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Final Generic Environmental Impact Statement Study on Timber Harvesting and Forest Management in Minnesota

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Prepared for:

Minnesota Environmental Quality Board
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FINAL GENERIC ENVIRONMENTAL IMPACT STATEMENT ON TIMBER HARVESTING AND MANAGEMENT IN MINNESOTA

April 21, 1994

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ABSTRACT: A Generic Environmental Impact Statement (GEIS) on timber harvesting and management in Minnesota was requested by the Environmental Quality Board to examine the effect expanded timber harvesting might have on the environment. The GEIS assesses environmental and related impacts at three different levels of statewide timber harvesting intensity. Mitigation strategies are suggested to address those impacts identified as being significantly adverse.

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EXECUTIVE SUMMARY

Overview

Indicative of a growing concern about the impact of increased timber harvesting on Minnesota's environment, a citizens' petition was brought before the Minnesota Environmental Quality Board (EQB) in July 1989. The petition requested the EQB to prepare a Generic Environmental Impact Statement (GEIS) on the cumulative impacts associated with timber harvesting and forest management in Minnesota. In December 1989, the EQB unanimously passed a resolution authorizing the preparation of such a GEIS and designated itself the responsible governmental unit for the study's preparation.

The EQB's resolution also established a ten-person citizen's Advisory Committee to help provide a direction and oversight through recommendations to the EQB. Specifically, the Advisory Committee was asked to assist in the preparation of the Final Scoping Decision (FSD), advise on selection of a project consultant, review and comment on all project work products, and make mitigation strategy recommendations.

The FSD was prepared during 1990 and issued in December 1990. The objectives called for in the FSD were to:

- develop a basic understanding of the status of timber harvesting and related forest management activities in Minnesota, and how this level of statewide activity relates to long-term sustainable levels of timber removals;
- identify and assess the environmental and related (i.e., economic and social) impacts associated with current and potential elevated levels of statewide timber harvesting and forest management activity; and
- develop strategies to mitigate potential significant adverse impacts that are identified.

A number of EQB-specified assumptions were used to prepare the GEIS. Key among these were:

Geographic Coverage and Forest Lands Under Consideration. The GEIS examines the impacts of timber harvesting and forest management on Minnesota's environment and on relevant sectors of the state and regional economies. The study was charged to consider all forest lands and resources within the state's boundaries to determine statewide cumulative impacts. This included commercial forest lands (timberlands), reserved, and unproductive forests. Emphasis was on the examination of cumulative impacts of timber harvesting and forest management activities occurring on all timberlands in Minnesota. This includes, to the extent possible, all public forest lands owned and/or managed by federal, state, county, or municipal governments as well as forest land owned by industrial and nonindustrial private interests.

Relationship to Timber Harvesting and Forest Management. The GEIS analyzes only those impacts resulting from timber harvesting and associated forest management activities in Minnesota. These include a broad range of human-induced activities such as logging, site preparation, reforestation, and forest road construction. In addition, changes due to ecological processes are also examined. Examples of these changes include aging of forest stands and the incidence of pests and diseases.

The GEIS assessed three levels of statewide timber harvesting activity that were prescribed by the EQB. These levels were the basis for incremental analyses of the potential impacts of timber harvesting and forest management:

- **4.0 million cords.** This was the level of statewide timber harvesting activity that occurred in 1990, the most recent year for which data were available at the time the study was undertaken;

- **4.9 million cords.** This is the level of statewide timber harvesting activity estimated to occur by 1995 if all announced or considered forest products industry expansions fully materialize; and

- **7 million cords.** This is the estimated maximum sustainable annual volume of timber growth available for harvest statewide for all tree species in the year 2000.

These three pre-established levels are referred to as the *base, medium,* and *high* scenarios, respectively. ***Note that these are not recommended levels of harvest nor should their development and analysis be considered a plan. Rather, they are levels the study was asked to analyze to determine what the impacts would be if these harvests were to occur.***

All three scenarios project the spatial and temporal distribution of timber harvesting activity that might occur across the state over a 50-year planning horizon. This included projecting what tree species might be harvested as well as when and where that occurred. The USDA Forest Service's Forest Inventory and Analysis (FIA) database served as the primary data input for modelling these three scenarios. The FIA data (13,536 forest plots and other information) provided a statistical sample of existing forest conditions including estimates for location, types and extent of tree species and covertypes present, timber volume, growth, and mortality and various site, stand, and surrounding area descriptors. These data were assumed to represent Minnesota's forest resources.

Modelling and Assumptions

The FIA plots provided a spatial approximation of the total resource and were used as the basic *units* for allocating timber harvesting activity. Computer models were then used to generate realistic harvesting scenarios by incorporating the most recent available data covering the following:

- the volume (by size and species), location, and ownership of wood potentially available;
- existing, planned, or potential wood-based industries and their locations;
- costs associated with timber harvesting, transport, and forest management activities;
- the regional transport network to link the wood supplies with the processing facilities;
- forest management practices and the implications of these on the structure and species composition of the forests and yields of timber in the short- and long-term;
- criteria used by industries to select stands when making purchases of timber; and
- existing land management policies that influence the availability of timber for harvest.

The forest growth model used is an individual tree-based model that projects individual tree growth and mortality on each FIA plot. That model output was also analyzed each decade to assess covertype change via growth and stand dynamics. As the forest was projected, harvesting and associated forest management activities were scheduled by models that addressed individual stands in a way that made the most economic sense, given the mitigations and constraints on the various locations and ownerships. Resulting data from the scenarios formed the basis for most of the subsequent impact analysis undertaken by the study groups. Examples of harvest and management options for stands included: clearcutting, thinning, selective harvesting, or no harvesting. After harvest, the choices included natural regeneration or planting. The most appropriate option for each stand at each decision point was selected by a scheduling model that matched demand for a product with the stand or forest area best able to supply that product and in consideration of mitigations and other constraints. Forest and timberland area change from 1990 to 2040 was also implemented gradually throughout the 50-year period using estimates of annual change rates.

Outputs from the model runs included plots harvested by ten-year planning period; the type of harvesting; the products harvested and their cost; and assumed management activities. FIA plot expansion factors were then used to convert this to stand, ecoregion and state level descriptions of the forest and outputs. The study groups used various parts of this output, depending on their specific requirements for conducting environmental impact assessments. For example, the forest soils study group required information on the amount of timber removed by covertype and the frequency of harvests; whereas the wildlife group required data including the presence or absence of certain key tree species, the age and size class structure of stands, and any changes in covertype. Additional assumptions in those study areas are described in the following sections on those subjects.

Importantly, the model runs included ownership constraints and mitigations that reflect current and prospective management procedures and policies applied by the major forest land managers. Examples include:

- extended rotation forests (ERF), i.e., lengthened (usually by 50 percent) minimum rotation ages for approximately 20 percent of the timberland on state and USDA Forest Service ownerships (note that the Superior National Forest does not currently have an ERF program);
- greater use of uneven-aged management;
- designation and reservation of old growth and old growth replacement acreage;
- best management practices (BMPs), i.e., thinning or ERF within 100 feet of water; and
- wildlife buffers (thinning only within 200 feet of water) on the national forests and in the southeastern part of the state.

In addition, estimates of the actual availability of timberlands for harvest or management, developed separately by ownership, were used to set aside a portion of the timberland as *not available* for various economic, environmental and social concerns.

Note that if these ownership constraints and mitigations are not routinely applied to all timber harvesting and forest management activities during the next 50 years, the number and severity of significant impacts identified (see Base Scenario Review below for examples) will increase for all three harvest levels.

The percent of timberland assumed available for harvest ranged from 98 percent for forest industry lands to 53 percent for the Superior National Forest. State and county timberlands were assumed to be 95 percent available. These model runs also incorporated the USDA Forest Service allowable cut limits for yields from their timberlands for the base and medium scenarios, i.e., the lower two levels of harvest. The USDA Forest Service constraints were then relaxed for the high scenario model run, even though the actual constraints on USDA Forest Service lands have the potential to become more stringent in the future.

Inclusion of the above constraints and mitigations suggests that the base and medium scenarios were reasonable depictions of current and future timber availability and predominant land management practices.

Issues Addressed

By utilizing these three levels of timber harvesting and their related forest management activities the GEIS examines how current and increased levels of timber harvesting and forest management affect a number of important issues identified in the study's FSD. These FSD issues identify important attributes and characteristics of Minnesota's forests which are collectively defined in the study as *forest resources*. The issues identified were:

- *maintaining productivity of forests for timber production*: examining primarily sustainable harvest levels, all ownership classes, geographic regions, and forest types today and in the future;
- *forest resource base*: conducting a historical assessment of the state's forest land base including current condition and its evolution;
- *forest soils*: examining impacts on nutrient cycling, erosion, compaction, and overall site productivity;
- *forest health*: examining insect and disease infestation risks across all landowners, geographic regions, tree species, and forest types;
- *plant and animal diversity in forest ecosystems*: examining forests' biological diversity at genetic, species, and ecosystem levels, as well as covertype spacial patterns; species of special concern, threatened, or endangered species; and old growth and old forests;
- *forest wildlife and fish*: examining forest dependent species and their specific habitat requirements;
- *water quality*: examining changes in sedimentation and nutrient loading levels and runoff in lakes, rivers, streams, and wetlands, including impacts of fertilizers, compost, sludge, and pesticides on water quality;
- *forest recreation*: examining quantitative and qualitative recreation opportunity impacts covering various consumptive and nonconsumptive recreation activity types;
- *economics and management*: examining regional and state direct economic relationships, the tourism and recreation industry statewide, habitats of game species and economic relationships, and timber stumpage distributions among various uses; and
- *aesthetics and unique historic and cultural resources*: examining visual quality and unique heritage resources found in forested areas.

Other areas requiring analysis were: (1) recycled fiber opportunities and their timber harvesting relationships; (2) possible impacts of global warming on Minnesota's forests; (3) Minnesota's public forestry organizations and policies; (4) harvesting systems; and (5) silvicultural systems.

Detailed analyses of these issues were carried out through development of nine technical and five background papers. Focus of the analysis in all papers was assessing cumulative impacts occurring across the state, by region, and for various ecoregions. Figure I.1 indicates the ecoregions used in these analyses.

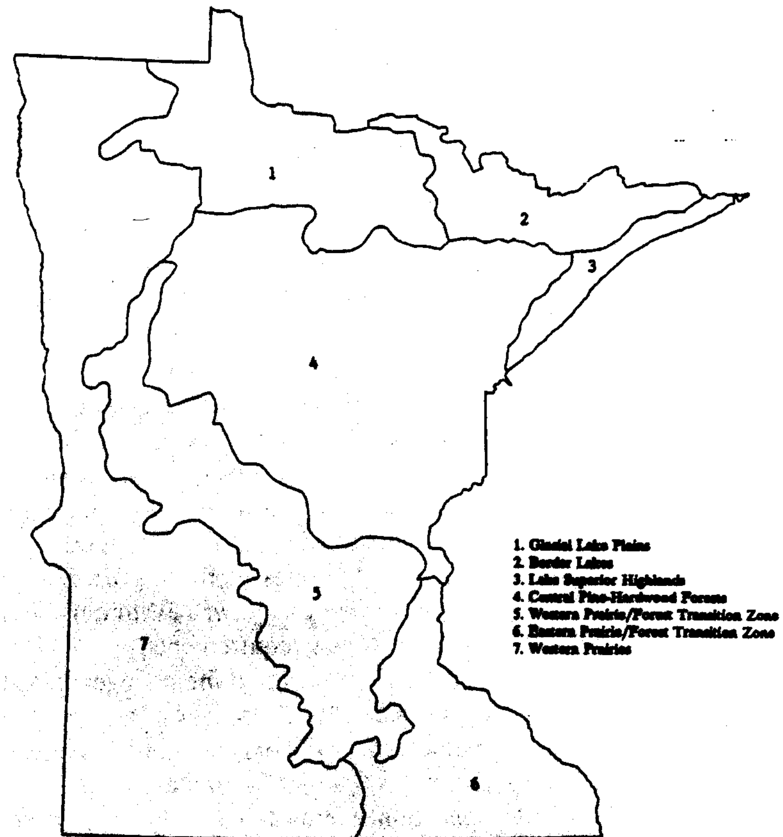

Figure I.1. Ecoregions used in the GEIS study. (Source: Jaakko Pöyry Consulting, Inc. 1992a.)

Data availability limited the extent to which impacts could be quantitatively assessed for certain issues. The GEIS study does identify areas where future research is needed to collect data that are currently unavailable, but that are necessary to completely address all GEIS-scoped issues.

GEIS Study Components

The study components, as summarized here, were designed to address the requirements outlined in the previous section:

- *Feasibility Study*: established the study's structure;
- *Workplan*: outlined the study's methodology;
- *Statewide Timber Harvesting Scenarios*: initial analyses of the three harvesting levels used to help identify probable impacts for all FSD issues;
- *Study Criteria*: criteria developed to help assess significant impacts, mitigation alternatives, and mitigation strategies;
- *Technical papers*: nine stand alone studies addressing collectively the FSD technical issues of concern;
- *Background papers*: five support studies addressing the other identified areas of interest (e.g., global warming, recycled fiber, etc.);
- *Draft GEIS document*: initial report targeted to fully synthesize and integrate the materials from the nine technical and five background papers, clearly summarize all relevant impacts, and describe recommendations to address the identified impacts; and
- *Final GEIS document*: subsequent and final report to address the above contents as modified to reflect review, commentary, and inputs from the peer review process, the Advisory Committee, the EQB, and the public at large.

Given these eight study components, the study criteria require some elaboration to put the balance of the executive summary into perspective.

First, the GEIS employed a number of models and submodels singly and in combination to develop projections for the study period. The models used, particularly those describing changes, were developed and/or employed to approximate the processes under study, natural or otherwise. However, there are limitations to any such modelling. Second, the interested study reviewer would benefit from examining work products associated with all eight study components. The criteria were developed to specifically evaluate each issue of concern from the perspective of cumulative impacts geographically and over time. Eighteen *categories* of impacts were discussed, based on the ten issue areas identified in the FSD. For each significance criterion developed, background information was used to determine levels or thresholds when impacts are likely to be considered significant. Similarly, a criterion was developed to identify possible mitigation measures and to select preferred strategies.

Minnesota's Forest Resources

Forest lands currently occupy about 16.7 million acres in Minnesota, or about 33 percent of the state's 50.8 million acres of land. This is approximately half the area of forest prior to European settlement (about 1850). The loss of forest area has occurred as a consequence of expanding agriculture and urbanization. In addition to a loss of forest area, timberland area (now 14.8 million acres) also declined by 3.4 million acres or 19 percent over the last 50 years. This was a result of a 700,000 increase in reserved forest area during the 1970s when the Boundary Waters Canoe Area Wilderness (BWCAW) and Voyageurs National Park were legislatively established, and 2.7 million acres of conversion of timberland to other land uses. Recent trends and projections of land use suggest the forest area in the north will continue to decline, largely due to development for other uses. However, the forest area in the southern part of the state is increasing due to reversion from marginal agricultural lands and that is projected to continue. Overall, the forest area in Minnesota is expected to increase slightly over 1990–2040.

The volume of timber in Minnesota's forests has increased severalfold since the 1930s as once small trees have matured from seedling/sapling status to pole- and sawtimber size. This accumulation of volume is due to net growth exceeding harvest rates for a number of decades.

Currently, timberland, reserved, and unproductive forest comprise about 88, 7 and 5 percent, respectively, of all forest land.

Minnesota's forest land can be classified into fourteen *forest types* (sometimes called *covertypes*), which was done for the GEIS. Each forest type bears the name of one or more tree species that form a majority of wood volume in the stand. Most stands have a considerable mixture of species and typically contain five or six species of trees. This can complicate the process of classifying stands into forest types.

Currently, the aspen forest type occupies about one-third of the state's total forest area. However, many aspen stands contain a high proportion of other hardwoods or conifers, so there is more diversity than this figure suggests. Black spruce occupies the largest area of any conifer type, due to its ability to grow on Minnesota's extensive peatland soils. Other major forest types include maple-basswood, oak-hickory, and elm-ash-soft maple, each comprising 7 to 8 percent of the total forest land area. The current forest landscape comprises a lower proportion of jack, red, and white pine forests; swamp conifers; northern hardwoods; and more aspen than in presettlement times.

Much of Minnesota's forest land was harvested in the late nineteenth and early twentieth centuries. In addition, other areas were cleared for agricultural uses, only to be returned to forest following the failure of these enterprises. Forests have reestablished on many formerly cutover and cleared lands and, once established, timber volume growth has exceeded removals (harvesting) and mortality. Therefore, despite ongoing harvesting, an increasing proportion of stands have grown into the older, larger size classes. The acreages in many forest types are now comprised of stands that are much older, on average, than they were in 1953, especially forest types that are of low commercial value. Although the average age of stands has been increasing recently, and most stands are in a mature state, there is still nowhere near the amount of old growth (>120 years old) that there was prior to European settlement, either as a percentage of the forest or in absolute acreage. Currently, there are about 610,000 acres of forest greater than 120 years old in the state (3.9 percent of all forest lands), compared with an estimated 13.9 million acres (51 percent of all forest) prior to European settlement (Jaakko Pöyry 1992e). This large shift in age structure, reduced forest acreage, and the species composition changes mentioned above, have reduced the biological diversity of Minnesota forests.

Minnesota's forest resources provide a variety of nontimber values important to addressing environmental, economic, and amenity interests and objectives. Among these are the following:

Water Resource Protection. Forest cover functions to affect the quantity, quality, and timing of water resources for human use and for aquatic species. Forest cover and the biological systems it includes has important mitigating effects on various land use practices in terms of protecting water quality.

Outdoor Recreation. Forests provide the habitat for wildlife species and the setting for many outdoor recreation activities, as well as for the very substantial resort industry that has developed in northern Minnesota.

Aesthetic Values-Attractiveness of the Forest. Maintenance of these values is important to insure that the forests continue to provide attractive recreational settings.

Cultural and Historical Values of the Forest. Forests contain a variety of heritage resources including sites that provide the most complete record of pre-European land use history, and sites of significance to contemporary Native Americans.

Biological Values of the Forest. The biological diversity of forests is of immense ecological, social, and economic importance to all regions of the world, for many reasons. Ultimately, the sustainability of forest resources, measured in either economic or ecological terms, depends on maintaining biodiversity.

Timberland Ownership and Timber Usage

Private individuals and corporations, other than the forest industry, own the largest area of Minnesota timberland—about 6.4 million acres or 43 percent. The state is the largest public landowner with over 3 million acres or 21 percent of timberland, followed by counties with 2.5 million acres or 17 percent; the national forests with 1.8 million acres and 12.3 percent; and the forest industry, 750,000 acres or 5 percent of all timberland in the state.

The six major forest products industries in Minnesota include: pulp and paper, hardboard, waferboard (also known as flakeboard) and oriented strand board (OSB), sawmills, veneer, and wood preservation.

The Minnesota forest products industry is in the midst of a significant expansion of output and wood consumption. Total demand from industrial, fuelwood, and nonindustrial uses increased from just over 1 million cords in 1960 to 1.5 million cords in 1975. Today, approximately 4.0 million cords are harvested statewide each year on approximately 200,000 acres. This includes wood consumption for pulpwood, paper and paperboard, OSB, lumber, fuelwood, and other uses. The greatest expansion has taken place in pulpmills, waferboard, and OSB mills. Much of the increase in the demand for pulpwood has been met by increasing the level of harvesting in the aspen forest type.

Sawmill roundwood receipts have also increased significantly, rising by 80 percent from 1960 to 1988. In contrast, there was little overall change in the demand for roundwood from other forest industries over this period.

The expansion of the wood industry in Minnesota is projected to continue for at least the next five years. Current forest industry expansion plans are based on previously discussed and/or permitted projects and include $1.6 billion in investments in new plants and equipment. These new mills, if built, will consume an estimated 790,000 cords of pulpwood per year in addition to the 4.0 million cords currently consumed as pulpwood, sawtimber, fuelwood, and other products.

Given the configuration of the state's pulp and paper mills, it is unlikely that market deinked pulp will replace *existing* virgin pulp production in Minnesota. However, use of market deinked pulp produced from Minnesota could replace up to 400,000 cords of pulpwood otherwise harvested in the state annually, if recycled pulp were used as a substitute for projected increases in virgin chemical pulp capacity. In addition, market deinked pulp could be used to replace purchased kraft pulp, which is the more likely ultimate scenario for Minnesota. Key here is that accurate projections regarding future use of recycled fiber are very difficult to make due to constantly changing technology and government policy.

Resource Management Framework

Minnesota, like other states, is faced with a highly complex natural resources decisionmaking environment. Minnesota's resources management framework is built on a myriad of policies, planning, coordination, programs, laws, regulations, guidelines, practices, and public participation. It involves federal, state, and county agencies; departments; commissions; boards; committees; and individuals, whose interests often overlap.

Key observations on the current status of forest land management are as follows:

- Minnesota has a substantial forest resource base today, regardless of how the overall effectiveness of its existing natural resources decisionmaking is viewed or judged;
- the complexity of these decisionmaking mechanisms and their present overlapping nature, both organizationally and functionally, create the potential for significant problems with development and implementation of future policies and decisions; and
- the natural resources decisionmaking process has grown inherently more complex over the past decade, consequently, the state will be faced with increasing potentials for difficulties in managing Minnesota's forest resources.

Contrasts Among the Timber Harvesting Scenarios

Comparison of the impacts projected to occur at the three different timber harvesting scenarios (base, medium, and high) illustrate important changes in forest resource conditions and associated values in response to these degrees of timber harvesting and forest management activities. The following highlights some of these major differences identified.

Acres Harvested Overview

Table I.1 contrasts the 1990 acres harvested one or more times and that not harvested during 1990-2040 for the three scenarios. Under the base scenario, 7.2 million acres are harvested while 7.6 million acres of timberland and 1.9 million acres of reserved and unproductive forest are not disturbed by harvesting over the study period. Thus, for the base scenario, a total of 9.5 million acres, or 57 percent of the forest, is not disturbed by harvesting over the study period. Timberland acreage is unharvested because it is still too young or under rotation age, of low productivity, uneconomic, or simply unneeded to achieve the specified harvest level. Although succession and stand development are controlled to some degree by humans in some managed forests (e.g., aspen managed to regenerate as aspen after harvest), 57 percent of Minnesota's forest landscape will not be harvested under the base scenario over the 50-year study period, so that natural forces of succession and stand development will be the primary influence on the landscape with or without timber harvesting. The percentage of the forest harvested increases considerably under the medium and high scenarios, but natural forces still play an important role in forest change.

Table I.1. Original acres harvested one or more times and not harvested during 1990–2040.*

Forest land use and harvest status	Total (thousand acres)
Total forest land acres	16,714.8
Reserved/unproductive	1,941.4
Timberland	14,773.4
Base Scenario	
Acres not cut	7,600.0
Acres cut	7,173.4
Medium Scenario	
Acres not cut	6,156.4
Acres cut	8,617.0
High Scenario	
Acres not cut	4,308.2
Acres cut	10,465.2

*Table 7.6 provides a breakdown of this acreage and harvest by ecoregion. See also section 5.1.1 for a discussion of assumptions and interpretation.

Forest Covertype Changes

Table I.2 contrasts the forest covertype acreage for timberland and all forest plots, 1990 and projected 2040, statewide for the three scenarios. Note that the forest covertypes used, by definition, contain a number of different tree species (see section 2.3.1). Perhaps most important is that acreage in various covertypes *is* sensitive to the level of harvesting. The increase in aspen timberland acreage with increasing harvest is an example of change due in part to harvesting. The overall forest and timberland acreage is expected to increase slightly, but the combination of harvesting and natural succession lead to important changes in future acreages by forest type. These changes argue for mitigations to slow such changes or at least to develop and seek to achieve covertype goals statewide. Failure to do so jeopardizes the timber and nontimber benefits the various forest types provide.

Note especially changes to selected covertypes. Jack pine experiences a significant reduction across all three timber harvesting scenarios, as does balsam fir. However, paper birch, which also shows a marked decline, seems to be less affected by harvest level. The same is found for black spruce. These changes indicate that a number of forces are affecting such changes, not just timber harvesting.

Table I.2. Forest type acreage for timberland and all forest plots under the base, medium and high scenarios, 1990 and projected 2040, statewide (thousand acres). Based on GEIS covertype algorithm. Each forest type contains a number of tree species. The reader should consult appendix 2 for forest covertype determination, and table 5.11 of this document for projected changes in individual tree species.

	1990		2040					
			Timberland			All Forest Land		
Forest Type	Timberland	All Forest Land	Base Scenario	Medium Scenario	High Scenario	Base Scenario	Medium Scenario	High Scenario
Jack pine	487.1	614.2	329.6	307.4	272.6	387.0	365.8	330.0
Red pine	350.6	430.1	452.4	454.4	433.2	541.0	543.0	521.8
White pine	137.3	148.3	141.0	136.0	120.2	174.9	169.9	154.1
Black spruce	1,320.8	1,997.9	1,001.2	945.4	957.8	1,637.0	1,581.2	1,593.6
Balsam fir	1,012.5	1,151.4	657.4	598.4	589.6	748.8	689.8	681.0
Northern white cedar	322.4	367.9	360.9	370.4	370.6	410.1	419.6	419.8
Tamarack	696.2	822.2	678.7	704.4	701.7	803.8	829.5	826.8
White spruce	137.0	181.0	227.9	202.7	158.2	334.6	309.4	264.9
Oak-Hickory	1,288.0	1,315.6	1,370.2	1,322.3	1,354.1	1,407.6	1,359.8	1,391.5
Elm-Ash-Soft maple	1,564.2	1,662.5	1,744.0	1,714.8	1,721.5	1,874.6	1,845.5	1,852.1
Maple-Basswood	1,301.8	1,334.5	1,460.2	1,368.6	1,255.2	1,497.1	1,405.5	1,292.1
Aspen	4,496.0	4,888.0	5,238.7	5,496.5	5,730.0	5,669.0	5,926.8	6,160.3
Paper birch	1,179.3	1,295.1	803.4	806.2	741.7	933.5	936.4	871.8
Balsam poplar	480.1	506.1	413.7	451.8	473.0	437.7	475.8	497.0
Nonstocked	0	0						
Other	0	0						
Total	14,773.4	16,714.8	14,879.4	14,879.4	14,879.4	16,857.0	16,857.0	16,857.0

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Stand Age Changes

Table I.3 compares the average stand age by covertype and scenario for timberland 1990-2040. Notable is the continued aging of the forest despite increased harvesting, which has important implications for aesthetics as older and larger trees are a positive component of such values. For most covertypes, the base and medium scenarios suggest the forest would be on average older and the largest trees larger in 2040 than at present. Notable exceptions to increasing average covertype age for these two scenarios are aspen and related forest types (e.g., balsam poplar) experiencing high demand. Under the high scenario, the mean age and size class of the forest would return to 1977-90 conditions (approximately) in the year 2040.

Table I.3. Average stand age by covertype and harvest scenario for timberland 1990-2040.

Forest Type	1990	2040		
		Base	Medium	High
Jack pine	48	77	69	42
Red pine	44	54	54	41
White pine	80	104	102	87
Black spruce	59	89	61	50
Balsam fir	46	82	71	58
Northern white cedar	97	116	106	94
Tamarack	57	99	85	55
White spruce	42	90	82	76
Oak-Hickory	69	78	71	63
Elm-Ash-Soft maple	56	86	75	60
Maple-Basswood	58	90	80	58
Aspen	41	34	33	28
Paper birch	58	92	81	61
Balsam poplar	41	33	31	31

Source: Jaakko Pöyry Consulting, Inc. (1992a). Projected ages for stands not clearcut were determined by adding 50 years to current age. See appendix 2 for more detail.

The changes in average age for aspen are due largely to harvesting, as demand is projected to be strong. At the same time, stands in reserved or otherwise unavailable status will continue to age. Consequently, aspen (and most other covertypes) will show a wider range of age classes than in the recent past.

Stand and tree age is also important as a major factor in determining tree size, quality, and value. For red oak, however, age may be deceptive as demand has been high for sometime and the quantity of high-quality timber is a concern. Locally, quality is problematic and depends heavily upon the history of stands with respect to grazing, logging, fire, etc.

Nominal rotation ages by covertype are shown in section 2.3.1 and range from 50 to 80+ years, but the actual age class distribution (many stands already older than the rotation age) and the need to schedule harvests over the entire study period precluded harvesting at rotation age for many stands.

Soil Resources Impacts
Soil resource impacts were developed by overlaying harvest locations on soil maps at a statewide scale. Harvest of merchantable bole did not remove either nitrogen or phosphorus beyond their rates of replenishment. Areas at risk for loss of calcium are most closely associated with harvest of aspen-birch and upland hardwoods on medium-textured soils and especially on coarse-textured soils (approximately 5 million acres are at risk for calcium loss). Loss of magnesium beyond rates of replenishment is especially associated with harvest on coarse-textured soils and organic soils. Under the base scenario, about 2.5 million acres are at risk for magnesium loss. Finally, potassium loss is primarily associated with harvest of aspen-birch on coarse-textured soils and the harvest of all deciduous types on organic soils. Under the base scenario, about 1.5 million acres are at risk for potassium loss.

For full tree harvesting, calcium losses increase slightly compared to merchantable bole harvest. In contrast, nutrient losses for magnesium and potassium are significantly increased.

The effect of nutrient losses on long-term site productivity are uncertain. Expectations are that nutrient losses, unless countered by inputs, will lead to diminished productivity in the long-term. Uncertainty remains over the levels of nutrients at which productivity may decrease.

Compaction and related disturbance would be most frequent on the well-drained medium-textured soils, which are the most common soils in the state, and the poorly-drained medium and poorly-drained fine soils which have the lowest strength.

Surface erosion rates were significant on less than 1 percent of the area harvested plus haul roads, and this significant impact was predominantly limited to well-drained soils which exist on steeper slopes in ecoregion 6.

Results for the medium and high scenarios are closely related to the acreage subject to harvesting and show a greater extent of impacts than under the base scenario.

Forest Health Impacts
All timber harvesting and forest management activities affect forest health; all have impacts. Those impacts range from nearly none (where the management activity is minimal) to very large (where major changes are brought about in the forest). Given changes, vulnerability to impacts is a function of the insect, disease, or health vector, the harvesting or management related disturbance that would hinder or favor its expansion or development, and the susceptibility of the forest as defined by vegetation patterns, forest age class structure, etc.

Certain assumptions were made as part of the analysis of significant impacts on forest health. In particular, it was assumed that the MNDNR pest management guidelines and other guidelines would be followed by all ownerships. If the guidelines are not followed, impacts of harvesting on the health of Minnesota's forests could be more severe. This is because the guidelines are intended to prevent pests and diseases from becoming established by avoiding the creation of conditions that are suitable for pests. The significant impacts projected to occur under the base level harvesting by forest type groups are developed for the major present and prospective pests and diseases. For most covertypes, insect and disease problems are closely related to the age class structure with older stands often, but not always, being the most susceptible. Thus harvesting, as it affects the age class structure, is an important factor in managing forest health. With the exception of unanticipated catastrophic outbreaks of pest or disease problems, forest health is manageable and can be improved.

Water Quality and Fisheries Impacts
Timber harvesting is, by nature, a disturbance to the forest and the landscape. As such, it could affect sedimentation, nutrient loading, changes to key aspects of the aquatic environment, and the amount, duration, and timing of runoff. The degree to which a given disturbance represents an *impact* is a matter of scale. For example, few if any landscape modifications associated with timber harvest will be detectable in large rivers such as the upper Mississippi. As one progresses further upstream, the probability of detecting impacts increases as changes outside of the identified standards and tolerances become more noticeable.

Application of the study significance criteria to the impacts identified indicates that the effects of timber harvest at the ecoregion level will not cause significant impacts. However, there will be a series of changes in the landscape and water resource. Most of those changes will be relatively local and short-term. Timber harvest which complies with Minnesota BMPs will have significantly fewer local water resource impacts than timber harvest carried out in the absence of such practices.

Projected Wildlife Species Impacts
Impacts on wildlife species were assessed by several criteria. Two of these are emphasized here. The first criteria was that an impact was significant if the available habitat of a species was projected to be changed by 25 percent or more *in any ecoregion.* Note that with this criterion, an impact occurred whenever a species in any ecoregion and decade met the criterion. The second criteria involved species federal or state listed as of special concern, threatened, or endangered or their habitat. With this criteria, an impact was significant if any timber harvest or forest management activity is projected to decrease the habitat and disturb a listed species by 5 percent or more

statewide. In all of these analyses, area of available habitat for each species serves as an index of population. It is this index that is modelled, rather than actual numbers of animals. Additional criteria considered lowland habitat, food species, habitat fragmentation and genetic variability.

Projected adverse significant impacts of timber harvesting on forest wildlife are shown in Table I.4. For the 173 species examined, 27, 44 and 53 percent are projected to be negatively impacted by the base, medium, and high scenarios on an ecoregion basis. Among species groups, no large mammals would be adversely impacted by any of the three harvest scenarios. Six small mammal species would be adversely impacted by the base and medium scenarios and eight would be impacted under the high scenario. Herps (amphibians and reptiles) show a similar pattern with the same number of impacts for the base and medium scenarios, but more species were negatively impacted under the high scenario. Forest birds are projected to have a major increase in the number of species negatively impacted as harvesting moves from the base to the medium scenario level (from 28 percent to 50 percent impacted). The high scenario shows a further but less dramatic increase in the number of species negatively impacted compared to the medium scenario. Fifty-six percent of the bird species are negatively impacted in one or more ecoregions under the high scenario.

Table I.4. Number of species projected to be significantly and negatively impacted on all forest lands by harvest scenario. The first number in a cell is the number of species showing a 25 percent or more decline for a species *in any ecoregion* or a 5 percent or more decline *statewide* for a species listed as endangered, threatened or of special concern. Values in parentheses show number of species projected to decline *statewide* by 5 percent or more for species listed as endangered, threatened, or of special concern or 25 percent or more for all other species.

Species Group (Number of species)	Scenario		
	Base	Medium	High
Small Mammals (22)	6 (0)	6 (2)	8 (5)
Large Mammals (5)	0 (0)	0 (0)	0 (0)
Birds (138)	39 (5)	69 (8)	78 (44)
Herps (amphibians and reptiles) (8)	1 (0)	1 (1)	5 (1)
All (173)	46 (5)	76 (11)	91 (50)

Table I.5 illustrates the projected changes in habitat-based wildlife population indices on a statewide basis, but interpretation is important. The table shows the number of species by species group that increase, remain stable or decrease statewide. However, an increase in already common species does not in a biological sense balance a decline in a rare species. Further, harvesting tends to favor early successional species or, in some instances, those that are not obligatory forest inhabitants, i.e., species that do not necessarily require forest habitat.

Table I.5. Number of species of interest that are projected to decrease by 25 percent or more, remain stable, or increase by 25 percent or more, statewide on all forest lands by harvest scenario.*

Species Group (number of species)	Decreasing			Stable			Increasing		
	Base	Med.	High	Base	Med.	High	Base	Med.	High
Small Mammals (22)	0	2	4	21	19	16	1	1	2
Large Mammals (5)	0	0	0	5	4	4	0	1	1
Birds (138)	5	8	43	111	106	61	22	24	34
Herps (amphibians and reptiles)(8)	0	1	1	6	5	6	2	2	1
All (173)	5	11	48	143	134	87	25	28	38

* *Stable* is a change of less than 25 percent. No special consideration given to species listed as endangered, threatened, or of special concern.

Recreation and Aesthetic Impacts

Harvesting and the development of roads needed to access timber from forests within unroaded areas (primitive or semiprimitive categories of land) is indicative of an increased level of disturbance. The total forest area in primitive and semiprimitive categories is 3.1 and 9.6 percent, respectively. Of these, 0.4 and 7.2 percent, respectively, occur on timberlands. Improved access provides opportunities for additional use by people who depend on motorized access. However, this will likely displace a proportion of existing users and will impact animals that are adversely affected when the level of human contact increases. Based on study criteria, the significantly impacted areas under the base scenario correspond to approximately 32 and 26 percent of the timberland area in the primitive and semiprimitive nonmotorized categories, respectively. Under the medium scenario these impacts would rise to 34 and 29 percent. Under the high scenario the impacts would be 43 and 35 percent, respectively, for primitive and semiprimitive categories.

The study also considered the use of visual management guidelines (VMGs), which are planning tools used by the federal and state ownerships to reduce visual impacts. Significant impacts can be avoided where visual planning is used to identify *where* and *how* harvesting and associated forest operations should take place, i.e., road location and design, use of buffers, size and shape of cut, and slash and debris disposal practices. Harvesting can reduce the aesthetic experience for subsequent users, therefore limiting the recreation value of harvested areas and the adjacent unharvested areas. However, harvest operations and associated roading can also create additional recreation opportunities of a more developed type.

Based on study criterion, significant visual impacts occur when timber harvesting and forest management activities do not follow VMGs. Only the USDA Forest Service and the MNDNR are assumed to use VMGs. Analysis of all other ownerships found that 58.7 percent of these timberland areas harvested under the base scenario would not be treated according to VMGs and these are therefore judged to be significantly impacted. As determined by the higher acreage harvested, the medium and high scenarios showed higher levels of impacts on the other ownerships, 67.1 percent and 74.1 percent, respectively.

Impacts on Unique Cultural and Historic Resources

Heritage resources include cultural landscapes, structural remains, archaeological remains, Native American traditional use sites, and cemeteries. These were considered significantly impacted if destroyed or, in the case of cemeteries, disturbed. However, use of this significance criterion requires that the term *destroyed* be defined. The term destroyed has been interpreted as damage to a site such that its scientific, cultural, or spiritual values are diminished in whole or in part. This interpretation results in a *conservative* assessment of impact by including those sites with a partial loss of values; however, this is appropriate for the purpose of a GEIS.

Given these definitions and interpretation the significant impacts are predicted for each type of heritage resource. There is insufficient data to assess, even qualitatively, the extent that sites will be impacted. However, the number of impacts will increase as the level of harvesting increases.

Economic Impacts Overview

Development of precise conclusions on the overall state economy impacts from increased timber harvesting were not possible. The available data and the modelling tools used did indicate that employment in certain sectors of the economy would increase. However, due to limited data availability, conclusions on economic changes in the tourism and recreation industries and related costs of possible mitigation efforts were not possible. These limitations prevented the study from assessing detailed impacts to Minnesota's overall economy associated with increased timber harvesting.

Additionally, the study did not seek to analyze potential costs and benefits of increased timber harvesting or alternative management scenarios except in the limited area related to the timber industry's increased employment and financial flows. Because of the necessitated narrow scope of this economic analyses, they should be viewed as suggestive of trends or directions only.

With the limitations noted, table I.6 summarizes economic impacts in terms of employment, additional employee compensation and total industrial output for the three harvesting scenarios. The medium scenario represents expansion of existing capacity while the high scenario would represent the development of new mills. The impacts are presented in terms of direct, indirect, induced, and total effects as determined from an input-output model. Direct impacts are the increased employment, income, and output attributable to the expansion of activity. Indirect impacts are due to increases in purchase of raw materials and other goods and services required for the expansion. Induced effects are those due to the consumer purchases that result from the increased employment generated by the original expansion.

The medium and high scenarios would also require substantial staffing and funding increases to handle the increase in workload for planning and administration of timber sales.

Table I.6. Summary of statewide changes: direct, indirect, and total effect of increase in employment, additional employee compensation, and increase in total industrial output by harvest scenario.*

Impact	Medium Scenario			High Scenario		
	Direct Effect	Indirect Effect	Total Effect	Direct Effect	Indirect Effect	Total Effect
Employment (jobs)	352	3,788	6,752	3,059	18,424	35,094
Additional employee compensation (millions of $)	16.9	84.4	146.4	133.2	418.9	790.4
Total industrial output (millions of $)	611.2	297.0	1,059.5	3,084.0	1.451.2	5,324.1

Note: Induced effects may be estimated by subtracting direct and indirect effects from total effect.

Impacts on the Tourism and Travel-based Industries

A lack of information on relationships between the level of harvest and its consequences for the tourism and travel industry precluded the quantification of impacts. However, some general observations are possible. Resorts and other tourism-based facilities depend on the visual amenity of the surrounding forest for their setting. It is thus likely that individual resort operations will be adversely impacted by visually obtrusive harvesting operations within their viewshed or along access routes. The consequences for the use levels of the facility or the recreational experience of the users would depend on the expectations of the clientele attracted to the resort. The overall result is complicated by the fact that increased access to forest areas provided by harvesting often increases the level of recreational activity, however, the type of activity (primitive versus motorized) may change. Use of VMGs can reduce the area adversely impacted and the duration of impacts.

Base Scenario Review

The base scenario was modelled using the existing levels of roundwood consumption as the basis for demand over the modelled period of 50 years. This assumes that no further forest-based industrial developments take place within this period.

The base level of harvesting is well below the level of tree and forest growth potential if timber production was the only objective. It also appears sustainable from a biological standpoint as it would allow retention of other forest characteristics and values of concern in this study. As with any modelling effort, this conclusion is valid within a range of error and to the degree that the assumptions employed are representative of actual conditions. In this context, based on long-term (modelled) sustained yield analyses, a timberland area of approximately 7.4 million acres could sustain close to a 4 million cord annual harvest level. This would leave over 7.5 million potentially harvestable acres of timberland unharvested over the long-term. This analysis suggests that large areas of timberland could potentially be shifted towards other nontimber management objectives, such as wildlife habitat, without severely impacting timber production at the 4 million cord level in the long-term.

This situation applies to aspen, but with an important caveat. Given significant increases of demand coupled with an unbalanced age class distribution, there will likely be constraints in the supplies of this species during the middle of the modelled period. In order to meet the prespecified statewide timber demand levels, the base, medium, and high scenario projections assumed that 25 percent of the demand for this species would be transferred to the northern hardwood species.

The projected harvesting patterns indicate that harvesting is projected to occur in virtually all forested regions of the state. This pattern reflects the well-developed road network in Minnesota and the decentralized nature of the timber industry. In essence, few stands in Minnesota are ruled out for harvesting because of their location.

Base Scenario Significant Impacts Summary

Analysis considered impacts statewide and by seven ecoregions. The base scenario identified the following significant impacts:

1. projected significant loss of forest area in ecoregions 1, 2, 3, and 4 due to land use change (also includes consideration of the loss of timberland in the north);
2. projected harvesting affecting patterns of forest cover in areas of mixed land use (considers amount, type, and fragmentation of cover important to wildlife habitat);

3. projected changes to tree species mix (important to maintaining biodiversity and wildlife habitat; four tree species show significant declines in stem number);
4. projected changes in the age class structure of paper birch (important to community replacement capability for this species; the young age classes appear deficient in acreage for replacing the older age classes);
5. projected harvesting affecting genetic variability of plant or animal species (important to maintaining biodiversity; critically endangered, endangered or threatened communities are identified);
6. projected harvesting affecting federal- or state-listed plant species of special concern, threatened, or endangered or their habitats (statewide 9, 7, and 37 species listed as endangered, threatened, or of special concern are projected to be adversely impacted by harvesting);
7. changes in the susceptibility and vulnerability of covertypes to forest health risks (important to community stability and productivity; largely dependent on age class structure and the amount and type of harvesting activity);
8. projected harvesting affecting site nutrient capital, i.e., nutrient supplies present and/or actually available (important to sustainability of forest growth and yield; results indicate nutrient losses with certain types of harvesting on various types of soils; approximately 5 million acres are at risk for calcium loss);
9. projected harvesting affecting soil physical structure (important to maintenance of forest growth; the actual area where significance criteria for compaction are exceeded is estimated at 330,000 acres plus haul road area);
10. projected harvesting causing accelerated erosion from forest roads (important to site productivity and water quality; about 25,000 acres plus haul roads are estimated to be impacted with major concern in ecoregion 6);
11. projected changes in the populations of forest dependent wildlife (by changes in amounts of habitat available; 46 species, about 25 percent of all wildlife species studied, were projected to be significantly impacted). Negative impacts are projected for the ringneck snake, beaver, northern flying squirrel, gray and fox squirrels, bobcat, lynx, as well as 39 bird species, for example, Cooper's Hawk, Great Gray Owl, Pileated Woodpecker, Eastern Bluebird, Ovenbird, Song Sparrow, Yellow Warbler and Hooded Warbler;
12. projected harvesting affecting populations of endangered, threatened, or special concern species of animals (two such species, Louisiana Waterthrush and Red-shouldered Hawk are projected to be negatively impacted);

13. projected harvesting affecting patterns of mature lowland conifer stands (important to wildlife habitat; many important patches of lowland conifer habitat may be lost with harvesting);
14. projected harvesting affecting the availability of food producing trees (important to wildlife; particularly oaks and other mast producing species);
15. projected harvesting in the absence of VMGs on visually sensitive areas (important to aesthetics and recreational use; visual aspects of landscapes and recreational settings are impaired);
16. projected development of permanent forest roads in primitive (undeveloped) and semiprimitive nonmotorized areas (important to maintaining primitive or undeveloped recreational opportunities; harvesting leads to a loss of such areas); and
17. projected harvesting affecting unique cultural and historical resources (important to the protection and integrity of these resources; disturbance from harvesting can effectively destroy these resources).

Base Scenario Recommended Strategies
Numerous strategies were identified to mitigate the significant impacts projected to occur at the base level of harvest. These recommended mitigations are presented under three categories which reflect their main focus:

1. site-level responses;
2. landscape-level responses; and
3. forest resources research.

Site-level Responses: Strategies in this category are intended to modify operational procedures used in the planning and execution of timber harvesting and forest management activities on an individual site or local scale. The responses considered are:

- ***Modifications to harvesting practices and equipment.*** Modifications to the practices and equipment used in Minnesota can be used to mitigate significant impacts projected to occur as a consequence of timber harvesting and forest management activities. Such modifications include:
  - *Retain Slash* (including bark where appropriate). This strategy is intended to modify harvesting systems and techniques in order to reduce the loss of nutrients from harvested sites and to maximize habitat values for small animals in the resulting cutovers. This must also encompass logger safety considerations.
  - *Equipment and practices for use in multiple entry harvesting operations.* The projected increase in the use of multiple entry, i.e., thinning, or uneven-aged silviculture will require modifications to existing safe equipment and practices to avoid excessive damage to retained stems during harvesting operations.

- *Modify season of equipment operation to minimize compaction.* This strategy is intended to reduce compaction by identifying susceptible sites and limiting operations on those sites to periods when the risk of compaction is lowest.

- ***Modifications to silvicultural practices.*** These specify the circumstances where modifications to normal silvicultural practices are required to maintain wildlife habitat and aesthetic values. Typically, the modifications represent a shift from clearcutting to techniques that retain a proportion of the stand following harvesting.
  - *Patterns of forest cover in areas of mixed land use.* A strategy to mitigate the negative impacts of changing patterns of forest land in the southern parts of the state requires modifications to the silvicultural practices used and specification of the size of individual cuts. Thinning or uneven-aged management should be used where feasible.
  - *Retention of key habitat requirements in clearcut areas.* Certain key habitat can be retained within clearcuts by retaining snag trees, trees with cavities; and retention of conifer patches and isolated trees when harvesting in predominantly deciduous forests.
  - *Retention of cavity trees* or mature trees that are likely to produce cavities in stands that are clearcut, will provide nesting and hiding places for a wide range of birds as well as some mammals in postharvest forests.

- ***Protection of sensitive sites.*** Sensitive nest sites, habitats, and rookeries should be identified and protected by appropriate buffers.

- ***Increasing the wood fiber productivity of timberlands.*** There are two elements to the strategy. The first provides short- to long-term benefits, and the second provides medium- to long-term benefits.
  - *Increasing Utilization.* This element is intended to increase utilization by making maximum use of the volume of wood available for harvest in any particular stand, as well as optimizing use at mills.
  - *Increasing Productivity.* Regeneration to full stocking levels and species-site matching are two of the most readily implemented and effective ways to increase the productivity of timberlands on a statewide scale. Thinning and management to reduce pest damage can also provide important gains.

Landscape-level Responses: These are typically long-term or broad-based solutions that require extensive analysis and/or planning to identify and achieve the intended objectives of developing regional or statewide responses. These responses also provide direction and coordination across ownerships. The strategic responses considered here are:

- ***Measures to reduce the area of forests converted to other land uses.*** This strategy seeks to develop policy instruments to discourage conversion of forested land to other, nonforest, land uses.
- ***Balancing age class and covertype structure.*** This strategy seeks to develop statewide objectives that cross ownership boundaries that addresses future age and/or size class and covertype structure goals.
- ***Riparian corridors.*** This strategy identifies environmentally sensitive areas near waterbodies. Harvesting can be carried out within these buffers; however, uneven-aged management or thinning rather than clearcutting are the most appropriate silvicultural systems. Riparian corridors are a special case of a broader strategy referred to as *connected landscapes*, which are wide corridors of mature or selectively cut forest between core areas such as patches of old growth, research natural areas, and scientific and natural areas. Connected landscapes are considered a potentially important tool. However, more research is needed to determine its effectiveness and approaches for implementation.
- ***Extended Rotation Forests (ERF).*** This strategy provides one means to manipulate age class distributions. ERF can be described as any forest managed on a rotation length that is longer than that recommended for the covertype for timber production. Management as ERF does not preclude harvesting and therefore does not remove lands from the timberland base; yet it helps provide many of the biodiversity features of older forests over large areas.
- ***Protection of sensitive sites for plant species.*** This strategy would exclude or modify harvesting in the known locations of rare plant species and rare plant communities that are likely to be sensitive to harvesting impacts and should be excluded from harvesting.
- ***Landscape-based road and trail plan.*** This strategy would involve planning and coordination between ownerships to develop landscape-based road and trail plans, and would cover the development of new roads (particularly in primitive and semiprimitive nonmotorized areas); long-term access needs; and closure policies.
- ***Develop VMGs.*** This strategy requires development and widespread application of VMGs. VMGs, especially if used in conjunction with nonpermanent roads, give attention to the important social attributes and long-term benefits of primitive recreation opportunities and reduce the likelihood of adverse visual impacts.
- ***Integrated Pest Management (IPM) strategies.*** The state should initiate and oversee development of IPM strategies for the major pests likely to increase as a consequence of timber harvesting.

Forest Resources Research: Strategies in this category are intended to: obtain the information needed to undertake strategic and operational planning; monitor changes at the landscape- and site-level; and provide the basis for developing management direction and planning tools. The responses considered here are:

- ***Monitor the age class and covertype structure of the state's forests and their pattern across the landscape.*** This strategy would develop monitoring of the age class and covertype structure of the state's forests and information on landscape patterns. This information is important to planning and analysis in a wide range of subject areas.
- ***Undertake an inventory of the state's biodiversity features.*** This strategy will speed up the identification of the occurrences of rare plant and animal species and communities, and key habitat features for wildlife species.
- ***Conduct an inventory of old growth forests across all ownerships.*** This strategy, in conjunction with the above inventory of biodiversity features, will speed up the identification of important sites and ensure their protection.
- ***Develop and fund a research program to investigate the effects of timber harvesting and forest management activities on the tourism and travel industry in Minnesota.*** This strategy is intended to identify and quantify the relationship between changes in the forest resource and induced changes in recreational/tourism user patterns in forested areas in the northern part of the state.
- ***Upgrade and maintain a listing of known heritage resource use sites in the state.*** These resources include cultural landscapes, standing structures, archaeological sites, cemeteries, and traditional use sites. This strategy will upgrade the quality, extent and utility of the database on the state listing of known sites and their locations and aid their protection.

Base Scenario Cumulative Unmitigated Significant Impacts

The mitigation strategies described in the previous section will likely mitigate many of the significant impacts projected to occur under the base level of harvesting. However, some unmitigated impacts such as loss of forest area and timberland in the north, loss of soil nutrients on some sites, and disturbance of archaeological resources will remain, despite implementation of the mitigation strategies. These impacts will likely be concentrated on NIPF lands as a consequence of likely lower standards of planning and supervision of field operations, compared to large ownerships with professional staffing. However, the mitigations proposed would reduce the likelihood of significant impacts that might degrade the long-term sustainability of the state's forest resources. The only exception is the projected reductions in the nutrient capital of some low productivity sites. These reductions will need to be carefully monitored. The relationship between changes in nutrient capital and changes in site productivity also needs to be closely observed.

The harvesting projected to occur at the base level (4 million cords) will likely be sustainable in a broad sense. That means this timber harvest level can be continued indefinitely and other forest resource characteristics such as soil productivity, water quality, wildlife habitat, and aesthetic values can be maintained *providing recommended mitigation strategies are implemented within the next few years.* There will be changes to the forest; however, the most profound of these will be a consequence of the natural forest aging process.

Medium and High Scenarios Overview

The previous section describes the changes projected to occur under the base scenario and the associated significant impacts and mitigation strategies. The differences in identified impacts projected to occur at the medium and high scenarios, compared to the base scenario, lie in the *degree* of impacts rather than the *types* of impacts. Similarly, the unmitigated impacts of the medium and high scenarios are the same type as those for the base scenario, but they differ in degree. As an example, the medium scenario impacts certain wildlife habitat availability to a greater extent than the base scenario, but the type of impact (say habitat loss) is the same. For any significant impact criteria, there is also only one threshold for significance. Beyond that threshold, impacts can assume increased importance, but that does not change the type of impact as defined here or its significance. In particular, the high scenario suggests many impacts are large and would be left unmitigated.

For most covertypes, the differences between the three scenarios are related to the intensity of timber harvesting and related forest management activities at the landscape-level. The types of site-level impacts will remain the same under the medium and high scenarios, although would typically apply to more area than under the base scenario. For example, 900,000 acres were projected to be significantly affected by compaction under the base scenario; while 1,025,000 acres were projected to be affected under the medium scenario. Other area-based impacts include the remaining impacts on soils (nutrient loss and erosion), impacts on cultural and historic resources, and impacts on primitive and semiprimitive areas.

In addition, the number of animal species affected (increases and decreases in populations) increased from the base to the medium, and medium to the high levels of harvesting (see tables I.4 and I.5). These changes were a consequence of changes in areas of particular forest types affected, and the projected intensity of harvesting reflected in changes in the age class distributions. Similarly, the increased intensity at the higher levels of harvesting also affected other nontimber values including aesthetics and recreation values, covertype species composition, and rare plants and plant communities.

The level of economic benefits evaluated in this study as accruing from the medium and high scenarios increased relative to the base level scenario.

Recall that these economic benefits were previously noted to be limited to only those for which data were available, primarily forest industry employment and financial flows. The studied increases in the forest industry sector were accompanied by flow on benefits to other sectors that service these industries or are otherwise likely to benefit from increased levels of economic activity. The increased levels of harvesting will increase direct and indirect employment.

The impacts of the increased levels of harvesting on the tourism and travel industry are unclear. These impacts are likely to be linked to the intensity of harvesting with increasing harvesting having an adverse impact, but in ways that are difficult to quantify.

The most important differences between the scenarios are those related to the long-term sustainability of the levels of harvesting. An analysis of long-term sustainability indicates that, with some modifications, the levels of demand specified under the base and medium scenarios are sustainable in the long-term. *However, harvest at these levels would need to implement the recommended mitigations relatively soon to avoid or mitigate the significant impacts described under these scenarios.* In contrast, the levels of harvesting specified under the high scenario could not be sustained for timber assuming the levels of productivity investments and net increments (forest growth) used in the GEIS analysis. Additionally, there is concern that some significant impacts to forest resources at that level of harvest could not be fully mitigated.

The results, as based on the modelling techniques and assumptions used, indicate that a level of approximately 5.5 million cords is the maximum that could be sustained. *However, these conclusions also assume the site-specific or other mitigations below the modelled level of resolution are implemented within the next few years and do mitigate otherwise significant impacts.* This assumption is critical since the 5.5 million cord harvest level was not explicitly examined for impacts as was done for the base, medium, and high scenarios. Also, at this level of harvesting there is little flexibility available to meet timber supply demands while making provision for nontimber values. Importantly, if some of the significant impacts cannot be effectively mitigated, then the 5.5 million cord level would not be sustainable as described for this study.

The high level of harvesting is still below the level of tree and forest growth potential if timber production was the only objective. However, harvest levels above 5.5 million cords appear sustainable only if, in addition to effective mitigation of significant impacts, the loss of forest land projected in the north was halted, and substantial investments in forest management are made to improve productivity. Clearly, such harvest levels would require long-term investment. Additionally, such harvest levels might require the USDA Forest Service allowable sale quantities on the two national forests in Minnesota to be increased.

The high level scenario was not analyzed with a view to examining it as a feasible goal for the statewide level of harvest. The level was specified as the estimated maximum level of harvesting that could be sustained from a timber production standpoint. As such, it served a useful analytical purpose. The analysis has shown that, with the assumptions and constraints applied, this level is not achievable on a sustainable basis.

Suggested Strategic Programmatic Responses

The GEIS presents a variety of mitigation recommendations at each of the three alternative levels of statewide timber harvest that are required of each level of harvesting to assure mitigation of the identified significant impacts. While such tactical mitigations are extremely important and useful study outcomes, the GEIS also serves the broader purpose of providing direction on the types of policy (programmatic) strategies the state should consider to help verify and effectively address and implement these recommended mitigations. The various mitigation options can be integrated into a comprehensive set of policy strategies that can serve as the focus for an implementation program. This will require a well-coordinated statewide policy formulation effort aimed at establishment of the following:

Forest Resources Practices Program

The GEIS study team recommends that the most coordinated way to collectively consider the site-level recommendations is through a *state comprehensive Forest Resources Practices Program* (FRPP). Such a program would serve as an umbrella structure for the implementation of a wide range of specific management prescriptions. These management prescriptions could include guidelines that address the following activities associated with timber harvesting, and that are recognized in the GEIS as desirable approaches to mitigating adverse impacts:

- timber sale design and layout to incorporate nontimber concerns (e.g., visual BMPs, wildlife habitat, protection of rare plant occurrences, and archeological sites);
- methods for the disposal/redistribution of slash and other woody biomass;
- establishment and management of riparian corridors;
- BMPs for water quality;
- biomass retention (e.g., inclusion of snags);
- postharvest reforestation practices;
- style and methods of road construction;
- managing for visual/aesthetic objectives;

- managing for protection of unique historical/cultural resources; and
- traffic control/site amelioration to minimize compaction.

The following implementation steps are associated with adoption of the new FRPP:

- The FRPP should initially be voluntary to help avoid costly public and private steps. However, the FRPP must also clearly define the following elements:
  - logger, forest operator, and forester certification or licensing programs;
  - statistically sound monitoring and evaluation of compliance activities, wherein if compliance falls below a specified threshold for two consecutive years, mandatory compliance rules become effective automatically for the area out of compliance, and stay mandatory until three consecutive years of successful compliance are once again achieved;
  - wood purchasing industries will be encouraged to adopt a forest operators/loggers code of practices (COP) that is congruent with forest practices guidelines. This COP would then be introduced into all forest operators/loggers contracts to ensure statewide standard compliance; and
  - the state should work with its own agencies and departments, the counties and especially the USDA Forest Service to develop financial assistance and incentives programs for private landowners, operators, and loggers.

Sustainable Forest Resources Program

The GEIS study team recommends that to successfully mitigate, in advance, unacceptable *landscape-level* impacts from timber harvesting and forest management activities, a statewide *Sustainable Forest Resources Program* (SFRP) should be adopted. This initiative would provide a broad, landscape-level focus on managing Minnesota's forest resources for a variety of outputs and objectives. The basic objective of this SFRP would be to establish a statewide structure for: systematically identifying existing resource conditions; evaluating these conditions in light of past forest resource trends; determining desired future forest conditions; identifying and developing specific strategies necessary to achieve those desired future forest conditions; and providing feedback to assess the success in achieving those objectives.

In contrast to forest or land use planning efforts conducted by federal, state, and county agencies, the SFRP would identify and set goals for desired future forest conditions that *transcend ownership boundaries*. In addition, the temporal requirements associated with achieving these goals could be longer-term than existing individual planning efforts. Achieving desired statewide forest covertype and age class goals along with developing coordinated plans to protect especially sensitive plant and animal species are examples of mitigations that would be administered through a SFRP. The steps in developing and enhancing such goals are:

- identify present and past resource conditions;
- identify future forest condition goals;
- formulation of management alternatives to achieve these goals; and
- monitoring and evaluation (feedback).

Forest Resources Research Considerations
In addition to recognizing specific gaps in the existing information relating to Minnesota's forest resources, the GEIS study process underscored the need to focus future forest resources research efforts to address the following information needs:

- multidiscipinary considerations;
- broadening spatial and temporal dimensions;
- linkages to resource management; and
- investment and response linkages.

As well as identifying information gaps, the GEIS study process also noted areas where additional research will be needed to fully mitigate projected timber harvesting and forest management significant impacts. Examples of research initiatives that could be included as foundation steps for this program are:

- to develop a better understanding of timber harvesting and forest management impacts on ecosystem functions and processes;
- to identify the full role of forest soils and their various conditions in forest resources productivity in Minnesota;
- to provide the scientific basis for setting and refining desired age class and covertype goals to meet biological diversity objectives;
- to determine the interaction between the level of timber harvesting and forest management activities and the tourism/outdoor recreation industry;
- to determine management techniques and impact assessments for forest pests;
- to identify and evaluate low impact timber harvesting techniques and technologies applicable to Minnesota;
- to identify potentially complementary forest industries for Minnesota; and
- to fulfill some of the monitoring functions identified under the harvesting practices and SFRP.

In order to meet previously identified research program goals and objectives, and effectively deal with the other issues raised here, the GEIS study team recommends the state assume the central role for the development of a comprehensive cross-landowner, statewide *Forest Resources Research Program* (FRRP). The statewide FRRP should also become the driving force for extension, technology transfer, and continuing education activities. This applies to current programs and those to be developed in cooperation with the Minnesota Extension Service (MES).

The GEIS study team recommends the establishment of a Minnesota Applied Forestry and Harvesting Program within the statewide FRRP and in coordination with the MES. The program would be jointly administered by the MNDNR and the MES and would:

- be the basis of certification/licensing for employment and subcontract work in forest areas for all landowners and agencies in Minnesota as required by the COP;
- integrate forest management, harvesting, and other forest multiresource subjects into a comprehensive extension education program; and
- be supportive of the needs of the FRPP and SFRP.

Minnesota Board of Forest Resources
The study considered a range of possible administrative and organizational structures to carry out the major strategic program recommendations (FRPP, SFRP, and FRRP). These included the identification of the advantages and disadvantages of the EQB, MNDNR, and the Minnesota Forestry Coordinating Committee (MFCC) and a forestry board in this role. Important attributes considered for the organization included the need to:

- provide opportunities for representative stakeholders of Minnesota's forest resources to provide input;
- provide an environment that fosters interagency coordination;
- have defined opportunities and procedures for providing public input to decision making;
- be recognized as the focal point that can provide input to legislative and executive branches on statewide forest resource policy matters;
- be recognized as the organizational entity with the authority to implement the strategic program recommendations;
- have adequate staff and financial resources to fully accomplish program objectives; and
- have the authority and responsibility without being in conflict with other existing agency policies or programs.

Implementation of the broad, strategic programmatic recommendations developed here will need to be carried out through means that involve executive and legislative branch participation. While the FRPP, SFRP, and FRRP efforts *could* be developed independently, the GEIS study team analysis concluded that a forest resources board is the most appropriate administrative structure for implementing these initiatives. As such, the team views the creation of a forest resources board as crucial to effectively develop these three major policy initiatives. Functional responsibilities of the board should include the following:

- to coordinate all forest resource issues, policies, plans, and programs;
- to serve as the primary advisory body on forest resource issues to the executive and legislative branches of the Minnesota state government;
- to design, implement, administer, and assume responsibility for the FRPP, SFRP and FRRP; and
- to work with both the executive and legislative branches of government to secure funding, and to implement the organizational structures required to meet its mission.

As a means of implementing the strategic policy responses presented in this section, the GEIS study team recommends the initial focus should be on *establishing* a state board of forest resources. As the recommended umbrella structure under which the site- and landscape-level strategic policy and forest research initiatives are largely carried out, it is essential that this organizational structure be created in advance of the other policy initiatives. Only after a forest resources board is created can these other strategic policy responses be fully implemented. As an initial step in the development of this board, the GEIS study team suggests the creation of an ad hoc task force with broad representation that includes both legislative and executive branches. This task force could decide upon the key mission, authority, functions, and structure of such a board. The intended outcome of this task force would be draft legislation to create a Minnesota Board of Forest Resources.

Conclusions

Two broad issues are paramount: biodiversity and the social and economic health of our society. Analyses in this study indicate that few aspects of either issue are in peril at this time in Minnesota. However, the actions taken now can do much to minimize resource problems and provide opportunities for society in the long-term.

Follow-up efforts need to ensure that, to the extent desirable and practical, the recommendations put forward in this assessment are fully implemented. The model runs used to project future forest conditions for the three harvest scenarios employed mitigation strategies, such as for 20 percent ERF on state and federal lands, reservation of old growth, and buffer strips along certain waterways for wildlife. The model runs necessitated employment of these strategies to reduce the cumulative negative impacts of harvesting during the 1990-2040 timeframe. Therefore, actions are also necessary to implement these and other recommendations of the GEIS in the field as soon as possible. The GEIS study team also suggests that efforts should be undertaken to disseminate the information and findings of the GEIS to the state's land management organizations. In addition, educational efforts should be directed at disseminating the findings and recommendations of the GEIS to the 130,000 NIPF owners, as they are collectively responsible for managing nearly one-half of the state's forest land base. Workshops, seminars, and other similar forums are suggested as appropriate ways to disseminate the GEIS findings and recommendations.

The GEIS study team strongly recommends that processes to implement these recommendations should begin immediately. Public interest in the management and protection of Minnesota's forest resources has grown tremendously in the last few years. The GEIS study process has characterized many of the important forestry issues, providing a focus for the debate about the extent of problems or concerns, as well as how to effectively deal with them. Given this momentum, the study team believes successful implementation of the study's recommendations will be enhanced by their prompt consideration by the appropriate policymakers.

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LIST OF PREPARERS

Contractor

The contractor hired by the Minnesota Environmental Quality Board (EQB) to prepare a Generic Environmental Impact Statement (GEIS) on timber harvesting and forest management in Minnesota is Jaakko Pöyry Consulting Inc. of Tarrytown, New York.

Qualifications

Jaakko Pöyry Consulting, Inc. is a member of the Jaakko Pöyry Group, the world's leading independent consulting and engineering organization specializing in forestry and forest industry development. Jaakko Pöyry was established in 1958, and has its world headquarters in Helsinki, Finland. It employs nearly 6,000 people in over twenty countries.

Since the 1960s, the Jaakko Pöyry Group has focused on the environmentally sound development and sustainable management of forest resources, based on progressive forestry practices. The Group has a worldwide reputation as advisor to forest industries, national governments, and international agencies. Jaakko Pöyry companies have carried out forest resource management and utilization planning assignments in more than 100 countries, acquiring extensive expertise in all aspects of natural resource and ecosystem management. Much of this experience is related to the forest sector Master Plans and forest industry projects, and the Group has carried out approximately 60 forest-based/related projects over the last five years. In particular, the Jaakko Pöyry Group has considerable experience in conducting environmental impact assessments and environmentally-based development plans for a region, based on an objective, analytical, and comprehensive approach that includes estimating the economic impact of the recommendations.

Personnel

For the Minnesota GEIS project, Jaakko Pöyry has created a multidisciplinary team led by senior consultants from the USA, Australia, Canada and the United Kingdom. Jaakko Pöyry personnel were provided through the Jaakko Pöyry consulting network, and directed by the Jaakko Pöyry Consulting, Inc. office in Tarrytown, New York.

Because a detailed local perspective was an essential element of the project, Jaakko Pöyry subcontracted with a select group of scientists drawn largely from the University of Minnesota (UofM). In addition to their technical abilities, these experts were hired because of their thorough understanding of the practices and issues associated with managing, using, and protecting Minnesota's forest resources. Collectively, these scientists contributed expertise in: forest growth modelling, forest ecology, biometrics, forest economics, timber supply analysis, water quality, fisheries, entomology, watershed management, wildlife, soils, forest health, remote sensing, aesthetics, landscape architecture, forest recreation, cultural resources, forest policy, wood utilization and harvesting, and database management. A complete listing of all GEIS study participants is provided in section 2.1 of the main report.

1 INTRODUCTION

1.1 Minnesota Environmental Quality Board

1.1.1 Authorization

The Minnesota Environmental Quality Board (EQB) was established by the Minnesota Legislature in 1973 to serve as an interdepartmental forum for addressing and resolving environmental problems and issues.

1.1.2 Responsibilities

Legislated responsibilities of the EQB are to: (1) initiate interdepartmental investigations into state environmental problems; (2) review and coordinate the environmental programs of state agencies to ensure compliance with state environmental policy; (3) review the rules and criteria of state agencies for granting and denying environmental permits; and (4) coordinate the development of legislative proposals submitted by state agencies (MS 116C.04, Subd. 2, 1990).

In practice, the EQB accomplishes these responsibilities through the administration of specific programs and activities such as the state's Environmental Review Program, Power Plant Siting and Pipeline Routing, and Water Resource Planning. Staff support for EQB activities are provided by the Minnesota Planning Office, although member agencies may also assign their own staff to work on specific projects.

1.1.3 Membership

The EQB is a 15-member executive branch board, consisting of both state agency administrators and citizens. The chair of the EQB is appointed by the governor and is considered a representative of the governor's office. The nine agency administrators represented on the EQB include the commissioners of Natural Resources, Pollution Control, Public Service, Agriculture, Health, and Transportation; the directors of the Office of Waste Management and Strategic and Long-Range Planning; and the chair of the Board of Water and Soil Resources. The five citizen members are appointed by the governor at staggered, four-year terms. Current membership of the EQB is as follows:

- Robert Dunn, chair (governor's representative)
- Rod Sando, Department of Natural Resources
- Charles Williams, Pollution Control Agency
- Kris Sanda, Department of Public Service
- Elton Redalen, Department of Agriculture
- Mary Jo O'Brien, Department of Health
- James Denn, Department of Transportation
- John Chell, Office of Waste Management
- Linda Kohl, Minnesota Planning Office
- D. James Nielson, Board of Water and Soil Resources
- Bruce Bomier, citizen member
- Carolyn Engebretson, citizen member
- Deanna Fairbanks, citizen member
- Douglas Magnus, citizen member
- Paul Toren, citizen member

1.2 Generic Environmental Impact Statements

1.2.1 Authorization

A Generic Environmental Impact Statement (GEIS) is a specific form of environmental review that can be used to study certain types of projects not adequately reviewed on a case-by-case basis. The authorization for conducting alternative forms of environmental review, such as a GEIS, is found in Minnesota's Environmental Policy Act, MS 116D.04, Subd. 4a. Specific criteria for determining the need for a GEIS and the unit of government most appropriate to oversee its preparation, and the general process and content of a GEIS are identified in Minnesota Rules, part 4410.3800. Although only the EQB is authorized to order a GEIS, any person or government body may request the EQB to consider the preparation of a GEIS.

1.2.2 Unique Attributes

A GEIS differs from project-specific environmental impact statements (EIS) in the following four major ways:

1. **Cumulative Impacts Focus**. While a project-specific EIS typically examines environmental impacts within a limited geographic area, a GEIS analyzes the cumulative impacts associated with a number of separate, yet related activities. In the case of the GEIS on timber harvesting and forest management, cumulative impacts are those resulting from the hundreds of individual logging activities occurring in the state

each year—in effect, the collective impacts of these individual operations on the state's overall environmental quality.

2. **Discretionary Nature**. The administrative rules governing the state's Environmental Review Program establish general criteria for determining when it would be in the state's best interest to prepare a GEIS. However, these criteria do not specify explicit thresholds which, if exceeded, mandate the EQB to order such a study. The decision by the EQB to prepare a GEIS is voluntary. Additionally, because a GEIS is considered an alternative form of environmental review, projects under consideration by a GEIS are still subject to normal environmental review procedures and requirements, as well as environmental permit procurement procedures. In essence, a GEIS is considered a long-range planning document that can provide useful information regarding geographically broad and long-term consequences that are unlikely to be identified in project-specific environmental review processes. Therefore, a GEIS provides the context within which future project-specific EISs can be assessed.

3. **Recommendation Development**. A third distinction between project-specific EISs and GEISs is the focus of the GEIS on developing recommendations. Traditional environmental review documents assess the likely consequences of feasible and prudent alternatives to a proposed action (e.g., changes in process technology, proposal size or site location), but do not state which of the analyzed alternatives is preferred. These decisions are left to the government agencies responsible for issuing the necessary development and/or environmental permits. However, a GEIS is not limited to strictly the analysis of impacts, but can advocate strategic policy and program direction through the development of recommendations to address the identified impacts.

4. **Funding Mechanism**. Unlike project-specific development proposals where the costs associated with preparing environmental review documents are borne by the project proposer, no mechanism exists for assessing the costs of preparing a GEIS. Funding for a GEIS is typically via special legislative appropriations, contributions of EQB member agencies, or outside funding sources. The EQB does not have the authority to establish rules relating to assessing the costs of preparing a GEIS.

1.2.3 GEIS Need Criteria

Although Minnesota's Environmental Review Program does not recognize circumstances in which preparation of a GEIS is mandatory, certain factors are considered by the EQB in determining the need for a GEIS. These factors are:

- whether reviewing the proposed action can be better accomplished by a GEIS than by project-specific review;
- whether the possible effects on the human environment are highly uncertain and involve unique or unknown risks;
- whether a GEIS can be used in a subsequent project-specific EIS to provide a context in which the individual project can be assessed;
- the amount of basic research needed to understand the impacts of such projects;
- the degree to which decisionmakers or the public have a need to be informed of the potential impacts of such projects;
- the degree to which information to be presented in the GEIS is needed for governmental or public planning;
- the potential for significant environmental effects as a result of the cumulative impacts of such projects;
- the regional and statewide significance of the impacts and the degree to which they can be addressed on a project-by-project basis; and
- the degree to which governmental policies affect the number or location of such projects or the potential for significant environmental effects.

1.3 EQB Decision: GEIS on Timber Harvesting and Forest Management

In July 1989, a citizen petition was brought before the Minnesota EQB. This petition cited a number of environmental and economic issues that could be directly impacted as a result of accelerated timber harvesting in Minnesota, and requested that the EQB prepare a GEIS to examine the cumulative impacts resulting from timber harvesting and forest management activities. The major concern of the petitioners was that no formal environmental review process currently existed to provide an analysis of the collective impacts that expanded timber harvesting activities might have on Minnesota's environment.

Support for the study was given by several individuals and groups involved in the management and use of the state's forests. After lengthy deliberation, the EQB unanimously passed a resolution to authorize the preparation of a GEIS on timber harvesting and forest management activities in December 1989. The EQB designated itself as the governmental unit responsible for the study's preparation.

1.3.1 Advisory Committee

A central component of the EQB's resolution ordering preparation of the GEIS on timber harvesting and forest management was the establishment of an advisory committee. This ten-person committee was created to provide direction and oversight of the GEIS study process through their recommendations to the EQB. Committee membership includes economic development, environmental, conservation, tourism, and public land management interests, reflecting a broad cross-section of stakeholders in the management and use of Minnesota's forest resources.

Membership. Members of the GEIS Advisory Committee are as follows:

- Don Arnosti
- Janet Green
- Dennis Kmit
- Roy Linder
- Tom Sawle
- Wayne Brandt
- Butch Eggen
- Darrell Lauber
- Gerald Rose
- Jim Woehrle

Doug Jackson and Bob Raufs also served on this committee.

Charge. The EQB asked the Advisory Committee to assist in the preparation of the GEIS by assuming the following major responsibilities:

- to advise the EQB on the scope of the GEIS, including the issues to be examined, the type and level of detail of studies to gather and analyze information, and the schedule for preparation of the GEIS;
- to advise the EQB on the selection of a consultant to assist in preparation of the GEIS;
- to review and provide comment to the EQB on reports prepared by the consultants, and on the proposed draft and final GEIS documents; and
- to make recommendations on the alternatives presented for the mitigation of impacts where analysis has indicated the potential for significant impacts.

To enhance the Advisory Committee's ability to develop consensus advice on these four areas, the EQB secured the services of Howard S. Bellman, Madison, Wisconsin, to serve as facilitator to this committee.

1.4 GEIS Funding Sources

Funding for the GEIS, which totals $875,000, comes from the following public and private sources: Minnesota Environment and Natural Resources Trust Fund ($400,000), state legislative appropriations ($300,000), Crow

Wing County via the Iron Range Resources and Rehabilitation Board ($100,000), and the Cuyuna Range Economic Development Corporation ($75,000). In addition, the Northwest Area Foundation provided a grant of $47,000 to the EQB for facilitation services associated with operation of the GEIS Advisory Committee.

1.5 GEIS Process

This section of the document sets out the key aspects of the study process from the initial scoping process to the completion of the draft and final GEIS documents.

1.5.1 Scoping Process

The first step in conducting a GEIS is to identify and define the issues to be addressed in the study. This is accomplished through a scoping process. The main purpose of scoping is to focus the study by clearly defining the critical issues in need of examination. In addition, the scoping process establishes other important GEIS study parameters such as study objectives, assumptions, and alternatives to be analyzed.

The scoping process for the GEIS was initiated by the EQB in early 1990. Over the course of four meetings, the GEIS Advisory Committee worked to develop a draft scoping document that would specify the study's general format and issue content. Upon receiving this document from the Advisory Committee, along with the recommendation that it be used as the basis for public review, the EQB issued the committee's report as the draft scoping document in July 1990. Shortly after the draft scoping document was released, the EQB established a 40-day comment period in which the public could comment and suggest modifications to the draft document. During that public comment period, the EQB held three public meetings (Rochester, Twin Cities, Grand Rapids) to discuss the proposed format and content of the GEIS, and to solicit public input on that draft.

In total, 94 individuals or organizations submitted written comments during the scoping period, and 84 individuals or organizations provided testimony at the three public meetings. Upon completion of the scoping period, the Advisory Committee reviewed the public comments. After three meetings, the committee reached consensus on the recommended content of the final scoping document. In December 1990, the EQB approved the Final Scoping Decision (FSD) for the GEIS as recommended by the Advisory Committee. The final scoped issues are repeated from the FSD in section 1.5.5.

1.5.2 Study Objectives

The FSD calls for a GEIS study to be based on three overarching objectives:

1. to develop a basic understanding of the status of timber harvesting and related forest management activities in Minnesota, and how this level of statewide activity relates to long-term sustainable levels of timber removals;
2. to identify and assess the environmental and related (i.e., economic and social) impacts associated with current and potential elevated levels of statewide timber harvesting and forest management activity; and
3. to develop strategies to mitigate the existing or potential significant adverse impacts that are identified.

1.5.3 Major Assumptions

The following are major assumptions used in defining the scope of the GEIS on timber harvesting and forest management in Minnesota:

Geographic Coverage
The GEIS examines the impacts of timber harvesting and forest management on Minnesota's environment and on relevant sectors of the state and regional economies. To the extent possible, all forest lands and resources within the state's boundaries have been considered in this study. Issues and data have been gathered and analyzed at appropriate levels of resolution in order to determine the statewide cumulative impacts.

Forest Lands Under Consideration
The GEIS examines the cumulative impacts of timber harvesting and forest management activities occurring on all forest lands in Minnesota. This includes, to the extent possible, all public forest lands owned and/or managed by federal, state, county, or municipal governments as well as forest land owned by industrial and nonindustrial private interests. Both commercial and noncommercial forest lands are the subject of this study.

Relationship to Timber Harvesting and Forest Management
The GEIS analyzes only those impacts associated with timber harvesting and associated forest management activities in Minnesota. Timber harvesting and forest management is defined to include a broad range of human-induced activities related or incidental to altering forest environments. Although not inclusive, typical activities include logging, site preparation, reforestation (through both artificial and natural means), forest road design, density and construction, chemical applications, and thinning operations.

1.5.4
Alternative Statewide Timber Harvesting Scenarios Analyzed

The purpose of discussing alternatives in an EIS is to compare the environmental impacts of the proposed project with other reasonable alternatives to the project, including the alternative of no action. In the case of this GEIS, the proposed project was defined in terms of the state's cumulative timber harvesting and related forest management activities. Therefore, alternatives addressed in the GEIS are defined as different levels of statewide timber harvesting activity. In addition to examining the existing levels of harvesting, potential future timber harvesting levels are also analyzed to identify impacts that would result if such levels of statewide activity were actually achieved.

The FSD specifies that, to the extent possible, all issues are to be reviewed from the following three levels of statewide timber harvesting and associated forest management activity:

4.0 million cords. This was the level of statewide timber harvesting activity that occurred in 1990, the most recent year for which data was available at the time the document was drafted.

4.9 million cords. This is the level of statewide timber harvesting activity estimated to occur by 1995 if all announced or considered forest products industry expansions fully materialize. (This also approximates a 50 percent increase in timber harvesting and associated forest management activity over 1988 statewide harvest levels.)

7 million cords. This is the estimated maximum annual volume of timber available for harvest statewide for all tree species in the year 2000. (This also approximates a 100 percent increase in timber harvesting and associated forest management activity over 1988 statewide harvest levels.)

These alternatives provide for analysis under three different perspectives:

1. the current level of timber harvesting and forest management activity;
2. a level of statewide timber harvesting activity that is estimated to occur within the next five years if proposed expansions occur; and
3. estimated long-term maximum sustainable annual statewide timber harvest levels.

As is discussed more fully in section 2.3, the first alternative (4.0 million cords) was adjusted upward from the 3.2 million cord level specified in the FSD to reflect up-to-date information on existing statewide timber harvesting activity.

1.5.5 Scoped Issues

The following are the *issues of concern* identified in the FSD as those needing investigation in the GEIS. Under each major issue is a series of questions intended to more clearly define the significant aspects of each issue.

Maintaining Productivity of Forests for Timber Production. *Making sure that forests are able to sustain (over long periods of time) the production of ample supplies of timber in an environmentally sensitive manner is of major importance to society. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:*

1. *Based on most recent statewide forest inventory information, what allowable timber harvest rates are sustainable for major Minnesota forest types? What rates are possible for sustaining economic activity based on pulp, fuelwood and quality sawtimber products? What methods are used (or could be used) to estimate allowable harvest rates (considering structural and taxonomic diversity, specific geographic areas, and various landowner classes)?*
2. *What is the relationship between current and future estimates of sustainable timber supplies and the demands expected for the supply of such timber? Are there seasonal differences in timber demand and supply?*
3. *Are there classes of landowners, geographic regions or forest types where timber harvest rates may be expected to exceed allowable timber harvest rates or biological growth? If needed, what strategies can be implemented to assure the perpetuation of a renewable forest resource? What are the impacts of these strategies and what forest conditions will result from their implementation.*

Forest Resource Base. *Forests are dynamic ecosystems which change naturally and in response to human intervention (e.g., timber harvesting). Understanding the nature and extent of such change is important to the making of wise management and land use decisions. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:*

1. *To what extent have changes occurred in the size and composition of Minnesota's forest land base (using reliable statewide information)? What were the major factors contributing to this change?*
2. *To what extent do timber harvesting and management activities impact the abundance, composition, spatial distribution, age class structure, genetic variability and tree species mixture (for example, in creating forest monocultures) of Minnesota's forests (based on reliable*

information)? To what extent are changes in these characteristics specifically attributable to timber harvesting and management of certain forest landowner categories?

Forest Health. The management of forests should be undertaken so as to ensure that they are sustained in a healthy condition over long periods of time, recognizing that endemic pest conditions will be present. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:

1. *What impact does timber harvesting and management have on the change in risk of disease and insect infestations to Minnesota's forests?*
2. *To what extent are changes in the risks of insect and disease infestations specific to a particular forest landowner class, geographic region, tree species or forest type?*

Plant and Animal Diversity in Forest Ecosystems. A diverse range of plants and animals are associated with forest ecosystems. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:

1. *What impact does timber harvesting and management have on the biological diversity of forests at the genetic, species and ecosystem levels? What spatial patterns of forest cover does timber harvesting create, and how do these patterns impact wildlife and native plant communities (for example, fragmentation of forests)?*
2. *To what extent are federal and state-listed species of special concern, threatened, or endangered species or their habitats impacted by timber harvesting and management?*
3. *Based on the DNR's final definition of "old growth" forests and "old" forests, to what extent do these forests exist in Minnesota; how are they identified and managed; and how are they impacted by timber harvesting and management?*

Forest Wildlife and Fish. Forest wildlife and fish are an integral part of forest ecosystems. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:

1. *What are the forest dependent wildlife and fish species, their specific habitat requirements, and their current status and distribution?*
2. *To what extent does timber harvesting and management impact populations and habitats of each of the ten groups of wildlife as defined in Appendix B to the FSD.*

Water Quality. Forests are capable of influencing the flow of significant quantities of water of various qualities. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:

1. *To what extend does timber harvesting and management result in changes in the level of sedimentation, nutrient loading and runoff in lakes, rivers, streams and wetlands?*
2. *To what extent are fertilizers, compost, sludge and pesticides used in timber management, and what are their impacts on the quality of surface and groundwater?*
3. *To what extent does timber harvesting and management impact aquatic ecosystems, wetlands and peatlands?*

Forest Soils. Forest soils are a fundamental resource on which rests the ability of forests to provide a wide variety of benefits. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:

1. *To what extent does soil erosion occur as a result of timber harvesting, and how does this rate of erosion compare with forest soil erosion rates in undisturbed forests? What specific timber harvesting and management activities are major contributors to the erosion of forest soils?*
2. *To what extent do timber harvesting and management (e.g., short cycle rotations) activities impact nutrient cycling and the productivity of forest soils? To what extent do specific management and timber harvesting practices impact the productivity of forest soils?*
3. *To what extent do timber harvesting and management activities impact the compaction of forest soils? To what extent does soil compaction impact forest productivity and the growth of forest plants?*
4. *To what extent does the time of year in which timber harvesting occurs impact forest soil productivity and the success of forest regeneration?*

Forest Recreation. Forests provide significant opportunity for a wide variety of outdoor recreational experiences. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:

1. *To what extent are forest recreation opportunities, both quantitatively and qualitatively, impacted by timber harvesting and management? Do such impacts vary by type of recreation (e.g., day use, overnight use, dispersed, nondispersed, on-site, off-site, consumptive, nonconsumptive)?*

Economics and Management. Forests provide a variety of benefits which are critical to the economic and social health of regional and statewide *economies. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:*

1. a) To what extent does timber harvesting and management impact regional and state economies?
b) Which and to what extent do specific economic sectors benefit from timber harvesting and management?
c) Which and to what extent are specific economic sectors adversely impacted by timber harvesting and management?
2. a) To what extent is the state's recreation and tourism industry impacted by timber harvesting and management?
b) Which and to what extent do specific segments of the recreation and tourism industry benefit from timber harvesting and management?
c) Which and to what extent are specific segments of the recreation and tourism industry adversely affected by timber harvesting and management?
d) To what extent will an increase or decrease in timber harvest affect the habitats of deer and ruffed grouse, other game species and other recreational use of wildlife; and how will these changes affect state and regional economies?
3. What is the current distribution of timber stumpage among various users? What laws, policies and procedures influence this distribution?

Aesthetics and Unique Cultural Resources. *Forests provide a variety of scenic vistas and often are the setting for important cultural and historic resources. Considering previously specified timber harvesting levels and looking at timber harvesting and management activities statewide:*

1. *To what extent are unique historical and cultural resources (e.g., Native American cultural, religious and spiritual resources) in forested areas impacted by timber harvesting and management.*
2. *To what extent does timber harvesting and management impact the visual quality of Minnesota's forests?*

As discussed in subsequent sections of the document, data availability limited the extent to which impacts could be quantitatively assessed for certain issues. The GEIS study does identify areas where future research is needed to collect data that are currently unavailable but needed to more completely address all GEIS-scoped issues. The primary vehicle for addressing these FSD-scoped issues is the collection of nine technical papers, *Maintaining Productivity and the Forest Resource Base, Forest Soils, Forest Health, Water Quality and Fisheries, Biodiversity, Wildlife, Unique Historical and Cultural Resources, Economics and Management Issues,* and *Recreation and Aesthetics* (Jaakko Pöyry Consulting, Inc. 1992a,b,c,d,e,f,g,h; 1993), outlined in section 2.3.

1.5.6 Other Analyses

In addition to the previously mentioned scoped issues, two other issues were identified for analysis. These issues were related to, but not dependent on, levels of timber harvesting and forest management being examined. The first issue was the assessment of opportunities for using recycled fiber to meet additional wood fiber demand, including an assessment of any consequent impacts on the environment and the economy. The second issue required the identification and description of studies that address global warming and its possible effects on Minnesota's forests.

1.5.7 Study Timeframe

The FSD specified a schedule for study preparation that envisioned the preparation of the feasibility assessment and study workplan by June 1991. The GEIS study was to be started in June, and a draft GEIS, including input from the Advisory Committee, was to be completed in January 1992 and released for public comment in February or March 1992. The final document was to be completed in June 1992.

This schedule constrained the time available for the study and was a fundamental and critical factor shaping the study methodology. The proposed methodology was unconstrained by cost but constrained by a final reporting date of July 1992 (Jaakko Pöyry Consulting, Inc. 1991a).

The manner in which the GEIS process ultimately evolved extended the study timeframe to the middle of 1993. The major factors responsible for this extension included: (1) initial delays in securing funding for the approved GEIS Workplan (Jaakko Pöyry Consulting, Inc. 1991b); (2) difficulties associated with critical data sets required to conduct the analysis; (3) a more extensive oversight role for the GEIS Advisory Committee than originally envisioned; and (4) additions to the EQB-approved study process as set out in the Workplan, such as conducting a consultant-initiated external review of all technical papers prior to their submission to the EQB.

2 GEIS STUDY COMPONENTS

This section provides an overview of the general structure and methodology used to conduct the GEIS study, as well as its principle outputs. A description of the study's main elements is included, as well as a chart that illustrates the organization of the study. The overall study structure was originally developed in the Feasibility Study and the methodology was developed in the Workplan. The study methodology was specifically developed to meet the study's three objectives, major assumptions, and original work schedule, and structured in a way that explicitly addresses the ten major issue areas identified in the FSD.

2.1 Study Participants

The study team of Jaakko Pöyry international consultants and local experts was organized into a core group, six specialist study groups, the preparers of five background papers, and other specialist staff. In total, more than 60 individuals were utilized by Jaakko Pöyry to help prepare the GEIS. An organizational chart identifying the subdivision of the study into the six study groups and core group is set out in figure 2.1. A brief description of the major responsibilities of the key groups is described below.

Core Group
The group was comprised of Jaakko Pöyry consultants and the local study group coordinator. It was responsible for the overall analysis, writing, and preparation of the study workproducts; preparation of the draft and final GEIS documents; presentations to the EQB, the Advisory Committee, and the public; and ongoing liaison with the state and contract administration matters.

Individuals in this group include:

- Dr. James A. McNutt, Project Manager;
- Doug G. Parsonson, Project Coordinator;
- Dr. Alan R. Ek, Study Group Coordinator; and
- Dr. Lee E. Frelich, Associate Project Coordinator.

Specialist Group
The specialist group was subdivided into six study groups to provide in-depth technical analysis of the ten issues specified in the FSD. In addition, individuals were brought to the project to develop the background papers or provide GIS and pattern analysis. The specialist study groups and their participants are as follows:

Principal Local Study Team Members
Maintaining Productivity and the Forest Resource Base
Dr. Dietmar W. Rose, Dr. Thomas E. Burk, Dr. Alan R. Ek, Dr. Howard M. Hoganson, Dr. Marc E. McDill, David K. Walters, Douglas C. Kapple

Forest Soils and Forest Health
Dr. David F. Grigal, Dr. Peter C. Bates, Jane Cummings Carlson, Dr. Deborah G. McCullough, Dr. James C. Balogh

Water Quality and Fisheries
Dr. James A. Perry, Dr. Raymond M. Newman, Dr. Kenneth N. Brooks, Dr. Nels H. Troelstrup, Jr.

Biodiversity and Wildlife
Dr. Peter Jordan, Dr. Lee E. Frelich, Dr. Gerald J. Niemi, Dr. Donald P. Christian, Joann M. Hanowski, Calvin J. Harth, Dr. Edward J. Cushing, Paul H. Glasser, Will Pitt, Kristina Miller

Recreation, Aesthetics and Cultural Resources
Dr. Dorothy H. Anderson, Dr. David W. Lime, Dr. Leo H. McAvoy, Dr. David G. Pitt, Dr. Christy A. Hohman-Caine, Wayne A. Freimund, Jerrilyn L. Thompson, Grant E. Goltz, Doug G. Parsonson

Economics and Management Issues
Dr. Allen L. Lundgren, Dr. Marc E. McDill, Donald G. MacKay, Dr. Benedict Arias

Several of the specialist study groups addressed more than one issue area. The senior members of these groups are identified in figure 2.1 and the Workplan. A number of other people also provided specific inputs to the study process.

In preparing these papers, each study group carried out the following activities: data collection, technical literature review, evaluation of the existing conditions, background analysis, and the development and evaluation of significant impacts and related mitigation measures. The methodology used for each of these components is outlined in section 2.3.3 of this document, and is set out in detail in the various technical papers.

Each study group was responsible for the preparation of one or more technical papers which, together with the background papers, address all questions stated in the ten issue areas.

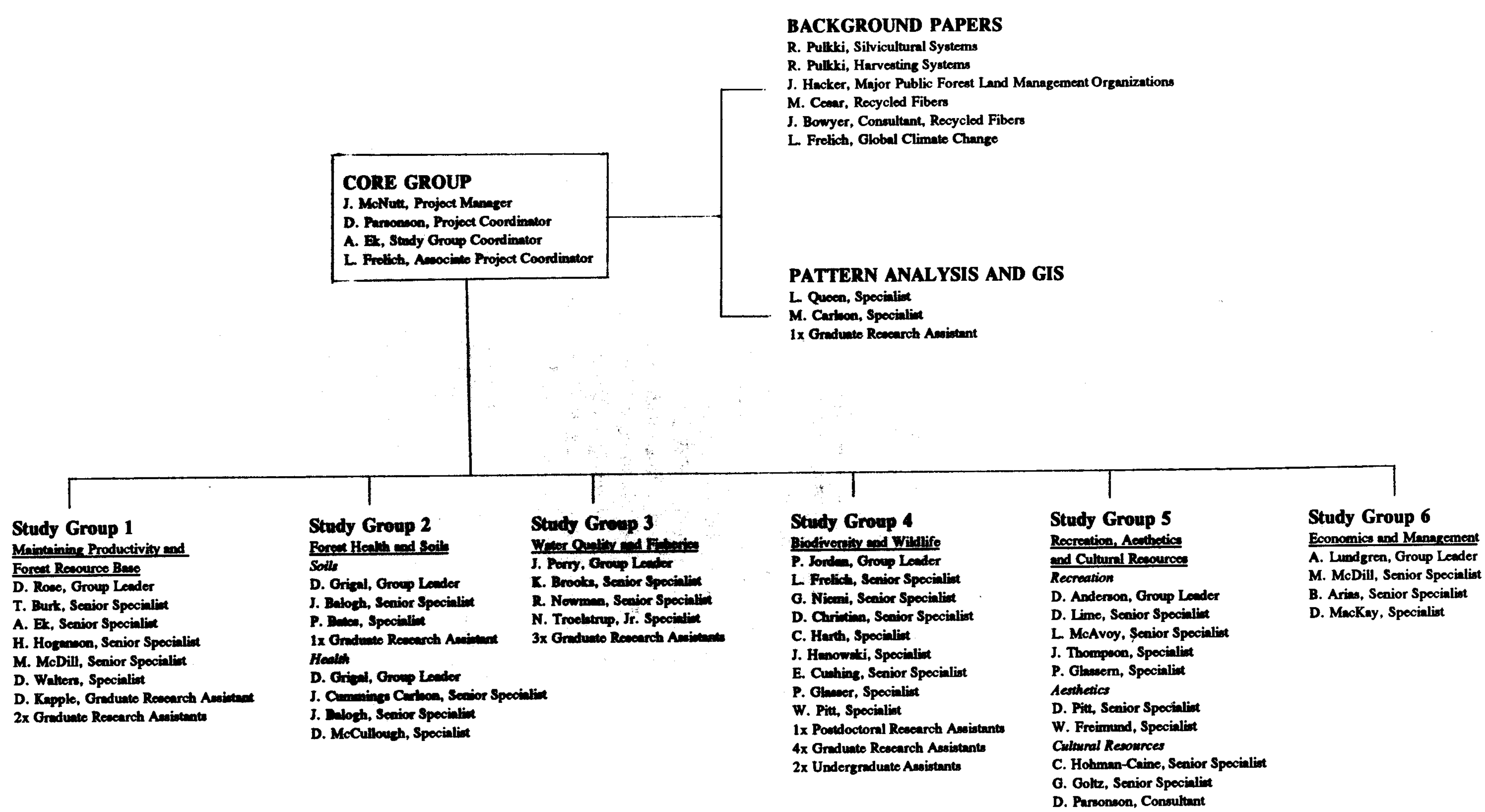

Figure 2.1. Study team organization.

Other individuals involved in preparing the technical and background papers and other workproducts used to develop the GEIS document are identified below. This list does not include the many people who undertook data analysis and other background work.

Jaakko Pöyry Personnel
Louis Carbonnier, Mary Cesar, Dr. Reino Pulkki, Ben Airas, Doug Gill, Scott Estey, Jan Rushing, and Sheila Parsonson

Others
Dr. James L. Bowyer, Dr. LLoyd Queen, Jan J. Hacker, and Clara M. Schreiber

2.1.1 Other Study Participants

In addition to the contractor's study team, the following groups of individuals and organizations also contributed to the study process.

Jaakko Pöyry Network Support Group: This group included Jaakko Pöyry senior management members and specialists who were available for consultation and special analyses relating to issues of policy, industry, and technology.

Minnesota Planning Office: The Minnesota Planning Office was the state's agent for administering the GEIS study. As project manager, the Minnesota Planning Office was responsible for the overall management of the study and was actively involved in all aspects of planning and preparing the GEIS. The Minnesota Planning Office assigned Dr. Michael Kilgore as the state's GEIS project coordinator and to serve as the liaison between the contractor, Jaakko Pöyry Consulting Inc., and the EQB. Dr. Kilgore also administered the GEIS Advisory Committee.

GEIS Advisory Committee: The GEIS Advisory Committee provided inputs and advice to the EQB at various stages of the study process, as discussed in section 1.3.2. The Advisory Committee played an important role in formulating the final significance criteria and selecting mitigation alternatives to be considered in the technical papers and this document. In addition, some Advisory Committee members secured technical advice in the review of draft documents by soliciting comment from independent outside experts and/or agency personnel.

Environmental Quality Board: The EQB role in the study process was to provide overall study direction as necessary and to approve workproducts. The major work of the EQB was conducted through the Board's GEIS

Committee, chaired by Dr. Paul Toren. Other committee members were Rod Sando and Robert Dunn.

Consultant-initiated Ad hoc Peer Review Group: Selected technical experts reviewed the final draft technical papers prior to their submission for approval by the EQB.

Maintaining Productivity and the Forest Resource Base
Dr. Charles Scott, USDA Forest Sciences Laboratory
Dr. Doug Brodie, Oregon State University
Dr. John Pastor, Natural Resources Research Institute

Forest Soils
Dr. Jim Bockheim, University of Wisconsin-Madison
Dr. Bill Atkinson, Dr. Hank Froehlich, and Brian Kramer, Oregon State University

Forest Health
Dr. Bill Miller and Dr. Bob Blanchette, University of Minnesota

Water Quality and Fisheries
Dr. Sandy Verry, USDA North Central Forest Experiment Station
Dr. John Clauson, University of Connecticut

Biodiversity
Dr. Malcolm Hunter, University of Maine
Dr. Thomas R. Crow, USDA Forest Sciences Laboratory
Dr. Steve Chaplin, Nature Conservancy

Wildlife
Dr. Robert Giles, Virginia Polytech Institute
Dr. Robert W. Howe, University of Wisconsin-Green Bay
Keith McCaffery, Wisconsin Department of Natural Resources

Recreation and Aesthetics
Dr. Wayne Tlusty, University of Wisconsin
Dr. John Schomaker, U.S. Fish and Wildlife Service
Dr. Herb Schroeder, USDA Forest Service

Unique Historical and Cultural Resources
Dr. Bill Lovis, Michigan State University
Gordon Peters, USDA Forest Service

Economics and Management Issues
Dr. Robin Gregory, Decision Research
Dr. Randall O'Toole, Cascade Holistic Economic Consult.

Dr. Richard Alston, Weber State University
Dr. Rebecca Judge, St. Olaf College

Independent Peer Review Group: An independent peer review of the draft GEIS was provided by a panel of objective experts prior to the public release of the draft document:

Review Coordinators
- Dr. Roger Sedjo, Resources for the Future
- Dr. Harold Burkhart, Virginia Polytech School of Forestry and Wildlife Resources
- Dr. Bill Lange, USDA Forest Service

2.2 Study Structure

The study flow chart (figure 2.2) shows how the study process was structured to integrate the work products from the various study teams. It also illustrates how opportunities were provided for input from other participants. The steps followed in the study are numbered from 1 to 19 in this figure. The figure identifies some of the preliminary documents which were instrumental in shaping the study approach. Other important factors in shaping the study included the provision of opportunities for the EQB, Advisory Committee, and the public to provide input; the internal relationships between elements of the study team; and the EQB-defined key study workproducts.

Although the major tasks of the study shared several common elements, many of these tasks were undertaken independently and combined later to create the GEIS document. This approach was adopted primarily because of the time constraints originally imposed on the study (refer to section 1.5.7). The short time frame meant that a more desirable linear study format was not possible; therefore, the parallel format was adopted, with six study groups and background paper authors working concurrently on steps 3 to 14, as shown on the study flow chart.

Aside from sharing common objectives stemming from the FSD, the common elements referred to above included using:

- the Forest Inventory and Analysis (FIA) data set from the USDA Forest Service as primary data inputs;
- ecoregions to provide uniform subdivisions of the state for analyzing/reporting impacts at a level of resolution below statewide level;
- the model run outputs from three timber harvesting scenarios as a common basis for data with which to quantitatively assess impacts;

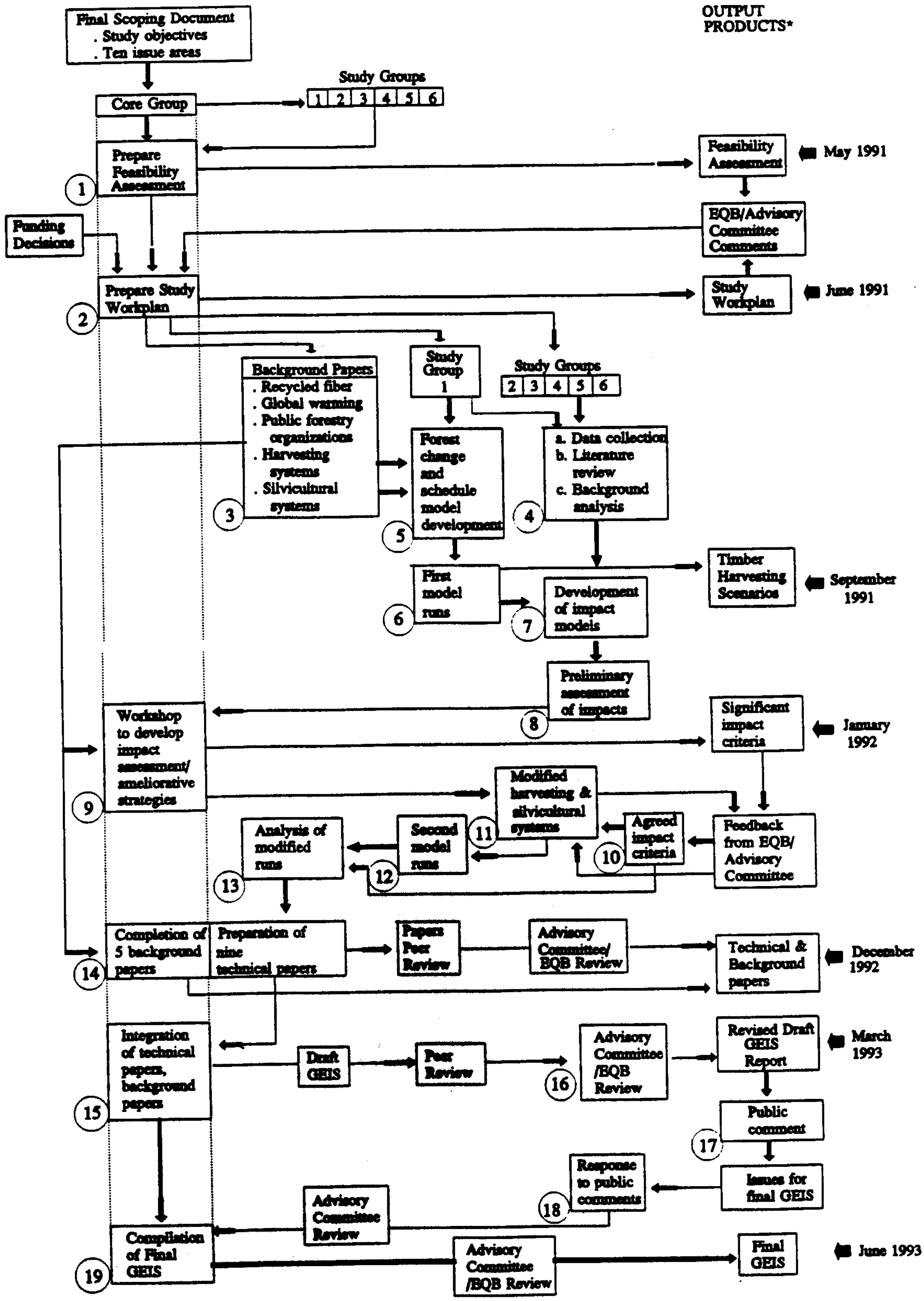

Figure 2.2. Study flow chart.

- approved criteria to identify significant impacts, mitigation alternatives, and preferred mitigation actions;
- information on predominant silvicultural and harvesting systems and techniques used in Minnesota and the current policies, programs, and practices of Minnesota's public forestry organizations; and
- a common structure and format.

2.2.1 Data Inputs

The USDA Forest Service 1990 FIA unit data formed the basis for the harvest scenario modelling and was used by the other study groups to develop characterizations of the forests and forested areas of Minnesota. A comprehensive description of the FIA data can be found in section 4.2.1 of the *Maintaining Productivity and the Forest Resource Base* technical paper. Generally speaking, the FIA data provides the following:

- statewide coverage, reinventoried every 10 to 15 years;
- on-the-ground measurements augmented with aerial photographic interpretation;
- a statistical sample to represent existing forest conditions; and
- estimates for
  - types of tree species and covertypes present,
  - area,
  - volume,
  - growth and mortality, and
  - average annual removals.

The preliminary 1990 FIA test data set was made available to the study team by the USDA Forest Service under the terms specified in a memorandum of understanding between the USDA Forest Service and the EQB. The FIA data were structured into a relational database to facilitate retrieval of user-defined information. Where appropriate, other data were linked to the FIA plot locations to provide a consistent basis for subsequent analysis. The FIA data were examined by each study group to identify data attributes that could be used in subsequent analyses.

2.2.2 Ecoregions

The FSD called for a study that would enable the EQB to assess the cumulative impacts of timber harvesting and related forest management issues at a statewide level, over time, for the specified range of harvesting levels. In order to achieve the stated objectives, the study had to be conducted at a scale of resolution that provided this broad perspective, while still including sufficient detail to substantiate the analysis and to enable development of appropriate strategies to avoid and/or ameliorate identified impacts. A uniform format for the presentation of information was also needed. These requirements were met by subdividing the state into 7 **ecoregions** shown by figure 2.3.

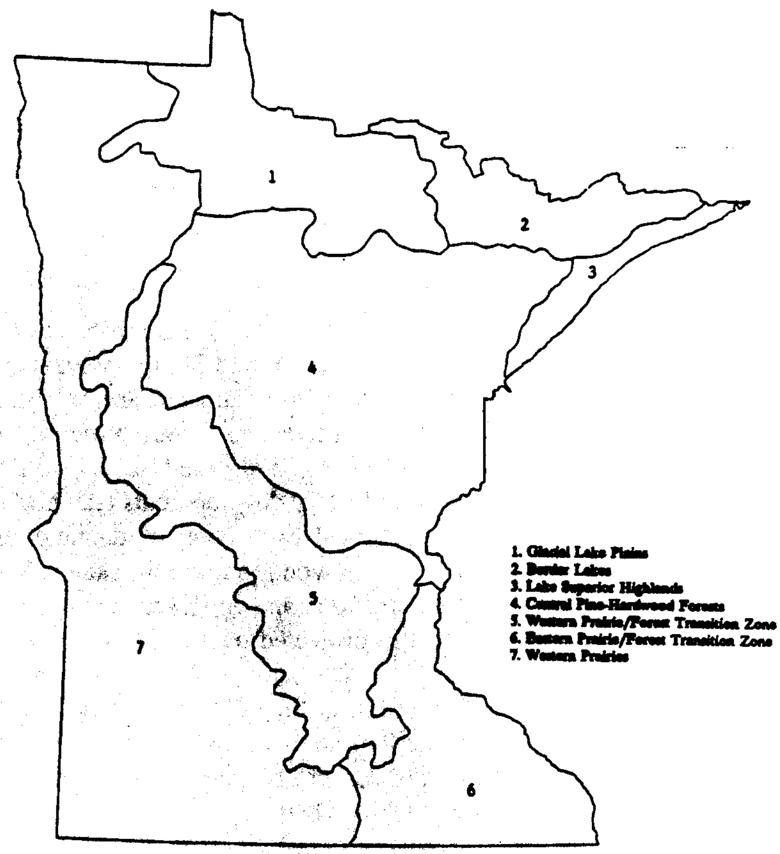

Figure 2.3 Ecoregions used in the GEIS study. (Source: Jaakko Pöyry Consulting, Inc. 1992a.)

These ecoregions are geographic regions with similar physical and biophysical characteristics, and were derived from the ecoregions defined by the Upper Great Lakes Biodiversity Committee (UGLBC). Some of the analysis was performed using smaller units than the above ecoregion subdivisions. Where possible, results from analyses undertaken at these levels of detail are aggregated and reported at the ecoregion scale.

In the technical papers, the reporting of economic, social, and other impacts was sometimes best handled using other types of regional subdivisions. The choice of the subdivisions used was governed by the form of data available and its ability to provide meaningful interpretations.

2.3
GEIS Workproducts

The following sections describe the major workproducts produced as part of the GEIS study process.

2.3.1
Statewide Timber Harvesting Scenarios

The initial harvesting scenarios were produced as the third workproduct from the study process and are shown as step 6 in the study flow chart (figure 2.2).

Three harvesting scenarios were produced in accordance with the explicit requirement set out in the FSD to analyze environmental and related impacts at three distinct levels of timber harvest intensity. These scenarios model the timber supplies needed to meet (1) the existing levels of demand (4 million cords/ annum), (2) a demand level projected to occur if all planned or announced industrial developments take place (4.9 million cords/annum); and (3) a hypothetical high level of demand that would require harvesting 7 million cords of wood per annum statewide. These three are referred to as the *base, medium,* and *high* scenarios, respectively. All three harvesting scenarios are projected over a 50-year planning horizon.

The base scenario for the statewide timber demand is 800,000 cords higher than the 3.2 million cord level specified in the FSD. These differences reflect more recent estimates of contemporary wood consumption levels than were available when the FSD was issued. Details of demand levels for industrial wood and fuelwood used to compile the three scenarios are provided in section 3.5.

Harvesting Scenarios Preparation Process

Harvesting Scenarios as Alternatives: The GEIS uses an analysis of the three EQB-specified levels of harvesting as a surrogate for an analysis of project-specific alternatives when assessing impacts. The base and medium levels are derived by summing demand for wood from existing or planned industry facilities. The locations of these industry facilities and the volumes and types of wood they require is known. The high level of harvesting specified additional harvesting activity needed to reach a level of harvest estimated to be equal to the long-term maximum sustainable level of harvest from the state's forests.

By structuring the study alternatives in this way, the FSD required development of a methodology to allocate or schedule harvests across Minnesota's forests, and over time, to meet the specified levels of demand. The harvesting scenarios were developed to match the demands from specific industries with the capacity of the forests to meet that demand. Harvesting operations and associated forest management activities were scheduled for individual stands in a way that made the most economic sense, i.e., least cost overall within the framework of mitigations and constraints. Constraints were imposed by market demand and the availability of particular categories of forest land for harvesting.

Data yielded from the scenarios formed the basis for most of the subsequent impact analysis undertaken by the study groups. Therefore, the scenarios were a critical element to being able to assess impacts for those issues of concern identified in the FSD.

The scenarios had to be prepared at a scale that would yield the following categories of information for each harvesting level:

- where and how timber harvesting and forest management activities would need to occur to meet the specified demand;
- a plausible schedule for harvesting over the 50-year study period;
- consequent likely changes to the age class, species composition, and structure of the state's forests during, and at the end of, the period being assessed; and
- projections of the proportion of the specified level of harvest that would be yielded by the various ownerships.

Data Requirements and Model Development: The scope of the study and the need to address the issues of concern required the collection of data describing the existing forest condition and existing and future industry demands and related factors. This information was used in the generation of scenarios that depict how, when, and where harvesting would have to take place. It was also used to depict the type of changes that would occur to the forests under the various levels of harvesting.

The previously described FIA database was selected as the most useful characterization of the state's forested lands and the starting condition of the state's forests. The FIA database contains enormous detail derived from an intensive sampling of the state's forest. Statewide this database for 1990 provided records from 13,536 field checked plots classified as forest. Additionally, the database contained 760 plots classified as nonforest land with trees. The forested plots were further classified into three categories: ***timberlands*** (productive forests potentially available for harvest); *reserved forest* (productive and unproductive forest unavailable for harvesting); and *unproductive forest*. Subsequently, only the timberlands were assumed to be available for harvest.

The plots provided a spatial approximation of the total resource and were used as the basic *units* from which the scenarios allocated timber harvesting activity. Each plot from the FIA database has an *expansion factor* that is used to convert plot characteristics to the stand scale the plot represents. As an example, most timberland plots represented 900 to 1,500 acres.

Development of computer models to generate the three scenarios was necessary to handle the amount of information required and to project the scenarios far enough into the future to insure that long-term, as well as short-term, impacts could be detected. Models were adapted and/or specifically developed to generate realistic harvesting scenarios by incorporating the most recent available data covering the following:

- the volume (by size and species), location, and ownership of wood potentially available;
- existing, planned, or potential wood-based industries and their locations;
- current costs associated with timber harvesting, transport, and forest management activities;
- the regional transport network to link the wood supplies with the processing facilities;
- forest management practices and the implications of these on the structure and species composition of the forests and yields of timber in the short- and long-term (see below);
- criteria used by industries to select stands when making purchases of timber; and
- existing land management policies that influence the availability of timber for harvest.

Specific estimated timberland availability by ownership is shown in table 2.1.

Table 2.1. Availability of timberland by ownership assumed for second runs.

Ownership	Percent Available
National forests	
Chippewa	87
Superior	53
State	95
County	95
Other public	64
Forest industry	98
Other private	90

Source: Jaakko Pöyry Consulting Inc. (1992a).

In addition to these data, other important inputs were used in the modelling process. These were:

- the ability to simulate tree growth and the forest development, including forest area and land use change, that would occur during the planning period to reflect the regeneration after harvest, growth (including volume and size increments) changes in the mix of species occupying a site over time (termed *succession*); and
- the ability to alter *utilization levels*, (defined as the minimum and maximum diameters that are used to determine if a log is suitable for a particular use), on a per tree or per acre basis.

Recent and assumed forest area changes are shown in table 2.2. See section 6.12 in the Maintaining Productivity and the Forest Resource Base technical paper for more detail on actual implementation.

Table 2.2. Recent and assumed forest land area change by survey unit, 1990–2040.

FIA Unit	1977–90 (percent)	1990–2040 (percent)
Aspen-birch	-1.47	-5.7
Northern pine	-2.70	-10.7
Central hardwood	9.96	34.9
Prairie	13.57	46.0
All units	0.03	0.2

Source: Jaakko Pöyry Consulting, Inc. (1992a).

Two timber harvest and forest management planning models were also incorporated in the development of the statewide timber harvesting scenarios. These models were:

1. RxWRITE: a set of programs used to develop options for how each area of forest or stand (as represented by the plots) might be managed at each of the 10-year planning decision points used in the study, and
2. DTRAN: a forest management scheduling model that *optimizes* harvesting and management activities by selecting from the options available.

Examples of the types of options produced for a stand old enough for harvesting might include: clearcutting; thinning a certain proportion of the stand; selective harvesting; or no harvesting. For a stand that has just been harvested, the choices might be to allow the stand to naturally regenerate, or to plant it and develop a forest consisting of different species than those occupying the site prior to harvest. Thus, the range of options changed either as the stand aged, or in response to changes brought about by choices made in earlier periods. The range of options available branches out over time and is referred to as a *decision tree,* illustrated by figure 2.4.

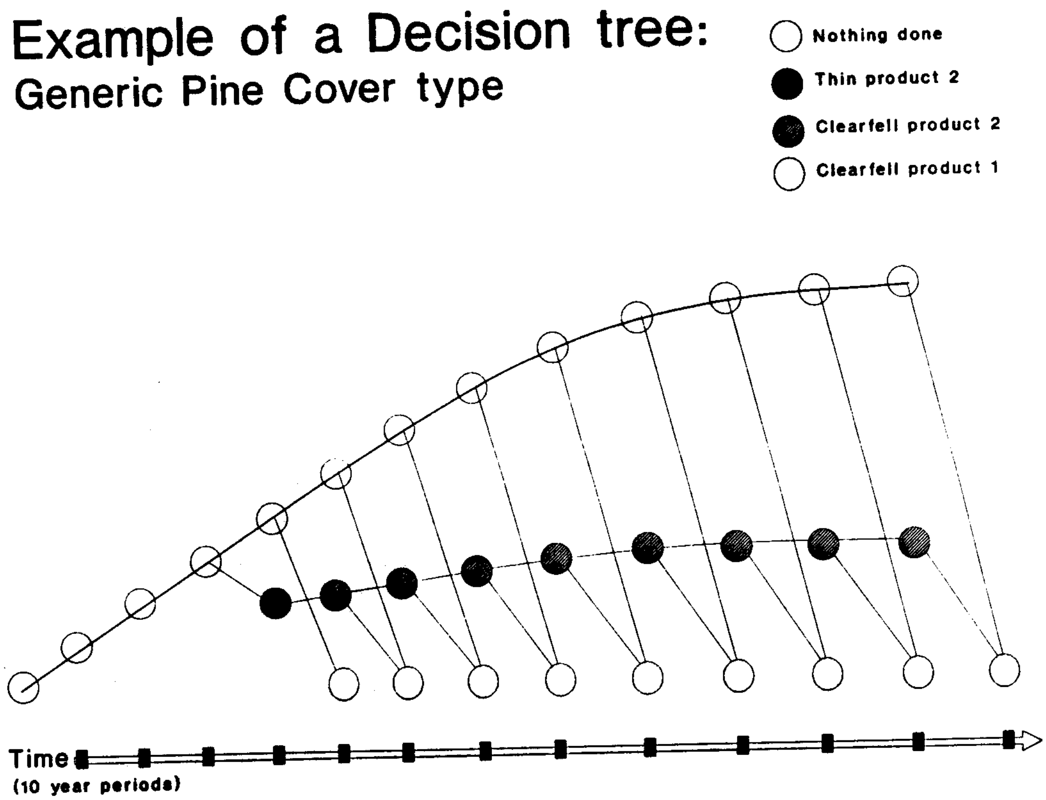

Figure 2.4 Example of a Decision Tree. (Source: Jaakko Pöyry Consulting, Inc. 1992a.)

The most appropriate option for each stand at each ten-year decision point was selected by the forest management scheduling model, as it matched demand for a product with the stand or forest best able to supply that product. Demand was aggregated into six *market centers* to simplify the analysis. These are shown by figure 2.5. No market centers were defined in the south of the state because demand was assumed to be comprised of many smaller enterprises.

The rotation ages for various covertypes and the covertypes themselves that were assumed in the GEIS are shown in table 2.3.

Other models were incorporated within this framework as necessary to generate data, and to modify and interpret inputs and outputs: (1) a tree

Table 2.3. FIA covertypes and minimum nominal rotation ages assumed in the GEIS.

FIA Code	Description	Nominal minimum rotation age*
1	*Jack pine.*—Forests in which jack pine comprises a plurality of the stocking. (Common associates include eastern white pine, red pine, aspen, birch, and maple.)	50
2	*Red pine.*—Forests in which red pine comprises a plurality of the stocking. (Common associates include eastern white pine, jack pine, aspen, birch, and maple.)	60
3	*White pine.*—Forests in which eastern white pine comprises a plurality of the stocking. (Common associates include red pine, jack pine, aspen, birch, and maple.)	60
12	*Black spruce.*—Forests in which swamp conifers comprise a plurality of the stocking with black spruce in the most common. (Common associates include tamarack and northern white-cedar.)	60
13	*Balsam fir.*—Forests in which balsam fir and white spruce comprise a plurality of stocking with balsam fir the most common. (Common associates include aspen, maple, birch, northern white-cedar, and tamarack.)	50
14	*Northern white-cedar.*—Forests in which swamp conifers comprise a plurality of the stocking with northern white-cedar the most common. (Common associates include tamarack and black spruce.)	70
15	*Tamarack.*—Forests in which swamp conifers comprise a plurality of the stocking with tamarack the most common. (Common associates include black spruce and northern white-cedar.)	60
16	*White spruce.*—Forests in which white spruce and balsam fir comprise a plurality of the stocking with white spruce the most common. (Common associates include aspen, maple, birch, northern white-cedar, and tamarack.)	60
50	*Oak-hickory.*—Forests in which northern red oak, white oak, bur oak, or hickories singly or in combination, comprise a plurality of the stocking. (Common associates include jack pine, elm, and maple.)	60
70	*Elm-ash-soft maple.*—Forests in which lowland elm, ash, red maple, silver maple, and cottonwood, singly or in combination, comprise a plurality of the stocking. (Common associates include birches, spruce, and balsam fir.)	60

Table 2.3. continued.

FIA Code	Description	Nominal minimum rotation age*
80	*Maple-basswood.*—Forests in which sugar maple, basswood, yellow birch, upland American elm, and red maple, singly or in combination, comprise a plurality of the stocking. (Common associates include white pine, elm, and basswood.)	70
91	*Aspen.*—Forests in which quaking aspen or bigtooth aspen, singly or in combination, comprise a plurality of the stocking. (Common associates include balsam poplar, balsam fir, and paper birch.)	40
92	*Paper birch.*—Forests in which paper birch comprises a plurality of the stocking. (Common associates include maple, aspen, and balsam fir.)	50
94	*Balsam poplar.*—Forests in which balsam poplar comprises a plurality of the stocking. (Common associates include maple, aspen, and balsam fir.)	40

* The full set of harvest and treatment options and ages are considerably more complex than indicated by this column. For example, ERF rotations are longer than those specified here. See appendix 1, Jaakko Pöyry Consulting, Inc. (1992a), for details.

Assumptions

Development and application of the models generating the three timber harvesting scenarios required certain assumptions generally relating to:

- the use of FIA plots and their associated expansion factors as an adequate approximation of the state's forest resource;
- growth of trees and changes in forests over time and regeneration of trees after harvesting;
- costs of timber harvesting and forest management activities; and
- availability of timberlands for harvest, and applicability of management practices for the different ownerships.

With respect to forest growth, the model used (GROW) is an individual tree-based model that projects individual tree growth and mortality on each FIA plot. The rates of growth and mortality are developed from submodels which themselves were calibrated by USDA Forest Service NCFES researchers and others using data from remeasured and other field plots. The growth and mortality estimated by the model are a function of tree species, size, crown development, site quality, stand density, and to some extent stand treatment. These calibrations and hence the precision and accuracy of estimates reflect the level of disturbance in the calibration data itself. Given that catastrophic disturbances such as fires, windstorms, and insect and disease outbreaks are difficult to incorporate in such databases, we suspect that overestimates of growth are still possible for some forest types. Consequently, for the second model runs, adjustments developed by FIA researchers were also employed with the net effect being to reduce forest growth estimates (see section 4.10.1 of Jaakko Pöyry Consulting, Inc. 1992a). The model also assumed site quality (site index) would remain stable over the 50-year projection period.

For the second runs, covertype changes were developed on an individual plot basis in two ways, that due to harvest and that due to succession or stand dynamics. The first type of change occurred at harvest (clearcut) and was developed from (1) decision trees for planting and (2) in the case of natural regeneration from covertype change matrices developed separately by FIA unit from changes in harvested plots over the period 1977–90 (see section 4.10.1 and appendix 2 of Jaakko Pöyry Consulting, Inc. 1992a). The second type of covertype change was developed from the GROW model results at ten-year intervals over the study period. Covertype change or succession was evaluated by applying the covertype algorithm to the projected FIA plot tree list (the list of trees on the plot and their associated characteristics) at that time and reclassifying the plot by covertype as appropriate. Thus the differing projected tree size, mortality and thinning by species determined the covertype and thus any change. Preliminary comparisons of this approach to actual FIA plot covertype changes over the period 1977–90 suggested this rather direct approach seemed to capture the direction of covertype change.

More specific assumptions for each of the three harvesting levels are discussed in sections 5, 6, and 7. A detailed discussion of all such assumptions can be found in the Maintaining Productivity and the Forest Resource Base technical paper.

Information on predominant harvesting and silvicultural systems, along with the policies of the state's public forestry organizations, were used to develop a detailed profile of the current methods of forest management, silviculture, and timber harvesting practices in Minnesota. Methods with potential application in Minnesota were also considered. Using this information, profiles of typical operations were developed for a range of operations, covertypes, and ownerships and incorporated into the management alternatives used in the forest change and scheduling model. These alternatives describe the silvicultural and harvesting systems that are assumed to apply to each category of operation, covertype, and ownership. This included assessments of the availability of timberlands over time (see below).

Model Runs

Two model runs were made for each of the three timber harvesting scenarios, creating two sets of harvesting scenarios. The major differences between the model runs was the incorporation of covertype dynamics and the assumed availability of timberlands for harvest.

The first model runs assumed that stands retained their original covertype designation throughout the study period, regardless of harvesting or other factors. The second runs incorporated model refinements to include (1) possible covertype change with harvesting, and (2) succession to other covertypes associated with aging and stand dynamics.

In the first model runs, an important assumption was that all timberlands in the state were available for harvesting. The only exceptions were those within legislatively designated reserve areas and those designated as unproductive. The first model runs also assumed that management objectives for all available lands included the possibility of timber harvesting, therefore ignoring and/or simplifying some of the constraints imposed by the various ownerships. The second model runs introduced ownership constraints and mitigations. These constraints and mitigations reflect current and prospective management procedures and policies applied by the major forest land managers. Examples include:

- extended rotation forests (ERF), i.e., rotation for a given forest covertype lengthened, usually by 50 percent, compared to minimum rotation ages. Approximately 20 percent of the timberland on state and USDA Forest Service ownerships to be managed under an ERF prescription (note that the Superior National Forest does not currently have an ERF program);
- greater use of uneven-aged management;
- designation and reservation of old growth and old growth replacement acreage;
- best management practices (BMPs), i.e., thinning or ERF within 100 feet of water; and
- wildlife buffers (thinning only within 200 feet of water) on the national forests and in the southeastern part of the state.

Old growth forest designation was implemented by identifying approximately one to two plots over 120 years old in each covertype (younger when necessary, but no less than 90 years old) and one replacement plot from an adjacent younger age class. Such plots comprised 57,500 acres of old growth and a similar acreage of replacement forest. These plots were then reserved from harvest for the duration of the study period. Much of this acreage was located on state and federal lands.

In addition, estimates of the actual availability of timberlands for harvest or management, developed separately by ownership, were used to set aside a portion of the timberland as *not available* for various economic, environmental and social concerns.

Other model changes for the second runs included refinement of thinning options, notably to reflect desired practice within buffers and for approximating and encouraging uneven-aged management. Forest and timberland area change from 1990 to 2040 was also implemented gradually throughout the 50-year period using estimates of annual change rates (see section 5.2.1 for a description of those rates). The second runs also applied the USDA Forest Service allowable cut limits for yields from national forest timberlands for the base and medium scenarios. National forest cut limits were relaxed for the high scenario. Additionally, a technological change assumption was that northern hardwoods could be substituted for aspen. Section 4.10 of the Maintaining Productivity and the Forest Resource Base technical paper provides a detailed discussion of the second model runs formulation and constraints.

Inclusion of the model refinements described here including stand dynamics, ownership constraints, and mitigations means that the second runs are a reasonable depiction of current and future timber availability.

More runs and more detailed alternatives might have been developed. However, it must be noted that the GEIS is not an agency-specific planning exercise, rather it is an attempt to assess impacts of specified levels of harvesting at an ecoregion and state level across ownerships.

The outputs from the model runs were in the form of plots harvested by planning period; the type of harvesting (clearcutting and thinning); the products harvested; products delivered and their cost; and assumed management activities (aside from harvesting). These outputs were used as an input into the forest change model which generated depictions of the forest condition on each plot over time. Depictions of changes on each plot were created at an individual tree level of resolution. The tree and plot expansion factors and stand acreage were then used to convert this to stand level and ecoregion changes.

The study groups used various parts of this output, depending on their specific requirements for conducting environmental impact assessments. For example, the forest soils study group required information on the volume of timber removed by covertype and the frequency of harvests; whereas the wildlife group required data including the presence or absence of certain key tree species, the age and size class structure of stands, and any changes in covertype.

The forest changes projected under the scenarios were then used to develop and characterize impacts affecting the issues of concern for each of the three harvesting scenarios.

Descriptions of the study group analyses using the model outputs are set out in more detail in subsequent sections of this document.

2.3.2 Study Criteria Development

There are three types of criteria developed for the GEIS:

1. *significant impacts* criteria;
2. *mitigation alternatives* criteria; and
3. *mitigation strategies* criteria.

These criteria were prepared as the major component of the fourth work product of the study process, which corresponds to step 10 in the study flow chart (figure 2.2).

The criteria were developed to facilitate input from the Advisory Committee and EQB into the study process. The first category was developed to assess the significance of each of the impacts identified in the study process. For those impacts identified as significantly adverse, a second set of criteria was developed to identify potentially suitable mitigation alternatives. Finally, the third set of criteria was developed (to select between mitigation alternatives) to identify appropriate strategies for policy development.

The criteria developed were critical work tools that ensured the study remained focused on the process needed to develop the best set of mitigation strategies to address cumulative, statewide impacts. Key issues and objectives in this process were:

- to comprehensively identify all potential impacts;
- to develop a systematic approach for assessing impacts in order to identify those which are considered significant;
- to develop intellectually sound/objective alternatives to minimize those impacts identified as significant;
- to facilitate two-way feedback between the GEIS study team and the EQB Advisory Committee on development of these criteria; and
- to develop a framework for identifying practical mitigation strategies that have the uniform support of all parties involved.

Criteria Development Process

A sequential process was used to develop the criteria. The initial or first run timber harvesting scenarios were analyzed to identify impacts, by issue area, that could occur at the three levels of timber harvesting. Technical criteria were developed that identify (in most cases) threshold levels that indicate when impacts were considered to be significant. These levels were developed using existing standards where appropriate, and from the literature or based on expert judgement where standards do not exist. In practice, very few standards had been previously developed to address the issues examined in the GEIS. Consequently, expert opinion and judgements were dominant factors in shaping the significance criteria.

The criteria, which have been approved by the EQB, reflect input from the EQB, based partly on advice from the GEIS Advisory Committee. The GEIS study team provided draft, technically-based criteria, and the Advisory Committee added a social dimension. This two-stage approach to criteria development reflects the identified role of the Advisory Committee and EQB (and its staff) (FSD section IV.C) to determine those issues where significant impacts could result from timber harvesting.

The sequence of how the criteria were applied, and the points where Advisory Committee and EQB input were required as part of the criteria development process are illustrated in figure 2.6.

Significant Impacts Criteria

Impacts identified in the course of this study varied in their significance and therefore in the need to develop a specific mitigation response. This was a critical stage of the study process, as these tests of significance ultimately defined the scope of mitigation responses developed by the GEIS.

Identification of an impact as being significant does not automatically prescribe a specific mitigation response. The significance criteria were developed to be inclusive rather than exclusive. Their purpose was to identify the issues and circumstances where policy initiatives were required. The range of possible policy responses, the factors used to choose between them, and the implications of selecting a particular response were all evaluated by subsequent criteria.

Criteria were developed to evaluate each of the issues of concern in the FSD. The categories of impacts to be considered are set out in the FSD within the Issues of Concern (section viii, page 8). Eighteen *categories* of impacts were identified, based on the ten issue areas in the FSD. The categories are set out in the left hand column of table 2.4.

For each significance criterion developed, several background factors were used to determine levels or thresholds when impacts are likely to be considered significant. These background factors were provided to support the significance assessment and/or to provide insight as to the basis for the specified threshold. They include:

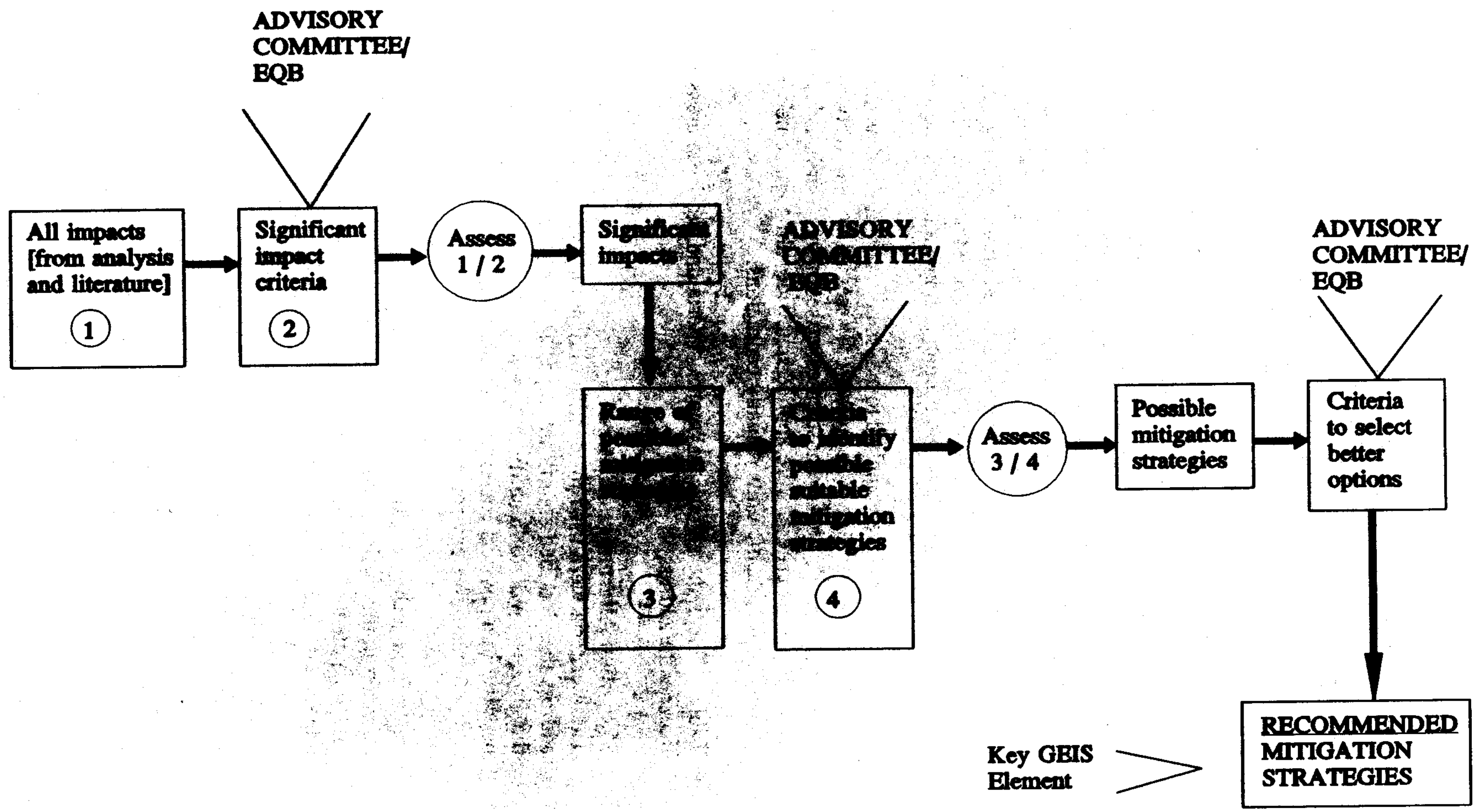

Figure 2.6. Process for criteria and mitigation strategy development. (Source: Jaakko Pöyry Consulting, Inc. 1991c.)

- severity and spatial extent of impact;
- certainty of impacts;
- duration of impact (irreversibility);
- consideration of existing guidelines and standards; and
- biological and economic implications.

The first factor identified the likely extent and severity of an impact. Impact extent varies from very localized site-specific impacts to those impacting a watershed, physiographic region, soil type, covertype, ecoregion, or the entire state. The second factor identified the degree of certainty that a predicted impact would occur. The key factors influencing certainty are identified for each criterion. The third factor incorporated the anticipated duration of the impact, and whether or not it is reversible. Duration was defined as very short-term—less than 2 years; short-term—2 to 10 years; medium-term—10 to 50 years; long-term—greater than 50 years; and irreversible. The fourth factor incorporated those existing standards and guidelines that are applicable to the respective issue areas. The fifth factor identified the key biological and economic implications of the impact.

Most of the criteria were applied to assess both positive and negative changes to the specified variable. Changes were assessed cumulatively over the 50-year study period, and in most cases, assessments were made at ten-year intervals. Most criteria were applied statewide, although some were applied to smaller geographic units, usually ecoregions.

Table 2.4 lists the significant impact criteria and the issue areas they were intended to address.

Mitigation Alternatives Criteria

These criteria were used to identify mitigation actions with the potential to address the identified significant impacts. The purpose behind this stage of the process was to identify mitigation actions which are effective and practical in a physical context, as well as in terms of the political, financial, and administrative environments in Minnesota.

Input from technical experts, the Advisory Committee, and the EQB are reflected in the final criteria. Unlike the significance criteria, the criteria to identify potential mitigation alternatives were applied uniformly across all issue areas documented in the FSD.

Major considerations used in the development of criteria to identify potential mitigation alternatives included:

- financial considerations;
- administrative considerations;

Table 2.4. Coverage of FSD issues of concern by significance criterion.

Final Scoping Decision issues of concern		Significance Criterion																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
A1	*Descriptive**																					
2	*Descriptive*																					
3	Unsustainable harvest					X																
B1	Changes to forest area	X																				
2	Abundance, composition, spatial distribution, age class structure, genetic variability, and tree species mixture	X	X	X	X	X				X		X	X									
C1	Risk of disease and insect infestations					X	X															
D1	Biological diversity at genetic, species, and ecosystem levels-patterns of forest		X	X	X	X				X	X	X										
2	Federal and state species of special concern, threatened, or endangered species or habitats								X		X	X										
3	Old growth and old forests					X		X														
E1	*Descriptive*																					
2	Populations and habitats of ten groups of wildlife and fish		X	X	X	X					X	X	X			X						
F1	Sedimentation, nutrient and runoff													X	X		X					
2	Fertilizers, compost and sludge													X								
3	Aquatic ecosystem, wetlands and peatlands													X		X						
G1	Erosion																X					
2	Nutrient cycling, productivity																		X			
3	Compaction																	X				
4	Seasonality of harvest																	X				
H1	Recreation			X																X		
I1	. Regional and state economies . Sectors benefitting . Sectors disadvantaged																				X	
2	. Recreation and tourism industry . Segments that benefit . Segments that are disadvantages . populations and habitat of game species consumptive uses																			X	X	
3	*Descriptive*																					
4	*Descriptive*																					
J1	Cultural, historical resources																					X
2	Visual quality																			X		

Source: Jaakko Pöyry Consulting, Inc. (1991c).

*Some issues in the FSD require description of existing conditions rather than change.

Significance Criterion and corresponding number (key to table 2.4)

KEY

1 Changes to MN forests - size and composition of forest land base
2 Changes to MN forests - patterns of forest cover in areas of mixed land use
3 Changes to MN forests - patterns of forest cover in predominantly forested areas
4 Changes to MN forests - tree species mix
5 Changes to MN forests - age class structure
6 Forest health - change in susceptibility or vulnerability
7 Old growth forests
8 Federal- or state-listed species of special concern, threatened, or endangered species or their habitats
9 Forest species - genetic variability
10 Forest dependent wildlife - habitats (lowland conifers)
11 Forest dependent wildlife - habitats
12 Forest dependent wildlife - food species
13 Lakes, rivers, streams, and wetlands - level of sedimentation/nutrient loading
14 Lakes, rivers, streams, and wetlands - runoff
15 Lakes, rivers, streams, and wetlands - aquatic ecosystems
16 Forest soil productivity - soil erosion
17 Forest soil productivity - compaction/puddling
18 Forest soil productivity - nutrient removals
19 Forest recreation and aesthetics - visual impacts
20 Regional economics - changes in economic parameters
21 Historical and cultural resources - forestwide impacts

- certainty of effectiveness; and
- social implications.

Mitigation Strategies Criteria
The criteria developed for this aspect of the process were used to identify the preferred mitigation strategies that form the basis of the tactical GEIS recommendations set forth in sections 5 to 7. Selection of preferred mitigation strategies depended on consideration of the following characteristics of each mitigation alternative:

- effectiveness—Can the mitigation alternative accomplish its intended objectives?
- feasibility—Can the mitigation be implemented?
- concomitant effects—What effects, beneficial and adverse, would the mitigation measure have on other resources values?
- implementation success—What is the likelihood that the mitigation will be successfully implemented?

As with the criteria used to identify mitigation alternatives, these criteria were applied uniformly to all mitigation actions identified in the previous stage of the process. The objective was to develop workable mitigation strategies that collectively addressed the significant impacts in an integrated fashion, thus insuring strong, workable policy options.

2.3.3 Technical Papers

The following describes the subject matter and role of the technical papers in the GEIS process. The subject matter of each paper is related to the issues of concern identified in the FSD. All the technical papers shared some common elements, and these are described here, followed by a brief synopsis of each of the papers' objectives and methodology.

Role in the GEIS Study Process
The technical papers were developed to provide an in-depth analysis wherever possible of each issue of concern identified in the FSD. Information sources are identified, and the methods used to conduct the impact analysis are explained.

The impact analyses identified cumulative impacts that could be linked to the statewide levels of timber harvesting and forest management activities developed in the three harvesting scenarios. The impacts were assessed for significance, and mitigations were identified and assessed using the EQB-approved criteria and the processes previously discussed.

Each technical paper describes the application of this process to the relevant issue area(s). The outcome of the process is an assessment of significant impacts, the range of mitigation options available (if any), and the preferred alternatives. The criteria referred to previously were used for decision making. The analysis required to apply the criteria also provides results that justify the conclusions and recommendations of each technical paper. The technical papers represent a comprehensive record of the way each issue area was addressed, why it was addressed in this way and the outcome of the analysis.

Conclusions from the technical papers are integrated into the GEIS document, together with information from the background papers, primarily in sections 3 to 7.

Common Elements

Some common elements in the technical papers were necessary in order to integrate the papers into the GEIS. These were described in section 2.2. In addition to a common structure, the technical papers used similar approaches to the literature review and background analysis.

The key elements of the technical papers and a proforma for their structure were specified in the contract for consultant services between the state and Jaakko Pöyry Consulting, Inc. This format was acknowledged in the Workplan. The specified format has been modified slightly to aid in presentation.

Literature Review

Comprehensive literature reviews were carried out by the study groups. The literature reviews were used to identify the ecological, biological, and physical processes of relevance to the study area. They were also used to identify the cause and effect relationships between these processes and timber harvesting and forest management activities. Reviews typically involved a tiered approach, focusing on ecoregions and USDA Forest Service FIA units in Minnesota, then subsequently the Great Lakes region, the United States, and where appropriate, the world.

Background Analysis

The information and data collected during the literature review were used to augment existing information held by the experts in the study groups. Data and information were used as follows:

1. to describe the types of timber harvesting and forest management activities that could be applied under the various scenarios;
2. to describe existing conditions in the natural, social, and economic environments of relevance to the ten issue areas including an analysis of the current level of industry and related harvesting activity;

3. to analyze the relevant processes and changes that have shaped present conditions, including the rate and direction of changes; and
4. to identify how timber harvesting and forest management activities interact with the forest environment in terms that reflect the ten issue areas.

Where appropriate, models that simulate the processes of change, particularly those caused by timber harvesting and forest management activities, were examined and tested by the study groups to determine their suitability for use in the study.

A separate analysis was conducted to identify and characterize the patterns in forest cover, particularly changes resulting from timber harvesting and forest management activities. Patterns in forest cover were examined, with thirty sample sites randomly selected from the list of FIA ground plots where timber harvesting has occurred recently. Aerial photo interpretation was then used to map patterns of forest cover for the section surrounding these plots. The patterns were interpreted and mapped by land use, forest covertype, stand size, and density classes, as per FIA procedures. A ground check was made to verify this interpretation and mapping. Based on these data, profiles of the typical patterns created by the range of timber harvesting and forest management activities were generated. This information was subsequently used by various study groups to interpret the impact spatial harvesting patterns might have on specific resources. Section 4.3.3 provides a good example of how this information was used in interpreting timber harvesting impacts on riparian corridors.

Objectives and Methodology
The following section provides an overview of the objectives and methodology used by each of the study groups to address the issues of concern from the FSD, identified in section 1.5.5. Unless otherwise noted, study methods and analysis pertain to the second model runs.

Maintaining Productivity and the Forest Resource Base
Objectives: This study group had three primary objectives, which collectively were of key importance to the entire GEIS process:

1. to develop the three FSD-required timber harvesting scenarios, which describe projected future forest conditions up to 50 years based on assumed levels of timber harvesting (as described in section 2.3);
2. to assess the current productive potential and long-run sustainable yield potential of Minnesota forests; and
3. to describe the key attributes of the forest resource base, including identification of historical changes, factors affecting change, and description of the current statewide forest resource base.