areas. See Figure GG-3. The site map or on-site review should clearly identify 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, and
- 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 (e.g., early successional wildlife habitat, retention or regeneration of long-lived conifer species).

✓ **Document the configuration of leave tree clumps or scattered individual leave trees** within the general harvest area that will achieve wildlife objectives associated with leave tree retention, while maintaining operability of the management activity.

- ✓ **Document any silvicultural justification for deviating** from slash retention guidelines during harvesting operations (e.g., lower retention to facilitate post-harvest planting, higher retention to inhibit browse damage to regeneration, etc.).
- ✓ **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.
- ✓ **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.

Figure GG-3 Harvest Site Map



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 may increase in frequency with climate change and 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.
- ✓ **Consider climate change impacts on the preferred operating season**, including winter conditions and changing precipitation patterns, which may limit access or load bearing capacity of the soil. Use lower ground pressure equipment or restrict operations on sensitive sites to soil conditions sufficient to support needed equipment. Plan ahead to check and monitor frost depth and soil conditions to ensure soil can support equipment needed for onsite operations.
- ✓ **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 developing infrastructure** in wetlands and filter strips, including landings, skid trails and roads. Where avoidance is not practical, minimize impacts by limiting the extent of infrastructure in wetlands.

✓ **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:

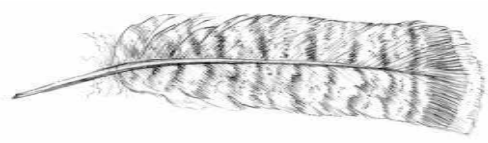
- Limits the impact on the hydrologic and biologic characteristics of the wetland.
- Does not result in the construction of dikes, drainage ditches, tile lines or buildings.
- Does not result in the drainage of the wetland or public waters.
- Avoids filling whenever possible.

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).

When planning new non-silvicultural uses for a road originally constructed for silvicultural purposes, consult WCA (BWSR) Guidance Paper 2004-01 and Minn. Rules 8420.



Rare or Sensitive Species

✓ **Modify management activities** to maintain, promote or enhance ETS species (endangered, threatened or of special concern) on the site, including retention of all slash during harvesting operations if slash-dependent ETS species are present.

✓ **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, including consideration of climate change impacts. Consider local and regional forest habitat, watershed, or cooperative ecosystem management plans that may be relevant to your property. Technical and financial assistance to help the site contribute to those plans may be available from various sources. 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*.



Invasive Terrestrial Plant Species Guidelines

Scope

The guidelines outlined in this section are designed to control the spread of invasive plant species during timber harvesting operations. Other forest management and recreational activities also contribute to the spread of invasive species, and comprehensive planning and control methods may be necessary for effective invasive species management. Regulated invasive insects such as the emerald ash borer are not addressed in these guidelines, but there are several existing laws that govern their control and transport which are outlined in the additional resources listed below. Invasive insect pests are regulated by the Department of Agriculture and are not specifically addressed here.

Introduction

The spread of invasive species is one of the greatest threats to sustainable forestry and the maintenance of native ecosystems and the many benefits they provide.

Invasive species are those species not native to Minnesota whose establishment causes or is likely to cause economic, environmental, or human harm. Once established, invasive species are generally able to outcompete many of our common native species, inhibit regeneration and growth of our native forests and reduce biodiversity. The ecological and economic impact of invasive species is tremendous, underlying an urgent need to utilize practices that inhibit their establishment and spread.

There are several laws in Minnesota which govern the transport, control, and eradication of invasive species (see resources listed below). Of particular applicability to forestry is the Noxious Weed Law, which prohibits sale or transport of certain plant species and their reproductive parts including many that are considered invasive such as buckthorn, garlic mustard, and non-native thistles. The recommended practices outlined below are not intended to replace the requirements of the Noxious Weed Law and other related regulations but will assist landowners and managers with compliance of those regulations by providing a range of practices to limit the establishment and spread of invasive species.

Timber harvesting can increase the spread of invasive species by creating conditions conducive to their transport, establishment and growth. One of the most efficient approaches to slow the spread of invasive species during timber harvesting is to evaluate and develop a plan to address any threat prior to commencing operations. Because planning is fundamental to application of invasive species guidelines, landowners and resource managers are the primary entities responsible for determining and applying appropriate guidelines for their specific site conditions and desired future stand conditions. Communication of the invasive species plan to loggers will

be essential for effective plan implementation. Working together, landowners, managers, and loggers will be critical to slowing the spread of invasive species during timber harvesting operations.

Pre-harvest Planning Guidelines

Prior to designing the timber harvest or putting the sale out for bid, landowners or managers should utilize the following planning guidelines as appropriate to control the spread of invasive species during timber harvesting operations.

- Become familiar with invasive species common to your area of operation including their identification and life cycle.
- Review the existing invasive species laws and regulations to determine any regulatory requirements that might be associated with your timber harvesting operation.
- Consider contacting the local county agricultural inspector (weed inspector), Minnesota DNR, and EDDmaps.org to learn more about invasive species known to occur in or around the planned harvest area, and to learn about treatment options.
- If materials including fill, soil, plants or seeds, will be brought to the site, ensure practices to limit the spread of invasives are used when procuring and transporting material.
- Inspect the site for the presence of invasives, the severity and extent of infestation, and delineate areas of infestation in the harvest plan.
- Consider using one or more of the following options depending on the severity of infestation and the threat of spread:
    - Where feasible, implement pre-operation treatments to control known infestations. Use control measures such as mowing, herbicide

application, mechanical pulling, or prescribed fire to reduce invasive species populations where appropriate. Some examples when control may be necessary include Common and glossy buckthorn, Common tansy, Non-native knotweeds, Wild parsnip, and Knapweed. Consult local and statewide noxious weed lists for more information.

- Avoid or minimize the time of contact with areas of high infestation, including cutting those areas last if possible (e.g., work from least to most invaded areas).
- If possible, schedule harvest operations for seasons when the likelihood of spread is reduced (e.g., winter).
- Utilize existing roads and landings to minimize the amount of disturbed area in the harvest unit whenever possible.
- When possible, utilize equipment and practices that minimize the amount of vegetation and soil disturbance while meeting objectives for desired future stand conditions.

Recommended Practices During and Following Operations

Use the following practices when appropriate to limit the spread of invasive species during and following timber harvesting operations:

- Manipulate stand structure to minimize germination of invasive species seeds.
- Retain or promote native vegetation communities during operations.
- Minimize soil and plant disturbance when not required for regeneration of the stand.
- Make reasonable efforts to remove plant propagules (seeds, roots, shoots, etc.) on clothing, equipment,

vehicles, and logs prior to arriving at and leaving the harvest site.

- Avoid traveling between infested and clean sites during operations if possible. If avoidance is not possible, plan activities to visit all clean sites prior to visiting infested sites.
- Re-vegetate the site as soon as possible following harvesting using appropriate non-invasive species and silvicultural methods.
- Match the species to the site resources to ensure healthy native plant communities capable of competing against invasive species.
- Conduct post-harvest monitoring to assess if follow-up activities are necessary to limit the spread of invasive species.

Useful Resources

Minnesota Department of Agriculture Noxious and Invasive Weed Program webpage
http://www.mda.state.mn.us/plants/pestmanagement/weedcontrol.aspx

Minnesota Department of Natural Resources Invasive Terrestrial Plants webpage
http://mndnr.gov/invasive-plants

Minnesota Forest Industries Private Landowners webpage
https://minnesotaforests.com/private-landowners/

Sustainable Forestry Initiative Minnesota's Forest Invaders-A Guide to Invasive Species pdf
https://minnesotaforests.com/wp-content/uploads/2023/09/Invasive-Species.pdf

National Invasive Species Information Center website
https://www.invasivespeciesinfo.gov/

University of Minnesota Minnesota Invasive Terrestrial Plants and Pests Center webpage
https://mitppc.umn.edu/

Minnesota Invasive Species Advisory Council Minnesota's Urban and Community Forest Best Management Practices for Preventing the Introduction, Establishment, and Spread of Invasive Species pdf
https://files.dnr.state.mn.us/natural_resources/invasives/terrestrialplants/is-bmp.pdf

DNR Contractor Prevention webpage
https://www.dnr.state.mn.us/invasives/dnrlands.html

EDD Maps website
https://www.eddmaps.org/

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.

Table GG-1

Filter Strip Width Guide

Slope of land between activity and water body	Recommended width of filter strip (slope distance)*
0-10%	50 feet
11-20%	51-70 feet
21-40%	71-110 feet
41-70%	111-150 feet

*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

Figure GG-4 Filter Strips and RMZ for Non-Trout Perennial Streams < 3 Feet Wide of Varying Slopes

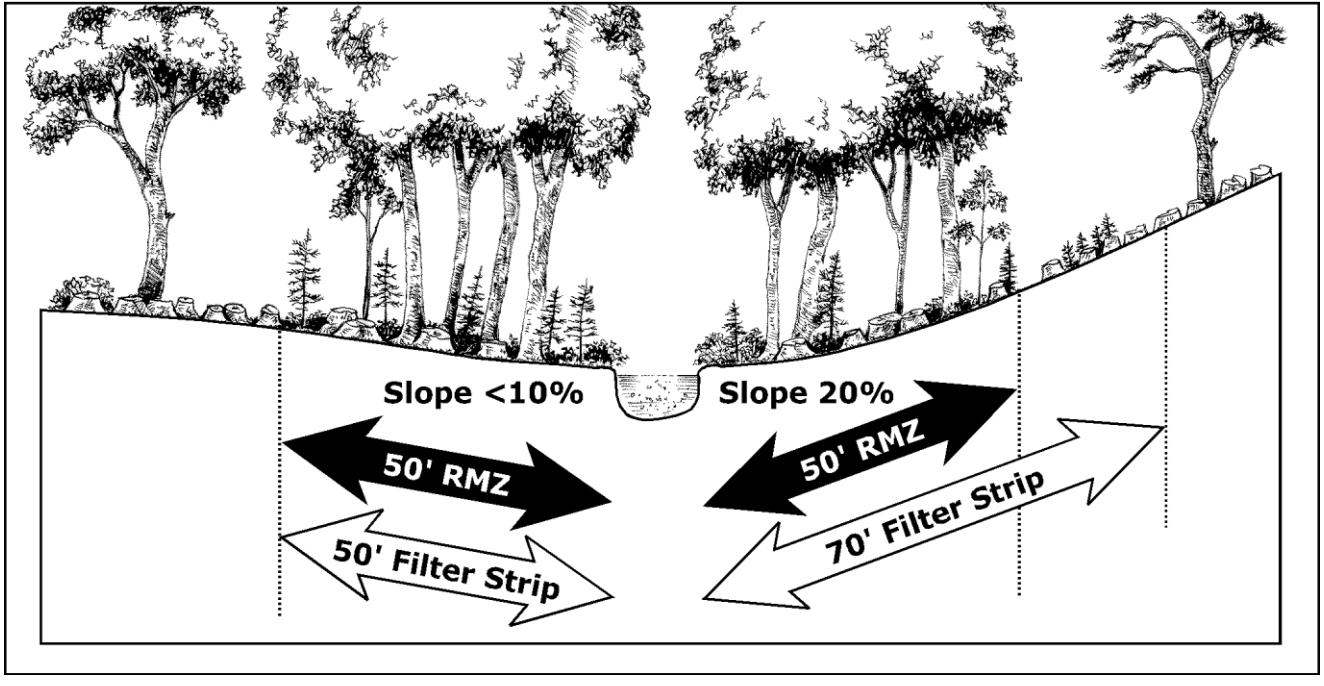
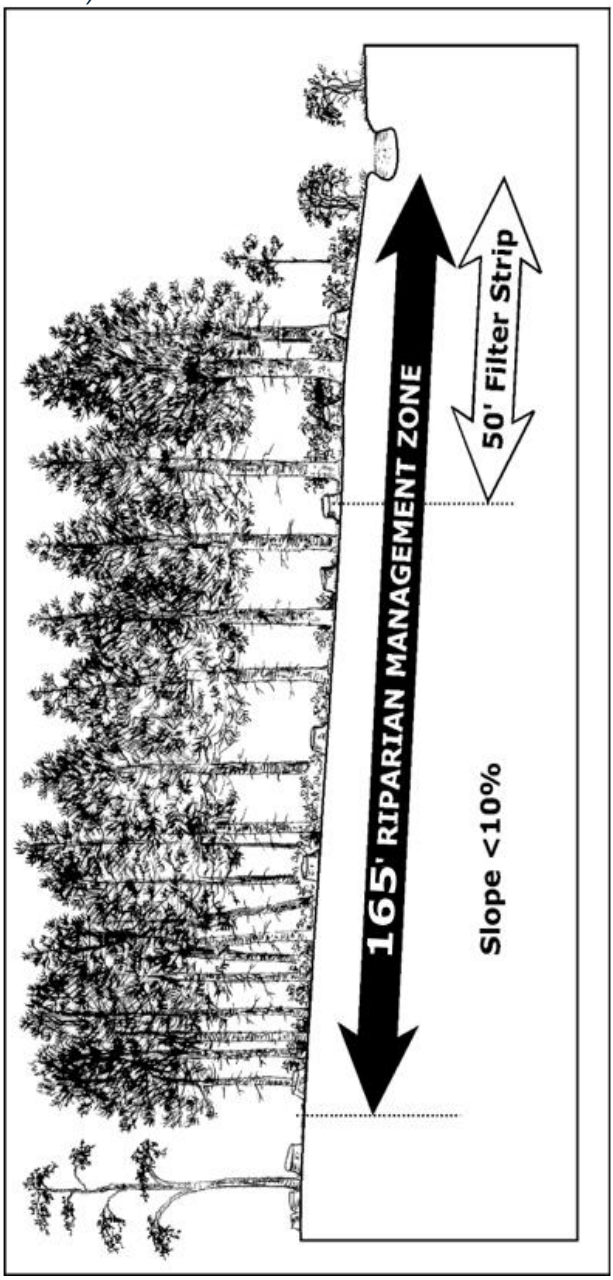


Figure GG-5 Filter Strips and RMZ for Trout Lakes and Streams (slope < 10%)

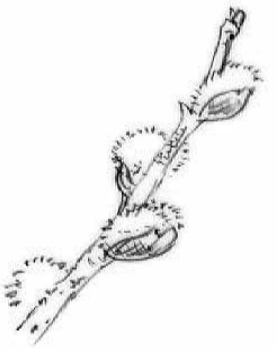


- Minimize compaction in filter strips while conducting forest management activities on soils susceptible to compaction by:
    - Harvesting under frozen soil conditions; or
    - Using equipment that minimizes the potential for compaction; or
    - Using such operating techniques as slash mats for skid trails and roads.

Consider additional stabilization measures. When necessary, use practices such as distributed or concentrated 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.
- When overland flow resulting from increased precipitation may occur, consider additional filter strip width and/or stabilization measures



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.

Widths are based on the water body type, its size, and whether or not it is trout bearing. Residual basal area recommendation are the same for all water bodies and assume that riparian areas are primarily being managed for longer-lived covertypes.

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.

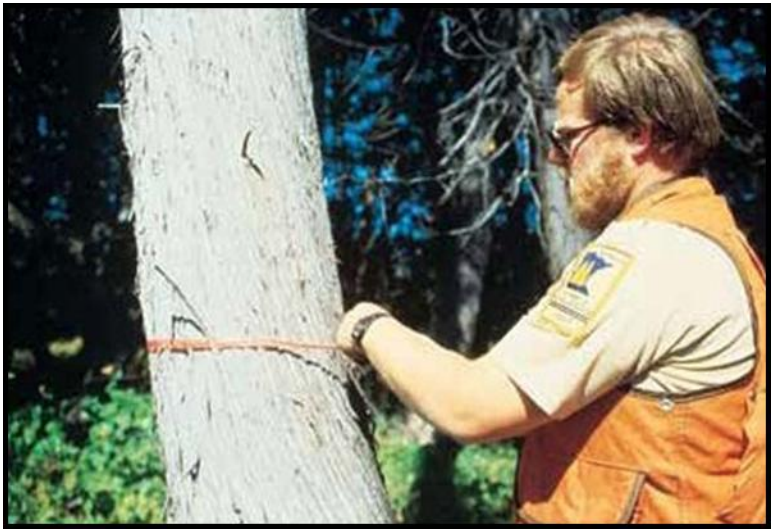
Forest management activities may be conducted within the riparian management zone.

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 (ft^2/tree) or per acre (ft^2/acre). See *Appendix E: Determining Basal Area*

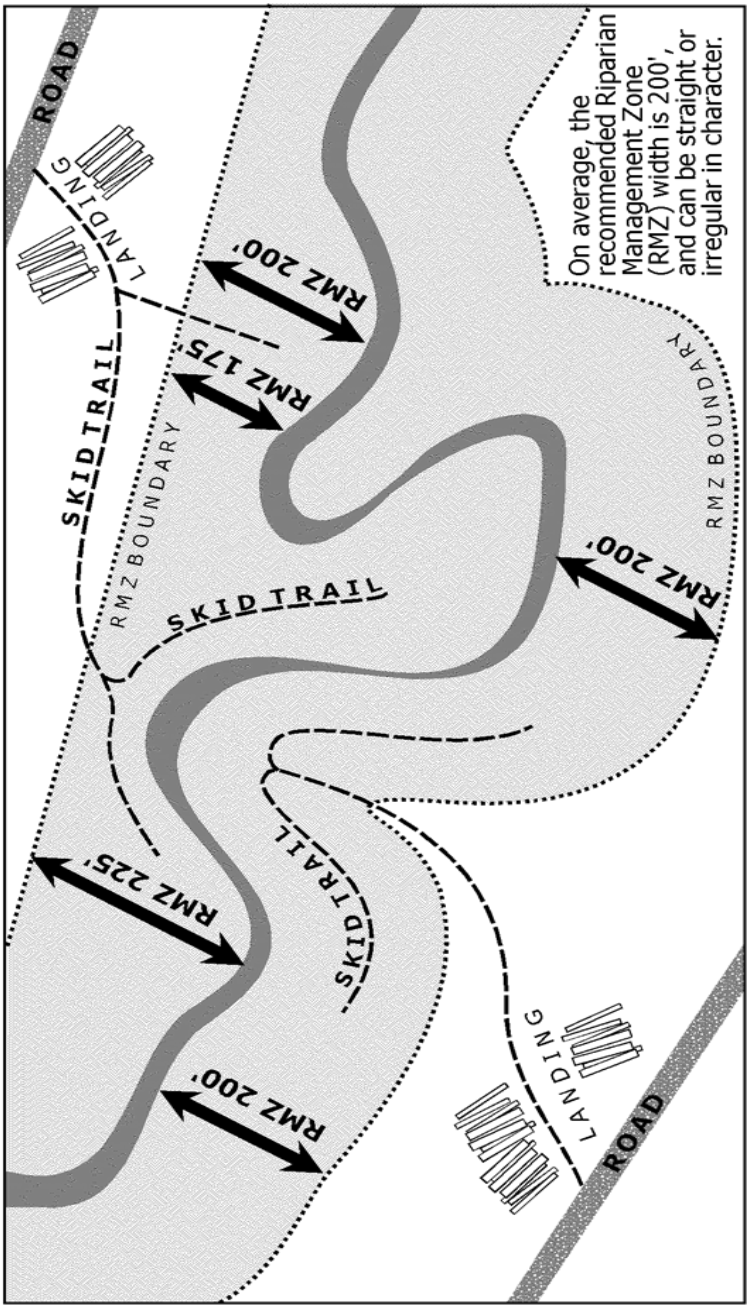


Basal area is the cross-sectional area of a live tree 4.5 feet above ground (based on its diameter at breast height, or DBH). Photo courtesy of Minnesota DNR

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*.

Figure GG-6


ROAD
LANDING
SKID TRAIL
RMZ BOUNDARY
RMZ 175'
RMZ 200'
On average, the recommended Riparian Management Zone (RMZ) width is 200', and can be straight or irregular in character.
RMZ BOUNDARY
RMZ 200'
SKID TRAIL
SKID TRAIL
RMZ 225'
RMZ 200'
LANDING
ROAD

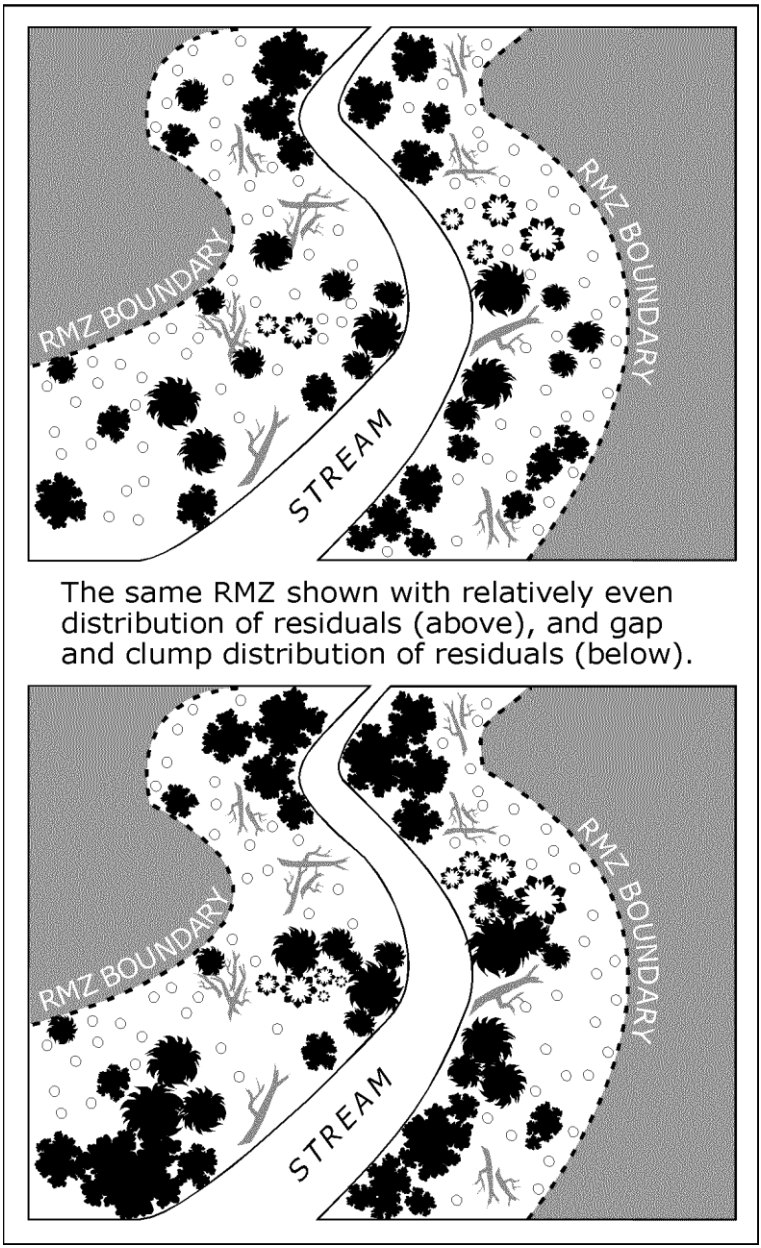
Flexibility Considerations

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.

Figure GG-7

Residual Distribution Options Within the RMZ



- **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*.
- **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)*
    - 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.

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 recommendations are based on the type and size of the water body as outlined in Table GG-2. **Recommended minimum residual basal area for all RMZ's is 60 ft^2 (80 ft^2 if using as leave tree clump)**. Width and residual basal area recommendations apply to the average condition of the RMZ and should not be viewed as strict minimums for every portion of the RMZ. See important considerations below for proper application of the riparian guidelines.

Table GG-2

Recommended RMZ Widths for Various Water Body Categories

Water body characteristics	RMZ width (ft)
Designated trout streams, tributaries, and lakes	165
All non-trout streams ≥ 3 ft. wide, and lakes and open water wetlands ≥ 1 ac. in size	120
All non-trout streams < 3 ft. wide and lakes and open water wetlands < 1 ac. in size[1]	50

[1] These recommendations do not apply to seasonal ponds. See *General Guidelines: Protecting Non-Open Water Wetlands and Seasonal Ponds* for more information on recommended practices related to seasonal ponds

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*** 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, and
  - 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-3: Leave Tree Preferences for Longevity, Windfirmness and Cavity Potential.

✓ **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.

✓ **Retain at least four leave logs per acre within RMZs when** harvest activities are conducted within RMZs. 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, and
  - 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.*
- ✓ **Increased heavy precipitation events** may elevate the importance of using diversion structures on approaches to water crossings or on roads and trails within the RMZ to divert water off the right-of-way before it reaches the water body.

✓ **Large precipitation events may become more frequent with climate change**, increasing the risk of erosion on steep slopes. When implementing RMZs on steep slopes, such as in **high bank forests**, consider employing the following practices to protect bank stability:



- Extend RMZ width 25ft past the bluff to prevent slumping,
- Avoid harvesting at the edge of the bluff when possible,
- Harvest on frozen ground when feasible, and
- Utilize appropriate equipment and methods to minimize soil impacts.

✓ **Consider climate change impacts to tree mortality in the RMZ** based on vulnerability assessments, invasive species, insect and disease threats, hydrologic changes, severe wind and weather events, and other concerns.

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.

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. I**t 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.

- ✓ **State law requires immediate action** as reasonably possible to clean up all petroleum spills, regardless the amount, to minimize or abate pollution of waters of the state.
- ✓ **Report all petroleum spills of five or more gallons**, including the location of the spill, the type of material and volume of the spill, and a description of what you plan to do for cleanup. 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.
- ✓ **Petroleum contaminated soil of ten cubic yards or less** may be thin-spread on a suitable site without the requirement to do follow-up sampling as long as the following conditions are met:
    - Permission from the landowner has been received to thin-spread.
    - The area of spread is isolated and at least 200 feet from surface water, wells, and sewers.
    - Thin-spreading will occur between April 1 and November 1.
    - Contaminated soil is spread at a maximum thickness of 2 inches and incorporated into the native soil.
- ✓ **If you estimate that you will be digging up ten or more cubic yards of soil**, ask the duty officer to connect you with the on-call MPCA emergency responder for immediate advice and approval of your cleanup plan.

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.



This non-open water wetland is located within an upland site. Photo courtesy of Minnesota DNR

Protecting Non-Open Water Wetlands and Seasonal Ponds

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 1/2 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.

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, condition, and economic value. 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, wind firmness 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-3 characterizes leave trees as excellent, good or fair in terms of longevity, wind firmness and cavity potential. Wind firmness may vary based on site characteristics

Table GG- 3

Leave Tree Preferences for Longevity, Wind Firmness and Cavity Potential

Excellent	Good	Fair
white pine oaks elms sugar maple yellow birch basswood aspens	red pine* tamarack cedar red maple white spruce* black cherry hickories box elder cottonwood walnut hackberry	white birch balsam fir* jack pine* black spruce* balsam poplar ashes*

*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.
- **Economic value:** Consider the economic value of the leave trees when selecting which ones to leave.



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), and
- 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.
- 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.



Both aquatic and terrestrial coarse woody debris enhance aquatic and wildlife habitat in forested areas. Photo courtesy of Minnesota DNR

- ✓ **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), and
    - Visual quality issues.

Post-Operational Activities and Follow-up 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. Erosion control is usually necessary on all landing, road and skid trail segments where sedimentation to lakes, streams, and wetlands is possible including when the slope is greater than 2% and vegetative cover is insufficient to control erosion. Erosion control is recommended for all approaches to wetland and stream crossings and may be necessary in other situations depending on site-specific factors. Potential increases in heavy precipitation and run-off associated with climate change serve to highlight the importance of proactive erosion control practices.



- 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 follow-up 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 follow-up visits can help assure that the protection measures remain functional.

Forest Road Construction and Maintenance

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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.

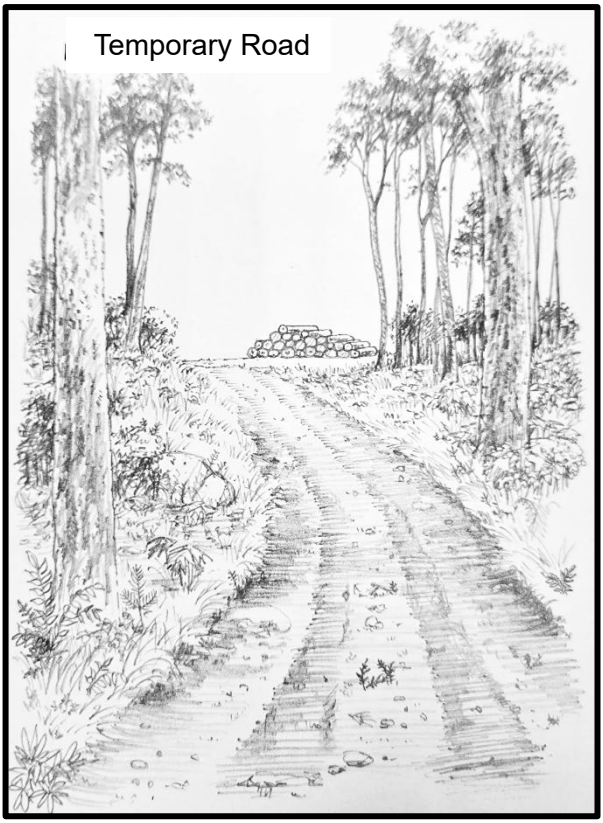


Figure ROAD-1. Temporary Road.

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.

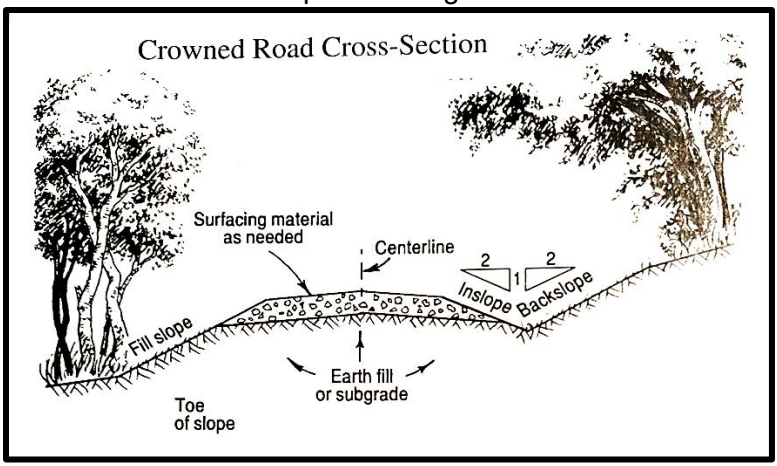


Figure ROAD-2

- **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.
- **Consider potential high-flow events** in the selection of culverts and crossing designs to accommodate potential higher intensity precipitation associated with climate change.



- **During road construction, consider installing erosion control** measures to minimize bare soil exposure and runoff.
- **Consider climate change impacts on seasonal site operability** when designing roads and wetland crossings. Additional road stabilization and/or crossing techniques may be needed.

- **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.

Upland 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 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 to prevent sedimentation of lakes, streams, and wetlands. Check structures frequently enough to ensure that they are functioning as designed, especially in situations where sedimentation risk is high.
- ✓ **Minimize road width** consistent with road safety and design considerations.

Additional Consideration

If road closure is anticipated, consider designing road approaches to facilitate effective closure after completion of management activities.

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 the Gopher State One Call website (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*.

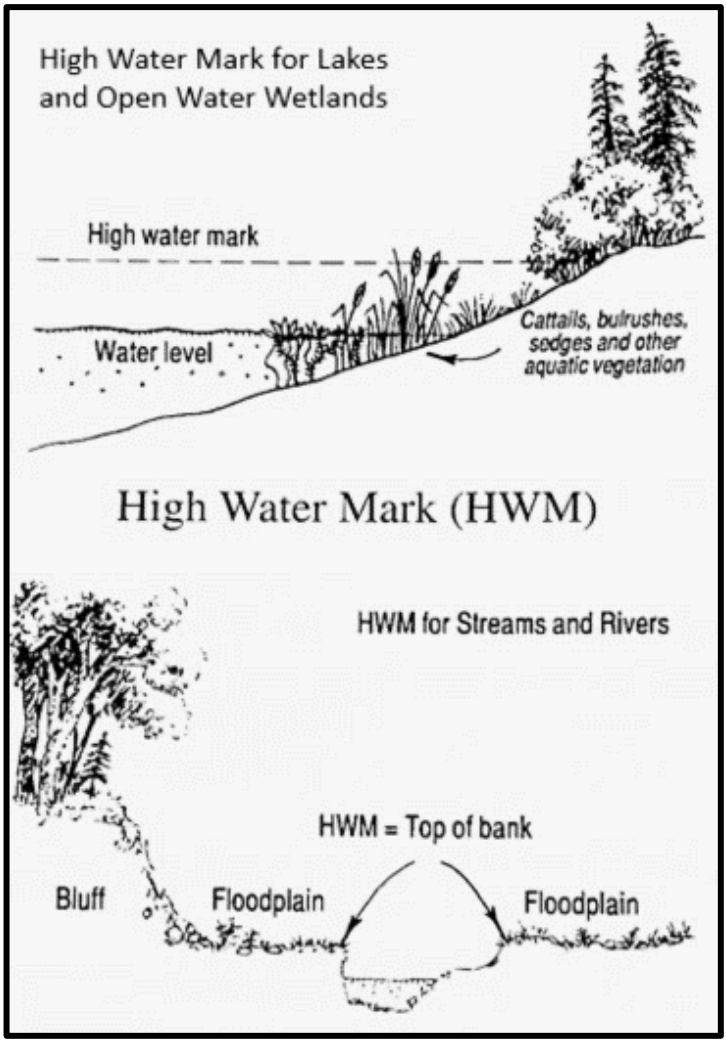


Figure ROAD-3

- ✓ **Locate roads to avoid concentrating runoff** and reduce the potential for nonpoint source pollution.
- ✓ **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

In Areas Classified as Most Sensitive*

- ✓ **Minimize the number of roads** approaching travel routes or recreation areas.

In Areas Classified as Most Sensitive or Moderately Sensitive*

- ✓ **Locate roads and trails to minimize visibility** from nearby vantage points, such as scenic overlooks, streams and lakes.
- ✓ **Reduce visual penetration** with appropriate curves in the road alignment.
- ✓ **Minimize total road mileage and ground disturbance** required to meet landowner objectives and anticipated traffic loads.
- ✓ **Avoid tracking mud onto highways** by using appropriate road surface material.

In Areas Classified as Less Sensitive*

- ✓ **Consider visual quality to the extent possible.**

✓ **Minimize total road mileage and ground disturbance** required to meet landowner objectives and anticipated traffic loads.

*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.

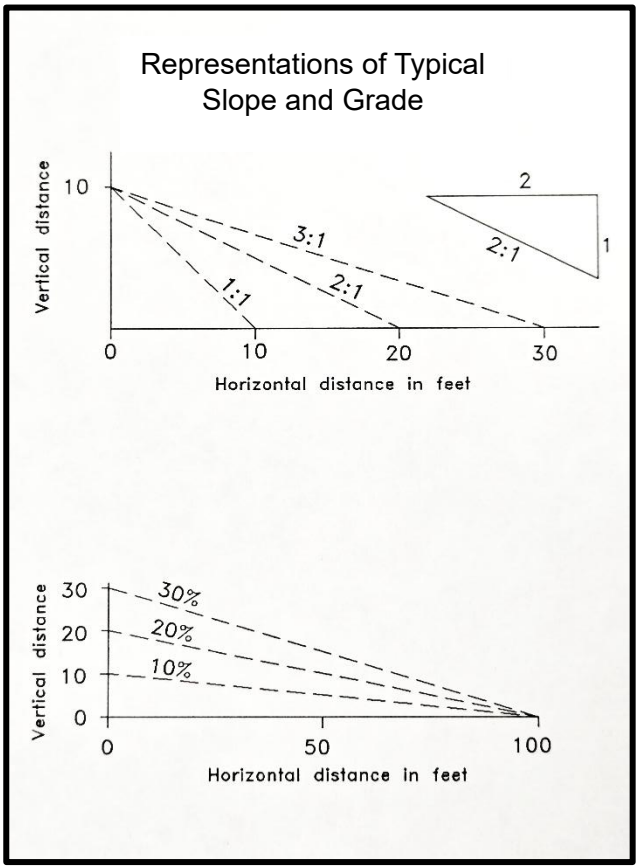


Figure ROAD-4. Representations of typical slope and grade.



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 Minnesota Department of Natural Resources Public Waters Inventory Program webpage (https://www.dnr.state.mn.us/waters/watermgmt_section/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 (6264.0050) can also be found at the Minnesota Legislature Minnesota Administrative Rules 6264.0050 Restrictions on Designated Trout Lakes and Streams webpage (https://www.revisor.mn.gov/rules/6264.0050/). 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.

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.

Winter Roads



Winter roads provide access under frozen ground conditions for timber harvesting and other timber management activities. With warming winters, winter rain events, changes in freeze-thaw cycles, and shorter frozen periods, careful planning for winter road establishment, use, and decommissioning is important. 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.

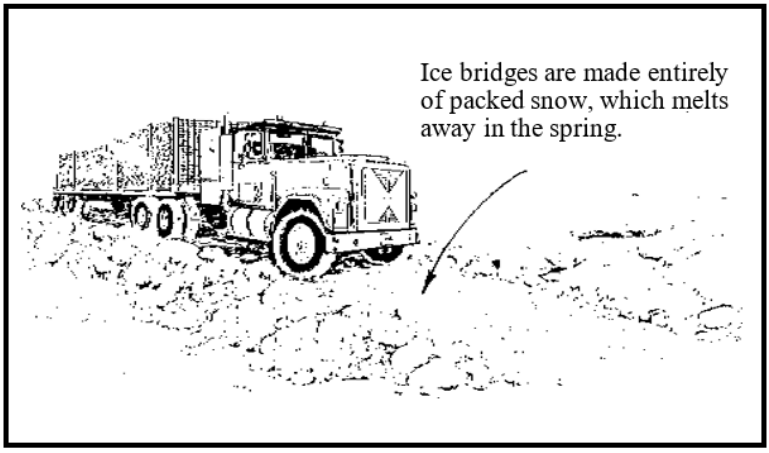


Figure ROAD-5

- ✓ **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.
- ✓ **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.

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 Clearings

In Areas Classified as Most Sensitive*

- ✓ Utilize merchantable timber within road clearings.
- ✓ 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.

In Areas Classified as Moderately Sensitive*

- ✓ Utilize merchantable timber within road clearings.
- ✓ Move cleared debris outside of the travel route right-of-way so that it is minimally apparent.

In Areas Classified as Less Sensitive*

- ✓ **Encourage utilization** of all merchantable right-of-way timber.
- ✓ **Avoid creating a corridor of debris.**
- ✓ **Do not leave jackstrawed or overturned stumps** in immediate foreground.
- ✓ **Reduce height of dozed clearing debris** during road construction.

**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 Minnesota Department of Natural Resources Publications webpage (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

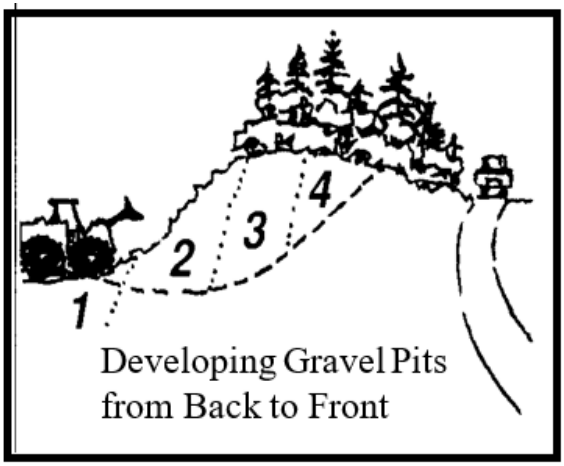


Figure ROAD-6: Develop gravel pits from back to front, moving toward predominant viewer or vantage point. In this illustration, Stage 1 has been completed, Stage 2 is in process, and Stages 3 and 4 will follow. Leaving the area adjacent to the road beyond Stage 4 untouched could result in no negative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

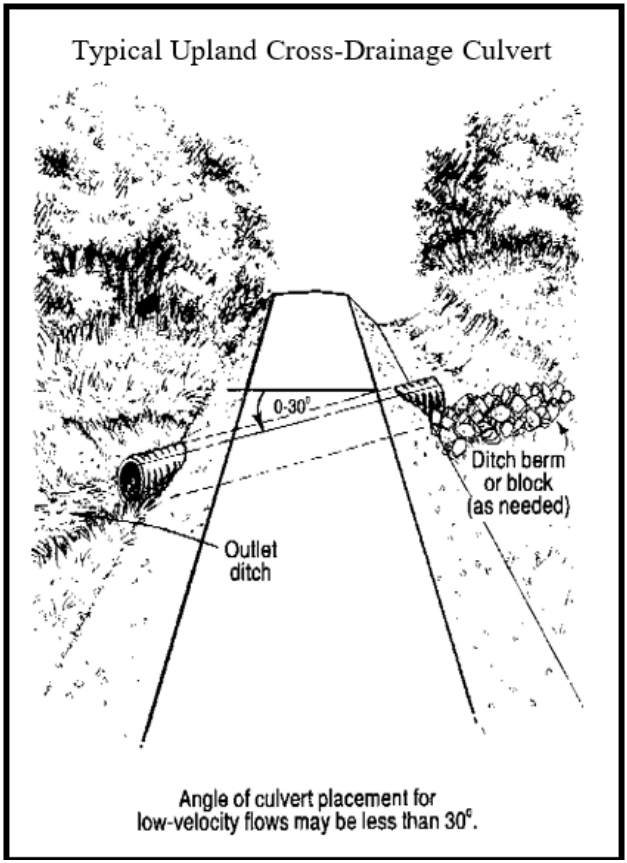


Figure ROAD-7

- ✓ **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. Consider the potential for increased high-flow events due to changing precipitation patterns with climate change. For sources of technical or financial assistance, contact local SWCD, NRCS, or regional DNR, BWSR, or county highway department offices.



- ✓ **Compact fill firmly around culverts**. Pay special attention to the sides and lower portion. Cover the top of culverts with fill to a depth of one-half the pipe diameter or 12 inches, whichever is greater. Culverts should extend to the toe of the fill without changing the sideslopes of the fill. See Figure ROAD-8.

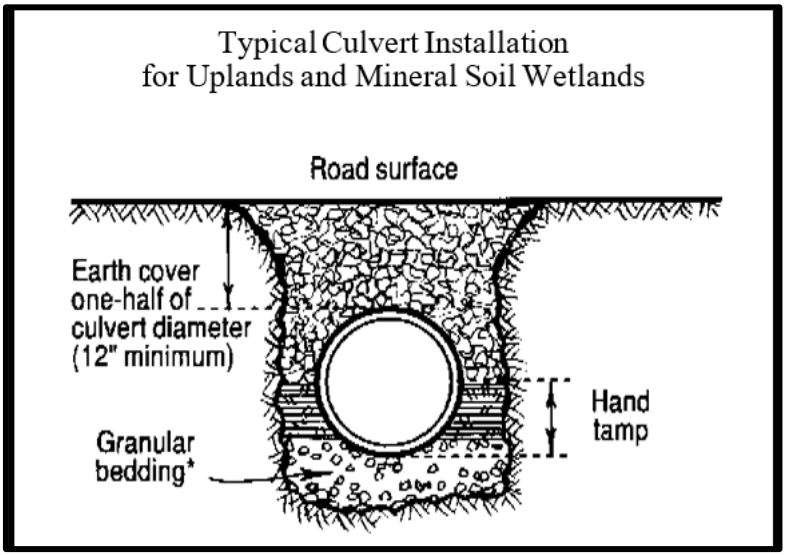


Figure ROAD-8

- ✓ **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*.
- ✓ **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

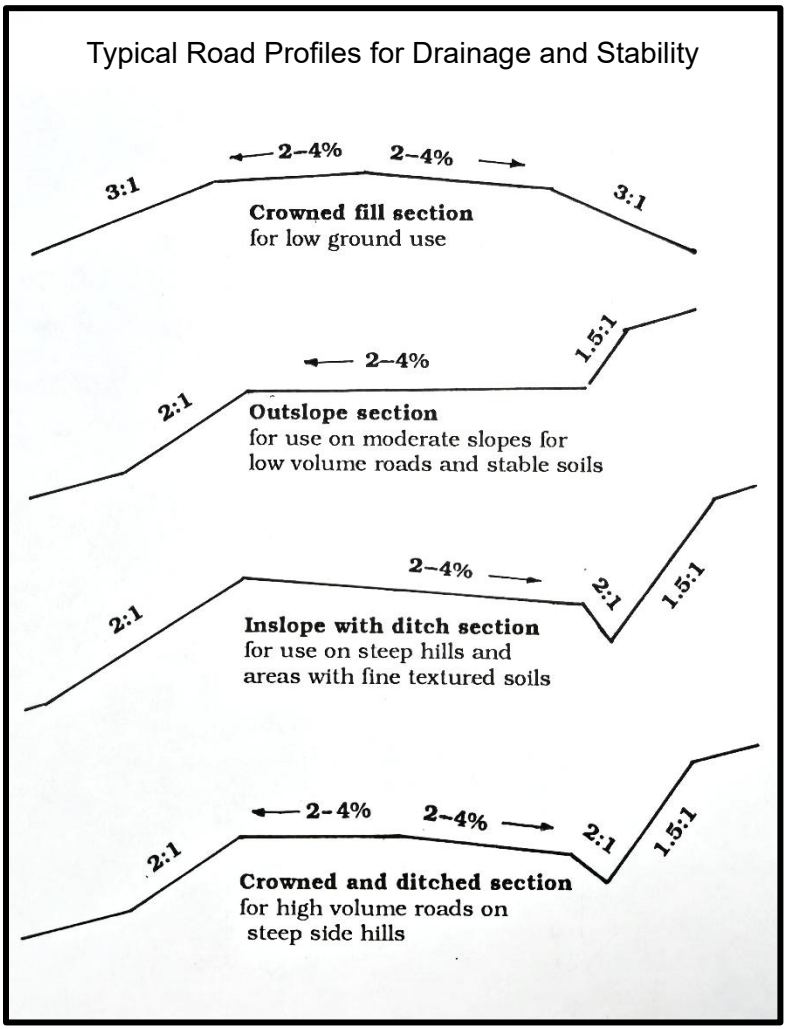


Figure ROAD-10

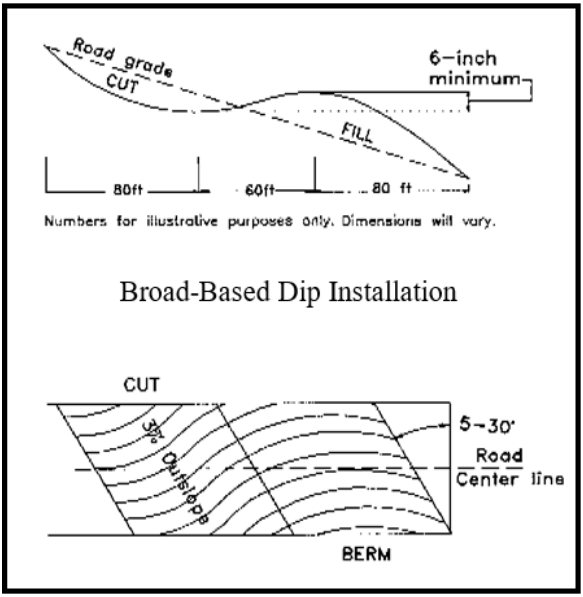




Table ROAD-1[1]

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

Grade	Spacing between dips or upland culverts
0-2%	500 ft
3-4%	300 ft
5-7%	180 ft
8-10%	150 ft
11-15%	130 ft
16%+	110 ft

[1] Consider closer spacing of erosion control structures where increased frequency and intensity of precipitation events could result in higher volume and velocity of run-off. Consider flow accumulating area uphill from the practice

and adjust accordingly where overland flow may add to run-off events.

Figure ROAD-11

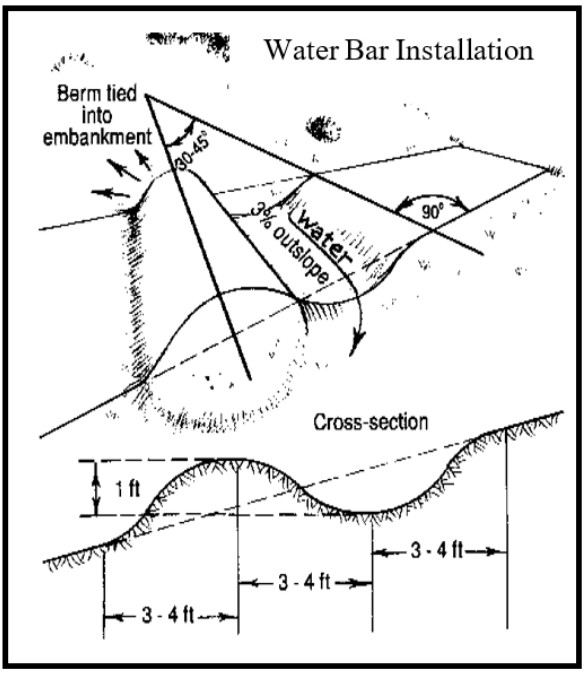




Table ROAD-2[2]

Water Bar Spacing	
Grade	**Spacing between dips or upland culverts**
2%	250 ft
5%	130 ft
10%	80 ft
15%	50 ft
25%+	40 ft

[2] 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. Consider closer spacing of erosion control structures where increased frequency and intensity of precipitation events could result in higher volume and velocity of run-off. Consider flow accumulating area uphill from the practice and adjust accordingly where overland flow may add to run-off events.

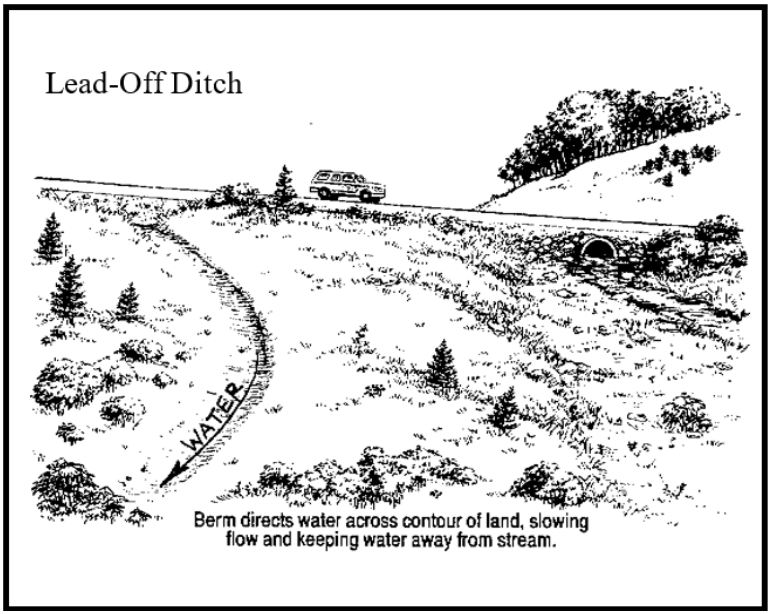


Figure ROAD-12

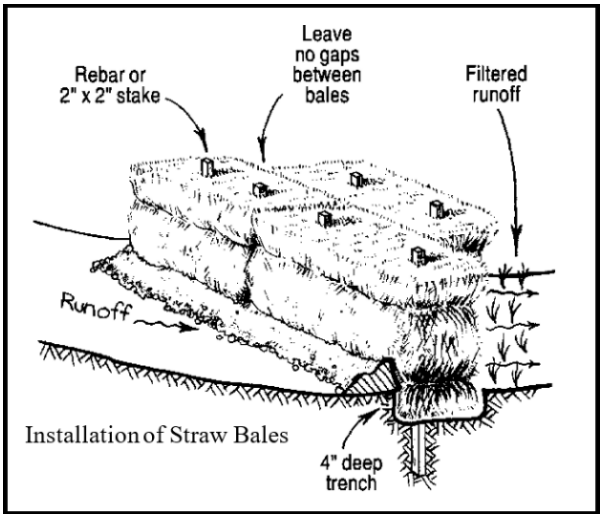
- ✓ **Drain surface water that is diverted from roads** into the filter strip or vegetative area, rather than directly into streams, lakes, open water wetlands, non-open water wetlands or seasonal ponds.
- ✓ **Increased heavy precipitation events** may elevate the importance of using diversion structures on approaches to water crossings or on roads and trails within the RMZ to divert water off 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)
- ✓ **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:

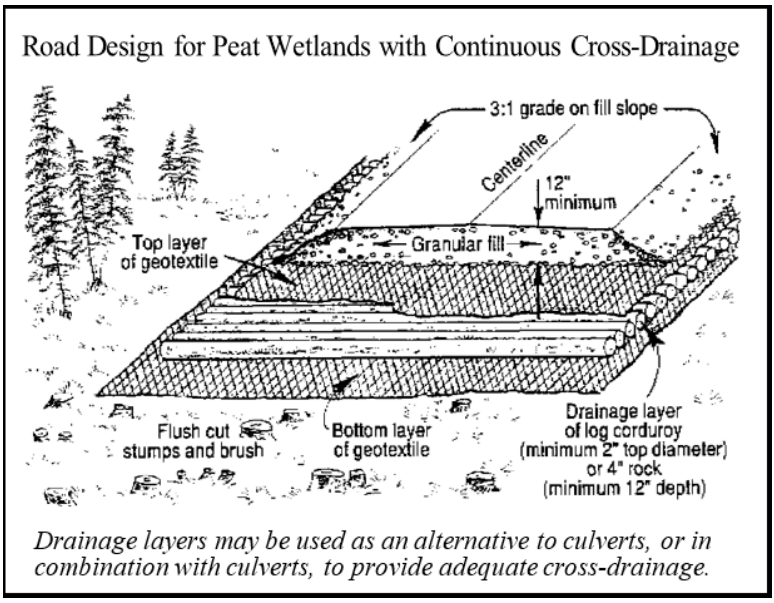
- Use construction methods that allow free water flow throughout the entire roadbed. See Figure ROAD-14.
- Place culverts or other cross-drain structures at each end of each wetland crossing and at intermediate low points. Space culverts or other cross-drain structures at maximum 300-foot intervals to 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



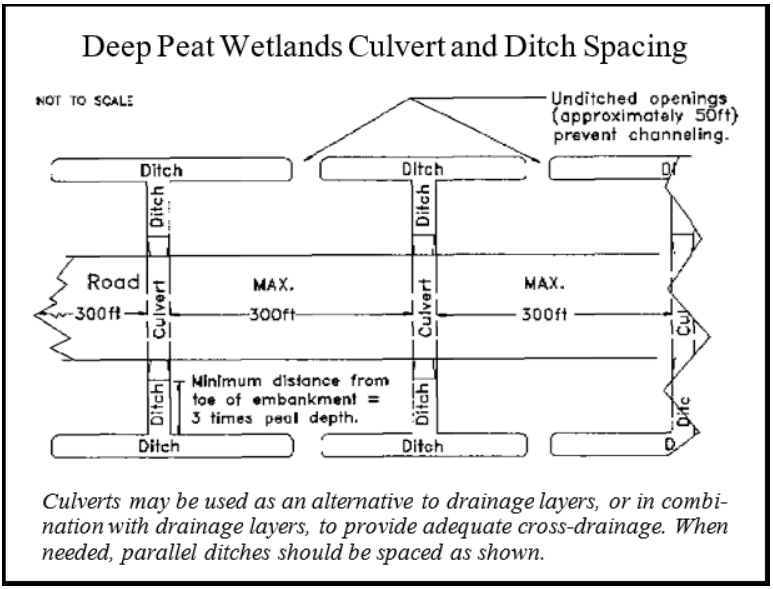


Figure ROAD-15

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).

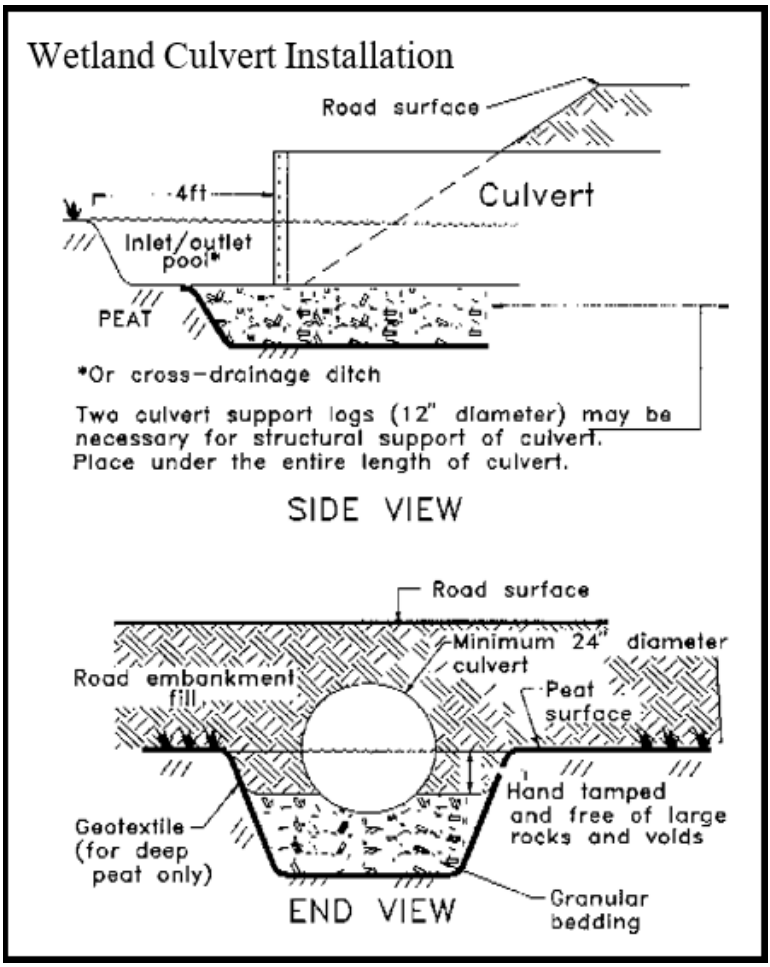


Figure ROAD-16

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)

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)

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 though 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.

✓ **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.

✓ **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.

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.

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.

- ✓ **Provide adequate filter strips** near open water. See *General Guidelines: Maintaining Filter Strips* and *General Guidelines: Managing Riparian Areas*.
- ✓ **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.

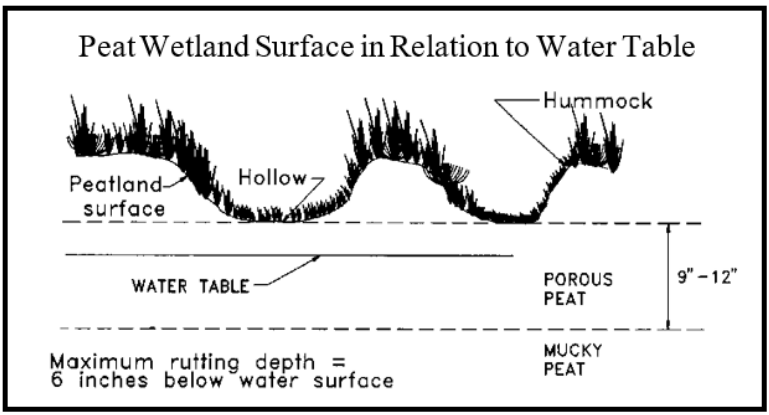


Figure ROAD-17

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 Follow-up 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 suitable material (such as gravel or compacted fill). 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.



Seeding forest access roads after completion of use provides multiple benefits, including stabilizing the road and protecting it from erosion, and providing food and cover for wildlife. Seeding also eliminates negative visual impacts. Photo courtesy of Minnesota DNR

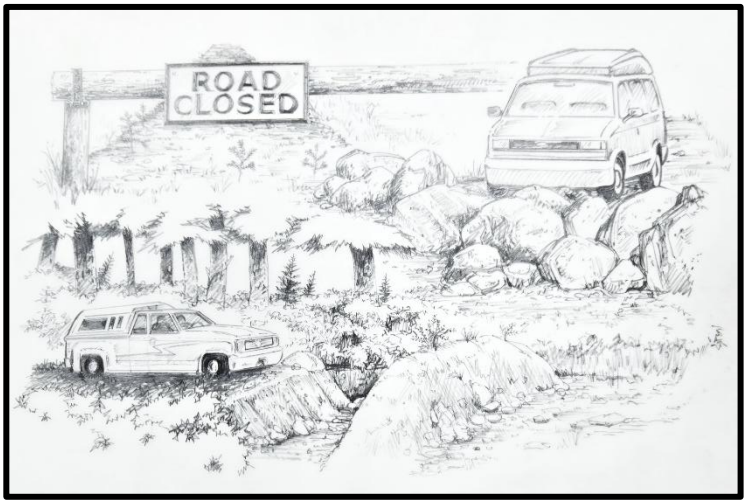
These are: 1) stabilizing surfaces to minimize erosion and sedimentation to water, and 2) stabilizing and maintaining road surfaces to provide for future access.

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.

Figure ROAD-18



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.
- ✓ **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 Minnesota DNR



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.

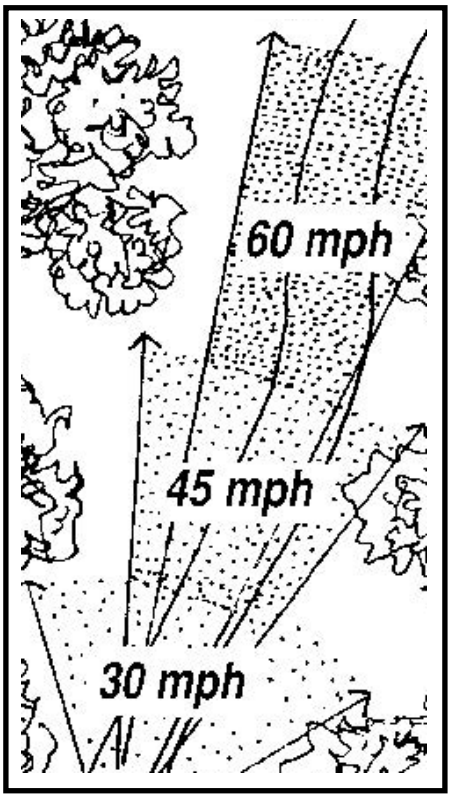


Figure TH-1: Travel speed affects field of vision and observation time.

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.

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.

Design Outcomes to Maintain Soil Productivity

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
- Timber harvest area occupied by roads and landings should not exceed recommended amounts shown in Table TH-1
- 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

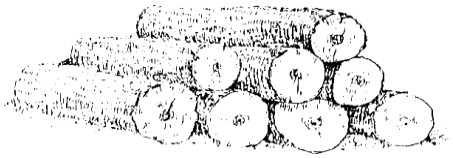
IMPORTANT! Review General Guidelines

- 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.

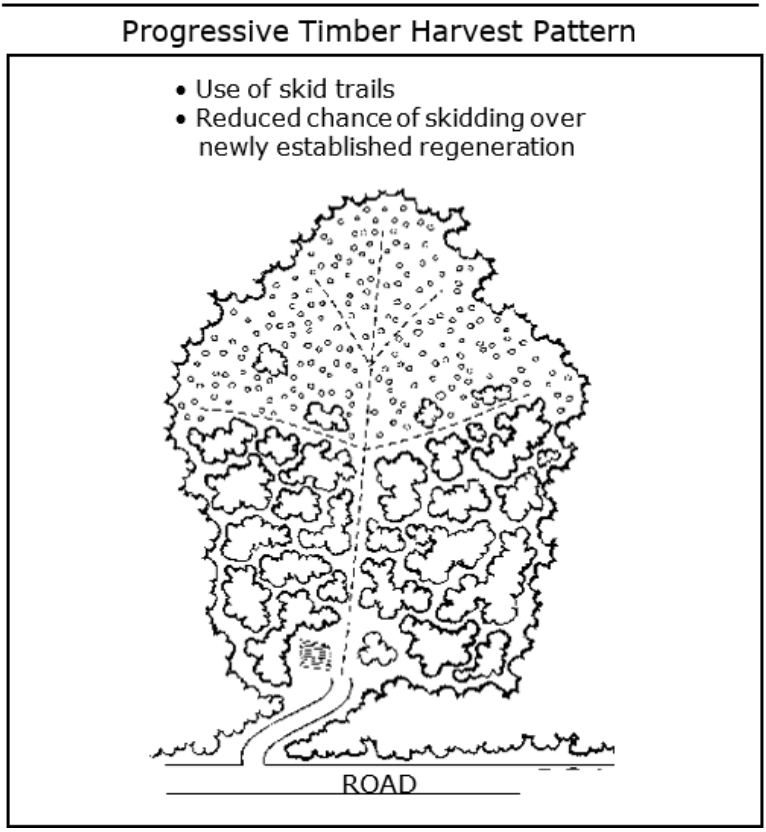
✓ **Consider soil or site conditions** that may dictate specific timing, harvest methods or equipment to be used, or that may lead to weather-related or seasonal closure of the operation.



✓ **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.*

Figure TH-2



✓ **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.*

Fingers and Fire Shadows

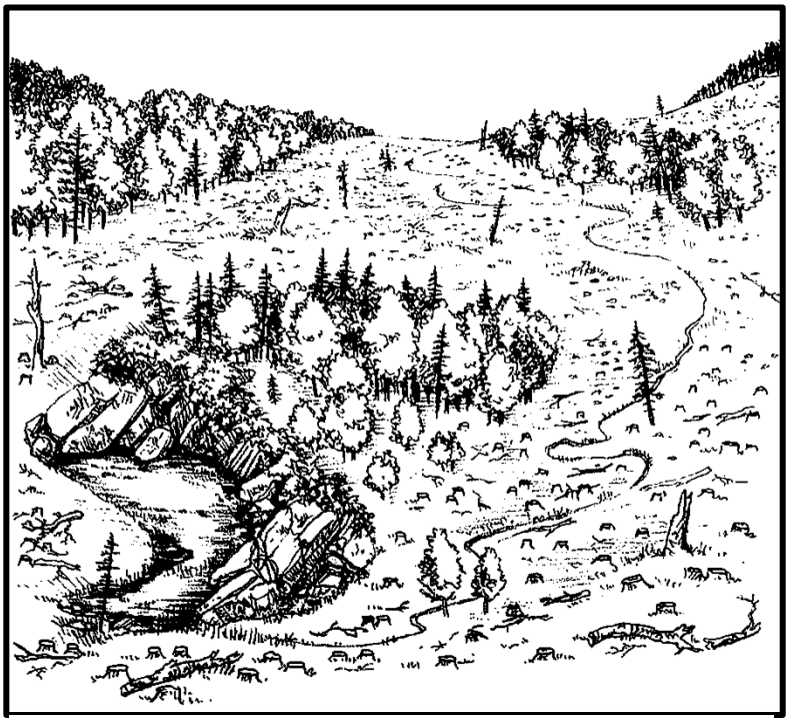


Figure TH-3

✓ **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.

- 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.



Reducing Visual Impacts of Apparent Harvest Size

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.

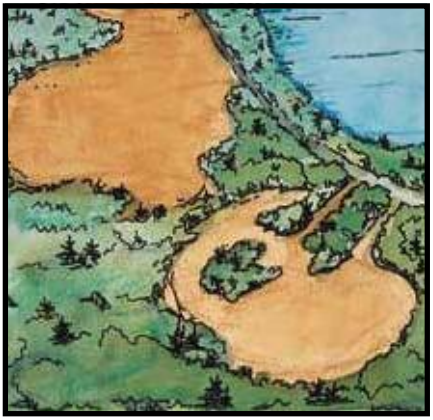


Figure TH-4: The impact of a highly visible harvest (upper left) is reduced by the use of narrow openings into the harvest area (lower right). A vegetative island further blocks the view into the harvest area.

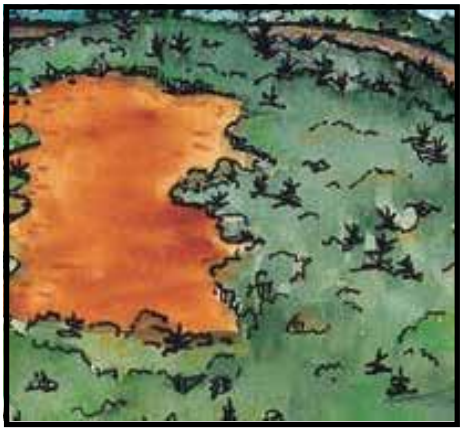


Figure TH-5: Using natural terrain to screen clear-cuts from view can reduce the apparent size of a harvest area.



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.

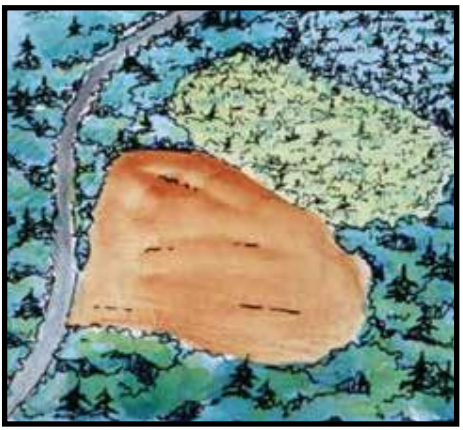
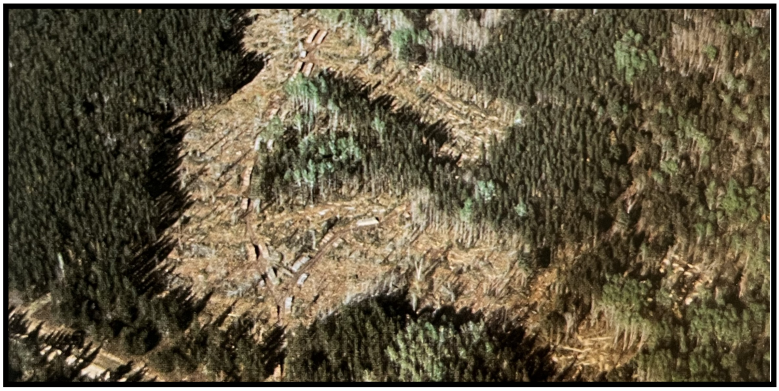


Figure TH-7: Multiple-stage cutting (left) can reduce apparent harvest area size.

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 constructing and maintaining forest roads**, refer to *Forest Road Construction and Maintenance* guidelines.

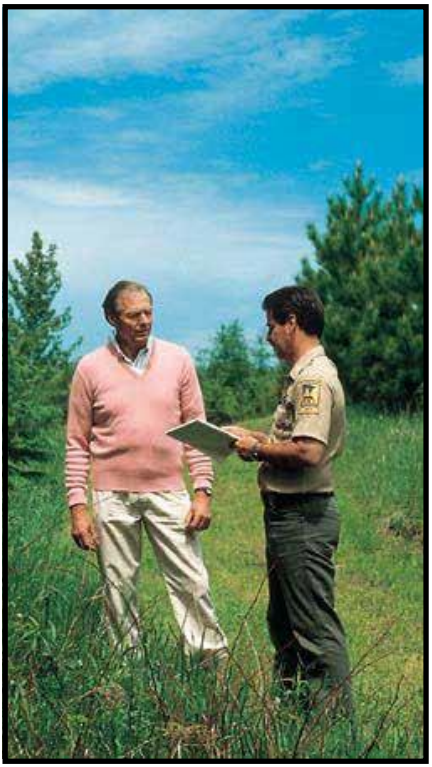
✓ **Conduct on-site meetings** with the logger, landowner and resource manager prior to moving equipment onto a site. Such meetings can help assure common understanding of landowner objectives, timber harvest specifications and site conditions.

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.

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



✓ **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.



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. When feasible and prudent, utilize strategies to limit the amount of landing area such as the use of roadside decking and loading, and backing load trucks into a landing.
- ✓ **Plan roads and landings to occupy no more** area than recommended in Table TH-1. See Figure TH-8 as an example.

Table TH-1

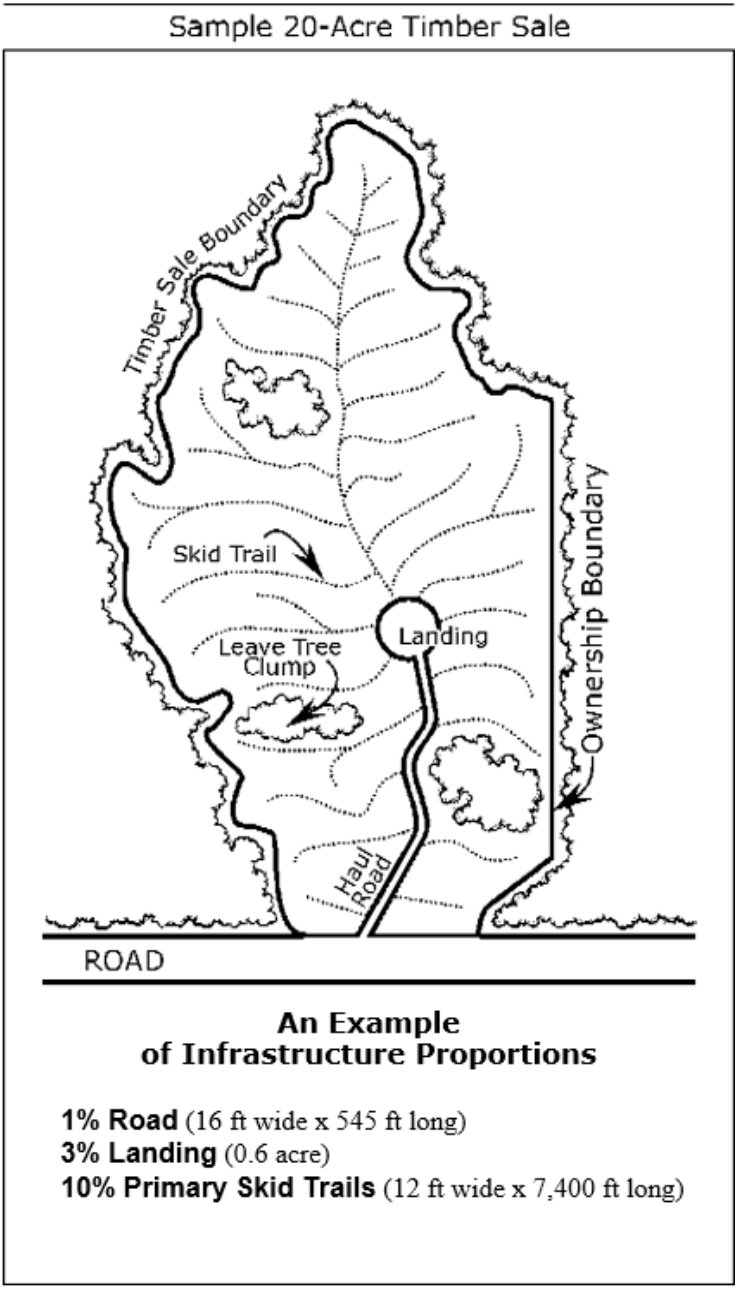
Maximum recommended area of landings and roads

Harvest Area	Infrastructure Area
<20 acres	1 acre
20-30 acres	5% of harvest area
>30 acres	3% of harvest area

* not including skid trails

- ✓ **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* and *General Guidelines: Managing Riparian Areas*.), and
  - Away from areas where a cultural resource is present.
- ✓ **Avoid locating landings and yarding areas in wetlands,** filter strips or RMZs where possible (or where upland areas are available).
- ✓ **Avoid locating landings** and yarding areas on open water wetlands.

Figure TH-8


Sample 20-Acre Timber Sale
Timber Sale Boundary
Skid Trail
Leave Tree Clump
Landing
Ownership Boundary
Haul Road
ROAD
An Example of Infrastructure Proportions
1% Road (16 ft wide x 545 ft long)
3% Landing (0.6 acre)
10% Primary Skid Trails (12 ft wide x 7,400 ft long)

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.

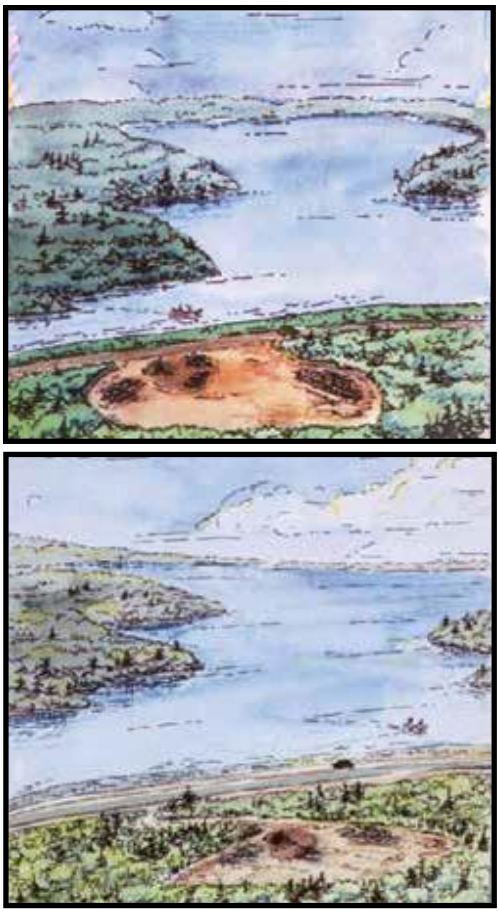


Figure TH-9: In visually sensitive areas, a recommended practice is to avoid placing landings within view of travel routes or recreational areas. The landing and slash piles above are in full view of travelers and recreational users along the adjacent travel route and waterway. The landing and slash 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*.)
  - 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 the *Forest Road Construction and Maintenance* guidelines.

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, and
  - 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.
- ✓ **Retain and disperse at least one-third of the slash following harvesting at most sites**. Retain and disperse all slash in the following situations:
  - Native plant communities listed in *Appendix J* are present*,
  - If slash-dependent ETS species are present*,
  - When harvesting in riparian management zones,
  - Within 25 feet of a dry wash bank,
  - Erosion prone sites with steep slopes (>35%),
  - Sites with shallow soils (8 inches or less) over bedrock, and
  - Sites with ombrotrophic soils greater than 24 inches deep (These sites typically have sparse (25-75%) cover that is predominantly (>90%) black spruce and stunted (<30 feet high).).

  **Consult with local DNR offices to determine if slash retention is necessary at your site.*

- ✓ **When moving or redistributing slash on the site is desirable,** use equipment and tactics that minimizes soil disturbance including soil compaction.
- ✓ **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.

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.

Visible slash is unsightly, as demonstrated in this blowdown site. In visually sensitive areas, eliminate or minimize slash within the first 50 feet from travel routes or recreation areas. Photo courtesy of Superior National Forest



Water Quality and Wetlands

- ✓ **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 and consider erosion control practices** 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, and
- 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.

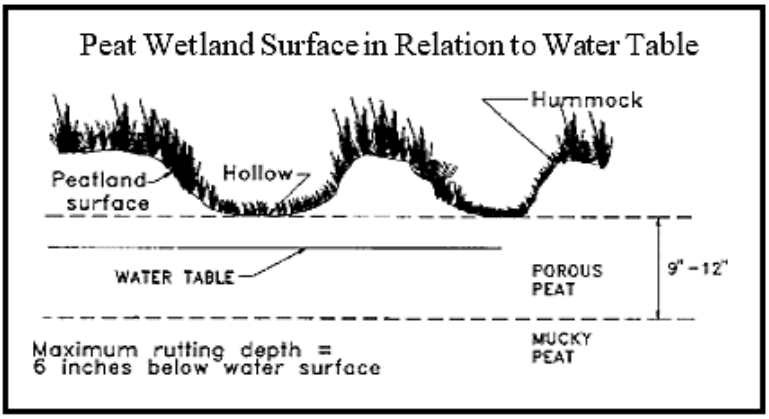


Figure TH-10: The water table (solid line) is near the bottom of the hollows (upper dotted line). Operations should stop when ruts reach 6 inches below the water table or 6 inches below the bottom of the hollows, whichever is lower. Peat is usually still porous 9 inches below the hollows, and ruts will 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.

Additional Consideration

- **Consider retaining oak inclusions** when harvesting non-oak cover types.





Snags provide habitat for wildlife. Photo courtesy of Potlatch Corporation

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



This harvest area demonstrates implementation of several guidelines, including retaining leave trees and snags, dispersing slash throughout the site, and keeping slash low to the ground. These practices protect the soil, enhance wildlife habitat and reduce negative visual impacts. Photo courtesy of Minnesota DNR

Plans for retaining leave trees may utilize one or both of these options in combination. Clumps are the preferred option because they can increase benefits to multiple resources (see below) and increase efficiency of harvest operations. Plans for leave tree retention should be designed to achieve specific wildlife, silvicultural, and landscape objectives, and tailored to site-specific conditions. 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. Trees left to protect cultural resources, visual quality, non-open water wetlands, seasonal ponds, mast or other resources, and forested RMZ areas, **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.

Benefits of Clumping Leave Trees

- 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 in a configuration that achieves wildlife and silvicultural objectives and maintains efficient harvesting operations
- 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. (Including forested RMZs that are serving as leave tree clumps).
  - 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-2.
- **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 scattered leave trees** in a configuration that achieves wildlife and silvicultural objectives and maintains efficient harvesting operations

✓ **Option 1 is the preferred option** for leave trees.

Suggested Numbers of Leave Trees for Clearcut Harvests Using Scattered, Individual Leave Trees

(Clumped leave trees are preferred in most cases.)

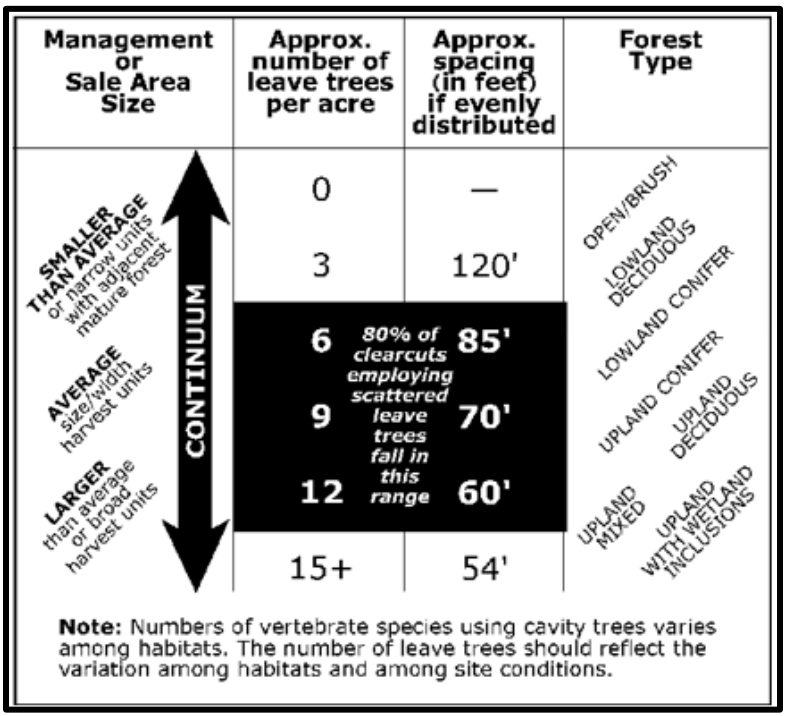


Figure TH-11

✓ **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.



Cavity trees enhance the quality of wildlife habitat. Photo courtesy of Itasca County Land Department

✓ **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.

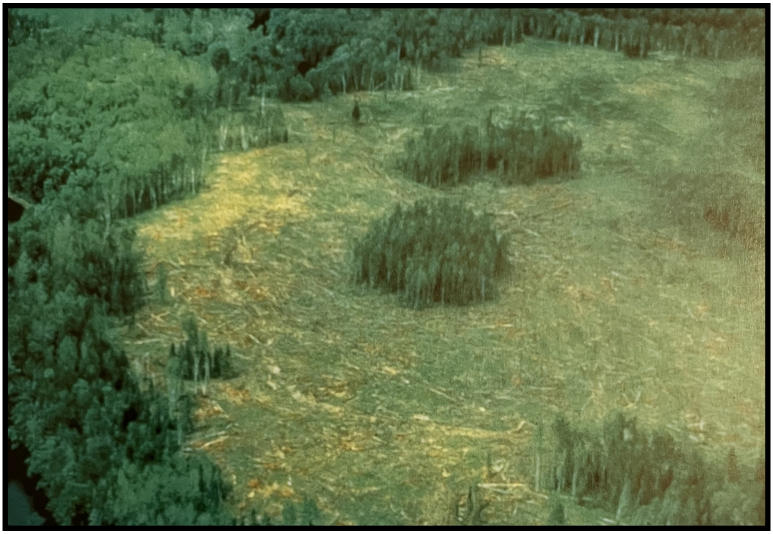
- Prevent damage to leave trees in initial and followup harvest entries.

✓ **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), and
- 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. In some instances it may be appropriate not to retain conifer regeneration for insect and disease considerations or when natural disturbance regimes are altered (e.g., absence of fire in fire-dependent systems). See *Leave Trees* and *General Guidelines: Retaining Leave Trees* for guidelines on retention of mature conifer trees. Clumps of conifers are preferable to scattered trees.

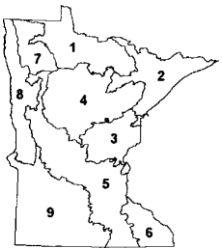
✓ **Retain mast trees with bear claw marks** on trunk, which indicate a preferred food source.



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.

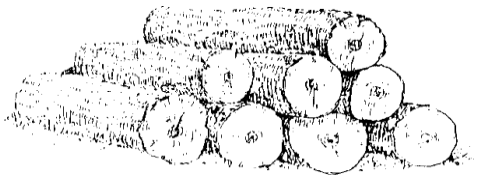
✓ **Plan for removal of equipment and cut material** from wetland areas at the end of the winter season prior to thawing.

✓ **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.



Mechanical Site Preparation

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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

Site preparation on forest lands is the practice of altering site conditions to favor the establishment, survival and growth of a desired tree species, browse or other vegetation. Site preparation can be accomplished through mechanical means, prescribed fire, the use of herbicides, or any combination of these approaches.

Mechanical site preparation accomplishes two goals:

- It facilitates planting, direct seeding and natural regeneration.
- It provides partial initial control of vegetation competing with crop trees for light, water and nutrients.

Common mechanical site preparation techniques include patch scarification, row scarification, raking, disking, bedding, roller chopping and shearing. Herbicides are often applied in conjunction with mechanical site preparation, to increase control of competing vegetation.

The guidelines in this section focus on **mechanical** site preparation. **For chemical use**, either in conjunction with or in place of mechanical site preparation methods, refer to the guidelines in *Pesticide Use* for additional information related to non-mechanical site preparation methods. For prescribed burning, refer to the guidelines in *Fire Management*.

The Benefits of Guidelines

Benefits to cultural resources: Mechanical site preparation guidelines can minimize disturbance of cultural resources that may not have been affected by harvest activities, particularly if harvest was conducted during the winter. Guidelines address soil disturbance and erosion concerns in particular.

Benefits to forest soils: Mechanical site preparation guidelines can minimize excessive exposure of mineral soil, compaction or rutting of soil, removal of surface soil, increased erosion, and impacts on the nutrient balance of the site. By maintaining good soil conditions, guidelines can help assure that the goals of site preparation are accomplished (favoring the establishment, survival and growth of a desired tree species).

Benefits to riparian areas: Mechanical site preparation 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: Mechanical site preparation guidelines can reduce both the visual impacts of site preparation activities and also the duration of time that the effects of these activities are visible.

Benefits to water quality and wetlands: Mechanical site preparation guidelines can protect water quality and wetlands. Guidelines can minimize potential erosion, runoff and resulting sedimentation that may occur as a result of site preparation practices that expose or compact mineral

soil on erodible slopes or in areas where the prepared site is located adjacent to open water or wetlands. Guidelines that address equipment operations and maintenance can help protect water quality.

Benefits to wildlife habitat: Mechanical site preparation guidelines can help to maintain ground cover, shrubs, woody debris, snags, naturally regenerating tree seedlings and other live trees important to wildlife on a site.

Considerations

- **Maintaining good soil condition is critical** to accomplishing the goals of site preparation (to favor the establishment, survival and growth of a desired tree species). Practices that result in excessive exposure of mineral soil, compaction or rutting of soil, or removal of surface soil should be avoided. If soils are negatively impacted in the process of site preparation, then the "advantage" of the site preparation is reduced either through poor establishment, poor survival or, more often, lowered growth and productivity.
- **Properly planned harvest operations** should include consideration of mechanical site preparation needs. Site preparation methods that minimize the potential for surface erosion should be evaluated prior to implementation of site preparation operations.
- **Selecting the appropriate technique**, intensity and timing of a site preparation activity is important in maintaining the soil productivity of a site. Heavy equipment should be operated on a site when adverse soil impacts are unlikely.
- **Mechanical site preparation techniques and intensity** for a given site should be determined by soil/site conditions, crop tree species and site preparation objectives. Specific site conditions (including soil characteristics, topography, vegetation,

access and distance to surface water) dictate what techniques may work best or provide the best operating window for any given site. Some sites may be planted with no site preparation other than removing the overstory.

- **Practices that result in exposure of mineral soil or soil compaction** on erodible slopes should not be used where surface erosion or runoff is likely to result in sedimentation of water or wetlands. For sources of information and planning assistance, see *Resource Directory*.
- **Activities that disturb soil,** such as disking, scarification, rock raking and shearing, may not be appropriate within cultural resource areas.
- **Contour preparation methods can minimize erosion**, as well as the cost of remedial action or repair.
- **Site preparation methods vary considerably,** depending on the desired regeneration species.
- **Every site preparation method has a different cost**. For any method being considered, costs (both short-term and long-term) should be balanced against effectiveness of the method in attaining visual quality objectives.
- **Composition and condition of the original stand** can impact the regeneration method chosen for a particular site.

Design Outcomes to Maintain Soil Productivity

Site preparation activities should be designed and implemented to achieve the following beneficial outcomes regarding soil productivity:

- Soil in a condition that favors the establishment, survival and long-term growth of the desired tree species

- Displacement of only enough soil as needed to effectively accomplish tree establishment
- Site preparation techniques employed so that surface soils 1) remain intact; 2) are only displaced a short distance (such as in scalping); or 3) are incorporated (such as in disking)
- Slash dispersed on the site, rather than piled or windrowed, where appropriate
- Site preparation practices employed so that they avoid funneling water (such as furrowing, scarification and scalping on the contour)



- **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

IMPORTANT! Review General Guidelines

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

Planning and Design Considerations

✓ **Consider alternative methods** of site preparation, such as non-mechanical, or combinations of mechanical and non-mechanical methods, to accomplish site preparation goals while minimizing disturbance. Examples include:

- Utilizing harvest operations to accomplish preparation goals. For example, full-tree skidding can be used for preparation of black spruce or jack pine seed and can eliminate the need for additional re-entries, trafficking or site disturbance, especially on steep slopes. Chemical treatments, prescribed burning and hand scarification should be given serious consideration as alternatives to mechanical site preparation, especially on steep slopes, highly erodible soils, or soils sensitive to additional trafficking.

✓ **Design mechanical treatments of regenerating stands** to protect reserve areas and structural habitat components retained in previous stand treatments.

✓ **Favor practices that do not remove surface soils** or only remove surface soils from the small areas in which an individual seedling will be planted.

✓ **Favor practices that allow for dispersed slash** or slash in small piles on the site, rather than piling or windrowing, where slash does not conflict with management objectives or reforestation.

- ✓ **Select appropriate species and stocking levels** for reforestation, and plan site preparation intensity accordingly.
- ✓ **Plan for a diversity of tree species** where possible.
- ✓ **Design practices to avoid direct runoff** of sediment into water and wetlands.

Timing and Intensity of Activities

- ✓ **Enter a site the fewest number of times necessary,** and avoid multiple passes of equipment over the same spot.
- ✓ **Time site preparation activities** and use proper equipment to minimize rutting and compaction of soils.
- ✓ **Avoid shearing and raking operations on organic soils** except under frozen conditions.

Reducing Visual Impacts of Mechanical Site Preparation

In Areas Classified as Most Sensitive*

- ✓ **Use low-impact site preparation methods**, such as patch or row scarification.
- ✓ **Use spot or strip treatment of herbicides**, rather than broadcast treatment applications.
- ✓ **Initiate revegetation efforts** as soon as possible.

In Areas Classified as Most Sensitive or Moderately Sensitive*

- ✓ **Use land contours** in site preparations.
- ✓ **Avoid the effect of linear straight rows** and resulting visual penetration immediately alongside travel routes or recreation areas.
- ✓ **Avoid or screen windrows** and slash piles.

In Areas Classified as Moderately Sensitive*

✓ **Initiate revegetation efforts** as soon as appropriate.

In Areas Classified as Less Sensitive*

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

**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.



Favor practices that allow for dispersed slash or slash in small piles on the site, rather than piling or windrowing. Photo courtesy of Chippewa National Forest

Selecting Application Methods

- ✓ **To increase success of oak regeneration**, use such pre- and post-harvest techniques as burning, stump sprout thinning or scarification.
- ✓ **Consider targeted mechanical site preparation methods** (low intensity, spot or band) in preference to broadcast applications. Regenerating oak, an important mast species, may warrant more liberal application.
- ✓ **Use patch or row scarification** as the preferred mechanical site preparation method for artificial regeneration when terrain or soil type necessitates minimal soil disturbance.
- ✓ **If moving slash on-site is desirable**, use equipment that minimizes soil disturbance.

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

- ✓ **Conduct on-site meetings** with the contractor, landowner and resource manager prior to moving equipment onto a site. Such meetings can help assure common understanding of landowner objectives, contract specifications and site conditions.

Managing Slash and Windrows

- ✓ **Where shearing or windrowing slash is necessary**, avoid scraping soil material or forest floor into windrows or piles. Preferred practices include:
  - Shearing and raking under frozen conditions, and
  - Light raking, which only removes slash.
- ✓ **Avoid placing residues into wetland areas** from operations on upland sites. Deposit residues in stable upland locations.
- ✓ **Locate windrows and slash disposal piles** so as to:
  - Avoid cultural resources.
  - Minimize interference with natural drainage patterns.
  - Be outside of filter strips, riparian management zones and leave tree clumps. Refer to *General Guidelines: Maintaining Filter Strips and General Guidelines: Managing Riparian Areas.*
  - Follow contours when possible to mitigate the effects of overland flow.

Protecting Resources

- ✓ **Scarify or trench only the area necessary** for seedling establishment and growth.
- ✓ **Operate equipment following contours of the land** where appropriate, as long as operator safety is maintained.
- ✓ **Protect existing conifer regeneration** less than 4 inches DBH in formerly mixed deciduous coniferous stands during site preparation. Clumps of conifer are preferable to scattered trees.
- ✓ **Avoid operations during periods of saturated soil conditions** when such operations may cause rutting, compaction or accelerated erosion.

Additional Considerations

- **Consider scarifying the soil i**n the vicinity of conifer seed trees to enhance regeneration of these species.
- **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.

Post-Operational Activities

IMPORTANT! Review General Guidelines

- Post-Operational Activities and Followup Visits

✓ **Regenerate site as soon as possible** after site preparation.

✓ **Evaluate success of site preparation methods** relative to site conditions and silvicultural prescriptions.

✓ **Monitor and manage the site** to ensure success of establishment, so that the operation will not have to be repeated.

Pesticide Use

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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

The purpose of a pesticide application is to assist in meeting forest management, utility and rights-of-way objectives by promoting the establishment, survival, growth or maintenance of a desired species or condition through the use of chemical compounds or biological agents that control undesirable plants, animals, insects or diseases.

The Benefits of Guidelines

Benefits to cultural resources: Pesticide use guidelines can help assure that vegetation that is part of a cultural property is not altered, which can diminish the value of the cultural property. Guidelines can also minimize the effects of herbicide applications on natural resources that are used by traditional communities for subsistence and other cultural practices.

Benefits to riparian areas: Pesticide use guidelines can minimize 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: Pesticide use guidelines can reduce the visual impacts of dead standing vegetation during the growing season or summer tourist season.

Benefits to water quality and wetlands: Pesticide use guidelines can protect water quality from pesticide residues during all phases of the pesticide use cycle. Guidelines can also help protect vegetative cover and minimize toxic effects on aquatic organisms. Guidelines that address equipment operations and maintenance can help protect water quality.

Benefits to wildlife habitat: Pesticide use guidelines encourage application methods that retain desirable ground cover, shrubs, live trees, insects or other invertebrates, thus maintaining on-site species diversity.

Considerations

- **Planning is the essential first step** in reducing pest problems. Maintaining water quality and protecting other resources is an important consideration in all aspects of pesticide operation planning. Consider any sensitive native plant communities (see *Appendix J: Sensitive Native Plant Communities*) on site prior to pesticide application.
- **Broadcast herbicide application methods may have a greater visual quality impact** than band or spot treatment methods.
- **The effective treatment time for most herbicides** is during the active growing season, which corresponds with the summer tourist/recreational use season.
- **Vegetation that is part of a cemetery** is protected by law and must not be damaged or altered by herbicide application.
- **If the project area is on ceded lands** or within the boundaries of a reservation, consult tribal cultural resource specialists to determine whether there are

any concerns about traditional cultural practices in or near the project area. See *Resource Directory*. For locations of ceded lands, see *Appendix D: Ceded Lands and Reservation Boundaries*.



- **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

IMPORTANT! Review General Guidelines

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

Incorporating Integrated Pest Management Strategies

✓ **Employ integrated pest management (IPM) strategies.**

Pesticide use should be considered as part of an overall program to control pest problems. Integrated pest management (IPM) strategies have been developed to control forest pests without relying solely on chemical pesticides.

These strategies incorporate a balanced combination of chemical, biological and cultural activities to control forest pests.

- A good IPM program has four steps:
    - Identify problems.
    - Select tactics.
    - Consider economic factors, including whether it pays to use pesticides.
    - Evaluate the program.

For sources of information on IPM programs, see *Resource Directory.*

Characteristics Affecting Contamination Potential

The three main pesticide characteristics that can greatly affect a pesticide's potential to contaminate surface or ground water are solubility, adsorption and half-life.

- **Solubility** is the ability of a pesticide to dissolve in water. The greater the solubility, the greater the chance that the pesticide will leach to ground water or move in solution in surface water. Pesticides with very low water solubilities tend to remain at the soil surface and

potentially move to surface water attached to sediment carried in runoff.

- **Adsorption** is the inherent ability of a pesticide to attach to soil particles. Some pesticides stick very tightly to soil, while others are easily dislodged:
    - The greater a pesticide's ability to adsorb to soil particles, the less the potential for that pesticide to move (except by soil erosion in surface runoff).
    - Conversely, the lower a pesticide's ability to adsorb to soil particles, the greater the potential for that pesticide to leach to ground water or move in solution in surface runoff.

  Adsorption increases as soil organic matter increases. An index or measure of soil adsorption is expressed by the Koc value.
- **Half-life** is the time it takes for a pesticide in soil to be degraded so that its concentration decreases by one-half. Each pesticide will have successive half-lives that will continually decrease concentrations by one-half.

The **persistence** of the pesticide in soil is the time it takes for the pesticide to degrade to the point where it is no longer active. Pesticides that do not break down quickly can be a hazard if they move to ground water or surface water in toxic forms.

Selecting Pesticides

When the decision is made to use pesticides, choose products suitable for use on the target species and registered for the intended uses. A clearinghouse for pesticide and pest management information is available at the Minnesota Pesticide Information and Education website (https://www.mnpie.org/).

- ✓ **Use only pesticides registered** by the U.S. Environmental Protection Agency and the Minnesota Department of Agriculture. See *Resource Directory*.
- ✓ **Read and follow all label directions** carefully prior to using any pesticide.
- ✓ **Maintain current labels and Material Safety Data Sheets (MSDS).** The MSDS is a source of cautionary information and data.
- ✓ **Evaluate other factors besides effectiveness and cost** when selecting among pesticide options. Factors that influence potential impacts on water quality and other forest resources include site characteristics, pesticide characteristics, application conditions, delivery systems and application techniques. For pesticide characteristics that affect contamination potential, see Table PEST-1. For additional information on registered pesticides, see *Resource Directory*.
- ✓ **Select only pesticides labeled for aquatic use** on sites where surface water is present at the time of application.
- ✓ **Select pesticides, application methods, equipment and formulations** that:
  - Minimize the potential for pesticide drift.
  - Minimize pesticide residue movement to surface water and ground water.

Table PEST-1 provides information on pesticide characteristics that influence the potential for the chemicals to leach to ground water. In a given situation, pesticides with the highest water solubilities, greatest persistence, lowest affinities for adsorption to soil particles, and highest application rates have the greatest potential for movement in surface runoff and for leaching to ground water.

Table PEST-1

Pesticide Characteristics Influencing Leaching Potential

Characteristics	Threshold value for high leaching potential*
Water solubility	30 mg/liter or greater
Adsorption to soil organic matter (Koc)	Less than 300-500
Field dissipation half-life	Greater than 3 weeks

**No one value will indicate leachability.*

For sources of assistance in evaluating pesticide alternatives and determining potential pesticide loss due to surface runoff or leaching, see *Resource Directory*.

Selecting Application Methods

- ✓ **Design chemical treatments of regenerating stands** to protect reserve areas and structural habitat components retained in previous stand treatments.
- ✓ **Promote protection or growth of mast species and browse** by employing chemical site preparation methods that target pesticide application (low intensity, spot, band) in preference to broadcast applications. Regenerating oak, an important mast species, may warrant more liberal application.



- ✓ **Use pesticide application equipment** that minimizes soil disturbance.
- ✓ **Consider non-broadcast application of pesticides** where appropriate. Limit broadcast application of pesticides, particularly from the air, to situations where it is the only feasible management option.
- ✓ **If pesticides must be applied to sites containing endangered**, threatened or special concern species (ETS species), select pesticides, application methods, equipment and formulations to protect those species. For sources of assistance regarding ETS species, see *Part 2: Endangered, Threatened and Special Concern Species* and the *Resource Directory.*



Ground application of pesticides limits unintended effects on the forest overstory. Photo courtesy of Minnesota DNR

Reducing Visual Impacts of Treated Vegetation

In Areas Classified as Most Sensitive*

✓ **Favor non-herbicide treatment methods.**

In Areas Classified as Most Sensitive or Moderately Sensitive*

✓ **Favor band treatment or spot treatment** over broadcast treatment.
✓ **Leave untreated or selectively treated areas adjacent to travel routes** and recreation areas.
✓ **Favor late-season or dormant-season herbicides.**

In Areas Classified as Less Sensitive*

✓ **Use methods of application** consistent with integrated resource management principles.

*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.

Spill Response

Forestry pesticides that are spilled can enter surface water or ground water. Spills near or in geologically sensitive areas have a high probability of a portion of the spill reaching ground water. Equip site with a minimum of one pill kit during pesticide application.

✓ **Contact the Minnesota Duty Officer** whenever a spill occurs. Phones are answered 24 hours per day. In the Metro Area, call (651) 649-5451. In Greater Minnesota, call (800) 422-0798. The Minnesota Duty Officer will contact appropriate state agencies.
✓ **Treat spills properly.** Recommended steps include the following:

- Act quickly.
- Protect yourself.
- Control the spill. (Stop the leak.)
- Contain the spill. (Keep it from spreading.)
- Guard the site.
- Notify the authorities.
- Clean up the spill.

✓ **Maintain an adequate spill kit** that includes:

- Detergent or soap
- Hand cleaner and water
- Activated charcoal, adsorptive clay, vermiculite, kitty litter, sawdust or other adsorptive materials
- Lime or bleach to neutralize pesticides in emergency situations
- Tools such as a shovel, broom, dustpan and containers for disposal
- Proper protective clothing and equipment

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

✓ **Conduct on-site meetings** with the contractor, landowner and resource manager prior to moving equipment onto a site. Such meetings can help assure common understanding of landowner objectives, contract specifications and site conditions.

Proper pesticide management practices make efficient use of chemicals while preventing or minimizing impacts on surface water, ground water and other forest resources. Residues of pesticides used in forestry can affect these resources at any time—from transporting of pesticides to container and waste disposal.

Transportation of Pesticides

- ✓ **Inspect all containers** prior to loading, and ensure that all caps, plugs and bungs are tightened.
- ✓ **Select transportation routes** to minimize the impact of a potential spill on water quality.

Storage of Pesticides

- ✓ **Locate pesticide storage facilities** at sites that minimize the possibility of impacts on water quality in case accidents or fires occur.
- ✓ **Avoid storing pesticides on or adjacent to treatment areas.** Where impractical, select unloading and operational storage locations where spills resulting from accidents or vandalism will not have impacts on water quality.
- ✓ **Use storage buildings that have floors** constructed of concrete or other impermeable materials, so that spills are easy to clean up. Storage buildings should contain drains or sills with sumps large enough to contain the contents of the largest container stored in the buildings.
- ✓ **Avoid storing pesticides for extended periods** in buildings not equipped to contain a complete spill from the largest container being stored.

Mixing and Loading Operations

- ✓ **Review the label before opening the container** to ensure familiarity with current use directions.

- ✓ **Exercise care and caution** during mixing and loading of pesticides.
- ✓ **Avoid mixing near wells** or where pesticide spills could enter open water or wetlands.
- ✓ **Mix and load pesticides outside of riparian management zones,** filter strips and other reserve areas.
- ✓ **Transport and store hoses** used to fill pesticide application equipment in a manner that prevents direct contact with pesticides, gasoline or oils, or surfaces on which these substances have been spilled.
- ✓ **Fill equipment from water sources** before introducing pesticides into mixing or application equipment.
- ✓ **Replace pour caps and close bags** or other containers immediately after use.
- ✓ **Avoid leaving a spray or mix tank unattended** while it is being filled.
- ✓ **Provide an air gap** between the water source and the mixture surface to prevent backsiphoning.
- ✓ **Avoid filling pesticide mixing or application equipment directly** from a public water supply unless the outlet from the public water supply is equipped with a backflow prevention device.
- ✓ **Avoid filling pesticide mixing or application equipment directly** from surface water unless the equipment contains proper and functioning anti-backsiphoning mechanisms.
- ✓ **Triple rinse all empty plastic and metal pesticide containers** and add the rinse water to the spray solution.

Pre-Application Activities

- ✓ **Ensure that pesticide applicators are properly licensed** in the appropriate category by the Minnesota

Department of Agriculture when a license is required. See *Resource Directory*.

- ✓ **Protect vegetation** that is part of a cultural resource (such as historic homestead sites) if it will be impacted by herbicide applications.
- ✓ **Mark the boundaries of the area** for treatment.
- ✓ **Refer to label directions** before applying a pesticide.

Timing and Weather Considerations

- ✓ **Avoid applying insecticides during the spring bloom** when pollinators are most active. If there is a choice, spray earlier or later.
- ✓ **Avoid applying pesticides when the likelihood of significant drift exists.**
- ✓ **Use a drift control agent** where appropriate.
- ✓ **Consider applying pesticides near dawn or dusk**, when wind speeds are generally lowest.
- ✓ **Apply pesticides when wind speeds are 6 mph or less** for aerial application and 10 mph or less for ground broadcast application.
- ✓ **Limit broadcast applications** (both aerial and ground) to appropriate temperature and relative humidity conditions as noted on the product label. High temperatures enhance loss of volatile pesticides and the rate of evaporation of droplets. Relative humidity also influences the rate of evaporation, with the rate increasing with decreases in humidity.

Applying Pesticides

- ✓ **Check all application equipment carefully**, particularly for leaking hoses and connections and plugged or worn nozzles.
- ✓ **Calibrate spray equipment periodically** to achieve uniform pesticide distribution and rate.

- ✓ **Select a nozzle type** that produces the largest drops at a given rate and pressure appropriate to the chemical being applied.
- ✓ **Employ the lowest reasonable equipment pressure** when applying pesticides.
- ✓ **Mix pesticides in upland areas**, where practical.
- ✓ **Apply pesticides in accordance with** the product label.
- ✓ **Avoid applying pesticides on all wetlands and seasonal ponds** in upland areas unless that application is part of the management objective. If unable to avoid pesticide use in these areas, select only pesticides labeled for aquatic use when surface water is present at the time of application.
- ✓ **Avoid broadcast application methods within filter strips and riparian management zones (RMZs). Appropriate treatments within filter strips and RMZs include:**
  - Use of pesticides labeled for aquatic use,
  - Manual or mechanical treatments,
  - No treatment,
  - Spot, banded, stump, basal bark, hack and squirt, frill or injection treatments,
  - Use of less soil-mobile pesticides, and
  - Increasing filter strip width when using toxic to highly toxic insecticides.

Additional Consideration

- **Consider maintaining the diversity** of mast sources on the site, as well as some level of current production of mast sources. For example, leave shoulders of roads or plantation spot failures untreated, or maintain landings as openings.

Protecting Water Resources

- ✓ **Avoid applying pesticides directly to water** except where specifically labeled for application to water. For pesticides not labeled for aquatic or ditchbank use, avoid riparian management zones, filter strips or shade strips and other reserve areas adjacent to all streams, lakes, wetlands and ditches that contain water at the time of application.
- ✓ **Prohibit aircraft that are transporting pesticides** from crossing open water where practical. Aircraft also should not fly down the course of any recognizable stream. Where stream crossings cannot be avoided, they should be made at right angles to the stream course. Chemical application should be shut off during turns and over water.

Post-Operational Activities

IMPORTANT! Review General Guidelines

- Post-Operational Activities and Followup Visits

Equipment Cleanup

- ✓ **Avoid cleaning pesticide application equipment** in surface waters.
- ✓ **Clean equipment** in areas where pesticide residues will not enter streams, lakes, wetlands or ground water.
- ✓ **Clean all mixing and loading equipment thoroughly** after each use.
- ✓ **Rinse mixing apparatus** at least three times.
- ✓ **Apply rinsate in spray form** to the area to be treated.
- ✓ **Avoid discharge of rinse water in wetland areas** that are not part of the application site.

Container and Waste Disposal

- ✓ **Dispose of pesticide wastes and containers** according to state and federal laws. Some pesticide wastes are specifically identified as hazardous wastes by law; these must be handled and disposed of in accordance with hazardous waste regulations. For sources of information about proper management of waste pesticides, see *Resource Directory.*
- ✓ **Rinse all empty plastic and metal pesticide containers three times**, and add the rinse water to the spray solution. To properly triple-rinse containers:
  1. Empty the pesticide into the spray tank and allow the pesticide container to drain.
  2. Fill the container 10% to 20% full with water (or solvent, in some cases), rinse, and pour the rinse water into the spray tank.
  3. Repeat Step 2 two more times and apply rinsate to the spray site.
  4. Apply all leftover solutions and rinsates to the treatment area.
- ✓ **Puncture and flatten containers** not intended for return to the manufacturer.
- ✓ **Dispose of triple-rinsed containers** in one of two ways:
  - By recycling through an approved program. A list of dealers or locations who recycle these containers is available at county University of Minnesota Extension offices.
  - As ordinary solid waste at a landfill licensed by the Minnesota Pollution Control Agency.
- ✓ Refer to the product label for additional information on proper disposal.

Reforestation

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Figures

Figure REF-1: Planting Irregular or Offset Rows To Discourage Visual Penetration. 10

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

Reforestation includes the process of planting (or otherwise regenerating) and establishing a desired forest community on a given site. An important part of reforestation is the selection of an appropriate tree species or forest community to manage.

Common reforestation techniques include both natural and artificial methods:

- Natural regeneration methods include root suckering, stump sprouting or natural seeding.
- Artificial regeneration methods include aerial and ground seeding, machine planting and hand planting.



Artificial regeneration methods include aerial and ground seeding, machine planting and hand planting. Photo courtesy of Minnesota DNR

The Benefits of Guidelines

Benefits to cultural resources: Reforestation guidelines can minimize damage to cultural resources resulting from reforestation of cut-over sites. Guidelines can protect archaeological sites from erosion, compaction and rutting, which can destabilize historic buildings, structures and historic areas.

Benefits to forest soils: Reforestation guidelines can help minimize exposure of mineral soil, compaction or rutting of soil, removal of surface soil, increased erosion, or impacting the nutrient balance of the site.

Benefits to riparian areas: Reforestation guidelines can minimize 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 also have a positive impact on aesthetics, wood products and recreation. Reforestation guidelines provide flexibility to exceed mineral soil exposure recommendations within the filter strip guidelines, if needed, to successfully regenerate certain desired species.

Benefits to visual quality: Reforestation guidelines help address the potential negative visual impacts of artificial regeneration by promoting natural-appearing stands.

Benefits to water quality and wetlands: Reforestation guidelines provide opportunities to reduce the potential for increased erosion and subsequent sedimentation of water bodies and wetlands due to reforestation activities that protect mineral soil from exposure. Guidelines that address

equipment operations and maintenance can help protect water quality and wetlands.

Benefits to wildlife habitat: Reforestation guidelines encourage approaches to regeneration of cut-over sites that result in tree species diversity, appropriate species selection for a particular site, and maintenance of habitat structure.

Considerations

- **Increasing planting complexity** may increase planting costs.
- **Management methods associated with natural-appearing stands** (such as mixed-species planting and randomized spacing) can have increased long-term costs.
- **Leaving residual trees** can require increased disease-control measures, especially when residuals and regeneration are the same species.



- **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

IMPORTANT! Review General Guidelines

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

Other guidelines that apply: In addition to specific reforestation guidelines and related general guidelines provided below, refer to the following forest management activity sections for additional guidelines appropriate to reforestation activities.

For activities involving:	Refer to these guidelines:
Building, maintaining, relocating or closing roads	*Forest Road Construction and Maintenance*
Use of heavy equipment	*Mechanical Site Preparation*
Pesticide use	*Pesticide Use*

Species Selection

✓ **Select suitable tree species** to regenerate. Consider such factors as:

- Site capabilities,
- Native species,
- Existing natural regeneration,
- Historical vegetation,
- Variation in growth rates and seed production,
- Mixing of deciduous and coniferous species,
- Sunlight requirements, and
- Climate change impacts.



✓ **Choose seed or seedlings from a locally adapted source.**

✓ **Use pre- and post-harvest techniques that will increase success of oak regeneration where appropriate**, including burning, stump sprout thinning or scarification.

Reducing Visual Impacts Due to Species Selection During Reforestation

In Areas Classified as Most Sensitive*

- ✓ **Promote a mixture of species,** both naturally occurring and planted.
- ✓ **Encourage and maintain diversity** within the stand.
- ✓ **Favor long-lived species where appropriate** to minimize frequency of management activities.

In Areas Classified as Moderately Sensitive*

- ✓ **Use species appropriate for site.**
- ✓ **Promote a mixture of species,** both naturally occurring and planted.

In Areas Classified as Less Sensitive*

- ✓ **Choose species** consistent with integrated resource management principles.

*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.



Promoting a mixture of species encourages and maintains diversity, which also provides wildlife habitat diversity and the positive visual impact of a natural-appearing landscape. Photo courtesy of Superior National Forest



Promote natural-appearing stands by avoiding planting rows perpendicular to travel routes, which can result in a negative visual impact. Photo courtesy of Minnesota DNR

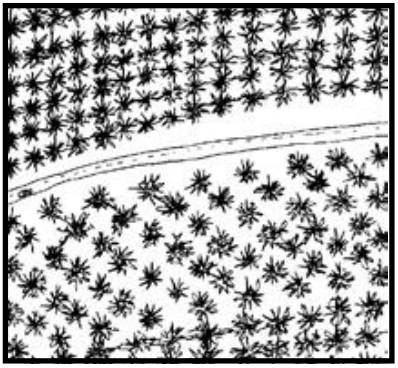


Figure REF-1: To avoid the perception of unnatural straight rows (as shown above the travel route), plant irregular or offset rows for the first few rows along a travel route (as shown below the travel route) to discourage visual penetration and increase the perception of a natural stand.

Reducing Visual Impacts Due to Planting Layout and Design

In Areas Classified as Most Sensitive*

- ✓ **Do not plant rows perpendicular to travel routes** or recreation areas.
- ✓ **Plant irregular or offset rows** to encourage natural-appearing stands. See Figure REF-1.
- ✓ **Use wider initial spacing** to minimize number of re-entries to the site and to encourage establishment of other species.

In Areas Classified as Moderately Sensitive*

- ✓ **Avoid rows perpendicular to travel routes** or recreation areas.
- ✓ **Use wider spacing** along sensitive boundaries.

In Areas Classified as Less Sensitive*

- ✓ **Choose species and plantation design** consistent with integrated resource management principles.

*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.

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

✓ **Conduct on-site meetings** with the contractor, landowner and resource manager prior to moving equipment onto a site. Such meetings can help assure common understanding of landowner objectives, contract specifications and site conditions.

Additional Considerations

- **Consider reintroducing** yellow birch, white pine, red oak, black walnut, and/or white cedar to mesic hardwood sites where they once existed.
- **Consider scarifying the soil** in the vicinity of conifer seed trees to enhance regeneration of these species. Do this with consideration for controlling erosion and sedimentation.

Timber Stand Improvement

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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

Introduction

Timber stand improvement (TSI) includes activities or treatments that improve the composition, structure, condition, health and growth of even-age or uneven-age stands.

Such activities may include mechanical or chemical treatment of vegetation that competes with desirable trees; removing diseased or dying trees; thinning; pruning; and post-harvest treatments on natural regenerating stands.

These practices are intended to do three things:

- Increase the value of the stand
- Improve the growth and form of crop trees
- Manipulate stand composition



Row thinning is an example of a timber stand improvement activity that increases the value of the stand, improves the growth and form of crop trees, and manipulates stand composition. Photo courtesy of Minnesota DNR

The Benefits of Guidelines

Benefits to cultural resources: TSI guidelines can minimize the direct or indirect effects of timber stand improvement activities (such as mixing of surface soils, rutting, compaction and erosion) on certain kinds of cultural resources. Guidelines particularly address the use of heavy equipment, which can be of most concern to protection of cultural resources.

Benefits to forest soils: TSI guidelines can help minimize the effect of equipment trafficking on soils, thus reducing soil compaction, rutting and erosion. Reducing these potential impacts eases root penetration, availability of water, ease of water absorption by plants, available amounts of oxygen and other gases in the soil, and the degree to which water moves laterally and vertically through the soil.

Benefits to riparian areas: TSI guidelines address TSI activities that can alter the 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: TSI guidelines can minimize visual impacts of some TSI activities that result in alterations to the stand or the accumulation of debris.

Benefits to water quality and wetlands: TSI guidelines address the potential for increased erosion and subsequent sedimentation of water bodies and wetlands as a result of TSI activities exposing mineral soil.

Guidelines that address equipment operations and maintenance can help protect water quality and wetlands.

Benefits to wildlife habitat: TSI guidelines can help avoid reductions in overall species diversity on a site while maintaining or enhancing structural diversity.

Considerations

- **Timing of TSI activities** should take into account disease and insect cycles that may be enhanced by the presence of slash.
- **Restricted operating hours** (to regulate noise near recreation areas) may affect the cost of TSI activities.
- **Additional slash disposal requirements** (to control disease or to enhance visual quality) may affect the cost of TSI activities.
- **TSI (including removal of brush and small suppressed trees) can allow people to see** into the stand.



- **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

IMPORTANT! Review General Guidelines

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

In addition to specific TSI guidelines and related general guidelines provided below, refer to the following forest management activity sections for additional guidelines appropriate to TSI.

For TSI activities involving:	**Refer to these guidelines:**
Felling trees	*Timber Harvesting*
Application of pesticides	*Pesticide Use*
Trafficking sites with heavy equipment	*Mechanical Site Preparation and Timber Harvesting*
Road building or access development	*Forest Road Construction and Maintenance*

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

✓ **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.

✓ **Allow for a diversity of species and ages** when implementing TSI activities.

✓ **Avoid cultural resources** when mechanically strip thinning with heavy equipment.

- ✓ **Leave standing a minimum of 6 cavity trees**, potential cavity trees, and/or snags per acre during TSI operations. These trees and snags should be distributed throughout the site as much as possible. For preferred characteristics, see *General Guidelines: Retaining Leave Trees*.
- ✓ **Rehabilitate landings and skid trails** where necessary to mitigate soil compaction and reduce erosion.

Additional Considerations

- **Consider retaining some stems of non-commercial species** (such as ironwood and bluebeech) in TSI operations to maintain natural diversity and/or mast production on site.
- **Consider creating snags during commercial thinning of even-age, low-diversity stands** (such as old-field pine plantations). Girdling, topping, or herbicide injection may be used to kill selected trees and create snags where none exist. Physical injury will induce fungal decay to create a potential cavity tree. (These techniques, if applied to pines in summer, will increase risk of bark beetle infestation to adjacent healthy pines.)
- **Consider maintaining the diversity of mast sources on the site**, as well as some level of current production of mast sources. For example, avoid operations in pockets of fruit-producing shrubs.

Reducing Visual Impacts of Timber Stand Improvement

In Areas Classified as Most Sensitive*

- ✓ **Time TSI operations** so that they will not occur during periods of peak recreational use.

- ✓ **Treat slash and debris from TSI operations** (by lopping, removing, crushing or burning) whenever possible. Keep slash height below 2 feet. See *Timber Harvesting: Managing Slash.*
- ✓ **Reduce noise** in early morning, late evening and other appropriate times whenever possible near residences, businesses and outdoor activity areas.
- ✓ **Inform and educate recreational users** regarding the concept and benefits of TSI prior to, during and after TSI activities.

In Areas Classified as Moderately Sensitive*

- ✓ **Avoid TSI operations during periods of peak recreational use** whenever possible.
- ✓ **Inform and educate recreational users** regarding the concept and benefits of TSI prior to, during and after TSI activities.
- ✓ **Treat slash and debris** as per guidelines in *Timber Harvesting: Managing Slash.*

In Areas Classified as Less Sensitive*

- ✓ **Use methods and applications** consistent with integrated resource management objectives for the area.

*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.

Fire Management

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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

The term fire management includes both prescribed burning and fire suppression:

- **Prescribed burning** is the intentional application of fire to wildland fuels (in either their natural or modified state) under specified environmental conditions.
- **Wildfire suppression** is the effort to control, contain or extinguish wildfires in order to protect life, property and resources.

The Benefits of Guidelines

Benefits to cultural resources: Fire management guidelines can help protect surface features of archaeological sites, cemeteries, historic buildings and structures from the adverse effects of fire. Guidelines for construction of fire breaks and movement of heavy equipment can minimize direct or indirect disruption of soils, rutting, compaction and erosion that can damage cultural resources.

Benefits to forest soils: Fire management guidelines address concerns related to those soils in Minnesota that are particularly sensitive to the effects of fire—especially intensive slash burns where fuels are close to the ground. Fire management guidelines can help minimize the potential for these slash burns to reduce soil productivity. Under the appropriate soil and site conditions, prescribed

burning releases nutrients, reduces competition, and can temporarily improve soil productivity. For information about conducting prescribed burns, contact local DNR or U.S. Forest Service offices.

Benefits to riparian areas: Fire management guidelines can minimize 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; maintaining 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 water quality and wetlands: Fire management guidelines address concerns related to the exposure of mineral soil from the burning of organic matter and from fuel break construction, the release of plant nutrients following burning, and increased post-burn surface temperatures, which can increase nonpoint source pollution. Guidelines that address equipment operations and maintenance can help protect water quality and wetlands. Properly applied guidelines also help ensure maximum benefits of fire to wetland ecosystems.

Benefits to wildlife habitat: Fire management guidelines address the potential for both wildfires and prescribed burns to eliminate important structural habitat components on a site, such as snags and coarse woody debris. Guidelines can minimize the potential adverse effects of fire on unprotected sensitive sites, unique habitats and rare species.

Considerations

- **Safety and the protection of life and property** are the priority in fire management.
- **Other fire management considerations should include** protection of cultural resources, forest soils, riparian areas, water quality and wetlands, and wildlife habitat.
- **Making fire management personnel aware** of cultural resources, through training and advance planning, can help protect cultural resources.
- **Slash burning, where fuels are close to the ground**, can in some cases reduce soil productivity by consuming the forest floor and superheating the surface of some soils (particularly dry sandy soils). This results in reduced water-holding capacity, volatilization of some nutrients, and allowing other nutrients to become rapidly available for plant uptake, runoff or leaching.
- **The timing, intensity and severity of burning** can help reduce threats from insect cycles and diseases (e.g., dwarf mistletoe control in black spruce).
- **Because pulp and paper industries cannot accept charred wood**, merchantability may be negatively affected by burning in standing timber.



- **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

IMPORTANT! Review General Guidelines

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

Burn Plan Development

✓ **Consult with local DNR offices** for technical advice and assistance in prescribed burning. See *Resource Directory*.

✓ **Obtain a DNR permit prior to burning** as required under Minn. Statutes, Chapter 88.17. See *Resource Directory*.

✓ **When planning burns in or near wetland areas and seeps,** avoid damaging the hydrology on sites during management operations.

- ✓ **Plan prescribed burns to increase success** of oak and conifer regeneration where applicable.
- ✓ **Consult with** the Office of the State Archaeologist and the Minnesota Indian Affairs Council if there are burial sites within prescribed burn areas. For sources of information and assistance, see *Resource Directory*.
- ✓ **Include cultural resource information** in both wildfire suppression and prescribed burn plans. Important information includes:
  - Locations of known cultural resources,
  - Locations of high probability areas for the occurrence of cultural resources,
  - List of professional cultural resource managers and tribal representatives who can be contacted for assistance. For sources of information and assistance, see *Resource Directory*.
- ✓ **Minimize impacts of fuel break construction** by applying one or more of the following guidelines:
  - Consider such alternatives as herbicide use, mowing or other non-erosion-causing practices for fuel break maintenance on areas where prescribed fire will be used on a recurring basis.
  - Use natural or in-place fuel breaks (such as roads, streams, lakes and wetlands) where appropriate, as an acceptable way to minimize the need for artificial fuel break construction.
  - Consider the use of fire retardant in place of plowed fuel breaks where fuel break construction would result in unacceptable soil erosion, water quality degradation, or damage to cultural resources.
  - When artificial fuel breaks must be used, place fuel breaks, fueling and maintenance areas outside of filter strips or the RMZ, whichever is wider, whenever practical. See *General Guidelines: Maintaining Filter Strips* and *General Guidelines: Managing Riparian Areas*.

- Locate fuel breaks on the contour whenever possible, and avoid straight uphill-downhill placement.



The goal of this prescribed burn is to underburn pine for regeneration. Photo courtesy of Minnesota DNR

✓ **When conducting prescribed burns**, use low- or moderate-burning intensity so that the minimum amount of forest floor is consumed consistent with meeting the objectives of the burn, especially for dry sandy soils or shallow soils over bedrock.

✓ **Avoid placement of piles for burning** within filter strips or drainage channels adjacent to streams, lakes and wetlands.

Additional Consideration

- **Consider maintaining the diversity** of mast sources on the site, as well as some level of current production of mast sources. For example, establish fuel breaks around key pockets of mast-producing shrubs along the edges of prescribed burn sites.
- **Climate change may increase the risk of wildfire** or change the frequency and intensity of wildfires when they occur.



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

✓ **Conduct on-site meetings** with the contractor, landowner and resource manager prior to moving equipment onto a site. Such meetings can help assure common understanding of landowner objectives, contract specifications and site conditions.

Pre-Ignition Activities

✓ **Delineate cultural resource areas** and carefully consider the effects of prescribed burns on them.

✓ **Pre-position fire-fighting personnel and equipment** at cultural resources that are susceptible to damage by fire.

- ✓ **If cultural resources cannot be avoided** within prescribed burn areas:
  - Treat above-ground features with fire retardant.
  - Protect below-ground archaeological sites from compaction and rutting.
- ✓ **Protect the largest coarse woody debris** from prescribed burning.
- ✓ **Control the pattern and timing of burn ignition** by evaluating existing or developing conditions on the ground.

Managing Fuel Breaks and Accesses

- ✓ **Construct fuel breaks** outside of cultural resource areas. Use cultural resource professionals or tribal representatives to help determine fuel break location. For sources of information and assistance, see *Resource Directory*.
- ✓ **Construct fuel breaks only deep enough and wide enough** to control the spread of the fire.
- ✓ **Avoid construction of fuel breaks** for fire management that result in drainage directly into a water body.
- ✓ **Provide adequate filter strips** when constructing fuel breaks that expose bare soil near wetlands.
- ✓ **Use fuel break construction methods in wetlands** that do not expose bare soil, whenever practical. These may include wetlines and existing constructed or natural barriers.
- ✓ **Avoid application of foam or fire-retardant chemicals** into lakes, streams and open water wetlands, where practical.
- ✓ **Maintain erosion control measures** as needed on fuel breaks. For sources of seeding and fertilizing recommendations, see *Resource Directory*. Refer also

to water bar construction and spacing specifications in *Forest Road Construction and Maintenance: Drainage*.

- ✓ **Employ suitable water diversion structures** on fuel breaks, 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.
- ✓ **Monitor the effectiveness** of cultural resource management practices during prescribed burns and wildfire suppression activities.
- ✓ **Control access** to sensitive cultural resources.

Protecting Water Quality and Wetlands

- ✓ **Establish unburned zones containing no fuel breaks** to protect water quality in situations where steep slopes, highly erodible soils, or the likelihood of substantial organic matter removal are present. See *General Guidelines: Maintaining Filter Strips and General Guidelines: Managing Riparian Areas*.
- ✓ **When working with foam or retardants** near lakes, streams or wetlands:
  - Follow manufacturer recommendations.
  - Prevent or minimize runoff of fire-retardant chemicals into water by keeping filter strip areas off-limits to retardant use.
  - Avoid cleaning fire-retardant application equipment in lakes or streams.

Post-Operational Activities

IMPORTANT! Review General Guidelines

- Post-Operational Activities and Followup Visits

✓ **Stabilize erodible soils** through such techniques as seeding, mulching and water bars. For sources of seeding and fertilizing recommendations, see *Resource Directory*. Refer also to recommended water bar construction and spacing specifications in *Forest Road Construction and Maintenance: Drainage*.

✓ **Assess the condition of cultural resources** that may have been affected by prescribed burning or wildfire suppression activities.

✓ **Field inspect the burned area** to identify cultural resources that may not have been previously identified but have been newly exposed by the fire.

✓ **Remove temporary fire management features** that are inappropriate to the historic character of adjacent cultural resources.

✓ **Restore water source sites** used for fire management activities as soon as practical following control, or at the completion of mop-up activities.

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General Guidelines and Activity-Specific Guidelines Are Closely Related

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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.



The goal of forest recreation management is to select, develop, operate and maintain forest recreation areas to provide quality outdoor experiences for the recreational user. Photo courtesy of Minnesota DNR

Introduction

The goal of forest recreation management is to select, develop, operate and maintain forest recreation areas to provide quality outdoor experiences for the recreational user.

The Benefits of Guidelines

Benefits to cultural resources: Recreation management guidelines address the fact that campgrounds, boat

landings and other recreational facilities tend to be located in areas that have high sensitivity for cultural resources. Guidelines can help assure that construction and operation of such facilities do not adversely affect cultural resources through soil disturbance, rutting, compaction and erosion. Guidelines also address issues of public use that may increase the potential for deliberate vandalism or inadvertent disturbance of sensitive sites.

Benefits to riparian areas: Recreation management guidelines address the fact that development of trails, campsites or other recreational facilities can alter the 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; maintaining 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 water quality and wetlands: Recreation management guidelines help assure that development of trails, campsites or other recreational facilities do not disturb sensitive sites or water features, thus reducing sedimentation to water bodies and wetlands. Guidelines that address equipment operations and maintenance can help protect water quality and wetlands.

Benefits to wildlife habitat: Recreation management guidelines can minimize the disturbance to sensitive sites, rare species, water features or unique habitats that may occur directly or as a result of development of trails, campsites and other recreational facilities, or indirectly through increased human use of an area that such facilities bring.

Considerations

- **Planning for recreational development** should address cultural resource issues in terms of both protection and interpretation. Existing cultural resource inventories should be reviewed early in the planning process. If no information is available, field inspections should be conducted before development plans are finalized to determine presence or absence of cultural resources.
- **If cultural resources are present** in the development area, it may be possible to modify construction plans to reduce or eliminate damage to the resources. Cultural resource professionals can help determine the best approaches to mitigation of potential damage. For sources of information and assistance, see *Resource Directory*.
- **Recreational developments provide opportunities for education** through interpretation of on-site cultural resources. For sources of information and assistance, see *Resource Directory*.



- **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

IMPORTANT! Review General Guidelines

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

Construction of Recreation Areas

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 contractor, landowner and resource manager prior to moving equipment onto a site. Such meetings can help assure common understanding of landowner objectives, contract specifications and site conditions.

Protecting Cultural Resources

✓ **Select and designate borrow** areas and gravel quarries prior to the start of construction to avoid cultural resource locations.

✓ **Select and designate the staging area** for equipment prior to the start of construction to avoid cultural resource locations. If avoidance is not feasible or practical:

- Use “fill-only” construction techniques in the area of the cultural resource.
- Construct temporary crossings over the cultural resource (including slash, tire mats, or fill over geotextile).

✓ **Do not allow surfaces in archaeologically sensitive areas** to erode, slump or wash out. Implement temporary stabilization methods to preserve the shape, slope, elevation and contours of archaeological sites

and historic features. Stabilization should not alter the historic character of the cultural resource.

- ✓ **If practical and feasible, avoid cultural resource areas** when constructing recreational facilities.
- ✓ **If it is not possible to completely avoid a cultural resource**, minimize or eliminate soil disturbance and erosion in the vicinity of the resource by:
  - Minimizing cut sections and following existing contours to the extent possible,
  - Avoiding unnecessary disturbance to the ground surface, and
  - Considering data recovery if it is not possible to avoid impacting the resource.

For sources of information and assistance, *see Resource Directory.*



Archaeologists excavate a site in advance of development of a new recreational facility. Photo courtesy of State Parks Cultural Resource Program

Protecting Water Quality and Soil Productivity

✓ **Install and maintain appropriate erosion control structures** to protect water quality and soil productivity. See also appropriate erosion and water control guidelines in *Forest Road Construction and Maintenance: Alignment and Location and Drainage*.

Public Use Considerations

Recreational Traffic

✓ **In areas that will receive a lot of traffic** (pedestrian or vehicular), periodically inspect the facility to determine whether the cultural resource is being damaged by public use of the area. If so, special protective measures may be desirable.

✓ **When operating within the riparian management zone**, confine recreational off-highway vehicle use and other non-foot traffic to trails that are designed, constructed and maintained using guidelines for skid trails and forest roads. Refer also to appropriate guidelines in *Timber Harvesting: Skidding and Skid Trails and Forest Road Construction and Maintenance.*

Public Education Opportunities

✓ **Retain flagging, signs or other markings** on cultural resource areas in cases where they might be appropriate long-term protection or interpretation tools.

✓ **Treat public use areas as opportunities** for interpretation of cultural resources, as long as interpretive plans take into account the need to safeguard the resource from deliberate or inadvertent damage. Design interpretive signage and displays in consultation with cultural resource specialists. For sources of information and assistance, see *Resource Directory.*

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Figure BHF-3: Fuel Reduction 37

Acknowledgments

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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

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.

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.

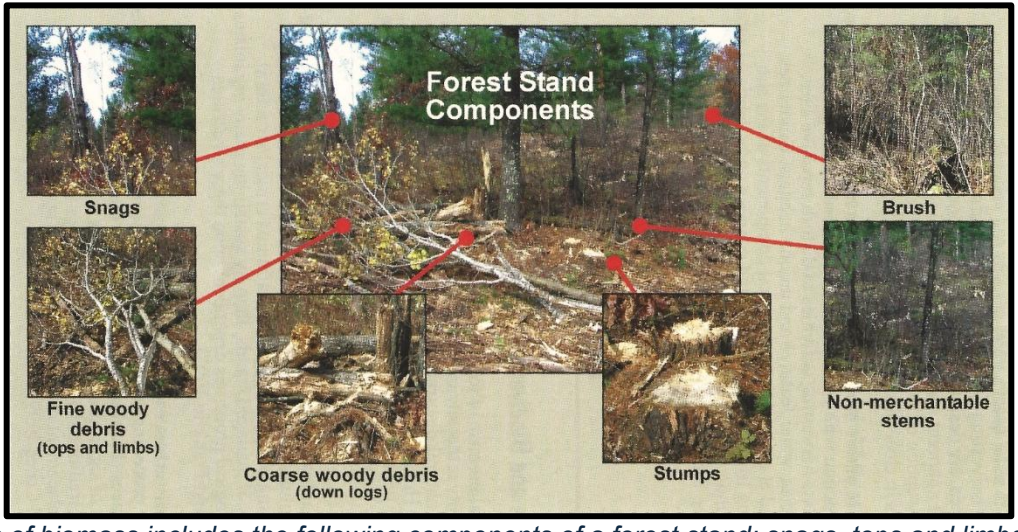
The Benefits of Guidelines

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 con- junction 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.

Figure BHF-1



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 directly below.)

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.

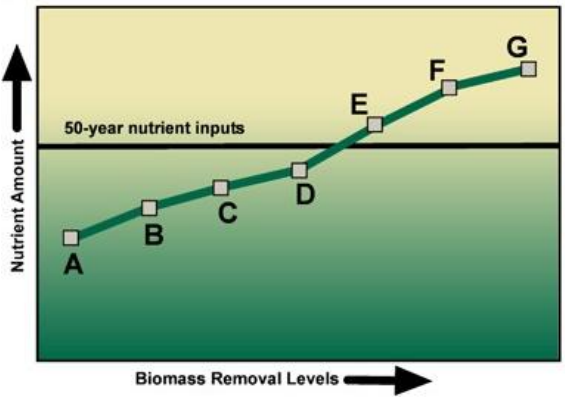
Future technology, however, may make it possible to remove much more of the woody material from sites, along with nutrients associated with that material. For example, Figure BHF-2 qualitatively compares the increasing removal of biomass and nutrients with the natural nutrient inputs estimated to occur 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.

Figure BHF-2

Comparison of Biomass and Nutrient Removal Levels with Natural Nutrient Inputs

(typical aspen-birch cover, 50-year rotation, 20 cords/acre yield)

Note: The nutrient capital of an average Minnesota forest soil is about 20 times greater than that removed under Scenario "G".



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 infra- structure, 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 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*.

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 section
- Rare or Sensitive Species section
- Protecting Cultural Resources section

Timber Harvesting:

- Protecting Sensitive Areas section

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 Minnesota Geospatial Commons Website (https://gisdata.mn.gov/ (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, or
    - 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.



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* 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
- Maintaining Filter Strips
- Managing Riparian Areas
- Protecting the Normal Flow of Streams and Wetlands
- Protecting Non-Open Water Wetlands and Seasonal Ponds
- Managing Dry Washes in Southeastern Minnesota

Timber Harvesting:

- Water Quality and Wetlands

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
- Managing and Minimizing Infrastructure

Timber Harvesting:

- Design Outcomes to Maintain Soil Productivity
- Protecting Sensitive Areas
- Minimizing Rutting

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 following page.)

✓ **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 following page.)



Photo at left: Avoid biomass harvesting (over and above bolewood utilization) on organic soils deeper than 24 inches that are ombrotrophic. This photo depicts an ombrotrophic site (APn80) in northern Minnesota. Photo courtesy of Minnesota DNR Ecological Resources

Photo at right: Avoid biomass harvesting (over and above bolewood utilization) on aspen or hardwood cover types on shallow soils (8 inches or less) over bedrock. This photo depicts a birch stand on shallow soil in northern Minnesota. Photo courtesy of Minnesota DNR Ecological Resources



✓ **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 area than recommended in Table TH-1.

✓ **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*). 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*.)
- **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.



This large slash pile is surrounded by aspen regeneration. Once regeneration has begun or planting has been completed, re-entry into the general harvest area should be avoided. Photo courtesy of Minnesota DNR Forestry

- ✓ **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)
- Providing Coarse Woody Debris

Timber Harvesting:

- Snags (standing dead trees)
- Leave Trees (live trees)

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)*
- *Providing Coarse Woody Debris*

Timber Harvesting:

- *Snags (standing dead trees)*
- *Leave Trees (live trees)*

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.

- ✓ **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). It is appropriate to adjust the amount of retention if incidental breakage during felling is more or less than 10-15% (see *Retaining Fine Woody Debris: The Overall Goal section below*).
- ✓ **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 below)
- ✓ **It is acceptable to adjust the amount of slash retention** if necessary to meet silvicultural objectives (see examples on *Biomass Harvest as a Tool for Silviculture Management*)



Retaining Fine Woody Debris: The Overall Goal

The overall goal of FWD retention is to retain about one-third of the tops and limbs from trees that are harvested on a site. This goal is achieved by intentionally retaining 20% of tops and limbs with an assumed additional 10-15% achieved by incidental breakage during felling and

skidding. Incidental breakage will vary depending on equipment type, season of harvest, cover type, and stand condition. Adjust the amount of intentional retention if incidental breakage is more or less than 10-15%. 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.)
- ✓ **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

In addition to the *General Guidelines*:

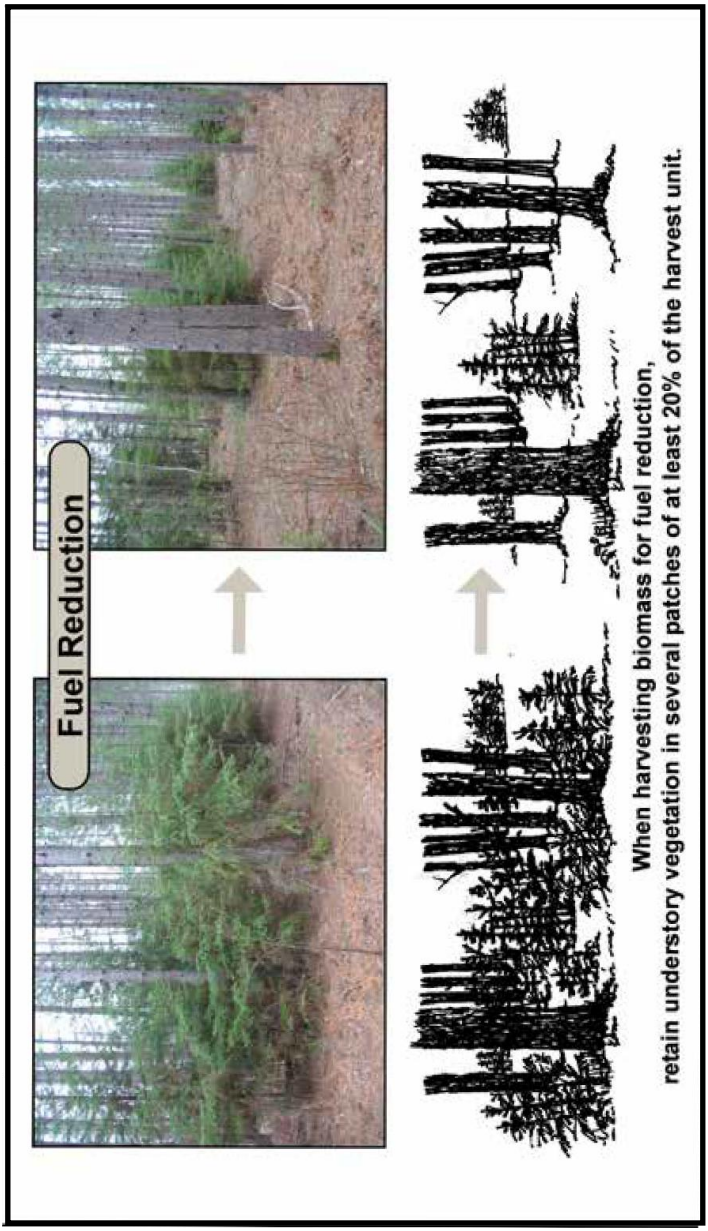
✓ **Evaluate the harvest operation and plan future adaptations** at post-harvest conferences with the logger and landowner.

✓ **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

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

Minnesota Leigslature Office of the Revisor of Statutes Minnesota Law Webpage
https://www.revisor.mn.gov/pubs/

Minnesota Legislature Office of the Revisor of Statutes Website
https://www.revisor.mn.gov/

Biomass Power Mandate: Go to the Minnesota Leigslature Office of the Revisor of Statutes Minnesota Law Webpage
https://www.revisor.mn.gov/pubs/
Enter 216B.2424 in the Retrieve by number search bar.

Sustainable Forest Resources Act, Chapter 89A: Go to the Minnesota Leigslature Office of the Revisor of Statutes Minnesota Law Webpage
https://www.revisor.mn.gov/pubs/
Search for Chapter 89A by entering 89A in the Retrieve by number search bar.

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 the University of Minnesota Department of Forest Resources Staff Paper Series Webpage
https://hdl.handle.net/11299/5775

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 Minnesota Logged Area Residue Analysis pdf
https://files.dnr.state.mn.us/forestry/um/mnloggedarea_residueanalysis.pdf

Potential Markets for Woody Biomass

Potential markets, including a directory of primary and secondary forest products in Minnesota: Minnesota Department of Natural Resources Forestry Utilization and Marketing Program Webpage
https://www.dnr.state.mn.us/forestry/um/index.html
See “Information and reports on forest resources, industry and wood utilization” section.

Minnesota DNR Ecological Classification System

For additional information, including descriptions of Native Plant Communities (NPCs), visit the Minnesota Department of Natural Resources Ecological Classification System Webpage
www.dnr.state.mn.us/ecs



Glossary

Biological legacy: Anything handed down or carried over from a pre-disturbance 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, 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.)

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

Astrom, M., M. Dynesius, K. Hylander and C. Nilsson. 2005. Effects of slash harvest on bryophytes and vascular plants in southern boreal forest clear-cuts. *Journal of Applied Ecology*, 42: 1194-1202.

Brakenhielm, S., and Q. Liu. 1998. Long-term effects of clear-felling on vegetation dynamics and species diversity in a boreal pine forest. *Biodiversity and Conservation*, 7: 207-220.

Crow, T. R. 1988. Biological diversity: Why is it important to foresters? In: Managing north-central forests for non-timber values. Duluth, Minnesota. Society of American Foresters, pp. 969-977.

Crow, T. R. 1990. Old growth and biological diversity: a basis for sustainable forestry. In: Old-growth forests: What are they? How do they work? Proceedings from the conference on old growth forests: 1990 January 20: Toronto, Ontario, Canada. Canadian Scholars' Press, Inc., pp. 49-62.

Ecke, F., O. Lofgren and D. Sorlin. 2002. Population dynamics of small mammals in relation to forest age and structural habitat factors in northern Sweden. *Journal of Applied Ecology*, 39: 781-792.

Foster, D. R., J. D. Aber, J. M. Melillo, R. D. Bowden and F. A. Bazzaz. 1997. Temperate forest response to natural catastrophic disturbance and chronic anthropogenic stress. *BioScience*, 47: 437-445.

Franklin, J. F., P. M. Frenzen and F. J. Swanson. 1995. Recreation of ecosystems at Mount St. Helens: Contrasts in artificial

and natural approaches. In: Cairns, J., Jr. (ed.), *Rehabilitating Damaged Ecosystems*, 2nd Edition. CRC Press, Boca Raton, Florida, pp. 287-333.

Franklin, J. F., T. A. Spies, R. Van Pelt, A. B. Carey, D. A. Thornburgh, D. R. Berg, D. B. Lindenmayer, M. E. Harmon, W. S. Keeton, D. C. Shaw, K. Bible and J. Chen. 2002. Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. *Forest Ecology and Management*, 155: 399-423.

Grigal, D. F. 2004. An update of Forest soils. A technical paper for a generic environmental impact statement on timber harvesting and forest management in Minnesota. Submitted to Laurentian Energy Agency, Virginia, Minnesota. 32 pages. (mimeo)

Grigal, D. F., and P. C. Bates. 1992. Forest soils. A technical paper for a Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota. Jaakko Pöyry Consulting, Inc. Tarrytown, New York. 155 pages.

Gunnarsson, B., K. Nitterus and P. Wirdenas. 2004. Effects of logging residue removal on ground-active beetles in temperate forests. *Forest Ecology and Management*, 201: 229-239.

Hammond, H. E. J., D. W. Langor and J. R. Spence. 2004. Saproxylic beetles (Coleoptera) using Populus in boreal aspen stands of western Canada: spatiotemporal variation and conservation of assemblages. *Canadian Journal of Forest Resources*, 34: 1-19.

Hunter, M. L., Jr. 1999. Maintaining biodiversity in forest ecosystems. Cambridge University Press, Cambridge, Massachusetts. 714 pages.

Kohm, K. A., and J. F. Franklin. 1997. Creating a forestry for the 21st century: The science of ecosystem management. Island Press, Washington, D.C. 475 pages.

Lee, P., and S. Crites. 1999. Early successional deadwood dynamics in wildfire and harvest stands. In: Lee, P. (ed.): Fire and harvest residual project: the impact of wildfire and harvest residuals on forest structure and biodiversity in aspen-dominated boreal forests of Alberta. Alberta Research Council, Vegreville, Alberta, pp. 65-85.

Mahendrappa, M. K., and D. G. O. Kingston. 1994. Intensive harvest impacts on soil temperature and solution chemistry in the maritimes region of Canada. *New Zealand Journal of Forest Science*, 24: 402-414.

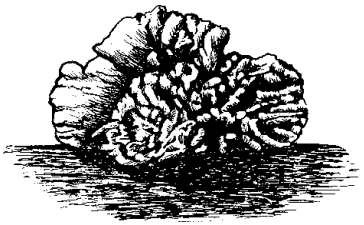
McInnis, B. G., and M. R. Roberts. 1994. The effects of full-tree and tree-length harvest on natural regeneration. *Northern Journal of Applied Forestry*, 11: 131-137.

Minnesota Department of Natural Resources. *Field Guides to the Native Plant Communities of Minnesota: The Laurentian Mixed Forest Province* (2003) and *The Eastern Broadleaf Forest Province* (2005). Ecological Land Classification Program, Minnesota County Biological Survey, and Natural Heritage and Nongame Research Program. St. Paul, Minnesota. 352 pages; 394 pages.

Minnesota Forest Resources Council. 2005. *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers*. St. Paul, Minnesota.

Proe, M. F., J. Dutch and J. Griffiths. 1994. Harvest residue effects on micro-climate, nutrition, and early growth of Sitka spruce (Picea sitchensis) seedlings on a restock site. *New Zealand Journal of Forest Science*, 24: 390-401.

Samuelsson, J., L. Gustafsson and T. Ingelog. 1994. Dying and dead trees–a review of their importance for biodiversity. Swedish Threatened Species Unit, Uppsala, Sweden.



Woody Biomass Harvesting for Managing Brushlands and Open Lands

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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 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** brushland sites. Woody biomass may also include **upland** brush species harvested on upland sites. (See next photo.)



Winter shearing of this brushland management site resulted in significant amounts of potential biomass. Photo courtesy of Minnesota DNR Wildlife

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.)

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).

Figure BHB-1 - Biomass Harvesting Guidelines



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. 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

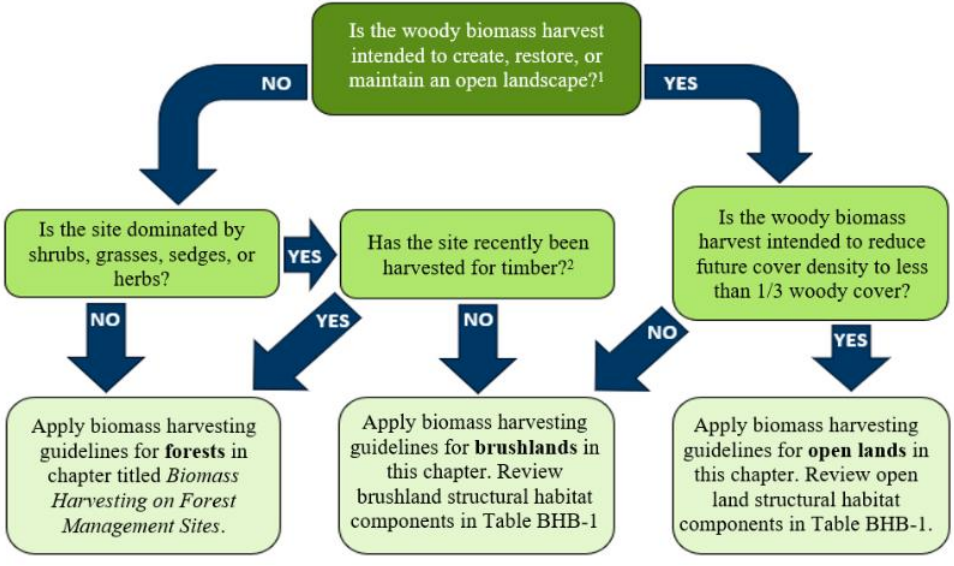
lands differ from each other only by the percent cover of trees and shrubs:
    - Open lands are plant communities with less than one-third (1/3) total cover by trees and shrubs.
    - Brushlands have higher tree and shrub cover.

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 in the *Visual Examples and Definitions of Ecological Systems* section.)

The decision key in Figure BHB-2 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).
- **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).

Figure BHB-2: Key to Selection of Most Appropriate Guidelines for Woody Biomass Harvest



[1]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 Brush- land Wildlife Habitat in Northern and Central Minnesota, Minnesota DNR.)

[2]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 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, 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*
- *Maintaining Filter Strips*
- *Protecting Cultural Resources*
- *Managing Equipment, Fuel and Lubricants*
- *Protecting the Normal Flow of Streams and Wetlands*
- *Protecting Non-Open Water Wetlands and Seasonal Ponds*
- *Managing Dry Washes in Southeastern Minnesota*

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*
- *Conducting a Site Inventory*
- *Incorporating Sustainability into Forest Management Plans*

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.
  - 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 Minnesota Geospatial Commons website (https://gisdata.mn.gov/) (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*

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*.



Sensitive Area and Species Protection

Review existing guidelines, including *General Guidelines:*

- *Gathering Information*
- *Rare or Sensitive Species*

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 Minnesota Geospatial Commons at https://gisdata.mn.gov/ (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.
- ✓ **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* 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 below.)

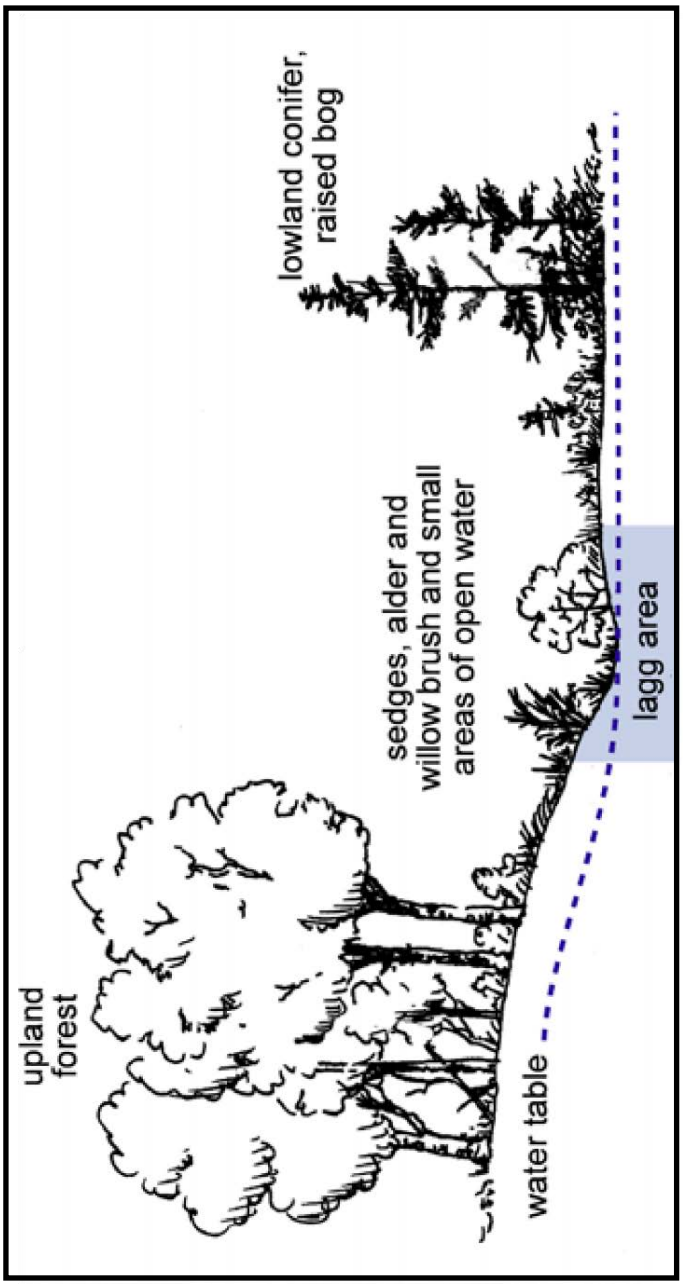


This sharptail dancing ground, or "lek," is one example of the kinds of sensitive areas that may be found in brushland or open land management sites. Photo courtesy of Minnesota DNR Wildlife

- **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) 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.



Figure BHB-3 - Representation of Lagg Area



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.

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* 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*
- *Designing Operations to Fit Site Conditions*
- *Managing and Minimizing Infrastructure*

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 below.)

✓ **Minimize rutting in primary haul trails**, roads and landings.



Winter harvesting is one example of timing management activities to protect soil and cultural resources. Photo courtesy of Minnesota DNR Wildlife

- ✓ **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.
- ✓ **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:

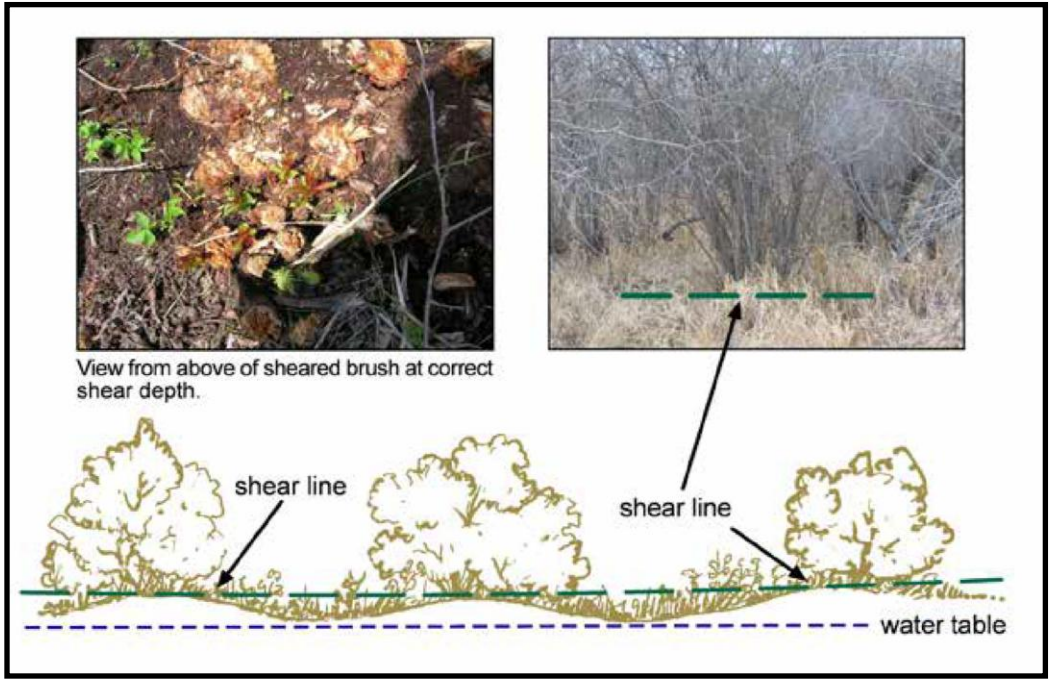
- ✓ **Use a site's inherent productivity** (as indicated by rate of vegetative regrowth) and management strategy to indicate frequency of biomass harvest. Rapid regrowth allows for more frequent harvest; slow regrowth suggests longer intervals between harvests.
- ✓ **Lay out haul trails to minimize site disturbance** while achieving necessary operating efficiency.

- ✓ **Plan roads and landings** to occupy no more area than recommended in Table TH-1.
- ✓ **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.)

Figure BHB-4 - 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 channelizes water. Photos courtesy of Minnesota DNR Forestry

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 the 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* and *Cross-Road Drainage*.

✓ **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* and *Cross-Road Drainage*.

✓ **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*

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.)

✓ **Avoid operation of heavy equipment directly adjacent to streambanks** or shorelines of water bodies. Utilize hand felling and/or equipment with the

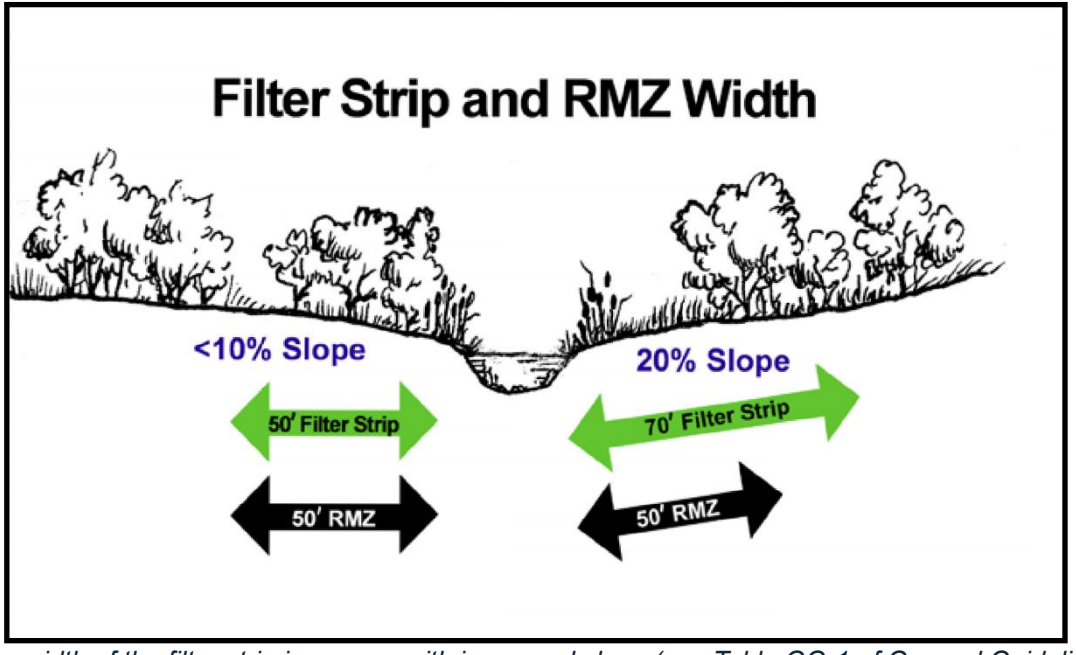
ability to reach into this zone (such as boom cutting heads) as a means of managing vegetation.

✓ **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.



Figure BHB-5



Note that the width of the filter strip increases with increased slope (see Table GG-1 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.*



Brush within an RMZ in a forested landscape: In a brushy riparian zone within a forested setting, use forest biomass harvesting.



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 Minnesota Department of Natural Resources Public Waters Inventory Program webpage https://www.dnr.state.mn.us/waters/watermgmt_section/pwi/index.html
  - 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) 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.

✓ **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 below describes desired structural habitat conditions for various habitat classes associated with brushlands or open lands.

Table BHB-1

Structural Habitat Components of Reserve Areas and RMZs in Woody Biomass Harvest Sites

Habitat Class	Ecological System[1]	Open Land Habitat	Brushland Habitat
Lowland shrub	See definitions within *Visual Examples and Definitions of Ecological Systems* section		
	Open peatland[2]	Primarily herbaceous. No live trees, shrubs and snags > 2 meters or 6.6 feet tall.	Herbaceous with widely scattered stunted trees and snags (< 10 meters or 33 feet) and sparse tall shrubs.
	Forested rich peatland	Tall shrub-dominated (> 50% cover). No live trees and snags > 2 meters or 6.6 feet tall. (Note: Applies primarily to Northern Alder Swamp.)	Apply woody biomass guidelines for forests.
	Wet meadow/carr	Primarily herbaceous with sparse (< 25% cover) tall shrubs. No live trees, tree regeneration and snags.	Variable tall shrub cover. Tall trees (> 10 meters or 33 feet) occasionally present. Leave all snags and down CWD.

	Wetland prairie	Primarily herbaceous. No trees, tall shrubs and snags.	Primarily herbaceous. No trees, tall shrubs and snags.
Upland shrub	Upland prairie[3]	Primarily herbaceous with sparse low shrubs. No trees, snags, tall shrubs and CWD.	Primarily herbaceous with sparse low shrubs. No trees, snags, tall shrubs and CWD.
	Rock outcrop[4]	Primarily herbaceous with variable shrub density. No live trees and snags.	Primarily herbaceous with variable shrub density with widely scattered tall trees and snags. Retain all down CWD.
	Fire-dependent forest/woodland (cut-over)	Primarily herbaceous. No live trees, shrubs and snags > 2 meters or 6.6 feet tall.	Apply woody biomass guidelines for forests.
Old fields[5]	None	Primarily herbaceous. Sparse tall	Old fields[5]

[1]Minnesota DNR. Field Guides to the Native Plant Communities of Minnesota. Ecological Land Classification Program, Minnesota County Biological Survey, and Natural Heritage and Nongame Research Program. St. Paul, Minnesota.

[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.

Visual Examples and Definitions of Ecological Systems

For each ecological system defined and represented below, the photo at left represents a more open land habitat, while the photo at right represents more of a brushland habitat, or, in some cases, a woodland habitat.



***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*

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.

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, and
- 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** recommended in Table TH-1.
- ✓ Locate landings to be:
  - On upland areas whenever practical,
  - On stable ground,
  - Outside of filter strips or the RMZs, and
  - 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 Follow-up Visits*

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

Minnesota Leigslature Office of the Revisor of Statutes Minnesota Law webpage
https://www.revisor.mn.gov/pubs/

Minnesota Legislature Office of the Revisor of Statutes website
https://www.revisor.mn.gov/

Biomass Power Mandate: Go to the Minnesota Leigslature Office of the Revisor of Statutes Minnesota Law webpage
https://www.revisor.mn.gov/pubs/ and enter 216B.2424 in the Retrieve by number search bar.

Sustainable Forest Resources Act, Chapter 89A: Go to the Minnesota Leigslature Office of the Revisor of Statutes Minnesota Law webpage
Visit https://www.revisor.mn.gov/pubs/ and search for Chapter 89A by entering 89A in the “Retrieve by number” search bar.

Potential Markets for Woody Biomass

Potential markets including a directory of primary and secondary forest products in Minnesota: Minnesota Department of Natural Resources Forestry Utilization and

Marketing Program webpage
https://www.dnr.state.mn.us/forestry/um/index.html, see Information and reports on forest resources, industry and wood utilization.

Managing Brushlands for Wildlife

A brochure titled Managing Your Brushland for Wildlife is available at the Minnesota Department of Natural Resources Section of Wildlife Publications and Reports webpage
www.dnr.state.mn.us/publications/wildlife

Minnesota DNR Ecological Classification System

For additional information, including descriptions of Native Plant Communities (NPCs), visit the Minnesota Department of Natural Resources Ecological Classification System webpage
www.dnr.state.mn.us/ecs



Glossary

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 micro-organisms, 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.

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[1]

Moose
Sharp-tailed Grouse[2]
American Woodcock[2]
Alder Flycatcher
Willow Flycatcher[2]
Gray Catbird
Brown Thrasher[2]
Loggerhead Shrike[2,3]
Blue-winged Warbler[2]
Golden-winged Warbler[2]
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 the following page 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*)

Type	ECS section	Classification code
Juniper Dune Shrubland (Lake Superior)	NSU (Northern Superior Uplands)	LKu32b
Beach Ridge Shrubland (Lake Superior)	NSU (Northern Superior Uplands)	LKu32d
Sandstone Outcrop (Northern)	WSU (Western Superior Uplands)	ROn12a
Bedrock Shrubland (Lake Superior)	NSU (Northern Superior Uplands)	ROn23b
Aspen Openings (Northern)	LAP (Lake Agassiz Aspen Parklands)	UPn24b
Dry Sand-Gravel Brush-Prairie	LAP (Lake Agassiz Aspen Parklands)	UPn12c
Mesic Brush-Prairie (Northern)	LAP, RRV (Lake Agassiz Aspen Parklands and Red River Valley)	UPn23a

Part 4: Additional Resources

Resource Directory

Glossary

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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 Guideline 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 Waters Wetlands and Public Watercourses
I. Silviculture Examples for Riparian Areas
J. Sensitive Native Plant Communities
K. References Cited and Additional Technical Literature

Resource Directory

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Introduction

The Resource Directory provides additional information and identifies resources to contact for assistance with many different forest management activities.

Directory organization: The directory is organized by topic, with a brief description of assistance available from various agencies and organizations. When telephone numbers are not provided, consult the government pages of local telephone directories for the numbers of local agencies and departments listed.

Begin with local sources of assistance: Contact local information sources first. In many instances, they can provide appropriate site-specific help based on firsthand knowledge of the area in question. If additional help is needed, these local sources will recommend appropriate regional or state resources.

A Guide to Acronyms

The following acronyms are used in the Resource Directory:

BWSR	Minnesota Board of Water and Soil Resources
COE	U.S. Army Corps of Engineers
DNR	Minnesota Department of Natural Resources
Extension	University of Minnesota Extension Service
FSA	Farm Service Agency
LGU	Local government unit
MDA	Minnesota Department of Agriculture
MFRC	Minnesota Forest Resources Council
MGS	Minnesota Geological Survey

MNDOT	Minnesota Department of Transportation
MPCA	Minnesota Pollution Control Agency
NRCS	Natural Resources Conservation Service
SWCD	Soil and Water Conservation District
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USF&WS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

General Resource Management Information via the Web

The following Web sites provide general resource management information, as well as links to other Web sites with more specific information:

Minnesota Department of Natural Resources
Minnesota Department of Natural Resources website
www.dnr.state.mn.us

Minnesota Pollution Control Agency:
Minnesota Pollution Control Agency website
www.pca.state.mn.us

Minnesota Forest Resources Council:
Minnesota Forest Resources Council website
https://mn.gov/frc/

Natural Resource Management and Stewardship: Information and Educational Materials

Contact Appropriate Extension Office

(Linked to the University of Minnesota's College of Food Agriculture and Natural Resource Sciences.)

Forest Resources Extension (St. Paul)
Invasive Species Extension (St. Paul)
Wildlife Extension (St. Paul)
University of Minnesota Extension website
https://extension.umn.edu/

Itasca County Extension Office (Grand Rapids)
(218) 327-7486
e-mail: mnext-itasca@umn.edu
University of Minnesota Itasca Extension website
https://extension.umn.edu/local/itasca

Contact Area Colleges or Universities

Central Lakes College (Brainerd)
Natural Resources Program
(800) 933-0346
Central Lakes College website
https://www.clcmn.edu/

Minnesota North College (Itasca) (218) 293-6850
e-mail: info@minnesotanorth.edu
Minnesota North College Itasca website
https://minnesotanorth.edu/campuses/itasca/

Minnesota North College (Vermilion)
(218) 293-6850
e-mail: info@minnesotanorth.edu
Minnesota North College Vermilion website
https://minnesotanorth.edu/campuses/vermilion/

University of Minnesota-Crookston Natural Resources Department (218) 281-6510 or (800) 862-6466
University of Minnesota Crookston website
www.crk.umn.edu

Additional Sources of Information

Minnesota Forestry Association (Grand Rapids)
(218) 879-5100

e-mail: info@minnesotaforestry.org
Minnesota Forestry Association website
https://www.minnesotaforestry.org/

DNR Information Center (St. Paul)
Metro Area: (651) 296-6157
Greater Minnesota: (888) MINN-DNR (646-6367)
e-mail: info.dnr@state.mn.us
Minnesota Department of Natural Resources website
https://www.dnr.state.mn.us/

Developing Forest Management Plans

The primary sources of assistance available for developing forest management plans are the DNR Division of Forestry, consulting foresters, industrial foresters and some local SWCD offices, as well as environmental and conservation organizations, the USFS and the USF&WS. The DNR Division of Forestry cooperates with other plan preparers to assure that landowners receive appropriate assistance.

Because types of services, scope of assistance and fee structures (if any) vary, be sure to have a clear idea of the type of assistance desired before making initial contacts.

Minnesota's Forest Stewardship Program provides voluntary long-range planning for individual landowners through the development of Forest Stewardship Plans. An overview of the Forest Stewardship Program is available at the United States Forest Service Forest Stewardship Program webpage (https://www.fs.usda.gov/managing-land/forest-stewardship/program).

The program also provides additional technical assistance to landowners implementing plans, including assistance with state and federal cost-share programs. (See *Implementing Plans: Cost-Share Programs*)

DNR Division of Forestry: The DNR provides forest management planning assistance through its Private Forest Management Program. For assistance, contact local DNR Division of Forestry offices (see government listings in local telephone directories).

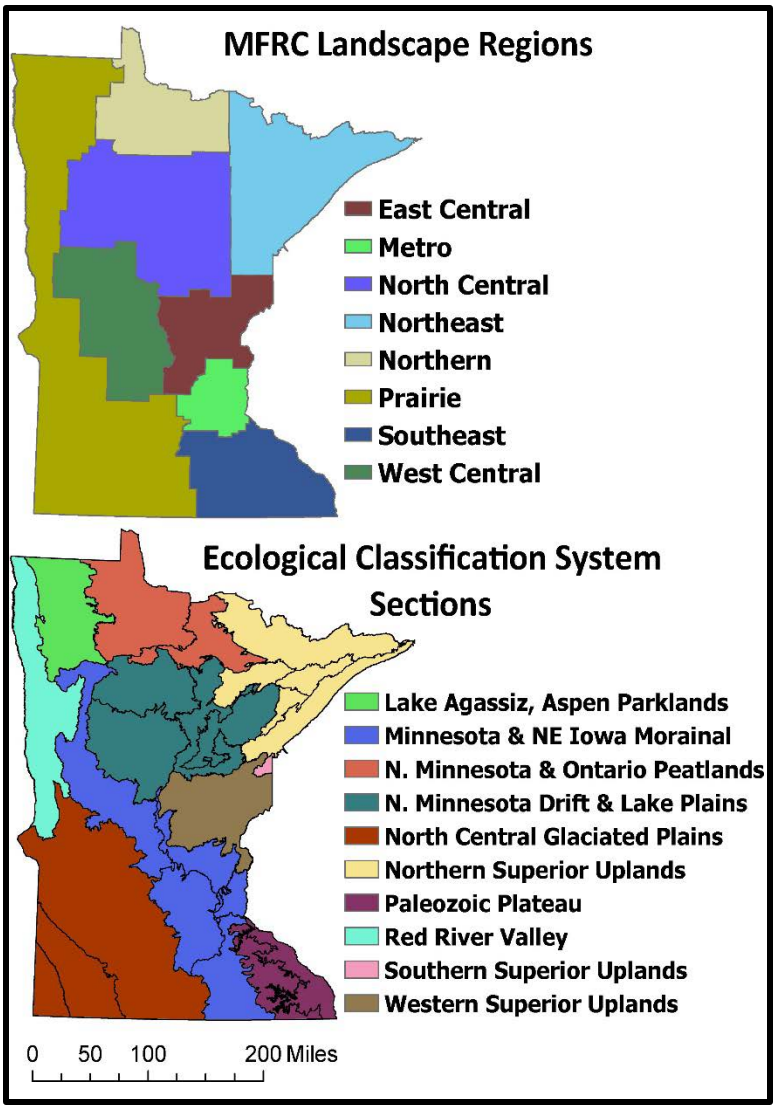
Consulting foresters: For a current listing of consulting foresters, contact local DNR Division of Forestry offices, or contact Extension offices for a copy of *Technical Assistance for Private Woodland Owners in Minnesota*.

Forest product companies with Private Forest Management Programs: For a current listing of companies offering Private Forest Management Programs, contact Extension offices for a copy of Technical Assistance for Private Woodland Owners in Minnesota.

Local SWCD offices: For a current listing of SWCD offices with Stewardship Plan preparers who provide forestry assistance, contact Extension offices for a copy of Technical *Assistance for Private Woodland Owners in Minnesota*, or call local SWCD offices to determine whether they provide this service (see government listings in local telephone directories).

MFRC Landscape Program: The Landscape Program works with local natural resource stakeholders in identifying regional forest issues and developing visions, goals and strategies (Figure RD-1). For information on landscape information, visit the MFRC Regional Landscape Program webpage (https://mn.gov/frc/landscape/).

Figure RD-1: MFRC Landscape Regions and ECS Sections



Technical Assistance for Private Woodland Owners in Minnesota

Technical Assistance for Private Woodland Owners in Minnesota is a directory that includes information on choosing a consultant, as well as a key to available services.

The directory also includes a detailed listing of private consultants, forest product companies with Private Forest Management Programs, SWCDs providing forestry assistance, and non-governmental organizations providing forestry assistance.

This directory is available at no charge from the following Extension offices:

Forest Resources Extension (St. Paul)
University of Minnesota Extension webpage
https://extension.umn.edu/

Itasca County Extension Office (Grand Rapids)
(218) 327-7486
e-mail: mnext-itasca@umn.edu
University of Minnesota Itasca Extension webpage
https://extension.umn.edu/local/itasca

Sources of Planning Tools

Soil Surveys, Soil Interpretations and Erosion Control

Contact local SWCD offices or local NRCS offices (see government listings in local telephone directories).

Aerial Photographs

DNR Division of Forestry
Resource Assessment Unit
Grand Rapids, Minnesota

e-mail: ForResourceAssessment.dnr@state.mn.us
Minnesota Department of Natural Resources website
https://www.dnr.state.mn.us/

USGS EROS Data Center
Sioux Falls, South Dakota
(800) 252-4547
e-mail: custserv@usgus.gov
United States Geological Survey website
https://www.usgs.gov/

Aerial photos for much of Minnesota are also available for viewing and downloading from MHAPO at the Minnesota Historical Aerial Photos Online webpage (https://apps.lib.umn.edu/mhapo/).

Topographic Maps

Local retailers: Topographic maps are available in a number of retail locations throughout the state, including local sporting goods stores, outfitters, bookstores and engineering supply stores.

Local libraries: Check with local libraries for availability of maps.

Beacon website: Local government GIS for the web (https://beacon.schneidercorp.com/).

Geological Survey

MGS: (612) 626-2969
USGS: (888) 392-8545
email: mgs@umn.edu
United States Geological Survey website
https://www.usgs.gov/

Landscape Information

MFRC Landscape Program

MFRC: (651) 603-6761
Minnesota Forest Resources Council website
https://mn.gov/frc/

National Wetland Inventory (NWI) Maps

Local SWCD offices (see government listings in local telephone directories)

US Fish and Wildlife Service
Wetlands Mapper
United States Fish and Wildlife Service website
https://www.fws.gov/

Implementing Plans: Cost-Share Programs

Landowners wishing to install conservation practices may receive cost-share assistance through a variety of local, state and federal programs. Many of these programs are available to help private landowners plant trees and shrubs. Most programs require an approved Forest Stewardship Plan.

Program requirements, emphasis, funding and availability may vary with time and location. Contact local foresters, local FSA offices, or local SWCD offices for current information.

Environmental Quality Incentives Program (EQIP): Provides approximately 50% reimbursement of establishment costs for plantings greater than one acre. This program provides funds for timber stand improvement work, wildlife habitat enhancement, and water quality practices. Contact local FSA or NRCS offices (see government listings in local telephone directories).

Conservation Reserve Program (CRP): Provides 50% of establishment costs and 10 to 15 years of annual payments as an incentive to retire highly erosive cropland. A special focus called Conservation Reserve Enhancement Program (CREP) exists in the Minnesota River Valley. Contact local FSA, NRCS or DNR Division of Forestry offices (see government listings in local telephone directories).

Reinvest in Minnesota (RIM): Similar to CRP, except that RIM is targeted to areas that will benefit wildlife. Provides 75% of actual cost for long-term easements and 100% of actual cost for perpetual easements. Contact local SWCD, DNR Division of Forestry or DNR Wildlife offices (see government listings in local telephone directories).

Forest Land Enhancement Program (FLEP): Provides up to 50% cost-share assistance to non-industrial private forest landowners for management activities that enhance fish and wildlife habitat, provide recreation opportunities, improve the aesthetic quality of forests, or increase the supply of timber and other forest products. The program is designed to enhance and increase the diversity of forestland benefits. An approved Forest Stewardship Plan is required. Contact a plan preparer or local DNR Division of Forestry office (see government listings in local telephone directories).

Wetland Reserve Program (WRP): Provides payments for conservation easements and cost-share assistance for wetland restoration and protection. Landowners are reimbursed up to 75% of actual cost for perpetual easements. Contact local NRCS or USF&WS offices (see government listings in local telephone directories).

State Cost-Share Program: Assists landowners in the installation of permanent non-production-oriented soil and water conservation practices. Cooperators are eligible to

receive up to 75% cost-sharing of specified erosion control and water quality practices. Contact local SWCD offices (see government listings in local telephone directories); or BWSR at (651) 296-3767.

Wildlife Habitat Incentives Program (WHIP): Provides up to 75% of establishment costs for practices designed to create or enhance wildlife habitat. Program is available everywhere in the state and includes prairie as well as forest practices for wildlife. Contact local NRCS offices for application information.

American Tree Farm System: The American Tree Farm System provides recognition and certification for quality forest management of non-industrial private forest lands. The program is sponsored by the American Forest Foundation. More information is available from Stewardship Plan preparers or contact local DNR Division of Forestry offices (see government listings in local telephone directories), consulting foresters or forest product companies with Private Forest Management Programs.

Implementing Plans: Sources of Forester and Logger Assistance with Timber Sales and Road Design

Unless a landowner has expertise and experience with conducting timber sales or designing roads, it is advisable to seek assistance from both professional foresters and professional loggers.

Because types of services, scope of assistance and fee structures vary, be sure to have a clear idea of the type of assistance desired before making initial contacts.

Minnesota Forestry Association – Call Before You Cut (CBYC) Program: The Call Before You Cut (CBYC)

program, offered by the Minnesota Forestry Association with support from the Minnesota Department of Natural Resources (MN DNR), provides free, introductory technical assistance to private woodland owners. Through this program, a professional consulting forester visits the property—typically spending a couple hours onsite—to help landowners better understand the condition and potential of their woodlands.

The forester offers initial guidance on sustainable forest management practices and introduces landowners to additional resources and programs, such as the Sustainable Forest Incentive Act (SFIA), 2c Managed Forest classification, or the Minnesota Tree Farm System. Recommendations may include strategies to improve wildlife habitat, enhance recreational use, strengthen forest carbon storage, increase timber productivity, or elevate scenic forest quality. The CBYC program aims to support landowners in realizing a wide range of forest benefits through thoughtful, voluntary stewardship.

For more information, visit the Call Before You Cut webpage (www.minnesotaforestry.org/minnesota-call-before-you-cut).

Sources of forester assistance: For a current listing of other sources of forester assistance, contact Extension offices for a copy of Technical Assistance for Private Woodland Owners in Minnesota, or call Minnesota Forest Industries at (218) 722-5013.

Sources of logger assistance: For sources of logger assistance, contact the following organizations:

Minnesota Logger Education Program
(218) 879-5633
e-mail: info@mlep.org
Minnesota Logger Education Program website
www.mlep.org

Minnesota Timber Producers Association
(218) 722-5013
Minnesota Timber Producers Association website
https://www.timberproducers.com/

Associated Contract Loggers and Truckers of Minnesota
(218) 345-6483
Associated Contract Loggers and Truckers website
https://www.acltmn.com/

Cultural Resource Inventories

Landowners and land managers should check available cultural resource inventories to determine if there are any known cultural resources in their management area as part of the planning process. Inventories of recorded cultural resources in Minnesota are maintained in several places.

The most comprehensive statewide database is administered jointly by the Office of the State Archaeologist and the State Historic Preservation Office. Contact either agency by phone, mail or email to request information about cultural resources in a specific area. Provide at least township, range and section numbers.

For individual parcels of land, expect to receive a response within a few days. For information about a large land area (such as an entire county) or a number of separate parcels of land (such as corporate holdings), it is advisable to make special arrangements to obtain the data:

Office of the State Archaeologist
328 W. Kellogg Blvd.
St. Paul, Minnesota 55102
(612) 725-2411
Fax: 612-725-2427
e-mail: mn.osa@state.mn.us

Minnesota Department of Administration State Archaeologist webpage
https://mn.gov/admin/archaeologist/

State Historic Preservation Office
Administration Building #203
50 Sherburne Ave.
Saint Paul, MN 55155
(651) 201-3287
e-mail: MNSHPO@state.mn.us
Minnesota Department of Administration State Historic Preservation Office webpage
https://mn.gov/admin/shpo/

Separate inventories of cultural resources are also maintained by federal agencies, some reservations and some state agency divisions. For detailed descriptions of these inventories and contact information, see *Appendix B: Summary of Cultural Resource Inventory Sources in Minnesota*.

Identifying, Assessing and Managing Cultural Resources

The following agencies can provide assistance in identifying, assessing and managing cultural resources:

Office of the State Archaeologist
328 W. Kellogg Blvd.
St. Paul, Minnesota 55102
(612) 725-2411

State Historic Preservation Office
Administration Building #203
50 Sherburne Ave.
Saint Paul, MN 55155
(651) 201-3287

Minnesota Indian Affairs Council
1819 Bemidji Ave. N
Bemidji, MN 56601
(218) 205-4752

It may be advisable in some cases to obtain the services of a consultant. For a list of firms that do cultural resource management work in Minnesota, contact the State Historic Preservation Office at (651) 201-3287.

For questions about treatment of an unplatted cemetery, or for assistance in verifying the presence of a cemetery on a particular property, contact the Office of the State Archaeologist at (612) 725-2411.

When working within the boundaries of a reservation or within ceded lands (see *Appendix D*), consider consulting with tribal cultural resource specialists during project planning. For current information, call the Minnesota Indian Affairs Council at (218) 205-4752 or visit Tribal Historic Preservation Officers webpage (https://mn.gov/indian-affairs/cultural-resources/tribal-historic-preservation-officers-.jsp).

Petroleum Spills

Notification of petroleum spills: Contact the Minnesota Duty Officer for petroleum spills of 5 gallons or more. Phones are answered 24 hours a day:

Metro Area	(651) 649-5451
Greater Minnesota	(800) 422-0798

The Minnesota Duty Officer will contact appropriate state agencies.

Nonpoint Source Pollution

MPCA regional offices:

Brainerd	(218) 828-2492
Detroit Lakes	(218) 847-1519
Duluth	(218) 723-4660
Marshall	(507) 537-7146
Rochester	(507) 285-7343
Mankato	(507) 389-5977

MPCA (St. Paul): (651) 296-6300 or (800) 657-3864

Wetland Protection

Contact LGUs, local SWCD offices (see government listings in local telephone directories) or BWSR offices. A listing of LGUs is available from BWSR and SWCD offices.

Contact BWSR in St. Paul at (651) 296-3767 or info.BWSR@state.mn.us, or contact BWSR regional offices:

Detroit Lakes	(218) 770-2767
Duluth	(218) 464-2505
Bemidji	(218) 755-4235
Brainerd	(218) 820-1679
Mankato	(507) 344-2816
Rochester	(507) 285-7458
Marshall	(507) 537-6060
St. Cloud	(320) 202-6478

Contact COE at one of the following offices:

Bemidji	(218) 788-6406
Brainerd	(218) 788-6406
Duluth	(218) 788-6407
St. Paul	(651) 290-5200
La Crosse	(651) 290-5902

Fish and Wildlife Habitat

Both the DNR and the US Fish and Wildlife Service can provide information on practices to maintain or improve fish and wildlife habitat. DNR offices can also provide current listings of designated trout streams (and their designated tributaries) and designated trout lakes.

DNR: Contact local DNR Fisheries or DNR Wildlife offices (see government listings in local telephone directories), or contact a regional DNR Fisheries or Wildlife office:

	Fisheries offices	**Wildlife offices**
Northwest Region (Bemidji / Detroit Lakes)	(218) 308-2339	(218) 846-8280
Northeast Region (Grand Rapids)	(218) 328-8836	(218) 328-8860
Southern Region (Waterville / Rochester)	(507) 497-1820	(507) 206-2858
Central Region (St. Paul / Rosemount)	(651) 259-5831	(651) 322-4643

Or contact the MN DNR Central Office (St. Paul) at: (888) 646-6367 or via the Minnesota Department of Natural Resources website https://www.dnr.state.mn.us/.

US Fish and Wildlife Service

Agassiz National Wildlife Refuge
22996 290th Street Northeast
Middle River, MN 56737-9754
(218) 461-8970

Agassiz National Wildlife Refuge webpage
https://www.fws.gov/refuge/agassiz

Big Stone National Wildlife Refuge and Wetland
Management District
44843 County Road 19
Odessa, MN 56276-2062
(320) 273-2191
Big Stone National Wildlife Refuge webpage
https://www.fws.gov/refuge/big-stone

Crane Meadows National Wildlife Refuge
19502 Iris Road
Little Falls, MN 56345-6262
(320) 632-1575
Crane Meadows National Wildlife Refuge webpage
https://www.fws.gov/refuge/crane-meadows

Detroit Lakes Wetland Management District
1732 North Tower Road
Detroit Lakes, MN 56501-7959
(218) 847-4431
Detroit Lakes Wetland Management District webpage
https://www.fws.gov/refuge/detroit-lakes-wetland-management-district

Fergus Falls Wetland Management District
18965 County Highway 82
Fergus Falls, MN 56537-7726
(218) 739-2291
Fergus Falls Wetland Management District webpage
https://www.fws.gov/refuge/fergus-falls-wetland-management-district

Glacial Ridge National Wildlife Refuge
C/O Rydell National Wildlife Refuge
17788 349th Street SE

Erskine, MN 56535-9253
(218) 6887-2229
Glacial Ridge National Wildlife Refuge webpage
https://www.fws.gov/refuge/glacial-ridge

Hamden Slough National Wildlife Refuge
21212 210th Street
Audubon, MN 56511
(218) 847-4431
Hamden Slough National Wildlife Refuge webpage
https://www.fws.gov/refuge/hamden-slough

Litchfield Wetland Management District
22274 615th Avenue
Litchfield, MN 55355-5818
(320) 693-2849
Litchfield Wetland Management District webpage
https://www.fws.gov/refuge/litchfield-wetland-management-district

Mille Lacs National Wildlife Refuge
C/O Rice Lake National Wildlife Refuge
36289 State Highway 65
McGregor, MN 55760-5875
(218) 768-2402
Mille Lacs National Wildlife Refuge webpage
https://www.fws.gov/refuge/mille-lacs

Minnesota Valley National Wildlife Refuge
3815 American Boulevard East
Bloomington, MN 55425-1600
(952) 854-5900
Minnesota Valley National Wildlife Refuge webpage
https://www.fws.gov/refuge/minnesota-valley

Morris Wetland Management District
43875 230th Street

Morris, MN 56267-5404
(320) 589-1001
Morris Wetland Management District webpage
https://www.fws.gov/refuge/morris-wetland-management-district

Northern Tallgrass Prairie National Wildlife Refuge
C/O Big Stone National Wildlife Refuge
44843 County Road 19
Odessa, MN 56276-2062
(320) 273-2191
Northern Tallgrass Prairie National Wildlife Refuge webpage
https://www.fws.gov/refuge/northern-tallgrass-prairie

Rice Lake National Wildlife Refuge
36289 State Highway 65
Mcgregor, MN 55760-5875
(218) 768-2402
Rice Lake National Wildlife Refuge webpage
https://www.fws.gov/refuge/rice-lake

Rydell National Wildlife Refuge
17788 349th Street SE
Erskine, MN 56535-9253
(218) 687-2229
Rydell National Wildlife Refuge webpage
https://www.fws.gov/refuge/rydell

Sherburne National Wildlife Refuge
17076 293rd Avenue NW
Zimmerman, MN 55398-6000
(763) 389-3323
Sherburne National Wildlife Refuge webpage
https://www.fws.gov/refuge/sherburne

Tamarac National Wildlife Refuge
Management District
35704 County Highway 26
Rochert, MN 56578-9638
(218) 847-2641
Tamarac National Wildlife Refuge webpage
https://www.fws.gov/refuge/tamarac

Upper Mississippi River National Wildlife and Fish Refuge
102 Walnut Street, Suite 204 and Suite 205 (Winona District Office)
Winona, MN 55987-3509
Upper Mississippi River National Wildlife and Fish Refuge webpage
https://www.fws.gov/refuge/upper-mississippi-river

Windom Wetland Management District
49663 County Road Number 17
Windom, MN 56101-3026
(507) 831-2220
Windom Wetland Management District webpage
https://www.fws.gov/refuge/windom-wetland-management-district

Endangered, Threatened or Special Concern Species

Endangered, Threatened or Special Concern Species in Minnesota

DNR Natural Heritage Program
Natural Heritage and Nongame Research Program webpage
https://www.dnr.state.mn.us/nhnrp/index.html

Federal Endangered Species Act, Federally Listed Species or the Endangered Species Listing Process

USF&WS Midwest Region Office of Ecological Services
5600 American Blvd. West, Suite 990
Bloomington, Minnesota 55437-1458
(612) 713-5350
United States Fish and Wildlife Service website
https://www.fws.gov/

Minnesota Web site:
Minnesota Department of Natural Resources website
https://www.dnr.state.mn.us/

Visual Sensitivity Classification Information

Aitkin County
Aitkin County Land Department (Aitkin) (218) 927-7364
Aitkin DNR Forestry Office (218) 429-3011

Becker County
Becker County Land Department (Detroit Lakes)
(218) 847-0099
Park Rapids DNR Forestry Office (218) 732-5391

Beltrami County
Beltrami County Natural Resources Management (Bemidji) (218) 333-4210
Bemidji DNR Forestry Office (218) 308-2065
Blackduck DNR Forestry Office (218) 888-7730
Warroad DNR Forestry Office (218) 450-5450

Carlton County
Carlton County Land Department (Carlton) (218) 384-9179
Cloquet DNR Forestry Office (218) 878-5640

Cass County
Cass County Land Department (Backus) (218) 947-3338
Backus DNR Forestry Office (218) 947-8600
Bemidji DNR Forestry Office (218) 308-2065
Deer River DNR Forestry Office (218) 212-2000

Clearwater County
Clearwater County Land and Forestry Department (Bagley) (218) 694-6227
Bagley DNR Forestry Office (218) 694-2146

Cook County
Cook County Land Department (Grand Marais) (218) 387-3650
Two Harbors DNR Forestry Office (218) 834-1420

Crow Wing County
Crow Wing County Land Services (Brainerd) (218) 824-1010
Backus DNR Forestry Office (218) 947-8600

Hubbard County
Hubbard County Land Department (Park Rapids) (218) 732-4270
Park Rapids DNR Forestry Office (218) 732-3309
Bemidji DNR Forestry Office (218) 308-2065

Itasca County
Itasca County Land Department (Grand Rapids)
(218) 327-2855
Deer River DNR Forestry Office (218) 212-2000
Hibbing DNR Forestry Office (218) 231-8020

Koochiching County
Koochiching County Land and Forestry Department
(International Falls) (218) 283-1129
Littlefork DNR Forestry Office (218) 888-9050
Hibbing DNR Forestry Office (218) 231-8020
Baudette DNR Forestry Office (218) 395-6039
Blackduck DNR Forestry Office (218) 888-7730

Lake County
Lake County Forestry Department (Two Harbors)
(218) 834-8340
Two Harbors DNR Forestry Office (218) 834-1420
Tower DNR Forestry Office (218) 300-7800

Lake of the Woods County
Lake of the Woods Land and Water Planning Office
(218) 634-1945
Baudette DNR Forestry Office (218) 395-6039

Mille Lacs County
Mille Lacs Land Services Office (320) 983-8308
Little Falls DNR Forestry Office (320) 232-1060

Pine County
Pine County Land Department (Sandstone)
(320) 216-4225
Sandstone DNR Forestry Office (320) 216-7550

St. Louis County
St. Louis County Land Department (Duluth) (218) 726-2606
- Duluth Area Office (218) 726-2000
- Virginia Area Office (218) 749-7100
- Hibbing Field Office (218) 312-8100
- Ely Field Office (218) 365-2399

Cloquet DNR Forestry Office (218) 878-5640
Hibbing DNR Forestry Office (218) 231-8020
Tower DNR Forestry Office (218) 300-7800
Two Harbors DNR Forestry Office (218) 834-1420

Water Crossings

Design standards; installation of bridges and culverts: Contact local SWCD or NRCS offices, county highway departments or local road authorities, or local MNDOT offices (see government listings in local telephone directories).

Permit requirements: Permits are required for work in waters and wetlands designated by the DNR in the Public Waters and Wetlands Inventory. For permit requirements, contact DNR Ecological and Water Resources local offices (see government listings in local telephone directories) or DNR regional offices. In some instances, further review is required by the COE or local ditch authority.

Regional DNR Ecological and Water Resources offices:

Bemidji	(218) 308-2462
Grand Rapids	(218) 328-8810
Brainerd	(218) 203-4300
Mankato	(507) 389-8800
Rochester	(507) 206-2852
Metro	(651) 259-5845

More specifically, area hydrologists are listed on the online Area Hydrologist List.
https://files.dnr.state.mn.us/waters/area_hydros.pdf

Integrated Pest Management

Contact DNR regional forest health specialists
Minnesota Department of Natural Resources Forest Health Contacts webpage
https://www.dnr.state.mn.us/treecare/forest_health/forest-health-contacts.html

Bemidji	(218) 308-2363
Grand Rapids	(218) 328-8897
Brainerd	(218) 203-4427
Metro	(651) 259-5821

Contact USFS: (800) 832-1355

Pesticide Use

For pesticide label interpretation questions, regulation of forestry-applied pesticides in Minnesota, pesticide use as it pertains to endangered and threatened species in Minnesota, and applicator training and licensing for state certification, contact:
MDA at (651) 201-6000.

Pesticide certification workshops:
Contact Minnesota Pesticide Information and Education at (320) 496-6343 or MDA at (651) 201-6000.
University of Minnesota Extension Pesticide Resources webpage
https://extension.umn.edu/pesticide-safety-and-environmental-education/pesticide-safety-and-certification

Disposal of waste pesticides: Contact the MDA Waste Pesticide Collection Program at (612) 214-6843.

MDA Waste Pesticide Collection Program webpage
https://www.mda.state.mn.us/pesticide-fertilizer/waste-pesticide-collection-program

Recycling pesticide containers: Contact Tri-Rinse at (314) 647-8338.

Notification of pesticide spills: Contact the Minnesota Duty Officer whenever a spill occurs. Phones are answered 24 hours a day:

Metro Area	(651) 649-5451
Greater Minnesota	(800) 422-0798

The Minnesota Duty Officer will contact the appropriate state agencies.

Fertilizing and Seeding

Fertilizer and seed mixture recommendations for exposed soil: Contact local SWCD, NRCS or DNR offices (see government listings in local telephone directories).

Prescribed Burning

Obtaining a burning permit: Contact local DNR Division of Forestry offices, state fire wardens, USFS district offices and fire wardens, LGUs or other designated county authorities (see government listings in local telephone directories).

Establishing goals and conducting prescribed burns: Contact local DNR or USFS offices (see government listings in local telephone directories).

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 Native American 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.

Certificate of exemption: A document from a local government unit describing activities exempt from provisions of the Minnesota Wetland Conservation Act.

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 Native American 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 1/2 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 of 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.

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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, Native American 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 emerging issues. Since their inception the guidelines have been revised several times as required in statute; comprehensive assessments were completed in 2003-05 and again in 2007 when biomass harvesting guidelines were added.

The MFRC initiated a third revision in early 2010 to address long standing issues related to riparian area guidelines. Prior to initiation, the MFRC convened a Riparian Science Technical Committee (RSTC) composed of technical experts in aquatic and wildlife biology, water quality, forest ecology, soils, and Silviculture to assess the current science as related to riparian area management. The purpose in convening the RSTC was to provide information and guidance to the Council when considering changes to riparian-related guidelines.

4 Appendix A

Following a comprehensive scoping process, a subset of MFRC members considered changes to the guidelines and made recommendations to the full Council after evaluating monitoring data, existing research, and other information including the findings of the RSTC. The MFRC then made initial recommendations on guideline revisions, which were evaluated by technical experts in associated disciplines and reviewed during a public comment period. Public comments and technical evaluations were considered and addressed prior to final adoption of guideline changes in the 2012 edition.

The fourth revision was initiated in 2020 and completed in 2024 using a multi-pronged approach. Different facets included: 1) A stakeholder survey related to perceived effectiveness of FMGs, 2) A review of implementation rates and effectiveness for FMGs monitored by the Guideline Monitoring Program, 3) A scientific literature review, 4) Peer review focus group engagement, and 5) A public comment period followed by additional refinement of FMG language.

Updates to the FMGs are modest but strategic and important to ensure the guidelines remain relevant and reflective of current science and management concerns. These recommended updates include new invasive plant species guidance, climate change considerations, and clarification or additional considerations related to riparian management zones, leave tree retention, erosion control, and other topics to guide and support the sustainability of our forestry operations. These updates are important to the credibility and relevance of the FMGs. They also are designed to provide operators and resource managers the flexibility they need to apply guidelines to site-specific conditions. This flexibility has been foundational to the FMGs since their inception.

In addition to the adoption of recommended changes, the MFRC recognizes the need for renewed training, outreach, and education efforts to support consistent application of the updated FMGs. The comprehensive nature and complexity of the FMGs further supports the need for education on the long-term intent and function of guideline practices.

Although the recommended updates address concerns of today, ongoing periodic review is essential for maintaining the FMGs' relevancy to forestry and forest conditions in Minnesota.

More detailed information related to the revision process is available on the MFRC website.

For more information, contact:

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Minnesota Forest Resources Council website
mn.gov/frc/

Appendix B: Cultural Resource Inventory Sources in Minnesota[1]

Source/Contact Information	Resource Types Included/Geographic Coverage
Minnesota State Historic Preservation Office Cultural Resource Database	Archaeological sites, cemeteries, standing structures, traditional cultural properties, cultural landscapes
State Historic Preservation Office Administration Building #203 50 Sherburne Ave. St. Paul, MN 55155 Phone: (651) 201-3287	*Geographic coverage*: Statewide
State Archaeological Site File	Archaeological sites, cemeteries,
Office of the State Archaeologist 328 W. Kellogg Blvd St. Paul, MN 55102 Phone: (612) 725-2411	*Geographic coverage:* Statewide
Chippewa National Forest Heritage Sites Database	Archaeological sites, cemeteries, standing structures, traditional cultural properties, cultural landscapes

Source/Contact Information	Resource Types Included/Geographic Coverage
Chippewa National Forest 200 Ash Ave NW Cass Lake, MN 56633 Phone: (218) 335-8600	*Geographic coverage:* Chippewa National Forest
Superior National Forest Heritage Sites Database	Archaeological sites, cemeteries, standing structures, traditional cultural properties, cultural landscapes
Forest Archaeologist Superior National Forest 8901 Grand Ave. Place Duluth, MN 55808 Phone: (218) 626-4300	*Geographic coverage:* Superior National Forest
Leech Lake Tribal Cultural Resource Database	Native American archaeological sites, cemeteries, traditional cultural properties
Preservation Officer Leech Lake Tribal Government 190 Sailstar Drive NW Cass Lake, MN 56633 Phone: (218) 335-2940	*Geographic coverage:* Leech Lake Reservation
Mille Lacs Tribal Cultural Resource Database	Archaeological sites, cemeteries, traditional cultural properties
Preservation Officer Mille Lacs Tribal Government 43408 Oodena Drive	*Geographic coverage:* Mille-Lacs Tribal Lands (under development)

Source/Contact Information	Resource Types Included/Geographic Coverage
Onamia, MN 56359 Phone: (320) 362-1393	
Minnesota DNR Forestry Heritage Resources Database	Archaeological sites, cemeteries
DNR Forestry Archaeologist Resource Assessment Office 483 Peterson Road Grand Rapids, MN 55744 Phone: (218) 322-2500	*Geographic coverage:* Non-federal lands statewide

[1]Note: 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.

2 Appendix C

Appendix D: Ceded Lands and Reservation Boundaries

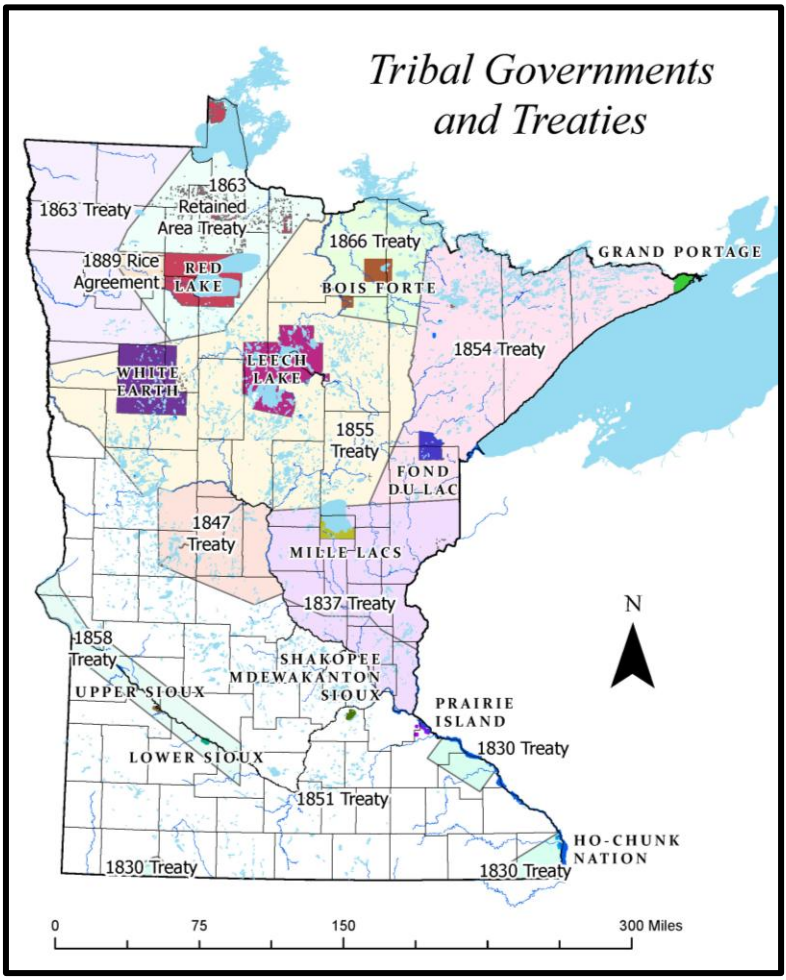
As used within these guidelines, the term “ceded lands” refers to territories ceded to the United States Government by the Ojibwe under treaties of 1837, 1854, 1866 and 1889.

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 and* MnDOT Tribal Map Application.

Figure D-1. Tribal Governments and Treaties in Minnesota



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 ft^2 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)

DBH (inches)	Number of trees/acre	BASAL AREA ft2/tree	BASAL AREA ft2/acre
1	168	0.005	0.840
2	107	0.022	2.354
3	93	0.049	4.557
4	77	0.087	6.699
5	52	0.136	7.072
6	33	0.196	6.468
7	26	0.267	6.942
8	21	0.349	7.329
9	17	0.442	7.514
10	13	0.545	7.085
11	10	0.660	6.600
12	8	0.785	6.280
13	5	0.922	4.610
14	3	1.069	3.207
15	2	1.227	2.454
Totals	**635 trees**		**80.011 ft^2/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 ft^2 per acre.

Table E-2

Approximate Relationship Between Crown Closure and Basal Area

Crown closure	Basal area (per acre)
30%	20 ft2
35%	25 ft2
50%	50 ft2
70%	80 ft2
75%	100 ft2
75%	120 ft2
80%	140 ft2
95%	190 ft2

Source: Verry 1969

Appendix F: Regulations, Rules and Ordinances Complementary to Timber Harvesting and Forest Management Guideline Recommendations[1]

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, Superior National Forest
Headquarters (Duluth)
(218) 626-4300
SM.FS.Superior_NF@usda.gov

[1] *Note: This list is not exhaustive, but the major regulations, rules and ordinances 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.*

Public Water Rules

Minnesota Rules 6115

Applies to: Statewide

Resource impacted: Streams, lakes, public water wetlands

Contact:
DNR Ecological and Water Resources (St. Paul)
(651) 259-5100
Minnesota Departement of Natural Resources Ecological and Water Resources webpage
https://www.dnr.state.mn.us/ewr/index.html

DNR Area Hydrologist
Area Hydrologist List
https://files.dnr.state.mn.us/waters/area_hydros.pdf

Land Use Management Ordinances

Applies to: Counties, townships or municipalities

Resource impacted: Shorelands, floodplains and zoning on private lands

Contact:
DNR Ecological and Water Resources (St. Paul)
(651) 259-5100
Minnesota Departement of Natural Resources Ecological and Water Resources webpage
https://www.dnr.state.mn.us/ewr/index.html

DNR Area Hydrologist
Area Hydrologist List
files.dnr.state.mn.us/waters/area_hydros.pdf

County Planning and Zoning
Minnesota Board of Water and Soil Resources Counties Webpage https://bwsr.state.mn.us/counties

North Shore Management Plan

Applies to: Counties, townships or municipalities

Resource impacted: Townships adjacent to the North Shore from Duluth northward

Contact:

DNR Ecological and Water Resources (St. Paul)
(651) 259-5100
Minnesota Department of Natural Resources Minnesota's Lake Superior Coastal Program webpage
www.dnr.state.mn.us/waters/lakesuperior/index.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 Ecological and Water Resources (St. Paul)
(651) 259-5100

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) 201-3287

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) 201-3287

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) 539-2200

Minnesota Indian Affairs Council (Bemidji)
(218) 205-4752

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[1] Work Permit on Public Waters, Public Water Wetlands and Public Watercourses

per Minn. Rules 6115 and 6264 at the Minnesota Legislature Office of the Revisor of Statutes webpage https://www.revisor.mn.gov/

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.

[1] 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.

- 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.

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*). 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.

Table I-1 shows recommended canopy retention and gap sizes for optimal regeneration and/or early growth or timber quality for each species and silvicultural system. Managing for less than optimal growth may be desirable to achieve other goals and objectives for management.

Table I-1

Residual Canopy Cover and Gap Sizes for Recommended Silvicultural Activities

Species	Shade Tolerance Rating	Percent Canopy Retention (Clearcut)	Percent Canopy Retention (Shelter-wood)	Percent Canopy Retention (Single Tree Selection)	Gap Size (acres)	Clearcut Strip Width (ft)	Seed Trees Retained (n per acre)	References
Aspen	0.7	0-5%	N/A	N/A	≥1			H, I
Tamarack	0.8	0-5%	N/A	N/A		200 ft	10	I
Paper birch	1	0-5%	20-40%	N/A	≥1		3-5	B, I
Jack pine	1.8	0-5%	15-25%	N/A			10	Q
Red pine	2.4	0-5%	N/A	N/A			6	I, N
Oak		0-5%	40-55%	N/A	≥1/2			P, Q
Black ash	2.4	0-5%	50-75%	80-100%				C
White pine	4.4	0-10%	40-60%	N/A			4-14	B, N, R

Species	Shade Tolerance Rating	Percent Canopy Retention (Clearcut)	Percent Canopy Retention (Shelter-wood)	Percent Canopy Retention (Single Tree Selection)	Gap Size (acres)	Clearcut Strip Width (ft)	Seed Trees Retained (n per acre)	References
Northern white cedar	5	0-5%	30-40%	N/A		66-124 ft		B, S
Yellow birch	6.3	0-5%	30-70%	N/A	1/10-1/5, 1/4-1/2	50-100 ft		D, E, F
Black spruce	6.4	0-5%	N/A	N/A		≤400 ft	2-5	T, U
White spruce	6.8	0-5%	20-40%	N/A		≤400 ft		V
Sugar maple/ Basswood	9.7/8.2	0-5%	45-80%	75-100%	≤1/10			D, G
Balsam fir	9.8	0-5%	55-60%	60-100%	1-5	≤200 ft		J

Early Relative Height Growth of Minnesota Species Regenerated under Varying Levels of Shade

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).

Table I-2

Relative Tree Height Growth (% of Maximum)

Species	Ideal (100-90)	Good (90-75)	Fair (75-50)	Poor (<50)	References (see below)
Aspen	0-10	10-25	25-50	>50	(K)
Tamarack	0-60	60-65	65-85	>85	(L)
Paper Birch	35-65	15-35, 65-100			(L)
Jack Pine	0-50	50-65	65-80	>80	(L)
Red Pine	0-55	55-75	75-85	>85	(L)
Red Oak	0-15	15-45	45-100		(M)
Black Ash	35-75	15-35, 75-100	0-15		(L for white ash)
American Elm	40-60	15-40, 60-75	0-15, 75-100		(L)
White Pine	0-60	60-70	70-90	>90	(L)
N. White Cedar	0-60	60-75	75-85	>85	(L)
Yellow Birch	45-75	10-45, 75-85	0-10, 85-100		(L)
Black Spruce	0-35	35-60	60-75	>75	(L)
White Spruce	0-55	55-60	60-70	>70	(L)
Sugar Maple	40-90	20-40, 90-100	0-20		(L)
Basswood	50-85	10-50, 85-100	0-10		(L)
Balsam Fir	5-60	0-5, 60-70	70-85	>85	(L)

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.

References Cited in Tables I-1 and I-2

Letters refer to last columns in Table I-1 and Table I-2.

A. Graham, S.A. 1954. Scoring tolerance of forest trees. Michigan Forestry, No. 4. Dept. of Forestry, School of Natural Resources, U of MI, Ann Arbor. 2p.

B. Wisconsin DNR. 2003. Silviculture and Forest Aesthetics Handbook, 2431.5. Wisconsin Department of Natural Resources. 417p.

C. Erdmann, G.G., T.R. Crow, R.M. Peterson, Jr., and C.D. Wilson. 1987. Managing black ash in the Lake States. General Technical Report NC-115. St. Paul, MN: USDA Forest Service, North Central Experiment Station. 10p.

D. Leak, W.B., D.S. Soloman, and P.S. DeBald. 1987. Silvicultural guide for northern hardwood types in the northeast (revised). USDA Forest Service, Northeastern Forest Experiment Station, NE-603. Broomall, Pennsylvania. 36p.

E. Godman, R.M. and C.H. Tubs. 1973. Establishing even- aged northern hardwood regeneration by the shelterwood method-a preliminary guide. USDA Forest Service, North Central Experiment Station, NC-99. St. Paul, Minnesota. 9p.

F. Tubbs, C.H. 1977. Natural regeneration of northern hardwoods in the northern Great Lakes region. USDA Forest Service, North Central Experiment Station, NC-150. St. Paul, Minnesota. 20p.

G. Tubbs, C.H. 1977. Manager's handbook for northern hardwoods in the north central states. USDA Forest Service, *North Central Experiment Station General Technical Report*, NC-150. St. Paul, Minnesota. 29p.

H. Perala, D.A. 1977. Manager's handbook for aspen in the north central states. USDA Forest Service, North Central Experiment Station *General Technical Report*, NC-36. St. Paul, Minnesota. 30p.
I. Burns, R.M. 1983. Silvicultural systems for the major forest types of the United States. *Agricultural Handbook* No. 445. USDA Forest Service. Washington D.C. 191p.
J. Johnston, W.F. 1986. Manager's handbook for balsam fir in the north central states. USDA Forest Service, *North Central Experiment Station General Technical Report*, NC-111. St. Paul, Minnesota. 27p.
K. Stoeckler, J.H. and J.W. Macon. 1956. Regeneration of aspen cutover areas in northern Wisconsin. *Journal of Forestry* 54:13-16.
L. Logan, K.T. 1965-1973. Growth of tree seedlings as affected by light intensity. Canadian Forestry Service, Department of Fisheries and Forestry. Publication No's. 1121, 1160, 1176, 1256, and 1323.
M. McGee, C.E. 1968. Northern red oak seedling growth varies by light intensity and seed source. USDA Forest Service, Research Note, SE-90. Southern Forestry Experiment Station. 4p.
N. Chapeskie, D.J., D.F. Galley, J.R. Mihell, N.W. Quinn, and H.H. Struik. 1989. A silvicultural guide for the white pine and red pine working groups in Ontario. Science and Technology Series, Volume 6. Ontario Ministry of Natural Resources, Toronto, Ontario. 102p.
O. Benzie, J.W. 1977. Manager's handbook for jack pine in the north central states. USDA Forest Service, North Central Experiment Station General Technical Report, NC-32. St. Paul, Minnesota. 18p.
P. Barrett, J.W., editor. 1995. Regional Silviculture of the United States – 3rd Edition. John Wiley & Sons, Inc, New York, New York. 643p.

Q. Sander, I.L. 1977. Manager's handbook for oaks in the north central states. USDA Forest Service, North Central Experiment Station General Technical Report, NC-37. St. Paul, Minnesota. 35p.
R. Lancaster, K.F. and W.B. Leak. 1978. A silvicultural guide for white pine in the northeast. USDA Forest Service, Northeastern Forest Experiment Station General Technical Report, NE-41. Broomall, Pennsylvania. 13p.
S. Johnston, W.F. 1977. Manager's handbook for northern white cedar in the north central states. USDA Forest Service, North Central Experiment Station General Technical Report, NC-35. St. Paul, Minnesota. 18p.
T. Johnston, W.F. 1977. Manager's handbook for black spruce in the north central states. USDA Forest Service, North Central Experiment Station General Technical Report, NC-34. St. Paul, Minnesota. 18p.
U. Barrett, J.W., editor. 1980. Regional Silviculture of the United States – 2rd Edition. Agricultural Handbook No. 445. John Wiley & Sons, Inc, New York, New York. 551p.
V. Wagner, R.G. and S.J. Colombo, editors. 2001. Regenerating the Canadian Forest, Principles and Practice for Ontario. Fitzhenry & Whiteside Limited, Markham, Ontario. 650p.

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 Resources page of the Minnesota Department of Natural Resources Ecological Resources webpage (https://www.dnr.state.mn.us/eco/index.html).
- 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

Table J-1

*	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	FDc12a
*	Jack Pine - (Yarrow) Woodland	FDc23a
*	Jack Pine - Oak Woodland	FDc25a
*	Oak - Aspen Woodland	FDc25b
*	Red Pine - White Pine Forest	FDc34a
*	Jack Pine Woodland (Sand)	FDn12a
*	Red Pine Woodland (Sand)	FDn12b
*	Red Pine - White Pine Woodland (Eastcentral Bedrock)	FDn22d
*	Black Spruce - Jack Pine Woodland: Jack Pine - Balsam Fir Subtype	FDn32c1
*	Jack Pine - Black Spruce Woodland (Sand)	FDn32d

*	Black Spruce Woodland	FDn33c
*	White Pine - Red Pine Forest	FDn43a
	Black Oak - White Oak Woodland (Sand)	FDs27c
	Oak - Shagbark Hickory Woodland	FDs38b
	Bur Oak - (Prairie Herb) Woodland	FDw24a
	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

_____. 1995. *Protecting Water Quality and Wetlands in Forest Management: Best Management Practices in Minnesota.* 140 pages.

_____. 1994. *Visual Quality Best Management Practices for Forest Management in Minnesota.* 78 pages.

Abrams, M.D. 1984. Uneven-aged jack pine in Michigan. *Journal of Forestry* 82:306-309.

Arbogast, C., Jr. 1957. Marking guides for northern hardwoods under the selection system. USDA For. Serv. Lakes States For. Exp. Stn., Stn. Pap. 56.

Bergeron, Y., B. Harvey, A. Leduc, and S. Gautheier. 1999. Forest management guidelines based on natural disturbance dynamics: stand- and forest-level considerations. Forestry Chronicle 75:49-54.

Corns, I. G. W. 1988. Compaction by Forestry Equipment and Effects on Coniferous Seedling Growth on Four Soils in the Alberta Foothills. *Can. J. For. Res*., 18:75-84.

Dissmeyer G. E., and G. R. Foster. 1980. *A Guide For Predicting Rill Erosion on Forest Land*. United States Department of Agriculture, Forest Service State and Private Forestry, Southeastern Area. 40 pages.

Froehlich, H. A., J. Azevedo, P. Cafferata, and D. Lysne. 1980. *Predicting Soil Compaction on Forested Land*. Final Report to USDA Forest Service Pacific Northwest Forest and Range Experiment Station and Missoula Equipment

Development Center. Corvallis, Oregon: Oregon State University Forest Engineering Department.

Froehlich, H. A., and D. H. McNabb. 1984. *Minimizing Soil Compaction in Pacific Northwest Forests. In: E. L. Stone (ed.) Forest Soils and Treatment Impacts*, Proc. 6th North American Forest Soils Conference, June 1983, University of Tennessee, Knoxville, Tennessee, pp.159-192.

Hatchell, G.E., and C.W. Ralston. 1971. Natural Recovery of Surface Soils Disturbed in Logging. *Tree Planter's Notes* 22:5-9.

Jaakko Pöyry Consulting, Inc. 1992. Forest Soils: Technical Paper for a *Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota*. Minnesota Environmental Quality Board, St. Paul, Minnesota.

Jaakko Pöyry Consulting, Inc. 1994. *Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota*. Minnesota Environmental Quality Board, St. Paul, Minnesota.

Laursen, S. B. (ed.). 1996. *At the Water's Edge: The Science of Riparian Forestry*, Conference Proceedings. Minnesota Extension Service, St. Paul, Minnesota. 160 pages.

Megahan, W. F. 1990. "Erosion and Site Productivity in Western-montane Forest Ecosystems." In: *Symposium on Management and Productivity of Western-montane Forest Soils*. General Technical Report INT-280. Boise, Idaho: USDA Forest Service.

Nyland, R.D. (ed.) 1987. Managing Northern Hardwoods: Proceedings of a Silvicultural Symposium. State University of New York, College of Environmental Science

and Forestry, Faculty of Forest Miscellaneous Publication No. 13 (ESF) 87-002.

Patric, J. H., and L. K. Brink. 1977. “Soil Erosion and Its Control in the Eastern Forest.” In: Soil *Erosion: Prediction and Control*. Soil Conservation Society of America Special Publication 21.

Perala, D. A. 1979. *Manager’s Handbook for Aspen in the North Central States*. USDA Forest Service, North Central Forest Experiment Station General Technical Report NC-36. 30 pages.

Pritchett, W. L. 1979. *Properties and Management of Forest Soils*. John Wiley & Sons, New York, New York. 500 pages.

Shaw, S. P., and C. G. Fredine. 1956. *Wetlands of the United States: Their Extent and Value to Waterfowl and Other Wildlife*. FWS Circular 39. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D. C. 67 pages + map.

Smith, D.M., B.C. Larson, M.J. Kelty and P.M.S. Ashton. 1997. The Practice of Silviculture, Applied Forest Ecology, 9th Edition, John Wiley & Sons.

Stone, D. M., and J. D. Elioff. 1998. Soil Properties and Aspen Development Five Years After Compaction and Forest Floor Removal. *Canadian Journal of Soil Science*, Vol. 78: 51-58.

Sutherland, B. J., and F. F. Foreman. 1995. *Guide to the Use of Mechanical Site Preparation Equipment in Northwestern Ontario*. Canadian Forest Service-Sault Ste. Marie, Natural Resources Canada, Sault Ste. Marie, Ontario. 186p.

Verry, E. S. 1969. 1968 *Vegetation Survey of the Marcell Experimental Watersheds. Table 7. Stand characteristics*

by watershed and type. USDA Forest Service, North Central Forest Experiment Station, Grand Rapids, Minnesota. Study Report for GR-W2-61. 38p.

Voorhees, W. B. 1983. Relative Effectiveness of Tillage and Natural Forces in Alleviating Wheel-induced Soil Compaction. *Soil Science Society of America Journal*, 47:129-133.

Wilson D. A., and D. F. Grigal. 1995. Effects of Pine Plantations and Adjacent Deciduous Forest on Soil Calcium. *Soil Science Society of America Journal*, Vol. 59:1755-1761.