ECONOMIC IMPLICATIONS OF PROPOSED FOREST MANAGEMENT GUIDELINES FOR MINNESOTA

A report to the

Minnesota Forest Resources Council
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PREFACE

Forests are the natural bounty and heritage of Minnesota. They are home for the howling wolf, calling loon, and rare warbler. They are the place of abundant and clean water with walleye and muskie and brook trout. They are the tall pines, abundant popple, resilient spruce, and majestic oaks used to make the books of the world, craft homes and furniture and warm the hearth. They are the clean air, sweet smell, and fresh breeze on a summer night. They are the ancient burial grounds and old settlements and special areas used for hundreds of years. They are the vacation spots that renew the spirit and kindle romance. They are the special places in the hearts of the people of Minnesota and many far from her borders.

The people of Minnesota need forests to live. They want them to be healthy and productive. They want them to be complete – with all their living and nonliving parts. They want them for the wood and wildlife, for the clean air and water, for the wildness and solitude, for the tradition and as their legacy. They need forests in order to live in Minnesota as Minnesotans do.

Visions of forests stir powerful emotions in most people and each person sees them differently. This study is about what it will take to manage forests in Minnesota in a way that will help keep them whole for a millennium or two or more. It is about sustaining forests – not the same as in the past, but nevertheless as abundant, productive and healthy ecosystems. The voluntary forest management guidelines proposed by the Forest Resources Council set a standard and offer a promise that Minnesota's forests could be managed better than in the past. The guidelines recognize that all the parts of a forest are essential and offer specific and tangible practices intended to protect the whole system when trees are cut and roads are built. They say what should be done to invest in a future of sustained forests.

The reality is that decisions to manage forests are tangled in ecological potentials and day-to-day economics. The hard facts are that implementing the proposed guidelines will not be free, or easy. It will require education and investments and changes in the way of managing forests and doing business. It will require a long view and perhaps sacrifice now for the greater good in the long run. It will take some giving up of old ways and learning new ones. The benefits to be had will flow to all of the people of Minnesota who value forests and all that they provide. Some will be asked to pay more of the costs than others, yet they can reap few of the benefits when they can not charge others for keeping healthy ecosystems. If the people of Minnesota are to have healthy forests forever then they must find ways to encourage forest owners and users to take the extra steps necessary. Moving to this next level of management will undoubtedly be a great challenge with many long-term payoffs.

This study was conducted over a short time frame and with a limited budget. We used existing data and found that much data we might like to have used was simply not available. We do not address all of the economic impacts and linkages that may result from comprehensive implementation of the voluntary guidelines proposed by the Forest Resources Council. This report considers benefits and cost effects, but does not include the full extent of a social benefit/cost analysis. While we recognize the substantial environmental benefits to be derived from these guidelines, we have not attempted to quantify the non-market values. We have identified those factors we believe represent the most significant financial and economic effects.

In the end, the choice to proceed with implementation of the forest management guidelines is a policy decision to be made by the Forest Resources Council. Just as any public policy decision, this one requires reasonable men and women to weigh the best available information, consider the options, and compare the many economic and non-economic factors. Their decision will affect the forests and people of Minnesota for a long time.

EXECUTIVE SUMMARY

The Minnesota Forest Resources Council is developing integrated forest management guidelines for voluntary use on all forest lands in Minnesota. Guidelines address four areas: forest management in riparian zones, activities to protect soil productivity, maintenance and enhancement of wildlife habitat, and protection of historic and cultural sites. These guidelines will be combined with existing visual quality and water quality and wetland best management practices into a comprehensive set of timber harvesting and forest management guidelines. The primary goal of the guidelines is to achieve forest resource sustainability by recommending standards for forest management activities such as timber harvesting, road construction, timber stand improvement and site preparation.

The goals of this study are to estimate the area and timber volume that would be affected by implementing the recommended practices, to better understand the benefits to be gained, to investigate the costs for landowners and several sectors that depend on forest resources, and to identify possible public policy strategies that might increase use of the guidelines and mitigate any particularly costly effects.

Policy context for use of economic implications

Information supplied in this report represents analyses of data and in some cases, expert judgment regarding the potential effects of the proposed guidelines. Some pieces of information have been much easier to capture than others. Benefits are broad-based improvements in environmental quality that are easy to know, but hard to quantify. We identified the many kinds of benefits, but did not evaluate them. That is a task for another study. Estimates of the area and timber volume that would be affected were based on the forest inventory done eight years ago and much has changed since then. Expert opinion was also used in some cases to help fill in missing information. Similarly, the cost effects are based on various limited data sources and expert judgment. The results represent estimates with uncertainty.

This analysis was conducted without the establishment of any guidelines on the ground. We had no track record to follow to see how the use of guidelines has actually affected landowners or other groups. The possible effects of the proposed guidelines presented here represent only one source of information useful for formulating public policy. They represent facts and opinions that are most useful to frame the discussion rather than to be a single deciding factor.

Key findings

- Minnesotans want diverse, productive, and healthy forests. The proposed guidelines would produce substantial environmental quality improvements that most people value greatly. Benefits include greater biodiversity and improved ecological integrity, more diversified wildlife habitat, improved visual quality, cleaner water, and enhanced cultural and historical resources that contribute to community values. Most of these are non-market values that accrue to the public at large.

- Application of the proposed guidelines would enhance the quality of Minnesota's forest resources for the recreation and tourism. The possibility of more extensive harvesting to maintain timber flows or landowner income may marginally increase the chances of conflict between harvesting and recreation activity, especially near major facilities.

- Effects on timber harvesters could be substantial. Assuming none of the recommended practices are currently used, application of proposed guidelines could cost as much as $3 per cord harvested for on-site activities needed to comply with guidelines. Increased costs would apply to the portion of timber harvested for landowners who are not already partially using similar practices. The highly competitive logging industry may not be able to pass along

costs to log buyers or cover costs through reduced stumpage prices paid to landowners. In the worst-case, additional logging costs would be more than $9 million if cost increases applied to all wood harvested each year.

- The proposed guidelines are complex and will require additional professional expertise, especially during an initial adoption phase. More foresters would be required for most organizations to fully use the guidelines. Access to technical assistance appears to be particularly limited for nonindustrial private (NIPF) landowners. Two-thirds or more of harvests on NIPF lands are conducted without technical forestry assistance.

- Riparian zones, the areas next to water bodies, are especially important. One out of every fifteen acres of timberland, about 980,100 acres, is within a riparian management zone as defined by the proposed guidelines. This is significantly more than the 514,700 acres of timberland, one out of 28 acres, that fall within the riparian zones defined by existing water quality and wetland Best Management Practices. In Minnesota, only one out of every five acres near water is actually forested.

- Guidelines that address historical and cultural sites are not likely to substantially impede timber harvesting. Less than 1.6 percent of timberland acres are likely to have such sites. Moreover, many sites are underground and unlikely to be detected or disturbed by harvesting, especially during the winter. Many above-ground sites can be protected by applying other leave-tree guidelines as is recommended for wildlife considerations.

- Activities recommended by the guidelines to protect soil productivity will not affect the area and volume of timber available for harvest. None of the soil productivity guidelines call for the reservation of timberland or leaving uncut trees on the site. Soil productivity guidelines primarily enhance many on-site environmental qualities and some added costs will be associated with applying them.

- The proposed guidelines do not affect all forest acres at once. Guidelines will primarily affect the 1.4 percent of the timberland area in Minnesota where harvesting activity occurs each year, about 200,000 acres. Over time, the area affected by guidelines will accumulate as more acres are harvested or receive direct management treatments.

- Older forests grow more slowly than younger forests. Increased rotation lengths on a small proportion of acres where trees are left to meet the proposed guideline recommendations will affect about 5 to 7 percent of harvested acres. This will result in a 0.6 to 0.8 percent reduction in net annual growth of merchantable timber statewide.

- Clearcutting is the dominant silvicultural system accounting for 85% of the harvest area. Three quarters of clearcut acres already have some residual trees. Meeting the intent of the proposed guidelines for leaving uncut trees in clearcut areas for wildlife purposes would require leaving more trees on some sites. The additional timber volume left on clearcut sites to meet this guideline would amount to 88,000 cords. Forty seven hundred (4,700) more acres would have to be harvested annually to maintain the total statewide harvest volume at 1996 levels.

- Growing stock volume within proposed riparian management zones is estimated at 12 million cords, or 6.3 percent of the statewide total growing stock volume. Slightly less than 2.6 of the 12 million cords have basal area levels below recommended residual levels. However, these stands will likely accumulate basal area with the result that they will become merchantable and available for harvest in the future.

- A major effect on landowners is the cost to incorporate guidelines in planning and conducting management activities and timber sales by professional foresters. Adequate planning to

incorporate guidelines during timber is estimated to cost $10 to $12 per acre. Some landowner groups, particularly nonindustrial private, lack adequate access to forestry skills needed to interpret and apply guidelines to diverse harvest sites. It could cost as much as $1 to $1.2 million to meet this need for forestry assistance on about half of the current harvest sites, about 100,000 acres each year.

- Approximately 80% of harvests observed in an aerial photo survey were more than 200 feet away from the nearest water body. Ten percent of the harvests observed had at least a portion of their area within 50 feet of water, suggesting that current Best Management Practices, to a degree, are not treated as no cut zones.

- Although the proposed guidelines will affect costs for some groups, most benefits are non-market improvements in environmental quality that generally accrue to society at large such as more biodiversity or better wildlife habitat. Many landowners own timberland for recreation and wildlife benefits, and they may benefit directly from use of the guidelines. Landowners who apply the guidelines improve their forest conditions and produce these social benefits but in most cases do not capture any market value from them.

- Substantial opportunities exist to mitigate the potential negative effects and enhance the widespread application of guidelines throughout the state. These include educational and technical assistance programs to assist with guideline implementation, financial and tax incentives to offset burdensome costs, programs to intensify management and increase wood supply, efforts to improve coordination between tourism and forest products sectors, and increased recognition of resource stewardship accomplishments.

- Finally, much of the data needed for a more comprehensive analysis of the potential effects of forest management guidelines was not available. Chief research needs include better data on the extent and distribution of seasonal ponds and coarse woody debris in forests; information on the occurrence of cultural features and archaeological sites; improved data on the attributes of water bodies, especially stream width; better methods to characterize the existing condition of riparian areas and improved information on the current forest management practices throughout the state. Most of this information will only come from substantial research investments. Also, further analysis is needed to quantify ecosystem improvements and estimate non-market values; model the inter-sectoral economic effects of guideline implementation with input/output analysis methods; and better understand the effects of changing forest management on community stability and values.

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I. INTRODUCTION

The Minnesota Forest Resources Council is developing integrated forest management guidelines for voluntary use on all forest lands in Minnesota. Guidelines address four areas: forest management in riparian zones, activities to protect soil productivity, maintenance and enhancement of wildlife habitat, and protection of historic and cultural sites. These guidelines will be combined with existing visual quality and water quality and wetland best management practices into a comprehensive set of timber harvesting and forest management guidelines. The primary goal of the guidelines is to achieve forest resource sustainability by recommending standards for forest management activities such as timber harvesting, road construction, timber stand improvement and site preparation.

The goals of this study are to estimate the area and timber volume that would be affected by implementing the recommended practices, to better understand the benefits to be gained, to investigate the costs for landowners and several sectors that depend on forest resources, and to identify possible public policy strategies that might increase use of the guidelines and mitigate any particularly costly effects.

A. Study Objectives

Objective 1: Identify the potential effects of proposed guidelines on forest conditions and vegetation patterns.

This objective involves assessing the area and volume of timberland affected as a result of implementation of the guidelines.

Objective 2 Estimate the costs of proposed guidelines.

This objective involves the identification of financial and economic costs associated with implementation of the proposed guidelines including direct financial costs to implement recommended practices by landowners, loggers, and others. Non-market costs are quantified to the extent possible, but not valued in monetary terms. A second component of this objective is to estimate the economic effects on logging, forest products and tourism sectors.

Objective 3: Estimate the benefits of recommended guidelines.

This objective involves estimating the financial and economic benefits associated with guideline implementation, including monetary effects resulting from shifts in management strategies and identification of non-market benefits.

Objective 4: Compare costs and benefits.

This objective involves comparison of costs and benefits, and the distribution of costs and benefits among landowners and the identification of situations where costs appear to be excessive.

Objective 5: Identify relevant policy and program responses

This objective involves examination of the financial, economic and timber resource implications identified in the above objectives to develop possible policy and program responses to reduce negative effects.

B. Forest management practices and current levels of compliance

Informed guidelines for forest management practices are not foreign to Minnesota's forest landowners. Most land managing organizations operate daily under an array of recommended management options.

These guides help forest managers decide how to meet their goals for timber production and sustainability of other forest components. Existing guides include voluntary statewide Best Management Practices (BMPs) for water quality, wetlands, and visual quality, organizational management policies, industry programs and regulations specified in law. The proposed integrated forest management guidelines reinforce and extend these existing frameworks. In some cases, organizational standards already in place may be more stringent than some elements of BMPs or the proposed integrated forest management guidelines.

Existing statewide BMP frameworks cover only visual and water quality, and wetland protection. Individual land management organizations also have specific policies that consider wildlife, historic and cultural resources, and soil conditions. Although they are not identical, elements of the proposed integrated guidelines for timber harvesting and forest management also cover these resources. The extent to which proposed integrated guidelines are applied on-the-ground will provide a measure of the success in attaining sustainable forests in Minnesota. Estimating potential effects requires an understanding of what is presently happening on the ground. Other than for water quality and wetland BMP use, little hard data are available to estimate the current level of application with the proposed integrated guidelines.

This overview of current management practices was generated from interviews with land managers[1], a study of water quality BMP application rates (Phillips et al. 1994) and other published information. Such limited information does not offer certainty about the level of compliance with existing or proposed guidelines. Generally details of practices used on-the-ground are not officially documented or kept in an easily retrievable format by land management organizations. Furthermore, while one organization mentions use of a particular set of management practices, the way in which these are interpreted and applied by other organizations may vary greatly. This summary provides a general sense of the differences among landowner groups with respect to various recommended management practices.

Informal interviews with representatives of six forest landowner groups[2] provide insights on how they apply existing guidelines, and the extent to which aspects of the proposed integrated guidelines are being applied in forest management activities.

1. Water quality and wetland Best Management Practices

Of the six landowner groups, state, county, federal and private industry all indicated broad application of the current water quality BMPs. Some use BMPs extensively, others vary substantially in their use of guidelines. BMPs address water quality and aquatic habitat concerns in a buffer zone somewhat narrower than specified in the proposed integrated guidelines. The proposed integrated guidelines recommend practices that favor longer rotations to maintain habitat and biodiversity, protect soil conditions, and maintain wildlife habitat.

Application of existing BMPs often varies and higher standards may be applied in specific places where needed to protect specific resources. For example, buffer widths suggested in water quality/wetland BMPs are exceeded in several regions of the DNR, in parts of the national forests, along some rivers and in certain areas of counties. These wide buffers, however, are not policy across all administrative regions of an organization.

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[1] Interviews were conducted during the summer of 1998 by David Bowes-Lyons, an intern with the Minnesota DNR and the Forest Resources Council.

[2] Landowner groups contacted include: state (Department of Natural Resources - DNR), County, Federal (USDA Forest Service), forest products industry, American Indian and nonindustrial private (NIPF).

American Indian and nonindustrial private forest (NIPF) landowners appear to implement water quality BMPs on fewer acres and less consistently than other owners. Some reservations follow BMPs closely, while others do not report that they use any guidelines. Application of BMPs on NIPF lands is also highly variable and depends on landowner awareness of BMPs, interest in long-term stewardship, and access to technical expertise.

2. Soil productivity

DNR and some counties indicated their direct oversight of skid trail, landing and road location, construction and maintenance. Some counties also work to minimize impacts to soils through specifications in timber sale contracts. The Forest Service reported mitigation and restoration policies to protect soil and water quality. One forest products company stated it suspends operations if rutting occurs. American Indian reservations show widely varying applications of BMPs that affect soil quality. Once again, regional differences exist within each landowner category. No information exists about NIPF considerations of soil quality during management activities.

3. Wildlife habitat

The DNR, Forest Service, some counties and forest industry reported that they leave snags and islands of trees in cutovers. The DNR, Forest Service and counties also manage some acreage for longer rotation stands to provide a balance of age-classes and cover types that represent numerous community types and habitat conditions. For instance, the DNR operates under their Extended Rotation Forest Guidelines. Counties appear to have the least specific leave tree guidelines, while the DNR and Forest Service follow more detailed recommendations. Endangered, threatened and sensitive (ETS) species are particularly accounted for on DNR and Forest Service lands. The Forest Service uses harvesting contract clauses and ground surveys on all management projects to protect species. County and industry landowners appear far more variable in ETS wildlife issues. Some manage sites for target species or consider wildlife when planning roads. One company reported a policy of avoiding areas known to be raptor nesting sites. In some instances American Indian landowners do special cuts for certain wildlife species. Other segments of this landowner group do not include specific wildlife management activities. While most NIPF landowners say reasons for owning land are primarily for the wildlife, few conduct habitat improvement activities.

4. Visual quality and aesthetics

Those DNR regions and forest products companies interviewed apply Visual Quality Best Management Practices guidelines on their lands. The Forest Service utilizes a long standing internal visual management system that allows for changes on sites while maintaining aesthetics. About half of the counties interviewed indicated that they follow visual quality BMPs. For the most part, NIPF and American Indian landowners do not apply visual quality BMPs in their management activities.

5. Historic and cultural resources

Although some historic and cultural resources are protected by law, incorporation of broader considerations of historic and cultural resources in management activities is less common than for other forest resource components. Counties and private industries indicated an intent to generate policies to protect these resources. Regions of the DNR again vary, but some lands are surveyed prior to harvest and strategies to mitigate impacts on these resources are currently being developed. The Forest Service and American Indian landowners reported that they consistently inventory cultural resources before harvesting or management activities and follow-up with protection and mitigation of adverse impacts where necessary.

6. Sustainable Forestry Initiative

The American Forest & Paper Association (1998) has developed the Sustainable Forestry Initiative (SFI) which defines management guidelines for use by member companies and their contractors in forestry operations. The SFI includes a broad range of "sustainable forestry practices that are economically and environmentally responsible." These guidelines generally include endorsements of existing state BMPs and other activities such as outreach and education. A comparison of SFI practices with proposed integrated forest management guidelines was not made, but SFI recommendations are less restrictive than the proposed guidelines for some elements.

7. Monitoring water quality and wetland BMP compliance

More formal information about use of water quality guidelines is reported in a study by Phillips, Rossman and Dahlman (1994). These accounts cover only a portion of guidelines and policies followed by forest management organizations. However, the BMPs were most often mentioned in the interviews as being the guiding framework for forest management.

The study rated the degree of compliance for 97 different BMP recommendations on 261 audited sites. Limitations in availability of information on recently harvested sites prevented a completely random sample on some ownerships. Nevertheless, they found an average 84% implementation rate overall. All owner groups met or exceeded BMP standards on at least 75% of the sites. About twenty percent of the sites evaluated had no departures from BMP requirements.

County and forest industry lands showed the highest compliance rates at 90% meeting or exceeding BMP recommendations. Compliance on DNR and US Forest Service lands was 85% and 87% respectively. NIPF and American Indian lands showed implementation rates of 77% and 75% respectively. Most deviations from BMP recommendations were minor and occurred in the use of water diversion devices and drainage structures for roads and skid trails. Major departures from BMP recommendations were found for less than five percent of the practices. When BMPs were properly applied, protection of water quality was adequate in virtually every case. Filter strips were applied 91% of the time showing that landowners are cautious when operating near open water.

Some notable points on guideline implementation can be derived from the interviews and BMP studies.

- Some land management organizations already use many elements of the proposed integrated guidelines. The DNR, Forest Service, private industries and counties regularly utilize current BMPs to maintain high water quality and minimize impacts to soil. Forest Service and DNR lands are quite often managed with wildlife in mind – snags and leave trees are consistently incorporated into management plans. Puettmann and others (1998) reported that 14 residual trees were left on the average harvested site. Segments of the forest are also left as longer-rotation stands to address riparian and wildlife needs. Counties and private industry do follow some of these same practices, but with more variability than on the other two mentioned land ownerships.

- Some components of guidelines, such as the historic/cultural guidelines, are far less emphasized than other types of guidelines. Although the Forest Service and American Indian landowners report that they protect cultural resources found on their timberlands, little other activity on this issue was reported by the other four landowner groups. This stands in contrast to wildlife, water, riparian and soil resources which are considered to varying levels by all landowner categories.

- Organizations may be informally adhering to certain forest management guidelines. If this usage is not officially documented, compliance levels reported in interviews will appear lower than they are in reality.

8. Reasons for compliance

Various reasons for landowners complying or not complying with either BMP recommendations or other guidelines and policies surface from the interviews and BMP implementation reports. Uncertainty in the science or rationale behind a particular recommendation at times limits acceptance and application of guidelines. Economic and financial impacts (excessive costs) were also cited as hurdles to using certain management practices. Low compliance levels on NIPF lands likely occurs because relatively few private landowners either seek or have access to professional assistance in designing timber sales or developing management plans.

Differences between implementation on state, federal, county and forest industry lands are suggested by Phillips, Rossman and Dahlman (1994). They posit four reasons for variability in application of current guidelines.

- Contracting procedures on state and federal lands limit opportunities for being selective of harvesting operators.
- Oversight of field foresters to ensure uniformity in contracts is constrained by organization size.
- State and federal employees carry highly diverse workloads leaving less time to oversee contract implementation.
- Private industry may have capacity to provide contract loggers with financial advantages and incentives to apply BMPs.

Beyond the BMP monitoring surveys conducted by the DNR, little information is available to quantify the specific use of forest management guidelines. No formal reports are produced and few records are maintained to document which practices are used and which aren't. Certainly timber sale contracts and management plans that indicate practices to follow are developed and stored. However, detailed information on the use of recommended practices is seldom compiled into retrievable data bases. Thus, quantification of compliance levels remains uncertain.

C. Significant forest management and economic trends

Forests resources provide the economic basis for the forest products sector and much of the tourism activity in Minnesota.

1. Wood products manufacturing

Timber production is an important economic use of Minnesota's forests and the wood processing industry is spread across the landscape. In 1992 there were 568 sawmills, 16 mills using wood to produce pulp and composite panels and 12 other wood-using mills operating in Minnesota (Hackett and Dahlman 1997). Approximately 80% of the timber volume produced is pulpwood used to manufacture paper and composite panel products.

In 1996, 3.8 million cords were harvested from Minnesota's forests. Of that, about 2.9 million cords of pulpwood were produced (Piva 1998). Pulpwood harvested in the state in 1996 was worth at least $35 million annually in timber sales for Minnesota landowners. Eight counties (St. Louis, Koochiching, Itasca, Cass, Beltrami, Pine, Lake, Hubbard) produce 73% of all the pulpwood harvested in Minnesota. Although annual sawtimber production statistics are not available, the most recent accounts (Hackett and Dahlman 1997) show that 323 million board feet of sawlogs were produced in 1992, roughly equivalent to 664 thousand cords of wood volume. Primary and secondary manufacturing of these raw materials into high value paper and solid wood products provides much value added and many jobs. In some communities, wood processing is the single largest employer.

Trends show that timber harvests increased substantially over the past several decades. Pulpwood production more than doubled from 1980 to the present and increased by 25% from 1990 to 1993. Pulpwood harvests were relatively constant from 1993 to 1996, the latest year with available statistics.

Aspen makes up 73% of the total pulpwood volume produced in 1996. Balsam fir, spruce, jack pine, balsam poplar, and paper birch are also important pulpwood species, but production from each of these species is 12% or less of the aspen volume. The sawlog mix was comprised of aspen (30%), jack pine (18%), red pine (13%), and high quality hardwoods (22%) including red and white oak, ash and basswood.

Timber prices also rose over the past several decades and increased faster than inflation from 1960 to the present for most species. Minnesota timber prices rose modestly from 1970 to 1990. However, a substantial increase, nearly double, occurred starting in 1990. Aspen pulpwood stumpage prices, for example, increased by 6.7% annually from 1960 to 1997 and 17.6% annually from 1990 to 1997. This recent market correction was a significant shift from prior trends and due to both supply-limiting and demand-increasing factors. Prices for pulpwood in Minnesota during the 1980s were consistently below comparable pulping species in other parts of the United States.

Some contend that the rapid price increases in the 1990s were due primarily to environmental constraints. While additional competition for timberland for development and increased emphasis on non-market resource values have affected prices, a far greater influence, in our opinion, has been the significant increase in competition and demand for wood (about 25 percent) during the same period. Similar price and demand increases have occurred elsewhere in the Lake States.

2. Tourism

Forests are vitally important for many non-consumptive uses as well, and Minnesota is ranked among the best places for outdoor pursuits. Substantial economic activity is generated by tourism in Minnesota. Healthy forests and abundant water are the raw materials that support tourism in forested regions.

Although tourism spending occurs in business establishments, people spend for the outdoor recreation opportunities that depend on healthy forests. Boating and fishing, hiking and camping, hunting, skiing and snowmobiling are all dominant activities that generate considerable spending. Forest resources also support large amounts of local recreation activity in hundreds of cities, small communities and major seasonal home development areas. Simply enjoying nature with activities such as bird watching, berry picking, and picnicking are especially important to people in urban and rural areas, even though these are usually hard to quantify.

Unlike basic resource and manufacturing sectors, tourism is not represented by a single economic sector in accounts of economic activity. The market activity of tourism includes portions of several service sectors including hotels, recreation services, restaurants, retail, transportation and some manufacturing and government. In many rural communities, tourism ranks among the dominant businesses.

According to Stynes (1997) tourism spending comprised 1.2 percent of Minnesota's total industrial output, more than $2 billion in 1990. Much of the state's tourism activity is accounted for by several major urban centers. Four counties (Hennepin, St. Louis, Ramsey, and Olmsted) comprised 44% of all tourism spending in 1990. In nine forested counties, tourism spending made up 5% or more of the total economic activity --Cook (30.0%), Cass (20.6%), Lake of the Woods (12.7%), Aitkin (12.5%), Hubbard (8.5%), Lake (7.4%), Crow Wing (6.9%), Pine (6.3%), and Becker (5.7%). Without healthy and abundant forests, the business activity from tourism would be much smaller or nonexistent in these counties.

Several major trends are affecting tourism and amenity resources in Minnesota (Stynes, 1997). Especially important are migration of people to forested areas for retirement and development of seasonal homes; increased emphasis on amenities over commodity uses of forests; and increased public participation in forest management choices by residents who favor amenities and ecosystem values, but

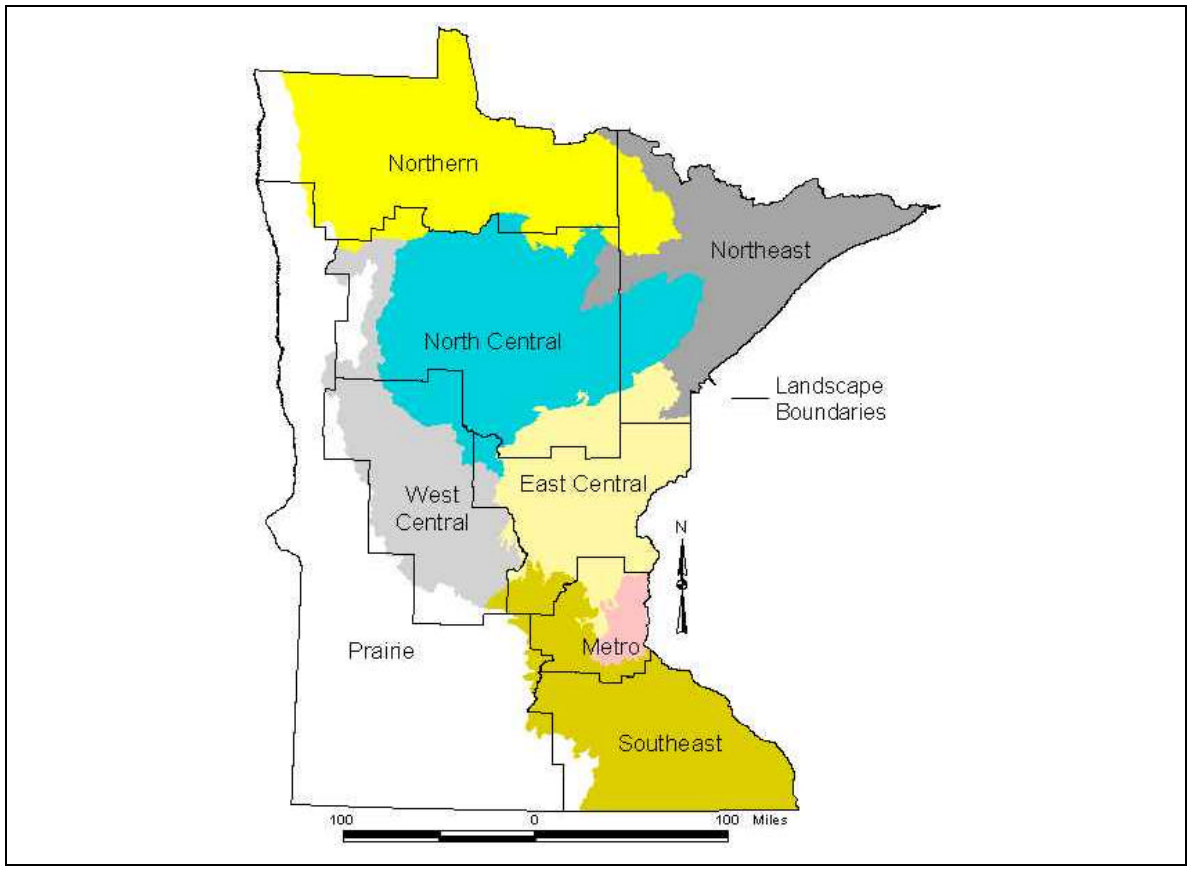
do not have a direct stake in traditional commodity uses. These trends reinforce the high levels of interest among broad segments of the population for sustaining healthy forests for many non-market values.

II. OVERVIEW OF METHODS AND DATA

A. Analysis units

The forest base was divided into analysis units using data from the 1990 Forest Inventory and Analysis (FIA) (Appendix C.) Each analysis unit was an aggregate of acres uniform in applicability of forest management practices. Forest type, physiographic class, potential productivity class, geographic location, land use, and owner were all used to create analysis units. FIA forest types, ownership, and potential productivity class were condensed to 9, 5, and 3 classes, respectively, in order to keep the number of analysis units manageable. MFRC regional landscape ecological areas provided the spatial framework (Figure II.1.)

Figure II.1. Ecological boundaries for MFRC regional landscapes.



The analysis assumed that forest management activities would be concentrated on timberland. At eighty-eight percent, timberland accounts for the majority of the state's total forest land (Table II.1.) Other forest land classes, including reserved timberland and forestland not capable of producing merchantable wood, account for 12 percent of Minnesota's total forest land.

Minnesota's forests occur more frequently in the northern regional landscapes. The North Central regional landscape has the most timberland at 4.8 million acres, 33 percent of the state's total. The Northeast and Northern regional landscapes each have more than 3 million acres of timberland. Timberland occurs to a lesser degree in the more southerly regional landscapes.

Table II.1. Land area in Minnesota by MFRC regional landscape and land use class. Areas are thousands of acres, 1990.

Regional landscape	Total land area	Forest land					Other land
		Total forest	Timber-land	Reserved timber-land	Other forest land	Reserved other forest land	
Northeast	4,718	4,096.7	3,050.8	963.1	65.9	16.9	621.3
Northern	7,755.5	3,986.7	3,429.2	13.4	531.8	12.3	3,768.8
West Central	4,477.5	598.5	584.5	6.3	7.7	0	3,879.0
North Central	7,727.6	5,074.5	4,839.6	34.3	199.2	1.4	2,653.1
East Central	4,873.0	1,907.4	1,826.6	48.2	32.6	0	2,965.6
Southeast	6,006.1	733.4	719.3	12.3	1.8	0	5,272.7
Metro	567.3	38.8	30.2	7.1	1.5	0	528.5
Prairie	14,785.9	245.1	243.0	2.1	0	0	14,540.8
Total	50,910.9	16,681.1	14,723.2	1,086.8	840.5	30.6	34,229.8

Proposed site-level guidelines will in all likelihood impact owners in different ways. For some owners, particular guidelines will represent a substantially new direction in management. Other owners may not have to alter current operational practice in order to comply with proposed guidelines. Of the five ownership groups considered in the analysis, NIPF and American Indian had the greatest amount of timberland and growing stock volume (Table II.2.) Forest industry had the least. The public agencies, federal, state, and county, account for 52 percent of the state's timberland.

Table II.2. Distribution of timberland and growing stock volume by ownership groups. Areas are thousands of acres and volumes are thousands of cords, 1990.

	Total for all owners	Owner				
		Federal	Forest industry	NIPF and American Indian	State	County
Timberland area	14,723.2	2,018.8	751.3	6,387.9	3,062.5	2,502.7
Growing stock volume	191,731.9	29,657.7	8,502.6	84,574.6	34,387.1	34,610.1

Forest type influences which guidelines should be considered when conducting forest management activities. For example, wildlife guidelines recommend extending the rotation length of oak forests. Other guidelines are targeted at specific silvicultural practices, like clearcutting. Such practices will affect those forest types where clearcutting is applied to a greater extent than other forest types (Table II.3.)

Table II.3. The extent of area and growing stock volume for nine forest types. Areas are thousands of acres and volumes are thousands of cords, 1990.

	Timberland area		Timberland volume		Average
	(1000s acres)	(% of total)	(1000s cords)	(% of total)	cords/acre
Jack pine	452.1	3.1	6,772.2	3.5	15.0
Red-white pine	445.0	3.0	8,371.9	4.4	18.8
Lowland conifer	2,918.2	19.8	25,733.8	13.4	8.8
Upland conifer	637.3	4.3	9,491.1	5.0	14.9
Oak-hickory	1,116.2	7.9	17,873.0	9.3	15.3
Lowland hardwood	1,289.9	8.8	15,013.1	7.8	11.6
Northern hardwood	1,393.1	9.5	22,118.9	11.5	15.9
Aspen-birch	6,317.2	42.9	86,314.7	45.0	13.7
Nonstocked	104.2	0.7	43.1	0.0	0.4
Total	14,723.2		191,731.9		13.0

B. Acreage and Volume Determination

1. General Approach

Guidelines were singled out for review by comparing each guideline against three criteria. The three criteria were:

Criteria 1. Implementation completely withdraws productive forestland from that currently available for harvest.

The 1st case occurs when productive forestland is either converted to a non-forest land use OR placed in a category of forest land where harvesting is prohibited. The former is typified by the conversion of forestland to roads, development, or agriculture. The latter is typified by practices that call for the exclusion of specific areas from forest management activities.

Criteria 2. Implementation impacts harvesting productivity, the amount of tree stemwood volume removed from a site.

The 2nd case occurs when timber harvesting is not completely prohibited but rather curtailed. Examples include practices where merchantable wood remains on the stump OR cut wood remains on the site following harvesting.

Criteria 3. Implementation affects future stand growth and yield.

Many factors influence growth and yield. Chief among these are age, site quality, and stand density. Practices that influence any of these factors are likely to exert a strong influence on the growth and yield of subsequent rotations.

A substantial number of guidelines met one or more of the criteria. Those that satisfied either criteria 1 or 2 were singled out for further analysis. This was in part necessitated by the timeframe and scope of the study and by the expectation that these guidelines were likely to have the greatest impact on acreage and volume available for harvest. Guidelines satisfying the third criteria were, on review, expected to have positive impacts on acreage and volume available for harvest.

2. Riparian

The riparian analysis relied on three data sources: 1990 Forest Inventory and Analysis (FIA), National Wetlands Inventory (NWI), and the Minnesota Department of Transportation (MNDOT) streams data. These data sets were brought together in order to analyze timberland acreage and growing stock volume in riparian areas. In the first step, a crosswalk between NWI wetlands and lakes and open water wetlands was created. The crosswalk allowed a search of the NWI data base to identify lakes and open water wetlands throughout the state. In the second step, the location of each FIA plot relative to intermittent and perennial streams, trout lakes, and lakes and open water wetlands was determined. All distance calculations were performed in a geographic information system (see Appendix D for a more complete description of steps 1 and 2). In the third step, the amount of land area adjacent to water was modeled. FIA plots falling in a buffer were identified based on the distance calculations performed in step 2. FIA plot level information was then expanded to statewide estimates.

Using this framework, three different scenarios were modeled: Water Quality and Wetland Best Management Practices (BMPs), Proposed Riparian Management Zone Guidelines (RMZs), and Riparian Management Zone Guidelines – Reduced Buffers (RMZs reduced buffers) (Table II.4.) The BMP scenario estimated the area currently within BMP shade strips. The RMZ scenario estimated the area subject to proposed riparian guidelines. The RMZ reduced buffer scenario was a variation of the RMZ scenario that represented a compromise between the BMP and RMZ scenarios.

Timberland acreage and growing stock volume of FIA plots adjacent to water are summarized by forest type and basal area class for each scenario. Even-age management was assumed to be prevalent in the aspen-birch, jack pine, red-white pine, lowland conifer, and oak-hickory forest types. Other forest types were placed in an uneven-age management category. The amount of acreage and growing stock volume below recommended residual basal areas are compared for each scenario.

Table II.4. Recommended and modeled buffer widths for the riparian analysis.

Water body type	Recommend buffer widths BMPs[A]	Recommend buffer widths RMZs[B]	Buffer widths used in the analysis BMPs[A]	Buffer widths used in the analysis RMZs[B]	Buffer widths used in the analysis RMZs reduced buffers[C]
Lakes and open water wetlands	(feet)	(feet)	(feet)	(feet)	(feet)
At least 10 acres in size	50	150	50	150	100
2.5 to 10 acres in size[D]	50	75	50	75	75
Less than 2.5 acres in size[D]	50	0	50	0	0
1 to 10 acres in size[E]	50	150	50	150	100
Less than 1 acre in size[E]	50	0	50	0	0
Designated trout lakes	100	150	100	150	100
Perennial streams					
Trout stream and tributaries	100	150			
Non-trout streams					
At least 10 feet wide	50	150	50[F]	100[G]	75[H]
3 to 10 feet wide	50	75			
Less than 3 feet wide	50	50			
Intermittent streams					
Trout stream and tributaries	100	150			
Non-trout streams			0[F]	100[G]	75[H]
At least 10 feet wide	0	150			
3 to 10 feet wide	0	75			
Less than 3 feet wide	0	0			

[A] Protecting Water Quality and Wetlands in Forest Management: Best Management Practices in Minnesota (1995).
[B] Proposed Riparian Management Zone Guidelines.
[C] The following variations of Proposed Riparian Management Zone Guidelines were made in modeling reduced buffers - 150 feet buffers were reduced to 100 feet buffers and 100 feet buffers were reduced to 75 feet.
[D] Counties with greater than 80% of their presettlement wetlands intact: Crow Wing, Kanabec, Lake of the Woods, Mille Lacs, Aitkin, Cass, Pine, Carlton, St. Louis, Beltrami, Itasca, Lake, Koochiching, Hubbard, Clearwater, Isanti, and Cook counties (Minnesota Wetlands Conservation Plan 1997, Figure 5).
[E] Counties with 80% or less of their presettlement wetlands intact: those counties not listed in [D] (Minnesota Wetlands Conservation Plan 1997, Figure 5).
[F] All perennial streams types were modeled at an estimated aggregate buffer width of 50 feet and all intermittent stream types were modeled at an estimated aggregate buffer width of 0 feet.
[G] All stream types were modeled at an estimated aggregate buffer width of 100 feet.
[H] All stream types were modeled at an estimated aggregate buffer width of 75 feet.

3. Wildlife

Numerous guidelines are suggested to address wildlife concerns. Two of those guidelines, leave trees and seasonal ponds, were considered heavily in the acreage and volume analysis. The others, to varying extent, were believed to have fewer impacts relative to those of the leave tree and seasonal pond guidelines.

Three pieces of information were needed to assess the impacts of the leave tree guidelines: (1) the degree to which clearcutting is applied, (2) the degree to which residual trees occur on clearcuts and (3) the area occupied by residual trees. Two primary sources of information used in the calculations were the report "Status of Minnesota Timber Harvesting and Silvicultural Practice in 1996" (Puettmann et al. 1998) and data from an aerial photo sample of harvests in northern Minnesota.

Harvests that occurred within the last five years were identified on a random selection of aerial photos from Carlton, Cook, Koochiching, Lake, St. Louis, Aitkin, Becker, Beltrami, Cass, Clearwater, Crow Wing, Hubbard, Itasca, Lake of the Woods, Mahnomen, Roseau, and Wadena counties. Counties were selected based on availability of recent photographs. For each harvest site, the distance to the nearest water body, type of water body, total harvest area, silvicultural system, crown cover of residual vegetation, and residual vegetation pattern was recorded. A total of 165 harvest sites were identified, covering 4,856 acres, or 29.4 acres per site on average.

Area expected to be clearcut in the coming year was taken as that reported for 1996 (Puettmann et al. 1998). Five percent of the clearcut area was taken as the amount of area in leave trees needed to be in compliance with the leave tree guidelines. The current rate of compliance – area produced under current operational practice that qualifies as leave trees – was estimated from the Puettmann et al. study and the aerial photo data. The impact of the leave tree guidelines was taken as the difference between the amount required under proposed guidelines and the amount resulting from current operational practice.

A significant amount of time was spent reviewing methods to determine the extent of seasonal ponds. Remote sensing was considered as one possible technique for determining the extent of these resources. However, seasonal ponds were expected to be small and in many cases indistinguishable from surrounding forest when viewed from satellite imagery or aerial photography. Consequently, remote sensing was ruled out. Various field inventories were reviewed in order to determine if (1) seasonal ponds were recorded or (2) information that could be used as a proxy for seasonal ponds was collected. The third option was to model their occurrence using a combination of landform data summarized in the ECS and inventory information. The development time needed for such an effort precluded its use in this study. At the time of this writing, no reliable method has been devised.

4. Historical and Cultural Resources

Five categories of historical and cultural resources are identified in the proposed site-level guidelines: historic structures, archaeological sites, cemeteries, historic areas, and traditional use areas. In this analysis only the extent of archaeological sites and cemeteries on timberland were modeled. The remaining cultural resources were not incorporated due to constraints in available data to adequately describe them or due to their limited distribution in forested regions of the state. For instance, the approximately 36,000 historic structures were not considered in the analysis. They are found primarily in developed areas and few are thought to be located on timberland. Further, the extent of traditional use areas and historic landscapes could also not be estimated due to lack of data that locates and describes them.

Several steps were taken to gather what information is obtainable on archaeological sites and cemeteries. Previous work that investigated the occurrence of historical/cultural resources was reviewed. Data in the GEIS Unique Historical and Cultural Resources Technical Paper provided the foundation for this study's estimates of cultural resource extent (Jaakko Pöyry 1992a). Up-to-date information was sought via a survey sent to historic and cultural resource experts at the Minnesota State

Historical Preservation Office, Chippewa National Forest, Superior National Forest, and Voyageurs National Park. Each organization was asked to provide the number of historic and cultural resource sites along with size, time period and location information listed in their data bases. All four surveys were completed and returned. Respondents contributed expert opinion when a shortage of data prohibited definitive responses to particular questions. For example, data on the sizes of historical and cultural resources are for the most part absent. In some cases, respondents estimated minimum, median, and maximum sizes based on their professional experience. In other cases the size fields were left blank. Survey data were used to establish assumptions used in the analysis.

The next stage was to assess the extent of archaeological sites and cemeteries on timberland and evaluate potential effects of historic and cultural resources guidelines on timberland acreage and growing stock volume available for harvest. These were estimated for each MFRC regional landscape. Because of the uncertainty about absolute numbers and sizes of cultural sites on timberland, a range of likely scenarios were analyzed. A low and high scenario is reported, representing the smaller and larger average site size provided in surveys and GEIS data. Each scenario assumes the site densities reported in the GEIS Unique Historical and Cultural Resources Technical Paper are accurate (Jaakko Pöyry 1992a).

In order to account for existing management practices that focus on historic and cultural resources, it was necessary to estimate the extent of cemeteries and archaeological sites separately. Thus, two categories were established for the analysis. The first includes archaeological sites on federal and tribal ownerships and all cemeteries. Current operational practice on federal and tribal lands is at a level at least equal to that recommended in the proposed site-level guidelines. A combination of federal and state laws currently protect all cemeteries, regardless of ownership. The second category of resources includes archaeological sites not on federal or tribal ownerships. No standard practices that the deal with management of these resources was identified. Archaeological sites were assumed to be more common than cemeteries. Seventy-five percent of the archaeological sites and cemeteries estimated to occur in a region were modeled as archaeological sites. The distribution of archaeological and cemetery sites was assumed to be proportional to land ownership. If 50 % of a regional landscape's area was in a particular ownership class, then 50 % of the regional landscape's sites were assigned to that ownership class.

5. Soil Productivity

These guidelines were developed for the purpose of maintaining soil productivity or reducing the conversion of forestland to non-forest uses. None of the soil productivity guidelines call for the reservation of timberland or the leaving of merchantable volume on the stump or site. The application of these guidelines over a long period of time should ensure that productivity levels would at least hold steady. It is reasonable to assume that all landowners endeavor to maintain forest productivity and are currently implementing many of the recommendations. The analysis does not suggest any of these guidelines will adversely impact the acreage and volume available for harvest.

III. POTENTIAL BENEFITS

Many of the benefits of the proposed forest management guidelines represent noncommercial values, or at least values which are extremely difficult to quantify, especially in a site-based analysis. In most cases all of society or particular segments of society benefit even though few can capture direct market benefits.

A. Beneficiaries

The following are likely benefits and beneficiaries associated with the application of site-based forest practices[3].

- Greater biodiversity and more resilient biophysical systems provide sustained or improved ecosystem services and environmental capacity to assimilate human impacts, including pollution, reduce costs and increase opportunities for protection of rare species, and reduce costs and losses from extremes in forest pest outbreaks by helping maintain viable populations of insect predators.

- Improved forest and water conditions provide a higher quality environment to support tourism businesses and recreation activity.

- Increased and more diversified habitat generally benefits publics interested in having diverse game and non-game wildlife and engaging in activities related to these, including hiking, nature observation, bird watching, and some types of hunting.

- Increased visual quality and avoidance of incompatible activities generally benefits recreation participants, tourism businesses and the communities that depend on them. Benefits from reduced visual and noise impacts are especially important along travel corridors and locations near recreation sites and facilities.

- Successional development of forests to more mature stages would, in the long run, provide increased availability of larger, more diverse, and higher quality timber and opportunities for rural economic development in solid wood and specialty products markets.

- Cleaner water resources and stabilized flows from improved riparian management provide increased opportunities for anglers, benefits to downstream landowners and communities from reduced flooding and other impacts, and possibly savings in public or private pollution abatement or mitigation activities.

- Increased carbon storage in above-ground forest biomass and soil carbon would help meet global interests to mitigate global climate change, reduce greenhouse gas effects and improve soil carbon storage. At some future time, these global environmental benefits may have value in national or international markets through tradeable carbon vouchers.

- Adoption of widely accepted management standards may offer reductions in the amounts and costs of conflict over issues such as development, resource use, and protection. Furthermore, widespread application of guidelines on all ownerships would increase options for resource management and reduce pressures on public lands for production of protected ecosystems. Adoption of standards will provide participants with improved state and

[3] See Lippke (1992) for a discussion of the economics of managing landscapes to enhance environmental values, including benefits.

community recognition for environmental stewardship, public relations benefits, and possibly increased access to some markets. Standards would provide opportunities for technical resource specialists who can assist landowners with guideline implementation.

- Protection of cultural and historical resources may provide some economic development opportunities such as historical sites with educational value. Preservation of historical sites and artifacts reinforces community values, provides for a cultural continuum, and helps establish and maintain a valuable historical perspective. In some cases, protection of traditional use areas and "places of the heart" sustains spiritual values and a sense of well being.

Unfortunately, few of these benefits flow directly to landowners, individuals or businesses closely associated with land management or commodity production in proportion to their costs for applying proposed forest management guidelines. Most of the benefits associated with sustainable site-level practices are public whereas most of the costs are borne by landowners and businesses that use forest resources.

B. Benefits of Implementing Guidelines

Sustainable forestry is a proactive form of management that provides for the multiple uses of the forest by balancing a diversity of both present and future needs. Sustainable forest management is a challenging process. Recognizing this, the proposed integrated guidelines were developed through a collaborative process to address projected impacts on forest resources as identified in the 1994 Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota (GEIS).

These voluntary site-level forest management guidelines provide valuable decision-making tools for landowners, resource managers and loggers throughout Minnesota, who share an ongoing responsibility to make balanced, informed decisions about forest use, forest management and forest sustainability. Guideline recommendations offer consistent, coordinated guidance in sustaining many of the functions and values of forest resources, including cultural resources, forest soils, riparian areas, wildlife habitat, visual quality, and water quality and wetlands. Addressing these six forest functions and values categories, the guidelines for forest management activities provide substantial benefits to the sustainability of forest ecosystems. In contrast to quantifiable costs of implementing forest management practices, these benefits manifest themselves in ecological and social conditions which are generally not quantifiable, let alone marketable.

1. Cultural/Historic Resources Guidelines

Cultural and historic resources signify a common heritage shared by all inhabitants of Minnesota. These resources are valued for spiritual, scientific and other reasons. Forest management guidelines account for and strive to sustain these important values. They protect important cultural resources by increasing the awareness of these among forest landowners, resource managers and loggers. The benefits of careful cultural resource management are not always easily defined, but are nevertheless significant.

Cultural resources provide modern-day societies with physical links to the past. They build a sense of national, community and personal identity for various cultures by fulfilling nostalgic and spiritual instincts shared by large segments of modern society. Understanding and appreciation of Minnesota's history and heritage comes with conservation of cultural resources and associated opportunities for learning about these resources. Buildings, cultural landscapes, traditional use areas and other above-ground cultural sites maintain diverse landscapes and in some cases are valued as works of art. Forest practices guidelines, which recommend avoiding cultural resources areas during management activities, contribute to sustaining these cultural resources.

While mindful management of cultural and historic resources directly affects structures and artifacts, other forest resources benefit as well. For example, actions taken to avoid historic structures in the forest

assist in efforts to maintain soil productivity, water quality and wildlife habitat conditions. Cultural resources can also be economic assets. Historic sites attract tourists and can help stimulate development of outdoor recreation opportunities. Community and corporate identity can also be enhanced through active management of and associated education about cultural resources. Such common community identity fosters economic productivity and new investment.

2. Forest Soil Productivity Guidelines

Soil is the fundamental resource of the forest. Without it and its productive capacity the conditions of other forest resources are diminished. Maintaining soil productivity is the key to sustainable forest management. Forest management guidelines provide recommendations to help maintain the productive capacity of forest soils to favor the regeneration, survival and long-term growth of desired forest vegetation.

Soil conditions influence the types of plants that can grow on a forest site and the number of trees or amount of wood that a site can grow. This in turn affects the level of timber harvest that the forest can sustain. Guideline recommendations can assist in minimizing impacts to forest soils to provide for sustainable plant and tree communities. These then also aid in meeting society's need for forest products and other forest amenities. Guidelines which help to maintain high soil productivity also serve other forest resources. Examples of such resources are wildlife habitat and biodiversity. Applying guideline recommendations for soil productivity is more beneficial and cheaper than mitigation costs to fix damaged soils which is not always possible.

3. Riparian Guidelines

Riparian areas are transition zones between aquatic and terrestrial ecosystems. These linkages between landscape components perform important ecological functions. Forest management guidelines serve to uphold the role of riparian areas. Guideline recommendations focus on maintaining and enhancing vegetation within riparian areas for the benefit of water quality, fish and wildlife habitat, timber production, recreation and aesthetics.

Specific ways in which forest management guidelines benefit riparian areas are by sustaining soil and stream bank stability and stream temperature. They allow riparian areas to retain water storage capacity, and continue to contribute nutrient and food input as well as large woody debris to the aquatic system. Guidelines account for other riparian functions such as providing a diverse and productive habitat for aquatic and terrestrial wildlife, and supporting travel corridors, habitat continuity, and unique habitats and communities. Additionally, guidelines which help maintain riparian areas benefit people by furnishing areas for recreation, tourism, forest products, hunting, fishing, biological diversity and other human uses.

4. Site-level Wildlife Habitat Guidelines

Forestlands are home to a multitude of wildlife species. Forest management guidelines encourage stewardship of wildlife habitat and forest communities to benefit this broad range of species. Benefits apply primarily to the wildlife habitat on a site, but improved habitat may lead indirectly to a better-functioning ecosystem and therefore improved overall site productivity in the long run.

Guidelines satisfy site-level wildlife habitat requirements by recommending a variety of harvest area sizes and shapes. They help to sustain the genetic diversity within tree species and maximize the potential for tree species to shift their geographic ranges in response to possible rapid climatic changes. Conifer retention is encouraged which results in mixed deciduous/coniferous stands that ensure a diversity of habitat, food, nesting opportunities and cover. Food availability is further enhanced through guideline recommendations by providing for adequate mast production from trees and shrubs. Various wildlife habitat guidelines attend to perches, tree cavities and bark foraging sites by retaining suitable leave trees and snags during forest harvesting and timber stand improvement. Other guidelines recommend retaining coarse woody debris and slash during forest management which furnish cover, food or substrate

for amphibians, reptiles, mammals, birds, invertebrates, fungi and green plants. Terrestrial species linked to wetlands and seasonal ponds within forests, along with those species that are dependent on riparian areas (riparian obligate species) benefit from site-level habitat features accounted for through guidelines. In addition, guidelines assist in raising awareness of, while helping to maintain or enhance, endangered, threatened and special concern (ETS) species, and sensitive communities and sites.

5. Visual Quality Guidelines

Managing for visual quality is an important component of broad-scoped integrated forest management. Tourists choose recreation and vacation sites according to the scenic quality of forested areas. Certain forest management guidelines help to minimize visual and audible impacts of forest management activities on tourists, recreational users, and casual travelers. Thus using visual quality guidelines can help sustain a healthy tourist economy.

Visual quality guidelines can minimize the visibility of harvest sites and various vegetation management activities while limiting the visual impact of slash and forest access roads. Stands appear more natural and the visual contrast of snags or broken trees is reduced. These guidelines also allow some individuals of longer-lived species to reach 200-300 years of age. Cumulatively these ecological and social benefits serve to reduce conflicts and negative perceptions of the timber industry, thereby helping to sustain a robust timber economy.

6. Water Quality and Wetland Guidelines

Abundant clean water is one of Minnesota's greatest resources. Since much of this water originates in forested watersheds, care is needed to minimize impacts to water quality and wetlands when carrying out forest management activities such as road building. An array of forest management guidelines seek to limit various pollutants arising from management sites that affect water bodies. Recommendations to maintain high water quality and wetland systems help prevent or minimize erosion and subsequent sedimentation of water bodies, and prevent non-point source pollutants such as pesticides, fuel, lubricants and other chemicals from moving to surface water, groundwater or wetlands. Further, these guidelines help maintain water temperatures within their normal range and sustain normal hydrological flows in wetlands.

IV. POTENTIAL EFFECTS ON ACREAGE AND VOLUME

A. Riparian

1. Minnesota's stream, lakes and open water wetlands resources.

To conduct this analysis it was first necessary to determine the amount and distribution of the water resources across Minnesota. Perennial and intermittent streams as well as lakes and open water wetlands are shown here by MFRC regional landscape. Stream and river length for the state is estimated at 64,000 miles (Table IV.1). The Southeast regional landscape has the highest concentration at 2.1 miles per thousand acres of area. Stream/river concentrations in the northern regional landscapes range from 0.7 to 1.3 miles per thousand acres of area.

Table IV.1. Estimated length of streams and rivers in Minnesota.

Regional landscape	Landscape area[A] (acres)	Stream and river length in miles[B] (miles/1000 acres)		
		Both types	Perennial	Intermittent
Northeast	5,365,000	6,970 (1.3)	4,710 (0.9)	2,260 (0.4)
Northern	8,425,000	6,050 (0.7)	3,440 (0.4)	2,610 (0.3)
West Central	4,843,000	5,860 (1.2)	1,460 (0.3)	4,400 (0.9)
North Central	8,444,000	7,420 (0.9)	4,380 (0.5)	3,040 (0.4)
East Central	5,124,000	5,600 (1.1)	2,600 (0.5)	3,000 (0.6)
Southeast	6,168,000	13,110 (2.1)	4,120 (0.7)	8,990 (1.5)
Metro	607,000	530 (1.1)	150 (0.2)	380 (0.6)
Prairie	15,020,000	18,280 (1.2)	5,130 (0.3)	13,150 (0.9)
Total	53,996,000	63,820 (1.2)	25,990 (0.5)	37,830 (0.7)

[A] Regional landscape area estimates gathered from the Ecological Classification System.
[B] Estimates of length from the MN Department of Transportation stream data.

Lakes and open water wetlands account for 9 percent of Minnesota's area (Table IV.2). Of the forested landscapes, the highest concentrations of lakes and open water wetlands were observed in the West Central regional landscape. The Southeast regional landscape had the lowest.

Table IV.2. Estimated area of lakes and open water wetlands in Minnesota.

Regional Landscape	Landscape area[A] (acres)	Lakes and open water wetlands area[B]	
		(acres)	(%)
Northeast	5,365,000	554,000	10.3
Northern	8,425,000	791,900	9.4
West Central	4,843,000	812,400	16.8
North Central	8,444,000	1,035,700	12.3
East Central	5,124,000	707,900	13.8
Southeast	6,168,000	380,000	6.2
Metro	607,000	64,300	10.6
Prairie	15,020,000	532,300	3.5
Total	53,996,000	4,878,500	9.0

[A] Regional landscape area estimates gathered from the Ecological Classification System.
[B] Lake and open water wetland area estimates derived from the National Wetlands Inventory.

2. Timberland area and growing stock volume adjacent to water bodies

To understand the effects of proposed guidelines on timberland acreage and growing stock volume, it is helpful to look at the total land area in Minnesota that is next to water bodies. The majority of Minnesota's water resources do not have forest adjacent to them. The most abundant land uses adjacent to water are nonforest classes like agriculture, residence, development and other non-forest habitats. BMP and RMZ practices are targeted at forestland next to water bodies. Of the total land near water, approximately 20% is forested. As modeled, 514,700 acres of timberland are subject to BMP practices – 1 out of every 28 acres of timberland. 980,100 acres are subject to RMZ practices – 1 out of every 15 acres of timberland. Timberland acreage in RMZ reduced buffers is 753,500, roughly the midpoint between the BMPs and RMZs.

Table IV.3. Land use area estimates for BMPs, RMZs, and RMZ reduced buffers, 1990.

Land use class	Statewide totals	BMPs[A]	RMZs[B]	RMZs – reduced buffers[C]
	Acreage (1000s)	Acreage within buffers (1000s)	Acreage within buffers (1000s)	Acreage within buffers (1000s)
Timberland	14,723.2	514.7	980.1	753.5
Reserved timberland	1,086.8	46.4	111.2	73.7
Other forest land	840.5	8.9	19.3	16.3
Reserved other forest land	30.6	3.0	3.0	3.0
Other land	34,229.8	2,730.1	4,199.3	3,497.2
Totals	50,910.9	3,303.1	5,312.9	4,343.7

[A] Protecting Water Quality and Wetlands in Forest Management: Best Management Practices in Minnesota (1995).

[B] Proposed Riparian Management Zone Guidelines.

[C] The following variations of Proposed Riparian Management Zone Guidelines were made in modeling reduced buffers - 150 feet buffers were reduced to 100 feet buffers and 100 feet buffers were reduced to 75 feet.

A breakdown of timberland acreage adjacent to various water bodies provided some useful insight (Table IV.4.) RMZ widths are at least as wide, and in most cases wider, than BMP widths; the one exception is small lakes and open water wetlands. The expanded buffers of the RMZs around large lakes and open water wetlands (at least 10 acres in size), intermittent streams, and perennial streams resulted in an increase of timberland acreage subject to residual basal area recommendations. Buffers around small lakes and open water wetlands (less than 1 or 2.5 acres, depending on county) were eliminated in the RMZ guidelines. As a result, 110,000 timberland acres near small lakes and open water wetlands are no longer subject to basal area recommendations (see table IV.4.)

Some interesting regional trends are apparent when the BMP and RMZ numbers are summarized by regional landscape (table IV.5). Relative to other forested regional landscapes, the Northeast and Northern regional landscapes have relatively low amounts of timberland acreage within RMZs and BMPs. Concentrations of timberland within BMPs and RMZs for the North Central regional landscape are close to statewide averages. The Southeast regional landscape experiences a substantial increase in timberland acreage and growing stock volume affected when RMZ buffers were applied to intermittent streams, which are abundant in this region.

Well over half of the timberland adjacent to water bodies falls in the joint NIPF and American Indian ownership group (table IV.6.) This condition holds for both the RMZ and BMP scenarios. State and federal ownerships are least affected by the transition from BMPs to RMZs. Forest industry experiences a 176 percent increase, from 6,700 to 18,500 acres, in the amount of timberland acreage subject to residual basal area recommendations. The statewide increase is 90 percent, from 514,700 acres to 980,100 acres.

Certain forest types are more common in BMP and RMZ zones than others (table IV.7.) Aspen-birch and lowland hardwood account for more than half of the timberland estimated to be in BMP and RMZ zones. Roughly 2.9 percent of the aspen-birch timberland falls within a BMP, and would increase to 5.2 percent within RMZ zones.

Table IV.4. Summary of timberland area and growing stock volume in BMPs, RMZs, and RMZs reduced buffer zones, 1990.

Water body type	BMPs[A]			RMZs[B]			RMZs reduced buffers[C]		
	Buffer width (feet)	Estimated timberland area within buffers (1000s acres)	Estimated growing stock volume within buffers (1000s cords)	Buffer width (feet)	Estimated timberland area within buffers (1000s acres)	Estimated growing stock volume within buffers (1000s cords)	Buffer width (feet)	Estimated timberland area within buffers (1000s acres)	Estimated growing stock volume within buffers (1000s cords)
Lakes and open water wetlands									
At least 10 acres in size	50	243	3,060	150	473	6,130	100	358	4,610
2.5 to 10 acres in size[D]	50	30	380	75	43	590	75	43	590
Less than 2.5 acres in size[D]	50	59	690	0	0	0	0	0	0
1 to 10 acres in size[E]	50	46	570	150	94	1,190	100	74	890
Less than 1 acre in size[E]	50	40	550	0	0	0	0	0	0
Designated trout lakes	100	0[F]	0[F]	150	0[F]	0[F]	100	0[F]	0[F]
Intermittent streams	0[G]	0	0	100[H]	181	2,210	75[I]	138	1,690
Perennial streams	50[G]	96	960	100[H]	189	1,940	75[I]	140	1,440
Totals		515	6,220		980	12,050		754	9,220

[A] Protecting Water Quality and Wetlands in Forest Management: Best Management Practices in Minnesota (1995).
[B] Proposed Riparian Management Zone Guidelines.
[C] The following variations of Proposed Riparian Management Zone Guidelines were made in modeling reduced buffers - 150 feet buffers were reduced to 100 feet buffers and 100 feet buffers were reduced to 75 feet.
[D] Counties with greater than 80% of their presettlement wetlands intact: Crow Wing, Kanabec, Lake of the Woods, Mille Lacs, Aitkin, Cass, Pine, Carlton, St. Louis, Beltrami, Itasca, Lake, Koochiching, Hubbard, Clearwater, Isanti, and Cook counties (Minnesota Wetlands Conservation Plan 1997, Figure 5).
[E] Counties with 80% or less of their presettlement wetlands intact: those counties not listed in [D] (Minnesota Wetlands Conservation Plan 1997, Figure 5).
[F] Seven FIA plots were within 100 feet of designated trout lakes, of which none were timberland. Nine FIA plots were within 150 feet of designated trout lakes, of which none were timberland.
[G] All perennial streams types were modeled at an estimated aggregate buffer width of 50 feet and all intermittent stream types were modeled at an estimated aggregate buffer width of 0 feet.
[H] All stream types were modeled at an estimated aggregate buffer width of 100 feet.
[I] All stream types were modeled at an estimated aggregate buffer width of 75 feet.

Table IV.5. Estimated impacts of BMPs, RMZs, and RMZs reduced buffers by regional landscape, 1990.

Regional landscape	Timberland area (1000s of acres)				Growing stock volume (1000s of cords)			
	State	BMPs[A]	RMZs[B]	RMZ – reduced buffers[C]	State	BMPs[A]	RMZs[B]	RMZ – reduced buffers[C]
Northeast	3,050.8	41.7	97.3	71.8	38,751.3	373.9	1,235.5	918.9
Northern	3,429.2	43.6	112.2	86.5	39,151.9	461.0	1,338.0	1,023.3
West Central	584.5	96.8	120.5	104.9	8,158.0	1,452.8	1,647.4	1,421.9
North Central	4,839.6	155.9	261.7	188.4	68,532.7	2,154.0	3,738.2	2,689.7
East Central	1,826.6	104.9	206.2	153.9	22,954.1	1,050.1	1,956.1	1,476.2
Southeast	719.3	40.6	126.7	99.6	10,536.4	373.0	1,511.4	1,150.3
Metro	30.2	7.3	10.2	10.2	402.3	71.8	96.8	96.8
Prairie	243.0	23.9	45.3	38.2	3,245.2	278.5	530.1	446.9
Total	14,723.2	514.7	980.1	753.5	191,731.9	6,215.0	12,053.5	9,223.9

Cells may not sum due to rounding.
[A] Protecting Water Quality and Wetlands in Forest Management: Best Management Practices in Minnesota (1995).
[B] Proposed Riparian Management Zone Guidelines.
[C] The following variations of Proposed Riparian Management Zone Guidelines were made in modeling reduced buffers - 150 feet buffers were reduced to 100 feet buffers and 100 feet buffers were reduced to 75 feet.

Table IV.6. Estimated impacts of BMPs, RMZs, and RMZs reduced buffers by owner, 1990.

Owner	Timberland area (1000s of acres)				Growing stock volume (1000s of cords)			
	State	BMPs[A]	RMZs[B]	RMZ – reduced buffers[C]	State	BMPs[A]	RMZs[B]	RMZ – reduced buffers[C]
County	2,502.7	62.4	104.6	72.1	34,610.1	997.3	1,658.1	1,161.1
State	3,062.5	70.1	138.7	105.9	34,387.1	750.4	1,474.2	1,237.8
Federal	2,018.8	51.5	86.4	65.0	29,657.7	559.8	1,244.7	902.0
NIPF and American Indian	6,387.9	324.0	631.9	497.3	84,574.6	3,808.7	7,404.3	5,752.2
Forest industry	751.3	6.7	18.5	13.2	8,502.6	98.8	272.1	170.8
Total	14,723.2	514.7	980.1	753.5	191,731.9	6,215.0	12,053.5	9,223.9

Cells may not sum due to rounding.
[A] Protecting Water Quality and Wetlands in Forest Management: Best Management Practices in Minnesota (1995).
[B] Proposed Riparian Management Zone Guidelines.
[C] The following variations of Proposed Riparian Management Zone Guidelines were made in modeling reduced buffers - 150 feet buffers were reduced to 100 feet buffers and 100 feet buffers were reduced to 75 feet.

Table IV.7. Estimated impacts of BMPs, RMZs, and RMZs reduced buffers by forest type, 1990.

Forest type	Timberland area (1000s of acres)				Growing stock volume (1000s of cords)			
	State	BMPs[A]	RMZs[B]	RMZ – reduced buffers[C]	State	BMPs[A]	RMZs[B]	RMZ – reduced buffers[C]
Jack pine	452.1	4.1	5.6	2.5	6,772.2	52.8	95.3	28.6
Red-white pine	445.0	10.7	21.5	16.6	8,371.9	168.6	347.3	279.5
Lowland conifer	2,918.2	34.2	69.5	50.5	25,733.8	221.9	553.5	387.1
Upland conifer	637.3	12.9	24.2	21.2	9,491.1	204.2	385.1	354.0
Oak-hickory	1,166.2	79.0	158.6	117.5	17,873.0	1,196.9	2,208.6	1,667.9
Lowland hardwood	1,289.9	114.0	210.6	173.4	15,013.1	1,093.2	2,174.1	1,760.5
Northern hardwood	1,393.1	69.8	147.8	119.9	22,118.9	987.0	2,075.9	1,652.1
Aspen-birch	6,317.2	182.2	327.8	240.9	86,314.7	2,287.5	4,203.8	3,088.5
Nonstocked	104.2	7.8	14.5	11.0	43.1	2.9	9.9	5.7
Total	14,723.2	514.7	980.1	753.5	191,731.9	6,215.0	12,053.5	9,223.9

Cells may not sum due to rounding.

[A] Protecting Water Quality and Wetlands in Forest Management: Best Management Practices in Minnesota (1995).

[B] Proposed Riparian Management Zone Guidelines.

[C] The following variations of Proposed Riparian Management Zone Guidelines were made in modeling reduced buffers - 150 feet buffers were reduced to 100 feet buffers and 100 feet buffers were reduced to 75 feet.

3. Impacts of residual basal area recommendations

There are two components of the riparian guidelines. The first component is a buffer around water bodies. The second component is a recommended residual basal area minimum within buffers. Both BMPs and RMZs recommend that residual basal area be left on site following harvest. Comparing BMPs to RMZs for even-age forests, the recommended residual basal area increases from 25 to 60 square feet per acre. For uneven-age forests, the recommended residual basal area increases from 40 to 80 square feet per acre. A strict interpretation of the proposed guidelines (assuming no harvest activity where minimum basal areas are not met) would suggest that the residual basal area recommendations have the net effect of temporarily setting aside timberland acreage from harvest. Under the BMPs, 0.7 percent of the total statewide timberland area is temporarily set aside. Under the RMZs, that percentage rises to 3.1 percent, more than a four-fold increase. The RMZs reduced buffers exhibit percentages between the BMP and RMZ scenarios.

Table. IV.8. Estimated amount of timberland that exceeds residual basal area recommendations adjacent to water. Areas are in acres, 1990. Numbers in parentheses are percentages of statewide timberland area.

	Timberland area within buffer zones		
Guideline	Stands with current basal area below recommended residual basal area	Stands with current basal area above recommended residual basal area	Total area
BMPs (25, 40)	100,400 (0.7)	414,300 (2.8)	514,700 (3.5)
RMZs (60, 80)	458,200 (3.1)	521,900 (3.5)	980,100 (6.7)
RMZs (25, 40)	170,900 (1.2)	809,200 (5.5)	980,100 (6.7)
RMZs reduced buffer (60, 80)	358,800 (2.4)	395,500 (2.7)	753,500 (5.1)
RMZs reduced buffer (25, 40)	133,800 (0.9)	619,700 (4.2)	753,500 (5.1)

Acreage temporarily set aside often contains stands in the early stages of development that are not ready for harvest. A more accurate assessment of the impacts of BMPs and RMZs is made by comparing the growing stock volume in areas temporarily set aside from harvest. Growing stock volume is influenced by the amount of acreage and age of the stands within buffers, as well as a host of other factors. Again assuming no harvest activity where minimum basal area is not met, growing stock volume in BMP temporary set asides is 0.1 percent of the statewide total. At 1.3 percent of the statewide growing stock total, RMZs represent a 13 fold increase in the amount of growing stock volume within temporary set asides. The RMZ reduced buffers and lower residual basal area recommendations represent a compromise between the BMP and RMZ numbers.

Table. IV.9. Estimated amount of growing stock adjacent to water. Growing stock volumes are in thousands of cords, 1990. Numbers in parentheses are percentages of statewide growing stock volume.

	Growing stock volume within buffer zones		
Guideline	Stands with present basal area below recommended residual basal area	Stands with present basal area above recommended residual basal area	Total volume
BMPs (25, 40)	194.8 (0.1)	6,020.2 (3.1)	6,215.0 (3.2)
RMZs (60, 80)	2,573.2 (1.3)	9,480.3 (4.9)	12,053.5 (6.3)
RMZs (25, 40)	319.8 (0.2)	11,733.7 (6.1)	12,053.5 (6.3)
RMZs reduced buffer (60, 80)	2,028.9 (1.1)	7,195.2 (3.8)	9,224.1 (4.8)
RMZs reduced buffer (25, 40)	247.7 (0.1)	8,976.4 (4.7)	9,224.1 (4.8)

4. Harvesting patterns near water

The RMZ guidelines could have unanticipated negative impacts on acreage and volume available for harvest if landowners treat the RMZs as no-cut zones. Such a scenario would have the effect of setting aside 1 out of every 15 acres of timberland. Sixteen of the 165 harvesting sites observed in the aerial photo sample had at least a part of their harvest area within 50 feet of a stream, lake or open water wetland, thus suggesting recommended buffers are not treated as no cut zones (Table IV.10.) Had a substantial number of harvests started 50 to 100 feet from water and relatively few below 50 feet, then one might conclude that the BMPs buffers were being applied as if they were no-cut zones. The possibility that harvesting on timberland adjacent to water has been reduced, but not eliminated, still exists.

Table IV.10. Observed distance between harvests and nearest water body for a sample of 165 clearcut and partial harvests in northern Minnesota. Numbers in parentheses are percentages are of row totals.

	Distance between harvest area and nearest water body					Total
	50 feet or less	51 to 100 feet	101 to 150 feet	151 to 200 feet	More than 200 feet	
Number of sites	16 (9.7)	5 (3.0)	5 (3.0)	6 (3.6)	133 (80.6)	165
Harvest area (acres)	492 (10.1)	215 (4.4)	141 (2.9)	141 (2.9)	3,867 (79.6)	4,856

B. Wildlife

For 1996, an estimated 192,500 acres were harvested (Table IV.11). Clearcutting was the dominant silvicultural system, accounting for 85 percent of the total area harvested. Due to the widespread application of the clearcutting regeneration method, leave tree guidelines have the potential to influence the habitat suitability of a large percentage of Minnesota's harvested timberland.

Table IV.11. Estimated extent of area harvested by silvicultural system for the state, 1996.

Silvicultural system	Estimated extent Acres	Estimated extent % of total
Clearcuts greater than 5 acres	163,955	85.2
Patch clearcut	1,400	0.7
Strip clearcut	454	0.2
Seed tree cut	2,629	1.4
Shelterwood	1,529	0.8
Selective logging	1,981	1.0
Thinning	20,555	10.6
Total	192,514	

Source: Puettmann et al. 1998.

The impacts of the leave tree guidelines will be different depending on ownership. Puettmann et al. reported that 76.5 percent of the area reported as clearcut in 1996 had residuals (Table IV.12). Federal land ownerships had the highest percentage of clearcuts with residual trees at 95% of clearcut area. Industry lands showed the lowest percentage at 34.3%.

Table IV.12. Extent of clearcutting with residuals by owner group, 1996.

Owner	Reported[A] amount of clearcuts greater than 5 acres		
	Total (acres)	With residuals (acres)	With residuals (%)
State	34,388	27,170	79.0
County	23,386	19,490	83.3
Federal	12,727	12,090	95.0
Industry	9,539	3,276	34.3
American Indian	4,527	2,709	59.8
Total	84,567[B]	64,735	76.5

Source: Puettmann et al. 1998.

[A] Survey respondents represented 100 percent of state, county, and federal land. Industrial and American Indian representation was 50 and 86 percent. NIPFs were not surveyed.

[B] The 84,567 total in this table differs from that in table IV.11. This reflects the discrepancy in clearcut acreage reported in surveys from Puettmann et al. (1998) and the clearcut acreage estimated for the entire state (163,955 acres).

An aerial photo sample confirmed that residuals commonly exist on clearcuts in northern Minnesota (Table IV.13.) A total of 111 clearcuts were sampled covering 3,017 acres for an average clearcut size of 27 acres. Seventy-seven percent of the sites and 85 percent of the observed clearcut acreage had residual trees. These numbers compare favorably with those reported in Puettmann et al. (1998).

Table IV.13. The occurrence of residuals in recent clearcuts. Numbers in parentheses are percentages of column totals.

	Number of sites	Acres
Clearcuts without residuals	27(24.3)	473(15.7)
Clearcut with residuals	84(75.7)	2544(84.3)
Total	111	3017

Scattering of residual trees was more common than clustering (Table IV.14.) The wildlife guidelines recommend clustering, however scattering is acceptable. Crown cover class is the area of the harvest covered with residual tree crowns. When crowns are relatively small, as in several species common in northern Minnesota, then the crown cover class gives a pretty good indication of the area of leave trees. It appears unlikely that the area of residuals in clearcuts with residuals averages more than 5 percent.

Table IV.14. Residual crown cover class and distribution pattern for 84 clearcuts with residuals.

	Residual crown cover class acres (number of sites)				All crown cover classes
Residual pattern	5%	10%	15%	> 20%	
Scattered individuals	1,251 (49)	53 (4)	108 (3)	109 (4)	1,521 (60)
Clustered	309 (9)	64 (1)	377 (5)	91 (5)	841 (20)
Inclusions of 1 to 3 acres	182 (4)	0 (0)	0 (0)	0 (0)	182 (4)
Total	1,742 (62)	117 (5)	485 (8)	200 (9)	2,544 (84)

Respondents of a silvicultural survey reported that the average number of residual trees left was 14 trees per acre (Puettmann et al.). A query of FIA plots in the aspen forest type between the ages of 40 and 60 found that, on average, there were 450 live trees per acre. Therefore, one might expect to see 23 trees per acre if the area of residual trees in clearcuts with residuals covered 5% of the harvest area. While residuals are being left on a regular basis, most likely leave tree guidelines will represent an increase in the number of trees that need to be left.

A reasonable estimate appears to be that current operational practice is such that 3 percent of the area clearcut with residuals could be classified as leave trees. Factoring in the 38,600 acres of clearcuts without residuals suggests that for every 100 acres clearcut in 1996 there were 2.3 acres of residual trees (table IV.15).

Table IV.15. Estimated area that meets leave tree specifications for 1996 clearcuts.

	Area harvested	Estimated area that qualifies as leave trees	
	(acres)	(acres)	(%)
Clearcut with residuals	125,400	3,760[A]	3.0
Clearcut without residuals	38,600	0	0.0
Total	164,000	3,760	2.3

[A] Assumes 3 percent of the area reported as clearcut with residuals in Puettmann et al. meets leave tree guidelines specifications.

Additional trees left on the stump needed to meet the 5% leave tree guidelines resulted in a harvest reduction of 88,000 cords (table IV.16.) This assumes harvesting patterns at the time of guideline implementation are similar to that observed in 1996. An additional 4,700 acres would have to be harvested to keep volume production at the level estimated in 1996.

Table IV.16. Estimated reduction in volume harvested attributed to leave tree guideline implementation.

	Area clearcut[A]	Area of leave trees	Volume harvested[B]	Volume in residuals[C]
	(acres)	(acres)	(cords)	(cords)
1996	164,000	3,760	3,173,000	74,400
Simulation	164,000	8,200	3,085,000	162,400

[A] Puettmann et al. (1998)

[B] Volume harvested was calculated as (area clearcut – area of leave trees) * 19.8 cords/acre.

[C] Volume in residuals was calculated as (area of leave trees) * 19.8 cords/acre.

The effects of seasonal pond guidelines could not be assessed (see the wildlife methods section). It should be noted that considerable overlap between leave tree guidelines and seasonal pond guidelines exist. Residual basal area on and around seasonal ponds could double for leave tree areas.

C. Historical and Cultural Resources

Total estimated timberland area in Minnesota with archaeological sites and cemeteries ranged from 124,000 (table IV.17.) to 239,000 acres (table IV.18). The North Central regional landscape had the most timberland acreage with archaeological resources and cemeteries. The Metro and Prairie have the least due to the relative scarcity of timberland in these regional landscapes. As a percentage of total timberland area, the Southeast regional landscape has the highest concentration of archaeological resources and cemeteries.

Effects of the historic and cultural resources guidelines will vary between the two categories used in the analysis. For sites in the second category – those archaeological sites not on federal or tribal lands – it is likely that the proposed site-level guidelines will represent a noticeable change in management. For example, the proposed guidelines will likely mean a substantial increase above and beyond current operational practice in the Southeast regional landscape. This is because little of the landbase in this region is under federal or tribal ownership.

Management of sites in the first category – archaeological sites on federal and tribal ownerships and all cemeteries – will not change significantly with the adoption of proposed site-level guidelines. Such sites are currently managed at a level greater than that being proposed. These account for approximately one

third of the timberland acreage with archaeological resources and cemeteries statewide. Over half of the timberland acreage with archaeological resources and cemeteries in the Northeast regional landscape is estimated to be currently managed at a level greater than proposed site-level historical and cultural guidelines.

Table IV.17. Estimated extent of archaeological sites and cemeteries on Minnesota's timberland, 1990: low scenario [A].

Regional landscape	Estimated site density[B] (#/1000 acres)	Estimated timberland area with archaeological sites and cemeteries: Timberland area (acres)	Area with category one sites [C] (%)	Area with category two sites [D] (%)	Growing stock volume [E] (1000s of cords)
Northeast	5	11,400	54	46	147
Northern	3	7,700	37	63	88
West Central	24	10,500	29	71	147
North Central	15	54,400	35	65	780
East Central	15	20,500	28	72	258
Southeast	32	17,300	27	73	244
Metro-Prairie	12	2,500	25	75	32
Total		124,400	34	66	1,696

[A] The low scenario assumed an average archaeological site and cemetery size of 0.75 acres.

[B] GEIS technical paper estimates of archaeological site and cemetery density by ecoregion.

[C] Archaeological sites on federal and tribal lands and all cemeteries regardless of ownership.

[D] Archaeological sites on ownerships other than tribal or federal lands.

[E] Product of timberland area with archaeological sites and cemeteries and regional average of growing stock volume.

Table IV.18. Estimated extent of archaeological sites and cemeteries on Minnesota's timberland, 1990: high scenario [A].

Regional landscape	Estimated site density[B] (#/1000 acres)	Estimated timberland area with archaeological sites and cemeteries: Timberland area (acres)	Area with category one sites [C] (%)	Area with category two sites [D] (%)	Growing stock volume [E] (1000s of cords)
Northeast	5	21,900	52	48	282
Northern	3	14,800	34	66	170
West Central	24	20,200	26	74	283
North Central	15	104,400	32	68	1,495
East Central	15	39,400	24	76	495
Southeast	32	33,100	24	76	468
Metro-Prairie	12	4,700	22	78	63
Total		238,500	31	69	3,256

[A] The high scenario assumed an average archaeological site size of 1.5 acres and cemetery size of 1.25 acres.

[B] GEIS technical paper estimates of archaeological site and cemetery density by ecoregion.

[C] Archaeological sites on federal and tribal lands and all cemeteries regardless of ownership.

[D] Archaeological sites on ownerships other than tribal or federal lands.

[E] Product of timberland area with archaeological sites and cemeteries and regional average of growing stock volume.

Certainly the numbers in the table suggest that historic and cultural resources guidelines could have a significant effect on acreage and volume available for harvest. When the existence of an archaeological resource is known, the landowner may elect to set the area aside from harvesting. Timberland acreage and growing stock volume available for harvest will then be decreased.

However, values reported represent a withdrawal of acreage for harvest only if several conditions hold. First, the estimated site density and average site size used in the model are accurate. Second, the location of these sites are known or can be easily determined. Third, landowners decide that it is undesirable to harvest in archaeological sites and treats these areas as no cut zones. Fourth, the bulk of harvesting occurs during summer months.

It seems quite unlikely that all these conditions will hold. Only a fraction of the estimated total archaeological sites have been observed and recorded. Locations of the vast majority of these sites are unknown and such sites lack readily observable surface features (Jaakko Pöyry 1992a). This greatly decreases the chance that cultural resource sites will be detected in the course of selected forest management activities. Unless sites are accidentally discovered, forest managers and loggers will unwittingly operate near and on archaeological resources. Furthermore, although the guidelines are fairly vague on this point, it appears that timber can be harvested within archaeological sites without sacrificing compliance as long as resources are not adversely impacted. Finally, a considerable proportion of harvesting occurs during winter months when ground is frozen. These conditions afford protection to certain cultural resources while still allowing harvesting to occur. Thus the impact of historic and guidelines on acreage and volume available for harvest will in all likelihood be small.

D. Cumulative Effects

The impacts identified in the individual guideline analysis will be tempered by the fact that there is considerable overlap in several of the guidelines. Thus, the previously reported impacts on individual resources (e.g. wildlife habitat) are not necessarily additive. Leave tree guidelines and historical/cultural guidelines can both be used to comply with the other. For example, typical clearcut sizes are around 30 acres. Five percent of the area, or 1.5 acres, will be in leave trees if the landowner/land manager/logger elects to implement wildlife guideline recommendations. Average sizes of cemeteries and archaeological sites are often less than 1.5 acres (see the historical/cultural effects section). One 1.5 acre leave tree area on the historical/cultural resource would be sufficient to meet both the leave tree and historical/cultural recommendations. Many archaeological sites are expected to occur within 1000 feet of past and present water features (Jaako Pöyry 1992a). In these cases, residual basal area within an RMZ can be placed on top of historical/cultural resources.

As reported in the riparian section, 84 percent of the harvests observed in the air photo survey were more than 200 feet away from a water source. Sixteen percent of the harvests had at least a portion of their area within 200 feet of water. In these cases, residual basal area left within RMZs could also be used to satisfy the leave tree guidelines.

V. POTENTIAL COST EFFECTS

A. Overview of cost effects

For many landowners, implementing guidelines will require changes in the way that forests are managed and harvests are conducted. Guidelines will also affect the operations of timber harvesters, stumpage prices and timber supply available to industry, and long-term stand management decisions such as the choice of silvicultural system, regeneration and intermediate cultural treatments, and road access. While we can not put a single dollar figure on the costs, this section reviews the financial and economic effects we consider to be significant.

1. Types of costs

Guidelines will induce both financial costs and broader economic effects for those who own and manage land and those who use timber. Financial costs are funds paid to apply guidelines. Broader economic effects influence operations or markets. The financial costs include:

- costs paid by landowners for the additional professional forestry skills needed to plan and conduct management activities and timber sales that meet proposed guideline recommendations;
- fixed costs paid by land management agencies and firms to incorporate the proposed guidelines into organizational procedures and train their staff;
- costs for applying recommended guideline practices on-the-ground;
- increased operational costs for timber harvesters to comply with guidelines. Increased costs will reduce profits if loggers can not pass costs on to landowners or secure higher prices for delivered wood; and
- increased raw material costs paid by mills for delivered timber;

Broader economic effects include:

- foregone timber growth and revenues from trees left uncut on the site to comply with leave-tree guidelines, or extended rotation management;
- potential stumpage price increases due to higher production costs and some constraints on supply; and
- effects on profitability and operational costs in the logging and wood processing sectors, including the economic supply of stumpage.

2. Who pays the costs?

Financial costs for implementation of proposed guidelines have to be paid by someone. For forest managers, just as for any production process, part of increased costs may be extracted from suppliers, part are paid by producers, and part are passed on to consumers. The extent to which forest managers, loggers or mills can avoid or pass along costs depends largely on the supply of and demand for the goods and services they use and the markets for their products.

To manage land and implement guidelines, landowners need to purchase materials and services from silvicultural vendors and foresters. Management practices and services are performed by agency or

company employees, by contractors, or in some cases, by public agency foresters for nonindustrial private (NIPF) landowners. It is not likely that landowners can pass along costs through lower payments to employees or contractors in the way of lower earnings. Costs for expanded services to NIPF landowners by public agencies or landowner assistance programs sponsored by industry, if provided to increase guideline use, would be paid by the public or private sponsoring organization.

Landowners also sell timber to loggers and forest products firms. They may require loggers (in harvest contracts) to perform practices during harvesting operations that meet guideline specifications. In this case, landowners are price takers and at the mercy of competitive stumpage markets and may be able to sell timber without a discount even though they require additional services (i.e. implement guidelines) from loggers.

Loggers have few opportunities to pass on increased costs to their suppliers (landowners who sell stumpage) or their customers (mills who buy delivered logs). Timber harvesters buy and process timber and sell delivered logs or operate under contract for forest products companies. Puettmann et al. (1998) reported on a survey of 390 timber harvesters throughout the state and found that six out of ten operators buy stumpage and the rest cut wood under contract for others suggesting that Minnesota has a very competitive logging industry dominated by small firms. Most producers in such industries earn slim profit margins and operate where average costs are close to average revenues. Also, they operate in a business environment with relatively few log buyers for their output and also many very large (mostly public) landowners who sell timber. Because of the high degree of competition in the logging industry and the high concentration in product markets, few operators can pass along much of their cost increases to either landowners as lower stumpage prices or perhaps even to timber buyers as higher log prices. If profits are so small that enough loggers can not remain in business, then the reduced supply of timber delivered by fewer loggers will eventually result in higher delivered log prices paid by forest industry.

Ultimately, costs for delivered timber used as raw materials are likely to increase for mills. Determining the potential magnitude of this effect would require a detailed model of stumpage supply and demand. Such a model is not available at this time. Prices have steadily increased faster than inflation (see Appendix E) and voluntary guidelines, if applied widely, may add some upward pressure to prices.

Costs for large public agencies (federal, state and county) are likely to increase and would be paid for by tax revenues or reduced proceeds from timber sale operations. Limited agency budgets from appropriated dollars could constrain the number of acres harvested or the extent of guideline application. In cases where agencies are funded from timber revenues, any costs of guidelines result in lower proceeds flowing to the treasury.

3. Harvesting rates

Puettmann et al. (1998) report that almost 200,000 acres are harvested each year. We used this figure as an expander for estimating some costs. Estimates of the amount of harvesting activity that occurs in different forest types and in riparian zones are needed to estimate annual costs of applying guidelines. These are presented in Appendix E. This evidence indicates that timberland in riparian buffers were harvested over the last inventory cycle, but at a rate that is no more and likely to be less than other timberlands. We estimate that 4.0 to 5.3 percent of all acres harvested over the past survey cycle fell within a RMZ buffer and that 6.7 percent of all timberland occurs within a RMZ.

Some increase in riparian zone harvesting activity may occur if the statewide level of timber removals expanded due to guidelines, although we have no basis to estimate the magnitude of this potential effect. A report on water quality and fisheries for the Minnesota GEIS (Jaakko Pöyry 1992b) projected substantial increases for harvesting in riparian areas over time and in the case of increased harvest levels. If guidelines applicable to RMZs are perceived as overly restrictive or costly, timber availability from other areas is not reduced, and timber removals do not increase, then harvesting rates may remain static within riparian buffers.

B. Effects by sector

1. Direct landowner costs

For landowners, the direct costs of implementing guidelines fall into several categories. Direct costs are associated with adopting and applying guidelines on the ground. These include fixed costs – those initial or constant costs required to apply guidelines that do not vary by the number of acres affected. Fixed costs are those that involve incorporating guidelines into the organizational decision process like training employees and modifying organizational procedures. Variable costs are those that are paid each time guidelines are applied and vary according to the total area harvested or managed.

For large land management organizations, fixed costs will accrue because of the need to change organizational policies, procedures, and culture, provide training in guideline application, and adjust staffing to meet added needs for professional expertise.

Professional forestry labor inputs: Guidelines suggest that more complex forest management judgments and decisions are needed and implementation will likely increase the labor intensity of forest management. In our opinion, forest management organizations will need additional professional forestry staffing to meet the increased need for resource planning on managed lands. We expect that the number of acres that can be adequately managed by a forester will decline, especially in the short-term while new guideline procedures are assimilated within the organization. We know of no studies that document the professional forestry labor inputs for management under different levels, so have no basis for estimating the potential magnitude, if any, of this effect.

Management and harvest planning: The proposed forest management guidelines are complex and require professional expertise for application in most cases. This is especially true for planning harvesting operations. The effect will be negligible for organizations that already have comprehensive programs similar to the proposed guidelines and have access to the full range of expertise needed to apply the guidelines. Guideline implementation will be a substantial challenge for landowners without access to adequate professional forestry assistance.

Guideline implementation for nonindustrial private forest landowners could be problematic if their access to technical assistance is limited. Less than 30% of nonindustrial private forest landowners received professional forestry assistance of any kind and only 14% had a written management plan (Cervantes and Baughman 1998). In most cases, access to the professional assistance necessary to plan management and harvests to meet guideline specifications is limited. Furthermore, only 21% of respondents indicated that they were willing to pay for technical assistance and the average was $2.58 per acre.

We surveyed forest managers to collect information on current costs for forest management practices and recommended rotation ages. The Minnesota Forest Resources Partnership and the Minnesota DNR helped identify and distribute the survey to potential respondents . We received 12 responses from forest managers responsible for state, county, federal, and forest industry lands. In general, responding individuals were in large organizations responsible for management of large areas of public or private forests.

We asked respondents to supply their best cost estimates for site preparation, regeneration, and stand cultural treatments, management and planning costs, and costs for harvest planning and follow-up. Some respondents had access to detailed treatment records and provided precise cost estimates. Others provided their best estimate of typical costs for their organization. We received a range of cost estimates for each treatment or activity. Responses for individual items were closely grouped for some standard and consistent treatments such as chemical site preparation. For others, responses showed greater variability.

Information provided by forest managers who responded provides a useful picture of the costs for managing timberland as shown in Appendix E. Respondents generally did not have experience with application of the proposed guidelines but did express concern over their cost. Several cost estimates that address harvest planning provide insights. Timber cruising and marking was least costly for clearcuts at $12 per acre. Adding additional efforts for marking with leave trees added $2 per acre to costs, about a 16 percent increase. Going from clearcut marking to selection marking moved costs per acre to $19 to $20 per acre. Other costs for practices suggested by guidelines included establishing wildlife food plots ($152/acre) and underplanting conifers ($158/acre).

We asked about harvest planning with and without the proposed guidelines. Responses on this estimate varied greatly from $20 per site to $3,800 per site for the most costly. The average difference, $300 per harvest site, was about $10 to $12 per acre for the average harvest tract size of 25 to 30 acres. In our estimation, this is a reasonable estimate of the added costs for full implementation of the proposed guidelines. As a check, we compare this with the typical range for consulting forestry fees found in the region for conducting timber sales, roughly 7% to 15% of gross sale revenues. This rate, about $21 to $45 per acre, for a typical sale of 20 cords per acre at a market price of $15/cord would provide professional services that include sale activities over and above guideline compliance.

If the additional cost of planning and conducting timber sales were applied to the approximately 200,000 acres harvested each year, total costs would be about $2 to $2.4 million annually. Costs for implementing the proposed guidelines, over and above the current level of use, would likely be much less since many landowners already use some guideline practices or can adapt them in planning harvests without significant increases in staffing or costs. Because at least half of the annual harvest acres already receive some professional timber sale planning (all except most nonindustrial private lands), the cost of implementing guidelines in timber sale planning is estimated to be as high as $1 to $1.2 million each year. This cost does not include direct costs for specific improvements or management activities.

2. Opportunity costs

Opportunity costs, another type of landowner effect, represent the economic value of resources that must be given up to implement guidelines. These include foregone or delayed revenues from leaving trees uncut on the site and reductions in the average growth from using extended rotations on some acres. Opportunity costs reflect profits that could be had if funds needed for guideline implementation were used in some other, and more profitable, way.

Effects on long-term timber management profitability: Guidelines will change the overall profitability of forest management investments for timber production because initial costs are higher, timber yields are lower, or stumpage prices are changed. If guideline practices were financially profitable treatments, then landowners would already apply them as voluntary investments. Although soil productivity guidelines directly affect potential timber growth rates, many recommended practices add costs that do not affect timber productivity or may increase rotations beyond the financial optimum.

Delayed harvest: Some guidelines recommend that trees should be left uncut during harvests in legacy patches, residual trees in clearcuts, or as some minimum residual basal area in riparian management zones. These restrictions do not permanently reserve these trees from harvest, but do affect the timing of their harvest. Taken as a whole, these guidelines create patches of older forests that some landowners would not prefer. In most cases, the residual trees may be unavailable until the next harvest in several decades and some may be lost to natural causes in the interim period. The effect on landowners is to delay or forego income they would have received from these trees when they harvest. Elsewhere in this report, we estimate that the volume in leave trees would amount to about 88,000 cords and would induce additional harvesting on 4,700 acres to maintain a constant flow of wood. At $15 per cord, this amounts to delayed or forgone earnings on about $1.3 million dollars that would be received if leave trees were harvested.

For large landowners with regulated forests, the temporary reservation of some trees on some timber harvests will disrupt the volume of wood flows and may require more extensive harvesting to maintain a constant dollar return or wood production level.

For small nonindustrial private landowners, the effect will be different. Landowners would, on average, receive less money for their timber because the volume produced from a timber sale may be lower to meet leave-tree guidelines than if trees were not left on the site. While this will not affect all sales, volume may be reduced by as much as 5 percent on the harvests where leave tree guidelines are applicable. In a few cases, this may present a financial hardship but could be offset in some cases by expanding the sale area to obtain the desired wood volume.

3. Effects of extended rotations

Some guidelines call for extended rotations (for leave trees, patches or in riparian zones) that would reduce timber productivity because harvests are delayed beyond the age where mean annual increment is maximized. To gauge the extent of this potential effect, we used the Chapman-Richards growth and yield model[4] to simulate yields for timber and extended rotation length scenarios for each forest type and for high, medium, and low site productivity classes. For some types, such as aspen, the extended rotation was 10 to 20 years longer than the timber rotation. For other types, such as red and white pine, the extended rotations were up to 85 years longer. Rotations for both scenarios were generally shorter on high productivity sites than on low sites. We calculated and compared the mean annual increment at the rotation age. Our goal was to estimate the average annual growth difference for growing stock timber due to lengthened rotations.

We estimate that extended rotations would decrease annual timber productivity by an average of 3.6 cubic feet per acre, if all acres were managed on extended rotations. Results depend on the specific rotation ages selected and vary markedly by forest type and site productivity class as shown in Table A.

Average growth was reduced by 3% to 35%, depending on forest type. An exception is jack pine where average productivity for slightly longer rotations is about 3% higher. For aspen, the most common forest type, mean annual increment declined by 3 to 5 percent when rotations were lengthened by 10 to 20 years. We were not able to estimate possible shifts in the species mix that might also result from lengthened rotations, especially in early successional forest types. The oak-hickory forest type showed the greatest declines in productivity, about 35%, for rotations that were 60 to 75 years longer.

A substantial reduction, about 29% appears likely for red and white pine stands on high sites managed on rotations that are nearly double timber rotation lengths. Shorter timber rotations of these forests are much more likely to be managed intensively for timber or as plantations. Substantially longer rotations will produce higher proportions of sawtimber but wider tree spacing and lower stocking would result in lower overall volume growth.

Although some public ownerships may manage a significant proportion of their lands on extended rotations, guidelines calling for longer rotations are most likely to apply to about 5 to 7 % of timberlands located in riparian areas, and areas where leave trees are retained, such as legacy patches. Based on this 5 to 7 % area and an average reduction of 3.6 cubic feet per acre per year on affected acres, we estimate that the potential annual reduction in timber growth amounts to about 0.6 % to 0.8 % of total current timber growth for the state. If extended rotations were applied on all timberland acres, growth

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[4] The Chapman-Richards model is a non-linear empirical basal area growth model calibrated and used by the Minnesota DNR for inventory updates. Basal area growth depends on forest type, site index, and stand age. Yields are estimated with a second set of equations as roundwood in cords. The model was supplied by Dr. Chung M. Chen, Minnesota DNR.

reduction would amount to approximately 52.6 million cubic feet annually, or about 12% less than current growth.

Table V.1. Average rotation ages, mean annual increments, and differences, for timber and extended rotations by forest type.

Forest Type	Rotation	Low Sites	Medium Sites	High Sites	Low Sites	Medium Sites	High Sites
			Rotation Age (years)			Mean Annual Increment (cubic feet/acre/year)	
Aspen-birch	Timber	55	50	50	25	38	50
	Extended	65	65	70	24	37	48
	Difference	10	15	20	97%	97%	95%
Jack pine	Timber	50	50	50	32	43	53
	Extended	75	70	65	33	44	54
	Difference	25	20	15	105%	103%	103%
Lowland conifer	Timber	90	80	75	15	28	44
	Extended	120	100	80	13	25	43
	Difference	30	20	5	85%	90%	98%
Lowland hardwood	Timber	80	80	80	21	32	39
	Extended	130	120	120	17	27	32
	Difference	50	40	40	80%	84%	82%
Northern hardwood	Timber	80	90	90	28	31	34
	Extended	150	130	130	19	24	26
	Difference	70	40	40	66%	77%	76%
Oak-hickory	Timber	95	80	65	19	31	41
	Extended	170	140	125	12	21	27
	Difference	75	60	60	64%	67%	65%
Red-white pine	Timber	100	95	95	34	50	65
	Extended	130	150	180	33	41	46
	Difference	30	55	85	95%	83%	71%
Upland conifer	Timber	65	60	55	31	35	43
	Extended	95	90	80	26	30	38
	Difference	30	30	25	83%	84%	88%

Site classes were based on potential timber productivity. High sites were capable of producing 85+ cubic feet per acre per year; medium sites 50 to 84 cubic feet per acre per year; and low sites 20 to 49 cubic feet per acre per year. Average site index used in the analysis varied by forest type and was based on mean values from forest inventory records.

C. Effects by landowner group

We contacted major forest management organizations in Minnesota to learn how their current management practices matched with the proposed guidelines. The results of this are presented elsewhere in this report. We found that inadequate information was available to document the current level of management with respect to the guidelines for most organizations. Nevertheless, we are able to provide some insights to compare effects by landowner groups.

Landowners will undoubtedly incur direct financial costs associated with guideline implementation. On an annual basis, most of these direct effects will be limited to the approximately 200,000 acres of timberland

harvested each year. The proportion of the annual harvest that occurred in different forest types for major landowners during 1977 to 1990 was estimated from past harvesting patterns identified in the forest inventory plots and is shown in Table V.2. below. Although current proportions may vary from this historical average, these proportions provide an initial basis for comparing effects. Financial effects are assumed to be proportional to the area harvested or managed each year and the extent to which each landowner group already uses management practices that comply with the intent of the guidelines. We could not estimate the proportion of harvested timberlands where guidelines are already applied at the time of harvest.

Table V.2. Percentage distribution of acres harvested by owner and forest type

Forest Type	County	Federal	Forest industry	NIPF & Indian	State	All Owners
			Percent of harvested acres			
Aspen-birch	16.3	5.5	8.1	20.6	11.8	62.3
Jack pine	0.8	0.5	0.3	0.6	1.1	3.4
Lowland conifer	0.6	1.1	0.6	2.7	4.6	9.4
Lowland hardwood	0.4	0.1	1.3	2.2	1.3	5.4
Northern hardwood	0.9	0.4	1.1	4.5	0.6	7.5
Oak-hickory	0.1	0.1	0.0	2.0	0.3	2.5
Red-white pine	1.5	1.3	1.2	1.0	0.8	5.9
Upland conifer	1.0	0.4	0.5	0.5	0.9	3.2
Non-stocked	0.0	0.2	0.0	0.0	0.1	0.3
All types	21.5	9.7	13.2	34.2	21.4	100.0

Puettmann and others (1998) also provide estimates of the distribution of harvested acres among landowners for 1996, however, their sampling procedures did not include nonindustrial private lands.

Access to information needed to fully comply with historical and cultural guidelines is limited for most landowners. Only the USDA Forest Service and American Indian managers reported that they routinely surveyed management areas for cultural features. In most cases forestry staffs were not trained to specifically inventory and identify potential sites which may need special treatment. Increased access to these skills will be necessary for other owners.

1. National Forests

Based on past inventory data, the national forests harvest about one-tenth of the total area cut each year. Based on our review of current level of compliance with management practices similar to the guidelines, the national forests report that they generally follow guidelines that are similar to the proposed standards. Although there may be some differences between existing standards and the proposed guidelines, we do not expect significant cost effects for the national forests other than the cost to incorporate guidelines into current standards and practices.

2. State lands

Timber harvests on state lands account for about one-fifth of all area harvested each year. The Department of Natural Resources has an extensive organizational structure in place to manage their timberlands and have substantially supported guideline development as an organization. DNR land managers reported more variable application of management practices similar to the proposed guidelines. Some regions reported a high level of practices that match guidelines and others less so. As in any large organization, adopting the proposed guidelines would require change. Increased staffing of foresters would be needed in those regions where significant management changes are necessary and this may require additional personnel or reassignments to increase staffing available for on-the-ground harvest and management planning. Unless resources are shifted from some other activity, increased budgets would be needed for widespread application of guidelines in all regions.

3. County lands

Collectively, counties harvest a little more than one-fifth of the acres cut each year. Managers of county lands are closely tied to and serve local community interests. Our review of compliance showed that some counties already substantially use management practices similar to the guidelines and others would require substantial changes. County timberlands are substantial sources of revenues for county governments. Costs of guideline implementation could increase land management costs and may marginally reduce county revenues. A more direct comparison of county operations, in our estimation, would provide insights regarding the ability of county forest managers to apply guidelines in a cost-effective manner.

4. Forest Industry

Timber harvests on industry lands account for about 8 to 13 percent of the area of timberland harvested in Minnesota. Forest industry lands are, for the most part, now covered by the Sustainable Forestry Initiative (SFI) program. While this program establishes industry recognized forest management practices, they are not all the same as the proposed forest management guidelines. We did not compare SFI practices with proposed guidelines.

Forest products companies are primarily interested in wood supply and manage most timberlands for economically efficient timber production to meet mill requirements. In addition, forest products companies incur the costs of forest management on company lands and logging costs through contract loggers and costs of delivered wood.

Significant issues for the forest industry are the evolution of competing standards for forest management operations and economic limitations on the most cost-efficient timber production practices. Resolving conflicts between SFI standards and the proposed guidelines could be problematic and costly. Furthermore, any practices that increase land management costs but do not increase revenues can increase their raw material costs. If delivered wood prices increased, for example, by $1 per cord on all wood delivered to mills, the total annual impact could be as much as $3 million dollars a year for the 2.9 million cords of pulpwood used by pulp and composite panel companies each year. Production of sawlogs is much less in volume than pulpwood each year. Comparable cost increases for sawlogs could amount to as much as $0.8 million. Markets for solid wood products are much more volatile and the market impacts more difficult to estimate for this sector.

5. Nonindustrial private and American Indian lands

These owners harvest slightly more than one-third of the acres cut each year based on analysis of harvesting patterns over the past forest inventory cycle (1977 – 1990). Management objectives for these owners vary greatly and they generally recognize and support non-timber goals in their management objectives.

Nonindustrial private forest and American Indian landowners would incur significant costs for increased management and harvest planning necessary for guideline implementation. Only about one-fifth of NIPF landowners currently receive professional forestry advice on their lands. Although American Indian lands generally have professional managers, some increase in costs to obtain additional forester expertise may result with guideline implementation. Widespread application of guidelines would require a significant increase in the availability of technical assistance either through public or private sources.

D. Effects on timber harvesters

We surveyed timber producers to get a better understanding of their production costs and factors that affected their operations. Assistance was provided by the Minnesota Forest Resources Partnership for, the Minnesota Association of Contract Loggers, and the Minnesota Timber Producers Association. We received detailed responses from 21 producers who provided information on harvesting systems used,

minimum harvest volumes needed per acre for profitable operations, the range of production costs, road construction costs, variation in costs for operations on different owner groups and comments on factors affecting their operations.

We asked producers to report a range of production costs for common harvesting situations. Most respondents provided a high and low value to represent costs to produce wood at an on-site landing. Costs for hauling from the harvest site to a mill were excluded. Loggers reported a variety of logging systems including chainsaw, feller-buncher, and cut-to-length systems. We were not able to separate out costs for specific systems. Results are shown in Table V.3.

Producers also reported the minimum volume per acre needed for profitable operations. Average minimum volume per acre depended on harvesting conditions and the logging system, but generally fell into a range of 12 to 14 cords per acre for pulpwood and 7.5 thousand board feet (about 15 cords) per acre for sawtimber. The full range of reported minimum volume was 7 to 20 cords per acre.

Costs for producing pulpwood varied greatly. The overall range of production costs reported for pulpwood production was a low of $13 for aspen clearcuts to a high of $45 per cord for pulpwood clearcuts in lowland conifer stands. This wide range in costs represented the best to the worst in logging conditions.

We received most responses (21) for clearcutting in aspen, the most common logging situation in the state with an average cost of $24.63 per cord. Production of jack pine pulpwood drew only 2 responses and averaged $23.00 per cord. The most costly logging situation was clearcutting in lowland conifers with an average production cost of $34.00 per cord. Lowland conifer sites are more likely to be less accessible, wetter and more difficult to operate with generally smaller timber in comparison with aspen stands.

Partial cutting costs were somewhat more costly than aspen or jack pine clearcuts. Costs for partial cutting in mixed stands to produce pulpwood and leave crop trees were $29.60 per cord. Costs per cord for thinning in pine were $31.56. Respondents reported that harvesting mature sawtimber stands by partial cutting cost $58.23 per thousand board feet (Mbf). On a cord basis (roughly 2 cords per Mbf), this is comparable to partial cutting for pulpwood production.

These data provide insights into the potential costs associated with guideline compliance by loggers. Although we have no direct way to compare logging costs with and without guidelines, the difference between high and low cost logging situations is a good starting place for deriving a per cord cost. Differences in average production costs represent variations in forest type, site and timber conditions, as well as harvesting contract requirements that may differ by major ownership.

The low to high cost range reported for each of the logging situations was $5 to $7 per cord. This margin represents the average cost differential between the least restrictive and most restrictive operating conditions for logging within a forest type. Some of this difference is due to timber and site differences within a forest type; some is due to operational factors. While we don't have a statistical basis for partitioning the cost margin, we feel that it's reasonable to initially assign half of the average margin ($3) to operational constraints, such as those that might be imposed by proposed guidelines. We estimate that compliance costs for loggers could add $3 to the logging cost per cord for situations where few if any guidelines are already in place. Since many forest owners already comply, at least partially, with standards that are similar or comparable to the proposed guidelines, the average $3 cost is not likely applicable to all pulpwood production.

Differences between the least costly silvicultural systems (jack pine and aspen pulpwood) and the most costly system (lowland conifers) were $10 to $11 per cord. This margin primarily represents the difference between site and timber conditions found for different timber types.

Logging costs in lowland conifer sites could be especially affected. These sites already show the highest average cost for logging and usually present the most difficult logging situations due to less accessible and wet terrain where more guidelines (such as riparian and soil productivity guidelines) are likely to be appropriate. Increases in guideline compliance costs may increase the proportion that are simply uneconomic to operate.

Table V.3. Summary of production costs per unit for harvesting timber under selected scenarios in Minnesota for 1998.

Silvicultural system	Forest type	Product	Min. Volume	Units	Low	Mean	High
Clearcut	Jack pine	Pulpwood	NA	Cords	$20.00	$23.00	$26.00
Clearcut	Aspen-birch	Pulpwood	13.0	Cords	$21.05	$24.63	$28.21
Partial cut	Various	Pulpwood	11.6	Cords	$26.50	$29.60	$32.70
Thinning	Pine	Pulpwood	12.5	Cords	$29.22	$31.56	$33.89
Clearcut	Lowland conifers	Pulpwood	13.6	Cords	$30.46	$34.00	$37.54
Partial cut	Various	Sawtimber	7.5	Mbf	$52.69	$58.23	$63.77

1. Differences in logging costs among landowner groups

Logging on different ownerships has different costs because of differences in timber conditions, sale size, access, operational limitations and contracts. To try to better understand these differences, we asked timber producers to provide a relative ranking of the average cost of logging on various forest owner groups. Respondents told us that logging on some ownerships was more costly than others. They ranked all the owner groups where they had experience and estimated how much costs were more or less than the cost of logging on the least costly land ownership. Some loggers were better adapted to logging on one or a few owner groups than on others, so each owner group was reported as the least costly by one or more loggers. Overall, forest industry land was indicated as the most efficient place to harvest timber.

We scaled all the responses so that they were comparable and computed the average percentage difference in logging costs for different owners, relative to forest industry land (which we assigned a value of 1.0). Among all owner groups, national forest lands were ranked the most costly for logging with costs estimated to be 14% higher than on forest industry lands. Indian and nonindustrial private lands were rated 12% and 11% more costly respectively. County lands were 10% more expensive for loggers to harvest and state lands were 9% more expensive. Interpretation of these differences is not straightforward. Based on the mean logging costs reported above for aspen, this range (9% to 14%) translates into a difference of $2.22 to $3.45 per cord more than the least-cost logging sites. Many factors can lead to higher costs on one ownership than another, including differences in accessibility, timber conditions, bidding practices, and the extent of site treatments and operational constraints required under timber cutting contracts. The magnitude of the difference reaffirms the range of costs that may be applicable to operational factors.

2. Factors affecting logging productivity and costs

Timber producers provided many comments on factors that they felt substantially affected their production costs and ability to operate profitably. Comments generally addressed factors that would be affected by the proposed forest management guidelines and included operating limitations, economies of scale, and additional required practices. In some cases, guidelines may significantly affect the factors identified below and in most cases, guideline effects would increase producer costs. Especially important to total increased costs are influences that reduce productivity or increase required activities. Factors mentioned in comments are summarized below.

- Sale size or configuration was frequently cited as a costly factor that lead to significantly greater unproductive time. Smaller sales require more downtime for equipment moving and in some cases, fewer acres can be harvested per landing. Operators felt that some cutting unit designs were less efficient and more costly to log.

- Timber volume available to harvest, harvestable volume per acre, and partial cutting requirements were recognized as important. Stands where harvesting was limited in volume or where partial cutting required protection of residual trees was cited as more costly.

- Loggers reported that costs were higher for sales with limited access, or in cases where longer log skidding was required. This generally reduced operating efficiency, increased soil disturbance, and in some cases, led to higher road costs.

- Operating near structures such as buildings, powerlines and protected features was more costly because extra time and care was required to assure safe operations.

- Requirements to perform some practices to meet landowner objectives or contract requirements were noted as leading to higher costs, but not contributing to logging output. Practices such as erosion control, slash piling or disposal, and meeting specific landowner requirements.

- The need to operate under highly variable physical and management conditions increased the complexity and cost of logging operations. Harvesting on more uniform sites and timber conditions was judged to be more cost-effective. In addition, complying with more complex operating or contract specifications added costs.

- Some timber harvesters indicated that their systems were not particularly well suited for efficient use in some timber types or under some harvesting conditions. These operators expressed concern that guidelines might further decrease their efficiency.

- Stumpage price increases were also mentioned as an important factor affecting profitability. In some cases, timber producers expressed concern that they had little control over their raw material costs (stumpage) and also could not generally affect prices they received for delivered wood. Most producers who responded were small businesses. Respondents felt that increases in stumpage prices could not be passed along to wood buyers.

E. Effects on tourism

In general, the proposed guidelines will benefit tourism activity by maintaining healthy and diverse forest and aquatic ecosystems.

One of the most significant effects of forest management activities is the temporary influence of harvesting activity that takes place near facilities such as campgrounds and resorts and popular recreation areas like lakes and rivers. These activities increase disturbances such as noise levels and truck traffic in the vicinity and may also adversely affect on-site or downstream water quality. Although guidelines recommend ways to minimize these effects, some influence can not be avoided. Because guidelines recommend leaving some uncut trees on harvest sites, the average timber volume cut from each harvested acre will, on average, be lower. As a consequence, it is likely that the total area harvested each year may increase by a few percent in order to maintain timber flows. This increased harvesting represent additional opportunities for conflict with recreation activities.

Guidelines would also affect opportunities for wildlife-based recreation, although potential effects are mixed. Guidelines would generally improve fish and wildlife habitat but would change habitat quality for different species. Long-term changes in forest composition and habitat may negatively affect populations of some game birds and animals that depend on early successional forests such as aspen.

F. Other effects

A broader set of economic effects of concern to landowners who sell timber and those who buy timber, mostly forest industry and timber harvesters.

1. Stumpage price effects

Guideline implementation will affect the market relationship between timber sellers and buyers. Unfortunately, no equilibrium timber supply/demand model is available for Minnesota to test the magnitude of potential effects on quantity produced or market-clearing price. The guidelines do not substantially remove major areas of timber from harvest availability, but they do restrict volume recovery per acre and impose additional operational costs. The net effect of this is likely to be increased stumpage prices although we can not estimate the magnitude of the increase.

Increased stumpage prices have a positive effect for landowners. Higher prices will provide additional capital at the time of timber sales. Higher stumpage prices will increase raw material costs for firms that process timber .

2. Effects on other sectors

Changes in economic activity related to forest management will affect other economic sectors as well in both a positive and negative way although these effects can not be quantified without more extensive modeling. For example, changes in the costs and amount of logging activity may affect purchases of equipment and supplies needed for logging. And, even small changes in the supply or cost of timber to mills would affect woodland and mill operations such as output levels, payrolls, and the extent of wood fiber imports to the state. Estimates of the direct, indirect, and induced multiplier effects requires the use and configuration of an Input/Output model, but was beyond the scope of this study.

G. Unintended negative consequences

Regulation of forest practices may lead to unintended and counterproductive outcomes for public or private interests. While these effects are primarily applicable to regulatory actions, some may also be effects of voluntary guidelines to a lesser degree and are worth watching for. We have not explored these in detail, nor quantified them, but they bear mention and further discussion within the policy arena. Lippke (1992) provides a somewhat expanded discussion of some of the effects identified below.

Reduced funds available for other investments: Costs needed to apply guidelines have to come from somewhere and most often, they reduce monies that would be available for consumption or other investments. For public landowners, added costs may displace other socially desirable programs or projects. In the private sector, added costs reduce funds available for other corporate investments or employment.

Financial penalties for increased biodiversity: One goal of guidelines is to increase biodiversity. Improvements in habitat quality that result from modified management strategies carries a risk that a protected species may colonize an area. The outcome may be the subsequent imposition of regulatory constraints that may limit allowable financial uses. Success in the social goal of improved biodiversity may limit landowner options for other uses. The chance that a protected species may move into an area may induce some landowners to take management actions to discourage expansion of the species.

More extensive timber harvesting: Although voluntary leave-tree guidelines do not appear to be greatly limiting, some landowners may harvest additional timberlands to maintain a steady income or timber volume stream. This may especially be true if funding for forest management activities is derived solely from timber sale revenues.

Increased development: Landowners who perceive that forest management regulations are onerous may sell their property for development or other purposes to avoid costs or constraints. Some landowners may divest timberland because it is no longer profitable for their particular goals.

Reduced competitiveness: Guidelines will, to some degree, increase average costs of timber production and logging. This effect reduces the ability of any producer to compete in a larger market with

other producers who do not have the same cost structure. Marginal producers may be driven from the market, reducing competitiveness within the economic sector. Imposition of guidelines have potential to make the timber production and logging sectors more costly and less competitive. The extent of this potential effect depends on the degree that guidelines affect operating cost structures.

Displaced environmental effects: Restrictions in timber supply or increases in production costs inevitably result in product substitution from other competitive regions with lower cost structures. If these regions have fewer environmental protections, or are marginal producers, then greater environmental impacts will occur in that region. Environmental losses in the gaining region may exceed the environmental benefits in the region losing market share.

Reduced choice in guideline adoption: Although the proposed guidelines are voluntary, some landowners may not always have free choice in their application. Social pressures for compliance may be substantial. For example, it may be socially unacceptable to not comply with guidelines.

Reduced property rights: Social pressure for adoption of guidelines by private landowners may be perceived as an unwarranted intrusion and reduction in private property rights, especially in the absence of public support. This is hard to quantify, but private property rights are highly valued in society.

VI. DISCUSSION

A. Implications and comparison of costs and benefits

The proposed guidelines present an excellent opportunity to establish consistent statewide practices for management of forest land. They offer a science-based approach that recognizes that all forest resource components have value ecologically and socially as well as commercially. It is clear that the voluntary guidelines, if widely applied, will result in substantial benefits to the public in the form of enhanced environmental quality. They particularly emphasize maintaining ecosystem components at the time of timber harvesting that enhance forest ecosystem structure and function.

The proposed guidelines do not address forest sustainability directly. They do not contain specific criteria or indicators – metrics to define sustainability. Nevertheless, the four teams of specialists who crafted the initial guideline recommendations believe that the guidelines are the "right" way to sustain forests. They strike a balance between management for timber and management for other components.

Tinkering with the way forests are managed, even with voluntary guidelines, will affect the ecological processes that take place, and it will affect the lives of everyone who depends on forests to meet their needs for wood or recreation or jobs or opportunities to have natural and wild places. The proposed guidelines will produce many benefits like forest diversity and abundance of less common flora and fauna that are not easy to measure and most have few links to commercial value. Yet, these noncommercial characteristics of forests are immensely important to people. These benefits are valued because people simply want forests to have those parts or they believe it is the proper way for forests to be. Some will argue that the value of the non-market benefits greatly exceed any costs that might be incurred. Our purpose was not to present imputed values for these. Rather, we recognize that there is a great societal desire or even demand for the many non-market values from forests. Many people also want to manage their land as they see fit for income or non-market values or both.

The effects we found describe more about how the proposed guidelines will play out on the landscape and how they will affect the economic interests of landowners and timber users than about the dimensions of environmental benefits. We found that it will cost landowners to plan and use guidelines. We found that loggers will be asked to change the way they operate, and it will probably be more costly for them too. We found that costs for raw materials used by forest products companies are likely to rise too. Some of these effects will be substantial.

It seems unreasonable for some of these participants to pay the costs so others can enjoy the benefits without cost. It also seems reasonable to ask that our forest ecosystems are managed in the best ways we know how so that all the pieces remain vital.

Costs expressed in physical quantities and monetary terms can not be directly compared with benefits that can not be expressed in similar terms, but are no less important to people's hearts. The best forum for comparing them is seldom a spreadsheet, but rather a conference table where the relative merits of each and the many diverse interests among people can be compared more effectively.

B. Possible mitigating program initiatives

The preceding analysis of the economic and financial implications of the proposed timber harvesting and forest management guidelines for Minnesota presents a variety of findings that have implications for policy and program development. Especially important are potential program responses that will help mitigate economically unacceptable consequences of guideline implementation. In this respect, the analysis could lead to a number of judgements about the guidelines, including:

<u>Guidelines should stand as now proposed</u>: costs and benefits are correctly allocated, nobody will be economically or financially disadvantaged because of the guidelines, and nobody will receive a

disproportionate share of the benefits of the guidelines. Program initiatives to mitigate costs probably are not necessary.

Guidelines need to be modified: costs to landowners, timber harvesters, and society (public)from implementing the guidelines exceed any identifiable benefits to landowners, timber harvesters and society; all segments of society are at a disadvantage because of the guidelines. Program initiatives to mitigate costs probably are not necessary.

Costs need to borne by landowners and/or timber harvesters: costs of implementing the guidelines are a normal part production operations; landowners and timber harvesters capture the benefits of guideline investments and thus should bear the costs. Program initiatives to mitigate costs probably are not necessary.

Costs need to be borne by society (public): landowners and timber harvesters are incurring guideline costs which they cannot recover and which are resulting in benefits enjoyed by a broader segment of the society (public); others need to absorb part or all the costs of providing these benefits. Program initiatives to mitigate costs probably are necessary.

Given the number of individual guidelines that are being proposed and the complex forest settings in which each guideline is likely to be applied, all of the above conditions may deserve attention. For sure, decisions about whether or not a program response is needed will be heavily influenced by perceptions of certainty regarding the results of this analysis, the financial condition of an individual landowner or timber harvester, and the set of values and beliefs that are adhered to by landowners, timber harvesters and others that have an interest in the state's forests. However, when discussions (informed by analyses such as this) conclude that the costs and benefits of guideline implementation are being disproportionately shared among landowners, timber harvesters and society (public), some sort of public and/or private program response may be necessary.

1. Major Focal Points of Program Initiatives

The MN Sustainable Forest Resources Act (SFRA) authorizes the development and voluntary use of comprehensive timber harvesting and forest management guidelines. In addition, the Act requires the establishment and accomplishment of guideline implementation goals for each of the state's major forest land ownership categories. These goals are to be accomplished in manners that avoid the imposition of adverse costs on landowners, timber harvesters, and society (public). Within this context, discussion of potential program initiatives should focus on their ability to:

Accomplish acceptable rates of guideline application. Program initiatives may be necessary to ensure that the guidelines are voluntarily applied at acceptable rates by forest landowners and timber harvesters. Especially important would be program initiatives that increase the rate of application in those situations where few landowners participate or gains in net benefits might be the greatest.

Avoid undesirable negative economic effects. Program initiatives may be necessary to offset unacceptably high costs that lead to derailment of implementation goals or other unintended consequences, including constraints on timber supply leading to unacceptable price increases, or timber harvesting business failures that lead to social strife and reduced competition. Especially important would be program initiatives that can address unusually high-cost circumstances (for example, purchase of extraordinarily high-cost timber harvesting equipment).

Assure equitable distribution of costs. Program initiatives may be necessary to balance the incidence of guideline benefits and costs among landowners, timber harvesters and society (public). Especially important would be program initiatives that enable those persons or sectors asked to modify management or harvesting practices to recoup returns on their investments. Traditional market transactions may not enable them to do so. Beneficiaries of these private investments need a way of making payment for the services they receive.

2. Potential Types of Program Initiatives

The variety of program initiatives available to address the above concerns is as diverse as the structure of the state's forest resources. If concern is with the application of the guidelines on forests that are publicly owned, administrators of county, state and federal governments have management authority to directly call for the application of the guidelines. In contrast, securing the application of the guidelines on the more than seven million acres of privately-owned forest in Minnesota is a much more complicated matter.

Program Types. Government program initiatives seeking to have forest practices applied on private forests presumes there is a public interest in the way such practices should be carried-out on these forests. If such is the case, there are a variety of program types available to government. The latter may, for example, assume a service orientation wherein information and technical assistance about the guidelines is provided, the assumption being that landowners and harvesters lack knowledge about the guidelines and their proper application. Government may also influence the application of guidelines by offering financial incentives. The provision of fiscal incentives presumes that landowners and timber harvesters lack the financial wherewithal to apply the guidelines. Financial incentives can take many forms including, direct cost-sharing of forestry practices, granting of low or no-cost loans, and special income tax credits or property-tax assessments. If service-oriented programs and fiscal incentives fail to result in the application of forest practice guidelines at rates considered to be generally acceptable, government can implement regulatory initiatives that force the application of guidelines.

Program Incidence. Of the many programs used by state forestry agencies to influence the use and management of private forests, educational and direct technical assistance are most common. Well over 90 percent of state governments have active programs in each of these areas (Table VI.1). In descending order of overall frequency, other state programs focused on forest practices applied on private land are: fiscal incentives (50 percent of states), and regulatory initiatives (36 percent), and tax incentives (19 percent). Regional disparities in the frequency with which programs are used by states are not large. Educational and direct technical assistance programs are equally common in all regions. Tax incentive programs are most common in the North and least common in the South, while regulatory initiatives are most common in the West and the North (especially the Northeast). Regional conditions affecting the types of programs used to influence private forestry activities include physical conditions excising within a region, importance of forestry in state and regional economies, and past traditions favoring or opposing state involvement in private forestry.

State forestry programs focused on private forests can focus on a variety of forestry activities ranging from protecting water quality to promoting reforestation. Again, state governments rely heavily on educational and direct technical programs as a means of influencing any one major private forestry activity (Table VI.1). Fiscal incentives are commonly focused on promoting reforestation and protecting water quality, while tax incentives seem to have virtue only for promoting reforestation and even then only 16 states have such programs. When used, state regulatory initiatives are most commonly focused on forest protection matters (wildfire, insects and diseases), water quality protection, and protection of wildlife and rare and endangered species. State agencies are unlikely to use a single type of program to influence private forestry. For example, although educational and technical assistance programs dominate as means of accomplishing reforestation objectives, 39 states also use fiscal incentives to accomplish the same purpose.

Program Effectiveness. The ability of state-initiated programs to influence forest practices on private forestland is important to program design and implementation. Unfortunately, very few detailed analyses of the efficiency and effectiveness of any one program type have been undertaken(for example, Defenders of Wildlife 1993, Ellefson and Risbrudt 1987, Ellefson, Cheng and Moulton 1995, Forest Service 1993, Greene and Siegel1994, Raper, C. F. 1995, U. S. Department of Agriculture 1989); even fewer analyses comparing the relative efficiency of competing programs (for example, American Pulpwood Association 1993, Cheng and Ellefson 1993, Hawks, Cubbage and others 1993, Henly 1992, Lippke 1992). This lack of information continues to make selection from among many program alternatives very difficult. Policy makers and program administrators must rely on past experience with similar programs, making program adjustments as they proceed to gain insight about a new program's

effectiveness. In this respect, administrators of state-initiated private forest management programs suggest that relative to other types of programs direct technical assistance and educational programs are most effective at influencing private forestry activities. Perceived as least effective for a variety of combined purposes are voluntary guidelines and regulatory initiatives (Table VI.2).

3. Sector Application of Potential Program Initiatives

Programs that might be used to mitigate unacceptable economic consequences of applying the proposed timber harvesting and forest management guidelines in Minnesota must be tailored to meet conditions unique to each of the state's major forestry sectors. What follows are example mitigating strategies grouped by major sector. The programs are presented in the spirit enhancing the forestry community's understanding of the range of program responses that are available. Further detailed analysis of the options (and others) will be necessary before they can be suggested for final adoption. At the very least, however, any program suggested as a means of dealing with unacceptable consequences of guideline implementation needs to be: effective (accomplish critical objectives), efficient (provide more net benefits than alternatives), proper scale (large enough to make a difference), equitably distribute costs (fairly distribute program expenses), avert substitution effects (avoid encouraging actions likely to be implemented anyway), easily implemented and administered, and politically and socially acceptable.

Nonindustrial Private Landowners. Simply becoming aware of and understanding the guidelines may well be a major challenge to Minnesota's 160,000 nonindustrial private landowners. Furthermore, they may resist guideline application because of the need to incur additional costs or of concerns that guideline application is an unwarranted intrusion on their private property rights. Additionally, they may face a challenge in securing access to technical specialists that can help explain the need for the guidelines and the manner in which they should be applied. Major program initiatives for nonindustrial private landowners could include:

- Educational programs focused on gaining understanding, acceptance, and support of the guidelines. Such could promote resource stewardship and landowner responsibility as corollaries to property rights concerns.

- Direct technical assistance focused on providing technical information and assistance needed to get the guidelines actually applied on site.

- Financial incentives and loans focused on offsetting higher costs or possibly reduced stumpage prices that result from guideline application.

Timber Harvesters. Adverse effects on productivity and profitability due to guideline limitations placed on harvesting operations may be faced by timber harvesters. However, the incidence of these concerns will probably vary greatly among the state's more than 1,000 timber harvesters. Highly efficient loggers with flexible operations may have little trouble adapting to the guidelines, while more marginal producers may be affected to the point of severe financial stress and subsequent exit from the industry. If the number of timber harvesters declines (or average firm size increases due to increased operating requirements), the level of industry-wide competition may decrease. Timber harvesters may also see stress from possible reductions in wood supply, greater demands for guideline education and certification, and an inability to capture some or all of their increased operating costs by unlikely offers of reduced stumpage prices or increased prices for delivered logs. Major program initiatives for timber harvesters could include:

- Educational programs focused on informing timber harvesters about guidelines and formally recognizing them when guidelines are applied.

- Financial incentives (including tax incentives) and loans focused on offsetting higher timber harvesting costs (e.g., harvest area layout; capital intensive harvest systems).

- Public stumpage price reductions focused on mitigating higher cost of guideline application.

- Alternative timber supply sources focused on offsetting forgone supplies due to guideline application.

Forest Products Industry. The availability of stumpage, increased timber prices, and possibly long-term shifts in the species product mix may be faced by the forest products industry. In addition, the industry may increasingly have to face timber harvesters seeking higher prices for delivered wood. Higher degrees of uncertainty regarding future timber supplies could affect long-term strategic planning and subsequent investments in manufacturing operations. Major program initiatives for the forest products industry could include:

- Tax incentives focused on management intensification leading to increased timber supplies.

- Improved resource information focused on reducing uncertainly regarding future timber supplies.

- Tax incentives focused on capital investments that improve efficiency in the use of raw materials.

- Recognition of resource stewardship and cost reductions focused enhancements in land management and harvesting and manufacturing operations.

Tourism Industry. In general, effects of guideline implementation are likely to be positive for the tourism industry. Concerns may be with increases in the amount of forest area treated annually as the harvesting intensity on any one site decreases. Also of concern may be the proximity and timing of specific timber harvesting operations. Major program initiatives for the tourism industry could include:

- Educational programs focused on enhancing tourism industry clients about the use and management of forests.

- Intensified linkages (coordination) between tourism, timber harvesting, and forest products sectors focused on increasing awareness and reducing potential for conflict.

Public Forestland Owners. Administration and application of guidelines may directly affect the cost structure of public organizations with forest land management responsibilities. Some governments may simply not have the necessary financial or staff resources required to fully implement the guidelines and at the same time maintain the same level of administrative intensity focused on current programs. Such could be especially critical for county governments which in part rely on commodity programs to generate revenues for the administration of their forestry programs. Major program initiatives for the public land management agencies could include:

- Appropriations focused on covering the added cost of administering and applying the guidelines.

- Financial transfers focused on other units of government (e.g., county) engaged in the administration and application of guidelines.

- Financial investment in guideline monitoring focused on securing high compliance rates on public lands.

- Financial investment in employee training aimed at improving knowledge and appropriate application of guidelines.

4. Summary

The economic analysis of the proposed timber harvesting and forest management guidelines can lead to a number of conclusions ranging from no change or slight modification in the guidelines, to the adoption of program initiatives that will better distribute the incidence of guideline costs amongst affected parties. These program initiatives should be selected and subsequently designed so as to secure acceptable rates of guideline application, alleviate undesirable negative economic effects, and ensue an equitable distribution of costs.

Governments have various administrative mechanisms for directly influencing the application of guidelines on public forest land. The situation is far more complicated for private forests, where a broad menu of programs is available to influence forest practices. These programs range from educational and direct technical assistance programs to a variety of fiscal incentives, including cost-share payments, tax incentives and various forms of loans. Also available are various timber supply enhancement programs and a wide variety of regulatory initiatives. The program (or mix of programs) used to mitigate the cost of applying the guidelines on private forests depends on the efficiency and effectiveness of the program in question as well as the special circumstances associated with each major forestry sector that is being asked to apply the guidelines.

Table VI.1. State government programs focused on major private forestry activities by activity, region, and type of program. 1992.

Major Forestry Activity and Type of Program	Number of States in Region Having Program Type			
	North	South	West	Total
Promote Reforestation				
Educational Programs	20	11	15	46
Technical Assistance	20	11	15	46
Tax Incentives	11	2	3	16
Fiscal Incentives	15	9	13	37
Regulatory Programs	7	0	7	14
Protect Water Quality				
Educational Programs	20	10	16	46
Technical Assistance	21	10	16	47
Tax Incentives	9	1	4	14
Fiscal Incentives	13	5	11	29
Regulatory Programs	13	5	8	26
Promote Reforestation				
Educational Programs	20	11	15	46
Technical Assistance	20	11	15	46
Tax Incentives	11	2	3	16
Fiscal Incentives	15	9	13	37
Regulatory Programs	7	0	7	14
Improve Timber Harvesting Methods				
Educational Programs	20	9	16	45
Technical Assistance	21	11	15	47
Tax Incentives	8	1	0	9
Fiscal Incentives	7	1	5	13
Regulatory Programs	8	2	7	17
Protect from Wildfire, Insects and Diseases				
Educational Programs	20	10	17	47
Technical Assistance	20	11	16	47
Tax Incentives	6	0	0	6
Fiscal Incentives	8	1	8	17
Regulatory Programs	11	5	11	27
Protect Wildlife and Rare and Endangered Species				
Educational Programs	21	11	14	46
Technical Assistance	19	11	14	44
Tax Incentives	3	0	0	3
Fiscal Incentives	13	6	9	28
Regulatory Programs	8	4	8	20
Enhance Recreation and Aesthetic Qualities				
Educational Programs	19	10	12	41
Technical Assistance	21	10	14	45
Tax Incentives	5	1	2	8
Fiscal Incentives	13	6	6	25
Regulatory Programs	3	0	5	8

Source: Ellefson, Cheng and Moulton 1995.

Table VI.2. Effectiveness of State Forestry Programs Focused on Private Forestry Activities as Judged by Program Managers and Administrators, by Activity and Program Type. 1992.

Forestry Activity or Objective	Rating of Program Effectiveness [a]					
	Educational Programs	Technical Assistance	Voluntary Guidelines	Tax Incentives	Fiscal Incentives	Regulatory Programs
Protect Water Quality	3.70	4.68	3.14	2.98	3.85	3.08
Promote Reforestation,	3.59	4.54	2.29	3.64	4.53	2.60
Improve Timber Harvesting Methods	3.96	4.58	2.82	3.58	3.64	2.74
Protect from Wildfire, Insects and Diseases	4.25	4.74	2.87	2.78	3.08	3.67
Protect Wildlife and Endangered Species	4.55	4.43	2.86	2.77	3.24	3.22
Enhance Recreation and Aesthetics	4.44	4.72	3.06	3.22	3.83	1.94
Mean Rank	4.08	4.61	2.84	3.16	3.69	2.87

[a] Effectiveness ratings assigned by program managers using a scale of 1 = very ineffective …. 6 = very effective.

Source: Ellefson, Cheng and Moulton 1995.

VII. APPENDIXES

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B. Limitations of the analysis and research needs

1. Data limitations:

Data on riparian area characteristics is limited: Riparian areas, where the land meets the water, are especially important ecological components and highly valued by people for recreation and water access. The management guidelines include many considerations for activities within riparian management zones. Data to characterize water bodies and the vegetation conditions near them are limited. For example, available stream inventory data lacks information on stream width. Information on vegetation characteristics within riparian zones was limited. These constraints affected our ability to quantify the implications of guidelines for varying buffer widths.

The extent of seasonal ponds is unknown: No reliable information is available on the number, size, and distribution of seasonal ponds, yet these features are especially important for many species. Because of their characteristics, it is unlikely that currently available remote sensing data can be used to map and characterize them. Some opportunities exist to model the occurrence of seasonal ponds due to their correlation with landforms.

Little information was found on the extent of coarse woody debris in forests: Guidelines call for leaving large downed logs and snags, but no information was available to describe the extent of this material in forests. Developing standard monitoring procedures and incorporating these into inventory and stand examination practices would help provide basic information on this feature.

Data on historical and cultural sites is not available: Much of the analysis of historical and cultural sites was based on expert opinion. Characterization of traditional use areas was particularly problematic. Efforts are needed to systematically sample and map distributions of these features in forested areas. Various public agencies maintain records of occurrence, but these were not collected in any statistical fashion, therefore limiting opportunities to make inferences on regional or statewide occurrence.

2. Research needs

Improved base data: Data limitations severely hampered this analysis. Improvements in available information would help produce better resolution of impacts. In some cases, this information need can be met through monitoring follow-up. Specific areas needing improvement include: characterization of riparian areas, guideline implementation costs (especially sale planning, effects on logging operations, and timber supply effects)

Determination of stumpage price effects: Stumpage prices have increased dramatically since 1990 due to a complex mix of factors. Development of a state-level equilibrium stumpage market would be a highly useful policy tool to better understand the effects of shifts in management policy on markets.

Distributed economic effects (I/O Sectoral analysis): Tracing economic effects throughout the economy is better done with an integrated multi-sectoral analysis that identifies linkages among sectors and identifies the direct, indirect, and induced impacts of these shifts. This is the type of work Wilbur Maki and his associates do. Also included in this area is the need for better information on potential community-based effects, identification of communities likely to be impacted.

Need for landscape-level analysis: Note that a site-based approach is inherently limited. Research is needed on the biophysical and economic impacts at the landscape level to better understand the distribution of effects. Perhaps this is a job for the FRC Regional Landscape Committees.

Quantification of ecosystem effects and values: Understanding and measuring the ecological effects of these treatments is problematic. We need to better understand what we measure in terms of ecological effects (biophysical/ecological parameters) and how these treatments influence those metrics. Seasonal ponds and emergent wetlands seem particularly important.

C. Forest Inventory and Analysis Data

Forest Inventory and Analysis (FIA) is a periodic inventory of the state's forest resources: their area, volume, growth, mortality, and removals. At various stages of the inventory, information is gathered from aerial photos, plot measurements, and tree measurements. The inventory generally occurs over several years with reports being produced on a 5 to 15 year basis. The most recent inventory for Minnesota was 1990 (Miles et al. 1995).

FIA is a sampling and estimation procedure, which means the reported figures are estimates only. Sampling procedures are selected to provide estimates of a certain level of reliability. FIA standards are a sampling error of less than 3 percent per million acres of timberland (Miles et al. 1995).

FIA has been used extensively in statewide analyses of Minnesota's forests. Most noticeably is the *Generic Environmental Impact Statement Study on Timber Harvesting and Forest Management in Minnesota* (Jaakko Pöyry 1994). The scope of the present study necessitated the use of a statewide inventory of Minnesota's forest. The Eastwide Forest Inventory data base is described in Hansen et al. (1992). Please see the referring documents, in particular Hansen et al. (1992), for definitions of data base terms used in this report.

1. Forest Types

Nineteen unique forest types are reported on forestland in the FIA data base, sixteen of which occur on timberland. FIA forest types with similar silvicultural characteristics were combined, resulting in 9 analysis unit forest types (AU forest types). For example, forest plots in the FIA forest types aspen-birch, aspen, paper birch, and balsam poplar were combined into an aspen-birch forest type. Non-pine conifer FIA forest types were split into a lowland conifer forest type and an upland conifer forest type depending on physiographic class.

Appendix Table 1. Distribution of timberland by FIA forest type and analysis unit forest types. Area in 1000s of acres, 1990.

FIA forest type	Analysis unit forest types									Total all forest types
	Jack Pine	Red-White Pine	Lowland Conifer	Upland Conifer	Oak-Hickory	Lowland Hard-wood	North. Hard-wood	Aspen-Birch	Non-stocked	
Jack pine	452.1	0	0	0	0	0	0	0	0	452.1
Red pine	0	375.3	0	0	0	0	0	0	0	375.3
White pine	0	63.7	0	0	0	0	0	0	0	63.7
Scotch pine	0	6.0	0	0	0	0	0	0	0	6
Balsam fir	0	0	323.7	409.1	0	0	0	0	0	732.8
Black spruce	0	0	1249.0	73.1	0	0	0	0	0	1322.1
Northern white cedar	0	0	630.2	51.4	0	0	0	0	0	681.6
Tamarack	0	0	695.5	12.4	0	0	0	0	0	707.9
White spruce	0	0	19.8	91.3	0	0	0	0	0	111.1
Oak-hickory	0	0	0	0	1166.2	0	0	0	0	1166.2
Elm-ash-cottonwood	0	0	0	0	0	1289.9	0	0	0	1289.9
Maple-beech-birch	0	0	0	0	0	0	1393.1	0	0	1393.1
Aspen	0	0	0	0	0	0	0	5058	0	5058
Paper birch	0	0	0	0	0	0	0	828.4	0	828.4
Balsam poplar	0	0	0	0	0	0	0	430.8	0	430.8
Non-stocked	0	0	0	0	0	0	0	0	104.2	104.2
Total	452.1	445	2918.2	637.3	1166.2	1289.9	1393.1	6317.2	104.2	14723.2

2. Ownership

Ten FIA ownership classes were reduced to 5 Analysis Unit ownership classes.

Appendix Table 2. Distribution of timberland area by FIA owner class and analysis unit owner class. Area in 1000s of acres, 1990.

FIA owner class	Analysis unit owner					Total all owner classes
	County	State	Federal	NIPF & American Indian	Forest industry	
National Forest	0	0	1,821.1	0	0	1,821.1
BLM	0	0	26.1	0	0	26.1
American Indian	0	0	0	483.8	0	483.8
Other federal	0	0	171.6	0	0	171.6
State	0	3,062.5	0	0	0	3,062.5
County and municipal	2,502.7	0	0	0	0	2,502.7
Forest industry	0	0	0	0	751.3	751.3
Farmer	0	0	0	2,213.3	0	2,213.3
Other private – corporate	0	0	0	613.0	0	613.0
Other private – individual	0	0	0	3,077.8	0	3,077.8
Total	2,502.7	3,062.5	2,018.8	6,387.9	751.3	14,723.2

3. Site Productivity Class

Minnesota's timberland is separated into 5 productivity classes. The upper three productivity classes were grouped into one class due to the low amounts of acreage in the 120 – 224 cubic feet per acre per year categories.

Appendix Table 3. Distribution of timberland by FIA productivity class and analysis unit productivity class. Areas in 1000s of acres, 1990.

FIA potential productivity class	Analysis unit potential productivity class			All productivity classes
	85 + ft^3/ac/yr	50-84 ft^3/ac/yr	20-49 ft^3/ac/yr	
165-224 ft^3/ac/yr	11.7	0.0	0.0	11.7
120-164 ft^3/ac/yr	254.1	0.0	0.0	254.1
85-119 ft^3/ac/yr	2,948.0	0.0	0.0	2,948.0
50-84 ft^3/ac/yr	0.0	5,355.2	0.0	5,355.2
20-49 ft^3/ac/yr	0.0	0.0	6,154.2	6,154.2
Total	3,213.8	5,355.2	6,154.2	14,723.2

4. Geographic Area

FRC landscapes for the purposes of landscape planning and coordination were selected as geographic units (see FRC approved document Landscape Delineations LP-0697). These boundaries follow combinations of sections and subsection lines. Each FIA plot, and the acreage and volume it represents, was assigned to the landscape in which the plot was located.

D. Riparian GIS Analysis

1. Data Sources

The following data were utilized in the geographic analysis: National Wetlands Inventory (NWI), Forestry Inventory and Analysis (FIA), trout lake information, and MN stream data. This data does not give precise information needed for site specific planning. It does provide a backbone for an analysis to get a rough idea of the affects of different management regimes on a statewide level. The data furnishes information for the entire state of Minnesota so that a complete picture can be formed. The questions being posed were at a scale larger than the data which must be considered when interpreting results.

The NWI data were obtained from the MN DNR Division of Waters. These data were collected from aerial photography and does not provide exact wetland boundaries. The data originated from 1:24,000 digital map sheets, which were then brought together into seventy-three, 1:100,000, sheets. The seventy-three sheets were joined together in order to run the analysis on a statewide level. Due to slight mismatch on the sheet boundaries, the process of joining the data decreased accuracy.

The NWI data contains information on the location, type, and shape of wetlands. The U.S. Fish and Wildlife Service uses the Cowardin System to classify wetlands (Minnesota Wetlands Conservation Plan, 1997). In this analysis lacustrine and palustrine wetland types were selected from the NWI data. These include deep and shallow water basins and selected emergent wetlands. The riparian guidelines specified that open water wetlands coincide with Circular 39 types 3, 4, and 5 . With assistance from DNR Division of Waters personnel, the following crosswalk between open water wetlands and Cowardin classifications was developed Appendix Table 4.

Appendix Table 4. Description of Cowardin Classes that are equivalent to Circular 39 types 3, 4, and 5.

System	Class	Water Regime
Lacustrine	*	*
Palustrine	Unconsolidated Bottom	*
Palustrine	Aquatic Bed	*
Palustrine	Unconsolidated Shore	*
Palustrine	Scrub Shrub	Permanently Flooded
Palustrine	Emergent	Seasonally, Semi-permanently, Intermittently, and Permanently Flooded

* Includes all subdivisions.

The FIA tree and plot level data were received from the U.S. Forest Service. This data contains detailed stand information for 43,957 plots randomly spread throughout Minnesota. FIA point coordinates were obtained from DNR Division of Forestry. FIA plot coordinate accuracy ranges from 2 to 70 meters.

The stream data were obtained from the MN DNR Division of Waters. It contains geographic stream data collected from the MN Department of Transportation (DOT) and from the NWI. The data lacks stream width information and contains minor positional inaccuracies. The inaccuracies can be up to 12 meters due to the modification of the data to digital format. Also, when these data were collected some meandering streams were not correctly inputted. Inaccuracies were also introduced when these data were edge-matched to create a statewide coverage. Even with these inaccuracies, this is one of the only detailed statewide geographic stream data sets available for MN.

The trout data were acquired from DNR Division of Water's list of known trout lakes in Minnesota. The information in the list was transferred into a geographic form. During the translation 18 out of 163 trout lakes were not geographically located causing them not to be identified as such in the analysis. The trout lake geographic data were integrated with the NWI data for the analysis.

2. Riparian GIS Analysis Steps

The riparian geographic analysis provided the information needed for the economic analysis. Specifically, the detailed information for the FIA plots in areas that would be affected by the riparian guidelines was required. The best management practices (BMP) and the proposed guidelines specify different protection sizes for riparian areas based on each riparian water type. The different water types were:

- Wetlands and Water Basins at least 10 acres in size
- Wetlands and Water Basins less than 10 acres but at least 2.5 acres in size
- Wetlands and Water Basins less than 2.5 acres but at least 1 acre in size
- Wetlands and Water Basins less than 1 acre in size
- Perennial Streams
- Intermittent Streams

Geographic information systems (GIS) were used to locate the FIA plots that fell within 500 feet of the 6 water types. For each plot located within 500 feet the GIS estimated the distance to the edge of the water type, and gave the description of the type. This description was either size in acres, for wetlands and water basins, or length in miles for streams. The FIA plot numbers, estimated distances, and water descriptions were then compiled into a data base that was used as input for the riparian acreage and volume analysis.

Some basic information also needed for this analysis was gathered using GIS, including: FIA plots located in water basins, total length (miles) of perennial and intermittent stream summed by FRC landscape, total area (acres) of land and water area summed by FRC landscape, and total area (acres) of water basins summed by FRC landscape.

I. Due to the abundance of data and the complex processes used to run the riparian GIS analysis on the FIA plot data, validation of the output data was required. Some possible steps where errors might have occurred include: pulling out the specific Cowardin classes needed for this analysis, joining the NWI data into a statewide coverage, splitting the data into the different riparian water types, running the distance determiner, and formatting the results for the economic analysis. For the validation, 280 FIA plots were randomly selected. These plots were then compared visually on a computer plotting FIA point coordinates on NWI data (1:24,000). The information gathered from the visual testing was then compared to the data generated. All the data from the validation, factoring human inaccuracies, matched up with the data used for input into the riparian acreage and volume analysis.

E. Economic analysis data

1. Timber prices

Timber stumpage price data for Minnesota were examined to identify long-term trends and rates of change for use in analyses of forest management regimes. Data were derived from a long series of timber stumpage price reports produced by the Minnesota DNR. Price reports for all regions within the state were pooled to develop a statewide average. Species were grouped by broad forest type to include the common species associates listed below.

Species groups include the following species:

Aspen-Birch:	aspen, balsam poplar, paper birch
Hardwood:	mixed hardwood, elm, soft maple
Lowland Conifers:	balsam fir, black spruce, larch, northern cedar
Northern Hardwoods:	basswood, sugar maple, white ash, yellow birch
Oak-Hickory:	red and white oak
Pine:	white, red, and jack pine
Upland Conifers:	white spruce

Appendix Table 5 shows historical prices for common species groups. These values were calculated as 3-year running averages. For example, the price shown for 1995 is the average of prices reported for 1994, 1995, and 1996. Prices reflect averages for woods-run timber sold on-the-stump by bidding in organized markets across the entire state. They are not indicative of higher or lower prices that may occur in specific regions, on specific sites or for varying timber quality. High quality timber may sell for several times the reported mean and low quality timber or timber on less operable sites may sell for less. Also these prices do not reflect prices paid for negotiated sales, salvage sales, or under special or unique circumstances.

Pine timber has the highest average prices for all species groups and products. Hardwood pulpwood (including oak-hickory and northern hardwood) had the lowest recent average prices followed by aspen. Boltwood prices exceed pulpwood and reflect higher quality (due primarily to size) and higher logging productivity for larger trees. Boltwood prices are higher for some species because at least some of the harvest enters markets for more valuable end solid wood products. Sawtimber prices exceed boltwood prices by a factor of 2 to 3 due to factors of size, quality, and end-market values.

Appendix Table 6 shows rates of price increase for selected time periods. Prices are nominal and not adjusted for inflation, therefore rates are comparable to annual market interest rates. Rates were determined by fitting a log-transform model to reported annual average prices:

$$P_t = a + bLN(t) + \varepsilon$$

Where: P_t is the price at time t
a is the intercept coefficient
b is the annual rate of price change

Appendix Table 7 shows the range of reported prices for 1997 and the coefficient of variation which reflects price variability across the state. Market prices vary because of locational differences, variation in market values for different species that occur within each group, and the price effects of variable t.

Appendix Table 5. Three-year running-average prices for Minnesota timber stumpage by species group and product for the period 1970 to 1975.

Species group	1970	1975	1980	1985	1990	1995
Pulpwood (Cords)						
Aspen-Birch	$1.14	$1.65	$2.40	$2.78	$3.88	$10.82
Hardwood	$1.02	$2.30	$2.53	$2.97	$3.12	$4.17
Lowland Conifers	$1.86	$3.48	$6.96	$6.33	$7.57	$12.84
Northern Hardwoods	$0.91	$2.69	$2.87	$3.68	$4.43	$5.00
Oak-Hickory	$1.01	$1.59	$3.26	$3.93	$3.83	$5.27
Pine	$2.28	$5.61	$10.30	$9.26	$11.03	$18.75
Upland Conifers	$4.43	$8.32	$12.97	$11.19	$12.38	$17.30
Boltwood (Cords)						
Aspen-Birch	$2.33	$3.50	NA	$2.78	$4.88	$13.89
Hardwood	$2.17	$4.78	NA	$7.68	$9.77	$12.57
Lowland Conifers	$2.13	$4.38	NA	$6.63	$7.87	$14.82
Northern Hardwoods	$3.00	$4.73	NA	$6.03	$12.35	$25.26
Oak-Hickory	$3.67	$6.33	NA	$13.21	$14.76	$29.55
Pine	$7.22	$11.00	NA	$16.57	$23.35	$42.20
Upland Conifers	$5.00	$7.00	NA	$9.71	$13.28	$24.37
Sawtimber (Mbf-Scribner)						
Aspen-Birch	$6.52	$8.61	$11.89	$14.40	$18.27	$45.21
Hardwood	$5.48	$10.89	$18.51	$26.02	$34.94	$55.64
Lowland Conifers	$5.12	$10.97	$16.64	$22.67	$26.74	$50.10
Northern Hardwoods	$9.84	$12.70	$19.24	$28.24	$42.34	$96.39
Oak-Hickory	$9.40	$14.12	$27.98	$40.70	$50.20	$95.60
Pine	$19.31	$33.41	$60.79	$54.13	$75.12	$124.45
Upland Conifers	$14.26	$21.97	$36.58	$35.53	$43.36	$61.74

Appendix Table 6. Average annual rate of price increase for Minnesota timber stumpage by species group and product in percent per year, not adjusted for inflation for the periods indicated.

Species group	1960-1997	1970-1997	1980-1997	1990-1997
Pulpwood (Cords)		Percent increase per year		
Aspen-Birch	6.7	8.3	9.3	17.6
Hardwood	5.2	5.1	2.4	11.2
Lowland Conifers	5.7	6.1	4.5	9.6
Northern Hardwoods	5.0	4.6	2.6	0.5
Oak-Hickory	5.7	6.9	1.0	8.1
Pine	6.2	6.0	3.4	10.5
Upland Conifers	4.0	4.0	1.5	4.9
Boltwood (Cords)				
Aspen-Birch	3.9	5.4	16.4	19.3
Hardwood	5.5	5.5	3.8	4.8
Lowland Conifers	4.8	6.3	9.0	11.7
Northern Hardwoods	6.4	8.4	14.6	12.0
Oak-Hickory	7.1	8.1	8.8	16.9
Pine	5.5	6.6	10.7	11.6
Upland Conifers	4.0	5.9	10.6	12.1
Sawtimber (Mbf-Scribner)				
Aspen-Birch	5.9	7.6	7.6	16.9
Hardwood	8.3	8.7	6.9	9.8
Lowland Conifers	6.9	7.6	6.2	11.6
Northern Hardwoods	7.7	9.5	11.0	10.5
Oak-Hickory	7.9	9.4	6.2	12.4
Pine	6.2	6.3	4.8	8.3
Upland Conifers	5.3	5.3	3.5	7.7

Appendix Table 7. Minimum, maximum, average and coefficient of variation (CV) for reported stumpage prices for 1995-1997 by species group.

Species Group	Minimum	Average	Maximum	CV (%)
Pulpwood (Cords)				
Aspen-Birch	$0.58	$11.94	$32.95	61.6
Hardwood	$0.66	$5.90	$50.00	125.3
Lowland Conifers	$2.00	$12.86	$36.00	57.2
Northern Hardwoods	$0.89	$4.77	$27.15	82.5
Oak-Hickory	$0.83	$5.62	$14.96	62.9
Pine	$0.88	$19.12	$55.04	50.6
Upland Conifers	$4.00	$16.84	$36.70	43.3
Boltwood (Cords)				
Aspen-Birch	$5.48	$14.51	$20.59	40.3
Hardwood	$8.24	$13.13	$18.25	41.1
Lowland Conifers	$7.78	$14.47	$23.76	49.6
Northern Hardwoods	$18.69	$26.48	$29.80	19.7
Oak-Hickory	$32.82	$34.15	$35.48	5.5
Pine	$31.27	$42.08	$53.05	21.8
Upland Conifers	$26.51	$28.04	$29.57	7.7
Sawtimber (Mbf-Scribner)				
Aspen-Birch	$7.30	$50.10	$120.64	46.6
Hardwood	$18.59	$58.52	$338.05	97.8
Lowland Conifers	$9.00	$54.13	$153.43	70.5
Northern Hardwoods	$24.00	$98.22	$273.37	52.7
Oak-Hickory	$28.86	$104.27	$290.00	64.7
Pine	$10.73	$122.01	$275.48	47.0
Upland Conifers	$21.74	$65.97	$107.50	31.2

2. Pulpwood production

Appendix Table 8. Estimated pulpwood production in Minnesota by species for selected years, 1970 to 1996.

	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996
Species						Thousand cords					
Aspen	600	616	699	1,361	1,658	1,698	1,985	2,185	2,155	2,103	2098
Balsam fir	45	121	111	122	197	197	187	199	185	198	252
Spruce	181	202	170	111	180	141	146	158	165	150	204
Jack pine		181	121	107	114	142	109	128	98	97	59
Balsam poplar		11	46	47	53	70	85	92	122	96	90
Paper birch	31	35	15	2	23	14	25	42	75	99	109
Red pine		11	23	27	19	20	22	26	22	24	58
Soft maple		0	0	0	20	20	12	20	24	14	4
Tamarack	36	56	43	9	4	4	1	3	3	12	13
Other softwood	221	7	7	3	9	1	5	2	0	1	1
Other hardwood	27	11	2	1	0	0	7	4	9	16	7
Total	1,141	1,251	1,237	1,790	2,277	2,306	2,585	2,857	2,858	2,810	2,897

Source: Data are from a series of pulpwood production reports published by the USDA Forest Service in cooperation with the states. See Piva 1998 for a recent example.

Appendix Table 9. Estimated pulpwood production in Minnesota counties for selected years, 1970 to 1996.

County	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996
					Thousand cords						
St. Louis	299	340	270	412	510	496	540	665	622	603	637
Koochiching	227	292	224	193	284	313	376	448	476	461	449
Itasca	130	116	208	343	380	364	411	409	344	357	321
Beltrami	77	94	89	147	163	177	167	180	205	179	153
Cass	44	49	67	128	171	187	188	165	168	181	198
Lake	66	74	71	93	116	83	98	97	107	112	102
Aitkin	49	50	44	57	96	86	102	106	102	100	98
Hubbard	33	44	44	99	49	83	97	117	115	108	115
Becker	3	2	2	22	55	81	110	97	92	76	90
Pine	12	10	13	25	62	60	67	87	101	117	141
Clearwater	50	27	30	69	76	66	70	69	68	80	94
Crow Wing	11	15	11	38	58	66	73	86	77	65	73
Cook	37	30	59	57	52	44	72	76	66	31	70
Carlton	26	24	18	27	53	43	42	46	47	55	63
Lake of the Woods	36	29	32	20	52	42	40	47	51	50	38
Mille Lacs	6	9	9	20	33	28	39	38	50	49	59
Roseau	13	25	9	6	26	22	21	24	27	29	15
Other counties	22	21	37	33	41	64	71	103	141	155	181
State Total	1,141	1,251	1,237	1,790	2,277	2,306	2,585	2,857	2,858	2,810	2,897

Source: Data are from a series of pulpwood production reports published by the USDA Forest Service in cooperation with the states. See Piva 1998 for a recent example.

3. Distribution of harvesting activity

We estimated the amount of acres harvested over the 1977 – 1990 forest inventory cycle by examining plot and tree records. Plots were identified as having past harvesting activity if one or more growing stock trees were identified by the field crews as cut since the last inventory. We also identified harvested plots based on the value of the disturbance code (4 – harvesting and thinning, > 20% loss) recorded for the plot from aerial photo interpretation. Area expanders were summed for all harvested plots and those that fell within a RMZ buffer. Estimates of the total acres harvested over the inventory cycle and harvested acres within a RMZ buffer are shown in Appendix Table 10 below for each forest type. Although the results are not the same, these approaches provide a way to bracket estimates of harvest proportions. We were not able to identify specific silvicultural systems such as clearcutting based on these data.

Appendix Table 10. Distribution of harvested acres that occur within a riparian management zone by forest type for the period 1977 to 1990.

Forest Type	Acres Cut	Acres Cut in RMZ	Acres Cut in RMZ	Acres Cut	Acres Cut in RMZ	Acres Cut in RMZ
	Based on cut trees			Based on disturbance code		
	1000s	1000s	Percent	1000s	1000s	Percent
Aspen-birch	587.7	22.0	3.7	714.4	41.7	5.8
Jack pine	31.8	0.0	0.0	41.8	0.8	1.9
Lowland conifer	88.9	5.2	5.8	150.6	6.5	4.3
Lowland hardwood	50.6	2.4	4.7	77.1	6.0	7.8
Northern hardwood	70.9	3.8	5.4	76.7	4.1	5.3
Oak-hickory	23.4	3.3	14.1	27.1	3.8	14.0
Red-white pine	56.1	0.0	0.0	61.3	1.3	2.1
Upland conifer	30.6	1.1	3.6	49.9	0.0	0.0
Non-stocked	3.1	0.0	0.0	3.1	0.0	0.0
All types	943.1	37.8	4.0	1,202.0	64.2	5.3

Appendix Table 11. Estimates of acres by forest type, acres in riparian management zones and distribution of harvested acres for the period 1977 to 1990.

Forest Type	Acres in type	Acres in RMZ	Acres in RMZ	Percent of all cut acres not in RMZ	Percent of all cut acres in RMZ
	1000s	1000s	Percent	Percent (range)	Percent (range)
Aspen-birch	6,317.2	327.8	2.2	58.0 (56.0 – 60.0)	2.9 (2.3 – 3.5)
Jack pine	452.1	5.6	0.0	3.4 (3.4 – 3.4)	0.0 (0.0 – 0.1)
Lowland conifer	2,918.2	69.5	0.5	10.4 (8.9 – 12.0)	0.6 (0.5 – 0.6)
Lowland hardwood	1,289.9	210.6	1.4	5.5 (5.1 – 5.9)	0.4 (0.3 – 0.5)
Northern hardwood	1,393.1	147.8	1.0	6.6 (6.0 – 7.1)	0.4 (0.3 – 0.4)
Oak-hickory	1,166.2	158.6	1.1	2.0 (1.9 – 2.1)	0.3 (0.3 – 0.4)
Red-white pine	445.0	21.5	0.1	5.5 (5.0 – 5.9)	0.1 (0.0 – 0.1)
Upland conifer	637.3	24.2	0.2	3.6 (3.1 – 4.2)	0.1 (0.0 – 0.1)
Non-stocked	104.2	14.5	0.1	0.3 (0.3 – 0.3)	0.0
All types	14,723.2	980.9	6.7	95.3 (94.7 – 96.0)	4.7 (4.0 – 5.3)

The distribution of harvest activity shown in Appendix Table 11 indicates that 4.7 percent of all harvested acres were located in a riparian management zone and 95.3 percent were outside a RMZ. These estimates are based on the inventory remeasurement period from 1977 to 1990 and more recent trends may have changed. Also, these estimates do not provide information to judge the annual extent or number of acres disturbed by harvesting. Puettmann et. Al. (1998) report that 192,514 acres were cut in 1996 based on a survey of timber harvesters. Using this value with the proportions above, indicates that 9,000 acres (range 7,700 to 10,200) are harvested annually within riparian zone buffers. This is approximately 1 percent of the 980,900 acres of timberland within a RMZ. We also estimate that 1.5 percent of the timberland or 183,500 acres (range 182,300 to 184,800) are harvested annually from timberland not located within a RMZ. These patterns are derived from past inventory data and harvesting patterns are likely to change with adoption of guidelines.

The extent of harvesting near water was confirmed in a sample of harvest sites measured on recent aerial photos. One hundred sixty five harvests occurring in 17 counties and representing 4,856 harvested acres were identified and measured. Details on this work are covered elsewhere in this report. The results

showed that 10% of the sites (16) had at least a portion of their area (492 acres) within 50 feet of water. For all sites, 1.8% of the harvest area measured was within 50 feet of water.

4. Forest management costs

We surveyed forest managers to collect information on current costs for forest management practices and recommended rotation ages. The Minnesota Forest Resources Partnership and the Minnesota DNR helped identify and distribute the survey to potential respondents . We received 12 responses from forest managers responsible for state, county, federal, and forest industry lands. In general, responding individuals were in large organizations responsible for management of large areas of public or private forests.

We asked respondents to supply their best cost estimates for site preparation, regeneration, and stand cultural treatments, management and planning costs, and costs for harvest planning and follow-up. Some respondents had access to detailed treatment records and provided precise cost estimates. Others provided their best estimate of typical costs for their organization. We received a range of cost estimates for each treatment or activity. Responses for individual items were closely grouped for some standard and consistent treatments such as chemical site preparation. For others, responses showed greater variability. The range of costs for common forest practices are shown in Appendix Table 12.

5. Rotation ages

We also asked forest managers to provide us with information on the recommended harvesting rotations for management of various forest types for customary and extended rotations (Appendix Table 13). Customary rotations were interpreted as ecologically feasible and economically viable rotations primarily for timber production. Extended rotations were longer rotations more suited for growth of larger timber and more diverse stand structures. In some cases, particularly for northern hardwoods, respondents recommended uneven-aged management.

Appendix Table 12. Reported average and range of costs for forest management treatments in Minnesota, 1998.

Treatment	Minimum	Mean	Maximum
	$/acre (except as noted)		
Site Preparation			
Chemical Site Prep – Broadcast spray	$45	$79.79	$148
Chemical Site Prep – Spot Treatments	$67	$80.67	$100
Pile/windrow slash	$40	$100.53	$220
Scarification	$40	$94.06	$163
Mechanical site prep	$20	$85.58	$175
Regeneration			
Machine plant conifers	$120	$167.50	$250
Hand plant conifers, harvested sites	$36.50	$118.91	$300
Hand plant conifers, underplanting	$50	$158.33	$300
Hand plant hardwoods	$85	$178.00	$350
Aerial seeding	$6.79	$32.56	$70
Conifer seedlings, containerized (1,000)	$100	$153.29	$262
Conifer seedlings, bare root (1,000)	$90	$146.43	$400
Hardwood seedlings (1,000)	$120	$197.40	$300
Stand Cultural Treatments			
Wildlife food plots *	$35	$152.22	$325
Prescribed burning	$5	$99.33	$200
Pruning	$46	$83.00	$150
TSI/Cleaning	$50	$71.20	$100
Precommercial thinning	$20	$54.17	$100
Release	$40	$72.42	$125
Management and Planning			
Regeneration survey	$3	$44.76	$150
Stand monitoring and evaluation	$1	$31.22	$150
Management costs (annual) *	$0.13	$15.77	$54.62
Harvest Planning			
Cruise/mark Clearcut	$1	$11.88	$37
Cruise/mark with leave trees	$2	$13.96	$39
Cruise/mark seedtree/shelterwood	$10	$23.83	$53
Hardwood marking	$10	$26.00	$70
Improvement or thinning marking	$10	$50.29	$160
Restore log deck/landing (site)	$50	$110.71	$200
Post-harvest consultation (site)	$20	$49.17	$100
Harvest planning, w/o guidelines (site) *	$20	$550.63	$3,800
Harvest planning, with guidelines (site) *	$60	$848.75	$3,700

In most cases, the estimated cost is the median or most commonly reported value. Cost estimates were based on additional expert information in cases where the distribution of reported prices was highly variable (marked with *).

Appendix Table 13. Rotation ages recommended by forest managers for Minnesota forest types.

	Low Sites		Medium Sites		High Sites	
Forest type	Mean	Range	Mean	Range	Mean	Range
			Customary rotations			
Aspen-birch	44	(30 – 60)	48	(35 – 60)	54	(40 – 65)
Jack pine	49	(40 – 55)	52	(45 – 63)	54	(50 – 60)
Lowland conifers	80	(50 – 100)	81	(50 – 100)	84	(50 – 120)
Lowland hardwoods	80	(60 – 90)	78	(60 – 90)	75	(60 – 90)
Northern hardwoods	62	(50 – 90)	75	(40 – 120)	77	(50 – 120)
Oak-hickory	70	(50 – 90)	82	(50 – 120)	84	(50 – 120)
White-red pine	90	(60 – 120)	91	(50 – 140)	93	(60 – 160)
Red pine			100	(100 – 100)	80	(80 – 80)
White pine			150	(150 – 150)	180	(180 – 180)
Upland conifer	61	(40 – 80)	66	(50 – 80)	67	(50 – 80)
			Extended rotations			
Aspen-birch	65	(50 – 90)	65	(50 – 90)	74	(60 – 90)
Jack pine	65	(50 – 80)	64	(50 – 80)	73	(70 – 80)
Lowland conifers	93	(50 – 130)	104	(50 – 150)	99	(50 – 130)
Lowland hardwoods	135	(120 – 150)	115	(95 – 150)	115	(80 – 150)
Northern hardwoods	140	(60 – 240)	141	(100 – 240)	167	(120 – 240)
Oak-hickory	140	(60 – 240)	157	(80 – 240)	149	(90 – 240)
White-red pine	185	(140 – 230)	165	(120 – 230)	205	(180 – 230)
Red pine					150	(150 – 150)
White pine					180	(180 – 180)
Upland conifer	83	(60 – 120)	87	(70 – 120)	95	(60 – 120)

6. Road costs

Producers also provided estimates of costs for constructing roads in combination with timber harvesting operations. Roads are often a big-ticket item for logging jobs. Most respondents supplied a high, medium, and low cost for each of the four categories we specified. We received a few very high cost estimates. While these represent real costs, they are likely to be extreme cases. Therefore, we excluded outlier responses that exceeded 2.5 times the standard deviation in order to calculate the range and averages shown in Appendix Table 14. The cost of temporary logging roads was very different for summer and winter months conditions. Temporary roads constructed during the summer were three times as costly as winter roads. We have inadequate information to judge the extent that guidelines will affect the need to build more or less roads on average harvest sites.

Appendix Table 14. Average 1998 costs for forest road construction reported by timber producers in Minnesota.

Road Type	Minimum	Average	Maximum	N
	$/mile	$/mile	$/mile	
Permanent road	$1,800.	$10,144.	$25,000.	14
Temporary road, summer	$200.	$2,829.	$10,000.	28
Temporary road, winter	$150.	$950.	$3,000.	28
Road closure	$100.	$574.	$2,500.	14

F. Glossary

Analysis unit	Acres of forest land that have similar conditions and are grouped together for the purpose of analysis. Analysis units are based on factors that are likely to affect guideline implementation and costs, including forest type, location, ownership, and site and stand conditions. Analysis units are derived from aggregates of forest inventory plot data.
Benefit	Any positive value flowing from a forest or resulting from a management treatment. Benefits can be commodity or market values that can be quantified in monetary terms (commercial values) or non-commercial values that that are not easily measurable in dollar terms.
Benefit/cost analysis	B/C analysis involves the comparison of forest management costs and benefits occurring over an extended period of time by discounting with an appropriate interest rate to adjust for the time-value of money. Various financial indicators are produced, including benefit/cost ratio, net present value, and rate of return. The purpose of B/C analysis is to compare the financial performance of alternative management treatments.
BMPs	Best management practices (BMPs) are sets of voluntary forest management practices intended to minimize non-point pollution and ecological impacts of forest management activities, especially in riparian areas (water quality BMPs) and visual impacts (visual quality BMPs).
Commercial values	Values from forest commodities, services, or use that can be quantified and assigned dollar values. These include market values for commodities and use derived from forest industry activities (timber) and other commercial activities such as hunting and tourism. (adapted from Stevenson et al. 1997)
Community values	Intangible values related to community identity, community cohesion and the quality of life. (adapted from Stevenson et al. 1997)
Cord	A measurement unit used for pulpwood or other roundwood timber volume equal to the volume of wood stacked in a pile four feet high, four feet wide and eight feet long. A cord is roughly equal to 75 to 80 cubic feet of solid wood.
Cost	Any expenditure or outlay required to achieve a specific forest management objective. Costs may be payments to implement forest management guidelines as direct expenditures or foregone revenues (opportunity costs).
Ecological values	"The value attached to the importance of maintaining forest biodiversity to ensure overall ecosystem health and human survival." (Stevenson et al. 1997)
Economic analysis	Economic analysis refers to evaluations of the changes in structure and performance of selected economic sectors due to public policy choices. Economic analysis considers how a specific program alternative (e.g. guideline implementation) is likely to affect business performance measures such as production, distribution, and consumption of goods and services, employment and incomes.
Existence value	"The value attached to the satisfaction people obtain from an amenity for various reasons other than their expected personal use; the satisfaction or peace of mind which comes just from knowing that a natural feature, such as a forest, exists independently of our experience or use of it." (Stevenson et al. 1997)
Forest land	Land that is at least 16.7 percent stocked by forest trees of any size, or formerly having had such tree cover and currently not developed for nonforest use. (Miles et al. 1995)

Forest products sector	For the purposes of this study, the forest products sector refers to primary wood processing industries that use roundwood as a raw material, such as pulp and paper and sawmilling. Secondary processing – those business activities that manufacture goods from processed wood or paper, such as furniture, and paper converting – will not be included in the analysis. Primary forest products generally include parts of SIC sectors 24 (lumber and wood products) and 26 (paper and allied products).
Historic and cultural resources	Important historical features such as historic buildings, cemeteries, archaeological sites, historic areas and traditional use areas.
Input-Output Analysis	A method of analysis that quantifies the relationships between economic activity occurring in various sectors of the economy. I/O analysis is used to trace the effects of changes in one sector on other sectors of the economy.
Integrated Guidelines	A comprehensive set of recommended forest management guidelines that define management practices and treatments as standards for application under specific forest conditions.
Intrinsic value	"The value something has in itself, independent of its value to any other being. For example, if something can be damaged or harmed, it has some value and this value is independent of, for example, its usefulness to other beings." (Stevenson et al. 1997)
Logging sector	Economic activity related to the cutting of timber for the production of industrial roundwood and transportation to local points of delivery. Logging is included as a component (241) of SIC sector 24 (lumber and wood products).
Management scenario	A sequence of activities necessary to implement a specific forest management regime. Scenarios are specified by the quantity and timing of treatments that generate costs and production of goods and services. Comparisons are usually made between management regimes that include the recommended treatments (such as integrated guidelines) and regimes that do not. Base management scenarios do not include recommended treatments and incremental or treatment scenarios include the recommended treatments. Marginal analyses evaluate the financial effects of the difference between the base and incremental scenarios.
Marginal analysis	An economic analysis that compares two mutually exclusive forest management scenarios – a scenario without the recommended treatment (the base scenario) and one with the recommended treatment. Only differences in costs and benefits between the two scenarios are used for comparison. The result of the analysis shows the effects of the treatment itself, rather than the complete management investment.
Market Values	See commercial values.
Mbf	Thousand board feet. A measurement unit used for sawtimber or sawlog volume representing the amount of rough lumber that could be sawn from the tree or log. A thousand board feet is roughly equivalent to two cords. Three distinct scales are commonly used: International ¼, Scribner, and Doyle.
Non-commercial values	"Values attributable to the forest that are not easily measured or quantifiable in dollar terms" These include intrinsic, spiritual, ecological, community, and existence values. (Stevenson et al. 1997)
Opportunity Costs	The maximum value of a resource employed in the most productive or profitable alternative use. Opportunity cost is the value of foregone earnings.

Pulpwood	Standing or cut timber generally of smaller diameter trees used for manufacture of pulp or composite wood products. Pulpwood is usually cut in 100 inch lengths and measured in cords.
Reserved forest land	Forest land withdrawn from timber utilization through statute, administrative regulation, designation or exclusive use for Christmas tree production as indicated by annual shearing. (Miles et al. 1995)
Riparian management zone	A designated buffer zone of varying width adjacent to a water body where special management practices are recommended to protect environmental resources.
Sawtimber	Standing timber generally of larger diameter trees used as raw material for the manufacture of lumber products and measured as thousand board feet. Sawtimber cut into logs are called sawlogs.
SFI	The Sustainable Forestry Initiative (SFI) is a program of forest management practices intended to promote sustainable forestry developed and implemented by the American Forest and Paper Association for use by member companies.
Spiritual values	"The value attached to something by people because of its importance to their spiritual and cultural sense of identity." (Stevenson et al. 1997)
Stumpage	The price paid for standing timber, usually expressed in dollars per cord or thousand board feet.
Timberland	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 from timber utilization, and that is not associated with urban or rural development. (Miles et al. 1995)
Tourism sector	Economic activity associated with providing services to those who travel for pleasure. Tourism generally includes extended day trips, and overnight trips with stays in hotels, campgrounds, seasonal homes, and with friends and relatives. Tourism activity is not specifically identified in standard industrial classifications, but is accounted for in part by multiple service sectors such as retail trade, hotels and other lodging places, amusements and recreation services, and others.

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