Implementation and Effectiveness Monitoring for Forestry in Minnesota

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Preface

The Minnesota Forest Resources Council (MFRC) is mandated under MN statutes 89.A, Subd. 2 to provide oversight and program direction for the development of an implementation and effectiveness monitoring program to evaluate the application of the recently approved and published timber harvesting and forest management guidelines. This report provides background information and describes the recommendations of the MFRC regarding the protocols for the implementation monitoring program. In addition, the report makes recommendations for the effectiveness monitoring program. The Minnesota Department of Natural Resources is responsible for administering these programs.

The report provides a detailed discussion site selection methodology and discusses how sites are to be monitored, what is to be monitored, when to monitor, and recommends who should do the monitoring.

The assistance of the MFRC guideline implementation monitoring committee and its guideline implementation of monitoring technical committee in developing the recommendations contained in this report is deeply appreciated.

Executive Summary

This report provides recommendations by the Minnesota Forest Resources Council (MFRC) regarding the development and implementation of the guideline implementation monitoring program for public and private forest lands in Minnesota. The recommendations are based on options developed by the guideline implementation monitoring technical committee (GIMTC), a technical advisory committee to the MFRC guideline implementation monitoring committee. The GIMTC reviewed issues related to what to monitor, when to monitor, how to monitor, and who should conduct the monitoring. Much of the effort of the GIMTC was focused on determining which of the guidelines were measurable and identifying the specific measures. This report also contains the design recommendations by the contractors from the Department of Forest Resources, University of Minnesota for a statistically sound and credible field sampling methodology. Following their review, the recommendations of the GIMC were presented to the MFRC for their discussion, modification and approval of the monitoring protocols.

Some of the important recommendations in this report are:

- Focus on guidelines in the timber harvesting, forest roads, and general guideline sections.
- Monitor only measurable and quantifiable guidelines. Of the 450+ guidelines contained in the timber harvesting, forest roads, and general guideline sections, 46% were determined by the GIMTC to be directly measurable.
- Use aerial photography as the means of identifying potential harvesting sites to evaluate. The township will serve as the primary sampling unit.
- Aerial photography will be conducted in the fall when most of the leaves are off but prior to snow fall.
- 120 sites/year, randomly selected to provide a representative sample of harvesting activity, will be targeted for monitoring.
- All sites should be given equal weight for selection without regard to any special site conditions.
- All sites selected should be monitored regardless of the difficulty of physical access.
- Effectiveness monitoring remains a high priority for monitoring. While recognizing that effectiveness monitoring involves both long and short term detailed studies, the MFRC, however, should collect effectiveness monitoring data, where possible, while conducting implementation monitoring.
- Independent contractors should conduct the field reviews with quality control coordinated

by MFRC staff. It is proposed that a MFRC team review 5 to 10% of the monitored sites for quality control purposes.

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I. INTRODUCTION

The Sustainable Forest Resources Act (SFRA) was established in 1995 as a comprehensive strategy for addressing timber harvesting and forest management concerns. It includes developing and implementing programs to promote sustainable forest management on specific sites as well as across large forest landscapes. Additionally, research, monitoring, information, and continuing education programs are established. The Minnesota Forest Resources Council (MFRC) provides a forum for many of the state's diverse forest resource interests to address and resolve important forest resource issues.

Much of the initial work of the MFRC focused on the development of the voluntary timber harvesting and forest management guidelines. These guidelines are a natural outgrowth of an enhanced interest in protecting multiple functions of the forest. For the past three decades nationally, the main focus for forestry has been on protecting water quality (i.e., development of Best Management Practices) as mandated in the federal Clean Water Act and its subsequent amendments. In recent years interest has shifted from protecting water quality exclusively to addressing forest resource issues in a more holistic manner.

In 1996, the MFRC appointed 65 representatives from a broad range of forestry interests to develop timber harvesting and forest management guidelines in four topical areas: riparian zone management, site-level wildlife habitat, forest soil productivity, and historical/cultural resources. An integration team was also appointed to integrate the topical area guidelines with existing water quality, wetland, and visual quality Best Management Practices (BMPs) into a single, comprehensive guidebook. The technical teams, each responsible for one of the topical areas, developed their guidelines over 18 months and submitted them to the MFRC for approval and submission to the integration team. The integration team developed the comprehensive guidelines and submitted them for approval to the MFRC. The MFRC approved the guidelines in 1998 following an economic analysis, peer, and public review. The guidebook was published in Spring 1999 (MFRC 1999).

II GUIDELINE IMPLEMENTATION MONITORING - BACKGROUND INFORMATION

A. SFRA monitoring requirements

The SFRA calls for the development of several monitoring programs. These include monitoring trends and conditions of the state's forest resources, the effectiveness of various practices, citizen complaints over timber harvesting, and use of various timber harvesting and forest management practices. Regarding the latter, 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.

Changes to the SFRA in the 1999 Legislative Session increased emphasis on the intensity of monitoring of forest riparian areas and seasonal ponds. The new language (Minnesota Statutes, Section 89A.07, subdivision 4) states:

89A.07, Subd. 4. The commissioner, with program advice from the Council shall accelerate monitoring the extent and condition of riparian forests, the extent to which harvesting occurs within riparian management zones and seasonal ponds, and the use and effectiveness of timber harvesting and forest management guidelines applied in riparian management zones and seasonal ponds. This information shall, to the extent possible, be consistent with the monitoring programs identified in section 89A.07. Information gathered on riparian forests and seasonal ponds as specified in this subdivision shall be presented to the legislature by February 2001 and in subsequent reports required in Section 89A.03, subdivision 6.

B. Defining implementation monitoring

Implementation monitoring is defined as "the process of determining if a planned activity was accomplished" (Noss and Cooperrider 1994). The implementation monitoring program is being developed to compliment the adoption and promotion of voluntary site-level timber harvesting and forest management guidelines. An implementation monitoring program is a natural by-product of a voluntary guideline development program. For a voluntary guideline implementation program to be successful and credible, the organizations that have an interest in ensuring that the guidelines are used need to evaluate their application and use. This monitoring provides accountability and will assist the forestry community in obtaining the information that will be used to correct deficiencies in guideline implementation.

C. Characteristics of an effective implementation monitoring program

A background paper that reviewed monitoring efforts in Minnesota and other states and provided a range of options for the administrative design of an implementation monitoring program for Minnesota was prepared for the MFRC in July 1997 (MacKay and Phillips 1997). At the time the paper was presented, the MFRC undertook a field tour of a Potlatch Corporation site to evaluate and discuss monitoring issues.

The following are key characteristics of effective implementation monitoring programs as described by MacKay and Phillips (1997).

- The implementation monitoring program should be simple and provide for timely review of multiple sites.
- The results should correctly estimate the rate of application of forest management guidelines.
- Field reviews should be comprehensive and the results easily summarized.
- The information should be available to interested individuals and organizations.
- The field reviews should be accomplished at reasonable cost.

MacKay and Phillips (1997) also identified a number of considerations that were relevant in developing the current implementation monitoring protocols.

- Guidelines should be written to facilitate implementation monitoring. The more precise the guidelines, the less difficult judgmental decisions will be made during monitoring.
- Uniform compliance standards should be developed for all landowners, as well as consistent evaluation and reporting techniques.
- Individuals conducting field evaluations must have some minimal level of training.
- The process must define the population of sites. Sites should be selected randomly, using a statistical sampling technique. Consideration needs to be given to sampling certain types of sites more intensively.
- Adequate financial resources should be made available to conduct implementation monitoring.
- The frequency (i.e., how often) and timing (i.e., how soon after completion of a forest management activity, and during which season) of monitoring will be important considerations in the design of a guideline monitoring program.
- Implementation monitoring results should be compatible over time so trends can be assessed.
- Operations should not be graded pass/fail. The goal is to determine the level of implementation of all guidelines so as to identify needed modifications to the forest management guidelines.

D. Past efforts in monitoring forest guidelines in Minnesota

Minnesota has a recent history of using field reviews to evaluate the application of voluntary forestry BMPs (Phillips et al. 1994). The use of BMPs has been actively promoted in Minnesota since 1988 in response to mandates contained in the 1987 Amendments to the Clean Water Act. As part of the implementation strategy, the Minnesota Department of Natural Resources, Division of Forestry (DNR/Forestry) established a field auditing program in 1991 designed to accomplish the following

objectives:

1. Evaluate the level of BMP application for all forestry ownerships (i.e, state, federal and county lands; private industrial lands; nonindustrial private lands [NIPF]; and American Indian lands);
2. Provide a qualitative assessment of BMP effectiveness;
3. Identify necessary modifications of the BMPs; and
4. Obtain adequate BMP application monitoring data to target future education efforts and technical assistance.

Field audits occurred in 1991, 1992, 1993, 1995, and 1997. They were conducted by interdisciplinary teams assigned to operate in four forested regions of Minnesota. The teams were composed of representatives from federal, state, and county agencies; forest industry; logging interests; forest landowner groups; the University of Minnesota; the public; and environmental and conservation organizations. Efforts were made to ensure that each team incorporated expertise in road engineering, soil science, hydrology, fisheries, and forest management.

Some of the major findings for the field audits were:

1. Compliance with BMP recommendations exceeded 84% across all forest land ownerships. Generally the highest rates of compliance were found for private industrial and county lands with a slightly lower compliance rate for state and US Forest Service lands. Lowest rates of compliance were found for NIPF and American Indian lands.
2. The majority of departures from BMP recommendations were minor in nature.
3. Minnesota BMP compliance rates were consistent with results reported nationally.

E. Linking implementation monitoring findings to MFRC's Guideline Implementation Goals

The SFRA directs the MFRC to establish implementation goals for guideline implementation on all forest land ownerships. The statute 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.

The adoption of an implementation monitoring program provides the direct link between the timber harvesting and forest management guidelines and the implementation goals established by the MFRC in December 1998. The MFRC Implementation Goals are attached as Appendix A. Specific goals and targets for guideline implementation were established under four broad headings. These headings were:

1. Obtaining organizational support for the guidelines,
2. Increasing user awareness and understanding of the guidelines,
3. Obtaining user commitment to apply the guidelines, and
4. Measuring actual application of specific practices set forth by the guidelines when timber harvesting and forest management activities are carried out.

Item # 4 above deals directly with field evaluations of guideline implementation. As stated in the guideline implementation goals document:

Actual application of the guidelines is the most direct measure of guideline use. Because Minnesota's forest practice guidelines are voluntary, their application is not compelling, especially on private forest land. Additionally, the application of specific recommended practices (or suites of practices) are dependent on the forest landowner's management objectives, the condition of the forest at the time of harvest, and major physical attributes of the forested property. Despite these conditions, goals can be established for aggregate levels of guideline implementation (not individual harvest sites) and for acceptable rates of improvement in guideline application.

The MFRC implementation goals document further identifies two general measures for guideline application.

1. *Specified percent application of guidelines by major forest landowner categories, landscape regions, and/or specific practices.* The guideline implementation goals document defers the establishment of specific goals until baseline data is collected and evaluated on the current state of timber harvesting and forest management guideline application. A target date of July 1999 was initially established to complete the baseline assessment.
2. *Continuous improvement (toward application goals) in the rate at which guidelines are being used.* The intent is to see improvement in the application of the timber harvesting and forest management guidelines over time for all landowner categories.

F. MFRC Guideline Implementation Monitoring Committee

To assist in developing the field monitoring program, the MFRC appointed a Guideline Implementation Monitoring Committee (GIMC) in October 1998. Specifically, the GIMC was charged with providing advise to the MFRC on:

- efforts needed to implement the timber harvesting and forest management guidelines consistent with the MFRC-established guideline implementation goals,
- design and implementation of a program to monitor use and effectiveness of the timber harvesting and forest management guidelines,
- status of the awareness, use, and effectiveness of the timber harvesting and forest management guidelines, and
- recommendations for improving the awareness, use, and effectiveness of the timber harvesting and forest management guidelines, such that the MFRC's guideline implementation goals are achieved.

To address the charge to the MFRC monitoring committee, two tasks were identified by the GIMC. These were: 1) develop a statistically unbiased methodology to select recently harvested sites to evaluate, and 2) convene a guideline implementation monitoring technical committee (GIMTC) to advise it on developing field monitoring protocols. Membership of the GIMTC was approved by the GIMC at its May 3, 1999 meeting.

G. Guideline Implementation Monitoring Technical Committee

The GIMTC was made up of the MFRC Integration Team members and representatives from the Rivers Council of Minnesota, Minnesota Association of County Land Commissioners, DNR/Forestry, DNR/Wildlife, DNR/Environmental Indicators Initiative, US Forest Service, Blandin Paper Company, Minnesota Center for Environmental Advocacy, and the Minnesota Indian Affairs Council (see Appendix B). The GIMTC met seven times over a nine week period beginning May 5, 1999. Attendance at the meetings averaged 61%. Notably absent from the discussions were the appointed representatives from the environmental community and DNR/Wildlife. However, due to the need to move the process along, the committee chair stipulated that the committee would move forward in developing the protocols with whoever was at the table providing input.

Over the seven meetings, the GIMTC was asked to address four questions:

1. What guidelines will be monitored?
2. When is the appropriate time to monitor?
3. How will the guidelines be monitored?
4. Who will do the monitoring?

Answering these four core questions prompted the listing of related questions which the GIMTC needed to address in order to thoroughly review the options and make appropriate recommendations to the MFRC on monitoring protocols. These ancillary questions included but were not limited to:

- Should only measurable "hard" guidelines (e.g., width of riparian area, number of bark-on down logs/acre) be monitored or should the more general "soft"

guidelines (e.g., plan landings to access future sales, locate landings for best economy and reuse on subsequent sales) also be monitored?

- What forest management activities should be monitored?
- How should data on site application of guidelines be evaluated and recorded where the landowner objectives result in an application either above or below the guideline recommendation?
- How should guideline flexibility be factored in the evaluation?
- To what extent will ease of access, both physical and social, affect selection of monitoring sites and thus the reliability of the results?
- What constitutes a "site"?
- Should sensitive sites be sampled more intensively (e.g., located on erodible soils, known presence of cultural artifacts or endangered plant and animal species, visibly sensitive sites, location in high recreation use areas)?
- To what extent should compliance monitoring be combined with effectiveness monitoring?
- Should actions be taken for sites where laws, rules, or contract provisions were not followed?

The GIMTC goal was to develop an implementation monitoring protocol to recommend to the GIMC that measures use of the timber harvesting and forest management guidelines on all forest land ownership categories in Minnesota. The specific objectives of implementation monitoring are to:

1. Collect information needed by the MFRC to determine if the landowner implementation goals established by the MFRC are being attained.
2. Identify necessary modifications to the timber harvesting and forest management guidelines.
3. Obtain adequate monitoring data to target future education efforts.

III. RECOMMENDED SITE SELECTION PROCESS

This section provides a summary of the major technical recommendations for the design of the system for monitoring the implementation of the timber harvesting and forest management guidelines. The focus of these guidelines is on the site selection methodology. The complete design proposal is found in Appendix C.

A. Responsibilities for development of site selection methodology

The MFRC contracted with Dr. Alan Ek, Dr. Tom Burk, and Dr. Jim Perry, Department of Forest Resources, University of Minnesota, to design an unbiased process for generating a representative sample of sites to be monitored. Although contracted to produce a specific product, the principal investigators worked closely with MFRC staff to identify impediments, practical limitations, and flexibility in the proposed monitoring

design.

B. Considerations for designing a site selection process

The monitoring system as proposed specifies sampling units, variables of interest, methods of measurement or observation, sample design (including number of samples, sample layout across the state, and estimators or procedures to develop estimates), logistics, data management, analysis, and reporting. The design needs to be cost and time effective and provide for:

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

C. Monitoring design framework

The authors' suggest two options for identifying potential sites for implementation monitoring. These are single-stage and multi-stage sampling. Single-stage sampling is problematic. It requires identifying all timber harvest activities in the state from which the monitoring sites would be selected. Since there is no requirement in statute for timber harvest activities to be reported to a state agency, there is no feasible way to collect that information in a timely and efficient manner. Additionally, the design must avoid landowner or agency influence on the selection of sites. Consequently the contacting of such parties in the preparation of a list for the selection process is unacceptable. Such parties would be contacted only after selection, and then only for access permission and background as information needed for the site audit.

Multi-stage sampling is the option recommended by the authors. This method requires the use of primary sampling units (i.e., townships) and then sampling of harvest sites within those primary sampling units. This is two stage sampling. Feasibility is enhanced by the fact that the identification and probability based selection of townships is simple. There are 1800+ statewide, with approximately 700 located in the forested regions of the Minnesota. Their size is known and approximately equal, their regular dimensions facilitate planning (particularly flight planning as noted below), and within a selected township, it is very possible to identify harvest sites. The advantages of this approach are feasibility in creating a list of harvest sites within primary sampling units and savings in travel time since a number of sites would be visited in each selected township rather than traveling to individual harvest sites located at random around the state as in single stage

sampling. The approach also provides for essentially unbiased estimates of implementation rates and precision of these estimates. In practice it requires the selection of townships, obtaining maps and aerial photographs of a specified portion of those townships to make a preliminary identification of recent harvest sites, field checking to ensure the sites meet criteria for inclusion, and finally a formal site audit team visit.

D. Sample size

Sample size is a function of the desired level of precision subject to cost constraints. The past history of BMP monitoring in Minnesota has shown that implementation of BMPs for all land ownerships varies in the range from 70% to 100%. Further, monitoring for BMPs have not shown widespread variability within or among ownership categories. Consequently, a statewide sample of 120 sites per year will provide adequate representation for most desired categorizations (e.g., ownerships, landscape region). Given the costs and logistics in the current proposal, a sample larger than 120 sites per year seems unlikely.

The authors suggest that trends and comparative trends over several years are more important than means and comparisons in any one year. Thus the primary output of this monitoring should be graphs of compliance by year by ownership category and over all ownerships, to be developed by region and statewide as data permits. While the trends (lines) will be most visible, it will also be possible to pool consecutive years to create larger sample sizes or develop rolling averages to improve the precision of estimates with time.

E. Treatment of nonrespondents

Typically up to several percent of private owners can not be located or will refuse to allow access for site audits. A partial solution is to substitute other sites to compensate. In doing so it is assumed that the new substitute sites are equivalent to those that were not accessed. However, this can be a source of bias. While it is often impossible to fully avoid the nonresponse problem, there are several ways to reduce its extent or mitigate the potential for bias. These are:

1. Try for access permission again;
2. Employ an incentive such as a nominal payment for access;
3. Conduct the audit from large scale aerial photography;
4. Use the aerial photography to compare the non accessed with accessible sites and substitute those appearing equivalent to that which can not be accessed.

F. Implementing a site selection process

Sample townships would be identified separately for the USDA Forest Service Forest Inventory and Analysis (FIA) Aspen Birch, Northern Pine, and Central Hardwood units. The selection would be developed annually so as to preclude persons or organizations working on harvest sites to anticipate their location. The sample township location process would be 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 would be those in which the grid dots fell.

For townships substantially less than nominal size (e.g., along state boundaries), the "subject township" area would include sections from the immediately adjacent townships so as to include 36 sections in an approximately 6 x 6 section layout. Grid points falling in reserved areas (e.g., BWCAW) would be excluded and replaced by grid points falling in timberland. The grid points, located by a random start, would select townships to be sampled that year, with grid density geared to obtain n = 120 harvest sites statewide each year. The grid, as opposed to selecting the townships from a list, will ensure a sample that is spread out and highly representative of the region in question. To insure credibility, 36 townships will be selected statewide for the primary sampling units 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) will be flown to cover three tiers of sections from south to north. The timing of flights will be when most deciduous leaves are off (i.e., late fall) to maximize the ability to see harvest site detail, but before snow cover. The flight line will follow the center of each tier of sections (see figure 2 in Appendix C). Subsequently a skilled aerial photo-interpreter will identify recent (within two years) harvest sites and categorize them by size and other characteristics. Subsequently, these sites will be field checked, possibly by aircraft, to insure they meet date of harvest and other criterion to be included. The process is designed to identify approximately 0-15 harvest sites per township for any one year .

IV. RECOMMENDED FIELD EVALUATION PROCESS

A. Guidelines to be evaluated

The GIMC requested that the GIMTC focus their efforts on timber harvesting, forest roads, and the general guidelines with the understanding the MFRC will likely expand the monitoring to the other forest management activities at a later date. Options and recommendations were presented to the GIMC for discussion and consideration. GIMC decisions were presented to the full MFRC. A primary task of the GIMTC was to determine which of the guidelines would be measured in the field reviews. The GIMTC concluded that the collection of data in the field reviews should be restricted to the guidelines that are measurable and quantifiable. The committee felt that it was critical to minimize subjective judgements in implementation monitoring. Two aspects of evaluating

the guidelines were:

1. determining what is and is not a measurable guideline, and
2. identifying appropriate measures to quantify their application in the field.

Much of the GIMTC's efforts involved working in small groups to make these determinations. Once the measurable guidelines were agreed to, the next step was to assign each guideline to one of three categories based on when the measure would be taken. Guideline implementation data will be collected:

1. as background information in the site profile,
2. during the pre-site visit review, or
3. during the on-site field evaluations.

Recommendations on the guidelines and their measures will continue to evolve and improve. The GIMTC will continue to modify the guideline measures, probably through early spring 2000.

The GIMTC recommended an approach to on-site evaluations modeled after the BMP field audit methodology but which has some key differences in how the field data is collected. As stated previously, the GIMTC recommended that only guidelines that are quantifiable be evaluated in order to remove subjective judgements from the process. In the BMP field audits, subjective judgements were made for a number of the BMPs (e.g., employ a suitable harvest system for the site, timing of harvest compatible with soil and topography). For the proposed monitoring effort, it would be preferred to make the field reviews as mechanical as possible. The GIMTC liked the interdisciplinary nature of the BMP audit teams, but did not necessarily think this is mandatory for conducting the field evaluations in a credible manner (see section on monitoring responsibilities). Another contrast between past evaluations and current recommendations is how effectiveness monitoring is addressed. Whereas the BMP field audits provided for a qualitative assessment of the effectiveness of the BMPs in preventing sediment movement to water bodies, the current recommendation is to eliminate effectiveness measurements from the monitoring of the timber harvesting and forest management guidelines (see section on effectiveness monitoring).

It is probable that specific features will occur several times on a site (e.g., multiple water crossings, multiple approaches to water crossings, seasonal ponds, open-water wetlands). Use of GPS to locate these features is warranted, especially if sites are to be revisited and evaluated as part of the effectiveness monitoring program.

<u>MFRC Recommended Actions:</u>

1. The implementation monitoring will focus on evaluating timber harvesting, forest

roads, and general guidelines. Monitoring efforts will be expanded to other forest management activities at a future date.

2. *Evaluate only measurable (quantifiable) guidelines.*

B. When to evaluate sites

The consensus of the GIMTC was to conduct field evaluations in the fall or spring during leaf-off and when the ground is snow-free. The GIMTC recommended that the monitoring occur only after timber harvesting is finished. Since the process will rely on aerial photography to identify monitoring sites, the GIMTC also recommended that the forest management activity must occur within 24 months of when the aerial photograph is taken. A further restriction is that monitoring of a site should be completed after no more than two growing seasons since harvesting.

MFRC Recommended Actions:

1. *Conduct field evaluations in the fall or spring during leaf-off and when the ground is snow-free.*
2. *No site is to be field reviewed after two growing seasons.*

C. Defining a site

An important consideration in designing site selection protocols and evaluating the timber harvesting and forest management guidelines is to determine what constitutes a "site" for purposes of monitoring. In developing the guideline measures, the GIMTC used a definition of "site" that included areas where harvest activities were conducted and adjacent areas that were taken into consideration when determining the actual harvest unit.

D. Prioritizing sites

An option for monitoring is for enhanced review of sites which are deemed to be sensitive for a variety of reasons (e.g., presence of cultural resources or threatened and endangered species, site contains erodible soils).

MFRC Recommended Actions:

1. *All sites will be given equal weight for selection without regard to any special site conditions.*
2. *Additional information will be collected for harvesting in riparian areas and near seasonal ponds through aerial photographic interpretation or other means.*

E. Accessing sites

Access to sites, both physical and social, pose difficulties for the implementation monitoring program. With the BMP field audits, one of the site selection criteria was that the site be located within a one mile walk of a road. With the current guidelines, all sites are subject to monitoring regardless of distance from a road. This will remove bias and improve the statistical reliability of the results, but it is likely to cause some logistical headaches. Travel time, including the time it takes to walk into and out of the site will increase, perhaps substantially, thus reducing the number of sites that can be monitored in a day.

MFRC Recommended Actions:

1. *Monitor all sites regardless of difficulty of physical access. Collect additional sites so that replacement sites are available for those sites that can not be accessed. It may be necessary to conduct frozen ground evaluations where non-frozen access is not possible.*

F. Obtaining permission

Gaining access to NIPF lands may also be problematic. The landowner may refuse entry of the field reviewers to conduct the monitoring, and in the final analysis, the private landowner rights of the individual must be respected.

MFRC Recommended Actions:

1. *The MFRC will work with the Minnesota Forest Resources Partnership and the landowner groups to encourage cooperation of the private landowners in the monitoring process.*
2. *DNR staff will be used to verify ownership and contact the landowner(s) to obtain permission to monitor activities on the site.*
3. *Acknowledgments such as stewardship program services, a copy of the timber harvesting and forest management guidebook, or a gift certificate for seedlings from the DNR nurseries will be used to indicate appreciation to NIPF landowners for participation in the field monitoring effort.*

G. Landowner involvement

Another issue for discussion was whether the effort should be made to ensure that the landowner is present on site during the field reviews. The majority view of the GIMTC was that it is not necessary to have the landowner present at the field review. Trying to coordinate field reviews with numerous landowners would reduce the efficiency of

reviewing sites if it were necessary to ensure that the landowner's and field team's schedules were compatible. However, the landowner has to be contacted. The GIMTC's recommendation was that a letter explaining the objectives of the field reviews be sent to the landowner requesting permission to allow the field review to be conducted on his/her property. The letter will be on MFRC stationary. After the letter is sent, there needs to be a follow-up telephone contact. Regardless of the organization that the caller works for, it is important that the callers identify themselves as representing the MFRC for purposes of contacting the landowner to discuss the use of his/her property for field monitoring. It was also recommended by the GIMTC that the landowner not automatically receive a written review of his/her land, but a generic thank you letter with perhaps a mechanism for the landowner to indicate if he/she would like a copy of the report.

MFRC Recommended Actions:

1. *All landowners whose property is selected as a potential site for field evaluations must be contacted in writing requesting permission to use their property for the evaluations. The landowner should also be provided the opportunity to receive a copy of the written field evaluation.*
2. *If the site is selected, MFRC staff will contact landowners to conduct pre-site visit evaluations and interviews and to collect information for the site profile.*

H. Problem sites

The GIMTC also discussed how the monitoring teams should deal with problem sites. There are at least three types of problem sites: 1) those where there is a violation of a law or regulation (e.g., dumping of fill in a wetland, violation of a protected waters permit), 2) those with very poor compliance with guideline recommendations, and 3) those which violate the conditions of a contract. The collective judgement of the GIMTC is that the teams are there to collect information, not to enforce laws, regulations, and policy. If the field evaluations are perceived by landowners as a punitive process, it will lose credibility and support.

MFRC Recommended Actions:

1. *Problem sites need to be addressed. For those sites where problems do not involve human health or safety concerns, then the monitoring team will focus on collecting data and informing the landowner about the problem and corrective action(s) needed. Sources of assistance to correct these problems may be provided to the landowner. If the problem involves human health or safety concerns, the appropriate agencies will be informed of the problem.*

I. Monitoring responsibility

The GIMTC identified three options on who might conduct the monitoring. The three options are: 1) use of a BMP style audit team consisting of citizens, scientists, resource managers, and loggers, 2) self monitoring of randomly selected sites by land managers with quality control (QAQC) provided by the MFRC, and 3) contract with an outside group with QAQC provided by the MFRC. The advantages and disadvantages of each of these options are discussed below.

Option 1: BMP style audit team

Advantages

- interdisciplinary nature of the BMP audit teams was one aspect of the BMP audit process that was universally supported. That support is likely to continue if extended to monitoring the timber harvesting and forest management guidelines.
- provides a participation opportunity for all forestry interests. If the disparate interests work together to evaluate complex natural resource issues, then an expected outcome would be improved understanding and communication among these interest groups.
- lower direct cost compared to contracting.

Disadvantages

- time and training needed for the teams is significant. All team members and alternates must be "calibrated" to reduce inconsistencies in measurements between teams.
- high indirect cost as organizations participating in the process would cover the salaries of their employees while they are members of the field evaluation teams.
- team members often bring their values and biases to the teams to a greater extent than might be expected with independent contractors.
- turnover among team members is significant and it is difficult to obtain commitment by some organizations to consistently provide team members.
- difficult to organize "rounded" teams that are interdisciplinary and also have the required expertise.
- nature of the process requires the team leader to overcome numerous logistical headaches such as ensuring that all relevant background information for the sites has been collected, arrangements for food and lodging have been secured, and all appropriate contacts have been made.
- control over completing audits to meet deadlines. Probably less control compared to hiring a contractor.

Option 2: Self monitoring by land managers

Advantages

- ensures that all land managers will become familiar with the timber harvesting and forest management guidelines.

- less direct cost compared to the other options.
- opportunity to collect lots of data.

Disadvantages

- lack of trust that land managers would provide an unbiased evaluation of their harvest activity (i.e., puts the fox in the henhouse with the chickens).
- need to "calibrate" all land managers.
- land manager will not have expertise in many of the guideline areas.
- deciding how and who will be responsible for evaluating NIPF sites.
- requires extensive QAQC.

Option 3: Contract with outside group

Advantages

- greater control over the timing, completion, and quality of field evaluations.
- low indirect costs.
- approach would be perceived as credible.
- many of the problems with logistics would be shifted to the contractor.
- most efficient approach.

Disadvantages

- higher direct cost compared to other options.
- need for contract administration and QAQC.
- may not get the same contractor(s) from year to year which could affect consistency and would require additional training efforts.

QAQC for options 2 and 3 will be provided by the MFRC.

Another consideration for monitoring is the extent to which the MFRC should specify the expertise on the field review teams. For option 2, there is limited opportunity to specify the expertise needed, as the land manager and possibly some of his/her staff will undertake the field assessments. For options 1 and 3, the MFRC has the option of specifying the expertise needed. If the BMP style audit teams are used, the team would likely consist of a broad range of constituency groups as has been done in the past. For the contractor, the MFRC could also specify a minimum level of expertise (e.g., soil scientist, hydrologist, wildlife manager, roads engineer). Another option would be not to specify in the request for proposal (RFP) the expertise required, but have the contractor identify what expertise they will utilize in conducting the field reviews. The resources proposed by the potential contractors would become part of the RFP selection process of review. In general, however, the GIMTC felt that at a minimum, there needs to be expertise in basic forest management, timber harvesting and wildlife management on the field review teams. It further recommends that an outside contractor conduct the field evaluations (option 3).

Another option is a modification of option 3. Under this scenario, sites difficult to access would be monitored by a MFRC team and the sites accessed without difficulty would be monitored by the contractor. In addition, the GIMTC suggests that serious consideration be given to the use of an independent party or contractor to provide an overall assessment of whether the goals and objectives of monitoring are being met.

MFRC Recommended Actions:

1. *The MFRC recommends that a contract with outside groups be developed for implementation monitoring (option 3).*
2. *The QAQC team will visit and evaluate 5% to 10% of the annual field review sites to ensure that the requirements of the contract are being fulfilled.*

J. Effectiveness monitoring

The SFRA establishes effectiveness monitoring as an important program for development and implementation and states:

89A.07,Subd. 3. The commissioner (DNR), in cooperation with other research and land management organizations, shall evaluate the effectiveness of practices to mitigate impacts of timber harvesting and forest management activities on the state's forest resources. The council shall provide oversight and program direction for the development and implementation of this monitoring program. The commissioner shall report to the council on the effectiveness of these practices.

Effectiveness monitoring is the process of evaluating whether the timber harvesting and forest management guidelines are achieving the desired goals for resource protection. To accomplish this involves gathering extensive field information and data that will provide an evaluation of the level of resource protection produced by the forest management guidelines. Effectiveness monitoring often requires significant investments of money, specialized equipment, highly trained personnel, sufficient time, and the appropriate spatial scale to conduct the monitoring.

MacKay (1997) suggested three approaches to effectiveness monitoring that could be considered by the MFRC in the discussions of designing the effectiveness monitoring program. The three approaches are:

1. Conduct qualitative effectiveness assessments during guideline implementation monitoring activities. This approach is comparable to the qualitative effectiveness assessments conducted during the BMP field audits.
2. Foster research projects focused on specific effectiveness monitoring questions. Studies would be developed through collaborative proposals with the appropriate research organizations (e.g., National Council of the Paper Industry for Air and

Stream Improvement, Inc.; North Central Forest Experiment Station; University of Minnesota; Natural Resources Research Institute). Potential sources of funding for these proposals include Section 319 grants (Clean Water Act), National Science Foundation grants, and Legislative Commission on Minnesota Resources grants.

3. Pursue a pilot site for long-term, landscape-based, quantitative effectiveness monitoring.

Effectiveness measures could be incorporated into the implementation monitoring reviews, but at a cost of time and efficiency for the field reviews. If effectiveness monitoring is carried out as part of the implementation monitoring program, it would need to be accomplished through follow-up reviews of previously monitored sites. Data that could be collected by field review teams to provide some measure of effectiveness of the guidelines include:

- visual quality impact assessments
- water quality impacts (e.g., sedimentation of water bodies [yes, no], temperature effects [upstream and adjacent to management activity])
- bulk density/soil resistance
- invertebrate sampling
- regeneration of trees
- blowdown of leave trees (RMZ also)
- regeneration success and productivity

It is the view of the majority of members of the GIMTC that effectiveness monitoring could only be carried out to a limited degree in conjunction with implementation monitoring. Much of effectiveness monitoring is long term, at variable spatial scales, and research driven. The GIMTC is concerned that with the time constraints on the field review teams, they will not have the time to collect the samples or to take the measurements that will address the appropriate questions on effectiveness of the guidelines. Because of these reasons, the GIMTC recommends that effectiveness monitoring be separated from implementation monitoring. However, the GIMTC strongly recommends to the MFRC that the development of an effectiveness monitoring program to compliment the implementation monitoring program should be initiated and remain a high priority for the DNR and MFRC.

<u>MFRC Recommended actions:</u>

1. *Effectiveness monitoring remains a high priority for monitoring. While recognizing that effectiveness monitoring involves both long and short term detailed studies, the MFRC, however, should collect effectiveness monitoring data, where possible, while conducting implementation monitoring.*
2. *Direct the MFRC's Research Advisory Committee to work with the GIMC to*

prioritize research efforts to obtain the information needed to determine the adequacy of the timber harvesting and forest management guidelines in protecting the forest's functions.

V. COMPILING AND EVALUATING MONITORING DATA

The guidelines and measures approved by the MFRC will be programmed on two Husky FC-PX5 notebook computers which have been purchased by the MFRC. These field use computers will be used by the monitoring teams to collect and record the guideline implementation data. The data will be transferred to the DNR/Division of Forestry for analysis. The results will be summarized and written into an annual report by MFRC staff to be presented to the MFRC and appropriate legislative committees.

VI. MONITORING PROTOCOL SUMMARY

Site selection process
- Select primary sampling units.
- Select flight lines for aerial photography.
- Photo interpret aerial photography to identify recent harvest sites categorized by size and other characteristics.

Who: DNR/Resource Assessment
Time required: 3 months

Verification of sample sites
- Determine specific ownership of all final candidate sites using county plat books or digital plat data.
- Field check potential sample sites, possibly by aircraft.
- Contact all landowners (get permission to monitor site, also verify ownership, management activity & date of activity).

Who: Local DNR Forestry
Time required: 80 hours

Adjust sample size (if needed)

Pre-site evaluations & interviews
- Complete the pre-site & site profile worksheets for all sample sites.
- Conduct pre-site interviews with landowners or resource managers.

Who: DNR/MFRC staff
Time: ½ day per site

On-site evaluations with teams or contractors
Who: Teams/ contractors
Time: 2 sites per day

Post site evaluation activities
- Down load data from data recorders.
- Evaluate data.

Who: DNR staff
- Development of monitoring report - interpretation of results.

Who: MFRC staff

VII. REFERENCES

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VII. APPENDICES

A. MFRC implementation goals
B. Guideline implementation monitoring technical committee membership
C. Design of a system for monitoring the implementation of forest management guidelines

APPENDIX A. MFRC Implementation Goals

Implementation Goals for
Timber Harvest and Forest Management Guidelines

November 1998

CRITERIA FOR ESTABLISHING IMPLEMENTATION GOALS

The Minnesota Forest Resources Council (MFRC) is directed to establish guideline implementation goals for each of the state's major forest land ownership categories. These goals are to be established prior to the implementation of the guidelines and should reflect societal aspirations for acceptable rates of guideline use. Among the many possible criteria that should be considered when selecting guideline application goals are the following:

- Easily to identify and capable of being measured;
- Attainable with existing or soon-to-be available technologies;
- Achievable within economically acceptable parameters;
- Able to accomplish important forest resource protection goals;
- Accommodating of the voluntary nature and complexity of the guidelines;
- Respectful of forest landowner rights, responsibilities, and objectives;
- Consistent with applicable state and federal environmental quality laws;
- Allow for appropriate responses to forest health emergencies or other natural catastrophes; and
- Recognize the variety of public and private interests that manage forest land in Minnesota.

GUIDELINE IMPLEMENTATION GOALS

Specific goals for guideline implementation can take many forms. For example, goals can be specified for the desired extent of: 1) organizational support for the guidelines; 2) user awareness and understand of the guidelines; 3) user commitment to applying the guidelines; and 4) actual application of specific practices set forth by the guidelines when timber harvesting and forest management activities are carried out. The following describes implementation goals for each of these areas.

Organizational Support of Guidelines

Guidelines implementation will not be successful unless major public and private organizations that have an interest in the sustainability of Minnesota's forests are willing to support the guidelines and their application. Many organizations have been involved in developing the MFRC's timber harvesting and forest management guidelines. An even greater number of organizations have an interest in assuring site-based forest management practices are sustainable. Publically acknowledged support of these organizations will, in part, play a major role in determining the degree to which the guidelines are widely implemented.

Measure of Guideline Support
Statement of support for the guidelines by a variety of public and private organizations with an interest in the management, use, and protection of Minnesota's forest resources.

Goal for Guideline Support:
By 2000, statements of support for the guidelines from:

MN Forest Resources Partnership
Chippewa National Forest
Superior National Forest
MN Department of Natural Resources
MN Association of County Land Commissioners
MN Forest Industries
MN Timber Producers Association
Associated Contract Loggers
The Nature Conservancy
MN Center for Environmental Advocacy
National Audubon Society
Sierra Club
MN Deer Hunters Association
MN Ruffed Grouse Society
Izaak Walton League
Trout Unlimited
MN Lakes Association
Society of American Foresters
The Wildlife Society
Hospitality MN (MN Resort Association)
MN Wood Fiber Council
MN Indian Affairs Council
MN Association of Consulting Foresters
MN Forestry Association

Awareness and Understanding of Guidelines

The application of the MFRC guidelines cannot be expected unless potential users are aware of their existence and subsequently understand the reasoning behind the need for their application. Timber harvesters, forest landowners, and resource managers need to be aware that the guidelines exist and must understand how to apply the specific practices being recommended.

Measure of Guideline Awareness
Percentage of forest landowners, timber harvesters, and resource managers who have attended guideline education and training programs.

Goals for Guideline Awareness:
By 2000:

4) *75 percent of all wood harvested in Minnesota is done by timber harvesters who have attended both introductory guideline training and field demonstrations.*
5) *75 percent of the state's natural resource professionals who have direct responsibility for administering timber sales or silvicultural operations have attended both introductory guideline training and field demonstrations.*
6) *100 percent of the state's non-industrial private forest landowners who own greater than 20 acres of forest land are provided written information about the guidelines.*

By 2002:

1) *90 percent of all wood harvested in Minnesota is done by timber harvesters who have*

attended both introductory guideline training and field demonstrations.

2) *100 percent of the state's natural resource professionals who have direct responsibility for administering timber sales or silvicultural operations have attended both introductory guideline training and field demonstrations.*
3) *100 percent of the state's non-industrial private forest landowners who own greater than 10 acres of forest land are provided written information about the guidelines.*

Commitment to Apply Guidelines

Awareness and understanding of the guidelines must be accompanied by a willingness to actually apply the guidelines. Evidence of a commitment to apply the guidelines can be the forest landowner (or resource manager) and timber harvester engaging in discussion of guideline application during pre-harvest planning activities. At such time, the parties involved can explicitly acknowledge the existence of the guidelines and subsequently discuss their application prior to commencing harvest operations. The discussion of guideline considerations can done on site in conjunction with conducting a pre-harvest site walk-through.

Measure of Guideline Commitment

Percentage of harvest sites where the timber harvester and forest landowner (resource manager) explicitly discussed and considered the guidelines on site prior to commencing harvest operations.

Goals for Guideline Awareness:

By 2000:

1) 75 percent of all public (federal, state, county) forest resource agency's timber sales are conducted with a pre-harvest site walk-through during which guideline application is discussed jointly by the timber harvester and resource manager.

2) 75 percent of all timber sales on private, industrial forests are conducted with a pre-harvest site walk-through during which guideline application is discussed jointly by the timber harvester and resource manager.

3) 75 percent of all timber sales on private, non-industrial (NIPF) and Native Indian forests where professional forestry assistance is provided are done so with a pre-harvest site walk-through during which guideline application is discussed jointly by the timber harvester and forest landowner (or resource manager).

4) 50 percent of all timber sales on private, non-industrial (NIPF) and Native Indian forests where professional forestry assistance is not provided are done so with a pre-harvest site walk-through during which guideline application is discussed jointly by the timber harvester and forest landowner (or resource manager).

By 2002:

1) 100 percent of all public (federal, state, county) forest resource agency's timber sales are conducted with a pre-harvest site walk-through during which guideline application is discussed jointly by the timber harvester and resource manager.

2) 100 percent of all timber sales on private, industrial forests are conducted with a pre-harvest site walk-through during which guideline application is discussed jointly by the timber harvester and resource manager.

3) 100 percent of all timber sales on private, non-industrial (NIPF) and Native Indian forests where professional forestry assistance is provided are done so with a pre-harvest site walk-through during which guideline application is discussed jointly by the timber harvester and forest landowner (or resource manager).

4) 75 percent of all timber sales on private, non-industrial (NIPF) and Native Indian forests where professional forestry assistance is not provided are done so with a pre-harvest site walk-through during which guideline application is discussed jointly by the timber harvester and forest landowner (or resource manager).

Application of the Guidelines

Actual application of the guidelines is the most direct measure of guideline use. Because Minnesota's forest practice guidelines are voluntary, their application is not compelling, especially on private forest land. Additionally, the application of specific recommended practices (or suites of guidelines) are dependent on the forest landowner's management objectives , the condition of the forest at time of harvest, and major physical attributes of the forested property. Despite these conditions, goals can be established for aggregate levels of guideline implementation (not individual harvest sites) and for acceptable rates of improvement in guideline application. These goals must be linked to appropriate physical attributes of the forest. For example, guideline application goals for defined riparian management zones versus application goals for certain guidelines to be applied on all sites harvested (e.g., disposal of limbs and tops). Goals for guideline application and for rates of improvement could be different for major forest landowner categories, landscape regions, and/or types of practices.

Measures of guideline application:
P*ercentage of harvested sites in which various recommended practices are applied, and improvement in the application of these practices over time.*

Goals for guideline application:

1) *Specified percent application of guidelines by major forest landowner categories, landscape regions and/or specific practices.* Identifying specific goals for the application of the guidelines is premature without an understanding of the extent to which the recommended practices are currently applied. Doing so could lead to goals that are

arbitrary or that fail to meet the goal selection criteria specified above. To develop such goals for guideline application by forest landowner category, landscape region, and groups of practices. The following two step process is needed:

a) Using field monitoring, develop a comprehensive baseline assessment of how Minnesota's current forest management and timber harvesting practices (i.e., pre-guideline conditions) compare to recommended practices suggested in the forest practice guidelines. The goal would be to have this baseline assessment complete by July 1999.

b) Using goal selection criteria and results from the base-line assessment (pre-guideline conditions), specify goals for the application of the guidelines by forest landowner category, landscape region, and/or groups of practices. The goal would be to have application goals established by September 1999.

2) Continuous improvement (toward application goals) in the rate at which guidelines are being used. Over time, successive field monitoring should indicate continuous improvement in use of the practices recommended in the guidelines compared to pre-guideline application rates, and progress toward the application goals specified in #1 above.

Appendix B: Guideline Implementation Monitoring Technical Committee

Guideline Implementation Monitoring Technical Committee

Name	Organization
Mike Phillips (chair)	DNR - Forestry
Dick Rossman (vice-chair)	DNR/Division of forestry
Charlie Blinn	U of M Department of Forestry
Dave Parent	MN Forestry Association
Kent Jacobson	Potlatch Corporation
Harry Fisher	North Shore Forest Products
Alan Jones	DNR/Division of Forestry
Pat Emerson	DNR Forestry Archeologist
Rick Dahlman	DNR/Division of Forestry
Tim Quincer	DNR/Division of Fisheries and Wildlife
Barbara Liukkonen	Rivers Council of Minnesota
Jim Jones	Indian Affairs Council
Barbara Leuelling	Superior National Forest
Tom Martinson	Lake County Land Commissioner
Bob Morrow	Blandin Paper Company
Terry Weber	MN Forest Resources Partnership
Jim Erkel	MN Center for Environmental Advocacy
Clarence Turner	DNR/Environmental Indicators Initiative

APPENDIX C. Design of a system for monitoring the implementation of forest management guidelines

Design of a system for monitoring the implementation of forest management guidelines.

A Research Report Submitted to the Minnesota Forest Resources Council

By

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October 14, 1999

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Design of a system for monitoring the implementation of forest management guidelines.

1 Introduction

The Minnesota Forest Resources Council (MFRC) has recently approved and published voluntary site and landscape level forest management guidelines. The Council's intent is to encourage the implementation of these guidelines statewide across all ownerships through various education efforts. This report addresses the need for a statistically credible monitoring design to assess the implementation of these guidelines. Specifically, this report provides a design recommendation plus cost, time, logistics, technology, and statistical options/alternatives that would allow the MRFC to modify or narrow down the approach per precision requirements and/or available funding.

2 Design Considerations

The monitoring of guideline implementation needs to take place at three levels; statewide, landscape, and site specific evaluation. The site specific observations details are beyond the purview of the proposed design effort. However, knowledge of the site specific observation plans is important to the proposed design in terms of process and observational details, and in developing cost, time, logistics, and statistical considerations at the landscape and statewide levels. Thus the proposed design will interface with site specific observation efforts. In fact, the monitoring system design authors have worked with the technical committee of the MFRC monitoring committee, particularly to identify impediments, practical limitations, and flexibility in the implementation of the proposed monitoring designs. We have also sought out research on cumulative effects for the insight this work can provide to design.

Design at the statewide level has considered objectives provided by the Council[1] and specific sampling units, variables of interest, methods of measurement or observation, sample design (including number of samples, sample layout across the state, and estimators or procedures to develop estimates), logistics, data management, analysis, and reporting. In doing so, it is understood that the design would need to be cost and time effective and provide for:

- statistically credible estimates of implementation rates statewide;
- statistically useful comparisons among ownership categories (NIPF, Industry, State, County, Indian, U.S. Forest Service, other);
- trends in implementation over time statewide and by major ecoregion, landscape region, or watershed;
- trends in implementation over time by ownership categories; and
- flexibility with respect to available data, current and future technologies for data capture including remote sensing, and facilitating modeling.

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[1] The authors acknowledge generous advice from Council staff, notably Dr. Michael Kilgore, Executive Director, Dr. Michael Phillips, and the technical committee of the site specific design team.

3 Design Development Procedure

A first step in survey or monitoring system design is an assessment of objectives and the subject population. Here interest lies in the implementation of guidelines across the state, ultimately implying acreage, with the elemental unit of examination a harvest or management site, which typically vary in acreage. Below we examine the survey situation to set the stage for detailed design specification.

The harvest site

The study of timber harvesting and silvicultural practices by Puettmann et al. (1998) indicated a median harvest site of approximately 29 acres. This figure includes clearcuts and partial cuts. However, definitions are problematic as sales (distinct from harvest sites) may consist of one to several sites across an ownership separated by immature stands, or other features. A site examination will also include access or road development, including water crossings to reach the site, as well as factors affecting wildlife habitat, cultural resources, soils, and riparian features. The anticipated general format for these site examinations is illustrated by the audit worksheet shown as Appendix B in Phillips et al. (1994) which has been implemented in 1991-1997. This site audit sheet will be expanded to include additional factors as described by the new site level forest management guidelines (Minnesota Forest Resources Council 1999), but the general format is expected to remain the same. Given interest in implementation rates by site, but also potentially by acreage, it will be important for the site audit sheets to allow characterization of implementation on both a site and area basis. It is anticipated that estimates of implementation will be expressed in terms of percent of sites and percent of acreage across sites.

Implementation variables of interest

The site audit consists of a checklist of practices and associated ratings. It is possible for a site to achieve 100 percent compliance in terms of practices for all of the forest management activities undertaken. However, sites will differ with respect to the number of practices under consideration, e.g., if there are slope or wetland considerations, and due to variation in the activities actually undertaken. For any activity, a practice may exceed or meet requirements, or it may be a minor, major, or gross departure from requirements. The plethora of activities, practices, and ratings considered may lead to confusion in describing overall compliance. Consequently, it is recommended that reporting be developed by general practices, major practices (e.g., forest roads, harvest, visual management, etc.), and then overall. Further, compliance would seem to be best characterized by sites first and practices second, as the number of possible practices for any site is large, and some practices are more important for some purposes than others. It follows that recording the activities undertaken on sites is essential to interpretation.

In terms of overall reporting, the variable of interest could be whether or not a site met all requirements. Then compliance would be the percentage of sites in full compliance. However, given that percent compliance can be developed for each site from its checklist, e.g., 77 percent of checklist items, then it might be more informative to report the average compliance and the number of sites by compliance percent groups, say 100-95, 95-90, 90-85, 85-80, etc. The obviously many ways of reporting argue for a simple monitoring design where all observations (sites) carry equal weight. However, as noted below, there are good reasons for seeking a higher sampling intensity for certain kinds of sites, particularly those with riparian considerations.

Frequency of harvests across the landscape

Given the harvest estimates in 1996 of 192,514 acres with a median of 29 acres (Puettmann et al 1998), the

number of harvest sites anticipated annually is approximately 192,514 ÷ 29 Ñ6600 . With an estimated 14,723,200 acres (equivalent to 639 townships) of timberland[2] statewide (Miles et al. 1995) , this implies a harvest site approximately every 14,723,200 ÷ 6600 Ñ2200 acres of timberland. Alternatively, this is 10.5 per township or 0.29 per section of timberland. However, the number per nominal section or township considering all land uses would diminish as the timberland area in the township decreased. If a region was 50 percent timberland, we would expect 5.15 per township. Additionally, the frequency of harvest sites probably varies by FIA unit or part of the state. These estimates of harvest frequency, as shown below, are fundamental to the monitoring design and particularly the number of sites to be sampled.

Monitoring design framework

A clear operational objective is to obtain a representative sample of timberland harvest sites sufficient to provide unbiased and precise estimates of implementation rates and to enable the estimation of the precision of the findings. The fields of sampling and survey design (see for example Cochran 1977) present a finite number of options for meeting such objectives. In general, the options are single-stage or phase sampling and multi-stage or -phase sampling. In single-stage sampling, one chooses sampling units (sites) from a list of such sites by a probability based (random) selection process. However, creating that list can be difficult, i.e., enumerating all 6600 sites annually, especially since the State of Minnesota does not require the reporting of timber harvests to a state agency (Phillips et al. 1994). Additionally, it is clear the design must avoid landowner or agency influence on the selection of sites. Consequently, contacting such parties in the preparation of a list for the selection process is unacceptable. Such parties would be contacted only after selection, and then only for access permission and background as information is needed for the site audit.

Given the infeasibility of single-stage sampling, we look to multi-stage sampling, specifically the use of primary sampling units, say townships, and then the sampling of harvest sites within those primary sampling units. This is two stage sampling. Feasibility is enhanced by the fact that the identification and probability based selection of townships is simple (there are 1800+ statewide), their size is known and approximately equal, their regular dimensions facilitate planning (particularly flight planning as noted below), and within a selected township, it is very possible to identify harvest sites. The advantages of this approach are feasibility in creating a list of harvest sites within primary sampling units and savings in travel time since a number of sites would be visited in each selected township rather than traveling to individual harvest sites located at random across the state as in single stage sampling. The approach also provides for unbiased estimates of implementation rates and precision of these estimates. Another attractive feature of the method is that the formula for constructing estimates are straightforward and estimates are robust to departures from an equal number of harvest sites per township. In practice we envision the selection of townships, obtaining maps and aerial photographs of a specified portion of those townships to make a preliminary identification of recent (for the subject period) harvest sites, field checking to ensure the sites meet criteria for inclusion, and finally a formal site audit team visit.

There are other designs that might be considered, such as multi-phase sampling, but the complexity and cost factors do not seem as attractive as two stage sampling.

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[2] Timberland is defined by FIA as forest land that is producing or capable of producing in excess of 20 cubic feet per acre per year of industrial wood crops under natural conditions, that is not withdrawn form timber utilization, and that is not associated with urban or rural development. Currently inaccessible and inoperable areas are included (see Miles et al. 1995).

Sample size

Sample size is a function of the desired level of precision subject to cost constraints. In this case the above design considerations (see section 2) do not provide explicit guidance. In fact, implementation rates are based on numerous observations from a checklist on a site. Further, monitoring for BMPs has not shown widespread variation within and even among ownership categories (state, county, U.S. Forest Service, tribal, forest industry, and nonindustrial private forest landowners (NIPF). In fact, the technical committee studying this problem indicated the major sources of variation are site related (e.g., topography and soils) rather than ownership related.[3] The BMP audits to date (Phillips et al. 1994) suggest implementation of the forest management guidelines will vary mostly in the range of 70-100 percent compliance, depending upon the compliance criterion or checklist and rating considered.

To develop an estimate of desired sample size, one must have an estimate of the variation of the variable of interest, in this case percent compliance. Here we assume the coefficient of variation (cv) of the percent compliance in an ownership category is approximately 10 percent. Assuming a normal distribution for percent compliance, this implies that 2/3rds of the site specific compliance rates within a category lie within $\pm$10 percent of their mean. Thus for an average 70 percent compliance, two thirds of the sites would lie within 63 and 77 percent. Recent (1997) BMP audit results[4] indicate this is a appropriate assessment of variability. Next, assuming a desire to estimate ownership category compliance within a desired error (E) of $\pm$5 percent, standard formula for single stage simple random sampling suggest a sample size (n) of:

$$n = t^2 cv^2 / E^2 = 2^2 10^2 / 5^2 = 16$$

to obtain a desired confidence interval (at the 95 percent level), where *t* is approximately 2 for small n. Treatment of compliance as a categorical (binomial) variable would lead to similar (slightly higher) results for n. If variability were higher, say a cv of 20 percent, the desired sample size would be n = 64. We note another aspect of sample size with data expressed in percent of sites; reporting precision is limited to the nearest 100/n percent, consequently a sample of size n = 16 would only allow expression of precision to the nearest 100/16 Ñ 6 percent. Clearly, if one sought results expressed to the nearest percent, a sample of n = 100 would be required.

It would appear that BMP monitoring to date (Phillips et al. 1994) with approximately n = 120 sites per year utilized an adequate sample size statewide. Yet for equally precise breakdowns by region (say MFRC landscape regions), one would need nearly n = 120 samples in each region! However, given the costs and logistics of such work, a sample larger than n = 120 overall seems unlikely.

A similar situation exists with respect to comparisons among ownerships. The precision of estimates of differences between ownership categories is a function of the sum of their respective sampling errors, which implies that means are more precisely estimated than differences.

This is a typical problem–desired precision statewide is obtainable, yet breakdowns by region and precise comparisons among ownership categories are lacking in precision. There is no exact or perfect solution to

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[3]Personal communication from MFRC Technical Committee for Monitoring, 1999.

[4]Personal communication from Dr. Michael J. Philips, 1999.

this problem. How do we resolve it? By careful judgement based upon study objectives and our understanding of the problem. The authors suggest that trends and comparative trends over several years are more important than means and comparisons in any one year. Thus the primary output of this monitoring should be graphs of compliance by year by ownership category and over all ownerships, to be developed by region and statewide as data permits. Such graphs would also illustrate means and variances as an aid to understanding and future design considerations. While the trends (lines) will be most visible, it will also be possible to pool data from consecutive years of observation to create larger sample sizes or develop running averages to improve the precision of estimates and comparisons with time.

A related problem is that of obtaining adequate sample sizes by ownership category and/or site features, such as riparian conditions. Alternatively, one might seek sample sizes that lead to approximately equal timber harvest volumes for each ownership category. It is possible to force sample selection to obtain an equal number of harvest sites, or even timber harvest volumes, by category. However, to do so alters selection probabilities and would add complexity (say a new stratum) to the selection process and sacrifice the otherwise simple expansion of estimates based on the area of townships considered. We recommend against this. However, if this route is chosen, say for tribal lands or riparian conditions, both infrequent categories, then the sampling intensity could be increased in such a category until the desired sample size was reached. In practice, we would recommend increased search areas within existing sample townships until sufficient such categories were found. Alternatively, we would increase the number of sample townships to obtain such samples. In the case of timber volumes, we recommend this variable, both per acre and for the site, be recorded as interpretive information for later correlation analysis, but not using it as the basis for sample size directly. Additional qualitative information such as type of riparian area or related features would likewise be useful for interpretation.

Treatment of Nonresponse

Typically up to several percent of private owners can not be located or refuse to allow access for site audits. A partial solution is to substitute other sites to compensate. In doing so we assume the new substitute sites are equivalent to those that were not accessed, however, this can be a source of bias. While it is often impossible to fully avoid the nonresponse problem, there are several ways to reduce its extent or mitigate the potential for bias. First, try for access permission again; second, employ an incentive such as a nominal consideration or payment for access, third, conduct the audit from large scale aerial photography; or fourth, using the aerial photography, compare the non accessed with accessible sites and substitute those appearing equivalent to that which can not be accessed. The first way, i.e., trying for access permission again, if successful in part, will allow consideration of a nonresponse stratum and testing of whether or not results are different from accessible classes.

4 Implementation

There are a number of steps and technologies necessary to implement this design. These are outlined below for 1999-2000:

1) Selection of townships: Sample townships would be identified separately for the USDA 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 harvest sites to anticipate their location. The sample township location process would be 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 would be those in which the grid dots fell. Appendix 1 describes the township and section selection procedure in detail.

For townships substantially less than nominal size (e.g., along state boundaries), the "subject township" area would include some sections from the immediately adjacent townships so as to include 36 sections in an approximately 6 x 6 section layout. Grid points falling in reserved or urban areas (e.g., BWCAW, City of Duluth) would be excluded as they are not FIA timberland. However, the procedure does allow for sample townships to be located adjacent to or near these areas. The grid points would select townships to be sampled that year, with grid density geared to obtain approximately n = 120 harvest sites statewide, such sites having been harvested in the last two years. Such planning is possible given the known timberland acreage and anticipated annual frequency of harvests per township (see Appendix table 1). The grid, as opposed to selecting the townships from a list, will ensure a sample that is spread out and highly representative of the region in question. To insure precision and associated credibility, at least thirty townships would be selected statewide annually. To guard against imprecision in planning data that might affect the realized n in the first year of the monitoring, we would actually seek 20 percent more or 36 townships. Such an effort would allow subsequent year township selection to proceed with improved planning data. An illustration of township locations is shown in Appendix figure 1 along with the specific townships drawn for 1999-2000. While this systematic selection of townships is helpful in facilitating a representative sample in an effective manner, especially considering logistics and travel costs, a result may be an underestimate of the precision of the estimates of implementation. Conversely, the clustering or grouping of sites within townships will typically provide less precision than 120 sites chosen at random.

2) Identification of harvest sites and aerial photography: Option #1–Given the selected townships, color or color infrared aerial photography at a print scale of 6.3 inches to the mile (RF =1:10,000) would be flown to cover three tiers of sections from south to north. The timing would preferably be with most deciduous leaves off, i.e., late fall, to maximize the ability to see harvest site detail, but before snow cover. The sections to be considered would be the east half (18 sections) of the township. The flight line would then follow the center of each tier of sections (see Appendix figure 2). Subsequently a skilled aerial photo-interpreter would identify and circle recent (within two years) harvest sites and categorize them by size, etc., and determine the percentage of the site in roads, landings, and primary skid trails. The ownership will be determined from county plat books or digital plat data. These sites would then be field checked, possibly by aircraft, to ensure they met date of harvest and other criteria to be included.

Specifications for the aerial photography are: [5]

- -fall, most deciduous leaves off, no snow
- -RF 1:10,000, format/contact print size–9"x9"
- -camera etc. minimum shutter speed–1/200 second with image motion compensation
  (this implies a contemporary Wild or Ziess camera)
- -forward overlap percent–55-60, location of flight lines by GPS
- -anticipated cost $30-40 per square mile or $360-480 per township
- -bidding and contract procedures to be handled by DNR Division of Forestry

Alternatively, DNR Division of Forestry aerial photography staff could provide coverage as:

- -fall, most deciduous leaves off, no snow
- -RF 1:40,000, format/print size–blown up to 9"x9" or 1:10,000 print scale
- -camera etc. minimum shutter speed–1/500 second with image motion compensation
  (70 mm camera (approximately) with a 75mm focal length lens and focal plane shutter)

[5]Personal communication from Dr. William Befort and Stephen Gallay, MN DNR September 8, 1999.

-forward overlap percent–55-60, location of flight lines by GPS
-anticipated cost $30-40 per square mile or $360-480 per township
-procedures to be handled by the DNR , but acceptance of photography would rest with the MFRC.

Final products would be one set of 9 x 9 color or color infrared prints for office and field use. Additional copies for field crews and records could be made by inexpensive copy processes.

Upon inspection and acceptance of the aerial photography, a trained aerial photo interpreter would identify candidate sites at the rate of approximately one township (12-18 sections per day). Subsequently, field staff would field check these candidates for acceptability at the rate of 4-8 sites per day per person, including the seeking of additional site records and permission for access on private lands. Acceptability would be based solely on the presence of forest harvesting activity within the last two years for the majority of a site, however, additional interpretative data (ownership, date of harvest, type of harvest, basic site features, etc.) from photo-interpretation and the field check would be assembled to aid further selection consideration and sample size scaling as noted below. Additional data for analysis and interpretation could include proximity to water, proximity to roads, spatial context including nearby land use or development, descriptors of vegetation patterns, etc.

Steps 1) and 2) above are anticipated to identify approximately m = 0-15 harvest sites per township in any one year. In fact, the consideration of a two rather than one year window for sites is considerable compensation for the possibility that sites may be less frequent than expected. If more than the n = 120 sites are found after checking, the number of sites in a township would be scaled back proportionately on all townships until the desired n was reached or approximated, the constraint being that at least one site be retained in any one township. Conversely, if fewer than n =120 sites were found, the number of township sections considered could be scaled up from, say 18 to 19, etc., until the desired overall sample size was reached. To simplify the timing and flying of photography, these additional sections could be drawn from the end of the planned flight lines and thereby spill over into the adjacent township. In practice the initial flying would cover these additional areas to avoid the possibly considerable extra cost of having to make a second flight. Alternatively, this scaling could be done to achieve sample size targets separately by region noting this is but a modest constraint on procedure and randomization. As mentioned earlier, given the lack of *precise a priori* knowledge of the spatial frequency of harvests, we recommend that the 1999-2000 sample specify 36 rather than 30 town townships, i.e., a 20 percent larger sample area.

Table 1 and its assumptions about annual harvesting frequency across townships suggests the above procedure will lead to more than the desired n = 120 sites, thus a scaling back is likely. It will be easier to cut back on sites than to seek out more. It may also be feasible to cut back on the photo scale, say to an RF of 1: 12,000 or even 1:15,840 and thereby reduce costs. However, until the 1999-2000 effort is conducted, we can not be sure. Experience obtained the first year will allow planning for the second year photography and sample size to be more precise.

We note this procedure will select sites on an approximately equal probability basis across the three FIA units. If the effort also collects information on the area of sites, activities, and practices, it will also be possible to estimate the total area affected by various activities and practices. Thus this effort could supplement future harvesting and silvicultural practice survey efforts, e.g., the work illustrated by Puettmann et al. (1998).

3) Access: Audit teams would seek permission for access, background information, and visit and assess each harvest site, likely at the rate of two per day per team.

4) Compilation and analysis: Regional and statewide estimates of implementation would be developed by treating all sites equally, as a simple random sample, since step 2 provided for approximately equal weights for each site in each region. In effect, estimates by ownership category or ecoregions could be developed by simply considering sites that fell in those groupings. Estimates of precision could also be developed in a similar manner, but with the caution about the interpretation of sampling errors if simple random sampling formula were used. In brief, the systematic layout of selected townships would likely lead to an underestimate of precision, but the correlation among sites within a township would counter that by an overestimate of precision. Alternatively, more complicated two stage sampling formula could be used to obtain the same means but a more precise estimate of sampling error. The utility of the latter formula would be taking into explicit account the fact that the numbers of harvest sites and forest acreage will differ among townships. If fact, we recommend estimates be calculated both ways, but we suspect differences will be small due to the robust nature of two stage sampling with respect to the number of observations per primary sampling unit.

Analysis and interpretation should focus on compliance versus category of interest relationships. It is anticipated that ownership category results will be of most interest. However, we suspect that site conditions (topography and soils) are the most important factor in terms of difficulty in compliance. Analyzing that might suggest future sampling focus on the most difficult sites, or that "difficulty" be the basis for future stratification in sampling.

5) Additional uses of the sites and data: These monitoring data could provide alternative estimates of silvicultural and harvesting practices as compared to the survey methods used by Puettmann et al. (1998) as well as other estimates of changing forest resource conditions. They might also be revisited and used for 1, 2, 3, or 5 year follow-up observations to assess the effectiveness of practices. Additionally, the identification of a block of 18 sections within townships may facilitate possible landscape level analyses. Given this potential, these data need to be carefully documented and archived.

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Appendix

Figure 1. Forest Practices monitoring primary sampling units fall 1999 11

Figure 2. Possible flight lines within a subject township (heavy lines) 12

Table 1. Sample size planning for forest practices monitoring for 1999 13

Procedure for selecting sample townships and sections 14

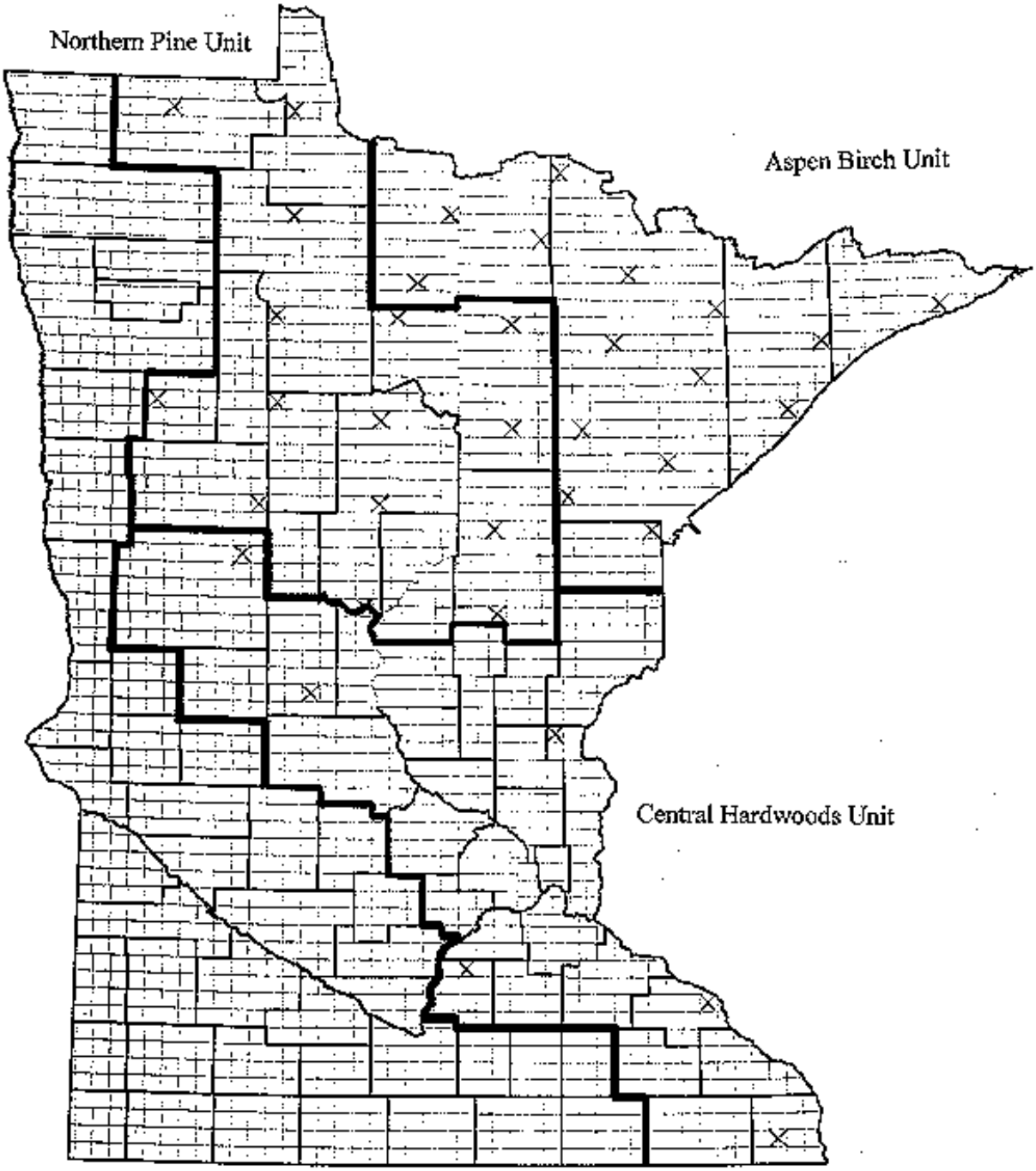
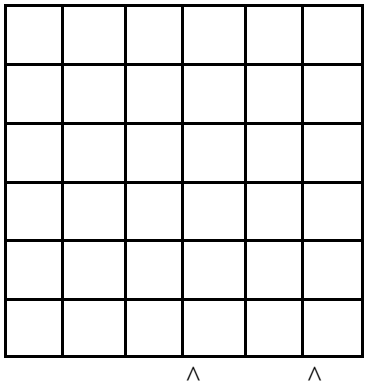
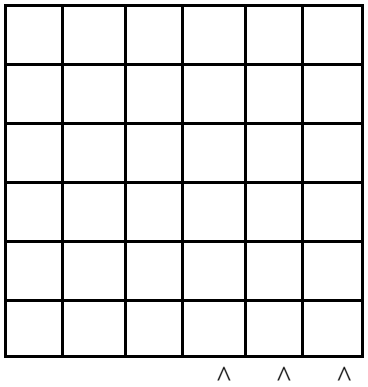


Figure 1. Forest practices monitoring primary sampling units fall 1999.



a) at an RF of 1:15840 fly the boundary between a tier of two sections



a) at an RF of 1:10,000 fly the center of each tier of sections

Figure 2. Possible flight lines within a subject section.

Table 1. Sample size planning for forest practices monitoring for 1999.

Item	FIA Unit Aspen-birch	Northern Pine	Central Hardwood	Total
	---Timberland acres (thousands)---			
a) Ownership category				
State	1331.3	1356.9	298.2	2986.4
County*	1234.4	1201.7	59.6	2495.7
U.S. Forest Service**	1299.4	650.3	55.3	2005.0
Tribal	102.4	373.8	7.6	483.8
Forest Industry	462.3	285.0	4.0	751.3
NIPF***	1448.9	2076.3	1836.0	5361.2
Total timberland area	5878.7	5944.0	2260.7	14083.4
Total land area	8679.3	11110.5	11950.7	31740.5
	---Sample size factors---			
b) Sample size determination				
Proportion timberland	0.68	0.53	0.19	0.44
Proportion of timberland across the three regions	0.42	0.42	0.16	1.00
Sample size (k=30 Townships) k(unit) = proportion timberland across the three regions x 30	12.5	12.7	4.8	30.0
Sample size k rounded up	13.0	13.0	5.0	31.0
Sample size for fall 1999 x 1.2	15.0	15.0	6.0	36.0
Anticipated m per nominal township for 2 yrs (mean timberland acres in township / 2200 x 2)	14.2	11.2	4.0	
Anticipated m per ½ of township	7.1	5.6	2.0	
Anticipated m per FIA unit	106.4	84.0	11.9	202.3

*including municipal
**including BLM and other federal
***Individual and other corporate

Procedure for selecting sample townships and sections:

Using a state map of township locations, in this case from the MN Department of Transportation, prepare a rectangular dot grid, preferably square. These may be constructed from word processing software and then enlarged or reduced as transparencies to produce a range of dot densities (the "dots" are the intersection of table row and column boundaries). Then choose a dot grid such that when placed at random (with respect to location and azimuth) over the subject FIA unit the desired number of dots k is achieved. This placement can be executed simply by closing one's eyes and dropping the grid upon the map. Alternatively, one may locate a particular dot within the FIA unit by randomly chosen coordinates and then orient the grid axis according to a randomly chosen azimuth. This procedure will locate the remaining dots on the grid. It may take several trials to identify the dot grid that produces the desired sample size. Exclude dots falling in the BWCAW, Voyagers National Park, and major cities including their suburbs. If the number of dots exceeds the sample desired sample size by just 1, choose a random number between one and k and delete that dot. Note that these steps constitute constrained randomization.

Now mark the townships in which dots have fallen and inspect them to assess whether they contain three adjacent tiers of six sections (18 sections total) with timberland. Timberland in this case follows FIA definitions but may lie in stands as small as 2.5 acres in size, but in no case less than 240 acres collectively across the 18 sections. Such inspection may be carried out with the DNR's *ForestView* satellite, aerial photography, or other map data. Assuming the first three tiers on the east side of the township contain sufficient timberland, they will become the sampled sections. If not, the next westerly tier of three sections will be considered, etc. Assuming satisfactory tiers of sections can be identified, the selected townships will be acceptable as primary sampling units. Note that the adjacency of sampled townships is intended to provide a landscape context for interpreting results.

In the case of unacceptable townships, choose from the adjacent townships (there may be up to six) beginning on the north and proceeding clockwise until an acceptable township is identified.

Following the inspection of townships and the identification of sections to be sampled, aerial photography should be planned to follow the flight lines shown in Appendix figure 2, depending on the scale of photography to be flown.