Monitoring the Implementation of the Timber Harvesting and Forest Management

Guidelines on Public and Private Forest Land in Minnesota: Report 2000

A report by the Minnesota Department of Natural Resources

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Respectfully submitted to the Minnesota Forest Resources Council

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EXECUTIVE SUMMARY

This report discusses the findings from the first year of conducting field monitoring of timber harvesting and forest management practices on public and private forest land in Minnesota. The objective of this monitoring program is to provide information to the state's forest land managers and policy makers on the application of sustainable harvesting and management practices as defined in the guidebook: *Sustaining Minnesota's Forest Resources: Voluntary Site-Level Forest Management Guidelines.* Prepared by the Minnesota Forest Resources Council (Council), this guidebook contains recommendations for addressing site-level water quality, wetland, wildlife habitat, riparian management, soil productivity, historic and cultural resources, and visual quality issues associated with conducting timber harvesting and forest management activities. The guidebook was published as an integrated manual for use by the state's loggers, forest landowners, and forest resource managers in 1999.

A total of 108 harvesting sites were monitored in 2000. These sites were identified using a statistically based sampling procedure that randomly selected blocks of land ½ township in size throughout the forested area of the state. A total of 41 blocks were selected. Within these blocks aerial photography, in combination with assistance from local forestry personnel, was used to identify recently harvested forest land. Landowners were subsequently contacted to secure permission to visit the site and gather site background information prior to conducting the field reviews. The focus of the field review was to describe conditions and practices in the context of quantifiable timber harvesting and forest management guidelines.

All sites monitored in 2000 were harvested and/or its stumpage sold under contract prior to publication of the Council's timber harvesting and forest management guidebook. Therefore, with the exception of water quality, wetland protection, and visual quality practices where guidelines have existed for several years, the report describes BASELINE harvesting and management practices (i.e., those that existed prior to publication of Minnesota's comprehensive timber harvesting and forest management guidelines). Subsequent annual field monitoring will describe how harvesting and management practices change over time, and assess the extent to which the management practices recommended in the guidebook are being applied across the state.

Some of the important findings from the first year's monitoring are given below:

The application of timber harvesting and forest management guidelines was monitored on state, county, U.S. Forest Service, forest industry, nonindustrial private forest landowners, and other government land distributed broadly over the forested regions of the state.

- Twenty-six percent of the monitored sites were visually sensitive. Landowner and loggers were aware of the visual sensitivity classification on 36% and 29% of these sites, respectively.

- Landowners and/or resource managers checked cultural/historic resource inventories on 50% of the sites monitored prior to timber harvesting. Inventories for ETS species were checked on 69% of the sites monitored prior to timber harvesting.

- Filter strip compliance with the guideline recommendation (<5% mineral soil exposure, dispersed over the filter strip) was 70%.

- For lakes, perennial streams and open water wetlands, 50% of riparian management zones (RMZ) met the guideline recommendations for width and residual basal area. A higher proportion of RMZs that met the guidelines recommendations were adjacent to the harvest area compared to those for waterbodies that were within (i.e., open water wetlands, lakes) or traversed (i.e., streams) the harvest area.

- A high percentage of skid trail and road approaches to wetlands and streams did not have the appropriate water diversion devices installed to divert surface run off from directly entering these waterbodies.

- The guidelines recommend that site infrastructure (i.e., roads, landings) should occupy no more than 3% of the harvest area. The statewide average was at the guideline recommended 3% level.

- Landings were located outside of filter strips and RMZs 95% and 99% of the time, respectively.

- Slash was retained at the stump or redistributed back on the site for 73% of the sites monitored.

- Rutting was found on 33% of the sites monitored and was most prominent on skid trails, wetland inclusions and roads. The use of slash and shifting operations until conditions improved accounted for 70% of all techniques used to minimize rutting.

- The percentage of sites classified as even-age management with reserves (percent of site in leave trees) that met the guideline recommendations ranged from 57% to 67% depending on the method of calculation.

I. INTRODUCTION

The Sustainable Forest Resources Act (SFRA) of 1995 and modified in 1999 (Minnesota Statutes, Sections 89A.01 to 89A.10) initiated an effort to resolve important forestry policy issues through collaborative approaches among diverse forestry interests. These forestry interests were organized into the Governor-appointed Minnesota Forest Resources Council (Council). Much of the initial effort of the Council focused on the development of timber harvesting and forest management guidelines for use on public and private forest land in Minnesota. The process of guideline development began in April 1996. Site level guidelines were developed for the topical areas of riparian zone management, forest soil productivity, historic/cultural resources, and wildlife habitat. These guidelines were integrated with existing water quality and wetland best management practices (BMPs) and visual quality BMPs into a single comprehensive guidebook. These guidelines were approved by the Council in December 1998, and the guidebook titled *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines was published in April 1999.*

To compliment the adoption and promotion of voluntarily applied timber harvesting and forest management guidelines, the SFRA mandated application of the guidelines be monitored on public and private forest land. Implementation monitoring is the process of identifying and recording the combination of guidelines applied to protect specific resource functions and values on a site where timber harvesting or other forest management activity is conducted. 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.*

Responsibility for implementation monitoring rests with the Minnesota Department of Natural Resources (DNR), with oversight and program direction provided by the Council. The monitoring program builds on past efforts to monitor the implementation and effectiveness of the BMPs to protect water quality and wetlands and visual quality (Phillips et al. 1994, unpublished data 1995, 1997).

The SFRA also requires the Council to identify specific guideline implementation goals by landowner category. Specifically the SFRA states:

> *89.05, Subd. 3. Application. The timber harvesting and forest management guidelines are voluntary. Prior to their actual use, the council must develop guideline implementation goals for each major forest land ownership category. If the information developed as a result of forest resources, practices, compliance, and effectiveness monitoring programs conducted by the department or other information obtained by the council indicates the implementation goals for the guidelines are not being met and the council determines significant adverse impacts are occurring, the council shall recommend to the governor additional measures to address those impacts.*

Implementation monitoring provides one important approach for evaluating the extent to which the implementation goals established by the Council in December 1998 are being met. This analysis will be presented in a separate report (ME - 0301).

Initial site-level implementation monitoring represents a baseline evaluation of the application of timber harvesting and forest management practices. All sites that were monitored were harvested before and/or were contracted for harvesting prior to the publication of the timber harvesting and forest management (TH/FM) guidebook. However, the application of water quality and wetland BMPs and visual quality guidelines were not evaluated as baseline data as these guidelines were the forestry standard in Minnesota for several years before the publication of the TH/FM guidebook. It should also be borne in mind when reviewing these results that for the landowner categories, forest industry and other government land, only five and three sites, respectively, were monitored. It will, therefore, be difficult to draw definitive conclusions for these landowners from this small pool of sites.

II. METHODOLOGY

The process of designing the implementation monitoring program was divided into four components: A) convening a guideline implementation monitoring technical committee (Technical Committee) that advised the Council's Guidelines Implementation Monitoring Committee (GIMC) on field monitoring protocols, B) designing the site selection methodology, C) field monitoring of timber harvesting sites, and D) analysis of field monitoring data.

A. Development of field monitoring protocols

The GIMC convened the Technical Committee in May 1999 to develop the field monitoring protocols. The Technical Committee was made up of representatives from the DNR/Forestry, DNR/Wildlife, DNR/Environmental Indicators Initiative, logging interests, U.S. Forest Service, Minnesota Association of County Land Commissioners, environmental interests, Rivers Council of Minnesota, Blandin Paper Company, Potlatch Corporation, Minnesota Forestry Association, University of Minnesota, and Minnesota Forest Resources Partnership. The Technical Committee made recommendations to the GIMC on: 1) which guidelines to monitor, 2) when to monitor, 3) how to monitor, and 4) who should do the monitoring. The GIMC reviewed the recommendations which were then presented to the Council for approval at their October 1999 meeting.

The Technical Committee was reconvened in October 2000 following the first round of monitoring to review program successes and problems and to identify program modifications for the second round of implementation monitoring. Many of these proposed modifications to the program are contained in Section V of this report.

1. Defining "site"

For purposes of monitoring, site was defined as the area where harvesting activities were conducted (harvest area) and adjacent areas that were taken into consideration when determining the actual harvest unit. The total site acreage included the harvest area plus leave tree and riparian management zone (RMZ) areas adjacent to the harvest area.

2. Identification of guidelines to be monitored

Collection of field monitoring data on guideline application was restricted to those guidelines that were measurable and quantifiable. This was done to minimize subjective judgements in implementation monitoring. The determination of what constituted a measurable guideline was made by the Technical Committee. Once the measurable guidelines were identified, the appropriate measures were developed to quantify their application in the field. The guideline implementation data collected included background information obtained from the landowner/resource manager and during the onsite field evaluations.

B. Site selection process

1. Statistical design

A monitoring system was designed to be cost and time effective and to provide for:

- statistically credible estimates of implementation rates statewide;
- statistically useful comparisons among landowner categories (i.e., nonindustrial private forest (NIPF), forest industry (FI), state, county, American Indian, U.S. Forest Service (USFS), and other government (OG));
- trends in implementation over time by major ecoregion, watershed, or landscape;
- trends in implementation over time by landowner categories; and
- flexibility with respect to available data, current and future technologies for data capture including remote sensing, and to facilitate modeling.

A multi-stage sampling method was adopted. This method used primary sampling units (PSUs) (i.e., ½ townships) and then sampled harvesting sites within those PSUs. This was two stage sampling. In practice, townships were selected and the east half of the township was designated the PSU unless it fell below the criteria for minimum forest acreage. In that case the west half of the township was used as the PSU (or an adjacent ½ township, if necessary). Feasibility was enhanced by the fact that the identification and probability based selection of townships and PSUs was simple. There are 1800+ townships statewide, with approximately 700 located in the forested regions of Minnesota. Their size is known and approximately equal, their regular dimensions facilitate planning, particularly flight planning. The advantages of this approach were feasibility in creating a list of harvesting sites within PSUs and savings in travel time since a number of sites were visited in each selected ½ township rather than traveling to individual harvesting sites located at random around the

state. The approach also provided for essentially unbiased estimates of implementation rates and precision of these estimates. In practice it required the selection of townships, obtaining maps and aerial photographs of a specified portion of those townships to make a preliminary identification of recent harvesting sites, field checking to ensure the sites met criteria for inclusion, and finally a formal contractor visit to collect the onsite data on TH/FM guideline implementation.

Sample size is a function of the desired level of precision subject to cost constraints. The past history of BMP monitoring in Minnesota showed that implementation of BMPs for all landowner categories varied in the range from 70% to 100%. Further, monitoring for BMPs has not shown widespread variability within or among landowner categories. Consequently, a statewide sample of 120 sites per year was estimated to provide adequate representation for most desired categorizations (e.g., landowner categories, landscape region).

Sample PSUs were identified separately for the U.S. Forest Service Forest Inventory and Analysis (FIA) Aspen Birch, Northern Pine, and Central Hardwood units. The selection will be developed annually so as to preclude persons or organizations working on harvesting sites to anticipate their location. The sample PSUs location process was developed by applying a systematic grid (with a random start) to a map of townships in each of three FIA units. In practice, the selected townships were those in which the grid dots fell.

For PSUs substantially less than nominal size (e.g., along state boundaries), the "subject area" was modified to include sections from the immediately adjacent township so as to include 18 sections in an approximately 3 x 6 section layout. Grid points falling in reserved areas (e.g., Boundary Waters Canoe Area Wilderness) were excluded and replaced by grid points falling in timberland. The grid points, located by a random start, were used to select townships, with grid density geared to obtain n=120 harvesting sites statewide. The grid, as opposed to selecting the townships from a list, ensured a sample that was spread out and representative of the region in question. To insure credibility, 41 townships were selected statewide for the PSUs for the 1999–2000 field reviews.

Given the selected townships, color or color infrared aerial photography at a print scale of 6.3 inches to the mile (RF =1:10000) was flown to cover (the PSU three tiers of sections from south to north). The timing of flights occurred when most deciduous leaves were off (i.e., late fall) to maximize the ability to see harvesting site detail, but before snow cover. The flight line followed the center of each tier of sections. Subsequently a DNR Resource Assessment aerial photo interpreter identified recently (December 1997–October 1999) harvested sites and categorized them by size and other characteristics. The process is designed to identify approximately 0–15 harvesting sites per township for any one year.

An estimate of ownership within the selected PSUs was determined by using Geographic Information Systems (GIS) public land survey and ownership data. First the 41 ½ townships were selected from the public land survey GIS data. The ownership data was then summarized in a GIS using the selected ½ townships.

The source of the ownership data is from land records in the 1980s. The data represents only major landowners and was mapped based on 40 acre public land survey boundaries. Since the ownership data is not comprehensive, many small ownerships were either classified as "unknown" or not classified at all. For this report these were all added into the NIPF category.

2. Timing of monitoring

Field evaluations of guideline application were conducted from April to August 2000 on sites where timber harvesting was completed. Sites selected for monitoring had been harvested within two years of when the aerial photography was taken.

3. Landowner contacts

The DNR Resource Assessment unit evaluated the aerial photography of the selected PSUs. Potential harvesting sites were identified, and the boundaries of the harvest area were delineated. These aerial photographs were sent to the DNR/Forestry area offices in which the PSUs were located. The area offices were instructed to confirm the landowner category, contact the landowner to confirm when harvesting for the specific site was completed, and request permission to monitor the harvesting site. If the landowner agreed, the site was added to the statewide pool of potential harvesting sites from which 120 sites were to be randomly selected for monitoring. There were not 120 sites identified where permission was obtained and all sites were monitored where permission to monitor was obtained. For the

sites selected for monitoring, the landowners were contacted by Council or DNR staff to obtain background (site profile) and some guideline (presite visit) information.

4. Interpretation of aerial photography

Once the harvesting sites were confirmed for monitoring, DNR Resource Assessment undertook aerial photo interpretation of these sites. The objective of this interpretation phase of the project was to identify features on the monitoring sites that could be most accurately and efficiently evaluated through aerial photo interpretation, rather than with onsite measurements. The following procedures and measurements were used in the interpretation of the aerial photos.

a. The aerial photos were rectified using Digital Ortho Quads as the reference. They were then brought into ArcView for further measurements. ArcView is a specific GIS system software used to analyze spatial data.

b. Site boundaries were refined using information gained through the landowner contacts and site acreage was determined.

c. The occurrence and location of any open water wetlands, lakes, or streams on the site or adjacent to the site were identified and mapped.

d. Actual RMZs (what exists onsite) and theoretical RMZs (as recommended in the guidebook) for each open waterbody on or adjacent to the site were identified and mapped and site acreage of all actual and theoretical RMZs was determined.

e. The trout stream GIS layer was queried to determine if lakes or streams were designated trout streams. This information was used to establish theoretical RMZ widths.

f. Other clearly identifiable nonopen water wetlands on the site were mapped.

g. All roads within the harvest unit were identified and mapped, and the length of the road within the harvest unit was determined.

h. All landings within the harvest unit that could be identified were mapped and measured, and the area of the landings recorded.

i. The apparent method(s) of leave tree management used (scattered individual trees versus clumps, strips, and islands) were identified. The number of clumps, strips and/or islands was determined and the total acreage on and adjacent to the site was measured. The average number of scattered individual leave trees per acre within the harvest unit was also estimated.

j. The Natural Heritage database was queried to determine if known heritage elements were present on or near the site.

k. The visual quality database was queried to determine the visual sensitivity of the site. This information was recorded on the site profile data sheet.

Figure 1 illustrates the delineation of some of these site features on an aerial photograph for one of the sites monitored in 2000.

C. Field monitoring of timber harvesting sites

1. Procedure for selecting contractor to monitor guidelines

Field monitoring of timber harvesting sites was conducted with the use of independent contractors selected through the formal state bidding process. Prospective contractors were requested to submit proposals that specified: 1) how they planned to conduct the monitoring in the time frame identified in the request for proposal, 2) what resources and expertise they would utilize in the monitoring, and 3) the per site cost for monitoring based on a maximum of 120 timber harvesting sites. The successful contractor was selected by the DNR upon review of the proposals submitted.

2. Guideline instruction manual

A guideline monitoring instruction manual was developed to facilitate the contractor's proper and consistent application of the guideline monitoring measures identified in the onsite worksheet. It was intended to make clarifications and to establish units of measure that were not clearly identified in the onsite worksheet. It was not designed to be a substitute for knowledge of standard forest mensurational techniques. This manual also was not designed to replace the need for the contractor to thoroughly read and understand the guidebook, *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines.*

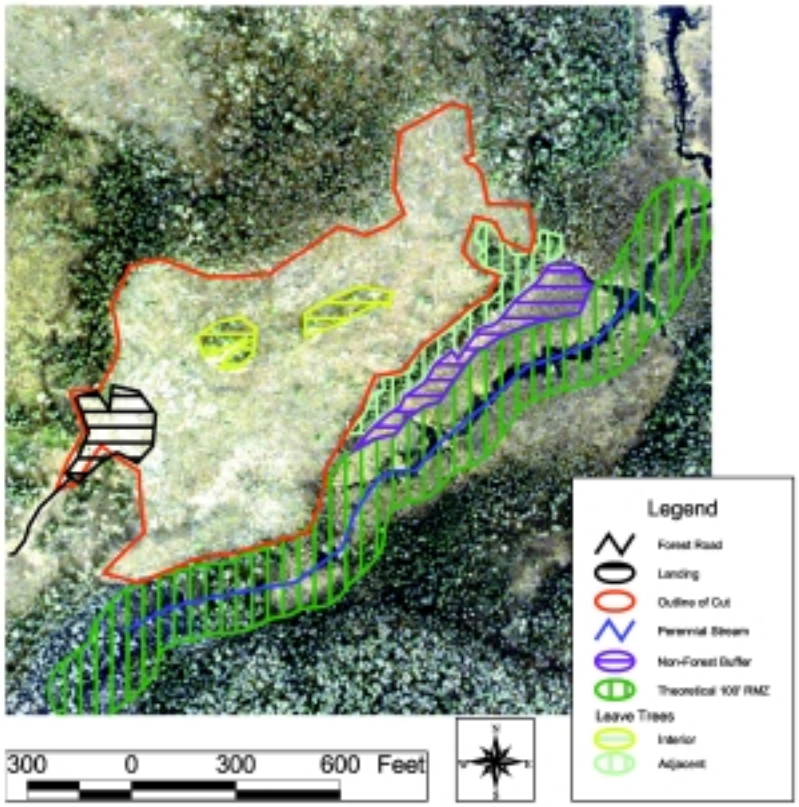

Figure 1. Delineation of some site resources on an aerial photograph for one of the sites monitored in 2000

3. Calibration workshop

The successful contractor was required to attend a three-day calibration workshop held in April 2000 to discuss and review the guidelines and implementation monitoring protocols. Workshop instruction was provided by members of the Technical Committee and employed both classroom discussions and field exercises designed to provide an understanding of the guidelines and their measures, and to demonstrate the proper collection of field data and use of the field monitoring forms. During the calibration workshop measures that were unclear were discussed and clarifications to these measures were developed. After the calibration workshop, the guideline instruction manual was revised to reflect the discussions and changes agreed to during the workshop.

4. Visual quality assessment

As part of the site profile survey, landowners and/or resource managers were asked if they were aware of the visual sensitivity classification (VSC) for their site, and if so, what was the classification. The classification that was identified was then used as the VSC for the site. That classification was then passed along to the contractor, and the guidelines were assessed onsite based on this classification.

Visual quality guidelines were assessed onsite from the perspective of where the general public would normally view the site. If it was from a road, the contractor would stand on the road and look at the site to monitor the guidelines. If the site was visible from a river or lake, the contractor stood on the shore of the lake or on the bank of the river and responded to the appropriate guideline questions. If the road, waterbody or trail bordered the site for a distance, the contractor was to walk these areas and get an “average” view of the site. The contractor was instructed to assess the visual quality guidelines before he/she entered onto the site so that initial reactions were used in the assessment similar to what would happen when the general public encountered the site.

The contractor assessed visual quality guidelines for the following aspects of the harvest:

- Access roads - assess characteristics of road building debris.
- Apparent harvest size - estimate apparent harvest size by taking a quick look at the site and then determining how big the site appeared.
- Landings - if landings were seen from the view of the public, the visible characteristics of the landing addressed by the guidelines were assessed.
- Slash management - if slash was seen from the view of the public from the road, waterbody, or trail, the slash guidelines were assessed.
- Snags - If snags were visible, the contractor judged how conspicuous they were.

5. Leave tree determination

Analysis of leave tree clumps and scattered individual leave trees was restricted to sites with even-age management objectives. Acreage of the site in leave tree clumps was calculated two ways. For the first determination, total leave tree clumps were calculated as those internal to the harvest area (i.e., those with all clump boundaries totally within the harvest area), plus those peninsular intrusions of leave trees that protruded into the harvest area, plus leave tree clumps adjacent to the harvest area (e.g., those that were adjacent to offsite RMZs, plus those that were left as visual buffers to the harvest area, and those that protected cultural resources adjacent to the harvest area). The proportion of the site in leave tree clumps was determined by total clump acreage as a percent of harvest area, plus adjacent leave tree area, plus adjacent forested RMZ area. For the second determination, the area in clumps was calculated for interior leave tree clumps as a percent of harvest area only. Many of the measures of leave tree area were conducted off of aerial photographs utilizing the onsite data as verification of leave tree clump locations.

6. Site infrastructure

The acreage of roads and landings contained in the harvest area was used to calculate site infrastructure. For determination of the road area onsite, length of road was determined from the aerial photograph and road width was assumed to be 16 feet. In addition, the contractor was required to evaluate data for road components (e.g., water and wetland crossings, use of water diversion devices for road segments having slopes $\geq$ 2%) within 1/4 mile of the harvest area. These evaluations for offsite roads were confined to those constructed or modified for the timber harvest. Landing acreage was based on the onsite measurements collected by the contractor or determined from the aerial photographs by the DNR Resource Assessment unit. Determination of the percentage of the site in infrastructure was calculated as a weighted mean.

7. Data collection forms

The measurable timber harvesting and forest management guidelines were organized into three forms: 1) site profile (background information), 2) presite visit (planning guidelines), and 3) onsite evaluation (field application guidelines). These forms were programmed on Husky FC - PX5 notebook computers to collect and record the guideline implementation data. The data was to be downloaded nightly to the DNR/Forestry computers in St. Paul, MN. Due to design problems with the computer database, the field computers were not used to collect the monitoring data for 2000. Instead, the Microsoft® Access program forms were printed and provided as field worksheets for the contractors. Completed forms were sent to the DNR in St. Paul for data entry.

8. Gaining access to sites

Prior to monitoring the site, the contractor was required to contact the landowner to reconfirm permission to monitor the site, inform him/her of the impending field review, and provide the landowner with the opportunity to be present for the review.

9. Quality control

A quality control team, made up of Technical Committee members, were to visit 5% to 10% of the monitoring sites to ensure that the requirements of the contract were being fulfilled. Two of each group of 20 sites were randomly selected for quality control review. Where waterbodies were present on or adjacent to the monitoring site, effectiveness monitoring as defined in procedures identified in Phillips et al. (1994) was also conducted.

D. Procedures for analyzing field monitoring data

1. Data entry

The timber harvesting and forest management guideline monitoring data was captured by a relational database, Microsoft® Access 97 for Windows® 95. A database is a collection of information that is organized as a list. The data was stored in a series of related tables in Access which enabled the data to be queried and made available for analysis.

2. Analysis of results

SAS (Statistical Analysis System) Version 8.0 was the program used to analyze the implementation monitoring results.

III. RESULTS AND DISCUSSION

A. Site distribution

Timber harvesting and forest management guidelines were monitored on the following forest landowner categories: state, county, USFS, FI, NIPF, and OG (i.e., University of Minnesota, City of Ely). The distribution of sites within the Council landscape regions is shown in Figure 2. In total, 108 timber harvesting sites were evaluated. These sites were contained in 24 of the 41 randomly selected PSUs. The largest number of timber harvesting sites (49) was found for the Northeast Council landscape region.

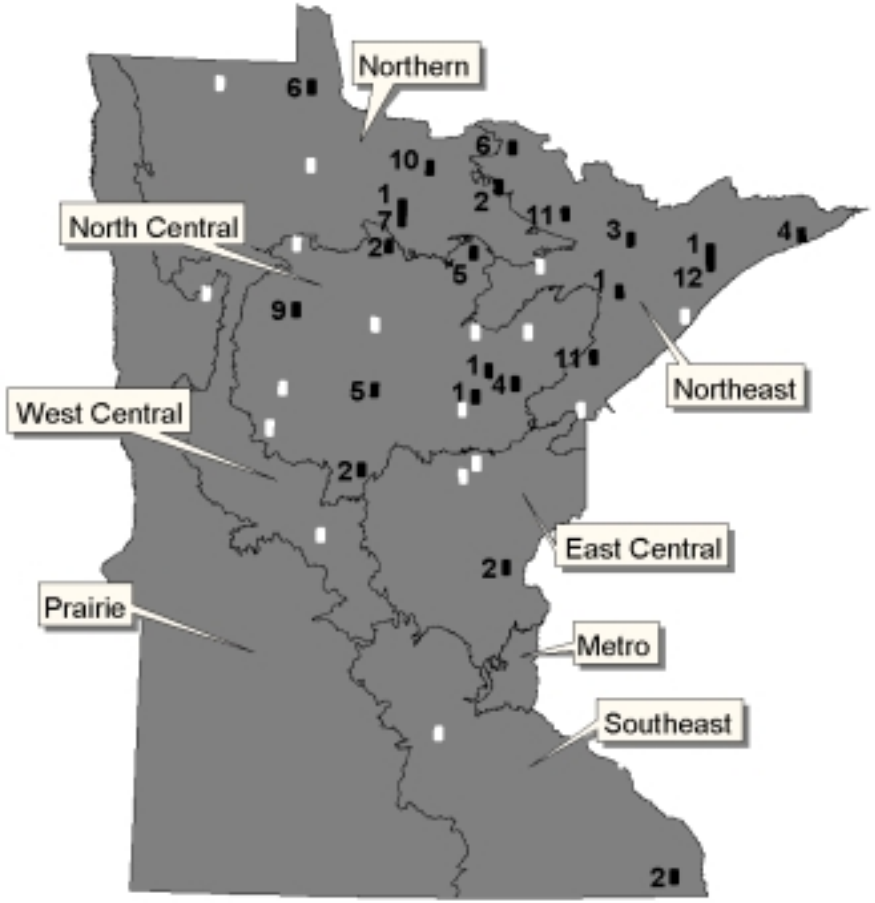

Figure 2. Location of monitoring sites by MFRC landscape region.

B. Harvest characteristics

1. Average harvest unit size

The number of sites by landowner category is shown in Figure 3. The number of NIPF sites is fewer than the number identified on the aerial photos or through local knowledge of NIPF timber harvesting activity. This was due to: 1) the inability to contact absentee landowners, and 2) refusal by landowners to permit monitoring of the landowner's timber harvesting activity. The Council did not receive permission to monitor because of the inability to contact the NIPF landowner (five sites) or was refused permission to monitor (three sites).

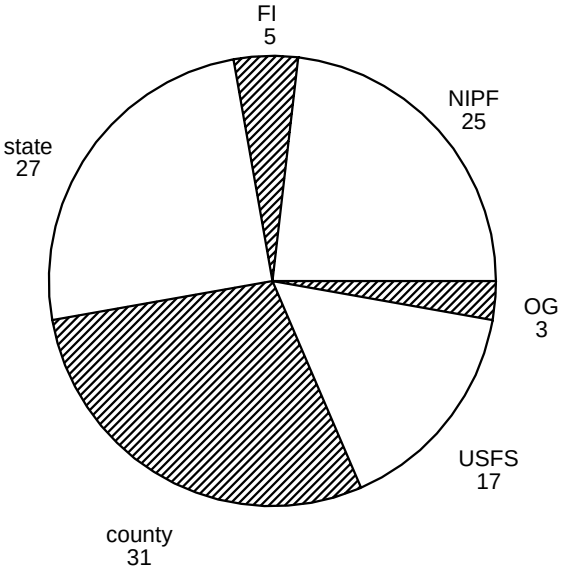

Figure 3. Number of timber harvest sites monitored by landowner category.

The average size of timber harvest for all sites was 26.6 acres (Figure 4). Average size of sites based on total site acreage (i.e., harvest area + adjacent leave tree acreage + adjacent RMZ) was 28.2 acres. Harvesting sites were largest for forest industry and smallest for NIPF sites. Using either method of calculating acreage, the average size of timber harvesting sites decreased in the order:

FI > OG > USFS > county > state > NIPF.

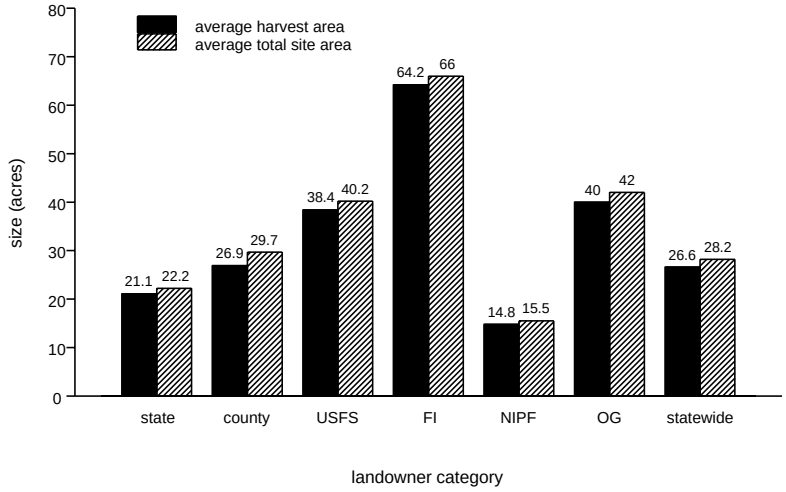

Figure 4. Average harvest and total site area by landowner category statewide.

State forest, U.S. Forest Service, and forest industry sites were monitored in relative proportion to their ownership of forest land within the PSUs (Table 1). County sites, however, were monitored more than twice their proportion of ownership within the PSUs. There was no obvious reason for the higher number of county sites, it may just reflect a higher level of timber harvesting on the selected county forest properties. The lower number of NIPF sites monitored relative to their degree of ownership in the PSUs could reflect smaller, less intensively harvested sites common to these landowners which would make them more difficult to identify on the aerial photos.

Table 1. Ownership within primary sampling units.

Landowner category	Ownership within PSUs		Ownership of sites monitored within PSUs	
	acres	percent	number of sites	percent
State	89,145	19	27	25
County (and local government)	56,662	12	31	30
Federal	62,230	14	17	16
Private industry (forest and non-forest)	22,012	5	8	6
NIPF (unknown and not classified)	222,335	48	25	23
American Indian	6,255	1	0	0
Total	458,639	100	108	100

C. Landowner objectives

Landowners and resource managers were asked on the site profile form to identify up to three management objectives for the timber harvest. These results are presented in Table 2. There were essentially three tiers of response. Timber harvesting and silviculture were the dominant landowner objectives for all landowner categories except for NIPF where timber production was replaced by income. Timber production and silviculture were cited by the U.S. Forest Service as objectives for management for all sites monitored on their land.

The second tier of landowner objectives was income and wildlife habitat. The third tier of landowner objectives was recreation, insect and disease control, and investment. Landowner objectives for a particular site did not influence the way a site was monitored, but may have influenced how the landowner applied the flexibility built into the guidelines. An example of how guideline flexibility is influenced by landowner objectives for management is given in section III.H.3.

D. Pre-harvest planning

There are planning considerations that are emphasized in the TH/FM guidelines related to the protection and sustainability of forest resources. The use of appropriate materials and resources (e.g., maps, aerial photos) is encouraged for developing the plans for the timber harvest. The preparation of a site map is recommended to identify the location of harvest area boundaries, special concern or special feature areas, and to note locations for roads and landings. An onsite meeting between the landowner and/or resource manager and the logger or operator is encour-

Table 2. Landowner objectives for management.

	State	County	USFS	FI	NIPF	OG	Total
Recreation	1	3	0	0	4	0	8
Insect and disease control	7	0	0	0	3	0	10
Silviculture	19	13	17	3	13	3	68
Timber production	24	27	17	5	3	3	79
Income	1	9	0	1	11	3	25
Investment	0	0	0	1	0	0	1
Wildlife habitat	5	12	1	0	6	0	24
Total number of sites where landowner objectives were identified	27	31	17	5	25	3	108
Total number of sites by landowner category	27	31	17	5	25	3	108

aged to share information and ensure a common understanding of what is expected.

The landowner and resource manager were asked to identify specific site information resources used in the preparation of timber harvest plans. The results are presented in Table 3. One or more types of site information resources were used on 87% of sites. The most commonly used resource was aerial photographs. These were used for all sites on all landowner categories other than for NIPF land. Fifty-six sites utilized multiple sources of materials. The use of multiple sources of site information was especially common for the USFS. Some form of site map was also commonly available. Only for NIPF sites were site maps not routinely available (Table 4). Site maps were developed for 78 sites or 72% of those monitored.

The guidelines encourage the landowner, resource manager, and logger or operator to meet onsite prior to any equipment being moved onto the site to discuss road issues and timber harvesting specifications. It is likely that the landowner is the same as the resource manager where the response was answered for state, county, U.S. Forest Service, and forest industry land. It appears that onsite meetings to discuss issues related to roads and timber harvesting were common for all landowners (Table 5). Onsite meetings between the landowner/resource manager and the logger/operator to discuss forest road issues and/or timber harvesting specifications were held on 71% and 94% of the sites, respectively.

Table 3. Site information resources used to provide landowner assistance for evaluating and developing plans.

Material	Landowner						
	State	County	USFS	FI	NIPF	OG	Total
Aerial photographs	25	31	17	5	11	3	92
Topographic maps	4	3	17	0	3	3	30
Soil surveys	2	1	16	0	3	1	23
Visual sensitivity maps	3	5	12	0	0	0	20
Other	8	7	0	4	1	1	21
Total	42	47	62	9	18	8	186
Total number of sites where site information resources were used	25	31	17	5	13	3	94
Total number of sites by landowner category	27	31	17	5	25	3	108

Table 4. Number of sites for which site maps were developed by landowner category.

State	County	USFS	FI	NIPF	OG	Total
23	25	17	5	5	3	78

E. Harvest stand management

Timber harvesting is the process of felling, skidding, processing, loading and transporting forest products, roundwood, or logs. Variations of even-age and uneven-age management are the harvesting methods commonly employed in forestry in Minnesota. Information on timber harvesting methods for the monitored sites is found in Figure 5. This information was obtained as part of the site profile landowner/resource manager survey. All but two of the sites were harvested by some method of even-age management.

Most of the timber harvesting activity occurred in winter (Figure 6), accounting for 58% of total harvests that were monitored. Summer was the only other season where substantial harvesting occurred.

Using a variety of timber harvesting methods can assist the landowner in meeting many of the TH/FM guideline objectives. For example, the guidelines recommend leaving trees as scattered individuals or in

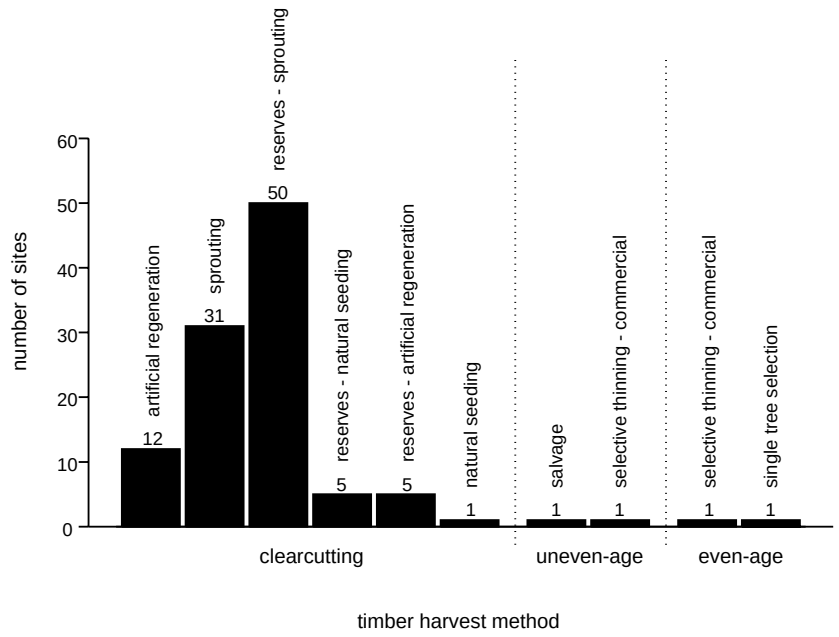

Figure 5. Number of monitored sites by timber harvest method.

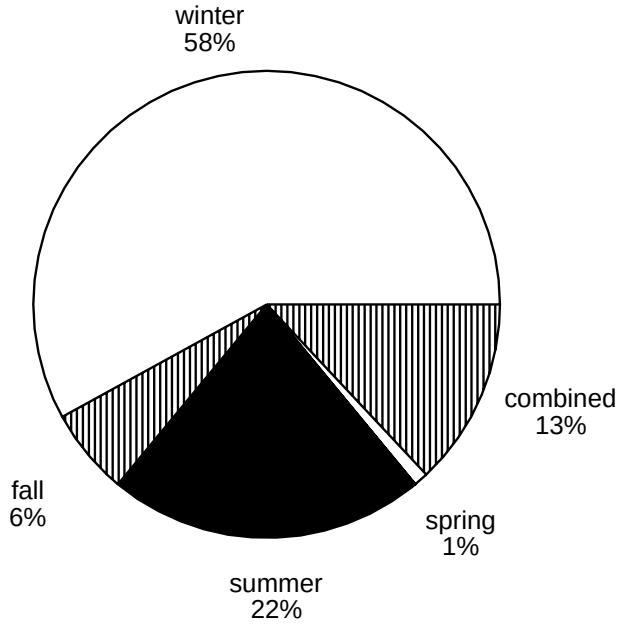

Figure 6. Statewide seasons of timber harvest activity (percent).

clumps, strips, or islands that provide vertical structure for wildlife habitat. Puettmann et al. (1996) reported a substantial shift in harvesting methods in Minnesota to a greater reliance on leaving reserves on clearcuts. The authors found a doubling of clearcut harvesting with residuals, increasing to 77% from 1991 to 1996. The increase was attributed to growing interest in providing for wildlife habitat, riparian protection, aesthetics, and nutrient retention. For the 2000 monitoring program, the stand management techniques identified in the site profile identified as timber harvesting with reserves were clearcutting with reserves - sprouting, clearcutting with reserves - natural seeding, clearcutting with reserves - artificial regeneration, even-age commercial selection cutting, and even-age single tree selection. These harvesting techniques were the methods employed on 62 of 106 sites or 58% of the even-age management sites monitored. The most common technique was clearcutting with reserves - sprouting, accounting for 46% of the sites monitored.

The lower percentage of sites harvested with residuals for monitoring compared to that reported by Puettmann et al. (1996) could be a definitional problem for the landowner in specifying the type of management on his/her property. Puettmann et al. (1996) reported that the definition of what constitutes a clearcut with residuals is not consistent across all landowner categories. For the current monitoring effort, the percentage of sites harvested with reserves (58%) is essentially the same as the 57% of sites that were found with internal leave tree clumps and/or scattered individual leave trees that met the TH/FM guideline recommendations (see section III.K.2). The lower results for residuals from implementation monitoring (57%) compared to the percent clearcut harvests with (77%) residuals reported by Puettmann et al. (1996) could reflect a higher standard under the TH/FM guidelines to be considered as reserves compared to the survey responses in the silviculture report (Charles R. Blinn, personal communication). Further discussion with landowners and resource managers may be necessary when collecting site profile

information to provide clarification to the issue of reserves from the landowner's and resource manager's perspectives.

F. Visual quality assessment

Landowner awareness of the visual sensitivity of their 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.

Twenty-eight of 108 sites had a visual sensitivity classification (VSC) (Table 6). Ten sites were classified "most sensitive," 12 sites "moderately sensitive," and six sites "less sensitive." However, five sites classified "most sensitive" were not assessed in the field for visual quality guidelines. This was mainly due to miscommunication with the contractor by Council staff.

The site profile survey enquired as to the landowner's and operator's awareness of the visual sensitivity of the harvested site (Table 7). Landowners were aware of the visual sensitivity of their land on 10 of 28 sites or 36% of the time. Operators were aware on eight of 28 sites or 29% of the time. Awareness of visual sensitivity was especially apparent for U.S. Forest Service land and least apparent for NIPF land.

In the presite visit survey of landowners and/or resource managers, questions were posed to determine if there were any alterations of timing or management techniques, or temporary relocations of recreation trails to reduce potential conflicts between harvesting and recreation use. The presite visit survey indicated that for this group of monitored sites, no alterations or modifications were made to accommodate recreation use.

For sites classified as most sensitive, two questions were asked concerning access roads: 1) Is all merchantable timber harvested within the road clearings?, and 2) Is road clearing debris visible along travel routes or recreation areas? On all five sites evaluated in this classification, both questions were answered either no or not applicable.

On sites classified as moderately sensitive, two questions were asked concerning access roads: 1) Is road clearing debris visible along travel route right of way?, and 2) Are jackstrawed or overturned stumps visible

Table 5. Meetings held onsite to discuss road construction and timber harvesting.

	State		County		USFS		FI		NIPF		OG	
	R*	TH**	R	TH	R	TH	R	TH	R	TH	R	TH
Landowner	1	1	2	3	0	0	2	2	10	9	2	2
Resource manager	13	16	11	24	17	17	3	3	2	4	3	3
Logger	11	14	9	23	17	17	5	5	2	9	1	1
Other	6	8	10	3	0	0	0	0	6	10	0	0
Total number of sites where onsite meetings were held	20	25	23	30	17	17	5	5	9	22	3	3
Total number of sites by landowner category	27		31		17		5		25		3	

* Roads
** Timber harvest

Table 6. Summary of sites by ownership and visual sensitivity classification.

Land Ownership	Visual Sensitivity Classification			Total number of sites
	Most	Moderate	Less	
State	4	1	1	6
County	2	1	3	6
USFS	0	2	1	3
Forest industry	0	0	1	1
NIPF	4	6	0	10
Other government	0	2	0	2
Total number of sites	10	12	6	28

Table 7. Landowner awareness of visual sensitivity of timber harvest sites.

Landowner category	Total number of sites by landowner category	Total number of visual sensitive sites	Landowner awareness	Operator awareness
State	27	6	2	2
County	31	6	2	1
USFS	17	3	3	3
FI	5	1	1	0
NIPF	25	10	1	1
OG	3	2	1	1
Total number of sites	108	28	10	8

in the immediate foreground from the travel route or recreation area? On five of 12 of the sites, road clearing debris was visible along the travel route right of way. For one other site jackstrawed or overturned stumps were visible in the immediate foreground of the travel route. These questions were not applicable on sites classified as less sensitive and, therefore, were not assessed.

Harvest areas tend to be more objectionable to the public as their perceived or apparent harvest size increases. This is particularly true for large, unbroken clearcuts. Apparent harvest size, which is the visible or evident dimensions of the site, applies to sites in the most and moderate VSCs. On sites classified as most sensitive, the guidelines call for an apparent harvest size of ≤5 acres. Three of the five sites monitored in this classification had apparent harvest sizes of seven acres, eight acres, and 100 acres. The apparent harvest size of the remaining two sites in the most sensitive classification was zero acres for each. On sites classified as moderately sensitive, the guidelines call for an apparent harvest size from five to 10 acres. Ten sites or 83% of the moderately sensitive sites had apparent harvest sizes of ≤10 acres. Four sites had apparent harvest sizes less than five acres. The two sites with >10 acres apparent harvest size were both perceived to be 20 acres in size.

The TH/FM guidelines recommend various techniques that can be used to limit the apparent harvest size of the site (Table 8). Seven sites used multiple techniques. Two sites that were >10 acres also used more than one technique to influence apparent harvest size. In fact, one site with an apparent harvest size of 20 acres used four techniques which suggests that for some sites, additional planning is needed on how best to limit the apparent harvest size to meet the guideline recommendations.

Table 8. Techniques used to limit apparent harvest size.

Technique	Visual Sensitivity Classification	
	Most	Moderate
Utilize natural terrain	1	4
Shape clearcuts to look more like natural openings	1	3
Create narrow openings into harvest area	0	2
Apply multiple stage cuts	0	3
Use tree buffers or uncut islands	2	9

From a visual quality standpoint, one of the objectives of the guidelines is to minimize the impact of landing operations on the public viewers. For sites classified as most sensitive, the operative guideline is to keep the landing out of view of the traveling public. Three of the most sensitive sites were assessed for visual quality landing guidelines. Two out of three of these sites had landings that were not visible. For the site with the visible landing, grubbed stumps and trees were not visible, no trash was visible, and the landing area had revegetated naturally.

For the sites classified as moderately sensitive, 11 sites had landings that were assessed for visual quality. The concern is the presence of landings that are conspicuous from travel routes or recreation areas. The landings for nine of these sites were judged not to be conspicuous. On only one site were grubbed trees and stumps associated with construction or use of the landing visible from the travel route.

The significant concern on sites classified as less sensitive is whether the landing is located in the travel route right-of-way. This was found for one landing on one of six sites with the less visual sensitivity classification.

Visible slash is unsightly and leaves an impression of poor harvesting and utilization. The objective of visual quality guidelines for slash management is to minimize the visual impact of slash. On sites classified as most sensitive, the first concern evaluated was whether slash piles were visible from the travel route. If slash was visible, then there were two follow up questions to address: 1) Is slash visible within 50 feet of travel route?, and 2) What is the average height of slash visible beyond 50 feet of the travel route? There was only one out of the five sites that were assessed in this classification that had visible slash from the travel route. On that site, there was no visible slash within 50 feet of the travel route, and the average height of visible slash beyond 50 feet was two feet.

For sites classified as moderately sensitive, two questions were asked: 1) Is slash visible? and 2) If yes, what is the average height? On nine out of the 11 sites, slash was visible and slash heights ranged from zero feet to 15 feet in height. Looking beyond the high and low extremes, the slash height range was between five and eight feet.

On sites classified as less sensitive, the concern was whether slash piles were conspicuous by being close to travel routes or recreation areas and readily visible. Conspicuous slash piles were found for two of the six sites.

Snags and broken trees are another site resource that can give the harvested area an unsightly appearance. The objective of the visual quality guidelines is to minimize the visual contrast created by snags and broken or leaning trees. The major visual quality issues associated with most and moderately sensitive sites were: 1) Can snags be seen in the foreground? and 2) Are snags hidden or camouflaged from view of travel routes and recreation areas? On the five sites classified as most sensitive that were monitored, two had snags in the foreground, but on each site the snags were camouflaged by placing the snags close to uncut islands of trees or close to the edges of the harvest area so that the snags tended to blend in. Snags were not silhouetted and conspicuous on these two sites. On the moderate sensitive sites, five of 12 sites had snags in the foreground that were not hidden or camouflaged and were easily seen from the travel routes.

G. 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 the effects of such disturbances as erosion, compaction, rutting, and other impacts associated with forest management activities. A knowledge of these resources is the first step in their protection. The cultural resource specialists involved with guideline development considered that one of the most critical of the guideline recommendations for cultural/historic resources is the need for landowners to contact the appropriate organization or individual(s) to check on the presence of these resources prior to the initiation of the forest management activities.

Inventories were checked for the presence of cultural/historic resources on 50% of the monitoring sites (Table 9). The most common contact was agency inventories followed by the state archeologist's office. For state forest lands, it is likely that the response for the categories "state archeologist" and "agency inventories" were one and the same. The DNR/Forestry has on contract an individual from the state archeologist's office. The "other" category included onsite inspections and reviews of other databases. The U.S. Forest Service was the only agency which had all sites evaluated for these resources which is consistent with their obligation to comply with federal law. All sites monitored during the 2000 TH/FM guideline monitoring were checked against the archeological site inventory maintained by the state archeologist's office (Pat Emerson, personal communication) who confirmed that there were no known cultural/historic resources on any of the monitoring sites.

Table 9. Cultural/historic inventories checked prior to harvesting activities.

Inventory resource	Landowner category						
	State	County	USFS	FI	NIPF	OG	Total
Historic preservation	0	1	0	0	0	0	1
State archeologist	3	13	0	0	0	0	16
Agency inventory	12	0	17	0	1	0	30
Private internal inventory	1	0	0	1	0	0	2
Consulting forester	0	0	0	0	1	0	1
Other	4	0	0	0	0	2	6
Total number of inventories checked	20	14	17	1	2	2	56
Total number of sites where inventories were checked	18	14	17	1	2	2	54
Total number of sites by landowner category	27	31	17	5	25	3	108

Checking inventories is also a principle TH/FM guideline recommendation for protection of endangered, threatened, and special concern (ETS) species. Inventories for ETS species were checked on 74 of 108 (69%) monitoring sites (Table 10). Multiple checks were noted for 12% of these sites. The DNR Natural Heritage staff were the most common source for review of sites for the presence of ETS species. Checking these inventories was most common for state forest, forest industry, and the U.S. Forest Service sites. Lowest rates of checking inventories (28%) were found for NIPF landowners. The DNR/Natural Heritage Program was

Table 10. Frequency of inventory checks for ETS species on timber harvest sites by statewide and landowner category.

Inventory contact	Landowner category						
	State	County	USFS	FI	NIPF	OG	Total
Wildlife manager	13	0	0	0	0	0	13
Regional nongame specialist	10	0	0	0	4	0	14
Forester	2	0	0	0	0	0	2
Natural Heritage staff	6	14	17	0	1	0	38
Other	5	8	0	2	2	3	20
Total number of inventories checked	36	22	17	2	7	3	87
Total number of sites where inventories were checked	23	22	17	2	7	3	74
Total number of sites by landowner category	27	31	17	5	25	3	108

also requested to evaluate all timber harvest sites for monitoring against the ETS species database. On one occasion, it identified where an ETS species was in the vicinity of a timber harvesting operation where the landowner had indicated that there were no ETS species on or adjacent to the site. This was a U.S. Forest Service site and the special concern species identified was the cerulean warbler *(Dendroica cerulea).*

H. Use of filter strips and riparian management zones

The forested riparian area is an important linkage between aquatic and terrestrial ecosystems. Protecting riparian functions and values is critical to the maintenance of these ecosystems. Management within an RMZ generally requires maintaining defined levels of forest cover, less intensive management, and reduced equipment intrusion into these areas. The TH/FM guidelines provide recommendations for managing around a variety of waterbodies and wetlands. The guidelines are based on modifying management near water and wetlands by providing specified widths where there is less intensive harvesting, where the forest floor is left relatively undisturbed, and where specified densities of residual trees are recommended. For purposes of monitoring, the types of waterbodies and wetlands evaluated were nonopen water wetlands (NOWW); open water wetlands (OWW); perennial and intermittent streams, lakes, and seasonal ponds; and seeps and springs.

1. Type and distribution of waterbodies

The types and numbers of waterbodies or wetlands found on or adjacent to the monitoring sites are shown in Figure 7. Nonopen water wetlands far exceeded the presence of any other waterbody or wetland type, accounting for 78% of the total. The numbers of the different types of waterbodies decreased in the order:

NOWW > perennial streams > OWW > intermittent streams > lakes > seasonal ponds.

At least one of these waterbodies or wetlands was found on or adjacent to 88 of the monitored sites which represents 81% of the total number of sites. Open water wetlands or nonopen water wetlands were identified on or adjacent to 83 sites. No seeps, springs or intermittent streams $\geq$ 3 feet were found on any of the sites.

One seasonal pond was identified on the 108 monitoring sites. Given the uncertainty as to the criteria that clearly defines a seasonal pond, there is not substantial confidence that this resource was properly

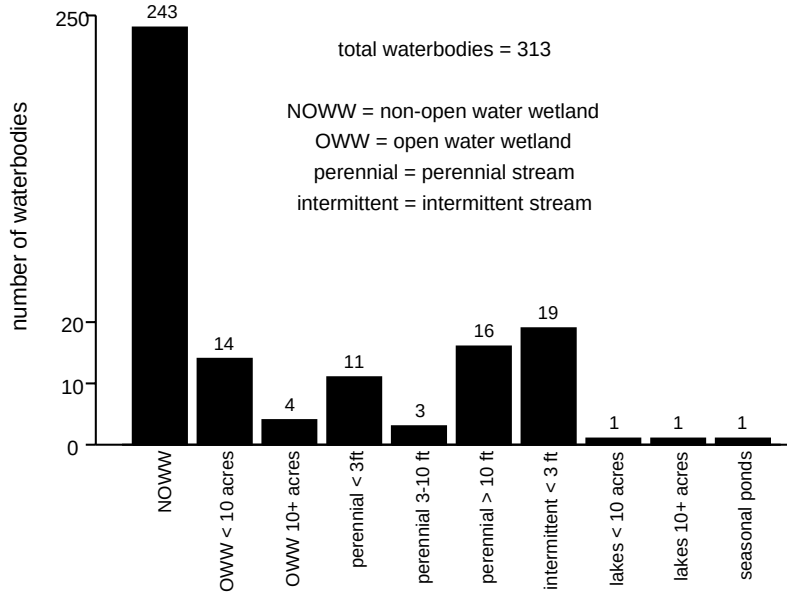

Figure 7. Number of each type of waterbody on or adjacent to the harvest sites monitored across all land ownerships.

evaluated across all 108 sites. There are two potential reasons for concern. The first is that the DNR is charged in statute with monitoring the extent of harvesting around seasonal ponds. There is a need to clarify the criteria that will allow the DNR to properly document management activities near this resource. The other concern is that seasonal ponds may have been incorrectly identified as open water wetlands. If this occurred, this water resource would have been evaluated for an RMZ rather than with a filter strip. The TH/FM guidelines recommend only a filter strip for seasonal ponds with the option of being a site location for providing leave tree clumps. As part of the calibration workshop for the second round of monitoring, clarifying the criteria for defining seasonal ponds will be a priority.

2. Filter strip application

One of the essential guideline protections for aquatic ecosystems during and following forest management activities is the use of filter strips. Filter strips are recommended for perennial and intermittent

streams, lakes, open water wetlands, nonopen water wetlands, seasonal ponds, and seeps and springs. The principle requirement for an effective filter strip is that the forest floor be retained essentially undisturbed to maintain its filtering capability to remove sediments, debris, nutrients, and pesticides, and to promote continued soil infiltration of surface flows. The width of a filter strip is based solely 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. For monitoring, maintaining an effective filter strip means 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 waterbody, 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 which increases for slopes greater than 10% to a maximum width of 150 feet for slopes up to 70% (Table GG-1 of the TH/FM guidebook and Appendix B of this report). This is the same standard used by the forestry community since publication of the 1995 BMP guidebook (MN DNR 1995).

The level and distribution of disturbance for filter strips is shown in Table 11. Filter strips were required 329 times. These are not 329 individual waterbodies or wetlands. Rather, some are filter strips evaluated on both sides of an intermittent or perennial stream that traversed the harvest area. The filter strip evaluations produced some surprising results. Filter strip application was found to meet the guideline recommendation (i.e., <5% mineral soil exposure, dispersed) for 70% of the evaluations. This represents a substantial decline in compliance with the filter strip guidelines reported earlier for BMP monitoring (Phillips et al. 1994; unpublished data 1995, 1997). Over five field seasons of BMP monitoring, filter strip compliance routinely exceeded 90% across all landowner categories. One possible explanation for the lower compliance levels with filter strip BMPs was the addition of the evaluation of nonopen water wetlands. Nonopen water wetlands were not evaluated in the earlier BMP monitoring program. An analysis of nonopen water wetlands and all other open waterbodies as independent groups show that there is little difference in the degree of filter strip compliance between these groups (Table 11).

Table 11. Filter strip disturbance number of sites).

Resource	<5% dispersed	<5% concentrated	>5% dispersed	>5% concentrated
NOWW	71	20	3	6
All other water bodies	69	27	2	2
Combined	70	22	3	5

Another possible explanation for the lower filter strip compliance rate may be in how the field data was collected. With the BMP monitoring program conducted from 1991 to 1997, data was recorded for each applicable BMP on the basis of the entire site. Under the revised field procedures, data for multiple resources on a site was collected for each location a particular guideline applied. The new field procedures also focus primarily on collecting observable, measurable data to avoid subjective judgments that were included in the previous monitoring efforts, such as effectiveness and apparent impacts.

The following illustration highlights the difference in approaches to monitoring that could explain, in part, the decrease in compliance with filter strip guidelines. Assume a site with one open water wetland, a three foot perennial stream, and three intermittent streams <3 feet wide. The typical five to six member interdisciplinary BMP audit team would walk over the site to review all of the pertinent onsite resources to be evaluated. Following the site walkover, the team would gather to discuss and answer all questions on the BMP worksheet.

The team might agree that the degree of disturbance to the filter strips for the open water wetland, the perennial stream and one of the intermittent steams <3 feet wide was <5% and well distributed throughout the filter strip. The team might agree that the degree of disturbance for the other two intermittent streams was also <5%, but the distribution of disturbance was concentrated rather than dispersed. In such a case the team could decide that, overall, the filter strips were in fine shape and, therefore, reach consensus that application of filter strip BMPs met or exceeded the recommendation. As part of the field review, the BMP audit team would also evaluate the effectiveness of the BMPs in preventing sediment movement to

waterbodies. In most cases for BMP audits, there was no observable impact and this could also have influenced the team rating of the site as a whole. With no observable impact, the team would have been more likely to give the benefit of the doubt that BMP recommendations were met.

Under the field review procedures used in 2000, the same site would be evaluated by a single contractor rather than an integrated team. The contractor would have evaluated each filter strip independently. The open water wetland, the perennial stream and the first <3 feet wide intermittent stream each would be rated as having <5% disturbance, well distributed over their filter strips. The other two intermittent streams, would each be rated as having <5% disturbance but concentrated within their filter strips.

The results with these two approaches to evaluating the guidelines are significantly different. One method (BMP audit) gives a rating of 100% for meeting the guideline recommendation. The other method (guideline monitoring) results in a 60% compliance rating for the filter strip guidelines.

A third possible explanation for observed differences in filter strip use between this and previous monitoring efforts is the sampling procedure. This year's monitoring sites were randomly selected. In contrast for previous monitoring efforts, sites were selected based on those submitted by various landowners.

An additional concern for filter strips is intrusion of roads, skid trails, landings, and associated clearing debris. These infrastructure components are heavy impact areas. Roads and skid trails should be located outside the filter strip and RMZ to the greatest degree practical. Water diversion structures should be installed whenever it is necessary to locate them in a filter strip or RMZ. Excluding crossings of waterbodies and wetlands, roads and skid trails intruded into filter strips and RMZs 18 times. However, only in two cases were water diversion devices installed. It was also noted that clearing debris from roads, skid trails and landings was deposited in a filter strip or RMZ on 27 sites.

3. Riparian management zones

The essence of protection for aquatic systems is found in the identification and implementation of appropriate modifications to timber harvesting operations adjacent to waterbodies and wetlands. The TH/FM guidelines provide protections by specifying widths of modified harvesting activity adjacent to waterbodies and wetlands with reduced equipment intrusion and the retention of specified levels of residual tree species. The guidelines recommend RMZs for open water wetlands, lakes, perennial streams, and intermittent streams $\geq$3 feet wide. The interest of the public, resource managers, and policy makers in the evaluation of RMZs necessitates the Council to provide a thorough analysis of the limited RMZ data collected during the first round of implementation monitoring. The reader is cautioned to remember that these results describe baseline data collected on 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.

The width and basal area recommendations for the RMZ are based, in part, on the management objective for the RMZ. The landowner was asked in the site profile interview to state the management objective for the RMZ. If the RMZ management objective was even-age management, then the RMZ guidelines for even-age management applied. If the RMZ management objective was uneven-age management, then the RMZ guidelines for uneven-age management applied. If the management objective of the RMZ was reserve/no harvest, the RMZ was evaluated using the uneven-age guidelines for width. Since the RMZ was not harvested, the default value for basal area was that recorded during monitoring. If the landowner indicated no specific management objective for the RMZ, then the stand management objective for the general harvest area (i.e., even-age, uneven-age) was applied to the RMZ. Table 12 shows the number of RMZs for each of the RMZ management objectives. Forty-seven of 60 (78%) of the RMZs were evaluated as even-age management. Only one RMZ was specifically identified by the landowner as uneven-age management. However, 12 other RMZs were reserved with no harvest and thus were evaluated as uneven-age management.

Fifty waterbodies were found on or adjacent to 34 monitoring sites for which RMZs were recommended. Thirty of the waterbodies were perennial streams, 18 were open water wetlands, and two were lakes

Table 12. RMZ management objectives.		
Number of RMZs for each management objective		
Even-age	Uneven-age	Reserve/no harvest
47	1	12

(Figure 8). For these waterbodies, 50% met the guideline recommendations (theoretical RMZ) for width and residual basal area for the type of waterbody and management objective (Figure 9). These results can be viewed in the context of shade strips which were the pre-TH/FM guidebook RMZ standards for directly protecting aquatic systems. Within the forested portion of a shade strip, a minimum of 60 square feet per acre of basal area was to be retained unless the regeneration of shade intolerant species was desired within the shade strip. Then basal area could be reduced to 25 square feet per acre. Since all but a few of the RMZs were managed as even-age, comparing the shade strip recommendations to existing RMZ guidelines resulted in essentially the same number of waterbodies meeting the minimum recommendations shown in Figure 9. Therefore, 50% of the measured RMZs for the 2000 monitoring would meet the existing shade strip standards at the time the current monitoring sites were harvested. Compliance with the shade strip guidelines from the BMP audits in 1995 and 1997 was 80% and 88%, respectively (unpublished data). This is a substantial reduction in the level of compliance. The reasons for the lower levels likely parallel those stated earlier for reductions in filter strip compliance.

The number of RMZs based on width for streams, open water wetlands, and lakes across all landowner categories is given in Figure 10 and by landowner category in Figures 11 and 12. For each stream that traversed the harvest area, the RMZ was evaluated on both sides of the stream, increasing the number of RMZs to 60. Half of the RMZs for perennial streams were in the 25–100 foot RMZ classes (Figure 10). Six of the RMZs had no residual forest and these were located on U.S. Forest Service and NIPF lands (Figure 11). Eighteen open water wetlands and two lakes were identified (Figure 10). For open water wetlands, eight of 18 RMZs were clearcut to the waters edge (Figure 12). All of these clearcut RMZs were located on county land. Six of the eight were located within the harvest area and the

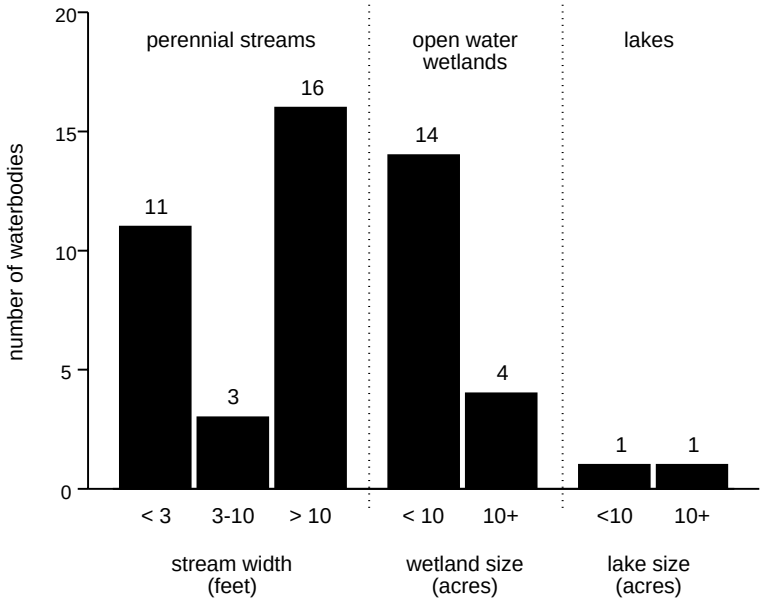

Figure 8. Number of waterbodies by type and size monitored statewide.

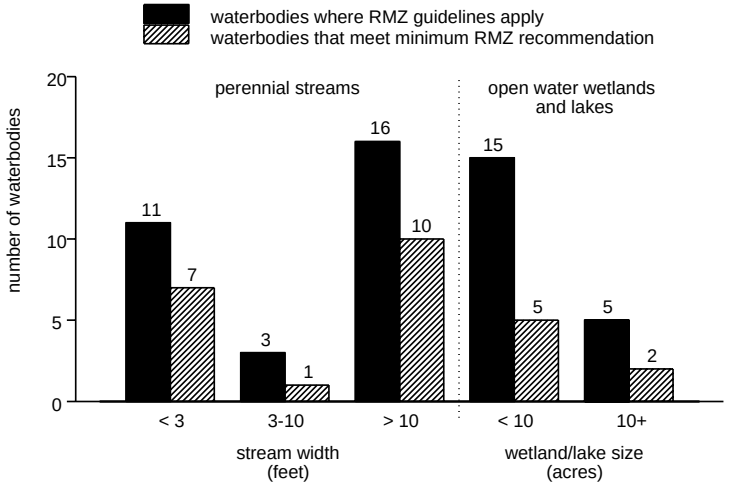

Figure 9. Comparison of the number of waterbodies statewide where RMZ guidelines apply to the number of waterbodies meeting the minimum RMZ recommendation for width and basal area.

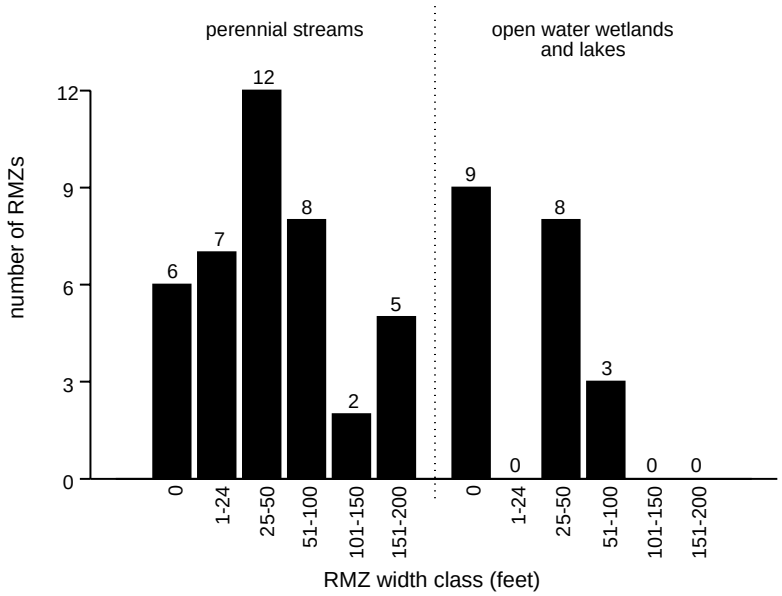

Figure 10. Number of RMZs for perennial streams, open water wetlands, and lakes in width classes statewide.

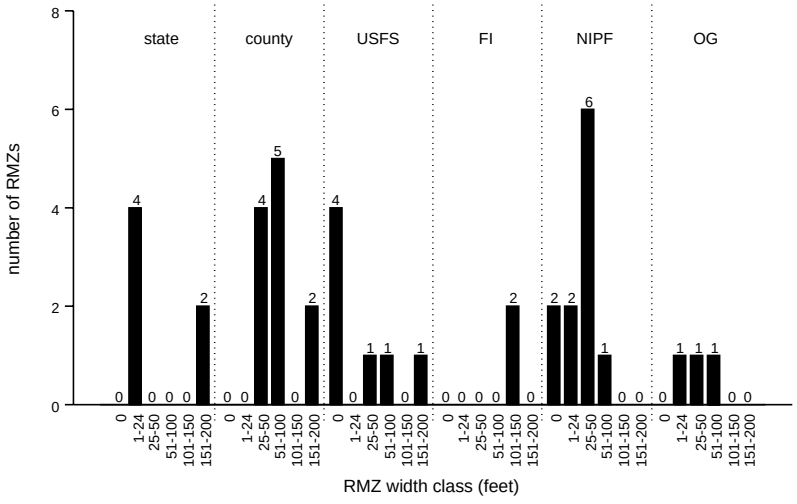

Figure 11. Number of RMZs for perennial streams in width classes by landowner category.

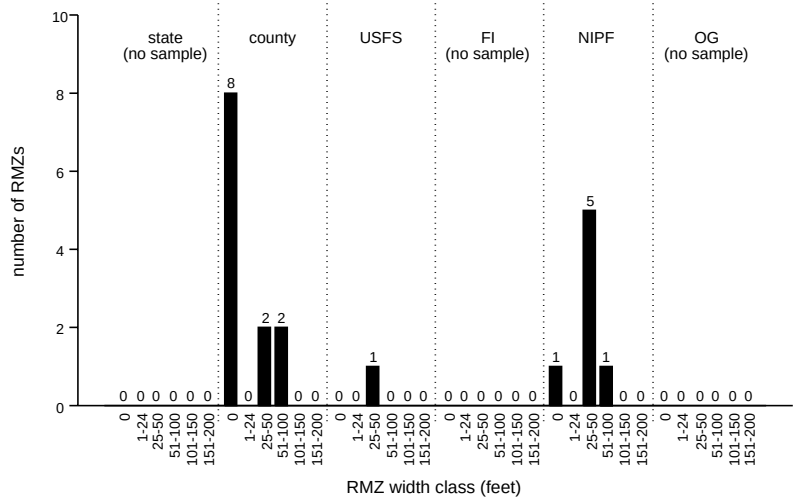

Figure 12. Number of RMZs for open water wetlands and lakes in width classes by landowner category.

other two bordered the harvest area. One of the lakes was located within the harvest area on an NIPF site and was also clearcut to the water's edge.

Basal area categories found for streams, open water wetlands, and lakes across all landowner categories are given in Figure 13 and by landowner category in Figures 14 and 15. There was no residual basal area for nine of 40 of the perennial stream RMZs (Figure 14). No residual basal area in some cases meant no forest tree component to the RMZ (i.e., it consisted of grass, sedge, brush, or shrubs). Where basal area was retained in the RMZs for perennial streams, 19 of 31 RMZs were in the 51–80+ basal area classes. For open water wetlands and lakes, six of the RMZs were in the 51–80+ basal area classes (Figure 15).

A comparison between waterbodies adjacent to the harvest area and those within the harvest area is striking. For the waterbodies adjacent to the harvest area, 63% met the theoretical RMZ guideline recommendation for width and residual basal area (Figure 16). For those

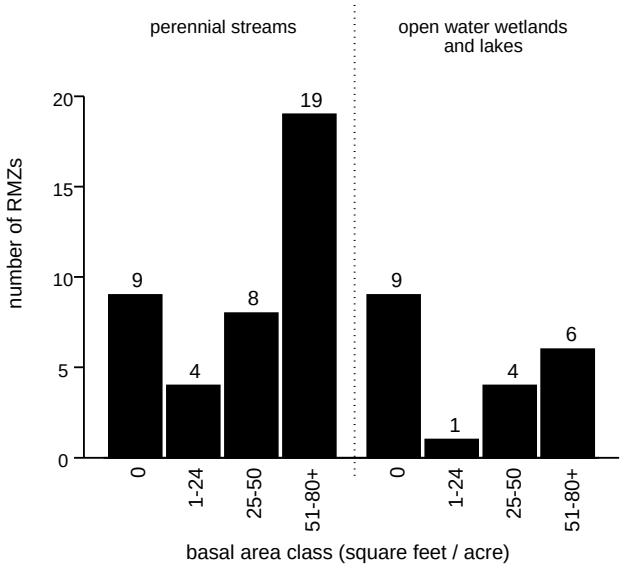

Figure 13. Number of RMZs by basal area class for each waterbody type statewide.

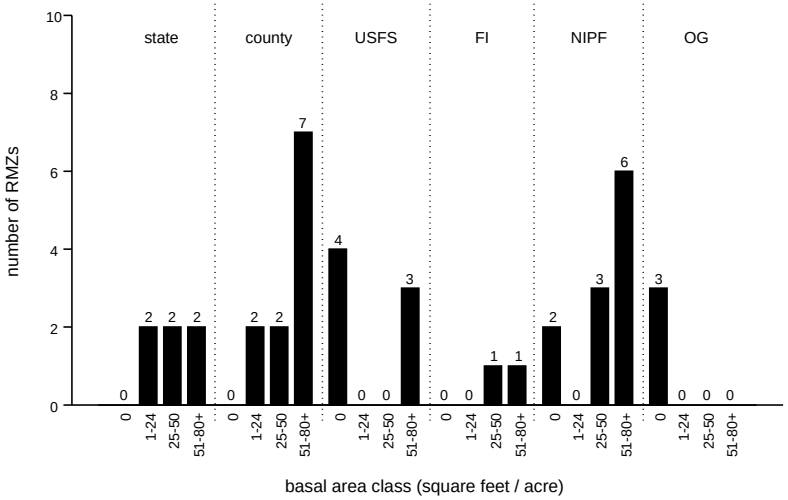

Figure 14. Number of RMZs by basal area class for perennial streams by landowner category.

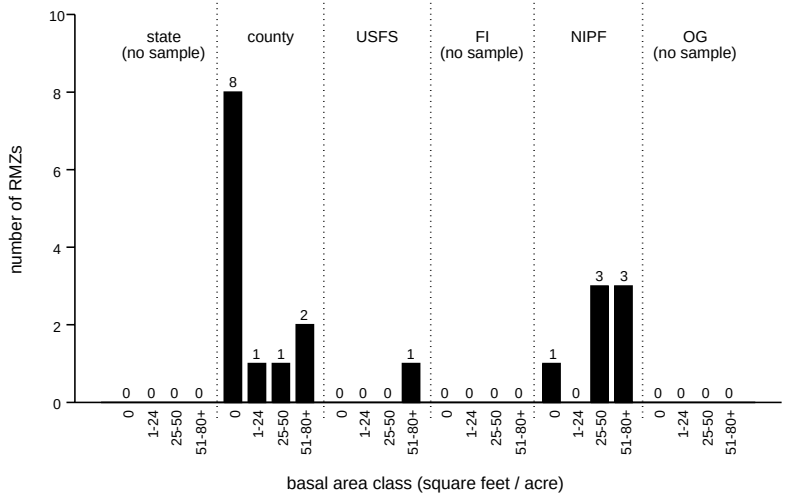

Figure 15. Number of RMZs by basal area class for open water wetlands and lakes by landowner category.

waterbodies within the harvest area, the proportion drops to 33% (Figure 17). Figure 18 shows the various RMZ width classes for waterbodies on or adjacent to the harvest area. Many of the adjacent RMZs not meeting the guideline recommendation for width still had a substantial forested RMZ width compared to those waterbodies within the harvest area. Six of 10 of the adjacent RMZs had a forested component at least 50% of the recommended guideline value. Within the harvest area, only two of 22 RMZs that did not meet the guideline recommendations for width and residual basal area had an RMZ that was at least 50% of the guideline recommendation.

Another contrast involved waterbodies adjacent to the harvest area where only two had the harvest area clearcut to the water's edge. Within the harvest area, 13 RMZs were clearcut with no residual vegetation retained. As indicated earlier, six of these 13 RMZs were for open water wetlands on county sites. All six were on sites where the management objective was for early successional wildlife habitat. One might expect that this type of management would include the removal of all trees around these open water wetlands to eliminate raptor perches and to encourage dense stands of regeneration to provide escape cover for young broods of grouse. In contrast, NIPF

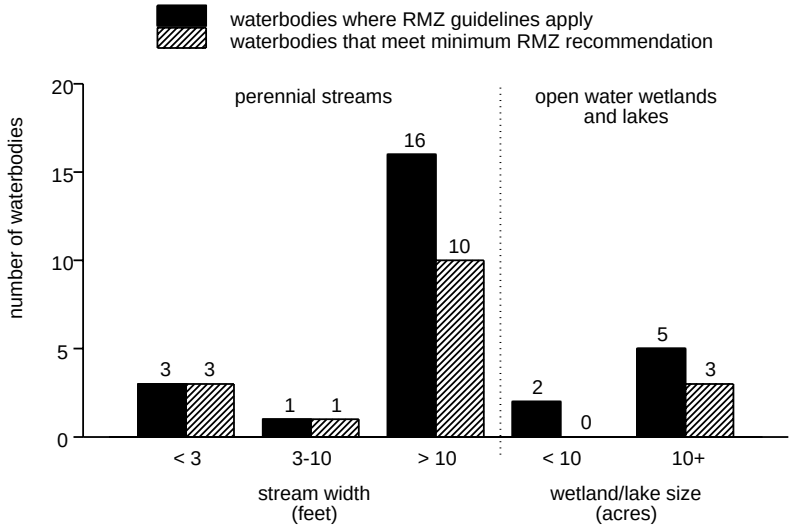

Figure 16. Comparison of adjacent waterbodies requiring a RMZ to the number of waterbodies meeting the minimum RMZ recommendation for width and basal area statewide.

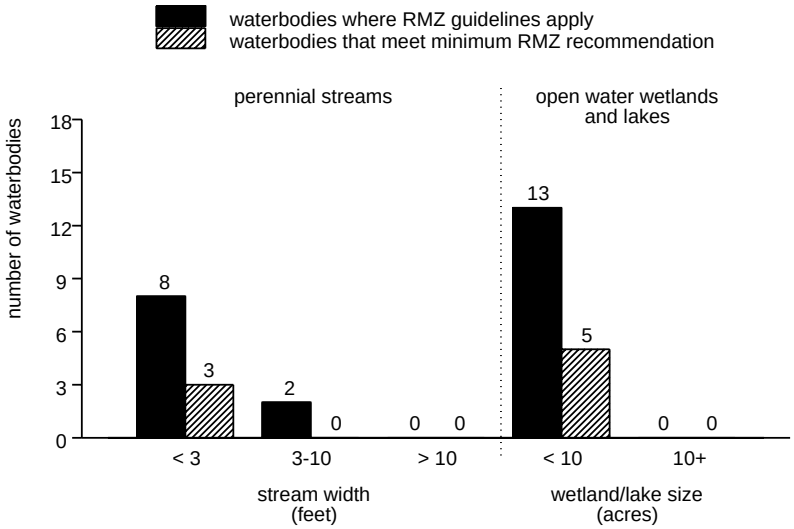

Figure 17. Comparison of onsite waterbodies in the timber harvest area requiring a RMZ with the number of waterbodies meeting the minimum RMZ recommendation for width and basal area statewide.

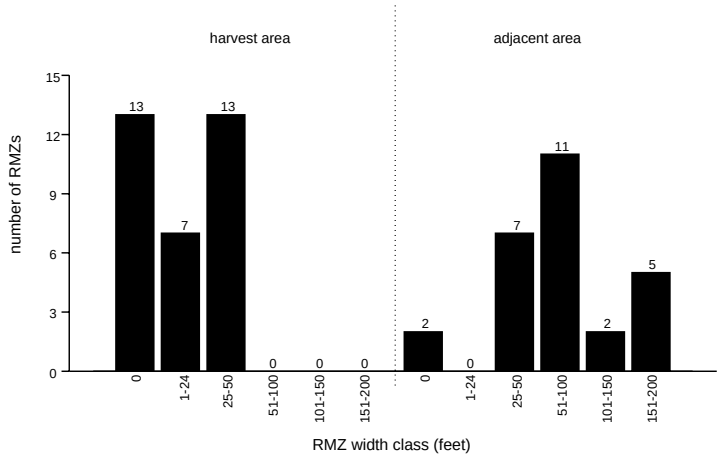

Figure18. Number of RMZs in width classes for waterbodies within or adjacent to the harvest area.

sites had five open water wetlands, all of which met the theoretical guideline recommendation. Several of these landowners also identified wildlife habitat as a management objective, but did not identify the successional stage for wildlife habitat.

The size of perennial streams monitored within the harvest area provides an interesting contrast to those found adjacent to the harvest area (Table 13). Most of the perennial streams monitored that were <3 feet wide were found to traverse the harvest area. Of these, three had RMZs that were clearcut to the streambank on both sides of the stream. Three of the other eight streams <3 feet wide and the two perennial streams 3–10 feet wide within the harvest area had RMZs that were around 10 feet wide on both sides of the stream. In contrast, the three perennial streams <3 feet wide and the one 3–10 foot wide stream adjacent to the harvest area had RMZs that met the guideline recommendations. One explanation for this result is that the resource manager or logger may not have been aware of the presence of some of these smaller streams at the time the timber was cruised and/or harvested. The landowner/resource manager could also have been interested in maximizing revenue from the timber

Table 13. Number and type of perennial streams monitored within and adjacent to the harvesting area.			
Location	Stream size (feet)		
	< 3	3–10	> 10
Within	8	2	0
Adjacent	3	1	16

harvest and made a conscious decision to harvest intensively near these waterbodies.

All of the perennial streams >10 feet wide were found adjacent to the harvest area. Riparian management zones for all but two of these waterbodies either met or were close to meeting the guideline recommendations for width and residual basal area. This suggests that landowners and resource mangers plan their sales, in general, to stay back from these larger waterbodies.

I. Protection of water quality and wetlands

1. Waterbody and wetland crossings

Crossing wetlands and open waterbodies has the greatest potential for directly impacting water quality and the hydrologic and biologic function of wetlands. Equipment using a crossing may carry mud and debris into the wetland or open waterbody, or leak fuel, oil, or other hazardous fluids. 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 open waterbody. In addition, the crossing itself may modify the movement of water within a wetland or open waterbody, causing upstream ponding, increased channel scouring, or destabilization of the banks. If not properly installed, maintained, and rehabilitated, many of these problems can become significant and continue long after the crossing ceases to be used.

Crossing wetlands and open waterbodies should be avoided whenever possible, but it is often necessary for hauling and harvesting equipment. Skid trail crossings for harvesting equipment are generally confined to the harvest area and are temporary in the majority of cases. Haul roads frequently must cross wetlands and open waterbodies to access a site as well as reach an appropriate loading area on the site. Many of these roads and associated crossings are considered temporary, but will often be reused years later to access the same or other harvest locations. Many others are or become part of a permanent, maintained management and recreational transportation system.

The field monitoring identified a total of 162 skid trail and road crossings with 315 approaches for nonopen water wetlands, open water wetlands, and perennial streams associated with 68 timber harvest sites (Table 14). Crossings of wetlands and open water by season of operation are given in Table 15. Two thirds of all crossings were winter crossings. Four of the six sites in the spring-summer-winter category only had activity during the spring and had no crossings. Six of the seven sites in the fall-winter category only had activity during the fall. The remaining site had six of the 10 crossings found on the fall-winter sites. It appears crossing wetlands and open waterbodies is avoided during the highest risk times of the year.

Table 14. Number of wetland and open water crossings for skid trails and roads.			
	Skid trail crossings	Road crossings	Total
NOWW	60	48	108 (69*)
OWW	0	2	2 (2*)
Streams	20	32	52 (37*)
Total	80	82	162 (108*)

Table 15. Wetland and open water crossings by season of operation.			
Seasons of harvest operation	Total number of sites monitored	Number of sites with crossings	Total number of crossings
All year	3	0	0
Spring, summer, winter	6	2	2
Summer, fall, winter	28	20	42
Fall, winter	7	3	10
Winter only	64	43	108
Total	108	68	162

* Indicates the number of winter crossings.

A total of 50 streams and two open water wetlands were crossed by roads and skid trails on or accessing the 108 timber harvest sites monitored in 2000. Only seven of the sites with crossings had protected public waters on or adjacent to the site. All crossings of protected waters were temporary, installing structures such as a temporary bridge or an ice bridge. No permits were required for these crossings.

Equivalent numbers of road and skid trail crossings were found for the sites monitored (Table 14). The majority of crossings (67%) were on nonopen water wetlands. Roads crossed one intermittent stream <3 feet wide. All other road and skid trail stream crossings were over perennial streams. Fourteen of the stream crossings were on access roads to 10 of the harvest sites, not directly on the harvest sites. Nine of these were winter roads.

Five of the winter crossings and four of the other offsite stream road crossings utilized one of the structures identified in Table 16. It was possible to identify the method of crossing for only 19 road stream crossings on 15 sites.

An issue with crossing structures is that they not impede the movement of aquatic organisms. One permanent culvert was identified as impeding movement of aquatic organisms. Six other crossing structures, a four-inch diameter permanent culvert, a log bundle road stream crossing and four skid trail stream crossings utilizing slash, would also impede movement of aquatic organisms. These six would plug easily with debris and be difficult or impossible to maintain to keep them open. Only one of the skid trail stream crossings that utilized slash was properly removed and rehabilitated. None of the other road and skid trail crossings, with and without identified structures, were rehabilitated.

It also appears that all nine culverts installed for stream crossings were too small which makes them highly vulnerable to washing out (Table 17). This increases maintenance costs, reduces productivity, and increases the potential for the culvert to wash out and deliver sediment to the stream which can degrade aquatic habitat. Some of these culverts may have been part of the existing road infrastructure and would not have been installed as part of the current timber harvesting operation.

Five crossings altered the cross-sectional area of the stream channel. Two were permanent culvert installations, one was an ice bridge, and the last two, both on the same site, were winter road stream crossings of an unknown type.

The method used to accomplish the other crossings is unknown. The landowner, resource manager, or logger likely assumed the 97 remaining crossings on winter harvest sites would be frozen during their operations. The warm weather during the past three winters made this an unreliable assumption. The remaining 46 crossings

Table 16. Stream crossing structures for roads.

Type of structure	Permanent	Temporary	Total
Culvert	9	1	10 (4*)
Bridge	3	1	4 (4*)
Ice bridge	0	1	1 (1*)
Low water ford	0	3	3 (1*)
Log bundle	1	0	1 (1*)
Total	13	6	19 (11*)

* Indicates the number of winter crossings.

Table 17. Culvert size compared to stream channel width.

Culvert size (inches)	Stream Width (feet)						Total
	1	2	3	4	5	6	
4	1	0	0	0	0	0	1
12	0	2	1	0	0	0	3
16	0	1	0	0	0	0	1
18	0	0	1	0	0	0	1
24	0	0	0	1	0	1	2
39	0	0	0	0	1	0	1
Total	1	3	2	1	1	1	9

occurred on sites harvested when the ground was not frozen. It is not known how these crossings were accomplished.

2. Approaches to waterbodies and wetlands

The approaches to any crossing are just as important in terms of water quality and wetland protection as the crossing itself. Failure to divert surface water flow off a road or skid trail before it reaches the open waterbody or wetland results in channeling that surface water and its load of sediment, organic material, and chemicals, directly into the open waterbody or wetland. The steeper the approach, the greater the problem. Water diversion structures need to be in place as soon as the crossing approach is created and needs to be maintained until the site is properly restabilized.

Approximately 42% of the approaches monitored had slopes ≤2% (Table 18). Nearly 81% of the approaches had a slope of ≤5. For all approaches, 69% were used during winter harvests. Those with a low slope may not be exposed to much surface flow of water. Those operated on during the winter may have retained the native ground cover. These situations will limit the risk to the wetlands and open waterbodies these approaches access. However, the lack of water diversion structures on so many approaches, and the number of approaches with slopes >5% raises serious concerns. Significantly more emphasis on crossings and approaches is needed in logger, natural resource manager, and forest landowner education. And more explicit contract language and project supervision is needed to improve performance. It might also be desirable to incorporate an assessment of soil stability and evidence of erosion on approaches into future implementation monitoring.

Table 18. Number of water diversion structures on crossing approaches.

Type of water diversion structure	Percent slope of approaches								Total
	1	2	3–5	6–10	11–15	18	26	50	
Water bar	0	0	2	2	0	0	0	0	4
Lead-off ditch	0	0	2	1	2	0	0	0	5
No structure	132	58	60	44	9	1	1	1	306
Total	132	58	64	47	11	1	1	1	315

J. Protection of forest soil resources

1. Site infrastructure

Forest soil productivity is protected by minimizing the proportion of the harvest area that is contained in site infrastructure (i.e., roads, landings). The TH/FM guidelines recommend that site infrastructure occupy no more than 3% of the harvest area. Figure 19 displays the mean percentage of the site in infrastructure across all landowner categories and by landowner category. The statewide average was at the recommended 3% level. The percentage in site infrastructure ranged from 4% for forest industry to 2% for other government. For landowner categories, site infrastructure as a percentage of harvest area acreage decreased in the order:

FI > NIPF > state > county > USFS > OG.

2. Landings

There were 197 landings identified during monitoring which is slightly less than two landings per timber harvest site. All of the landings were identified as being located on stable ground. Stable ground does not necessarily infer upland areas. A nonopen water

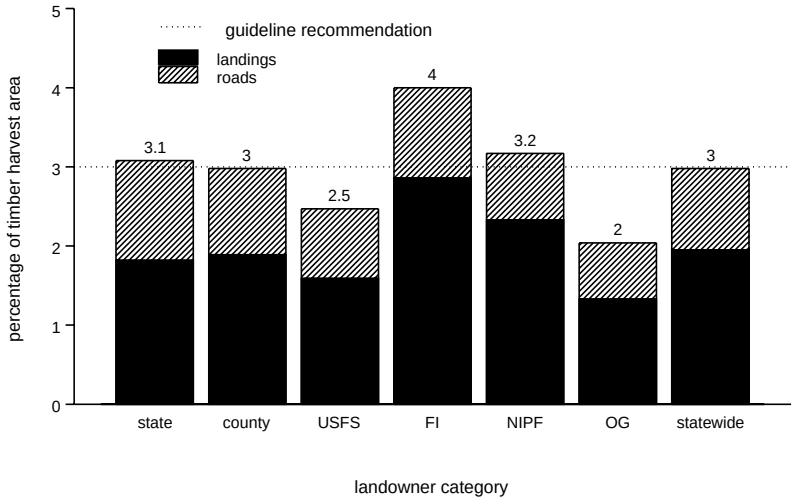

Figure 19. Percentage of timber harvest area occupied by landings and forest roads (total site infrastructure) by landowner category statewide.

wetland that is frozen can serve as a stable landing. Landings occupied on average 2% of the site across all landowner categories (Figure 19). Landings as a percentage of harvest area acreage for the landowner categories decreased in the order:

FI > NIPF > county > state > USFS > OG

One of the general recommendations for both landings and roads is to keep them out of filter strips and RMZs. Landings were kept out of the filter strips and the RMZs 95% and 99% of the time, respectively. Since fueling and maintenance are routinely done on landings, it can be inferred that fueling and maintenance were also located outside of the filter strips and RMZs 95% and 99% of the time, respectively.

3. Forest roads

The TH/FM guidebook emphasizes the need to design, construct, and maintain forest roads to access as many acres of the site as possible with the least amount of roads. The guidelines recommend no more than 1%–2% of the harvest area occupied by roads. Across all landowner categories, forest roads occupied, on average, only 1% of the harvest area with the highest proportion of the sites in roads found for state sales at 1.3% (Figure 19). The average percentage of timber harvest area occupied by forest roads by landowner category decreased in the order:

state > FI > county > USFS > NIPF > OG.

The roads data presented here only accounts for the roads acreage on the harvest area and does not include the roads constructed or modified to get to the site.

Properly constructed and maintained roads encourage efficient timber harvesting operations by lowering operating costs, reducing erosion and compaction, and minimizing impacts to the forest resource. Poorly constructed and maintained roads can result in an increase in erosion and rutting which can cause additional expansion to the road infrastructure generally by widening the road footprint as the equipment operator or truck driver attempts to move around the ruts in the road.

The TH/FM guidelines recommend using a combination of appropriate road cross section and water diversion structures to control water movement for road grades $\geq$2%. The guidelines recommend that erosion control practices should be applied to all road segments and not just those where there is the potential for surface runoff to directly impact water quality. This is a departure from previous BMP monitoring where only the portions of the road that could potentially impact water were evaluated. Data was collected on the drainage structures installed on roads to control the volume, velocity, and direction of water flow on the road surfaces. In total, 155 road segments were found with grades $\geq$2%. The distribution of these road segments by percent grade is given in Table 19. Half of the segments were in the 2% to 5% grade. However, none of the segments at any percent grade had any water diversion devices installed which is a cause for concern and needed discussion. In some of the cases the water diversion devices were probably not needed. For example, where boulders and large rocks were close to the soil surface, it is very difficult to install an effective water diversion device. The consequence is to accept some level of sheet erosion over the road surface. An option for the GIMC is to have the Technical Committee define and clarify the criteria when water diversion devices are appropriate for road surfaces and to implement those recommendations for the second round of monitoring.

An important action to maintaining the sustainability of the timber harvest area is to control access to the site. Controlling traffic diminishes problems with erosion and rutting and reduces continued maintenance needs. The TH/FM guidelines recommend closing roads (temporarily or permanently) when not in use. The contractor was required to collect information on road closures (Table 20). Most of the roads (54%) were rated as active. Only six sites had roads rated as permanently closed. Access to the sites for roads temporarily and permanently closed was controlled 92% of the time.

There were also six roads rated as active but where access to the site was controlled. This could be a situation where a gate was open at

Table 19. Number of road segments with grades of two percent or more.

2% to 5%	6% to 10%	11% to 15%	Total
79	60	16	155

Table 20. Road status for monitored sites.						
	Active	Temporarily closed	Permanently closed	Unknown	No roads	Total number of sites
Access controlled	6	30	6	0	0	42
Access not controlled	52	3	0	0	0	55
Not applicable	0	0	0	3	6	9
Total number of sites	58	33	6	3	6	108

the time the site was monitored. In reviewing the data it was clear that there was some confusion and inconsistency in how the contractor rated road closure. For three of the roads, not enough information was provided to make a determination as to the status of the road. Prior to the next round of monitoring, the Technical Committee will need to clarify for the contractor the criteria for what constitutes an active road and the type of closure.

4. Skid trails

Skid trails are generally more difficult to delineate on the harvest site 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. 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 were <15% or >15% or to determine that these values could not be estimated (Figure 20). Primary skid trails were found to occupy <15% of the harvest area on 75% of the sites. On 23% of the sites, the area occupied by primary skid trails could not be estimated. Secondary skid trails were reported to occupy <15% of the harvest area 28% of the time and could not be determined on 47% of the sites. Considering the uncertainties involved in separating primary from secondary skid trails, it might be more appropriate for the next round of monitoring to only estimate if total skid trails occupy <15% or >15% of the harvest area or whether the percentage cannot be determined.

The contractor was also required to determine the type of skidding pattern that was evident on the harvest site. These results are shown in Figure 21. Seventy percent of skidding patterns were either not evident or were randomly distributed lightly over most of the site.

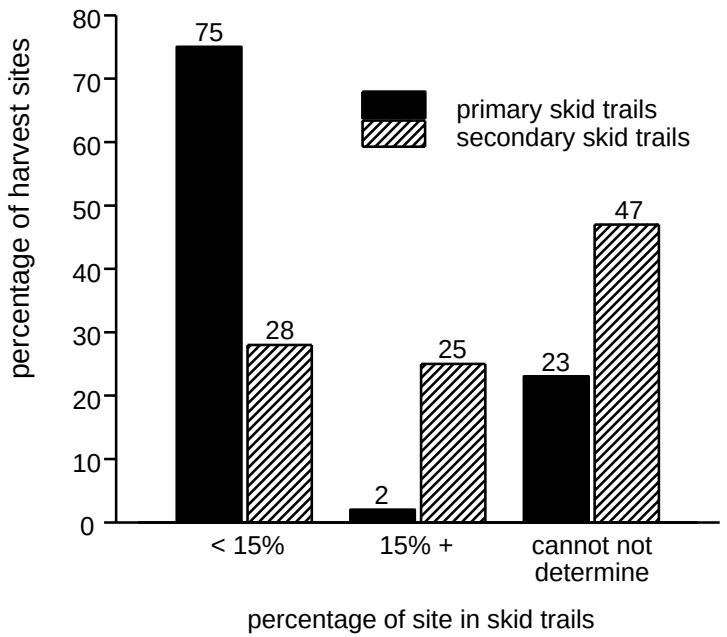

Figure 20. Percentage of timber harvest sites occupied by varying levels of primary and secondary skid trails.

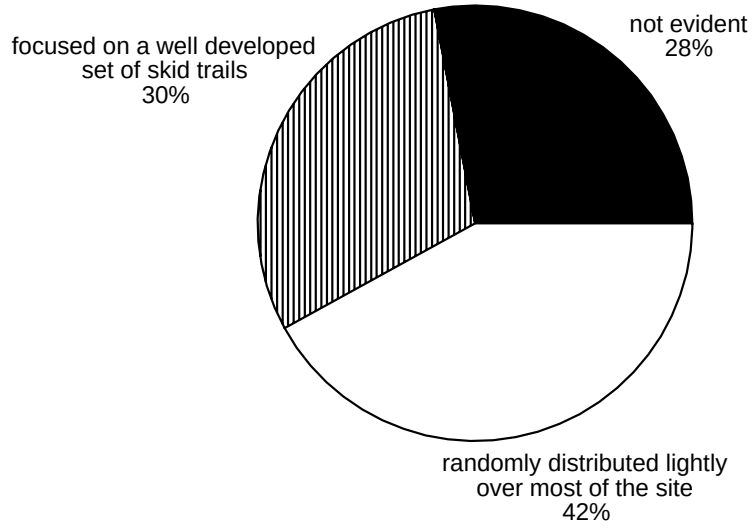

Figure 21. Skidding patterns on timber harvest sites statewide (percent).

Less than a third of the sites had skidding patterns that were identified as focused on a well developed set of skid trails. If primary skid trails are synonymous with a well developed set of skid trails, then this data might suggest that 1) skidding was not focused on primary skid trails (which is the guideline recommendation) or 2) that winter harvesting on frozen soils could mask the effect of concentrating the skidding on a well developed set of skid trails. On 67% of the sites, winter was the season when the skidding pattern was described as being either randomly distributed lightly over most of the site or not evident (Table 21). This roughly parallels the percentage of sites that were harvested in winter (Figure 6). Thus, frozen ground could have masked or minimized the visual impact of a well developed set of skid trails. This suggests that the guideline recommendation to concentrate skidding to a well developed set of skid trails should be changed to apply only to harvests on unfrozen ground.

The TH/FM guidelines recommend that water be diverted off the skid trails by properly shaping the trail surface and using broad based dips, lead-off ditches, or water bars. The need to divert water off these surfaces increases as slope increases. The contractor was required to identify segments of skid trails with slopes ≥2% and to record the surface profile shape used and the type and numbers of water diversion devices employed. Table 22 shows the number of skid trail segments that are ≥2% but have limited potential to directly impact waterbodies and wetlands with surface runoff containing sediment. Three quarters of these segments were found on gently sloping (6% to 15%) terrain with the majority of these segments (57%) being non-winter harvests.

Table 21. Skidding pattern by season of activity.

Skidding pattern	Season of timber harvest (number of sites)					Total
	Spring	Summer	Fall	Winter	Combined	
Focused on well developed set of skid trails	0	10	3	13	7	33
Randomly distributed lightly over most of the site	0	10	1	29	4	44
Not evident	1	3	2	20	3	29
Total	1	23	6	62	14	*106

* no data for two sites

Table 22. Skid trail segments with a grade of 2% or more.*

Topography	Winter harvest sites	Skid trail segments	Non-winter harvest sites	Skid trail segments	Total number of sites	Total skid trail segments
Level (2 to 6%)	3	9	6	22	9	31
Gently rolling (6 to 15%)	9	31	9	97	18	128
Steep (>15%)	1	2	0	0	1	2
Rock outcrops	0	0	1	8	1	8
Total	13	42	16	127	29	169

* three skid trail segments on two sites had slash water bars

As with roads, the recommendation to use the appropriate combination of profile shape and water diversion devices for segments that would not directly impact water quality or wetlands from surface runoff is a departure from previous BMP monitoring. The focus of BMP monitoring was on skid trail segments where surface runoff could directly impact waterbodies or wetlands. For current guideline monitoring, only three skid trail segments on two sites were found with any water diversion devices. As discussed in the forest roads section above, water diversion devices may not always be needed, but the lack of water diversion devices on these skid trail segments is problematic. If the surface of skid trail and road segments degrade over time, it could be difficult to reuse sections of the skid trails or roads. This could force the disturbance of new areas of the site on subsequent entry or increase the cost of using previous skid trails and roads. The Technical Committee should define and clarify the criteria when water diversion devices are appropriate for skid trail surfaces and implement those recommendations for the second round of monitoring.

5. 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 (>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 efficiently operate equipment on the site, to regenerate the stand, or to prevent additional compaction that might occur from redistributing the slash.

The contractor was required to evaluate which of the following three options was most commonly used for slash disposal on each site. The three options were: 1) slash retained on the site at the stump, 2) slash redistributed back onto the site, and 3) slash piled at landings. The results of this evaluation are given in Figure 22. The most common method of slash retention was retaining it at the stump. This method, in combination with redistribution of slash back onto the site, was found for 73% of the sites monitored. These are the two methods that are preferred for maintaining forest soil productivity.

On four sites the contractor could not determine the most common method of slash disposal. In these cases, the burning of slash at the landings prevented an accurate determination to be made of the most common method of slash disposal for the site.

6. Rutting

The objective of many soil specific guidelines is to minimize equipment effects on productivity by reducing the area of the site impacted by rutting. Rutting is the creation of depressions made by the tires of equipment involved in forest management activities (e.g., skidders, log trucks). It occurs when soil strength is not sufficient to support the applied load from the vehicles. The adverse effects of rutting include modifying surface hydrology of the site for both mineral soils and wetlands, severing roots, and reducing soil aeration and infiltration within the rut that will degrade the rooting environment and, in the case of wetlands, impede the normal surface flow of water. The contractor was required to collect information on whether rutting occurred in wetlands, RMZs, filter strips, roads, skid trails, and the general harvest area. For purposes of monitoring, rutting in the general harvest area occurred when it was found on ≥5% of this area. The general harvest area excludes roads, primary and secondary skid trails, filter strips, RMZs, and wetland inclusions.

Rutting occurred on one or more of these site features on 36 (33%) of the sites. The numbers of sites where rutting was found for specific site features is given in Figure 23. It was common to find rutting had occurred on more than one site feature. For one site, rutting was

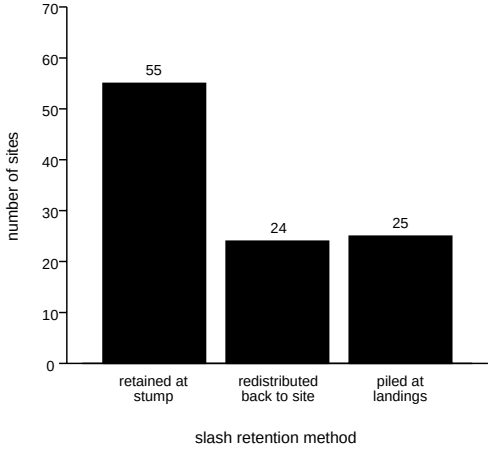

Figure 22. Method of slash retention most commonly used on timber harvest sites.

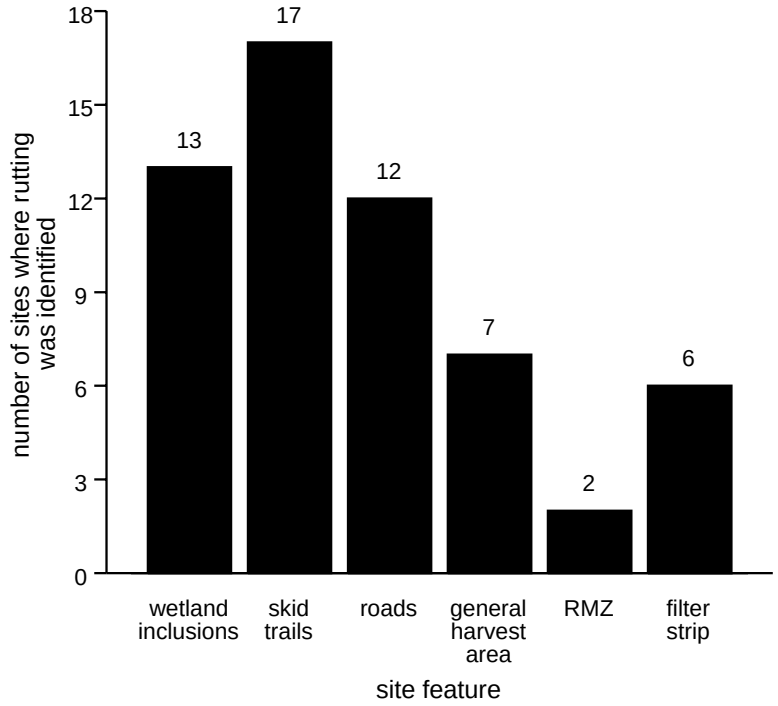

Figure 23. Location of rutting for specific site features on timber harvest sites monitored.

found to have occurred to some extent for all six site features. On five sites, the contractor reported ruts on skid trails in wetlands that exceeded six inches in depth for distances greater than 300 feet in length. Ruts in excess of these values can induce blockage of cross drainage, resulting in the ponding of water up-gradient to the flow. It is also necessary to minimize extensive rutting to minimize down road channelization of water. Overall, rutting on these site features was found to decrease in the order:

skid trails > wetland inclusions > roads > general harvest area > filter strips > RMZs.

Rutting was evident most often for harvests conducted in winter (Figure 24) accounting for more than half of the sites on which rutting occurred. As indicated earlier (Figure 6), however, 58% of the harvests were conducted during winter so that the 19 winter sites where rutting was found represents 30% of the winter harvests. The rutting found for winter sales probably reflects the warmer winters common for the past three years resulting in a ground surface not completely frozen. For the other seasons of harvest, no rutting was

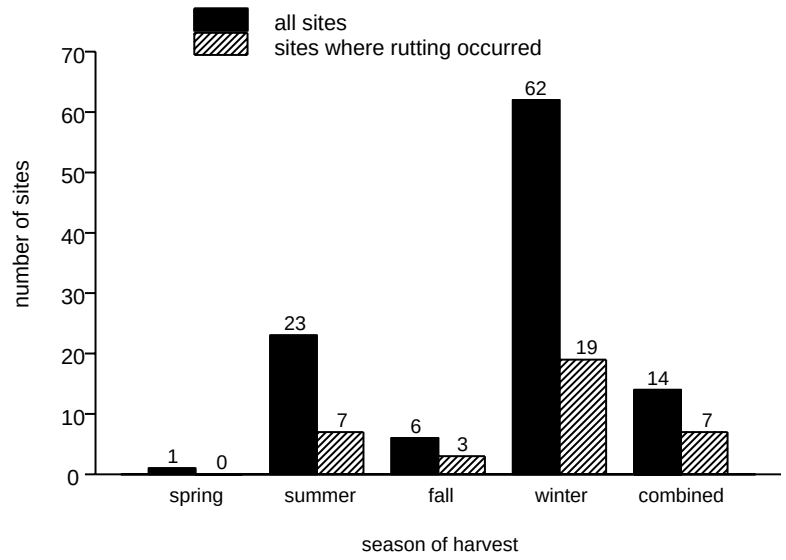

Figure 24. Number of sites by season of timber harvest where rutting was evident.

indicated for the single spring harvest but was found on 30%, 50%, and 50% of summer, fall, and combined season harvests, respectively.

The TH/FM guidelines identify operating techniques to employ to minimize rutting. The landowner/resource manager was asked on the presite visit worksheet to identify the techniques used to minimize rutting. However, the way the question is phrased it is not clear if the landowner/resource manager responded to this question with the understanding that either these were techniques that were to be used only after rutting had occurred or if these techniques were to be employed as prevention before rutting occurred.

Operating techniques to minimize rutting were used on 22 sites. The most common techniques used were the use of slash and the shifting of operations until conditions improved (e.g., freezing, drying) for continued harvesting (Table 23). These two methods accounted for 79% of all techniques used to minimize rutting.

Table 23. Operating techniques used to minimize rutting.

Operating technique	Number of sites
Low ground pressure equipment	1
Use of slash	16
Reduce loads	1
Shift operation to more stable area	14
Temporarily cease operations	4
Other	2

K. Applications for wildlife habitat

1. Coarse woody debris

Coarse woody debris is an important component of forest sustainability as it provides habitat for forest critters and plants as the stand regenerates following forest management activities. The guideline recommendation is to create or retain at least two to five bark-on down logs at least 12 inches in diameter per acre. The guidelines are further refined by recommending that hollow butt sections or other defective lengths of at least six feet are preferred, and that sound logs and six to 12 inch diameter logs can be used if they represent the best available candidates. Due to these two refinements in the guidelines, the standard that was adopted for the contractor to measure was bark-on down logs at least six inches in diameter and at least six feet in length. For riparian areas, the standard was to retain or create four bark-on down logs per acre.

The results of this evaluation are found in Table 24. Meeting the guideline recommendation was found for only 21% of the sites for the general harvest area and 22% of the time this recommendation was evaluated for riparian management zones. All of these sites were at least one to two years old. Although there were sufficient down logs on these sites as found in the quality control inspections, there were not enough "bark-on" down logs to meet the guideline measures as written. It is likely for many of these logs that the bark had sloughed off by the time the inspections were conducted. This would suggest that this is not a measurable guideline as currently written. It may be more appropriate to collect information on decay classes of logs (Tim Webb, personal communication). This will require additional discussion prior to the second round of implementation monitoring.

Table 24. Bark-on down logs per acre for general harvest area and RMZ by statewide and landowner category.

Landowner category	Total number of sites by landowner category	Bark-on down logs				
		General harvest area			RMZ	
		< 2	2–5	5+	< 4	> 4
State	27	25	2	0	4	2
County	31	19	9	3	14	9
USFS	17	15	2	0	8	0
FI	5	4	1	0	2	0
NIPF*	25	18	6	0	16	2
OG	3	3	0	0	3	0
Total number of sites	108	84	20	3	47	13

* missing one site

2. Leave tree distribution

Leave trees and snags are retained on timber harvests to provide structure and habitat for wildlife species as the stand regenerates. The TH/FM guidelines provide recommendations for retaining leave trees and snags at the site level while recognizing that there is a temporal and spatial (i.e., landscape) consideration for fully implementing these guidelines. The guidelines do not address directly in recommendations how to incorporate the landscape context into "on-the-ground" decisions. However, the Technical Committee recommended that the area adjacent to the clearcut be considered in evaluating leave tree acreage.

There are two components that make up the leave tree recommendations contained in the TH/FM guidelines. One component is retaining on clearcuts a minimum of 5% of the harvest area in tree clumps of at least 1/4 acre with trees of at least six inches in diameter. The second component is to retain $\geq$6 scattered individual leave trees per acre on the harvest area. In both cases the trees must be at least six inches in diameter of a mix of desirable species. If the site has leave trees that conform to either condition, the guideline recommendation is met. It is often the case that a site will have both components that meet the guideline recommendation.

The number of sites that meet the guideline recommendation for scattered leave trees by landowner category is given in Table 25. Fifty-two percent of the timber harvest sites had $\geq$6 scattered leave trees per acre.

As described earlier, leave trees were calculated for internal clumps and for total leave tree clumps which includes those adjacent to the harvest area. Internal leave tree clumps (i.e., those totally within the cut boundaries of the harvest area) were found on 38 of 108 sites and averaged 7.6% of the area of these sites across all landowner categories where $\geq$5% of the harvest area was retained in internal leave tree clumps (Table 26). The percentage of harvest area retained in internal

leave tree clumps by landowner category ranged from 11.9% for forest industry to 6.0% for the U.S. Forest Service and decreased by landowner category in the order:

FI > NIPF > OG > state > county > USFS.

Table 25. Number of timber harvest sites with greater than or equal to six scattered leave trees per acre.

Landowner category	Total number of sites by landowner category	Number of sites with >6 scattered leave trees per acre
State	27	14
County	31	12
USFS	17	12
FI	5	1
NIPF	25	15
OG	3	1
Total number of sites	108	55

Table 26. Percent of timber harvest area occupied by internal leave tree clumps by landowner for those sites with >5% acreage in internal leave tree clumps.

Landowner category	Total number of sites by landowner category	Number of sites with internal clumps >5% of harvest area	Average percent of internal clumps
State	27	9	7.1
County	31	11	6.2
USFS	17	7	6.0
FI	5	3	11.9
NIPF	25	6	10.8
OG	3	2	8.0
Total	108	38	7.6

The percentage of sites where internal leave tree clumps were retained by landowner category ranged from 67% for other government to 29% for county land and decreased in the order:

OG > FI > USFS > county > state > NIPF.

When forest land adjacent to the site was considered, total leave tree clumps (internal plus adjacent) were found on 53 of 106 even-age management sites and averaged 11.3% of the area of these sites across all landowner categories where $\geq$5% of the total site acreage was retained in leave tree clumps (Table 27). The percentage of the total site in clumps by landowner category ranged from 16.3% for state forest lands to 8.6% for other government and decreased by landowner category in the order:

state > county > NIPF > FI > USFS > OG.

Table 27. Percent of timber harvest site occupied by total leave tree clumps by landowner for those sites with >5% acreage in total leave tree clumps.

Landowner category	Total number of sites by landowner category	Number of sites with total leave tree clumps >5% of harvest site	Average percent of total clumps
State	27	9	16.3
County	31	20	11.2
USFS	17	9	8.8
FI	5	4	9.4
NIPF	25	9	10.4
OG	3	2	8.9
Total	108	53	11.3

The percentage of sites where leave tree clumps for total site acreage (harvest area + adjacent leave tree area + adjacent forested RMZ) were retained by landowner category ranged from 80% for forest industry to 33% for state forest land and decreased by landowner category in the order:

FI > OG > county > USFS > NIPF > state.

As stated previously, the guideline recommendation is met by providing for either the appropriate number of scattered leave trees per acre and/or by retaining the appropriate size and percentage of leave tree clumps. The proportion of the site retained as internal leave tree clumps (≥5%) or as scattered leave trees (≥6 trees/acre, diameter ≥6 inches) by landowner category is shown in Table 28. The number of sites where one or both of these conditions were met was found on 60 of the 106 even-age management sites or 57% of the total.

The proportion of total site acreage retained as leave tree clumps (≥5%) or as scattered leave trees (≥6 trees/acre, diameter ≥6 inches) by landowner category is shown in Table 28. The number of sites where one or both conditions were met was 71 of 106 even-age management sites or 67% of this total. This figure represents the baseline value of compliance with the recommendations of the TH/FM guidelines for retaining leave trees. This value is lower than results reported by Puettmann et al. (1996) who found that clearcutting with residuals accounted for 77% of acres clearcut. However, these authors evaluated residuals within the harvest area, not in adjacent areas (Charles R. Blinn, personal communication). Therefore, a comparison to the internal leave tree clumps may be more appropriate. This was discussed earlier in Section III.E.

Table 28. Number of sites occupied by each type of leave tree clump and/or scattered individual leave trees by landowner that met or exceeded the guideline recommendation.

Landowner category	Total number of sites by landowner category	Number of Sites	
		Internal clumps + scattered leave trees	Total clumps + scattered leave trees
State	27	15	18
County	31	14	19
USFS	17	12	14
FI	5	3	3
NIPF	25	15	16
OG	3	1	1
Total number of sites	108	60	71

3. Distribution of snags

Snags provide habitat for wildlife requiring tree cavities, perches, and bark foraging sites. The TH/FM guidebook is not specific in recommending numbers of snags or their distribution on the timber harvest site. The inference seems to be to provide for as many snags as possible. This lack of more specific guidance makes it difficult to determine if the guideline is being met. In the final development of the guideline measures, the Technical Committee decided that the contractor would be asked to answer the following question on each timber harvest site, "Were snags retained?" This question was answered affirmatively 80 times or 74% of the time.

4. Maintaining oaks

The TH/FM guidelines recommend retaining oaks on harvest areas for continued mast production during stand regeneration. Oaks were present on 23 of the sites monitored. On 21 of these sites, oaks were reserved as scattered individual trees or were left in leave tree clumps. On two of the sites, no measures were taken to reserve the oaks.

L. Quality control

A quality control team made up of representatives of the Technical Committee visited seven sites or 6.5% of the total to review and evaluate compliance with contract specifications for site monitoring. This team was also responsible for collecting effectiveness monitoring data based on the previous BMP procedures (Phillips et al. 1994). For the seven sites evaluated by the quality control team, only one site had an open waterbody with a recommended RMZ. The quality control team found that the contractor was generally in sufficient conformance with contract requirements for data collection. What was the most useful outcome for the quality control team was the time spent evaluating and discussing the guideline measures in the field and determining whether those measures were appropriate or needed modification for the second round of

monitoring. Many of the changes or refinements to the field monitoring procedures for 2001 identified in the Recommendations section were a direct consequence of the field reviews by the quality control team.

IV. SUMMARY OF FINDINGS

- The application of timber harvesting and forest management guidelines was monitored on state, county, U.S. Forest Service, forest industry, nonindustrial private forest landowners, and other government land distributed broadly over the forested regions of the state.

- A variety of site information resources, particularly aerial photographs, were commonly used to assist landowners/resource managers in designing timber sales and preparing timber harvest plans. Site maps were developed for 72% of sites monitored.

- Onsite meetings between the landowner/resource manager and the logger/operator to discuss forest road issues and timber harvest specifications were for 71% and 94% of the sites, respectively.

- Twenty-six percent of the monitored sites were visually sensitive. Landowner and loggers were aware of the visual sensitivity classification on 36% and 29% of these sites, respectively.

- Landowners and/or resource managers checked cultural/historic resource inventories on 50% of the sites monitored prior to timber harvesting. Inventories for ETS species were checked on 69% of the sites monitored prior to timber harvesting.

- Filter strip compliance with the guideline recommendation (<5% mineral soil exposure, well distributed over the filter strip) was 70%.

- For lakes, perennial streams and open water wetlands, 50% of riparian management zones (RMZ) met the guideline recommendations for width and residual basal area. A higher proportion of RMZs that met the guideline recommendations were adjacent to the harvest area compared to those for waterbodies that were within (i.e., open water wetlands, lakes) or traversed (i.e., streams) the harvest area.

- A high percentage of skid trail and road approaches to wetlands and streams did not have the appropriate water diversion devices installed to divert surface runoff from directly entering these waterbodies.

- The guidelines recommend that site infrastructure (i.e., roads, landings) should occupy no more then 3% of the harvest area. The statewide average was at the recommended 3% level.

- Landings were located outside of filter strips and wetlands 95% and 99% of the time, respectively.

- Access on roads temporarily or permanently closed was controlled 92% of the time across all landowner categories.

- Slash was retained at the stump or redistributed back on the site for 73% of the sites monitored.

- Rutting was found on 33% of the sites monitored and was most prominent on skid trails, wetland inclusions and roads. The use of slash and shifting operations until conditions improved accounted for 79% of all techniques used to minimize rutting.

- The percentage of sites classified as even-age management with reserves (percent of site in leave trees) that met the guideline recommendations ranged from 57% to 67% depending on the method of calculation.

V. CONCLUSIONS

The 2000 monitoring program establishes baseline conditions by which implementation of Minnesota's new timber harvesting and forest management guidelines can be assessed through subsequent monitoring efforts. Practices evaluated on the 108 harvest sites evaluated in this initial monitoring effort include logging road and skid trail infrastructure, cultural resource presence, slash disposal, leave trees and other wildlife habitat considerations, and riparian management. The 2000 monitoring program also assessed the extent to which the forestry community's existing guidelines (BMPs) for water quality and wetlands protection and visual quality are being implemented. However, changes in this year's protocols for conducting field monitoring limit comparison to past water quality, wetland, and visual quality monitoring findings. The current monitoring program provides for quantitative evaluations of each resource feature (e.g., wetland) individually, so multiple occurrences of the same resource on a given harvest site are treated as independent evaluations. This is in contrast to previous water quality, wetland, and visual quality monitoring efforts where evaluations characterized the predominant practice across the entire site when multiple occurrences of the same resource were found.

Due to the limited number of sites evaluated in this initial monitoring effort, substantive characterizations of harvest practices by landowner category or landscape region will be difficult. Most of the conclusions that can be drawn are statewide across all landowner categories. Through subsequent guideline implementation monitoring efforts, a database will be developed that will enable an assessment of how practices are changing in response to availability of the guidelines.

The inaugural TH/FM guideline implementation monitoring program provided the following.

- A description of various timber harvest practices being applied in Minnesota immediately prior to availability of the 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, pre-harvest review for cultural resources and ETS species, site infrastructure percentage, skid trail distribution and water diversion device use for roads and skid trails.
- Identification of changes needed for conducting future TH/FM guideline implementation monitoring efforts. Examples include modifications to criteria for identifying primary sampling units used in identifying harvest sites for review, presite visit landowner/resource manager/logger interview questions, and parameters evaluated during the site visit.
- 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.
- Information to assist the Forest Resources Council in evaluating the extent to which its guideline implementation goals are being met. This includes the goal of assessing awareness and understanding of the guidelines as measured through attendance of introductory guideline training and field demonstrations as well as application of the guidelines over time.

VI. RECOMMENDATIONS FOR FUTURE MONITORING

In preparing for the 2001 guideline monitoring effort, needed changes that will improve the efficiency and accuracy of data collection were identified. Meetings were held with the Technical Committee, aerial photo interpretation(s), and among "core" team members to identify improvements to the process for 2001. The following is a summary of changes planned for the 2001 monitoring effort:

A. PSU Selection

For 2001 the PSU selection criteria was altered to increase the potential for timber harvests within the sampled PSUs. The criteria for the minimum forest acreage within a PSU was increased from 160 acres of forest to six square miles of timberland (i.e., at least one third of the PSU in forest). Thus PSUs with less forest area were omitted from the sample.

B. Aerial photo interpretation and data collection

Phase 1 of aerial photo interpretation:
This phase consists of evaluating all of the photos in the selected PSUs and looking for timber harvests that occurred within the past two years. In advance of this phase of the process in 2001, a letter will be sent out to agencies and private industry requesting that they submit all timber harvests conducted within those PSUs on their lands. The aerial photo interpreter(s) will use this list to verify and further calibrate the identification of recent harvests.

Phase 1A:
Once the preliminary sites are identified, the landowners will be contacted to verify that a harvest did indeed occur at that location, and within the given time period. Each landowner will be asked to verify the delineation of the harvest boundary. Once the final site package is set, Council and DNR staff will contact all landowners and request a full set of documentation for the harvest site including but not limited to maps, regulations, planning documents, and documentation of considerations for special features.

Phase 2 of aerial photo interpretation:
Once the final set of 120 sites has been established, the aerial photo interpreter(s) will go back to rectify and geo-reference the photos, and conduct certain measurements on each site. Changes in 2001 include:

- Identifying and delineating all open water features that require an RMZ that are within 1.5 times the theoretical RMZ width of the cutting boundary.

- Identifying the visual sensitivity of the site and designating a location from which the contractor will evaluate the visual quality guidelines.

Phase 3 of aerial photo interpretation:
After the contractor has completed the field evaluations, the photos will again come back to the aerial photo interpreter(s) to add detail and make modifications as indicated by the field contractor. Changes for 2001 include:

- Mapping roads on the site and measuring the average width of each road. The aerial photo interpreter(s) will then measure length and surface area of delineated roads.

- The contractor will be delineating all leave tree clumps, strips, and islands (these will not be delineated ahead of time). The aerial photo interpreter(s) will then map and measure the size of the leave tree clumps, strips, and islands delineated by the contractor.

- The aerial photo interpreter(s) will calculate the area of landings based on the location delineated on the aerial photograph by the contractor. This calculation will be compared to the area of landings determined by the contractor onsite.

- The aerial photo interpreter(s) will be making more measurements of the area occupied by forested and non-forested portions of RMZs, both actual and theoretical.

C. Distribution of Request for Proposal (RFP)

After phase 2 is complete, the package of completed sites will be made available to the potential contractors for review in preparation of their bids. For 2000, not all photos were available at the time the RFP was available for review. In 2001, the packet will contain the locations and photos for all sites to be monitored.

D. Collection of presite and site profile information

At the same time as the aerial photo interpretation is occurring, Council and DNR staff will be collecting background information for each of the final sites. The vehicle to be used is the site profile and presite

worksheets. These worksheets have been modified for 2001. In addition, a user friendly questionnaire will be developed to be used for the landowner/resource manager interview that provides the data needed to complete the site profile and presite worksheets. Part of this data collection will include a request for copies of all documentation connected with the harvest.

E. Calibration workshop

The calibration workshop will be expanded for the second round of monitoring. In particular a full day will focus on wetland identification. As part of this calibration workshop, clarifying the criteria for defining seasonal ponds will be a priority. Additional training sites will be visited to provide more opportunities for discussion. It is anticipated that the workshop will last the better part of a week.

F. Onsite data collection

The contractor will be given more information for each site than in the first round of monitoring, including more complete timber sale documentation. Each packet will contain two different scales of aerial photo, and complete site documentation including site maps, landowner information, contact person, cruise information, visual quality concerns identified, and appropriate telephone numbers.

Some significant changes will be made to the onsite data collection worksheet. Changes for 2001 include:

- Global Positioning System data collection will be eliminated. Instead the contractor will be required to complete an accurate and legible map of each monitoring site with locations of features clearly identified on the map.

- Leave tree categories will be expanded to the following: <1, 1–5, 6–12, >12 trees per acre. Also a breakdown of leave tree clumps, strips, and islands will be developed according to their location.

- The occurrence of snags will be identified by one of four categories: 0, <1, 1–2 and >2 snags per acre.

- A review of coarse woody debris classes for the general harvest area and the RMZs. Identification of three or four measurable decay classes may replace numbers of "bark-on" down logs for coarse woody debris.

G. Visual quality evaluations

Visual quality sensitivity will be determined by the Resource Assessment unit when reviewing the aerial photographs rather asking the landowner/resource manager. The aerial photo interpreter will indicate on the aerial photo where the contractor will collect the data on visual quality. To determine the VSC for each monitoring site, the digital image of the county VSC map will be overlain with each monitoring site, and the VSC will be determined by photo interpretation. If the monitoring site is within a reasonable distance of a road, lake, river, or designated state trail so that the photo interpreter judges that the site is visible from the road or other site feature, the monitoring site will be given a VSC corresponding to the VSC of the road or other site feature. In some cases, sites may be visible from several features. For example, a site may be visible from both a road and a lake. The site would then have two VSCs and the contractor would have to rate the visual quality guidelines from each feature from which the site is visible.

Visual quality assessments should be expanded for the second round of monitoring to include streams, lakes and recreational trails, if specified on the applicable county maps. When the choice is discretionary on the map, the visual quality rating will be made. The accuracy of determining the VSC for sites which border roads, lakes, and rivers should be very high. When the site is not adjacent to the features, it will be more difficult to be certain that the sites are truly visible from the features. The place where the evaluation of lakes, streams, and recreational trails will take place is the closest place that is accessible to the public. For recreational trails, only those that are designated specifically on the visual quality sensitivity maps will be evaluated.

H. Monitoring follow-up

During evaluation of data, the additional acreage of various site components (e.g., leave tree clumps) located on the aerial photos by the contractor(s) will be used to finalize acreage of site components.

I. Other suggested changes for monitoring in 2001

- Define and clarify the criteria when water diversion devices are appropriate for road and skid trail surfaces.

- Clarify for the contractor the criteria for what constitutes an active road and the type of closure.

- Estimate if total skid trails (i.e., primary + secondary) occupy <15% or ≥15% of the harvest area or whether the percentage cannot be determined.

VII. GLOSSARY

Approach: (see "water crossing approach").

ArcView: Specific geographic information system software used to analyze spatial data.

Artificial regeneration: To replace 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 harvesting 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.

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

Dbh: Tree diameter at breast height (4.5 feet above the ground).

Digital ortho quads: Digital topographic quadrangle maps which utilize an orthophotograph for a base. The orthophotographic base essentially removes those displacements of points caused by tilt, relief, and central projection.

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 waterbody that acts to trap and filter out suspended sediment and chemicals attached to sediment before it reaches the surface water. Harvesting and other forest management activities are permitted in a filter strip as long as the integrity of the filter strip is maintained and mineral soil exposure is kept to a minimum.

Geographic Information Systems: A Geographic Information System (GIS) is a computer-based system for the capture, storage, retrieval, manipulation, analysis and display of geographic information. The number and type of applications and analyses that can be performed by a GIS are as large and diverse as the available geographic datasets.

Guidelines: A specific practice or combination of practices designed, when applied onsite, to protect specified functions and values.

Harvest area: The area of a site where timber harvesting actually took place as apposed to the entire area of the site where management activity occurred.

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 which 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 timber harvesting or other forest management activity is conducted.

Infrastructure: The network of access roads, approaches, 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 snow melt. 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 tree: 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 coarse. 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.

Nonopen 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.

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 wetland: 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.

Peninsular intrusions: A type of leave tree clump that protrudes out into a timber harvest site and that is directly adjacent to the harvest site on all but one side. The length of the one side that is not directly adjacent to the harvest site should be shorter than the distance that the clump protrudes into the harvest site.

Perennial stream: 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., ½ 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. The presite worksheet was completed by the forest manager, or by a member of the Council staff during a "presite visit" with the landowner.

Rectify (rectified): The process by which an image (in this case, an aerial photograph) is converted from image coordinates to real-world coordinates. For the purposes of this report, this was done by matching specific locations on the areal photograph to be rectified, to the same locations on a corrected or previously rectified map or photo.

Riparian management zone: 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.

Residual or reserve trees: Trees retained on a site after a timber harvest as single scattered trees or aggregated in clumps, strips, or islands.

Roundwood: A length of cut tree generally having a round cross section, such as a log or bolt.

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

Seasonal pond: Sometimes called *vernal pools,* seasonal ponds are depressions in the soil surface where water pools during wet periods of the year, typically in spring (vernal) and fall (autumnal). A seasonal pond will have an identifiable edge caused by annual flooding and local topography. The edge is best identified during the spring or fall, but it may be identified during dry periods by the lack of forest litter in the depression. Such depressions typically are fishless and retain water for longer periods that puddles. *(Note:* The leaf litter is replenished annually but is consumed during inundated periods and noticeably depleted thereafter. Deciduous litter will likely be consumed faster and more thoroughly than conifer litter.)

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 or two) that generally occur where ground water comes to the surface. Soils at these sites remain saturated for some portion or all of the growing season, and often stay wet throughout the winter.

Shade strip: A strip of vegetation adjacent to a waterbody, managed for the purpose of providing shade to the water's surface.

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.

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

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.

Spring (as a form of wetland): Small wetlands were ground water visibly flows to surface, typically year around, and 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.

Timberland: Forest land capable of producing in excess of 20 cubic feet/acre/year of industrial wood crops under natural conditions, that is not withdrawn from timber utilization and that is not associated with urban or rural development. Currently inaccessible and inoperable areas are included.

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.

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

Water crossing approach: That portion of a trail or road immediately previous to the crossing of a wetland, or waterbody. For the purposes of this report, a water crossing approach is considered to be that portion of a road or trail from the outer (landward) edge of the filter strip or RMZ, whichever is wider, to the water or wetland being crossed.

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.

Wetland inclusion: Wetland basin within an upland site.

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.

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IX. APPENDICES

Appendix A. Location of Implementation Monitoring Sites.

County	Twp	Rng	Landowner category and number of sites	Total sites
Chisago	37	22	NIPF (2)	2
Aitkin	50	24	County (1)	1
St. Louis	51	21	State (3), NIPF (1)	4
Aitkin	52	23	County (1)	1
St. Louis	53	15	County (11)	11
St. Louis	58	13	County (1)	1
Lake	60	6	USFS (12)	12
Lake	61	6	USFS (1)	1
Itasca	61	24	State (4), FI (1)	5
St. Louis	62	12	State (1), NIPF (1), OG (1)	3
Cook	62	2E	USFS (4)	4
St. Louis	64	17	State (3), county (4), FI (1), NIPF (1), OG (2)	11
Koochiching	66	22	FI (2)	2
St. Louis	69	21	State (2), NIPF (4)	6
Houston	102	6	NIPF (2)	2
Cass	133	30	NIPF (2)	2
Cass	139	29	County (5)	5
Hubbard	145	35	County (1), FI (1), NIPF (7)	9
Itasca	150	28	State (1), NIPF (1)	2
Koochiching	152	27	State (3), county (4)	7
Koochiching	153	27	State (1)	1
Koochiching	156	25	State (6), county (3), NIPF (1)	10
Lake of the Woods	162	34	State (3), NIPF (3)	6
			Total	108

B. Filter Strip Width Guide.

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

* For roads, distance is measured from the edge of soil disturbance. For fills, distance is measured from the bottom of the fill slope.

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