Baseline Monitoring for Implementation of the Timber Harvesting and Forest Management Guidelines on Public and Private Forest Land in Minnesota: Combined Report for 2000, 2001, and 2002

A report by the Minnesota Department of Natural Resources

Richard Dahlman and Michael J. Phillips

DNR Document MP-0904

Respectfully submitted to the Minnesota Forest Resources Council

For more information, contact:

Department of Natural Resources
500 Lafayette Road
St. Paul, MN 55155-4040

Metro area: 651-296-6157 (metro area)
Toll-free in Minnesota:1-888-MINNDNR (1-888-646-6367)

Telecommunication Device for the Deaf (TTY):
Metro area: 651-296-5484
Toll-free in Minnesota: 1-800-657-3929

http://www.dnr.state.mn.us

© 2004, State of Minnesota, Department of Natural Resources

Equal opportunity to participate in and benefit from programs
of the Minnesota Department of Natural Resources is available to all individuals
regardless of race, color, creed, religion, national origin, sex, marital status,
status with regard to public assistance, age, sexual orientation, or disability.

Discrimination inquiries should be sent to
the Minnesota DNR, 500 Lafayette Road, St. Paul, Minnesota 55155-4031;
or the Equal Opportunity Office, Department of the Interior, Washington, DC 20240.

This information is available in an alternate format upon request.

Printed on recycled paper containing a minimum of 20 percent post-consumer waste and soy-based ink.

Baseline Monitoring for Implementation of the Timber Harvesting and Forest Management Guidelines on Public and Private Forest Land in Minnesota: Combined Report for 2000, 2001, and 2002

A report by the
Minnesota Department of Natural Resources

Richard Dahlman and Michael J. Phillips

DNR Document MP-0904

Respectfully submitted
to the Minnesota Forest Resources Council

Acknowledgments

Gratitude is expressed to the following individuals for their assistance in developing and revising the implementation monitoring program and/or assistance in the preparation of this report:

➤ **Minnesota Forest Resources Council's Guideline Implementation Monitoring Committee** for their guidance and direction:

Greg Damlo, Rich Holm, Bob Oswold, Dave Parent (committee chair), Shawn Perich, Roger Scherer, and Dave Sterr

➤ **Implementation Monitoring Field Review Team** for their critical review of field procedures and suggestions for improving the monitoring process:

Erv Berglund, Charlie Blinn, Bruce Cox, Pat Emerson, Mike Houser, Alan Jones, Tim Quincer, and Dick Rossman

➤ **Special contributions by:**

Chung-Muh Chen (DNR) for data analysis
Steve Gallay (DNR) for aerial photo interpretation
Chad Skally (MFRC) for assistance with graphics
Carol Johnson (DNR) for computer program maintenance
Marge Meconis for data entry
Sara Phillips for data entry

Report formatting: Linda Schroeder

Cover photo: Rachael Shetka

Table of Contents

Executive Summary.....1
Introduction.....3
Methodology.....5
Data Collection Forms.....5
Site Selection Process.....7
Aerial Photography Interpretation.....7

Results and Discussion.....9
Site Distribution.....9
Harvest Characteristics.....10
Landowner Questionnaire.....10
Landowner Objectives.....10
Pre-Harvest Planning.....11
Commitment of Landowner To Apply Guidelines.....12
Forest Management and Harvest Methods.....14
Visual Quality Assessment.....15
Protection of Cultural/Historic Resources and Endangered, Threatened, and Special Concern Species.....17
Use of Filter Strips and Riparian Management Zones.....18
Type and distribution of water bodies.....18
Filter strip application.....19
Riparian management zones.....20
Protection of Water Quality and Wetlands.....21
Water body and wetland crossings.....21
Approaches to water bodies and wetlands.....22

Results and Discussion (continued)

Protection of Forest Soil Resources....23
Logging and hauling equipment traffic on forest soils....23
Landings....23
Forest roads....24
Skid trails....26
Slash disposal and distribution....27
Rutting....27
Applications for Wildlife Habitat....29
Coarse woody debris....29
Leave tree distribution....30
Distribution of snags....31
Maintaining oaks....32
Quality Control....32

Conclusions....33
Recommendations for Future Monitoring....35
Glossary....37
References....41
Appendix....43

Executive Summary

Minnesota forest practices have been guided by Best Management Practices (BMPs) for water quality since 1990. Additional BMPs to protect wetlands and visual quality were added in 1995. The Sustainable Forest Resources Act (SFRA) of 1995 mandated that the BMPs be expanded to provide protection for a broad range of functions and values on all forest lands in Minnesota. To address this mandate, the Minnesota Forest Resources Council (Council) utilized a multi-stakeholder process to develop guidelines to protect soil productivity, wildlife habitat, riparian management zones, and cultural and historic resources. These guidelines were integrated with the existing BMPs and, in 1999, Minnesota's comprehensive timber harvest and forest management (TH/FM) guidelines were published in a guidebook titled *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines*.

This report discusses the findings of the first three years of monitoring. It establishes a baseline of harvesting practices prior to publication of the TH/FM guidelines.

The SFRA also required that a process be developed to monitor forest management practices on all forest lands in Minnesota to ensure that the guidelines are properly implemented. A monitoring program was implemented, beginning in 2000. The program objective is to evaluate the implementation of the guidelines through field visits to randomly selected recent timber harvest sites on state, county, national forest, tribal, other public agency, forest industry, other corporate, and non-industrial private forest (NIPF) lands. This report discusses the findings of the first three years of monitoring. It establishes a baseline of harvesting practices prior to publication of the TH/FM guidelines.

A total of 334 harvesting sites have been monitored for implementation of the TH/FM guidelines: 108 in 2000, 118 in 2001, and 108 in 2002. Monitoring sites were randomly selected on all ownerships, with the selection process significantly revised each year as procedures were refined. Initially, sites were identified using a sampling procedure that randomly selected blocks of land 1/2 township in size throughout the forested area of the state. In 2001 this procedure was modified to compare the use of satellite imagery with aerial photography of randomly selected 1/6 township blocks for initial site identification.

Satellite imagery proved to be the most efficient and effective, and satellite imagery was used exclusively in 2002. Satellite imagery is also being used to identify a pool of sites for monitoring in 2004.

Landowners of all potential sample sites were subsequently contacted to secure permission to visit their sites and gather site background information prior to conducting the field reviews. The focus of the field review was to evaluate the application of measurable timber harvest and forest management guidelines.

This report summarizes the results for all monitored sites that were harvested and/or under contract prior to publication of the Council's TH/FM guidebook. This includes all sites monitored in 2000 and 2001, along with 89 of the 108 sites monitored in 2002, for a total of 315 sites. The remaining 19 sites monitored in 2002 were sold and contracted for after the publication of the TH/FM guidelines, or the harvest agreement was modified to incorporate the TH/FM guidelines. The results for these 19 sites will be analyzed along with the sites monitored in 2004.

Some of the important findings from the three baseline years of monitoring are given below:

➤ 53% of the monitored sites were harvested exclusively in the winter.

➤ 92% of the sites were managed as even-age. 93% of these were clearcut, and 2/3 of the clearcuts retained some reserve trees.

➤ 25% of the monitored sites were visually sensitive.

➤ Filter strip compliance with the guideline recommendation (< 5% mineral soil exposure, dispersed over the filter strip) was 73%.

➤ Riparian management zone (RMZ) guideline recommendations for width and residual basal area were met 52% of the time.

➤ Appropriate water diversion and erosion control practices were installed on 7.4% (three-year data) of skid trail and road approaches to wetlands and streams. However, more detailed information gathered in 2002 found that erosion was evident on only 5.8% of the approaches, and sediment was reaching a water body on 59% of those with erosion evident.

➤ 37% of the skid trail and road segments with a grade of 2% or more had the appropriate water diversion and erosion control practices installed. Detailed information gathered in 2002 found that erosion was visually evident on 22% of the segments, and sediment was reaching a water body on 20% of the segments where erosion was observed.

➤ Only 6% of more than 2,000 locations on the 89 sites monitored in 2002 had rutting 6 inches deep or deeper. Most rutted locations (78%) had less than 5% of their surface area in ruts, and 47% of the rutting was confined to roads, skid trails, and landings.

➤ The guidelines recommend that site infrastructure (i.e., roads, landings) occupy no more than 3% of the harvest area. The statewide average was 3% for all three years.

➤ Landings were located outside of filter strips and RMZs 77% and 98% of the time, respectively, and outside of wetlands 79% of the time.

➤ Coarse woody debris guidelines were met in 79% of the general harvest areas and in 69% of the RMZs.

➤ Slash was retained at the stump or redistributed back on the site for 75% of the sites monitored.

➤ 53% of the clearcut sites met the leave tree guideline recommendations.

Introduction

This report has been prepared as a periodic update to the Legislature and Governor under the requirements of the Sustainable Forest Resources Act (SFRA). The SFRA was enacted in 1995 and modified in 1999 (Minnesota Statutes, Sections 89A.01 to 89A.10) to resolve important forestry policy issues through collaborative approaches among diverse forestry interests.

To that end, the SFRA created the Minnesota Forest Resources Council (Council), made up of representatives from 15 key stakeholder groups and a chair appointed by the Governor, and an American Indian representative appointed by the Indian Affairs Council. The SFRA required that much of the initial effort of the Council focus on the development of voluntary guidelines for use on public and private forest land in Minnesota to minimize and mitigate the potential negative impacts of timber harvest and other forest management activities.

The process of guideline development as mandated by the SFRA began in April 1996. Site level guidelines were developed for four topical areas identified in the *Final Generic Environmental Impact Statement Study on Timber Harvesting and Forest Management* (Jaakko Pöyry 1994): riparian zone management, forest soil productivity, cultural/historic resources, and wildlife habitat.

These guidelines were integrated with two existing BMP publications: *Protecting Water Quality and Wetlands in Forest Management* (MN DNR 1995) and *Visual Quality Best Management Practices for Forest Management in Minnesota* (MN DNR 1995). The Council approved the integrated guidelines in December 1998 and published the guidebook *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines* in April 1999.

The SFRA mandated monitoring of the timber harvest and forest management (TH/FM) guidelines on public and private forest lands to evaluate their use. Specifically, the SFRA states:

89A.07, Subd. 2. Practices and compliance monitoring. The commissioner shall establish a program for monitoring silvicultural practices and application of the timber harvesting and forest management guidelines at statewide, landscape, and site levels. The Council shall provide oversight and program direction for the development and implementation of the monitoring program. To the extent possible, the information generated by the monitoring program must be reported in formats consistent with the landscape regions used to accomplish the planning and coordination activities specified in section 89A.06.

The statute requires the Minnesota Department of Natural Resources (DNR) to develop and administer the implementation monitoring program, with oversight and program direction provided by the Council. This monitoring program was built on experience gained between 1990 and 1997 in monitoring the implementation of the BMPs for protecting water quality, wetlands, and visual quality that preceded the TH/FM guidelines.

This report summarizes three years of monitoring sites harvested or contracted for prior to the publication of the integrated guidelines.

This report summarizes three years of monitoring sites harvested or contracted for prior to the publication of the integrated guidelines. Separate reports were published for the monitoring conducted in 2000 (Phillips 2001) and 2001 (Phillips and Dahlman 2002). Subsequent field monitoring will be compared to these pre-guideline baseline results to assess how harvesting and management practices change over time, and the extent to which the management practices recommended in the guidebook are being applied across the state.

The methods and procedures for site selection and data collection were modified each of the three years of monitoring. The majority of data reported reflects observations for all three years. However, due to revisions in questions and/or field procedures, some data were only collected for one or two years. The changes can be grouped into the following categories:

➤ Revisions in questions on the data form and modification of field procedures, focusing on those guideline practices that are measurable

➤ Shifting from aerial photography of randomly selected townships to the use of satellite imagery as a method for initial site selection

➤ Changes to which features are identified and measured onsite and which are identified and measured by aerial photo interpretation

Data Collection Forms

Two categories of forms were used to collect information about each site monitored. The first category focused on collecting site-specific information that could not be obtained through the onsite evaluation. In 2000 two forms were used for this purpose. The detailed nature of the "site-profile" and "pre-site visit" forms used in monitoring for 2000 often made it difficult to obtain timely completion and cooperation of the landowners, particularly the non-industrial private forest (NIPF) landowners.

These forms were consolidated into a single "landowner questionnaire" for 2001. Questions were deleted that elicited the landowner's perception or awareness of the presence of certain resources or conditions on their property (e.g., type and number of water bodies, soil type, and soil drainage characteristics). However, additional information was also requested of the landowner, which included identifying:

➤ His or her primary objective for management

➤ Whether or not the TH/FM guidelines were used in planning or modifying the timber harvesting or roads activities

➤ Whether or not the TH/FM guidelines were discussed between the landowner/resource manager and the logger/contractor (including where and how [e.g., onsite])

In 2002 these additions were maintained, but additional questions were deleted to further shorten the landowner questionnaire.

The second category of form was the onsite form and associated maps. This form and maps indicating the location of various features evaluated is where all observations of the actual site were recorded. The site was defined in two parts: the harvest area and the total site. The harvest area included the acreage of all features within the area where trees were harvested, or "onsite." The total site included the acreage of:

➤ Leave tree clumps adjoining the harvest area

➤ The RMZs and associated leave trees of water bodies within 1.5 times the recommended RMZ width of the harvest area

Data were recorded on the onsite form for all features of the harvest area and the total site as well as for wetlands and water bodies "adjacent" to a site and "off-site":

Adjacent: Outside the harvest area boundary, but within the recommended filter strip width (for those water bodies that only require a filter strip), or within 1½ times the recommended RMZ width (for those water bodies that require an RMZ).

Off-site: Outside the harvest area boundary and more than the recommended filter strip width (for those water bodies that only require a filter strip), or more than 1½ times the width of recommended RMZs (for those water bodies that require an RMZ). Off-site wetlands and water bodies were only noted if roads impacted them or their associated filter strips or RMZs, skid trails, or landings associated with the harvest site being evaluated.

Data were also recorded for guideline practices on the last 1/4 mile of roads and skid trails leading to a harvest area if:

- ➤ It was newly constructed for the purpose of the forest management activity, or had been significantly modified (widened, relocated, or reconstructed) for the forest management activity.
- ➤ It was a pre-existing seasonal road or skid trail that was primarily used for the activity being monitored.
- ➤ It was not a public road—such as a township road or a major forest system road—that had significant traffic not associated with the activity being monitored.

Data were not collected for any portion of a pre-existing road or skid trail that extended beyond the last landing area used for the harvest site being monitored, or for any road adjacent to or passing through the harvest site that was not used for the harvest activities on that site.

In 2001 and 2002 the "onsite" data collection form was also modified to better characterize the conditions observed:

Visual quality: Contractors were required to categorize the apparent harvest size of most sensitive and moderately visually sensitive sites into one of three measures: < 5 acres, 5-10 acres, or > 10 acres.

Approaches to water body crossings: In 2002 additional information was collected on the length and condition of each approach.

Water diversion structures: Additional questions were included that focused on the extent of erosion and sedimentation to water bodies related to the use of water diversion structures.

Riparian management zones: Data collected on RMZ width and basal area (BA) were expanded to include the following categories of response:

- ➤ Width of non-forested vegetation
- ➤ Width and BA of uncut riparian forest
- ➤ Width and residual BA of partially harvested riparian forest
- ➤ Width of clearcut (< 25 sq.ft/acre BA) for the remainder of the recommended RMZ width for the specific type and size of water body

Coarse woody debris: The working definition for identifying coarse woody debris (CWD) was modified from "bark-on" down logs to using the visual indicators for Decay Classes 1 and 2 described by Harmon et al. 1986.

Snags: The form was modified to capture the number of snags per acre present onsite rather than just noting their presence or absence.

Rutting: In 2000, the presence or absence of rutting was noted on the onsite form for wetland inclusions, filter strips, RMZs, roads, and skid trails. The presence of rutting was also noted for the general harvest area if rutting exceeded 5% of the surface area. This latter criteria was changed to 2% for 2001.

For 2002, six ranges of percent rutting were identified (none, ≤ 2%, 2 ≤ 5%, 5 ≤ 10%, 10 ≤ 25%, and > 25%) for wetlands, filter strips, RMZs, upland harvest areas, wetland harvest areas, water body crossings, approaches to crossings, road and skid trail segments with a grade ≥ 2%, and the general road and skid trail system observed on each site.

Independent contractors were selected by competitive bid to collect onsite data each year of monitoring. Their paperwork was thoroughly reviewed by DNR staff, and 10% of their fieldwork was re-evaluated by a multi-disciplinary team to assure accurate and consistent data collection.

In 2000 and 2001, DNR, Division of Forestry staff contacted all landowners to complete the site-profile and pre-site visit forms (2000) or landowner questionnaire (2001) and to obtain copies of timber sale permits and maps and other supporting background documentation.

In 2002 the contractor hired to collect the onsite data contacted the NIPF landowners, and Department of Forestry staff contacted administrators for all the forest industry and public agency sites to complete the landowner questionnaire and gather related background documentation.

In all three years, the contractor was given copies of all documentation obtained for each site in order to prepare for visiting each site. Paper copies of the onsite forms were used to record all onsite observations. The contractors returned the completed forms to the DNR in St. Paul for data entry and analysis.

Data entry

The TH/FM guideline monitoring data were captured by a relational database: Microsoft ACCESS 97 for Windows 95. The same database was utilized in 2000 and 2001. A new ACCESS database was developed for 2002 to make data entry and queries easier.

Statistical analysis of results

SAS (Statistical Analysis System) Version 8.2 was used to analyze the implementation monitoring results.

Site Selection Process

In both 2000 and 2001, the east halves of 41 townships in the forested area of the state were randomly selected as primary sampling units (PSUs). Aerial photography was flown of each PSU to identify a pool of harvest sites for monitoring.

Initially, in 2000, the criterion for including a half township in the pool of PSUs was that it contain at least 160 acres of forest land. This criterion failed to provide an adequate number of sample sites for monitoring. Funding was inadequate to fly aerial photography for a larger number of PSUs. Therefore, the area for forest land required for each PSU was increased from 160 acres to six sections (3,840 acres) of timber land in order to increase the number of harvest sites identified per PSU. This modification was retained for the 2001 monitoring program.

While preparing for monitoring in 2002, concern was expressed that requiring six sections of timber land in the eastern half of a township was creating a sample bias by restricting monitoring to the most heavily forested areas of the state. There was also interest in combining guideline monitoring with monitoring land use change and harvest in riparian areas. For these reasons, two approaches to identifying a pool of sample sites were tested in 2002. Aerial photography was flown for 80 randomly selected 1-mile by 6-mile strips, to spread the sample more widely across the state.

The photos were then analyzed to identify timber harvest sites of unknown age. This information was compared to computer analyses of satellite imagery for August 1999 and August 2001 to identify recent forest disturbance on approximately 70% of the state. Over 5,200 forest disturbances were identified by satellite imagery, from which monitoring sites could be randomly selected and aerially photographed.

Satellite imagery more accurately identified timber harvest sites than aerial photography of the 80 1-mile by 6-mile strips, with the added benefit of easy confirmation that a disturbance had occurred within the previous year. For these reasons, satellite imagery was used to identify the pool of sample sites for 2002, and it will be used exclusively in 2004.

Aerial Photography Interpretation

Responsibility for collecting onsite data was divided between the contractor and the DNR Resource Assessment Unit (RAU). In 2000, the RAU staff identified the location and measured the size of all landings within the harvest unit that could be identified on aerial photographs. In 2001, RAU identified all landing locations visible on the aerial photos, but the contractor was responsible for determining the size of the landings. As in 2000, the contractor also identified and delineated any additional landings that were not identified by RAU staff. In 2002 the contractor was responsible for identifying and measuring all landings. RAU staff did not identify landing locations.

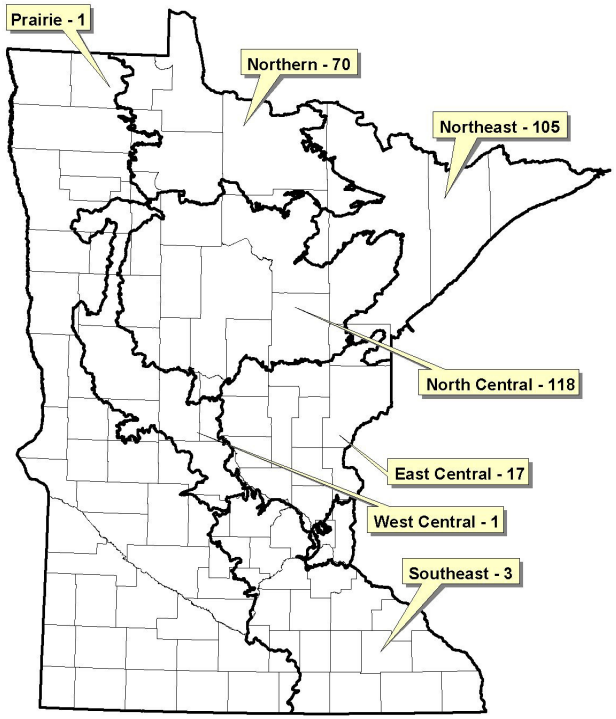
In all cases, the contractor delineated leave tree clumps within the harvest area on the aerial photo map for each site and determined the number of scattered leave trees per acre. Leave tree clumps located adjacent to the site were later identified and delineated on the aerial photo map by DNR monitoring program staff, not the contractor, based on onsite documentation and RMZ measures.

In 2000 and 2001, RAU then determined acreage for all leave tree clumps, harvest area, and total site area from the photos. In 2002, the contractor measured the size of all leave tree clumps within the harvest area, and RAU determined the acreage of the adjacent leave tree clumps, harvest area, and total site area from the photos.

Site Distribution

Timber harvest and forest management guidelines were monitored on all forest land ownerships: state, county, U.S. Forest Service (USFS), forest industry (FI), non-industrial private forest (NIPF), and other (tribal, other public and nonforest industrial). The distribution of sites based on Council landscape regions is shown in Figure 1 and by county in the Appendix. In total, 315 timber harvesting sites were evaluated over the three years of monitoring.

Figure 1. Location of monitoring sites by Council landscape region



The number of sites monitored by landowner category is shown in Figure 2. Permission was obtained from the landowners/managers for all sites that were monitored. NIPF sites were monitored less intensively than other ownerships—when comparing the volume of timber harvested on NIPF lands to the total volume harvested annually in the state—due to: 1) the inability to contact some landowners, or 2) the refusal of some landowners to permit monitoring of their timber harvesting activity.

In the future, a larger sample pool will be used to ensure a more adequate sampling of NIPF forest management activities.

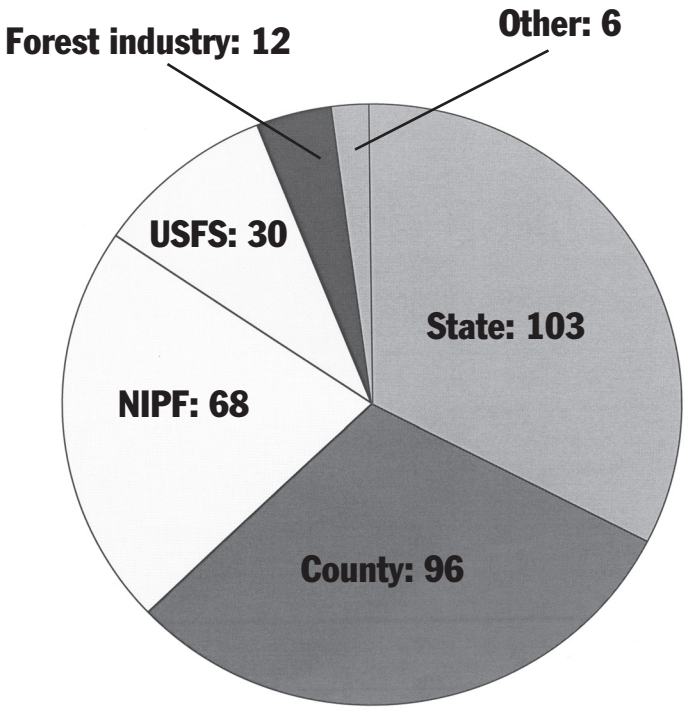
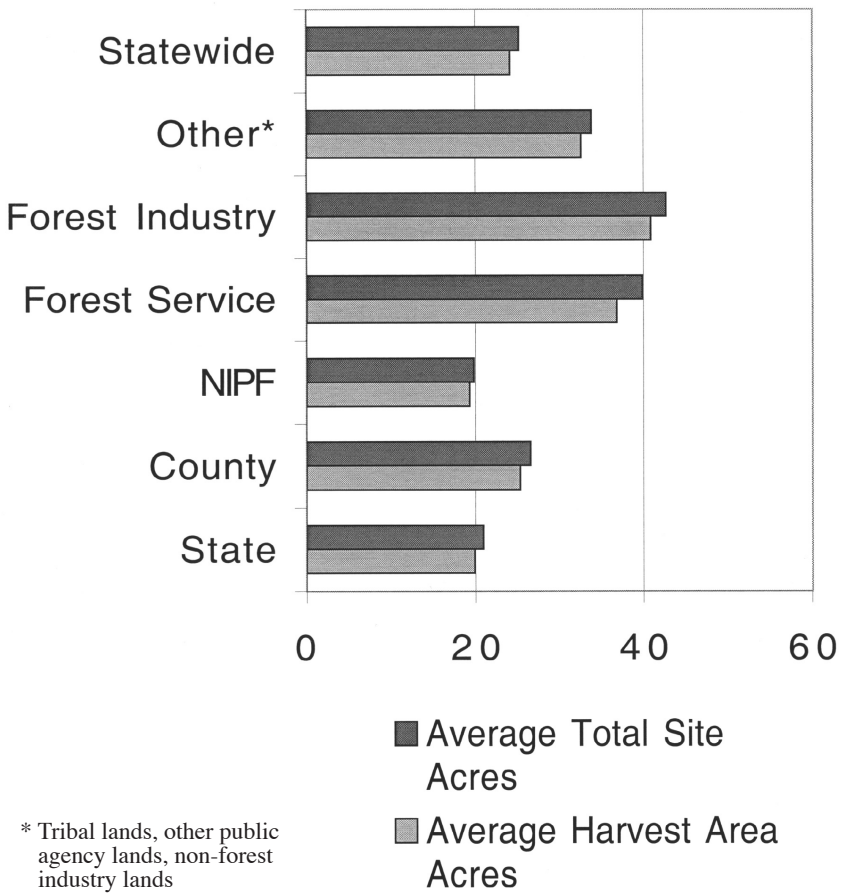


Figure 2: Number of harvest sites monitored by landowner category (2000, 2001, 2002)

Harvest Characteristics

The average timber harvest area for all ownerships was 24.1 acres (Figure 3). Average total site acreage (i.e., harvest area + adjacent leave tree acreage + adjacent RMZ) was 25.2 acres. Harvest area ranged from approximately three acres to more than 200 acres. On average, total site acres were 4.6% greater than the harvest area acres.

Figure 3: Average harvest and total site acres by ownership (2000, 2001, 2002)



* Tribal lands, other public agency lands, non-forest industry lands

Landowner Questionnaire

The site-profile and pre-site visit forms used in 2000 and the landowner questionnaires used in 2001 and 2002 were fully or partially completed for 307 of 315 monitoring sites. Eight of the 68 NIPF landowners chose not to fill out the landowner questionnaire, while still allowing their timber harvests to be monitored for the application of the guidelines. The questionnaires provided valuable information on management objectives, the extent of pre-planning for timber harvest, and landowner awareness of the guidelines.

Landowner Objectives

Management objectives are important factors influencing project planning and how a landowner might utilize the flexibility built into the guidelines. The landowner questionnaire asked landowners to identify up to three management objectives for their timber harvests. These results are presented in Table 1. Timber harvesting and silviculture were the dominant management objectives cited for all landowner categories. Wildlife habitat was second, followed by income, recreation, insect and disease control, salvage and timber stand improvement (TSI), and investment, in that order.

Table 1. Landowner objectives for management (2000, 2001, 2002)

Management Objectives	Landowner Category						
	State	County	USFS	FI	NIPF	Other*	Total
Timber Production	94	85	30	11	24	5	249
Silviculture	75	56	26	10	26	6	199
Wildlife Habitat	39	32	8	2	28	1	110
Income	11	44	0	3	29	4	91
Recreation	8	6	1	1	22	0	38
Insect and Disease	15	6	4	0	3	1	29
Salvage or TSI	9	7	0	0	2	1	19
Investment	0	0	0	1	4	0	5
Total Sites Where Landowner Objectives Were Identified	102	93	30	12	59	6	302**
Total Number of Sites	103	96	30	12	68	6	315

* Tribal lands, other public agency lands, non-forest industry lands
**13 landowners did not provide a response for this question

In 2001 and 2002 each landowner was also asked to identify his/her primary objective for management. These results are given in Table 2. Timber production and silviculture were identified as the primary management objective by 87% (137 of 157) of the state, county, USFS, and forest industry landowners. On NIPF lands, wildlife habitat and recreation were as important as timber production and silviculture.

Table 2. Primary landowner objective for management (2001, 2002)

Primary Management Objective	Landowner Category						
	State	County	USFS	FI	NIPF	Other*	Total
Timber Production	44	34	12	6	6	0	102
Silviculture	19	20	1	1	8	2	51
Wildlife Habitat	3	0	0	0	9	1	13
Income	0	2	0	0	4	0	6
Recreation	0	0	0	0	5	0	5
Insect and Disease	2	1	0	0	0	0	3
Investment	0	0	0	0	1	0	1
Other	7	5	0	0	1	0	13
Total Sites Where Landowner Objectives Were Identified	75	62	13	7	34	3	194**
Total Number of Sites	76	65	13	7	43	3	207

* Tribal lands, other public agency lands, non-forest industry lands
**13 landowners did not provide a response for this question

Pre-Harvest Planning

The TH/FM guidelines recommend the development of written plans for all forest management activities, including timber harvest. Plan writers are encouraged to utilize appropriate planning aids, such as aerial photography and topographic maps, when preparing a plan. They are also advised to prepare detailed site maps to help communicate the details of the plan to those who will carry it out.

Planning is particularly important for NIPF landowners because they 1) often live some distance away from the harvest area, and 2) generally have little or no experience with forest management and timber sale contracts.

Both limit the NIPF landowner's ability to effectively direct and supervise activities on his or her land. 46% (25 of 58) of NIPF landowners who responded to the question do not live on or adjacent to the property where their timber harvest occurred, and 14% (8 of 58) live more than 100 miles away (Table 3).

Table 3. How Close to Harvest Site Do NIPF Landowners Live?

Location	2000	2001	2002	Total
On or Adjacent to Property	21	5	7	33
<50 miles	2	6	7	15
50 to 100 miles	0	0	2	2
>100 miles	1	3	4	8
Not provided	1	9	0	10
Total	25	23	20	68

Only 26% of NIPF landowners reported having a timber harvest plan, written or oral, prepared with the assistance of a natural resource professional or logger (Table 4). Another 26% (18 of 68) had written management plans for their forest land, but not specifically for their timber harvest.

Table 4. NIPF Project Planning

Level of Planning		2000	2001	2002	Total
No Assistance		8	3	4	15
General Plan - Written		7	8	3	18
Timber Harvest Plan	Written	4	2	5	11
	Oral	4	1	2	7
No Response		2	9	6	17
Total		25	23	20	68

The landowner or resource manager was asked to identify the specific information resources they used in the preparation of their timber harvest plans. The results are presented in Table 5 (page 12). One or more types of information resources were used on 93% of sites where this question was completed on the landowner questionnaire. The most commonly used resource was aerial photography. NIPF landowners were least likely to use supplemental information resources to plan their timber harvest activities.

Table 5. Site information resources used to provide landowner assistance for evaluating and developing plans (2000, 2001, 2002).							
Resources	Landowner Category						
	State	County	USFS	FI	NIPF*	Other**	Total
Aerial Photographs	101	96	30	12	30	6	275
Topographic Maps	20	29	26	2	8	6	91
Soil Surveys	18	19	29	0	4	2	72
Visual Sensitivity Maps	24	29	21	0	1	0	75
Other	50	24	7	4	3	1	89
Total Number of Sites	103	96	30	12	68	6	315
Total Number Where Information Resources Were Used	101	96	30	12	42	6	287

*8 landowners did not provide a response for this question
** Tribal lands, other public agency lands, non-forest industry lands

Table 7. On-site meeting held by landowner/resource manager with the logger/contractor (2000, 2001, 2002).			
Landowner Category	Topic Discussed		
	Roads	Timber Harvest	No meeting Held or Cannot Determine
State	47	78	25
County	56	75	21
USFS	28	29	1
Forest Industry	9	12	0
NIPF	8	27	41
Other*	3	5	1
Total	151	226	89

* Tribal lands, other public agency lands, non-forest industry lands

One of the most effective tools for communicating the details of a timber harvest plan is a site map identifying the location of critical site features (Table 6). Site maps were developed for 272 of 307 sites (87%) where the landowner/resource manager completed the questionnaire.

Table 6. Number of sites for which site maps were developed by landowner category. (2000, 2001, 2002).							
	Landowner Category						
	State	County	USFS	FI	NIPF	Other*	Total
Number of Sites with Maps	98	85	29	11	23	6	272
Total Number of Sites	103	96	30	12	68	6	315

* Tribal lands, other public agency lands, non-forest industry lands

An onsite meeting between the landowner and/or resource manager and the logger/contractor is encouraged to share information and ensure a common understanding of what is expected. An onsite meeting was held on 74% (226 of 307) of the sites (Table 7). Timber harvest plans were discussed at all meetings, and road plans were discussed at 67% of the meetings. This calculation excludes sites where a landowner questionnaire was not completed or where the information provided was inadequate to determine whether or not an onsite meeting was held.

Commitment of Landowner To Apply Guidelines

One of the guideline implementation goals adopted by the Council was to obtain landowner commitment to apply the timber harvest and forest management guidelines. In the Council's document titled *The Timber Harvest and Forest Management Guideline Implementation Goals for 2000: A Progress Report* (Council Report #ME-0301), the need for this commitment was described:

"Background. Awareness and understanding of the guidelines must be accompanied by a willingness to actually apply the guidelines. Evaluating how often and the extent to which a discussion of guideline application takes place during the pre-harvest planning between the forest landowner, the resource manager, and the logger can measure evidence of a commitment to apply the guidelines."

To obtain a measure of landowner commitment to apply the guidelines, two questions were added to the landowner questionnaire for the 2001 and 2002 monitoring programs:

➤ Were the TH/FM guidelines used to plan the above activities or modify the plan?

➤ Were the TH/FM guidelines discussed during the onsite meeting?

Table 8. Willingness of landowners to apply timber harvest and forest management guidelines (2001, 2002)

Landowner Category		Guidelines used to plan or modify timber harvest plan					Guidelines discussed on-site between resource manager/landowner and logger/operator					
		Yes	No	No Answer**	NA	Total	Yes	No	No Answer**	Cannot Determine	NA	Total
State												
	TH*	54	19	0	3	76	58	13	1	4	0	76
	Roads	30	20	20	6	76	41	9	20	2	4	76
County												
	TH	45	17	3	0	65	44	10	3	8	0	65
	Roads	24	21	18	2	65	26	18	15	4	2	65
USFS												
	TH	8	5	0	0	13	7	5	0	1	0	13
	Roads	8	5	0	0	13	8	4	0	1	0	13
Forest industry												
	TH	5	2	0	0	7	3	2	0	2	0	7
	Roads	4	2	1	0	7	3	2	0	2	0	7
NIPF												
	TH	10	24	9	0	43	12	17	13	1	0	43
	Roads	4	15	20	4	43	8	10	17	3	5	43
Other												
	TH	2	1	0	0	3	2	1	0	0	0	3
	Roads	1	1	0	1	3	0	1	0	0	2	3
Total												
	TH	124	68	12	3	207	126	48	17	16	0	207
	Roads	71	64	59	13	207	86	44	52	12	13	207

*TH=timber harvest

**Includes both landowners who did not provide information in the landowner questionnaire and sites where roads were not constructed, reconstructed, or used for the timber harvest.

The Council's implementation goal (Council Report #ME-0301) relative to these two guideline questions is a minimum of 75% for all public forest resource agencies, forest industry, and professionally assisted NIPF timber sales.

The 2001 and 2002 responses to these questions are given in Table 8:

➤ For Question 1, 60% (124 of 207) of the landowners who completed the landowner questionnaire indicated that the TH/FM guidelines had been used to plan or modify the plan for their timber harvest. 37% (71 of 194) of the landowners who indicated that forest roads were constructed, reconstructed, or maintained as part of the timber harvest activity reported that the forest road guidelines were used to plan or modify the timber harvest plan.

➤ Question 2 provides information about whether the TH/FM guidelines were discussed onsite between the landowner/resource manager and the logger/contractor (Table 8). Due to the way a number of the questions were answered by the landowner/resource manager, it could not be determined whether or not an onsite meeting was held on 16 sites for 2001.

In addition, there were eight NIPF sites where the landowner did not fill out the questionnaire and three sites where no response was provided about an onsite meeting. The landowners/resource managers who did respond indicated that they had discussed the TH/FM guidelines with the logger/contractor 61% (126 of 207) of the time regarding timber harvest, and 44% (86 of 194) of the time regarding roads.

Considering that the data collected for these two questions were based on information from timber harvest planning activities conducted prior to the publication of the TH/FM guidelines, these results are somewhat surprising. The expected answer for both questions was "no."

Two reasons could explain the majority of these responses:

➤ The first is that landowners/resource managers answered questions based on what they thought the authors wanted to hear. Some respondents may have been averse to indicating that they were not using the TH/FM guidelines.

➤ The second and more probable reason is that the landowners/resource managers were answering the questions based on the application of the water quality and wetland BMPs that have been the forestry standard since 1995. These BMPs were incorporated into the comprehensive TH/FM guidebook. Several respondents did specifically note they were answering the questions from that perspective. This was the case for the three "NA" (not applicable) responses for state land managers for timber harvest.

Forest Management and Harvest Methods

Forest management is the deliberate manipulation of the forest stand to achieve a variety of desired outcomes or management objectives over an extended period of time. Timber harvest is the primary tool utilized by landowners and resource managers to accomplish forest management objectives. It involves the use of many different kinds of equipment to fell, skid, and process trees in the woods to recover usable products. Timber harvesting often requires the development and maintenance of temporary and permanent roads to permit these products to be hauled to manufacturing facilities and distribution centers.

There are two primary silvicultural systems for utilizing timber harvest as a management tool: even-age and uneven-age management. Several harvest methods can be utilized to implement both silvicultural systems. Selection of which harvest method to use on a site depends on the management objectives of the landowner/resource manager, as well as the silvics of the tree species being managed.

A summary of the silvicultural systems and harvest methods reported for the sites monitored is found in Table 9. Only six sites utilized an uneven-age management system; 293 used an even-age system; eight were salvage operations; and the management system was unknown for the remaining eight sites.

The guidelines recognize the importance of retaining critical vertical structure for wildlife habitat on clearcut areas. They recommend leaving some mature trees—6 inches diameter at breast height (DBH) or larger—as scattered individual trees, trees in clumps, or both.

Table 9. Number of monitored sites by timber harvest method (2000, 2001, 2002).

Even-Age Management Systems				
		W/O Reserves	With Reserves	Total
Clearcut	w/sprouting	66	158	224
	w/ sprouting & natural seeding	0	5	5
	w/ artificial regeneration	18	13	32
	w/ natural seeding	3	6	9
	w/ Sprouting & artificial regeneration	1	0	1
Seed Tree	NA		3	3
Selective Thinning	NA		20	20
Total	88		205	293

Uneven-Age Management Systems	
Selective Thinning	5
Group Selection	1
Total	6

Other Management Systems	
Salvage	8
Unknown	8
Total	16

Landowners/resource managers recognized the value of this recommendation before the guidelines were published. Puettmann et al. 1996 reported that clearcut harvests with residuals in Minnesota nearly doubled between 1991 and 1996, increasing from 41% to 77%. The increase was attributed to growing interest in providing for wildlife habitat, riparian protection, aesthetics, and nutrient retention.

The first three years of the current monitoring program found this trend continuing. Two-thirds of sites (185 of 273) managed with even-age regeneration harvests used one of four harvest-with-reserve methods: 1) clearcutting with reserves–sprouting, 2) clearcutting with reserves–natural seeding, 3) clearcutting with reserves–artificial regeneration, and 4) seed tree.

The most common harvest method, clearcutting with reserve–sprouting, accounted for 50% of all sites monitored. Onsite monitoring found that an additional 14 clearcut sites had scattered leave trees or leave tree clumps that met the guideline recommendations where the landowner/resource manager did not indicate the harvest method included reserve trees. Adding these sites to those previously identified as being managed with reserves, 199 of 273 (73%) used clearcutting harvest methods that provided for reserves, nearly the same proportion reported by Puettmann et al. 1996.

Most of the timber harvest activity occurred in winter (Figure 4). Winter-only harvesting occurred on 53% of the sites. An additional 13% of the sites (35) had a portion of the timber harvested in the winter. Harvesting over more than one season was found for 18% of sites.

Monitoring for 2001 and 2002 found fewer sites harvested in the summer than the 2000 monitoring results (seven and eight sites compared to 23). The difference between years likely reflects one or more of the following: 1) the random nature of site selection, 2) differences in weather between years, and 3) changes in the market situation.

Visual Quality Assessment

Landowner awareness of the visual sensitivity of his or her property is an important step in promoting the application of guidelines to protect aesthetic resources. County visual sensitivity classification maps were previously developed to assist landowners, resource managers, and operators in determining the visual sensitivity of the property to be harvested so that the appropriate guideline recommendations could be applied. Seventy-nine of the 315 sites monitored had a visual sensitivity classification (VSC) (Table 10), with 15 sites classified "most sensitive," 32 sites classified "moderately sensitive," and 32 sites classified "less sensitive." The remaining 236 sites were not visually sensitive.

Figure 4: Season of Harvest (2000, 2001, 2002)

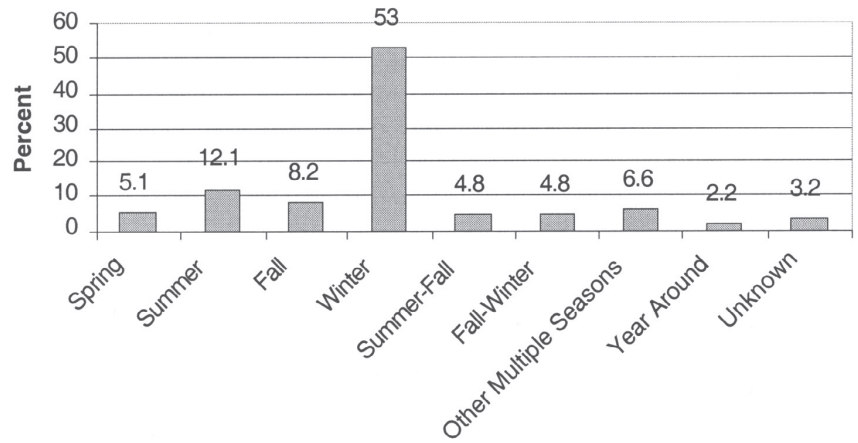


Table 10. Summary of sites by ownership and visual sensitivity classification (2000, 2001, 2002).

Landowner Category	Visual Sensitivity Classification			Total Number of Visually Sensitive Sites	Total Number of Sites
	Most	Moderate	Less		
State	6	8	15	29	103
County	4	6	9	19	96
USFS	1	2	2	5	30
Forest industry	0	0	1	1	12
NIPF	4	14	5	23	68
Other*	0	2	0	2	6
Total	15	32	32	79	315

*Tribal lands, other public agency lands, non-forest industry lands

The landowner questionnaire asked whether the landowner/resource manager and logger/operator were aware of the harvest site's visual sensitivity rating (Table 11). Landowners/resource managers reported they were aware of the visual sensitivity classification of their harvest sites on 80 of 315 sites (25%). Landowners/resource managers also reported their impression of logger/operator awareness of visual quality, indicating that only 41 of 315 (13%) were likely knowledgeable. Landowners/resource managers were incorrect about actual sensitivity ratings for their sites 9% of the time (8 of 89) (Table 12).

Table 11. Landowner awareness of visual sensitivity of timber harvest sites (2000, 2001, 2002).

Landowner Category	Total Number of Sites by Landowner Category	Total Number of Visually Sensitive Sites	Landowner Awareness	Operator Awareness
State	103	29	32	20
County	96	19	37	12
USFS	30	5	6	5
Forest industry	12	1	1	0
NIPF	68	23	3	3
Other*	6	2	1	1
Total	315	79	80	41

*Tribal lands, other public agency lands, non-forest industry lands

Table 12. Landowner Awareness Compared to Actual Visual Quality Rating in 2002

Landowner Category		Most	Moderate	Less	None	Total
State	Perceived	3	4	2	23	32
	Actual	3	4	3	22	32
County	Perceived	2	3	2	26	33
	Actual	2	4	2	25	33
USFS	Perceived	0	0	0	1	1
	Actual	0	0	0	1	1
NIPF	Perceived	3	4	0	13	20
	Actual	0	6	3	11	20
Other*	Perceived	0	0	0	3	3
	Actual	0	0	0	3	3
Total	Perceived	8	11	4	66	89
	Actual	5	14	8	62	89

* Tribal lands, other public agency lands, non-forest industry lands

The low level of awareness of visual quality sensitivity ratings and the guidelines is a concern. Information on visual quality sensitivity is available for 14 counties on the DNR Forestry Web page, but this is not well known. Efforts should be made to better inform land managers and landowners of the availability of this information.

Harvest areas tend to be more objectionable to the public as the perceived or apparent harvest size increases. This is particularly true for large, unbroken clearcuts. Apparent harvest size (the portion of a site visible from a visually sensitive travel route or vista) applies to sites in the most sensitive and moderately sensitive VSCs.

In both 2001 and 2002, the contractor conducting the onsite monitoring assigned each harvest site to one of three categories of apparent harvest: < 5 acres, 5-10 acres, and > 10 acres (Table 13).

The guidelines recommend an apparent harvest size of < 5 acres for sites classified as "most sensitive." Six of the eight sites classified as "most sensitive" had an apparent harvest size < 5 acres and the other two were 5-10 acres.

The guidelines recommend an apparent harvest size of 5-10 acres for moderately sensitive sites. 19 of the 21 moderately sensitive sites met this guideline.

Table 13. Apparent harvest size of timber harvest sites (2001, 2002).

Number of Sites by Visual Sensitivity	Apparent Harvest Size (acres)			Total
	< 5	5-10	> 10	
Most	6	2	0	8
Moderate	14	5	2	21

The TH/FM guidelines recommend various techniques be used to limit the apparent harvest size (Table 14, page 17). Eighteen of the most and moderately sensitive sites used multiple techniques to influence apparent harvest size. The techniques most commonly utilized to limit apparent size were the use of natural terrain, and tree buffers or uncut clumps of trees.

Table 14. Techniques used to limit apparent harvest size (2001, 2002).		
Technique	Visual Sensitivity Classification	
	Most	Moderate
Utilize natural terrain	4	15
Use tree buffers or uncut clumps of trees	4	15
Apply multiple stage cuts	3	7
Create narrow openings into harvest area	2	6
Shape like natural opening	2	4
Adjust contiguous linear feet of harvest frontage	1	2
Total	16	49

Protection of Cultural/Historic Resources and Endangered, Threatened, and Special Concern Species

Cultural/historic resources are generally fragile resources that are susceptible to damage from erosion, soil compaction, rutting, road construction, and other impacts associated with forest management activities. Knowledge of known resources is the first step in their protection.

One of the most critical of the guideline recommendations for cultural/historic resource protection is for landowners/resource managers to contact the appropriate organization(s) or individual(s) to check the inventory records for the presence of known cultural/historic resources prior to the initiation of the forest management activities. Nearly 55% of the landowners/resource managers did not request a check of inventory records (Table 15).

Table 15. Presence of Cultural/Historic Resources Checked by Landowner/Resource Manager (2000, 2001, 2002)

	State	County	USFS	NIPF	Forest Industry	Other*	Total
Sites Checked	55	48	23	8	2	4	140
Total Sites	103	96	30	68	12	6	315

* Tribal lands, other public agency lands, non-forest industry lands

While this low level of implementation is of concern, it needs to be viewed with caution. The individual who completed the questionnaire for each site was the landowner or the resource manager responsible for the site in question. These individuals may have answered "no" because they did not personally request the records check. However, someone else may have initiated a check of the record at an earlier stage of the planning process. This was very likely the case on state and USFS lands, and it may well be true for other ownerships.

Also, as part of the monitoring process, the state archaeologist's office was asked to check the location of all the sites monitored each year against the archaeological site inventory. The results indicated that there were no known cultural/historic resources associated with any of the sites.

However, cultural/historic resources were found or identified through personal knowledge by the landowner/resource manager on four of the timber harvest sites. Three of these cultural/historic resources were old homesteads and the fourth was an old logging camp and logging dam. For all four sites, the cultural resource areas were avoided. No landings or skid trails were located in the area of any of these resources.

Checking inventories is also a principal TH/FM guideline recommendation for protection of endangered, threatened, and special concern (ETS) species. Landowners/resource managers checked on the presence of ETS species for fewer than 50% of the sites (Table 16).

Table 16. Presence of ETS Species Checked by Landowner/Resource Manager (2000, 2001, 2002)

	State	County	USFS	NIPF	Forest Industry	Other*	Total
Sites Checked	64	49	19	2	15	4	153
Total Sites	103	96	30	68	12	6	315

* Tribal lands, other public agency lands, non-forest industry lands

Six landowners/resource managers identified the timber wolf as being in the vicinity of their land, and three noted bald eagles. These responses were likely generalized notions of wildlife habitat as opposed to these species specifically inhabiting those sites. One resource manager reported ramshead orchid near but not on a harvest site. A review of the DNR inventory of ETS species by DNR monitoring staff found one instance of a species of concern (cerulean warbler *Dendroica cerulean*) missed by the resource manager of a USFS site. No other problems were noted.

Use of Filter Strips and Riparian Management Zones

A major focus of the TH/FM guidelines is the protection of wetlands and water bodies, which include non-open water wetlands, open water wetlands, perennial and intermittent streams, lakes, seasonal ponds, and seeps and springs. The primary tools for providing this protection are filter strips and riparian management zones (RMZs).

Filter strips and RMZs serve different, but complementary, functions. Both define specified widths adjoining a wetland or water body where management activities are less intrusive than in the general harvest area. Filter strips are intended to maintain a relatively undisturbed forest floor around a wetland or water body while permitting the harvest of some or all trees within the filter strip. They disperse and slow surface flows of water, permitting the water to infiltrate into the soil and trap sediment, debris, nutrients, and chemicals before they enter a wetland or water body. Filter strips are recommended for all wetlands and water bodies.

RMZs are intended to minimize impacts to the ecological functions and values of riparian areas. Vegetative disturbance is minimized, and retention and establishment of longer-lived tree species is recommended so that critical wildlife habitats are maintained and water body temperatures remain within normal ranges. RMZs are recommended for all open water wetlands, lakes and perennial streams, and all intermittent streams wider than 3 feet.

Type and distribution of water bodies

The types and numbers of water bodies or wetlands found associated with the monitoring sites are shown in Table 17. More than 62% were found within the harvest area of a site. Nearly 38% were adjacent to the harvest area or off-site. At least one water body or wetland was found on or adjacent to 285 (90%) of the monitored sites. Non-open water wetlands far exceeded the presence of any other water body or wetland type, accounting for 77% of the total.

Table 17. Number of each type of waterbody on or adjacent to the harvest sites monitored across all landowner categories (2000, 2001, 2002).

Waterbody Type		Total	Percent
NOWW		848	77.2
OWW	<10 acres	62	5.6
	≥10 acres	12	1.1
Perennial Streams	≤3'	21	1.9
	3'≤10'	10	0.9
	>10'	26	2.4
Intermittent Streams ≤3'		43	3.9
Lakes	<10 acres	2	0.2
	≥10 acres	6	0.5
Seeps & Springs		4	0.4
Seasonal Ponds		65	5.9
Total		1099	100.0

Proper identification of seasonal ponds has been a problem for all three years of monitoring. There has been a dramatic increase in the number of seasonal ponds reported in each succeeding year of monitoring (1 of 313 water bodies in 2000, 16 of 346 in 2001, and 49 of 440 in 2002). The annual increase in the number and proportion of wetlands identified as seasonal ponds was due to additional training provided to the contractor on classification criteria for seasonal ponds.

Despite these efforts, uncertainty remains about how accurately seasonal ponds have been identified. For that reason, it is recommended that future monitoring teams include an expert in wetland classification.

Table 18. Filter Strip Disturbance

	NOWW					All Other Waterbodies					Total for All Waterbodies	
	2000	2001	2002	Total	Percent	2000	2001	2002	Total	Percent	Total	Percent
No Disturbance	NA	NA	288	632	72.2	NA	NA	167	287	74.2	919	72.8
<5% Dispersed	168	159	17			61	52	7				
<5% Concentrated	50	67	34	151	17.3	24	19	21	64	16.5	215	17.0
≥5% Dispersed	8	16	5	29	3.3	2	9	6	17	4.4	46	3.7
≥5% Concentrated	14	42	7	63	7.2	2	8	9	19	4.9	82	6.5
Total	240	284	351	875	100.0	89	88	210	387	100.0	1,262	100.0

Filter strip application

Establishment of filter strips is recommended adjacent to all perennial and intermittent streams, lakes, open water wetlands, non-open water wetlands, seasonal ponds, and seeps and springs. The recommended width of a filter strip is based on percent slope, with the width increasing as percent slope increases. The concept of the filter strip is also implicitly incorporated into the application of the RMZ.

Two primary factors assessed to evaluate implementation of the filter strip guidelines were the amount of disturbance (< 5% or ≥ 5% mineral soil exposure) and distribution of disturbance (dispersed or concentrated over the filter strip). The most effective filter strip is accomplished by keeping mineral soil exposure to < 5% dispersed over the filter strip.

Evaluating a filter strip requires measuring the slope of the land adjacent to the wetland or open water body, selecting the appropriate filter strip width recommended by the guidelines for that slope, and determining the amount and distribution of soil disturbance within that filter strip area.

The minimum filter strip width is 50 feet, increasing for slopes > 10% to a maximum width of 150 feet for slopes ≥ 70% (Table GG-1 of the TH/FM guidebook). This standard has been used within the Minnesota forestry community since publication of the 1995 BMP guidebook (MN DNR 1995).

The amount and distribution of disturbance for filter strips is shown in Table 18. A total of 1,262 filter strips were identified for 1,099 wetlands and open water bodies associated with monitored timber harvest sites. Two filter strips were required for 163 wetlands and water bodies because they completely traversed a site, or were crossed by roads or skid trails leading off the site.

The distribution and degree of disturbance in filter strips for non-open water wetlands was similar to that for open water bodies (i.e., lakes, perennial streams, open water wetlands) (Table 18). Filter strip application was found to meet the guideline recommendation (i.e., < 5% mineral soil exposure, dispersed) for 73% of the evaluations (Table 18). This result appears to be a substantial decline from the greater-than-90% compliance with the filter strip guidelines reported earlier for BMP monitoring (Phillips et al. 1994).

There are two important differences between the current and earlier monitoring procedures that help explain the apparent decline from the previous BMP monitoring results:

➤ Prior to 2000, non-open water wetlands (NOWWs) were not monitored for filter strips, and filter strips for all other water bodies on a site were rated together. Now, the filter strip (or strips) for each wetland and water body, including NOWWs, is evaluated independently.

➤ A closer review of the condition of the filter strips monitored in 2001 and 2002 reveals that more than 67% of the filter strips had no visible indications of active erosion, and 21% had sediment reaching a water body (Table 19). This may be a more appropriate comparison to the observations in prior years.

The intrusion of roads, skid trails, and landings, and the placement of associated clearing debris, can compromise the effectiveness of filter strips. These infrastructure components are the areas of greatest disturbance and should be located outside filter strips and RMZs to the greatest degree practical. Forest roads and skid trails intruded into filter strips and RMZs 132 times. This does not include entries for crossing wetlands or water bodies (see page 21).

Table 19. Filter Strip Condition – Effectiveness

	2001	2002	Total
No Erosion Visible	342	528	870
Erosion Evident	30	33	63
Sediment Reaching Waterbody	1	19	20
Total	372	561	933

Riparian management zones

The RMZ guidelines were introduced for the first time in 1999 with the publication of the TH/FM guidelines. **The reader is cautioned to remember that the results presented in this report are baseline data** reflecting management practices for sites that were harvested and/or the stumpage sold under contract prior to publication of the TH/FM guidebook. Subsequent monitoring will describe how these practices change over time in response to availability of RMZ guidelines.

A total of 142 water bodies for which RMZs are recommended were found on or adjacent to monitored sites: 75 of these were open water wetlands; nine were lakes; 57 were perennial streams; and one was an intermittent trout stream tributary (Figure 5). 11 of the streams (10 perennial and one intermittent) traversed the harvest area, and a separate RMZ was evaluated for each side, resulting in a total of 153 RMZs.

Data characterizing the full recommended RMZ width for each type and size of water body were collected from measurements of a representative cross section. The width of non-forest, undisturbed forest, partially harvested forest (BA > 25 sq.ft./acre), and clearcut (BA < 25 sq.ft./acre) was recorded. Many RMZs had significant areas of non-forest vegetation (i.e. grass, sedge, brush, or shrubs) or were entirely composed of non-forest vegetation. The recommended RMZ guidelines for width and residual tree BA were met nearly 52% of the time (Figure 5).

Figure 5: RMZs That Met Guidelines for Width and BA (2000, 2001, 2002)

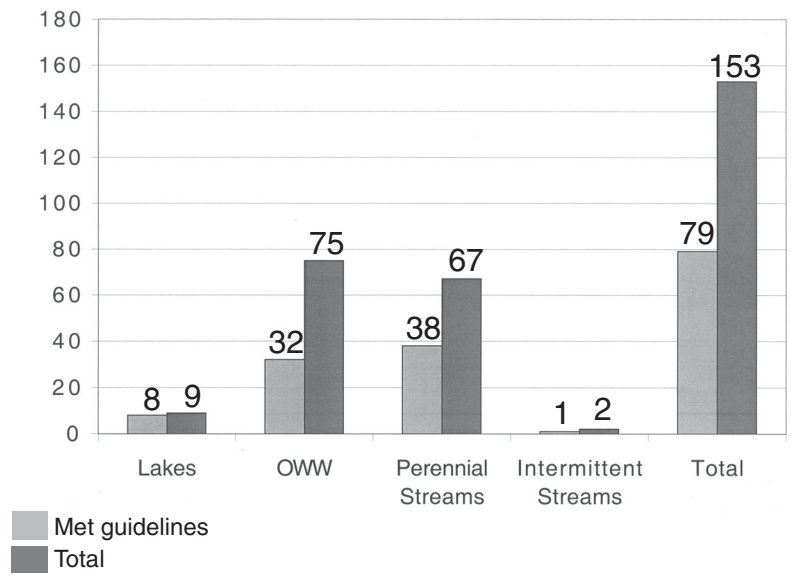
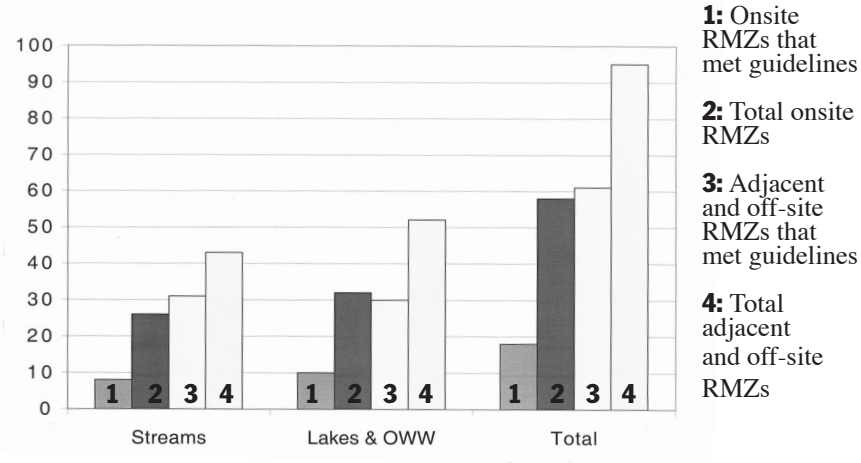


Figure 6: Width and BA Guideline Implementation: Onsite RMZs vs. Adjacent and Off-Site RMZs (2000, 2001, 2002)



Water bodies adjacent to the harvest area or off-site were more likely than water bodies within the harvest area to have an RMZ that fully met the guideline recommendations for width and residual BA (Figure 6).

Only 31% of the RMZs for water bodies within the harvest area fully met the guideline recommendations for width and basal area, compared to 64% of the RMZs for water bodies adjacent to the harvest area. The RMZ guidelines for basal area and width were met most frequently (76%) for streams wider than 3 feet, adjacent to or off-site, followed by lakes and open water wetlands (OWWs) larger than 10 acres, adjacent to or off-site (65%).

Protection of Water Quality and Wetlands

Water body and wetland crossings

Crossing wetlands and water bodies while conducting a forest management activity has the greatest potential for directly impacting water quality and the hydrologic and biologic function of these water bodies. Equipment using a crossing may alter the cross section of a wetland or water body, carry mud and debris into the wetland or water body, or leak fuel, oil, or other hazardous fluids into the wetland or water body. The approaches to a crossing can serve as a funnel directing surface water flow, and the attendant loads of sediment, organic debris, nutrients, and chemicals, directly into a wetland or water body.

In addition, the crossing itself may modify the movement of water within a wetland or water body, disrupt the movement of fish and other aquatic organisms, or cause upstream ponding, increased channel scouring, or destabilization of the banks. If crossings are not properly installed, maintained, and rehabilitated, many of these problems can become significant and continue long after the crossing ceases to be used.

Crossings of wetlands and water bodies should be avoided whenever practical, but they are often necessary to access or operate on a forest management site. Skid trail crossings are generally confined to the harvest area and are temporary in the majority of cases. Many forest roads and associated crossings are also temporary, while others become part of a permanent, maintained management and recreational transportation system.

The three years of field monitoring found 548 skid trail and road crossings of non-open water wetlands, open water wetlands, and perennial streams (Table 20). There were 1,033 approaches to these crossings, and an additional 80 approaches for entering wetlands to harvest timber (Table 21).

Table 20. Road and skid trail crossings by waterbody and wetland type (2000, 2001, 2002).

Waterbody Type	Road Crossings	Skid Trail Crossings	Total
NOWW	167	281	448
OWW	5	4	9
Seasonal Pond	1	1	2
Seep	0	1	1
Perennial Stream	46	26	72
Intermittent Stream	7	9	16
Total	226	322	548

Table 21. Types of approaches for roads and skid trails (2000, 2001, 2002).

	Roads	Skid Trails	Total
Crossings	401	632	1,033
Entering Wetland to Harvest Timber	18	62	80
Total	419	694	1,113

Crossings of and approaches to wetlands and open water by season of operation are given in Table 22. More than 68% of all crossings and approaches were found on winter-only operations. The majority of winter crossings of wetlands and open water bodies were assumed to have been frozen (Table 23), limiting the potential for damage. Fifty-nine percent of the crossings were for skid trails (Table 20, page 21), and the majority of crossings (82%) were on non-open water wetlands.

Table 22. Number of road and skid trail water and wetland crossings by season of operation (2000, 2001, 2002).

Season of Operation	Road and Skid Trail Crossings
Spring	2
Summer	31
Fall	36
Winter	366
Summer-Fall	19
Fall-Winter	26
Summer-Fall-Winter	44
Other Multiple Seasons	7
Year round	7
Unknown	10
Total	548

Table 23. Crossing structures applied on roads and skid trails (2000, 2001, 2002).

Structure Type	Number of structures		
	Roads	Skid Trails	Total
Frozen	93	117	210
Ice bridge	13	25	38
Corduroy or Slash Mat	1	33	34
Log or Slash Bundle	14	6	20
Culvert	16	2	18
Fill	12	1	13
Ford	9	1	10
Wood mat	2	2	4
Dry	0	3	3
Bridge	1	0	1
Total Crossing Structures	161	190	351
Unknown or No Crossing Structure	80	132	212
Total	226	322	548

Approaches to water bodies and wetlands

The approaches to any crossing are just as important for protecting water quality as the crossings themselves. Failure to divert surface flows of water off a road or skid trail before it enters a filter strip or RMZ—and before it reaches the wetland or water body—can increase erosion and permit sediment, organic materials, nutrients, or chemicals to flow directly into a wetland or water body. Water diversion practices need to be in place as soon as a crossing and/or approach are created. These practices also need to be maintained as long as the crossing exists and until the location is stabilized once the crossing is removed.

Selecting crossing locations where the approaches are nearly flat or have a minimal grade creates less potential for erosion. Operations on frozen soil generally result in less disturbance, which also minimizes the risk of erosion. Fortunately, most approaches are nearly flat. Approximately 49% of all approaches monitored had a grade ≤ 2%, and 75% had a grade ≤ 5% (Table 24).

Table 24. Grade of approaches to road and skid trail crossings (2000, 2001, 2002).*

Approach Grade	Number of Approaches		
	Roads	Skid Trails	Total
<2%	230	317	547
2<5%	97	191	288
5<10%	60	102	162
10<15%	13	29	42
15<25%	4	9	13
≥25%	1	6	7
Unknown	14	40	54
Total	419	694	1,113

* Length of approaches is not summarized due to contractor misunderstanding of what data to record

Only 77 of the 1,113 approaches had any type of water diversion practices in place (Table 25, page 23). However, more detailed data in 2002 indicate that most approaches are in good condition. Approximately 90% were found to be more than 50% vegetated; fewer than 6% were rutted or visibly eroding; and 3.4% had sediment reaching the wetland or water body (Table 26, page 23).

Table 25. Water diversion structures for road and skid trail approaches to crossings (2000, 2001, 2002).			
Structure Type	**Number of Structures**		
	Roads	**Skid Trails**	**Total**
Scattered slash	2	43	45
Seeding	11	0	11
Lead-off ditch	5	3	8
Water bars (all types)	2	4	6
Natural vegetation	0	2	2
Broad based dips	2	0	2
Gravel surfacing	1	0	1
Natural barriers	1	0	1
Mulch	1	0	1
Total with Structures	25	52	77
No Structures	394	642	1,036
Total Approaches	419	694	1,113

Table 26. Condition of Approaches (2002)								
	Roads			**Skid Trails**			**Grand Total**	
	Yes	**Percent**	Total	Yes	**Percent**	Total	**Percent**	Total
Diversions Used	14	**11.7**	120	35	**13.5**	259	**12.9**	379
>50% Vegetated	104	**86.7**	120	240	**92.7**	259	**90.7**	379
Rutted	2	**1.7**	120	20	**7.7**	259	**5.8**	379
Erosion Evident	12	**10.0**	120	10	**3.9**	259	**5.8**	379
Sediment Reaching Waterbody	9	**7.5**	120	4	**1.5**	259	**3.4**	379

While the problem appears to be limited, these results reinforce the need to strongly emphasize the use of water diversion practices for wetland and water crossing approaches in training programs for loggers, natural resource professionals, and landowners. It also highlights the need to encourage inclusion of explicit language regarding these practices in contracts, as well as improved project supervision to ensure effective crossing practices are appropriately employed.

Protection of Forest Soil Resources

Soil productivity is determined by a wide variety of factors. Human activities on a site can significantly impact many of them, enhancing or reducing soil productivity. The TH/FM guidelines attempt to limit negative impacts and encourage practices that will maintain or enhance productivity. The two most significant timber harvest activities that can affect soil productivity are logging and hauling equipment traffic on forest soils, and the removal of biomass from a site.

Logging and hauling equipment traffic on forest soils

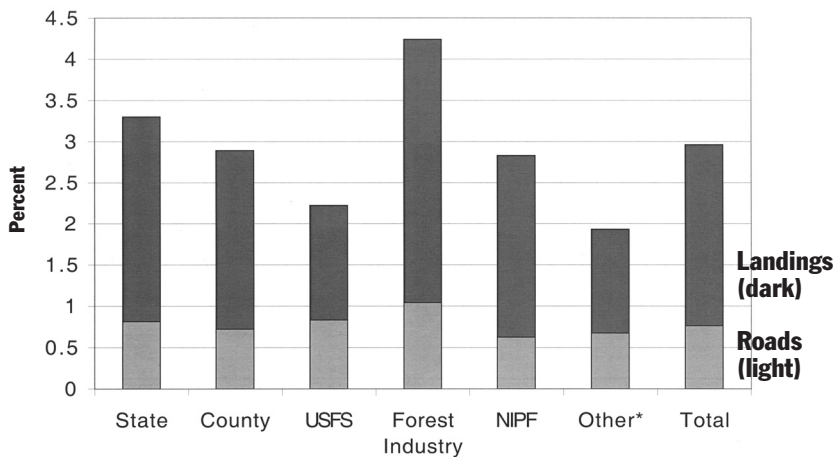
The greatest potential for adverse impacts from equipment trafficking on forest soils is on the roads, landings, and primary skid trails, where repeated traffic occurs. Equipment traffic can compact and rut soil, remove vegetation whose root systems hold the soil in place, reduce infiltration of air and water into and through the soil, and redirect surface water flow.

These impacts restrict plant root growth, reduce the availability of nutrients and moisture for plant growth, increase the potential for erosion, and can change the surface and subsurface hydrology of a site. Some impact from equipment operation is unavoidable during a timber harvest. The first step in minimizing those impacts is limiting the area trafficked by equipment.

The TH/FM guidelines recommend that basic infrastructure (i.e. roads and landings) occupy no more than 3% of the harvest area. Figure 7 (page 24) shows the average percentage of sites in roads and landings for all ownerships, and by landowner category. The statewide averages were very similar all three years. The percentage of infrastructure averaged 3.0% for all ownerships, ranging from a high of 4.2% on forest industry lands to a low of 1.9% on tribal lands, other public agency lands, and non-forest industry lands.

Landings

The most prolonged and intense equipment activity on a harvest site is normally on the landings. This is where the harvested trees or logs are skidded for processing and loading, and where most equipment maintenance and fueling occurs. Minimizing the area occupied by landings and locating them away from wetlands and water bodies and outside of filter strips and RMZs are especially important for these reasons.



* Tribal lands, other public agency lands, non-forest industry lands

A total of 540 landings was identified during monitoring. All landings were located on stable ground, indicating locations were utilized that are not susceptible to slumping or landslides. This included wetland locations, which were frozen during use. On average, landings occupied 2.2% of sites (Figure 7).

Landings and associated fueling and maintenance areas were located outside filter strips, RMZs, and wetlands 61% of the time. They were located outside wetlands and water bodies 79% (428 of 540) of the time (Table 27).

Table 27. Landing locations (2000, 2001, 2002).

	Total number of landings	Upland Outside Filter Strips, RMZs & Wetlands	In RMZ & Filter Strip	In Filter Strip	In Wetland & Filter Strip	In Wetland
Total	540	332	11	85	29	83

Table 28. Condition of Landings (2002)

Landowner Category	Total Number of Landings	>50% Vegetated	Rutting Evident		Erosion Visible	Sediment Reaching Waterbody	Logging Trash Present	Other Trash Present
			≤2%	>2≤5%				
State	65	55	1	0	10	0	15	3
County	53	43	1	2	3	1	8	4
USFS	1	1	0	0	0	0	0	0
NIPF	29	24	0	0	2	0	3	5
Other	3	2	0	0	0	0	0	1
Total	151	125	2	2	15	1	26	13
Percent		82.8%	1.3%	1.3%	10.0%	0.7%	17.2%	8.8%

Landings were generally found in fair to good condition. Data for 2002 (Table 28) showed that nearly 83% were vegetated, with very little rutting observed. Almost 10% of the landings did have visible erosion occurring, and trash was found on 26% (2/3 from logging and 1/3 from other sources).

Forest roads

The TH/FM guidelines recommend limiting the mileage on forest roads to the minimum necessary to accomplish the landowner's management objectives. The guidelines also recommend careful location, design, construction, maintenance, and closure of forest roads as a means of reducing costs and improving operability, and limiting the area disturbed, compacted, and exposed to minimize the potential for erosion.

Forest roads occupied an average of 0.8% of the harvest area on all ownerships for the three years of monitoring. The area in forest roads ranged from 1.0% for forest industry land to 0.6% for NIPF lands. These data only account for the acreage in roads within the harvest site. It does not include the area of roads utilized to access the site, or roads adjacent to or crossing the site but not utilized for the harvest operation monitored.

The TH/FM guidelines recommend using an appropriate combination of erosion control and water diversion practices on all road segments, especially those with a grade ≥ 2%. Unlike the BMPs in use prior to 1999, the current guidelines recommend using these practices in all locations, not just where there is a potential for surface runoff and sediment to impact water quality.

These practices should be employed during construction, as long as the road exists, and after it is permanently closed until the site is revegetated and stabilized. However, implementation monitoring is only able to collect data for practices in place after the harvest activity is complete, and data collection is only practical for road segments with a grade ≥ 2%.

A total of 311 road segments with a grade ≥ 2% were identified during the three years of onsite monitoring. More than 85% of the segments had a grade less than 10%, as is recommended in the guidelines (Table 29).

Table 29. Number of road and skid trail segments within various percent grades (2000, 2001, 2002).

Segment Grade	Number of Segments		
	Roads	Skid Trails	Total
2<5%	110	39	149
5<10%	156	298	493
10<15%	39		
15<25	5	146	151
≥25%	0		
Unknown	1	68	69
Rock Outcrops	0	8	8
Total	311	559	870

In 2001 and 2002, only 22 of the 156 road segments had any erosion control or water diversion practices installed (Table 30). In some cases, site conditions may have been stable enough so that these practices were not needed. However, 2002 data (Table 31) indicated more than 59% of road segments had visible erosion occurring, and nearly 12% had sediment reaching a wetland or water body. This lack of use of erosion control and water diversion practices is a cause of concern that has been and will continue to be addressed in future training programs for loggers and natural resource managers.

Access control is an important factor for limiting the negative impacts on soil and water of excess traffic on forest roads. Forest roads are frequently intended for temporary or seasonal use and have low traffic volumes. As a result, they are constructed to a lesser standard than county and state highways. If used when the road base is soft due to wet conditions, these roads can be easily damaged. Adequate access control limits such damage and reduces problems with erosion, rutting, and continuing maintenance. To this end, the TH/FM guidelines recommend temporarily closing roads when conditions warrant, and permanently or temporarily closing roads when not in use.

Table 30. Water diversion structures on road and skid trail segments (2001, 2002).

Structure Type	Number of Segments Each Type of Structure was Used		
	Roads	Skid Trails	Total
Scattered slash	2	165	167
Water bars (all kinds)	4	18	22
Profile	5	1	6
Seeding	4	0	4
Lead-off ditch	4	0	4
Natural barriers	1	1	2
Broad based dips	2	0	2
Number of Segments with Structures	22	181*	203*
Number of Segments with No Structures	134	209	343
Total Segments	156	390	546

*Multiple types of structures were used on some segments

Table 31. Condition of Segments (2002)

	Roads			Skid Trails			Grand Total	
	Yes	**Percent**	Total	Yes	**Percent**	Total	**Percent**	Total
Diversions Used	16	**23.2**	69	65	**50.7**	128	**41.1**	197
>50% Vegetated	24	**34.7**	69	60	**46.9**	128	**42.6**	197
Rutted	0	**0**	69	7	**5.5**	128	**3.6**	197
Erosion Evident	41	**59.4**	69	3	**2.3**	128	**22.3**	197
Sediment Reaching Waterbody	8	**11.6**	69	1	**0.8**	128	**4.6**	197

Twenty-four of the 315 sites monitored did not have forest roads. These sites were located adjacent to township or county roads or state highways. The status of three roads could not be determined. These were NIPF lands where the landowner declined to complete the landowner questionnaire, and the contractor was unable to determine the road status during the onsite inspection.

On the other 288 sites, approximately 50% (145 of 288) of the forest roads remained active (intended to be open to traffic) after the timber harvest being monitored was complete (Table 32). Only seven of these roads had access controlled by gates or other means. Many of these roads were all-season roads utilized for many activities. Most of the remaining roads (39%) were temporarily closed, and access was controlled on one-third of these. The roads on 30 sites (10%) were identified as permanently closed, and access was controlled on 80% of these.

Table 32. Road Status (2000, 2001, 2002).

Access Control Status	Active	Temporarily Closed	Permanently Closed	Cannot Determine	No Roads	Total
Controlled	7	75	26	NA	NA	108
Not Controlled	138	38	4	NA	NA	180
Cannot Determine	0	0	0	3	24	27
Total	145	113	30	3	24	315

Skid trails

Skid trails are generally more difficult to delineate than roads and landings. The TH/FM guidelines recommend limiting primary and secondary skid trails to no more than 10-15% of the harvest area. While primary skid trails are often relatively easy to detect, identification of secondary skid trails is problematic.

Because of this limitation, no effort was made to determine an exact proportion of the site in skid trails. Instead, the contractor was required to estimate whether the primary or secondary skid trails occupied < 15% or > 15% of the harvest area or to report that these values could not be estimated (Figure 8). Skid trails were found to occupy < 15% of the harvest area on 76% of the sites. On 19% of the sites, the area occupied by skid trails could not be determined.

The contractor was also required to identify the dominant skidding pattern for the harvest site. These results are shown in Figure 9. Skidding was focused on skid trails on 43% of the sites. On 57% of the sites, the skidding pattern was either not evident or was randomly distributed lightly over most of the site. These data conflict with the contractors' determinations that skid trails occupied < 15% of the harvest area for 76% of the sites. Short of adopting much more intensive and expensive sampling methods, it is unclear how to more accurately monitor the area occupied by skid trails.

Figure 8: Percent of Harvest Area Occupied by Skid Trails (2000, 2001, 2002)

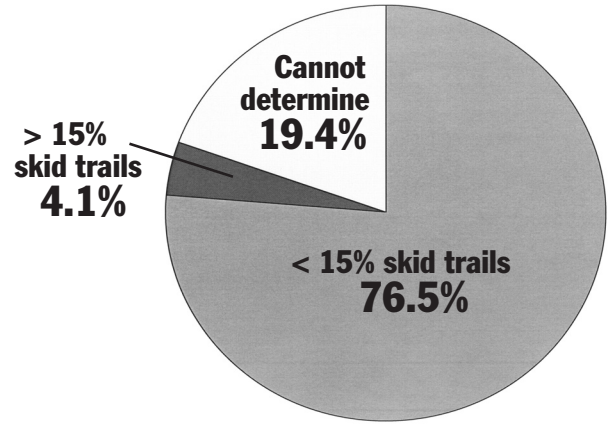
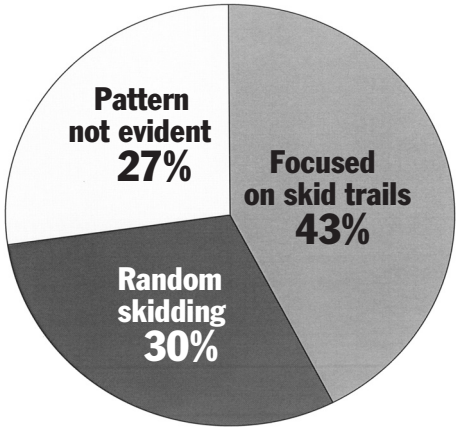


Figure 9: Skidding Pattern (2000, 2001, 2002)



As with roads, the TH/FM guidelines recommend using an appropriate combination of erosion control and water diversion practices on all skid trail segments, especially those with a grade ≥ 2%. Table 29 (page 25) shows the number of skid trail segments identified with a grade ≥ 2%. A total of 390 of these skid trail segments were identified, but data on the observed percent grade were recorded for only 322. Only 24% of these segments had a grade of ≤ 10%, while 7% had a grade > 25%.

Unlike roads, however, 56% of the skid trail segments had some type of erosion control and/or water diversion practice in place (Table 30, page 25). The most common practice was the placement of scattered slash embedded in the traffic surface, which helps divert and slow surface water flow. This practice likely contributed to the low (2.3%) occurrence of visible erosion noted during 2002 monitoring fieldwork (Table 31, page 25). Ongoing training should continue to emphasize the need for these practices.

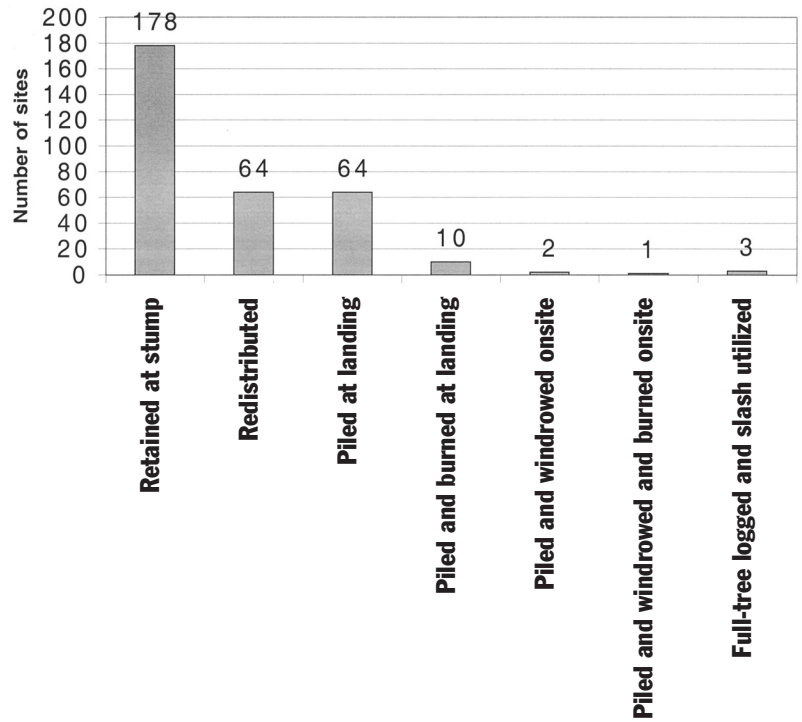
Slash disposal and distribution

Retaining or redistributing slash on the site is important as a major nutrient-retention strategy. This strategy is particularly important for nutrient-poor sites with soils that are: 1) predominantly deep, well-drained, or excessively well-drained sand; 2) predominantly deep organic soils (> 24 inches deep); or 3) predominantly shallow soils (< 8 inches deep) over bedrock.

Slash also provides cover, food, and growing sites for plants and animals. The positive benefits to retaining or redistributing slash on the site must be balanced with the need to safely and efficiently operate equipment on the site, to regenerate the stand, and to minimize the potential for additional compaction that might occur from redistributing the slash.

The results of this evaluation are given in Figure 10. Slash retained on the site at the stump was the most common method found and was applied on 59% of the sites. This is the preferred method of slash disposal for maintaining forest soil productivity on most sites. Slash piled at landings and slash piled and burned were methods utilized on 25% of the sites. Frequently this was done as part of preparing the site for replanting or as a means of pest control. A combination of two slash disposal methods was utilized on seven sites.

Figure 10: Slash Management (2000, 2001, 2002)



Rutting

Rutting is the creation of depressions made by the tires or tracks of equipment involved in forest management activities (e.g., skidders, forwarders, log trucks). It occurs when soil strength is not sufficient to support the load applied by the vehicles.

The adverse effects of rutting include modifying the surface hydrology of the site for both upland and wetland soils, damaging roots, compacting the soil, and plugging soil pores. The latter two inhibit root growth, reduce aeration, and slow or disrupt movement of water into and through the soil.

The contractor was required to collect information on whether rutting occurred in wetlands, RMZs, filter strips, roads, skid trails, and the general

harvest area. Some of these results are reported in the sections pertaining to these specific features. In 2000, the presence or absence of rutting was noted for wetland inclusions, filter strips, RMZs, roads, and skid trails. The presence of rutting was also noted for the general harvest area if rutting exceeded 5% of the harvest area.

This latter criterion was changed to 2% for 2001. For 2002, six ranges of percent rutting were identified (none, < 2%, 2 < 5%, 5 < 10%, 10 < 25%, ≥ 25%) for wetlands, filter strips, RMZs, upland harvest areas, wetland harvest areas, water body crossings, approaches to crossings, road and skid trail segments with a grade ≥ 2%, and the general road and skid trail system observed on each site.

The TH/FM guidelines recommend minimizing rutting on the roads, skid trails, and landings, and avoiding rutting in the general harvest area (TH/FM guidebook, Timber Harvest, page 28). Rutting was found on 122 (39%) of the sites (Figure 11). Rutting was confined to just the roads, skid trails, and landings on 48 of the 122 sites (Figure 11).

Figure 11: Sites Where Rutting Was Observed (2000, 2001, 2002)

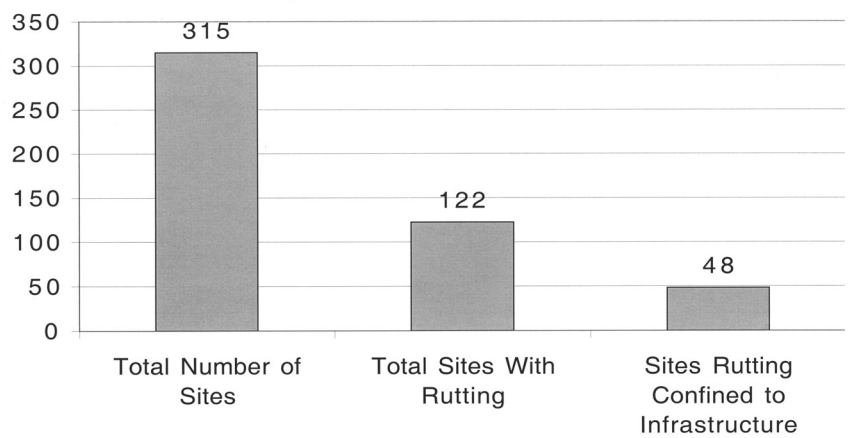
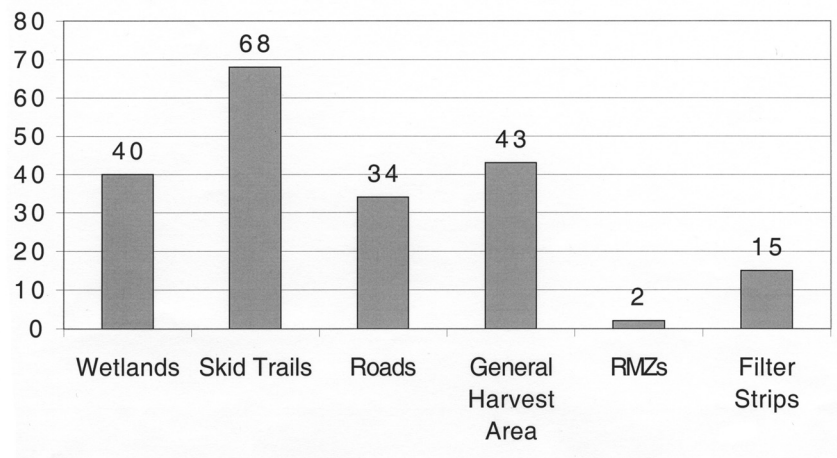


Figure 12: Locations Where Rutting Was Observed (2000, 2001, 2002)



These 48 sites meet the guideline for restricting equipment impacts to the site infrastructure but may depart from other guidelines due to erosion and sedimentation. The numbers of sites where rutting was found for specific site features is given in Figure 12. It was common to find that rutting had occurred on more than one site feature.

On 15 sites, the contractor reported ruts on skid trails in wetland crossings that exceeded 6 inches in depth for distances greater than 300 feet in length or that bisect the wetland. Ruts in excess of these values can induce blockage of cross drainage, resulting in the ponding of water up gradient to the flow.

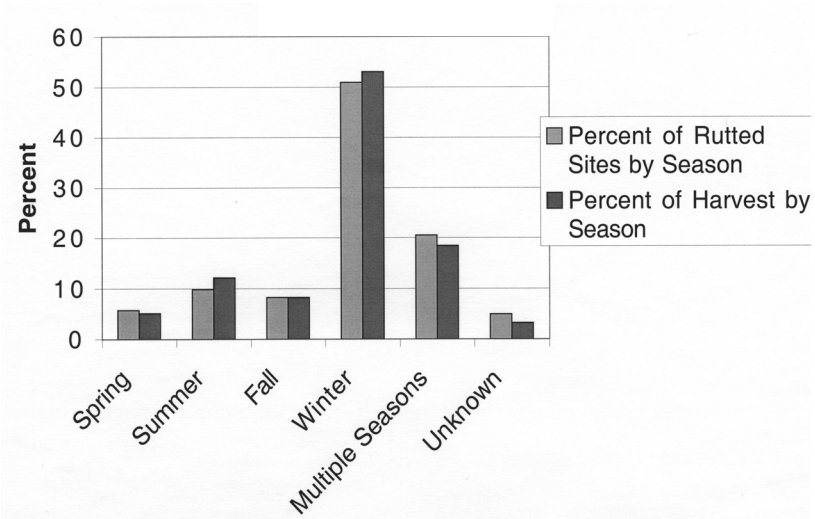
Data collected in 2002 provided more detail on the location and extent of rutting than in the previous two years. It is encouraging to note that only 136 of 2,257 locations evaluated for rutting in 2002 had been rutted (Table 33, page 29). Most (78%) had less than 5% of their surface area in ruts, and 47% (64 of 136) of the rutting was confined to roads, skid trails, and landings.

Table 33. Number of Site Features Rutted by Category of Rutting (2002)								
Feature or Location		Percent of Area in Ruts						
		≤2%	2≤5%	5≤10%	10≤25%	>25%	Total Locations With Ruts	Locations With No Rutting
General Harvest Area	Upland	3	1	0	0	0	4	73
	Wetland*	12	2	3	0	1	18	45
Adjacent or Small On-Site Wetlands	NOWW*	8	9	0	0	0	17	320
	Seasonal Ponds*	2	0	0	0	0	2	46
Crossings	Roads~	0	0	0	0	0	0	61
	Skid Trails#	0	0	0	0	3	3	115
Approaches	Roads~	0	0	0	2	0	2	117
	Skid Trails#	3	5	3	8	3	22	239
Segments	Roads~	0	0	0	0	0	0	69
	Skid Trails#	3	2	1	1	0	7	121
Filter Strips		15	7	0	0	1	23	538
RMZs		0	0	0	0	0	0	39
Landings		2	2	0	0	0	4	145
Roads	Active~	6	1	1	1	0	9	17
	Closed~	4	0	0	0	0	4	50
Skid Trails#		14	5	0	1	1	21	68
Total		72	34	8	13	9	136	2,121
Total Number of Locations Evaluated for Rutting							2,257	

* There is some limited overlap between these categories
~ There is some limited overlap between these categories
\# There is some limited overlap between these categories

Rutting occurred in roughly the same proportion for all seasons of timber harvest (Figure 13). This fact emphasizes the need for landowners/managers and loggers to ensure that the soil is dry and firm or adequately frozen to support harvest operations.

Figure 13: Season of Harvest vs. Rutting (2000, 2001, 2002)



Applications for Wildlife Habitat

Coarse woody debris

Coarse woody debris (CWD) is an important component of forest sustainability, as it provides habitat for forest animal life and plants as the stand regenerates following forest management activities. The guideline recommendation is to create or retain two to five bark-on down logs per acre at least 6 inches in diameter for the general harvest area.

The recommendation for riparian areas is for at least four “bark-on” down logs per acre that are at least 6 inches in diameter. The guidelines are further refined by recommending that hollow butt sections or other defective lengths of at least 6 feet are preferred, and that sound logs and 6-inch to 12-inch diameter logs can be used if they represent the best available candidates.

Monitoring results from 2000 (Phillips 2001) reported that landowners were not meeting the guideline recommendation. Only 21% and 22% of general harvest areas and riparian management zones, respectively, met the guideline recommendation for "bark-on" down logs (Phillips 2001). It was suggested that, for many of these logs, the bark had sloughed off by the time the inspections were conducted. For monitoring in 2001 and 2002, the standard was modified to evaluate decay classes of "sound" down logs as described by Harmon et al. 1986.

The results for 2001 and 2002, reported in Table 34**,** indicate the guideline recommendation for "sound" down logs was met 79% (162 of 205) of the time in general harvest areas. Twenty-nine of the 93 RMZs identified in 2001 and 2002 were entirely non-forested or had no harvest activity. Sixty-nine percent (44 of 64) of the RMZs that did have harvest activity met the CWD guideline.

Table 34. Bark-on down logs per acre for general harvest area and RMZ by statewide and landowner category. (2001, 2002)

Landowner Category	Total number of sites by landowner category	Total number of RMZs by landowner category	Bark-on down logs (number of sites)					
			General harvest area*			RMZ		
			< 2	2-5	>5	< 4	≥ 4	NA**
State	76*	34	14	28	31	8	16	10
County	65	28	7	31	27	1	16	11
USFS	13	2	1	7	5	0	0	2
Forest industry	7	3	2	3	2	2	0	1
NIPF	43	26	17	14	12	9	12	5
Other#	3	0	1	0	2	0	0	0
Total	207	93	42	83	79	20	44	29

Tribal lands, other public agency lands, and non-forest industry lands
*Data not recorded for the general harvest area for 3 state site2
**RMZs that are non-forest or had no harvest activity

Leave tree distribution

The TH/FM guidelines recommend retaining leave trees and snags on clearcut timber harvests to provide vertical structure for wildlife species as the stand regenerates. These guidelines provide two options for meeting the leave tree recommendations.

One option is to retain six or more scattered individual leave trees per acre on the harvest area. The second option is retaining a minimum of 5% of a clearcut harvest area in leave tree clumps of at least 1/4 acre. In both cases the trees must be at least 6 inches in diameter of a mix of desirable species. The preferred alternative is to retain clumps.

In 2001 and 2002, landowners/resource managers were asked whether their timber harvest planning included retaining leave trees and snags. The landowners/resource managers indicated that leave trees and snags were to be retained on 79% and 73% of the 2001 and 2002 timber harvests, respectively. Onsite observations revealed that at least some leave trees were retained on 92% of the clearcut sites.

Where these resources were not to be provided, the landowner/resource manager was asked to specify the reason. The major reason cited for not providing leave trees was to facilitate aspen management.

Other reasons included concern for operator safety, and insect and disease issues. Reasons cited (often several per site) for not providing snags included concerns for visual quality (8), public safety (4), specific forest management applications (8), insects and disease (3), and operator safety (5).

The leave tree guidelines were fully met by either scattered leave trees or clumps on 146 (49.8%) harvest areas and 167 (57%) total sites out of the 293 sites where the guidelines apply (Table 35). An additional 118 sites had some leave trees (both leave tree clumps and scattered leave trees), but did not fully meet the guidelines. Over all three years there were only 15 sites where the leave tree guidelines should apply that had no leave trees at all.

Table 35. Number of sites with ≥6 scattered leave trees and/or ≥5% of total site in leave tree clumps (2000, 2001, 2002).

Landowner Category	Number of sites for which leave tree recommendations apply	Number of sites with ≥6 scattered leave trees per acre	Number of sites with ≥5% of harvest area in leave tree clumps	Number of sites with ≥5% total site in leave tree clumps	Number of sites with ≥6 scattered leave trees and ≥5% of harvest area in leave tree clumps	Number of sites with ≥6 scattered leave trees and ≥5% of total site in leave tree clumps
State	91	47	14	17	44	49
County	93	33	23	34	38	44
USFS	29	19	9	15	19	22
Forest industry	11	1	3	6	3	5
NIPF	63	42	13	18	40	45
Other	6	1	2	2	2	2
Total	293	143	64	92	146	167

Nearly 49% (143 of 293) of the timber harvest sites met the guideline with scattered trees alone. Seventy-eight of these sites had scattered leave trees only, and 65 had both scattered leave trees and leave tree clumps.

Leave tree clumps are most frequently located onsite; however, appropriate areas adjacent to a clearcut may be considered in evaluating leave tree acreage. The Council's Guideline Implementation Monitoring Technical Committee adopted a standard for including adjacent clumps of mature trees as leave trees.

The clumps had to be located between the site and an adjacent RMZ or other resources (e.g., cultural resource, visual buffers, wetlands), and the leave tree clump could not be large enough to be commercially manageable by itself.

A total of 64 of 293 sites had ≥ 5% of the harvest area retained in internal leave tree clumps (i.e., those totally within the cut boundaries of the harvest area). The 64 sites averaged 11.1% of the harvest area in leave tree clumps (Table 36).

When leave tree clumps adjacent to a site were considered, 92 of 293 clearcut sites had ≥ 5% of the total site acreage retained in leave tree clumps (Table 37). Total leave tree clumps for the 92 sites averaged 12.2% of the total site. All sites that met the leave tree guideline with clumps also had scattered leave trees.

Table 36. Percent of timber harvest area occupied by internal leave tree clumps by landowner for those sites with >5% acreage in internal leave tree clumps (2000, 2001, 2002).

Landowner Category	Total number of sites by landowner category	Number of sites for which leave tree recommendations apply	Number of sites with internal clumps >5% of harvest area	Average percent of harvest area in internal clumps for those sites with internal clumps
State	103	91	14	13.2
County	96	93	23	11.0
USFS	30	29	9	9.0
Forest Industry	12	11	3	9.4
NIPF	68	63	13	11.6
Other	6	6	2	8.9
Total	315	293	64	11.1

Table 37. Percent of timber harvest sites occupied by total leave tree clumps by landowner for those sites with >5% acreage in total leave tree clumps (2000, 2001, 2002).

Landowner Category	Total number of sites by landowner category	Number of sites for which leave tree recommendations apply	Number of sites with total leave tree clumps >5% of harvest site	Average percent of total site area in clumps for those sites with clumps
State	103	91	17	15.1
County	96	93	34	11.7
USFS	30	29	15	11.3
Forest Industry	12	11	6	11.6
NIPF	68	63	18	11.7
Other	6	6	2	8.9
Total	315	293	92	12.2

Distribution of snags

Snags provide habitat for wildlife requiring tree cavities, perches, and bark foraging sites. For monitoring purposes, a snag was defined as a dead tree stem standing at least 8 feet tall and 6 inches DBH (diameter at breast height). The TH/FM guidebook is not specific in recommending numbers of snags or their distribution on the timber harvest site. The inference is to provide for as many snags as possible. This lack of more specific guidance makes it difficult to determine whether the guideline is being met beyond the question of "Were snags retained?"

The Council's Guideline Implementation Monitoring Technical Committee agreed to collect data on numbers of snags retained. Four categories for snags were agreed to: 0, < 1, 1-2, and > 2 per acre. These categories were selected with no definitive knowledge of the numbers of snags needed as a category or in combination with leave trees to provide the vertical structure for maintaining a sustainable level of wildlife habitat.

In 2000, 80 of 104 sites retained snags, but the number per acre was not recorded. In 2001 and 2002, the recommendations for leaving snags applied to 175 of 207 sites, excluding thinnings and shelterwood management. Over all three years, 94% (242 of 255) of the sites where the snag guideline applied did retain some snags. Seventy-two percent of the 2001-2002 sites retained at least one snag per acre, with 36% of sites having more than two snags per acre (Table 38).

Table 38. Number of timber harvest sites statewide with snags retained for vertical structure (2001, 2002).

	Snags/acre			
	0	< 1	1-2	> 2
Number of Sites	13	36	62	64

Maintaining oaks

The TH/FM guidelines recommend retaining oaks on harvest areas for continued mast production during stand regeneration. Eighty-three percent (44 of 53) of the sites with oak present in the adjoining stand had oak retained as leave trees within the harvest area.

Quality Control

A quality control team made up of representatives of the Technical Committee visited 29 sites, or 9.2% of the total, to review and evaluate compliance with contract specifications for site monitoring. This process confirmed that data were being properly collected and provided helpful feedback to the contractor as their work proceeded. In addition, the quality assurance/quality control (QAQC) process provided useful insight for the QAQC team for determining whether the monitoring forms and field procedures were appropriate or in need of additional modification.

Conclusions

The implementation monitoring data for 2000, 2001, and 2002 establish the baseline against which future implementation monitoring of Minnesota's timber harvest and forest management guidelines can be assessed.

Analysis of the data showed that, prior to the publication of the guidelines, the forestry community complied reasonably well with some of the guidelines and not very well with others.

Analysis of the data showed that, prior to the publication of the guidelines, the forestry community complied reasonably well with some of the guidelines (e.g. RMZ width and residual basal area, filter strip integrity, amount of infrastructure on site), and not very well with others (e.g. water diversion practices, roads and skid trail segments, and approaches to crossings).

Implementation of recommended guideline practices was highest on publicly administered and forest industry lands, and lowest on NIPF lands.

This baseline report on TH/FM guideline implementation:

➤ **Provides a description of timber harvest practices being applied in Minnesota prior to availability of the integrated TH/FM guidelines,** and how those practices compare to recommendations contained in the guidebook. Specific conditions and practices assessed include riparian management, water and wetland approaches and crossings, pre-harvest planning, conformance with visual quality recommendations, slash disposal and distribution, extent of rutting, leave tree distribution, site infrastructure percentage (roads and landings), skid trail distribution, and water diversion device use for roads and skid trails.

➤ **Confirms the need to emphasize continued education and training efforts for loggers, resource managers, and landowners,** particularly in the areas of installing appropriate protection measures for water and wetland approaches and crossings and the use of temporary structures.

➤ **Provides information to assist the Council in evaluating the extent to which its guideline implementation goals, established in 2000, are being met.** This includes the goal of assessing landowner/resource manager commitment to apply the guidelines as measured by the willingness of landowners/resource managers to use the TH/FM guidelines in planning or modifying the timber harvest plan, and their willingness to discuss the TH/FM guidelines onsite with the logger/contractor.

Recommendations for Future Monitoring

➤ **Continue to use satellite imagery for selecting timber harvest monitoring sites.**

➤ Identification of seasonal ponds has been a problem for all three years of monitoring. There has been a dramatic increase in the number of seasonal ponds identified in each succeeding year of monitoring. This was due to DNR staff urging the contractor to be more cognizant of seasonal ponds and provision of training for the contractor on identification of seasonal ponds. Despite these efforts, uncertainty remains about how accurately seasonal ponds have been identified. For that reason, **it is recommended that future monitoring teams include an expert in wetland classification.**

➤ **Continue to emphasize the need in ongoing training** for improved operator awareness and inclusion of explicit language in contracts regarding:

- Water diversion and erosion control practices and improved project supervision to ensure effective practices are employed more frequently on crossings, approaches to crossings, and road and skid trail segments with a grade ≥ 2%

- Identification of and designation of appropriate practices for operations in and around filter strips and RMZs and improved project supervision to ensure that effective practices are employed more frequently around wetlands and open water bodies, particularly those within the harvest area

- Wetland and water crossing practices and improved project supervision to ensure that effective practices are employed more frequently on crossings and approaches to crossings

➤ **Develop standards to address the concept of "excessive rutting"** in a variety of circumstances, particularly for the general harvest area (both upland and wetland) and filter strips and RMZs.

➤ The percent of site in skid trails has proven very difficult to accurately characterize. The guideline is appropriate, but **monitoring of this guideline should be discontinued until an effective and practical method to characterize skid trails can be identified.**

➤ **Further discussion is needed to decide how to evaluate the situation** where 1) both leave tree clumps and scattered leave trees are present, 2) neither individually meets the guideline recommendations, but 3) when summed together, they may meet the intent of the leave tree guideline.

Adjacent: Outside the harvest area boundary, but within the recommended filter strip width (for those water bodies that only require a filter strip), or within 1½ times the recommended RMZ width (for those water bodies that require an RMZ).

Apparent harvest size: The portion of a site visible from a visually sensitive travel route or vista.

Approach: That portion of a trail or road immediately leading into a wetland or onto the crossing of a wetland or water body, from the edge of the water body or wetland to the point where a turn or naturally occurring break would divert water off the road or trail. This may be to the outer (landward) edge of the filter strip or RMZ for the wetland or water body, but often extends further upslope.

Artificial regeneration: Replacing a stand of harvested trees with a group or stand of young trees by direct seeding or planting of seedlings or cuttings.

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.

Best Management Practices: A practice or set of practices that are determined by a state or a designated planning agency to be the most effective and practical means of controlling point or non-point source pollution. In this case, reference is to the set of BMPs in the publication *Protecting Water Quality and Wetlands in Forest Management: Best Management Practices in Minnesota*.

Clearcutting: A regeneration or timber harvest method that removes essentially all trees in a stand in one operation.

Coarse woody debris: Stumps and fallen trunks or limbs of more than 6-inch diameter at the large end.

Cultural resource: An archaeological site, cemetery, historic structure, historic area, or traditional use area that is of cultural or scientific value.

Culvert: A metal, wooden, plastic, or concrete conduit through which water can flow.

Endangered species: A species threatened with extinction throughout all or a significant portion of its range.

ETS species: Endangered, threatened, and special concern species *(see individual definitions)*.

Even-age management: A planned sequence of treatments designed to maintain and regenerate a stand of trees with one or two age classes. The range of trees ages is usually less that 20% of the rotation age.

Felling: The process of severing trees from stumps.

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, so that it does not reach 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.

Forest management: The deliberate manipulation of the forest stand to achieve a variety of desired outcomes or management objectives over an extended period of time.

Guidelines: Specific practices or combinations of practices designed, when applied onsite, to protect specified functions and values.

Harvest area: The area of a site where timber harvest actually takes place, as opposed to the entire area of the site where management activity occurs.

Heritage elements: (Natural heritage element): Rare plants, animals, native plant communities or sites (such as nesting sites), which are listed on the Minnesota Natural Heritage Database. The Natural Heritage Database is an accumulation of known locations of these rare plants, animals, native plant communities, or sites that may require special management considerations.

Ice bridge: A temporary bridge constructed from snow and ice, used to cross an area during winter.

Implementation monitoring: The process of identifying and recording the combination of guidelines applied to protect specific resource functions and values on a site where a timber harvest or other forest management activity is conducted.

Infrastructure: The network of access roads, trails, and landings used to move equipment onto and around a forest management site.

Intermittent stream: Streams with well-defined channels, banks, and beds that flow only certain times of the year, when they receive water primarily from runoff or snowmelt. During dry years, these streams may cease to flow entirely or may be reduced to a series of separate pools.

Landing: A place where trees and logs are gathered in or near the forest for further processing or transport.

Leave trees: Live trees selected to remain on a forest management site to provide present and future benefits to wildlife, including shelter, resting sites, cavities, perches, nest sites, foraging sites, mast, and coarse woody debris.

Log bundle: Several logs tied together or otherwise bunched, designed to provide support for crossing a small depression such as a stream course. A log bundle is normally laid so that the logs are perpendicular to the road or trail. Ideally, log bundles are removed upon completion of the need for the crossing. This is not a recommended practice in the TH/FM guidelines.

Low-water ford: A place in a stream designated for vehicle crossing during low-water flow.

Non-open water wetland: A wetland that generally does not have observable surface water. According to the USF&WS wetland classification system (Circular 39), it includes Type 1 (seasonal flooded basins), Type 2 (inland fresh meadows), Type 6 (shrub swamps), Type 7 (wooded swamps), and Type 8 (bogs) wetlands.

Off-site: Outside the harvest area boundary and more than the recommended filter strip width (for those water bodies that only require a filter strip), or more than 1½ times the width of recommended RMZ (for those water bodies that require an RMZ). Off-site wetlands and water bodies were only noted when monitoring if they or their associated filter strips or RMZs are impacted by roads, skid trails, or landings associated with the harvest site being evaluated.

Onsite: Within the harvest area, the area where trees were harvested.

Onsite worksheet: The worksheet used to collect the information needed for monitoring the implementation of TH/FM guidelines while on the forest management site.

Open water wetlands: Wetlands with 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 (Circular 39), it includes Type 3 (shallow marsh), Type 4 (deep marsh), and Type 5 (shallow open water) wetlands.

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.

Primary Sampling Unit: A stratified subsample of the state (e.g., 1/2 township) in which timber harvests are identified and added to the pool of potential monitoring sites.

Primary skid trail: An arterial route used by skidders or forwarders to haul trees and logs to the landing. Primary skid trails are heavily traveled routes, which are fed by a system of secondary skid trails of less frequent travel. Primary skid trails are typically traversed 10 or more times by heavy equipment.

Presite visit worksheet: The worksheet used to gather information about a monitoring site prior to actually going out onto the site. The information specifically relates to planning guidelines and can be obtained prior to onsite review.

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. See the TH/FM guidebook for specifics on recommended RMZ widths and management.

Rutting: The creation of linear depressions made by the tires or tracks of vehicles, usually under wet conditions.

Seasonal ponds: Small depressional wetlands where water collects during wet periods of the year, typically in the spring and fall, and 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 due to the presence of reduced (blackened) organic matter; 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 wood 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.

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.

Secondary skid trail: A skidding route used to haul felled trees or logs from the back portions of a site to the primary skid trails. Secondary skid trails branch out from a primary skid trail and are less heavily traveled. Secondary skid trails are traversed from 3-10 times by heavy equipment.

Seeps and seepage wetlands: Small wetlands (often less than an acre) that occur where groundwater comes to the surface. They are often located on or at the base of a hillside. Soils at these sites remain saturated for some portion or all of the growing season, and often remain unfrozen throughout the winter.

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.

Single-tree selection: A timber harvest method where individual trees of all size classes are removed more or less uniformly throughout the stand, to promote growth of remaining trees and to provide space for regeneration.

Skidding: The act of moving trees from the site of felling to a loading area or landing.

Slash: Residual woody material created by logging or timber stand improvement.

Snag: A standing dead tree.

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.

Springs: (as a form of wetland): Small wetlands where groundwater visibly flows to surface, typically year-round, often creating a small stream.

Sprouting: A forest regeneration method where shoots arise from the base of a harvested tree either from the stump or by suckering from the root system.

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 harvest: The felling, skidding, onsite processing, and loading of trees onto trucks.

Timber land: Land suitable for producing timber crops that is not withdrawn from timber production by statute or administrative regulation and is capable of producing at least 20 cu.ft./acre/year.

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.

Vista: The location(s) on a visually sensitive travel route or feature from which a timber harvest site is viewed when rating a site for implementation of the visual quality guidelines.

Visual quality: A subjective measure of the impact that viewing an object, landscape, or activity has on a person's perception of attractiveness.

Water diversion structure: A lead-off ditch, water bar, or other structure designed to carry water runoff into vegetation, duff, ditch, or dispersion area, so that it does not gain the velocity and volume which causes soil movement and erosion.

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 characteristics: 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); and 3) under normal conditions, a prevalence of hydrophytic vegetation.

Harmon, M.E., J.F. Franklin, F.J. Swanson, P. Sollins, S.V. Gregory, J.D. Lattin, N.H. Anderson, S.P. Cline, N.G. Aumen, J.R. Sedell, G.W. Lienkaemper, K. Cromack Jr., and K.W. Cummins. 1986. Ecology of coarse woody debris in temperate ecosystems. Advances in Ecological Research 15: 133-302.

Minnesota Department of Natural Resources. 1995. *Protecting Water Quality and Wetlands in Forest Management*. Minnesota Department of Natural Resources, Division of Forestry, St. Paul, Minnesota. 140 p.

Minnesota Forest Resources Council. 1999. S*ustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers*. Minnesota Forest Resources Council, St. Paul, Minnesota.

Minnesota Forest Resources Council. 2001. *The Timber Harvest and Forest Management Guideline Implementation Goals for 2000: A Progress Report*. MFRC #ME-0301. Minnesota Forest Resources Council, St. Paul, Minnesota. 12 p.

Phillips, M. J., R. Rossman, and R. Dahlman. 1994. Best management practices for water quality - Evaluating BMP compliance on forest lands in Minnesota: A three year study. St. Paul, Minnesota: Minnesota Department of Natural Resources, Division of Forestry.

Puettmann, K. H., C. R. Blinn, H. McIver, and A. R. Ek. 1998. Status of Minnesota timber harvesting and silvicultural practice in 1996. St. Paul, Minnesota: Minnesota Forest Resources Council. Report MP0698.

SAS Language Guide for Personal Computers Version 8.2. SAS Institute Inc. Cary, North Carolina.

Location of Implementation Monitoring Sites by County and Ownership (2000, 2001, 2002)

Location	State	County	USFS	Forest Industry	NIPF	Other*	Total
Aitkin	2	6			1		9
Becker					3		3
Beltrami	2	2					4
Carlton		2			3		5
Cass	8	18	1		7		34
Chisago	1				2		3
Clearwater	1	2			1		4
Cook	1		5				6
Crow Wing		4					4
Hubbard	14	3		1	19		37
Houston					2		2
Itasca	11	3	5	1	1		21
Kanabec	1						1
Koochiching	21	18		2	4	1	46
Lake		1	19	2			22
Lake of the Woods	12				3		15
Pine	1	2			1		4
Polk					1		1
Roseau					1		1
St Louis	27	35		6	18	5	91
Wabasha					1		1
Wadena	1						1
Total	103	96	30	12	68	6	315

* Tribal lands, other public agency lands, non-forest industry lands