APPENDIX 1

Preferred Mitigation Strategies

1.1
Mitigation Alternatives Criteria

The significant impacts identified in sections 5, 6 and 7 are those likely to occur at the three levels of harvesting if management practices including selected mitigations are applied as described for the second model runs. The impacts also include exogenous factors such as land use change. The significance criteria identify those impacts that exceed threshold levels and therefore require a mitigative policy response. The technical papers identify the range of possible mitigations that could be applied to address these significant impacts. In addition, significant impacts which cannot be mitigated are also identified. This appendix describes criteria for selecting preferred mitigation alternatives.

A variety of strategies can mitigate against adverse impacts of timber harvesting and forest management and exogenous factors affecting the resource. The final criteria document (Jaakko Pöyry Consulting, Inc. 1991c) describes how such strategies would be identified and selected.

Framework for analyzing mitigations and selecting preferred mitigation strategies
Criteria for selecting strategies are drawn from the final criteria document noted above and reproduced below:

> Based on an analysis of mitigation alternatives identified, preferred mitigation strategies will be selected by considering in relative terms:
> 1. the effectiveness at mitigating the identified significant impacts;
> 2. the beneficial effects on other resource values;
> 3. the adverse effects on other resource values;
> 4. the physical, biological, administrative (implementation and oversight), financial (costs, public and private, direct and indirect), and social (ability to organize, support and effect implementation) feasibility; and
> 5. the probability of success and duration of success.

In practice, the verbal and written input from the Advisory Committee on the potential mitigation strategies led to acceptance, rejection and/or refinement of the potential strategies. These results were then approved by the EQB and comprise the strategies considered and evaluated in detail. Additionally, for this analysis the above criteria were grouped as follows:

1. Effectiveness addresses a mitigation strategy in terms of its ability to either avoid or reduce the identified impacts.

2. *Feasibility* addresses the likelihood that the mitigation strategy can be implemented, based on existing or future economic, social, biophysical, or administrative constraints.
3. *Duration* of mitigation can best be scored into four classes: 1=long-term—greater than 50 years and irreversible; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
4. *Concomitant effects* refers to those strategies that have the potential to significantly affect other resources. It is clearly fallacious to consider that any forest management practice will only affect a single resource; forests are intricately interacting ecosystems, and each practice affects many resources.
5. *Probability of success*, though not tabulated explicitly in the following tables, is a combination of effectiveness, feasibility and duration with minimal negative concomitant effects. The strategies identified as highly effective, highly feasible, of long duration and with minimal negative concomitant effects are assumed to have the greatest chance of success in the long-term.

These criteria were then applied to the various mitigation strategies for the purpose of comparison among them and to help determine preferred mitigation strategies.

1.2 Mitigation Strategies

The rankings of mitigation strategies with respect to the above criteria have been grouped by impact or impact area and are presented below. This presentation pulls together impacts and corresponding consideration of mitigation strategies from all the GEIS technical papers.

1.2.1 Evaluation of Specific Strategies

The impacts or impact areas treated here are:

- loss of forest statewide and by ecoregion;
- loss of timberland statewide and by ecoregion;
- patterns of forest cover in areas of mixed land use;
- tree species mix;
- age class structure;
- forest health;
- soil nutrients;
- soil compaction;
- soil erosion;
- wildlife populations;
- maintenance of biodiversity;
- water resources and aquatic ecosystems;
- primitive and semiprimitive nonmotorized recreation opportunities;

- aesthetic resources;
- cultural resources; and
- economics and management.

Individual strategies corresponding to these impacts are ranked and discussed below. Explanations of the ranks for these mitigation strategies are provided in the discussion.

IMPACT—Loss of Forest Statewide and by Ecoregion

Two possible mitigation strategies are considered for the impacts of loss of forest land. These are summarized in table 1.1.

Table 1.1. Evaluation of mitigation strategies for minimizing negative impacts of loss of forest land on forest productivity and the forest resource base. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (+)[b]
Reduce loss of forest area - northern ecoregions	2	2	2	Wildlife (+)
- southern ecoregions	2	3	2	Wildlife (+)
Increase rate of forest establishment	2	2	1	Biodiversity (+)

[a]1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

Measures to reduce the area of forest land converted to other land uses seek to discourage landholders from converting forest land to other forms of land use. Such conversions will likely take place almost exclusively on private lands. Therefore, any initiatives that seek to limit or control uses must be framed in ways that recognize private property rights, including the rights of owners to use their land for its highest economic use. There are a variety of policy instruments that are available at the federal, state and local level. The effectiveness of these policy instruments to compete with economic forces varies considerably across the state. They are likely to be less effective and/or more costly closer to major urban areas, where the value of the land for other purposes increases. Conversely, in the northern part of the state, these instruments will likely be more effective where they are applied as the unit value of land decreases. Overall, the alternative is rated as being moderately feasible. This is because most of the conversion from forest to other land uses is occurring in the north of the state. However, there are limited stocks of nonforest land in this region. Therefore, *any* change in land use in this part of the state will likely reduce the area of forest land. Changes brought about under this mitigation are likely to persist over the medium-term.

Increasing the rate of forest establishment can reduce the net loss of forest lands. There are a range of federal and state government incentives to promote reforestation activities on private lands. These programs are not necessarily aimed at increasing the area of forest *per se* but do achieve this as a side effect of efforts to reduce the area of cropland or to reduce soil losses. The effectiveness and feasibility of this mitigation will likely be governed by the degree to which the objectives of these existing reforestation programs could be achieved while at the same time meeting the age class and covertype changes identified as being desirable. If funds do not become available through these programs, the feasibility of this alternative is likely to be constrained by the comparatively low returns from independent forest plantation enterprises. Low returns are unlikely to motivate private growers to expand their area of forest. Where forest is established, the duration of the effect is long-term.

Preferred Mitigation(s)
Both potential mitigations are likely to be moderately effective, but reducing the loss of forest land allows use of a variety of policy instruments tailored to the situations that require them. Thus it is the preferred mitigation. However, interest in establishing new forests will continue and should be encouraged, especially where environmental protection needs are evident, such as in riparian areas.

IMPACT—Loss of Timberland Statewide and by Ecoregion
Four possible mitigation strategies are considered for the impacts of loss of timberland. These are summarized in table 1.2.

Increasing the afforestation rate for selected covertypes would decrease the net loss of timberland as described in the previous section.

No net loss of timberlands would maintain the area of timberlands available for timber production. This policy may be effective in maintaining the land base; however, this is only one part of the timber supply equation. The productivity of timberlands is equally important. Therefore, while this alternative is appealing in its simplicity, it would be of limited effectiveness. This alternative is also not likely to be highly feasible because of budget constraints applying to the major state and federal agencies. None of these agencies has active timberland acquisition programs, although some land exchanges continue. The forest industries are the in the best position to give effect to this mitigation, and are also the most likely to benefit.

Table 1.2. Evaluation of mitigation strategies for minimizing negative impacts of loss of timberland on forest productivity and the forest resource base. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (+)[b]

Increase afforestation rate for selected covertypes	2	2	1	Biodiversity (+)
No net loss of timberlands policy	3	3	1	
Increase utilization of harvested stands	2	2	1	Economics (+) Soils (-) Wildlife (-) Biodiversity (-)
Increase productivity	1	2	1	Biodiversity (-)

[a]1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

Increasing utilization would raise per acre yields thereby avoiding the need to increase the area harvested to obtain additional wood. This mitigation could be achieved by using more of each stem harvested by reducing minimum top diameter and log length specifications of logs; and by changing production processes to accept the range of species available from the forest rather than only a proportion of the species available; or by redesigning products to meet design needs or product standards using less raw material. The feasibility of this alternative is dependent on the ability of the forest products industry to adapt to changing input specifications while remaining competitive with other domestic and international competitors. Additionally, such utilization would need to be cognizant of concerns about soils and wildlife habitat. Proposed new industries are moving in this direction; retrofitting existing industries will be more difficult. The benefits from this alternative would be long-term.

Increasing productivity of existing and future stands will likely be a more effective way to maintain future resource security than reliance on gross area. There are many ways to increase productivity of timberlands. Regeneration to full stocking levels and site-species matching are the two most readily implemented on a statewide scale. However, achieving fully stocked stand conditions and the matching of species to sites could adversely affect biodiversity. This is because, to achieve maximum productivity in one stand, trees that are important to biodiversity, such as minor tree species, and trees with cavities, take up space, water, and nutrients that would otherwise go to trees that produce usable timber. This mitigation would be feasible, as much can be achieved by changing the way harvesting is done, and by improved site survey and planning. Additionally, some practices could be expensive to the extent of reducing feasibility. The focus of this mitigation is on private lands where the standards of planning and management can be most improved. Improving these standards, and therefore productivity, is feasible using a combination of landowner education and wider ranging BMPs that include good harvesting practices likely to maximize regrowth success. This alternative would provide long-term mitigation.

Preferred Mitigation(s)

There is considerable difference in establishing a no net loss policy and actually implementing it with appropriate funding. Consequently, increasing utilization and productivity are the preferred alternatives. However, increasing productivity will require a commitment to management investments on a large-scale over long-term horizons.

IMPACT—Patterns of Forest Cover in Areas of Mixed Land Use

Two possible mitigation strategies are considered for the negative impacts of patterns of forest land. These are summarized in table 1.3.

Table 1.3. Evaluation of mitigation strategies for minimizing negative impacts of patterns of timberland on forest productivity and the forest resource base. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (+)[b]
Reduce site specific impacts	2	2	1	Biodiversity/ Wildlife (+)
Acquisition of key patches	1	2	1	Biodiversity/ Wildlife (+)

[a]1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

Reducing site specific impacts would involve thinning or uneven-aged management where feasible, and limiting harvesting and especially harvesting of small portions of any given tract in any one decade. Since most such lands are in private ownership, education, incentive and assistance programs would likely be most cost effective. Regulation of practices is an alternative, but likely a very expensive alternative, due to the scattered ownership. In reality, partial cutting, as opposed to clearcutting, is feasible and the most common practice in such regions. The impacts are likely to be long-term, but subject to the vagaries of changing ownership.

Acquisition of key forest patches is a strategy most appropriate to patches that are very important as habitat and to the connectivity of habitat. Easements or purchase may both be useful. In the case of wetlands, precedents provide experience with the approach and suggest it is feasible and effective. A practical limitation is the availability of funding.

Preferred Mitigation(s)

Both strategies can be effective and feasible, depending on program funding. Both should be pursued to encompass a large area in a cost-effective manner.

IMPACT—Tree Species Mix

Four possible mitigation strategies are considered for the impacts of loss of timberland. These are summarized in table 1.4.

Table 1.4. Evaluation of mitigation strategies for minimizing negative impacts of tree species mix on forest productivity and the resource base. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (+)[b]
Alter age class structure	1	1	1	Biodiversity (+)
Alter species composition	1	2	1	
Enrichment of species composition on private lands	2	2	1	Forest Health (+) Biodiversity/ wildlife (+)

[a]1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

Altering stand age class structure in many cases affects stand age-related species composition for both trees and understory vegetation. This mitigation is very feasible and could be coordinated with the existing extended rotation forest programs of the MNDNR and USDA Forest Service. Since changes in age class structure would be implemented through harvesting, manipulation of large numbers of stands would be a long-term process.

Altering tree species composition could also be achieved by varying harvesting and silvicultural practices. This mitigation relies on development of guidelines for management of types to promote desirable species or to effect covertype changes. These mitigations would logically apply to public ownerships which have a mandate for managing to promote biodiversity at a state or national level. This mitigation is very feasible and could be coordinated with the existing extended rotation forest programs of the MNDNR and USDA Forest Service. Manipulation of stands to effect species or covertype changes would necessarily be a long-term process. The feasibility of this alternative would be constrained by the ability to obtain funds for this purpose. It is unlikely that the costs of such conversions could be justified by returns from timber production alone. The contribution of such stands to maintenance of biodiversity and provision of other values would make these expenditures by public ownerships more justifiable.

Changing species composition would require wider application of existing species site matching guidelines. Application of these guidelines would be effective at preventing offsite planting. The MNDNR, USDA Forest Service, larger counties and forest industries lands typically already implement these guidelines. Therefore, increasing the use of guidelines is feasible assuming the MNDNR takes a leadership role to promote their use by NIPF ownerships via existing extension services. This mitigation would have significant positive impact on forest health. Once established, the forests will provide long-term benefits.

Enrichment of species composition can be effective, especially on public lands. It can be used to create a change in covertype or simply to enrich a stand. Difficulties are matching species regeneration requirements with site conditions and dealing with herbivory. Also, establishing meaningful enrichment over a large area would require substantial management investment over a long time period. For private ownerships, success would require a range of incentives, technical expertise and a clear description of the benefits for other purposes such as aesthetics, wildlife food or habitat, etc.

Preferred Mitigation(s)

Altering the age class distribution through harvesting is the preferred mitigation. Where that is not sufficient to achieve covertype or species composition goals, alteration of species composition directly is appropriate. Enrichment is the most expensive approach and likely to be limited by practical considerations to only a few species and site conditions.

IMPACT—Age Class Structure

Only one possible mitigation strategies was considered for the impacts of age class structure on forest productivity and the resource base. This mitigation is summarized in table 1.5.

Balancing age classes is technically feasible; however, in practical terms it depends on markets and/or management investments to fund implementation. Such investments are most likely to develop for species with commercial value. This balance also needs to be considered in the context of desired species composition for the forest and long-term goals for that. The task is complicated by the varied forest land ownership. Depending on the forest type and existing age class distribution, the process will invariably affect some wildlife species positively and some negatively.

Table 1.5. Evaluation of mitigation strategies for minimizing negative impacts of forest age class structure on forest productivity and the forest resource base. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (±)[b]
Balance the age class structure	2	2	2	Wildlife (±)

[a]1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.

[b] Effects that are noted are those with potential to *significantly* affect another resource.

Preferred Mitigation(s)

Balancing age classes in conjunction with changes in species composition is the preferred approach.

IMPACT—Forest Health

These criteria were then applied to the various mitigation strategies for the purpose of comparison among them and to help determine preferred mitigation strategies. A variety of strategies can mitigate potential adverse impacts of timber harvesting and forest management activities on forest health. A comparison of the strategies considered is summarized in table 1.6.

Monitoring and if required manipulating the proportion of forest type groups that are maintained in susceptible and/or vulnerable age classes would be an effective way to anticipate medium- and long-term changes in the incidence of certain pest outbreaks. The age class structure of a forest can only be changed over the medium- to long-term. It is therefore important to have a clear understanding of trends as early as possible to allow the maximum time to effect changes. While the alternative would be of value in the medium-term, because of the time necessary it would be of marginal effectiveness in the short-term. The alternative is feasible in that the data needed to undertake such analyses are periodically available, as are the tools needed to derive the relevant information. If implemented, this mitigation would provide a long-term benefit.

Changing harvesting equipment is potentially an effective mitigation that would reduce the incidence of pests that benefit from damage of retained trees. As discussed previously, logging contractors in Minnesota are typically small and therefore are unlikely to have the resources to experiment or to readily adopt new types of equipment that would involve extensive operator training. However, if a regional perspective is adopted, with support from other stakeholders including forest industries and major ownerships, then the alternative will be feasible. The benefits would extend from towards the end of the short-term to the long-term.

Table 1.6. Evaluation of mitigation strategies for minimizing negative impacts of timber harvesting on forest health. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative(-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (±)[b]
Monitor and/or manipulate age class distribution	2	2	1	Productivity (+)
Changing harvest equipment	1	2	1	Economic (-); Soils (+)
Worker training	1	1	1	Economic (+)
Monitor pests	1	1	1	
Develop IPM strategies	1	1	1	
Increased research	1	2	1	
Increase use of pest management guidelines	2	2	1	

[a]1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

Worker training is an effective way to mitigate impacts caused by damage to retained trees. This is a comparatively inexpensive alternative that also has significant benefits in terms of worker safety and compliance with BMPs. Benefits can be realized in the short-term and would extend to the long-term.

Strategies to monitor forest pest problems are an effective way to give forest managers more time to react to likely pest problems and also a better appreciation of the extent of the problem. Both are crucial pieces of information when choosing between alternative management responses. This mitigation alternative is feasible. This alternative would provide long-term benefits.

Development of IPM strategies for major existing and likely pests would be effective by allowing a faster and more focussed response than would likely occur if plans to deal with pest outbreaks are formulated during or immediately prior to an outbreak. This alternative would be most effective if linked to the monitoring programs set out in other alternatives. The mitigation is potentially very feasible assuming that a body is convened to develop this initiative. The benefits of this initiative would extend from the short-term to the long-term.

Increased research, to gather knowledge concerning the most serious pests would be effective. Some research may lead to *blind alleys*, but other work would be likely to have high payoff. This strategy would be feasible but depends on availability of funds to carry out the work. Mitigations developed from this strategy would be long-term.

Increased use of pest management guidelines, especially by those ownerships who do not currently have access to this information, would be moderately effective. The effectiveness of the guidelines would be limited due to problems caused by the lack of professional judgement that may be required. It is also only moderately feasible because of the difficulties of disseminating the information to landowners in the NIPF category. It would be more feasible to educate loggers and other field staff. The duration of the mitigation would be short- to long-term.

Preferred Mitigations
The mitigation strategies set out above are not mutually exclusive and there is no strategy that is preferred as the strategies presented each tackle a slightly different angle of the forest health problem. As described above, all are moderately to highly effective and feasible and all would provide long-term benefits.

IMPACT—Soil Nutrients
A variety of strategies can mitigate potential adverse impacts of timber harvesting on soil nutrients. A comparison of the strategies considered is summarized in table 1.7.

Dormant season harvesting retains material on the site, but its effectiveness is limited to the case of full-tree harvesting of deciduous trees. It is feasible for upland covertypes and its duration is long-term. It is not very effective at reducing nutrient loss because a relatively small proportion of nutrients are in the foliage of those deciduous species whose harvest tends to most seriously deplete site nutrients, and conifer species retain foliage all year.

Retaining or returning material on the site is an example of a very effective strategy for reducing nutrient loss. In some cases it can be implemented relatively easily. However, overall feasibility will depend upon operational and technical constraints, particularly on the harvesting technique, the equipment available, and to some extent the season of harvesting as it facilitates removal of bark. Equipment to remove branches and bark at the stump is currently operational for Eucalypts in Australia. In the long-term feasibility should be high. Return of slash to a site from a landing or elsewhere would also be similarly effective and long-term. Its feasibility would be affected by the added cost of another pass of equipment over the site and the potential compaction and puddling associated with such an activity. Returning material in winter would minimize the latter effect. The duration of the effect is long-term.

Table 1.7. Evaluation of mitigation strategies for minimizing negative impacts of timber harvesting on soil nutrients. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative(-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (±)[b]
Dormant season harvest	3	2	1	
Retaining material	1	2	1	
Longer rotations	2	2	1	Forest Health (-)
Species conversion	2	2	2	
Appropriate site preparation	1	2	1	
Fertilization	2	3	3	Water Quality (-)
Partial harvest	3	1	2	
No harvest	1	3	1	Biodiversity (+) Water Quality (-)

[a]1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

Longer rotations are effective by allowing natural processes to replenish the nutrients lost in harvest or in site preparation. The duration is long term, but effectiveness is reduced with time as species reach advanced ages and become less vigorous and more susceptible to forest health problems. Older stands are generally more susceptible to a variety of insects and diseases when compared to younger stands of the same species. Thus this mitigation may negatively affect the forest health issue area. Feasibility is problematic for short-lived species and benefits diminish with time as nutrient levels return to preharvest levels.

Species conversion, though moderately effective and initially appealing, would incur considerable cost because it primarily involves converting sites from nutrient-demanding species (aspen and upland hardwoods) to early-successional nutrient-conserving species (jack and red pine). This conversion would require substantial inputs for site preparation, seeding or planting, etc. Alternatively, allowing natural succession to replace aspen stands would lead to either upland hardwood or spruce-fir stands. Like aspen, these stands retain relatively large quantities of nutrients in aboveground tree components. Species conversion would also require overt action at nearly every rotation to maintain the effect, whereas the effect of such measures as retaining material and appropriate site preparation would continue well-beyond a single cycle. This is especially true if those latter practices were adopted as standard procedures.

Appropriate site preparation techniques are useful and can be implemented relatively easily, and they are often less costly than more adverse (i.e., heavy-handed) techniques. The effect of such measures would also continue well beyond a single rotation. This is especially true if such practices were adopted as standard procedures.

Fertilization is a strategy that corrects or replaces nutrients that are lost. It is effective, but only for short periods. It would require repeated applications during a rotation or within cutting cycles to maintain the positive effect, thus raising questions about feasibility and costs. It is an expensive technique. Additionally, the practice could have adverse (negative) impacts on other resources, notably water quality.

Partial harvest, whether by thinning or all-aged management, only reduces the nutrient depletion associated with a single stand entry. Over the long-term, equivalent volumes of products would be removed from a site and hence equivalent amounts of nutrients. It is therefore a feasible practice, but is of limited effectiveness. Its duration, similarly, would be only of medium term.

No harvest is another potential management strategy on sites with both very low nutrient capital and rates of replenishment. Because nutrients are not removed, this method is effective and long-term. If the management goal is wood production, however, this technique is not feasible and is equivalent to nonmanagement. Unharvested stands may positively contribute to management goals that are associated with old-growth. Because nutrients will ultimately leach from systems that do not have net volume growth, this strategy may have negative impacts on water quality.

Preferred mitigation(s)

Retaining material is the mitigation with the greatest chance for success in minimizing negative impacts of timber harvesting on soil nutrients. Thus it is the preferred mitigation. However, each of the mitigations may be useful, depending on site specific and operational circumstances. The least successful mitigation applied on a broad scale would appear to be fertilization.

IMPACT—Soil Compaction

A variety of strategies can mitigate potential adverse impacts of timber harvesting on soil compaction. A comparison of the strategies considered is summarized in table 1.8.

Table 1.8. Evaluation of mitigation strategies for minimizing negative impacts of timber harvesting on soil compaction. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long-term to 4=very short-term. Concomitant effects refers to potential positive (+) or negative(-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (±)[b]
Identify sites that are potentially susceptible to equipment impacts	2	2	1	Economics (-)
Limit equipment operation to periods of high soil strength	1	2	1	Economics (-)
Concentrate equipment trafficking	2	2	1	
Traffic on top of surface organic residues	2	2	1	Forest Health (-)
Use high flotation equipment	2	2	1	
Employ aerial yarding systems preparation	1	3	1	
Change type of equipment used to fell trees	2	2	1	Economics (-)
Develop long-term transportation plan	2	2	1	Wildlife (+) Recreation (+)
Develop site disturbance guidelines	1	2	1	
Ameliorative measures	2	2	1	Economics (-)
No harvest	1	3	1	Biodiversity (+) Water Quality (-)

[a]1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

Identifying sites that are potentially susceptible to equipment impacts would be an expensive and time consuming process if applied to all Minnesota sites. This limits its feasibility, as this work would have to be done in advance of harvesting.

Limiting equipment operation to periods of high soil strength is the most effective mechanism of minimizing compaction and related disturbances when ground-based equipment is used. Its feasibility is somewhat limited because it requires careful monitoring by natural resource professionals and may cause economic hardship to operators and some mills.

Concentrating equipment trafficking can effectively reduce the areal extent of site disturbance, though high levels of compaction and other disturbances can occur in areas that are trafficked. It may force operators to travel greater distances when skidding, which can reduce their productivity.

Trafficking on top of surface organic residues can protect the soil surface from equipment impacts for one or two equipment passes, provided the residues form a relatively continuous mat. This practice loses its effectiveness after the first several passes because the organic residues are broken down or displaced. Operators may be reluctant to operate on top of slash because it may get caught up in their equipment or slow them down.

Using high flotation equipment may be partially effective in reducing site disturbances. Previous research is not conclusive regarding the benefits of this type of equipment. Feasibility is limited because of the high cost of this equipment.

Employing aerial yarding systems would eliminate most, if not all, of the soil disturbances. However, the feasibility of these systems is very low in Minnesota because of their high cost and the low value of most forest products in Minnesota. A possible exception is in the southeast where the high species value and the steep topography may justify the introduction of cable systems. Their feasibility is further limited because there is currently no infrastructure to support these systems in Minnesota.

Change the type of equipment used to fell trees is potentially feasible for a proportion of harvesting operations. The feasibility of this alternative is limited by the ability to alter decisions on equipment choice that are made by loggers.

Development of a long-term transportation plan would effectively minimize the area disturbed by forest haul roads. It would require coordination between forest management organizations to implement properly.

Developing site disturbance guidelines would effectively limit the amount of disturbance on individual sites. Additional research would most likely be required to establish and document allowable disturbance limits. Also, it would take considerable debate to evaluate the pros and cons of voluntary versus mandatory guidelines. Creation of guidelines would require additional human resources to monitor their implementation and effectiveness.

Ameliorative measures such as discing and subsoiling may restore porosity in some areas. These practices are most effective on medium- and coarse-textured soils, particularly when compaction is limited to specific areas such as landings, skid trails, and haul roads. Tillage would be less effective on fine-textured soils because of the difficulty in pulling implements through these soils and the clodiness that can result. An additional concern of tillage is the potential damage that can be done to aspen roots which can reduce regeneration of this important species. Finally, all operators may not have access to the equipment necessary to perform these types of operations.

No harvest is another potential management strategy on sites sensitive to equipment impacts. If the management goal is wood production, however, this technique is not feasible and is equivalent to nonmanagement.

Preferred mitigation(s)
Limiting operations to periods of adequate soil strength, concentrating equipment trafficking, and development of long-term transportation plans are the preferred mitigation strategies. These are all potentially feasible under current conditions, though they would require the commitment of additional resources to planning and management. They would effectively reduce compaction and related disturbances.

IMPACT—Soil Erosion
A variety of strategies can mitigate potential adverse impacts of timber harvesting on soil erosion. A comparison of the strategies considered is summarized in table 1.9.

Constructing water bars can effectively divert overland flow from steeply sloping skid trails. Water bars can be constructed with the blades of standard harvesting equipment. Some training would be required to ensure proper construction techniques and spacing.

Revegetating or mulching bare soil areas effectively reduces erosion rates in steeper topography. These areas most commonly develop along roads, skid trails, and landings. This would require additional expense and training for individuals not traditionally involved in road construction operations.

Proper road engineering is an integral component to minimizing erosion wherever overland flow can accumulate on or adjacent to roads. The technology is available to accomplish this goal; however, it requires careful training and additional expense for individuals not traditionally involved in road construction operations. Vehicle safety and haul speed must always be considered during road design.

Table 1.9. Evaluation of mitigation strategies for minimizing negative impacts of timber harvesting on soil erosion. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative(-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (±)[b]
Construct water bars	1	1	1	Water quality (+)
Revegetate and or mulch areas of exposed mineral soil	1	2	1	Water quality (+)
Proper road engineering	1	2	1	Water quality (+)
Close roads after use	2	2	1	Water quality (+) Recreation (-)
Operator training in road design and construction	2	2	1	Water quality (+) Economics (-)

[a]1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

Closing roads after harvest will allow them to revegetate and decreases the chances of additional disturbances by vehicles when the roads are wet. This technique is most feasible for temporary roads that are constructed with minimal effort and end at log landings. The effectiveness of this technique can be significantly reduced by the continued use by off-road vehicles, which can retard revegetation and cause additional rutting, leading to rills and gullies.

Operator training in road design and construction is required to properly construct roads. Such training is particularly useful when building roads in steep topography or adjacent to rivers and streams. Such training would require an additional commitment of human resources.

Preferred mitigation(s)

Proper road engineering, revegetating bare soil areas, and closing temporary roads after harvest are the preferred mitigation strategies. These activities would reduce soil erosion along forest roads and major skid trails, the major areas where erosion problems caused by forest management activities occur. The additional expense incurred in implementing these measures would lead to important and long-term reductions in erosion problems.

IMPACT—Maintenance of Biodiversity

Maintenance of biodiversity in managed forests is a very complex process, often with several mitigations necessary for a single impact, and multiple effects of each mitigation. A summary of the significant impacts, and effectiveness of each strategy, as judged by the study group (table 1.10) provides a useful starting before evaluating the feasibility of each mitigation (table 1.11).

Table 1.10. Effectiveness of mitigation strategies relevant to each significant impact, from 1=high to 3=low. Empty box= little or no effect.

Significant Impact	Mitigation										
	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	5.10	5.11	5.12
Decline of old growth swamp conifer forest	1	2	2	1							1
Likely decline of hemlock, yellow oak, honeylocust, sycamore, Kentucky coffeetree and rock elm	1	1								1	
Potential loss of conifers in mixed-species stands		1				1			1		3
Decline of tree species near the range edge	1	1	1	2	3		1			2	2
Decline of rare communities	1			2	1	1	3			2	2
Effects of fragmentation on forest herbs	3	2	1	2							3
Effects of fragmentation during climate change		3	1								2
Deer browsing	3			1							1
Potential displacement of native species by hybrids								1			1
Decline of rare plants species	1	1	1	2	1	1	3	3	3	1	3
Decline of red-shouldered hawk	1	1	1	3							
Decline of Pine marten	1	1	1	1					1		

Key for tables 1.10 and 1.11:

Mitigation (numbered according to presentation in technical paper on biodiversity):

- 5.2 Inventory
- 5.3 Extended Rotation Forest
- 5.4 Connected Landscape
- 5.5 Biodiversity Maintenance Areas
- 5.6 Prescribed Burning
- 5.7 Return of Red and White Pines, and Upland White Cedar
- 5.8 Favor Tree Species Near the Edge of Their Range
- 5.9 Careful Use of Exotics and Hybrids
- 5.10 Retain Conifers in Mixed-Species Stands
- 5.11 Careful Harvest Near Rare Species and Communities
- 5.12 Resolution of Conflicting Management Goals

Table 1.11. Evaluation of mitigation strategies for minimizing negative impacts of timber harvesting in biodiversity. Number of impacts mitigated shows how many of the total 13 potential negative impacts identified above would be helped by each strategy. The number of impacts highly mitigated is the number of impacts that received a 1 in table 1.10. Feasibility is ranked from 1=high to 3=low, and for duration from 1=long to 4=very short term. Rankings apply only to those impacts indicated in table 1.10. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD, other than those considered in this paper (genetic variability, biodiversity, old growth and old forests, endangered, threatened and special concern species). Blank means no significant concomitant effects expected.

Mitigation Strategy	# Impacts Mitigated/ highly mitigated	Feasibility Physical/Administrative/ Financial			Duration	Concomitant Effects
5.2	9/7	1	1	2	2	Forest Wildlife (+)
5.3	9/6	1	1	1	1	Recreation, Esthetics (+), Forest Health (-)
5.4	7/6	2	2	2	1	Forest Wildlife (+)
5.5	8/3	2	3	1	1	
5.6	3/2	2	2	2	1	Forest Wildlife (+)
5.7	3/3	1	2	3	1	Forest Wildlife, Recreation and Esthetics (+)
5.8	3/1	1	1	2	1	
5.9	2/1	1	1	1	1	
5.10	3/2	2	1	2	1	
5.11	4/2	1	2	2	1	
5.12	9/3	1	3	1	3	

Inventory (5.2) is probably the most effective overall strategy at this time, because there is a need to simply identify occurrences of rare species and communities, and old growth so that forest managers can adapt harvest plans. Not all points on the landscape are equally important to protection of biodiversity. For example, small temporary wet areas within forests or stands used as stopovers by migratory song birds may contribute resources necessary for survival of many species at key times. Such natural features need to be inventoried. In the absence of complete inventory in the state's northern forest lands, many effects of harvesting on rare species and communities will be due to accidental harvest of sensitive areas. A complete inventory of biodiversity features of the state's forests would require a substantial investment of time and money over the next decade. Inventory alone is not sufficient to protect biodiversity; there need to be guidelines for management of rare features identified by inventory. However, inventory is the *starting point for protection of biodiversity.*

Optimizing timber harvest while guaranteeing preservation of statewide biodiversity requires, without question, uniform statewide information on existing and previous biota, without regard to current land ownership or jurisdiction. If the presence of a species or a whole biotic community is an objective of long-range planning within our state, then the current geographic status of those entities becomes a prerequisite to any planning strategies, to say nothing of implementation, however that may be directed.

Extended Rotation Forests (5.3) are effective overall because they directly help mitigate a large number of potential effects of harvesting on biodiversity. Extended rotation forests do not remove lands from the timberland base, yet they help provide many of the features of old growth forests over relatively large areas. The second run harvesting scenarios included 20 percent extended rotation forest on state and federal lands, and showed that a high yield of timber and pulpwood is still possible.

Generally, with increasing intensity of forest harvest, there is increased short-circuiting of plant succession and the development of structural diversity. Extended rotation forests assure the continued presence of large tree gaps, dead wood, and the species that depend on them, without being designated old growth and removed from the base of timberland. Extended rotations can mimic the natural rotation period for Minnesota forests more closely. Intensive management, with shorter rotations, is compatible with biodiversity, as long as other portions of the landscape are managed with extended rotations.

Connected Landscapes (5.4) are very effective at reducing the effects of fragmentation, without reserving large contiguous blocks of forest. They can be achieved by changing the spatial pattern of harvest, not the amount of harvest. However, it would be difficult to work out plans for the corridors, which would require interagency cooperation. The connected forest corridors would be managed under extended rotation forest guidelines, which would count as part of the recommended ERF forest percentage in the state or under uneven-aged management guidelines where appropriate.

By creating corridors for plant and animal species migration, this strategy would be the most cost effective way of allowing Minnesota's forest to respond to future climate change. Genetic variation in Minnesota generally occurs along a cline correlated with climate, from southwest to northeast. It is important not to disrupt the genetic spatial structure of forest trees by harvesting. Paleoecology shows that the climate has always been changing and this will continue, whether or not human-caused global warming occurs. Tree populations must be able to respond to changing climate, and gene flow and seed movement should be allowed to occur from southwest to northeast. Also, in all ecoregions except the border lakes (ecoregion 2), old growth forests are probably too isolated to allow exchange of genetic material among old growth species.

Biodiversity Maintenance Areas (5.5) in Minnesota's northern conifer forests are very effective at reducing effects of fragmentation, by providing examples of a landscape that is managed for timber harvest, but with a natural spatial pattern. This means very large clearcuts to mimic the largest size (>10,000 acres) of natural disturbances in Minnesota. Administrative and physical feasibility of these large clearcuts is moderate to low, because a large area within one administrative unit would have to be dedicated permanently to a biodiversity maintenance area. However, the financial feasibility is high because the mature forests within the area count as part of the total extended rotation forest in the state.

Reduction of deer browsing and grazing in biodiversity maintenance areas will allow combinations of species, interactions among species, and physiognomic structure of the forest to develop as they would under natural conditions. Conditions of low deer numbers already exist in the BWCAW, so that a biodiversity maintenance area is not necessary in ecoregion 2. Other suitable areas with low deer numbers may also exist and be revealed if mitigation 5.2 is carried out.

Prescribed Burning (5.6) is very effective for mitigating two impacts: the loss of rare fire dependent communities and the rare species that live in them. The physical feasibility varies a lot within the state, but is high in remote areas and low in heavily populated areas where there is potential liability for escaped fires. Financial feasibility is moderately low because prescribed burning is labor intensive with little or no gain in timber production results.

Return of Red and White Pines and Upland White Cedar (5.7). Many people would like to see more red and white pine on the landscape. The strategy outlined in the introduction for stopping the loss of biodiversity is to maintain the natural function of the forest landscape, including the balance of covertypes. It is difficult for the forest landscape of Minnesota to function naturally when a covertype once occupying 3.5 million acres now occupies only slightly over 400,000 acres. The physical feasibility for restoring these species is very high—there is a lot of suitable aspen forest within which the conifer component could be increased. However, the financial feasibility for replanting is low (about $127.00/acre), unless the species are restored by leaving individuals of currently existing seed sources during harvest.

Favor Tree Species Near the Edge of Their Range (5.8). Trees that are near the edge of their range are often poor competitors against other species that are in optimal habitat. To maintain their populations in the state, they should be retained in forest management—except in cases where it is known that their populations are stable or increasing.

The feasibility of this strategy is high because guidelines for leaving seed trees of the affected species/regions is all that is required.

Careful Use of Exotic and Hybrid Tree Species (5.9) will be very effective in preventing future loss of biodiversity due to displacement of native species by exotics. The physical, financial and administrative feasibilities are all high because this is a preventative strategy. Currently there is not a widespread problem. All that is required is development of guidelines for future purchases of exotic and hybrid stock.

Retain Conifers in Mixed-Species Stands (5.10). This strategy would be very effective in reducing the potential biodiversity effects of having a large proportion of the state or one ecoregion in one covertype, such as aspen. A substantial conifer component allows aspen stands to be used by many wildlife species and plants. Administrative feasibility is high, but economic feasibility is only moderately high because there would be some reduction in the amount of aspen pulpwood harvested per acre.

Careful Harvest Near Rare Species and Communities (5.11) is extremely effective at mitigating impacts of harvest on biodiversity. It is necessary in the case of most endangered, threatened or special concern species. The physical feasibility is high, but administrative and economic feasibility is only moderate because some the large number of species and communities would require many guidelines and some potential timber harvest would be lost.

Resolution of Conflicting Management Goals (5.12) would help managers look at biodiversity in a landscape context, rather than on a species-by-species basis. The most effective part of the strategy would be that it would help managers plan harvests to avoid future conflicts. Resolution of conflicting management goals is physically very feasible, and does not cost much since most managers are already involved with planning and continuing their education throughout their career.

Preferred Mitigations

Inventory of significant biodiversity features within Minnesota's forest lands, combined with a permanently ERF-connected landscape, restoration and retention of conifer cover, and careful harvesting near rare communities and plant species would appear to be the combination most suited to overall protection of biodiversity statewide. This combination has some positive ameliorative effect on all significant impacts of harvesting identified, except the potential effect of exotic and hybrid species. The main disadvantage is the physical and administrative difficulty of establishing a connected landscape. This is because these mitigations would have to be heavily concentrated on public forest lands, which may not always have the spatial extent or complex of communities needed. Also, all public agencies as well as interested private landowners would have to coordinate their efforts to an unprecedented degree. However, reducing fragmentation is biologically of overwhelming importance.

All of the mitigation strategies for biodiversity that were identified will be useful under some circumstances. The last strategy—resolution of conflicting management goals—would be the most useful way to develop a policy to determine when each mitigation should be applied.

IMPACT—Wildlife Populations

Extended Rotation Forests

Effectiveness: Species Mitigated

A variety of small- and medium-sized mammals (including red-backed voles, all species of tree squirrels, fisher and pine marten) would benefit most from older forests on the landscape. Bobcat, lynx, snowshoe hare and northern flying squirrel would also benefit from older lowland conifer forests, and deciduous forests where conifers are appearing in the understory. An upland deciduous forests may contain plentiful food for hares, but without cover-providing low conifer, hares cannot exist due to predation vulnerability.

White-tailed deer would benefit only to the extent that scattered lowland conifer stands in the north are preserved in a mature stage, and that some northern hardwood stands grow long enough to develop a conifer component of fir and spruce for cover. Moose, while favored by good acreages of young regenerating aspen, also do well in very old forests where the canopy is opening to permit a well-developed shrub layer of mountain maple, hazel and dogwoods. However, this stage of forest aging might more likely fall under old growth. Moose also seek conifer cover in summer and winter to avoid extremes in temperature.

Wherever oak mast is a critical resource to some mammals, particularly deer, bears, and squirrels, longer rotation is important. The importance of this feature is inversely proportional to the abundance of the oaks, so greatest priority should be applied in the northern regions where oaks become a minor part of forest composition. In general, most tree species are more prolific in seed/mast/fruit production at an age older than that normal for early timber harvest.

Many bird species projected to be significantly impacted by harvesting are associated strongly with mature forests, including Barred Owl, Long-eared Owl, Boreal Owl, Pileated Woodpecker, Black-backed Woodpecker, Yellow-bellied Sapsucker, Red-shouldered Hawk, Red-breasted Nuthatch, and Scarlet Tanager.

A variety of forest-floor herps are favored by old forests in that they require deep shade, a deep layer of moist leaf litter, and a good distribution of woody debris that is characteristic of the accumulations of dead material over many decades. These include all forest salamanders, the wood frog, milk snake, and eastern hognose snake. In addition, forest mice and shrews in many cases depend heavily upon small and large decomposing woody debris for cover and for sources of food. In turn, this benefit favors the avian and mammalian predators of these small mammals.

Silvicultural Methods Other Than Clearcutting

Clearcutting with Residuals

Effectiveness: Species Mitigated

Deer, moose, snowshoe hare, and pine marten will use the inclusions as cover from heat, cold, or predators while still having access to the emergent forage in the clearcut. Black bears will use conifer shade in summer while feeding on berries in clearcuts. A variety of birds will use the snags for nesting when cavities develop, including Tree Swallows, Northern Saw-whet Owls, Eastern Bluebirds, and most woodpecker species. Other birds use the snags for territorial singing perches, including Golden-winged Warbler, American Robin, and Chestnut-sided Warbler. Raptors use the snags for hunting perches—the Red-tailed Hawk, Kestrel, and Northern Saw-whet Owl.

Selective Cutting

Effectiveness: Species mitigated.

This mitigation will minimize reduction in important features of older forests needed by some small- and medium-sized mammals, amphibians, and reptiles in all ecoregions. It will favor black bears in the north by producing small openings where fruits, such as raspberries, will flourish, as well as herbaceous plants that sought in spring, while the selective pattern retains mast-producing, mature trees plus ample shade. This pattern will favor deer year-round throughout the state, by leaving thermal cover while producing temporary patches of forest herbs and of shrubs that provide summer and winter browse with high quality summer and winter forage. The deer would still need access to herbaceous openings. In the north, moose would be favored as well as deer, although the quantities of forage they require will not be provided as well as by clearcuts. Snowshoe hares will also be favored if some low conifer for security is present.

Where forests dominated by oaks are cut in this manner rather than by clearcutting, all mast-dependent species will be favored, particularly fox and gray squirrels, bears, deer, and Wood Ducks.

A wide variety of forest birds that would otherwise disappear from clearcut stands will remain in the select cuts. Forest raptors can often be protected by reserving a few acres around each nesting site. Apparently the Red-shouldered Hawk may not tolerate this level of disturbance. More data are needed to determine the extent to which it will tolerate forest cutting and at what times.

Ruffed Grouse will be partly favored, particularly if some aspen arises in the openings created by the cutting; however, numbers will not be as great as in small clearcuts. Woodcock will be favored in sites where soil is moist enough to provide their invertebrate food sources.

More Mast and Other Food Producing Trees

Effectiveness: Species Mitigated

Among small mammals, this mitigation is most applicable to the impacted squirrel species analyzed, and to forests in the southern and central portion of the state (including all of ecoregion 4).

The productivity and survival of white-tailed deer and black bear are higher, all other habitat features being equal, when good supplies of mast are available; this is true wherever the range of these large mammals overlaps with the range of oaks. In northern Minnesota, where oak stands are relatively rare, individual bears sometimes travel over 10 miles just to feed on acorns in the fall. The Wood Duck and the Wild Turkey are both mast-eating birds that will benefit from protection of the producing trees. In the case of the wood duck, the oaks used are generally in a riparian setting.

Berry trees are used by the Pine Grosbeak, Brown Thrasher, all thrushes, Evening Grosbeak, Cedar Waxwing, Bohemian Waxwing, Ruffed Grouse, Scarlet Tanager, Rose-breasted Grosbeak, and Northern Oriole; as well as by all tree squirrels, black bears, and red and gray foxes.

It is assumed that federal and state policy will regulate the harvest of the oak type, but the majority of the state's oak forests lie outside these ownership jurisdictions. Existing oak stands should be identified and managed so as to maintain the mast resource as a primary objective. Special silvicultural standards are needed to incorporate protection of key berry-producing species.

Retention of More Trees With Cavities
Effectiveness: Species Mitigated
As pointed out in the species accounts (section 2), studies in Illinois have shown that forests inhabited by gray squirrels contained a minimum of 6 cavity trees/ha (about 2.4 trees/acre); southern flying squirrels use a large number of tree cavities during each night's activity as escape sites, feeding stations, and resting areas. This mitigation should be applied over all Minnesota ecoregions, but for mammals it may be especially critical within the range of the gray squirrel, projected to be heavily impacted under all harvest scenarios.

Many bird species are dependent upon cavities for nesting, and a number of overwintering songbirds, such as Chickadees, require cavities for thermal protection in cold weather. Tree-cavity nesters range through all forest types and stand sizes; some species prefer lone trees in openings, hence the importance of cavity-snags on edges and within clearcuts. Cavity nesters in Minnesota forests include Owls—Boreal, Barred, Screech, and Northern Saw-whet; Woodpeckers—Red-headed, Red-bellied, Downy, Hairy, Three-toed, Black-backed, and Northern Flicker; Black-capped and Boreal Chickadees; Red-breasted and White-breasted Nuthatches; Eastern Bluebird; Tree Swallow; and several ducks—Common Goldeneye, Common and Hooded Mergansers, and Wood Duck.

Retention of Slash
Effectiveness: Species Mitigated
Slash retention should be applied statewide to benefit small mammals, such as the red-backed vole, shrews, and deer mice. This material also aids herps, such as the wood turtle, that begin to use clearcuts with early development of the shrub layer and increased soil-moisture retention. Although slash retention may not increase use of recent clearcuts by these animals substantially, presence of slash in older regenerating stands is an important habitat feature for these animals. Another important function of slash is the creation of a favorable subnivean substrate for small mammals, including predators and prey. The structure of slash—particularly branches with limbs—prevents packing of snow thus allowing extensive travel-ways, cover and foraging sites for mice, shrews, and weasels. The larger dimension slash including whole, unlimbed trees provides subnivean security for larger mammals such as snowshoe hares and pine marten. This habitat attribute is particularly critical in large clearcuts where wind otherwise compresses snow so as to impede subnivean movements.

An important effect of adequate slash cover for small mammals is provision of prey for such mammalian carnivores as foxes, and, in the north, pine marten and fisher. As discussed in the pine-marten account, snags, blowdowns, deadfalls, and slash comprise critical substrate, not only for supporting prey but also for the mobility and security-cover of the marten itself. Likewise, increased densities of small- and medium-sized mammals serve to increase prey for forest raptors, many of which are relatively tolerant of some forest clearing as long as suitable nest trees are left. Raptors affected here include the Red-tailed Hawk, Kestrel, and Goshawk; and many owl species found in forested areas throughout the state.

Because adequate food is promoted through slash retention, this tends to offset, in part but not entirely, some potential negative impacts of clearcutting on raptors.

Logging practices which leave large amounts of scattered slash and some larger logs will greatly reduce the impact of harvesting on herps. Although not all species are known to use slash, some species, such as the milk snake, wood turtle, blue-spotted salamander, redback salamander, eastern newt, boreal ringneck snake, eastern hognose snake, wood frog, and spring peeper will benefit.

Because BMPs do not apply to small or temporary wetlands and ephemeral streams, they should be modified or expanded to include protection of these wetlands from slash piling or other disturbances. Application of this BMPs modification should include instructions on recognizing such wetlands during dry periods and particularly during winter, when a considerable amount of harvest occurs.

Retention of More Conifers

Effectiveness: Species Mitigated

Mitigations directed at retaining conifer forest cover, conifer inclusions in mixed stands, and conifer understories are related to a very long list of birds of northern Minnesota. Many songbirds and raptors—either breeding in or migrating through the forested north—are associated with conifer cover.

Isolated patches of conifers are known to enhance the use of harvested areas by pine marten, at least during winter, and conifers are an important component of mature forest habitat for this species. The red squirrel, one of the prey for the pine marten, is strongly tied to spruce and cedar forests.

White-tailed deer and moose use conifer cover in northern Minnesota during winter because of the reduced wind chill and lower, less crusted snow cover within conifer stands. While research is being carried out on how conifer cover relates to survival of wintering deer in the north, according to the harvest model, the reductions of mature conifers are extensive enough under the high harvest scenario that mitigations would be required immediately. It is assumed that federal and state forest management guidelines for retaining lowland conifer for wildlife will be sufficiently effective for all federal and state lands, and to some extent, county lands. However, much of the harvesting will be on other ownerships. Therefore, the recommendations for mitigation include the reservation of plots of mature conifers, with northern white cedar having the highest priority, followed by white spruce, balsam fir, jack pine, red and white pine, and finally black spruce. The mitigation also includes extension of the rotation ages of clearcut forests to permit emergence and maturation of some conifers. These mitigations apply primarily to ecoregions 1, 2, 3, and the northern half of 4.

Conifer presence is important for moose, probably most critically in summer when, without deep conifer-shaded and moist-soil stands, the animals would be stressed by the heat of midsummer. Moose in winter also are more often found in the proximity of conifer clumps, even as they forage in open shrub vegetation. Retention of lowland black spruce, plus some types of jack pine, is critical to the Spruce Grouse.

Regionwide inventory and composition targets need to be developed to develop conifer-retention approaches that are truly effective in protecting habitats of so many northern Minnesota species. For relatively uniform habitat maintenance over the entire region, guidelines need to be applied at the level of a reasonably localized unit, perhaps the township, as was chosen here for analyzing projected impacts on deer in the north. Starting with the estimated percent conifer found on the 1990 FIA plot, this level could be used as a guide for pursuing a no-net-loss target for every township. While it may appear that the program is directed primarily towards deer, the effects would indeed impact a very broad spectrum of birds and mammals.

Retention of conifers will mitigate the adverse impacts of harvesting to bird species associated with mixed coniferous-hardwood or totally conifer covertypes. This is especially true for conifer inclusions within hardwood stands in ecoregions 1 through 4. Wildlife species that would be partially mitigated by this measure include most of those that are associated with conifer trees in otherwise hardwood-dominated forest covertypes and include Sharp-shinned Hawk, Swainson's Thrush, Red-breasted Nuthatch, Golden-crowned Kinglet, Ruby-crowned Kinglet, Northern Parula, Pine Warbler, Yellow-rumped Warbler, Chipping Sparrow, and Pine Siskin.

In addition to retention of conifers, it is also important to consider plantings designed in such a manner to increase conifer cover and inclusions.

The wood turtle, ringneck snakes, and red-backed salamander are associated with mixed species stands and would benefit from retention of conifer inclusions within aspen forests.

Spatial Patterns of Cutting
Large clearcuts and large patches of mature conifer forest.
Effectiveness: Species mitigated
The very large clear cuts will favor moose in the early stages; when mature, if they are eventually large patches of conifer, then they will favor such conifer interior birds as the Three-toed Woodpecker and mammals such as the pine marten.

Retaining relatively large tracts of mature forest in ecoregions 4, 5, 6, and 7 will potential mitigate harvesting impacts on the gray squirrel and all forest interior birds in that part of the state: Pileated Woodpecker, Acadian Flycatcher, Cerulean Warbler, Black-and-white Warbler, Ovenbird, and Scarlet Tanager. Much of this mitigation is related to reducing nest parasitism by the Brown-headed Cowbird, also an edge species. In addition, large areas of continuous, mature forest are required to mitigate negative impacts on forest raptors, especially the Red-shouldered Hawk and possibly the Goshawk.

Travel corridors
Effectiveness: Species Mitigated
Corridors will be particularly important to the pine marten, red squirrel, flying squirrel, and red-backed vole year round, and to deer and snowshoe hares in winter. In southern and central Minnesota corridors through larger cuts will serve tree squirrels and flying squirrels.

Riparian Corridors
Effectiveness: Species mitigated
The wider buffer will mitigate negative effects of harvesting on most herps as well as on birds such as the Prothonotary Warbler, Louisiana Waterthrush, Northern Waterthrush, and Cerulean Warbler, the habitat problems for which are concentrated mainly in the southern portion of the state. In the north, occasional exceptions to restricting harvest from stream edges will maintain favorable habitat for the beaver which requires young, emergent deciduous trees, mainly aspen; the beaver in turn creates extensive habitats through impoundments for birds, mammals and herps.

Protection of Sensitive Sites
Effectiveness: Species mitigated
This mitigation is aimed at species such as the Massasauga, timber rattlesnake, five-lined skink, and lined snake, which are too rare for analysis of habitat abundance in this paper. This mitigation is already in place for rare birds such as the Bald Eagle. Similar mitigations, tailored to the needs of each rare species, are necessary to preserve other species which may not be as publicly visible as the Bald Eagle.

Reduce Use of Herbicides

Effectiveness: Species Mitigated

Black bears, deer, moose, snowshoe hares and many bird species are highly dependent on the browse and fruit produced by many shrubs on conifer plantations. Birds whose hatchlings depend on insects from the herb or low shrub layers in plantations may be impacted from the reduction of this food source. All frogs and salamanders may be negatively impacted by the use of herbicides. However, since herbicide use is very limited in Minnesota's forests, this mitigation is not expected to produce major results.

Preferred Mitigations

Determination of preferred mitigation strategies for impacts of harvesting on wildlife is a complex process. Each of the mitigations strategies identified provides partial mitigation for a number of significant impacts, and concomitantly, each impact is mitigated by several strategies. In addition, each mitigation strategy, if implemented, affects the outcome of the other strategies. Also, some of the mitigations have long been in place and others just recently been implemented to some degree.

All of the identified strategies are of long-term duration, all are quite feasible physically, and all are very effective under certain circumstances. Financially, all of the mitigation strategies identified require administrative guidelines that would also cost time and money during preparation of timber sales. In addition, the cost of actually growing and harvesting timber would be higher, because most of the strategies, such as extended rotation forest, retention of mast trees and changes in spatial patterns of cutting would reduce timber production and require less intense harvest over a larger area or harvest over a longer time or at greater expense.

Concomitant effects of the mitigation strategies identified would be virtually all positive for biodiversity, and extended rotation forests would have a positive effect on soil nutrient balance and aesthetics. Retention of conifers and silvicultural methods other than clearcutting would also have a positive effect on recreation and aesthetics. Three mitigation strategies (extended rotation forests, retention of slash and retention of trees with cavities) may have negative effects on forest health and productivity in some cases.

The simplest way to determine which strategies are preferred is to find a combination of a few strategies that partially or wholly mitigate the maximum number of significant impacts identified in this paper. The mitigations that appear of greatest relevance to a broad spectrum of animals are *Retention of Conifers*, particularly for northern Minnesota, and *Protection of Riparian Zones*, particularly in southern and western Minnesota. The next two most important mitigation strategies appear to be *Extended Rotation Forest* and *Spatial Patterns of Cutting*. These four strategies in combination appear to provide some mitigation for a majority of significant impacts identified. However, all of the mitigations will be useful in certain cases.

The second runs of the harvest scenarios incorporated increases in forest area in all ownerships in the southern part of the state and decreases in forest area in private ownership in the northern part of the state. The results of this analysis could differ markedly with different area change estimates for several species of birds and mammals. In the southern part of the state, the projected increase in forest area ameliorates the effects of harvesting, while the projected decrease in forest area in the north exacerbates the negative impacts of harvesting. Therefore, the mitigation strategies in the MPFRB Technical Paper aimed at reducing the loss of forest area by ecoregion would also work well in conjunction with the mitigation strategies identified by the wildlife study group.

For sound economic policy and environmental management, it is not wise to consider applying the mitigation recommendations above in an isolated or generic manner. Rather, they need to be applied in relation to an understanding of regional wildlife and biodiversity problems and in conjunction with the potential of different land ownerships to contribute differentially to both protection of wildlife and production of timber products.

To implement regional, cross-ownership wildlife management and protection, a uniform data base on habitats and populations must be developed as the first step, as discussed in the Biodiversity Technical Paper. Such an inventory system must be far more uniform in coverage and comprehensive in parameters measured than any regional system now in place or being planned within the forested part of the state. Among other attributes, such a system must have a spatial dimension, so that landscape patterns are recorded at scales and with attention to relationships that are dictated by the needs of various animal species.

Under comprehensive regional wildlife habitat inventory and conservation planning, the need for any of the specific mitigations described above will be prioritized in terms of sites, timing, and funding allocations. The overall objective of such coordination will be an optimization of efforts and expenditures for protecting the state's forest wildlife and minimizing the risk of critical habitat loss.

IMPACT—Water Resources and Aquatic Ecosystems
There are no significant impacts on water quality or fisheries resources predicted at the ecoregion level.

However, there are numerous site specific impacts that are predicted to affect third order and smaller watersheds. These impacts include:

- increases in annual water yield and peak snowmelt runoff;
- increases in stream dissolved ions;
- where BMPs are not used, affected streams will experience increased sediment

loads and light levels and decreases in CWD inputs and stream fish populations (ecoregions 1, 4, 6); and

- even where BMPs are used, small watersheds will experience localized impacts including increased nutrient and sediment loads, and changed structure and functional rates of aquatic communities.

There are two general strategies that might be followed to reduce localized water resource impacts: improved watershed management and increased effectiveness of BMPs. In the first instance, several suggestions are presented below for increased coordination among agencies and increased monitoring and enforcement of water resource management and BMPs implementation. These suggestions will be most effective over relatively large areas (i.e., will affect multiple locations in which BMPs might be used). Second, several suggestions are presented which are intended to improve the effectiveness of individual BMPs on the ground (i.e., to increase the degree of protection afforded a given water resource from any specific application of BMPs). In combination, these two mitigative strategies would counteract all of the negative water resource changes predicted to result from forest harvest in Minnesota, at any of the three harvest scenarios modelled in this GEIS.

STRATEGIES TO IMPROVE WATERSHED MANAGEMENT

For the proposed levels of harvesting, and on an ecoregion basis there are no specific mitigative measures that can be specified. However, there are measures to prevent or avoid adverse impacts on the quantity of streamflow on a watershed-specific down to site-specific basis. The cumulative effects of widespread changes in forest cover over time and over specific watersheds should be monitored. The following are ways this might be achieved.

1 Integrated Watershed Management

Timber harvesting plans in Minnesota should consider the watershed areas affected and the initial (existing) forest cover and should ensure that for third order watersheds or larger, reductions in percentage of forest cover by large increments (20 to 30 percent of area) over any given 10- to 15-year period should be avoided. Such changes can lead to increases in stormflow peaks and volumes that can create conditions favorable to more frequent flooding for events with recurrence intervals of less than 30 years. Integrated watershed management programs, such as these recently implemented in several Minnesota counties, would further reduce any possible negative hydrologic impacts.

2 Measures to Accommodate Increased Flows
Harvesting plans should incorporate an understanding of increases in peak discharges when designing road culverts and other water conveyance systems immediately downstream from clearcuts to avoid over bank flow and accompanying streambank erosion and sedimentation associated with such flood events. First and second order watersheds that experience clearcuts of >60 percent are expected to show a doubling of peak discharges associated with recurrence intervals less than 30 years. All ownerships and/or purchasers of stumpage should be encouraged to plan harvests, including roading.

3 Evaluation of Changes in Snowmelt Peak Discharge
For operations within watersheds with persistent snow cover during the winter, harvesting plans should evaluate expected changes in annual snowmelt peak discharge. From a watershed perspective, the opportunity exists to exert beneficial effects as well as to avoid significant increases in snowmelt peak discharges. The only information needed is the existing level of forest cover and the proposed change in forest cover with planned harvests. The figure in Verry et al. (1983) (Jaakko Pöyry Consulting, Inc. 1992d) should be used for this evaluation.

4 Clearcut Area in Lowland Conifers
Extensive clearing of large, contiguous areas of lowland conifers (peatlands) should be avoided where: (1) there is a small mineral soil upland component in the watershed, and (2) there is a receiving stream that is sensitive to reductions in streamflow during dry periods. Clearcuts of 30 to 50 acres in most such watersheds will have little effect on low flows.

STRATEGIES TO PROTECT FISH POPULATIONS
1 Monitoring of a Sample of Timber Harvesting and Forest Management Activity Sites
The MNDNR Division of Fisheries and MPCA should be notified of timber harvest activities in advance and for a sample of harvesting operations to allow them to assist in the assessment of impacts. Many landowners will harvest with minimal impact if they understand the implications of various actions. Clearly, implementation of and compliance with BMPs will be the most important factor in protecting the fisheries resource as timber harvest increases. In addition, full implementation of MPCA regulations should, in theory, prevent any negative impacts on any of the coldwater resources. However, it is unlikely that MPCA can effectively educate the public to fully enforce regulations or even pursue complete compliance. To ensure protection of the resource and to reduce impacts, better coordination among MPCA, and MNDNR Fisheries, Ecological Services, Waters and Forestry divisions is needed. Limited efforts have been made in Minnesota to monitor the effects of timber harvest, to determine their effects on water quality and fisheries and/or to conduct public education campaigns to ensure minimal impact and compliance with BMPs. In addition, the complete lack of computerized monitoring databases makes monitoring and assessment of these activities difficult and makes large-scale predictions, such as those attempted in this report difficult

and tenuous.

Several additional factors should be considered in developing monitoring procedures. The percentage of an ecoregion's resource affected should be as important as total resource affected. Regions with few resources may be more affected by a level of impact than regions with many lakes or miles of stream. The persistence of impacts should also be considered; for example, small reaches of several different streams being affected each year are probably less important than if these impacts occurred on the same stream or drainage basin. Reversibility will also be important; no irreversible impacts (e.g., loss of acid neutralizing capacity in northeastern trout lakes) were identified, but continued monitoring is needed to ensure these do not occur.

2 Development of Pesticide Use Protocols

If increased use of herbicides and insecticides occurs, procedures should be developed to educate users and regulate pesticide use to prevent their entry into receiving waters. No impacts associated with herbicides and insecticides have been assumed because there appears to be little current use of these tools. A recent agreement between MNDNR and the forestry community on pesticide management further suggests little future impact (i.e., mitigated agreement on use of pesticides on forested lands).

3 Monitoring of Populations of Aquatic Species of Special Concern

Aquatic species of special concern should be explicitly included within monitoring programs. While the analysis conducted did not indicate that any of these species would be endangered, monitoring would provide advance warning of potential problems.

STRATEGIES TO INCREASE EFFECTIVENESS OF MINNESOTA BMPS

A set of mitigations that can reduce and ameliorate potential timber harvest impacts have been identified and are presented in the following section. Protective measures are the preferred approach. However, in the event that protective and educational measures fail, several restorative strategies are suggested. As with any management strategy, proper assessment and the use of adaptive management (i.e., understanding and adapting management to current, local conditions) (Walters 1986, Orians 1986) are the best approaches. Timber harvests should be monitored and management strategies altered if so indicated.

1 Water Quality Mitigations

As noted in the Minnesota BMPs manual, control of sediment from harvest activities requires a specific site assessment of probable problem areas. Some situations will require more mitigative actions than others. It is uneconomical to prescribe a specific mix of practices without an evaluation of the particular logging site. Assigning specific practices at the ecoregion scale is unrealistic. In this section, mitigative features are paraphrased from the Minnesota BMPs Manual. Mandatory enforcement of these BMPs would probably increase compliance and would also carry significant increases in administrative costs (Ellefson 1992).

Document possible threats to water quality associated with all timber sales, including potential access problems. Effective planning represents the single most important feature of successful BMPs implementation. Timber harvest activity need not impact Minnesota's water resources when risks are properly assessed before cutting the first tree. Acknowledgement of potential problems can lead to active problem avoidance.

Establish a minimum 25-foot filter strip along all intermittent and permanent streams, lakes, rivers and wetlands. Wider strips should be used as slope, slope length and soil erodibility increase. Filter strips or buffer zones between areas of soil disturbances and water trap dislodged soil particles before they enter streams, lakes, rivers and wetlands as sediment. Filter strips are vegetative zones open to restricted harvest activity. Minimizing disturbance of the litter layer and underlying mineral soil in the filter strip remains top priority. Width of a particular filter strip along both intermittent and permanent streams, lakes, rivers and wetlands varies with percent slope and slope length, as well as soil erodibility. The general rule applied states that necessary width is equal to 25 feet plus 2 feet for each percent rise in slope between the soil disturbance, including roads and the waterbody in question.

Establish a minimum 25-foot filter strip width along all temporary and permanent roads near waterbodies. Roadways should not parallel a waterbody within the 25-foot limit. Roadway placement in areas of higher slope and soil erodibility reflects the greater erosive potential of these areas and places roadways a greater distance from water (c.f., design examples in the Minnesota BMPs Manual). Forest roads, both temporary and permanent, require planning to reduce total new mileage created while incorporating existing routes to meet the goal of minimal stream and wetland crossings. Proper road design minimizes road slope to grades of 1 to 2 percent where feasible; grades in excess of 10 percent should be avoided, unless care is taken to provide drainage and avoid discharge directly from road surfaces to waterbodies.

Prevent unmitigated crossing of all permanent streams at any season and of streams large enough to have open water during winter. Minnesota's forests contain many streams, lakes and wetlands; timber harvest in these areas inevitably requires roadway water crossings. Careful planning reduces this number of water crossings substantially. Mitigated water crossings significantly reduce water quality impacts relative to unmitigated crossings. Planned crossings incorporate projected use patterns (e.g., duration of use) and other natural features (e.g, stable banks or high rock content) to reduce the amount of input and limit the amount of sediment transported within the stream itself resulting from use of the crossing. The BMPs Manual discusses this topic extensively, including crossing preferences, bridge and culvert design, bridge and culvert construction and materials and proper drainage techniques. This action regards both planning and crossing activities which are restricted exclusively to low water periods as mitigative acts. Crossings should occur at right angles to the stream. Permanent crossings require approved bridges and culverts meeting the minimum requirements stated in the BMPs manual. These structures should be designed to withstand low frequency storm events (i.e., $\geq$50 year RI). Water crossings should be constructed of nontoxic materials and allow proper drainage without disrupting fish migration.

Prevent use of soil in drainage and stream crossings, including those of temporary nature. Emphasize placement of winter road crossings in level areas. Prevent organic material placement and require removal of temporary winter crossings in areas where slope >3 percent. Winter roads access between 40 and 50 percent of each year's timber harvest sites. Travel is currently restricted on these roads during spring breakup. Use of these winter roads during spring thaw can impact water quality, particularly in wetland areas. The BMPs manual recommends that culverts or bridges be used when the expected duration of a crossing exceeds five years. Crossings should use native log materials when there is no alternative to crossing frozen water.

Prevent direct drainage of diverted water into lakes, streams or wetlands. Water should be drained into a filter strip of appropriate width for the slope and distance to water of the site. Roadway drainage constitutes a serious concern in reducing effects of harvest activity on water quality. Roadways designed to reduce erosion exhibit construction techniques such as grade rolls or dips, open-top culverts, cross drains and lead-off ditches. These techniques reduce the sediment carrying capacity of roadway runoff by reducing velocity.

Attain full implementation of the recommendations in the Minnesota BMPs Manual or increased emphasis placed on excavation and drainage components of roadway construction. Road construction creates situations where soil is exposed which may end up as sediment in nearby lakes, streams, rivers and wetlands. Proper planning reduces the probability of erosion. The BMPs manual lists actions to be followed in clearing, excavation, surfacing, drainage, soil protection and maintenance phases of roadway construction. Full implementation of these construction features ensures that a minimal amount of source material will be associated with harvest roads. This includes careful placement of debris in a manner not impeding water flow, careful shaping and stabilization of borrow pits to avoid problems with nearby water, installation of drainage structures on roads as soon as possible and considering armoring culvert inlets and outlets to reduce bank and channel erosion where necessary. Roadway surfacing with appropriate materials should be emphasized in high slope areas. Stabilization of exposed soil surfaces with grasses or sod should be mandatory.

Placement of a barrier across roads considered inactive, along with signs stating road closure; establish water bars in areas of road grade of >5 percent. Undertake followup inspections of roadway surfaces to ensure basic compliance with aims of the BMPs. All roads require some measure of maintenance, including debris removal from road surfaces and drainages. Traffic should be limited to associated harvest management activity wherever possible, particularly during spring thaw and wet periods. Ruts, holes and washouts require periodic attention and proper materials to reduce the chance of reappearance.

Improve education of recreational users of forested lands to sensitize these individuals to potential impacts on water quality and the role they can play to avoid water quality degradation including prevention of unmitigated stream crossings with recreational vehicles. Postharvest recreational vehicle activity on both permanent and temporary roads can extend the period of disturbance associated with some roads far beyond the time of tree removal, particularly where harvest roads allow new access to water.

2 Fish Habitat/Population Mitigations

The following modifications to Minnesota's BMPs manual will increase the probability that the local scale integrity of the riparian corridor is preserved and that significant site-specific impacts to water quality and the ecology of aquatic ecosystems are avoided.

Extend rotation of timber harvest. Harvest can lead to water resource impacts through exposing soils to precipitation and other climatic influences. Extended rotations would reduce the total percent of a watershed which is deforested during any time period. Longer rotations would thus mitigate some cumulative water resource impacts.

Timber harvesting and forest management activities within the filter strip should be kept to a minimum to prevent alteration of organic matter input timing, quantity and quality; alteration of CWD inputs to the stream channel; and changes in angular canopy density. BMPs guidelines recommend the establishment of a filter strip to prevent movement of sediment, nutrients and organic debris into an adjacent waterbody. However, no mention is made of managing the filter strip to maintain litter and CWD inputs to an adjacent waterbody. At a minimum, selected large (dead or live) trees should be left in the riparian zone to ensure a long-term input of CWD to the channel.

BMPs guidelines recommend that shade trees be left adjacent to a trout stream to minimize changes in temperature associated with harvest activities and management within a filter strip. This guideline is insufficient to protect stream temperature regimes. Only designated trout streams are mentioned within the guideline. Many designated trout lakes exist within Minnesota and many of them have tributary streams which are not designated trout streams. Clearly, this practice does not protect designated trout lakes or streams which are fed by streams that are not designated trout streams. In addition, no real management strategies are recommended. Questions such as: *What kind of shade trees*? *How is minimize defined*? are not addressed. Water quality statutes state that natural temperature regimes within designated trout waters may not change (i.e., *no material increase*) or a water quality standard will have been violated.

Removal of harvest slash and debris from temporary and intermittent drainages is necessary to prevent excessive loading during storm events. BMPs guidelines recommend that harvest slash and debris should be pulled away from waterbodies to prevent loadings of unstable organic matter to a stream or lake. However, no mention is made of temporary or intermittent drainages. Most organic matter loading to streams and lakes occurs during storm runoff events.

Enforce State Water Quality Standards. In many forest harvest situations, local violations of state water quality standards occur. These are rarely detected or enforced due to limits in staff and resources among state water quality agencies.

Implement stratified statewide monitoring of pre-, during and postlogging condition of a subset of streams and lakes. This should include public and private lands and at least four ecoregions (e.g., 2, 3, 4 and 6). Variables should include physical habitat, temperature and flow, water quality and fish population/community structure, including nongame fish.

In addition, the following ameliorative actions are available to mitigate impacts to fish populations at a particular site, or to another site as a resource trade-off.

- *Supplemental or reintroductory stocking of fish into disturbed systems.* When possible, stocked fish should come from local or indigenous sources to minimize genetic impacts and diseases. This should only be used as a means to restore populations in circumstances where preventative measures have failed to maintain fish stocks. It should not be viewed as a routine procedure.
- *Installation of stream habitat improvement structures or habitat enhancements.*

STRATEGIES TO INCREASE COMPLIANCE WITH BMPS

As discussed in section 1.5, compliance with BMPs in Minnesota is generally high for all ownerships. Increased compliance would further reduce the site specific impacts identified in section 5. The following are methods that could be used to increase the level of compliance, as well as the standard of compliance.

1 Mandatory Compliance with BMPs

The State of Minnesota could mandate compliance with BMPs for all timber harvesting and forest management activities and for all ownerships. Although field audits of BMPs compliance indicate relatively widespread use, this option could further improve the level of compliance, and would likely improve the standard of planning on those ownerships that currently do little planning in advance of roading and harvesting operations. Adoption of this option would necessitate development of a new regulatory framework to oversee operations to ensure compliance. Similar bodies in other states have carried significant administrative costs (Ellefson 1992).

2 Education and Training Programs

The State of Minnesota could develop an extension program to provide education and technical advice to increase the level of compliance with BMPs; and the *standard of compliance.* BMPs and associated techniques are comparatively new to Minnesota (LCMR 1989). Despite this, the level of compliance is typically high. This option is aimed at increasing the level of compliance by making landowners, supervisors and loggers aware of BMPs; and equipping them with the skills to effectively implement BMPs in the field.

3 Industry Specifications
Forest industries could make compliance with BMPs a contract clause in any agreements to supply stumpage or to undertake contract logging that they enter into with logging contractors. This approach, which has recently been adopted by some of Minnesota's forest products companies, could be backed by appropriate monitoring and penalties. This option places the onus on forest industries to increase compliance with BMPs on lands used to supply their stumpage intake. The mitigation recognizes that industry demand is the focus for timber harvesting and forest management activities; that industry is involved at an early stage in many operations; and that the ability to withdraw from purchasing wood or engaging a particular logger provides a strong incentive for compliance. The effectiveness of this requirement should be analyzed to determine its workability.

IMPACT—Primitive and Semiprimitive Nonmotorized Recreation Opportunities

Three strategies have been put forward to mitigate potential adverse impacts of timber harvesting on primitive types of recreation opportunities. A comparison of these strategies is summarized in table 1.12.

Explanations of the ranks for these mitigations are as follows:

Landscape-based road and trail plan.—This alternative would be very effective. It would provide a fundamental planning tool that would allow coordination between ownerships to insure that primitive and semiprimitive nonmotorized recreation opportunities are adequately provided for. The alternative has high feasibility assuming the MNDNR fulfills the leadership role. It would provide benefits over the medium- and long-term.

Table 1.12. Evaluation of mitigation strategies for minimizing significant negative impacts of timber harvesting and forest management activities on recreation opportunities. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long to 4=very short-term. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (±)[b]
Landscape-based road and trail plan	1	1	2	Biodiversity(±) Tourism (+) Water quality (+)
Nonpermanent road construction	2	2	1	Biodiversity (+) Water quality (+) Soils (-)
VMGs for primitive types of recreation opportunities	1	2	1	Biodiversity (+) Tourism (+) Water quality (+) Soils (-)

[a]1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to 10 years; 4=very short-term—less than 2 years.
[b]Effects that are noted are those with potential to *significantly* affect another resource.

Nonpermanent road construction.—An effective way to maintain primitive kinds of recreation opportunities on primitive and semiprimitive nonmotorized timberland plots that are primarily managed for timber harvesting. This option may not be feasible because use of nonpermanent roads may not be readily accepted as an alternative to conventional techniques to put in permanent roads. Disturbance to soils may also be greater where nonpermanent roads are used in dry physiographic areas. Long-term benefits could accrue.

Developing VMGs for primitive and semiprimitive recreation opportunities.—A highly effective way of retaining primitive kinds of opportunities in areas that will be harvested. VMGs, especially if used in conjunction with nonpermanent roads, give attention to the important social attributes and long-term benefits associated with primitive recreation opportunities. However, VMGs prescribed in the technical report (e.g., removal of slash) may run counter to prescriptions found in the Forest Soils technical report (Jaakko Pöyry Consulting, Inc. 1992e). The latter could limit the feasibility of some of the VMGs. Benefits would be short- to medium-term.

Preferred Mitigation(s)
The mitigations are not mutually exclusive and if used in combination would mitigate the identified significant impacts and would therefore retain primitive opportunities in the long-term.

IMPACTS—Aesthetic Resources
Several strategies have been developed to mitigate the potential adverse impacts of timber harvesting on forest aesthetics. A comparison of these strategies is presented in table 1.13.

Explanations of the ranks for these mitigations are as follows:

Visual Sensitivity Rank I Timberlands
Develop a buffer zone where harvesting is prohibited in visual sensitivity rank I timberlands.—While a desirable alternative for its effectiveness as a way to maintain recreation opportunities currently existing within the zone, may not be as feasible nor of as long-lasting a duration as might be desired. In the long-run, prohibiting any kind of forest management may diminish existing recreation opportunities found in semiprimitive motorized, roaded natural, and rural ROS classes.

Develop a buffer zone where special harvest practices are permitted on visual sensitivity rank I timberlands.—A desirable alternative, especially for semiprimitive motorized, roaded natural and rural ROS classes. Timber harvesting practices that would be allowed would be those designed to enhance existing recreation opportunities managed for within these zones. Maintaining these types of opportunities should be possible in the short-, medium- and long-terms.

Develop VMGs for resort areas.—While somewhat effective and feasible for resorts, it would do nothing to maintain recreation opportunities outside these areas. It would maintain recreation opportunities in the short-, medium- and long-terms for areas adjacent to resorts.

Table 1.13. Evaluation of mitigation strategies for minimizing significant negative impacts of timber harvesting and forest management activities on forest aesthetics. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long to 4=very short-term. Concomitant effects refers to potential positive (+) or negative (-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effect (±)[b]
Visual Sensitivity Rank I Timberlands				
Inventory visual sensitivity rank I timberlands	1	2	1	Soils (+) Tourism (+) Economics (-) Water quality (+)
VMGs for use in visual sensitivity rank I timberlands	1	2	1	Soils (+) Tourism (+) Economics (-) Water quality (+)
Alternative 1 guidelines	1	3	1	Tourism (+)
Alternative 2 guidelines	2	1	1	Biodiversity (+) Soils (+)/(-) Tourism (+) Forest health (-)
Visual Sensitivity Ranks II to IV				
Develop VMGs for resort areas	2	2	1	Tourism (+)
Develop VMGs for all forest lands under all ownerships	1	2	1	Biodiversity (+) Soils (+)/(-) Tourism (+) Forest health (-)

[a]1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to 10 years; 4=very short-term—less than 2 years.
[b]Effects that are noted are those with potential to *significantly* affect another resource.

Visual Sensitivity Ranks II to IV

Develop VMGs for all timberlands in visual sensitivity ranks II to IV under all ownerships.—This alternative would address maintaining visual quality and recreation opportunities for all ownerships on all forest lands. It would be effective, would address needs in the short-, medium- and long-terms and, although it would probably be expensive to implement, the costs are not expected to be prohibitive. The state is already moving in this direction so the feasibility of this alternative is, to some extent, validated. This approach would also ensure that resort interests were addressed.

Preferred Mitigation(s)

The preferred mitigations would be a combination of developing VMGs for all forest lands under all ownerships for visual sensitivity ranks II through IV and developing a buffer zone where special harvest practices would be permitted on visual sensitivity rank I timberlands. Guidelines have been outlined in table 8.2 (Jaakko Pöyry Consulting, Inc. 1993) for implementing VMGs for visual sensitivity ranks II through IV. Both mitigations have the potential to maintain visual quality and recreation opportunities on and around the timberlands impacted by harvesting.

IMPACT—Cultural Resources

Table 1.14. Evaluation of mitigation strategies for minimizing negative impacts of forest harvesting on historical and cultural resources. Rankings for effectiveness and feasibility from 1=high to 3=low, and for duration from 1=long- to 4=very short-term. Concomitant effects refers to potential positive (+) or negative(-) effects on issues of concern from the FSD.

Mitigation Strategy	Effectiveness	Feasibility	Duration[a]	Concomitant Effects (±)[b]
Statewide Coordination and Leadership				
Upgrade and maintain state listing of known sites	1	1	1	
Collecting information	1	2	1	
Predictive models	2	3	1	
Site protection protocols	1	1	1	
Education programs	2	1	1	
Location of Sites Prior to Harvesting				
Locate traditional use sites/modify access	2	2	1	
Preharvest surveys	1	2	1	Economic (-)
Modified Harvesting Equipment and Practices				
Harvest when soil strength high	2	3	2	Economic (-)
Lower impact equipment and practices	3	3	2	
Lower impact site prep practices	2	2	2	Water Quality (-)

[a] 1=long-term—greater than 50 years; 2=medium-term—10 to 50 years; 3=short-term—2 to ten years; 4=very short-term—less than 2 years.
[b] Effects that are noted are those with potential to *significantly* affect another resource.

1 Statewide Coordination and Leadership

Upgrading and maintaining the state listing of known sites is of fundamental importance to the effective protection of the cultural and historical resources. Access to information on the location of sites, the numbers of similar sites and the information within the sites is essential for informed decisionmaking and planning as well as for research purposes. This alternative is therefore likely to be very effective, feasible and will provide lasting benefits.

Collecting information on cultural resource and traditional use sites will increase understanding of the location and nature of these sites and will form the basis for more informed decisionmaking regarding these values. Hence, while this information will not afford any protection, it is a necessary prerequisite for being able to develop appropriate strategies. This alternative is achievable, subject to appropriate funding and the cooperation of Native American people.

Development of predictive models will likely improve the ability to identify areas with an increased likelihood of finding certain types of sites. These models can focus survey efforts and prioritize areas for survey. Therefore, where reliable models can be developed, they will form the basis for more informed decisionmaking regarding the survey needs and survey success. The feasibility of these models is limited because of the lack of data in many areas upon which to base such models. Therefore, while this information will not afford any protection, it is a necessary prerequisite for being able to develop appropriate strategies. This alternative is achievable subject to appropriate funding and the cooperation of Native American people.

Development of site protection protocols is an effective way to insure that identified sites are handled in the most appropriate manner to ensure protection, particularly during harvesting and subsequently for longer periods. This alternative is feasible. Drafting these protocols should be straightforward, subject to the participation and cooperation of all interested groups. Where the measures are employed, the duration of the effect is long-term.

Education programs can assist by increasing awareness of the values and significance of cultural and historic resources; and ways to protect those values. The effectiveness and feasibility of this option are linked by the need to identify the means to develop and disseminate information. This could most appropriately be done in conjunction with existing extension networks. This alternative is feasible. The duration of the effect is long-term, assuming that education programs are ongoing.

2 Location of Sites Prior to Harvesting

Consideration of Traditional Use patterns in roading plans is an effective way to reduce potential conflicts between forest managers and Native American people, primarily on public and reservation lands. This alternative is feasible and should be aided by the data collection identified above. The duration of the effect is long-term.

Preharvest site survey is currently employed on USDA Forest Service lands. This has been an effective mitigation where it is used, assuming located sites are dealt with appropriately (see below). The feasibility of this alternative is dependent on which ownership is being considered. It is currently unclear as to whether state and county land managers are legally required to actively survey timber sales for heritage sites before logging commences.

Private landholders are currently under no compulsion to undertake surveys although incorporation of Shoreland Regulations into county zoning regulations may require this.

The cost of surveys represents another potential constraint to the feasibility of this alternative. Costs have been estimated at approximately $3.00 per acre for large areas and $4.00 per acre for smaller size blocks. Despite these constraints, the increasing recognition given to these resources on public and private lands means this alternative is of moderate feasibility. Once located, sites can be accorded long-term protection.

3 Modified Harvesting Equipment and Practices

Modifications to harvesting equipment and practices are the least effective options. These options can mitigate impacts only in the sense that the risk of impacts is reduced under some circumstances. The degree to which risks are reduced on an individual site depends on factors as varied as operator behavior and prevailing weather conditions. There is no way to determine the success of the mitigation. Measures to increase or reallocate the area harvested during winter, when conditions would be within the range specified, would be difficult to specify and implement. The task of identifying candidate areas, monitoring conditions and supervising operations would require significant resources. The conflict between the need to harvest wet sites under these same conditions is also likely to reduce the feasibility of this option. Lastly, additional harvest during the winter months would require additional investments in equipment and personnel during the winter months but less for remaining periods. This would disrupt employment patterns and require significant new capital investments.

Therefore, while this alternative has varying effectiveness, its feasibility is uniformly low. Duration of benefits from this option are likely to be medium-term, as new impacts would be likely each time an area was harvested.

Preferred Mitigation(s)
Development of the leadership and coordination role in the handling of cultural and historical resources at the statewide level is of fundamental importance. There are several state agencies and bodies that could possibly handle this role, including the MNDNR, Minnesota Historical Society and the Office of the State Archaeologist. Of these, the Office of the State Archaeologist has the most direct responsibilities with respect to these resources and therefore should assume this role. The services and advice that could be provided will increase the likelihood of success for other mitigations. Therefore, these alternatives must be considered the highest priority. Of the remaining alternatives, those that seek to identify and or prevent impacts from occurring are preferred over those that seek to reduce the risk of impacts by changing equipment and practices without first identifying sites. This is because the latter type of mitigations only reduce impacts on certain categories of sites and do not eliminate the risk of damage to those categories of sites that can benefit. However, each of the mitigations may be useful, depending on site specific and operational circumstances.

IMPACT—Economics and Management
No significant impacts were identified, hence no mitigations are required at the base level of harvesting.

APPENDIX 2
Covertype Determination Methodology and Implications and Age Class Distributions

In making projections, it was not possible to project the FIA forest type classification. Consequently, a simpler forest type classification algorithm was developed—one that approximated the FIA classification and that could be projected. In doing to, it became evident that several covertypes, notably white pine, northern white cedar and white spruce were *very* sensitive to the algorithm used. These are among the most mixed covertypes (in terms of species composition) and thus understandably sensitive in classification. Because of differences between the FIA and the GEIS-specific algorithm, both are shown for 1990 in table 2.1. Subsequently, acreage projection tables are developed using the GEIS algorithm only. This avoids confusion in the interpretation of changes from 1990 forward.

Table 2.1. Forest type acreage for FIA timberland, reserved and unproductive plots for 1990, statewide (thousand acres).

Forest Type	1990			
	Timberland*	Reserved	Unproductive	Total
Jack pine	(487.1) 447.5	(125.9) 131.5	(1.2) 0	(614.2) 579.0
Red pine	(350.6) 301.6	(78.6) 80.4	(0.9) 0	(430.1) 382.0
White pine	(137.3) 63.2	(9.7) 3.8	(1.3) 1.3	(148.3) 68.3
Black spruce	(1,320.8) 1,322.1	(129.6) 126.6	(527.5) 533.7	(1,997.9) 1,982.4
Balsam fir	(1,012.5) 734.3	(117.0) 93.1	(21.9) 12.5	(1,151.4) 839.9
Northern white cedar	(322.4) 680.5	(8.2) 25.1	(37.3) 38.3	(367.9) 743.9
Tamarack	(696.2) 705.1	(7.9) 8.9	(118.1) 110.7	(822.2) 824.7
White spruce	(137.1) 93.8	(43.9) 39.9	(0) 0	(181.0) 133.7
Oak-Hickory	(1,288.0) 1,190.4	(13.6) 9.5	(14.0) 13.4	(1,315.6) 1,213.3
Elm-Ash-Soft maple	(1,564.2) 1,291.5	(64.9) 42.8	(33.4) 33.1	(1,662.5) 1,367.4
Maple-Basswood	(1,301.8) 1,396.7	(30.6) 17.0	(2.1) 0	(1,334.5) 1,413.7
Aspen	(4,496.0) 5,115.4	(358.1) 422.1	(33.9) 30.3	(4,888.0) 5,567.8
Paper birch	(1,179.3) 834.7	(109.7) 94.9	(6.1) 2.1	(1,295.1) 931.7
Balsam poplar	(480.1) 427.7	(15.4) 7.1	(10.6) 8.4	(506.1) 443.2
Nonstocked	(0) 168.9	(0) 0	(0) 43.5	(0) 222.8
Other	(0) 0	(0) 10.4	(0) 1.0	(0) 0
Total	14,773.4	1,113.1	828.3	16,714.8

Source: Jaakko Pöyry Consulting, Inc. (1992a).
*Values in parentheses are 1990 acres as determined by GEIS covertype algorithm.

Table 2.2 describes the age class distributions of forest types for 1990 and the projections to 2040 for timberland, reserved and unproductive forest land. These data should be interpreted with caution because (1) stand age is a difficult variable to measure accurately, and (2) projection and modelling methodologies involved simplifying assumptions about stand aging. Among these are that stands projected for 50 years will then be 50 years older. In reality, remeasurement of stand ages in 50 years may lead to somewhat younger estimates of age as the oldest trees die and are replaced by slightly or even much younger stems.

In these projections, postharvest covertype change was simulated for both (1) conversion by artificial means, and (2) for natural regeneration processes. The latter were developed stochastically based on patterns observed in the FIA data for the period 1977–90. Subsequent to regeneration, all plots were grown by the growth model and periodically evaluated for covertype based on the plurality of basal area by species. This evaluation used the GEIS specific algorithm that approximated FIA covertype classification. Thus, covertype acreage could change with harvest and also later through stand development and succession, i.e., as species composition changed. Some covertypes show the presence of age classes in 2040 that are in excess of the usual lifetime of species comprising that type. In such cases one may assume that stands have become uneven-aged and/or are in the process of succeeding to other species.

Slight differences between figures in this table and those in other tabulations in this document are due to differences in the completeness of FIA test data editing and data handling procdures that evolved as the study progressed.

Table 2.2. Age class by forest type for FIA timberland, reserved and unproductive forest acres, statewide 1990 and projected.

Forest Type	Age	Timberland				Reserved		Unproductive	
			2040 - 3 Scenarios						
		1990*	Base**	Medium**	High**	1990*	2040**	1990*	2040**
Jack pine	5	28,800	11,256	19,840	22,902				
	15	38,600	10,560	9,836	45,100				
	25	27,100	25,419	32,122	59,759				
	35	37,200	20,557	30,125	47,250				
	45	83,700	2,482	1,500	9,791	3,400			
	55	92,900	30,220	28,138	24,558	14,200			
	65	86,200	42,028	35,631	21,377	39,200			
	75	28,500	18,070	17,239	8,577	40,800			
	85	10,300	22,474	17,895	4,034	26,400	4,300		
	95	3,800	44,720	29,960	5,853	7,500	3,400		1,200
	105	3,300	37,737	37,055	6,154		16,200		
	115		39,291	34,205	5,600		21,400		
	125	5,300	15,965	10,803	7,251		10,900		
	135		3,506	2,300	1,200				
	145		1,400						
	155		755	755					
	165								
	175		3,200		3,200				
Total		445,700	329,640	307,404	272,606	131,500	56,200		1,200
Red pine	5	46,600	47,696	42,945	54,773				
	15	40,800	54,504	54,721	73,392				
	25	59,900	38,098	43,601	88,248				
	35	32,200	36,804	44,222	27,649				
	45	36,000	53,924	47,824	54,829	1,600			
	55	21,900	45,876	45,876	47,276				
	65	32,400	36,790	35,990	24,190	1,700			
	75	21,600	39,396	36,640	19,292	9,200			
	85	30,900	23,475	23,875	12,698	7,500			
	95	12,000	12,627	14,727	5,927	16,600	3,400		
	105	12,100	19,727	20,127	2,627	15,300			
	115	1,000	16,000	13,400	5,300	7,300	5,300		
	125	2,100	8,052	8,300	5,800	8,800	9,200		900
	135	1,400	9,629	9,829	3,129	3,600	7,500		
	145		7,315	7,315	5,615	8,800	18,500		
	155		1,300	3,800	1,300		15,300		
	165						7,300		
	175		1,200	1,200	1,200		8,800		
	185						3,600		
	195						8,800		
Total		350,900	452,392	454,392	433,245	80,400	87,700		900

Table 2.2. Age class by forest type for FIA timberland, reserved and unproductive forest acres, statewide 1990 and projected (continued).

		Timberland				Reserved		Unproductive	
			2040 - 3 Scenarios						
Forest Type	Age	1990*	Base**	Medium**	High**	1990*	2040**	1990*	2040**
White pine	5	1,900	2,400	2,400	4,500				
	15		7,140	5,494	16,597				
	25		6,303	5,855	10,983				
	35	2,200	6,051	8,851	7,000				
	45	6,300	15,034	15,034	10,054				
	55	7,900	5,559	4,808	5,559				
	65	6,700	4,183	4,183	4,183				
	75	10,700		1,000					
	85	8,400							
	95	5,000	6,000	6,000	1,900	2,000			
	105	8,000	8,355	7,396	5,896		3,400		
	115	2,800	14,732	13,654	6,310		4,100		
	125	3,700	6,034	7,034	4,534			1,300	
	135	1,300	21,233	17,402	12,402	1,800	21,300		
	145	3,700	15,424	14,324	12,424		2,000		
	155		5,994	5,994	4,894				
	165		4,182	4,182	4,182				
	175		6,006	6,006	3,506				1,300
	185		1,100	1,100			1,800		
	195		5,301	5,301	5,301				
Total		68,600	141,031	136,018	120,225	3,800	32,600	1,300	1,300
Black spruce	5	43,900	56,796	125,960	198,033			4,400	
	15	102,200	42,337	105,277	162,570	8,600		153,100	
	25	110,300	27,794	108,225	115,761	1,800		9,900	
	35	91,100	41,080	83,035	58,861	12,700		6,000	
	45	145,300	44,816	34,303	25,301	3,600		13,900	
	55	206,900	36,998	36,998	36,629	13,500		21,200	8,100
	65	172,800	71,224	61,972	58,772	19,800	8,500	30,400	153,100
	75	135,000	73,440	52,257	47,057	21,800		46,500	13,500
	85	110,900	58,600	37,921	32,621	5,100	7,000	18,200	7,300
	95	82,200	84,735	50,289	48,789	25,700	3,600	36,800	15,200
	105	60,400	119,185	78,009	56,958	9,000	7,200	53,800	17,200
	115	24,600	86,159	55,751	35,931	5,000	8,500	33,200	30,400
	125	25,900	69,086	40,906	24,406		14,000	35,300	50,500
	135	10,700	63,573	26,762	16,762		1,700	16,400	18,200
	145	16,800	41,917	17,237	11,837		23,800	54,600	37,800
	155		33,257	13,600	13,500		9,000		54,800
	165		17,500	8,800	7,200		5,000		33,200
	175		13,655	1,200	1,200				36,400
	185		8,500	2,700	1,400				17,200
	195		10,531	4,231	4,231				54,600
Total		1,339,000	1,001,183	945,433	957,819	126,600	88,300	553,700	547,500

Table 2.2. Age class by forest type for FIA timberland, reserved and unproductive forest acres, statewide 1990 and projected (continued).

		Timberland				Reserved Acres		Unproductive	
			2040 - 3 Scenarios						
Forest Type	Age	1990*	Base**	Medium**	High**	1990*	2040**	1990*	2040**
Balsam fir	5	60,600	25,472	40,232	49,584			800	
	15	85,900	41,592	61,974	85,449	3,600		5,500	
	25	68,600	60,918	80,513	114,283	3,400		900	
	35	48,600	38,271	61,372	58,707			900	
	45	121,000	20,456	22,901	44,885	25,100			
	55	194,200	58,238	45,050	40,150	29,900	3,500	2,400	1,900
	65	130,900	40,502	31,931	20,786	19,900			5,500
	75	50,900	32,988	24,231	13,131	1,900	5,200		900
	85	27,500	33,016	16,206	16,106	1,700			2,200
	95	5,300	52,549	24,417	17,317	1,900	10,600	900	1,000
	105	3,800	63,940	35,657	22,906	5,700	19,500	1,100	2,400
	115	4,500	52,149	35,420	20,763		14,700		
	125		31,160	24,660	15,960		7,100		
	135		36,252	27,952	15,052		5,100		2,600
	145	2,600	12,773	7,900	6,600		1,700		900
	155		8,555	7,155	6,455		1,900		1,100
	165		13,000	13,000	10,600				
	175		11,857	14,057	8,657				
	185		7,129	7,120	7,129		3,600		
	195		16,600	16,660	15,100				
Total		804,300	657,377	598,357	589,620	93,100	72,900	12,500	18,500
Northern white cedar	5	3,000	10,851	19,273	33,798			2,800	
	15	12,000	14,523	28,535	46,040	2,100		10,000	
	25	17,600	6,800	16,562	26,512				
	35	9,800	6,244	9,044	6,526				
	45	16,300	2,600	1,100					
	55	28,400	6,055	6,055	6,055			1,000	2,800
	65	29,400	18,152	18,152	18,152		3,100	1,400	10,000
	75	56,000	22,300	20,200	19,100	1,800		3,400	
	85	78,800	9,780	9,780	8,480			1,000	
	95	100,700	15,731	13,931	12,231			3,900	
	105	58,800	27,229	24,429	20,829	3,200		3,500	1,000
	115	63,900	24,106	20,900	18,000	2,300	1,800	4,100	1,400
	125	54,000	30,257	24,557	19,331	5,400			3,400
	135	28,700	20,100	17,800	15,100	8,900		1,600	1,000
	145	85,700	56,835	52,104	41,751	1,400	1,900	5,600	5,000
	155		26,400	25,100	20,800				3,500
	165		20,031	20,031	17,231				4,100
	175		19,351	19,351	18,251				1,300
	185		4,126	4,126	4,126		1,700		1,600
	195		19,400	19,400	18,300				5,600
Total		643,700	360,871	370,430	370,613	25,100	8,500	38,300	40,700

Table 2.2. Age class by forest type for FIA timberland, reserved and unproductive forest acres, statewide 1990 and projected (continued).

		Timberland				Reserved		Unproductive	
			2040 - 3 Scenarios						
Forest Type	Age	1990*	Base**	Medium**	High**	1990*	2040**	1990*	2040**
Tamarack	5	47,800	17,191	51,174	126,506			1,100	
	15	55,200	17,570	53,483	116,236	3,100		16,800	
	25	85,600	12,840	48,429	66,903			1,100	
	35	63,800	19,150	16,442	31,464			3,200	
	45	53,400	2,957	11,133	16,357			3,400	
	55	73,200	59,154	56,395	54,364			4,700	2,504
	65	86,300	43,045	40,694	31,594		1,100	4,000	18,300
	75	49,800	66,273	56,869	54,160			16,500	1,100
	85	45,200	53,726	46,395	39,864			12,800	3,200
	95	45,300	50,529	42,445	38,545	2,900		7,800	3,400
	105	26,600	57,460	40,960	23,017			15,100	5,800
	115	21,300	64,119	56,482	31,271			6,800	4,000
	125	24,700	46,662	36,704	27,980	1,900		6,100	16,500
	135	3,700	44,575	35,797	10,300			4,500	13,800
	145	20,600	34,685	28,307	1,851		3,900	8,800	7,800
	155		28,202	22,102	2,800				15,100
	165		18,652	18,652	10,200				4,800
	175		21,500	21,500	9,100		1,900		7,300
	185		2,600	2,600	1,100				4,500
	195		17,828	17,828	8,076				10,100
Total		702,500	678,718	704,391	701,688	8,900	6,900	110,700	118,204
White spruce	5	9,600	3,896	7,800	4,400				
	15	4,700	2,600	8,770	12,588				
	25	16,800	4,353	6,710	5,753				
	35	11,100	5,780	6,700	7,780				
	45	16,900	5,545	6,225	6,445	3,500			
	55	13,000	17,355	17,255	15,555	1,700			
	65	7,200	21,879	19,779	18,722	4,700	5,400		
	75	2,100	35,043	30,999	25,999	8,800	5,400		
	85	2,600	15,574	8,653	7,253	7,200			
	95	1,500	24,001	20,601	13,901	9,000	8,800		
	105		28,243	22,137	12,755	1,400	15,400		
	115		31,689	18,231	4,331	3,600	18,300		
	125	2,000	10,300	8,000	3,400		21,800		
	135	1,700	2,182	1,351	4,796		8,900		
	145		11,400	11,400	7,700		13,000		
	155		0	0	0		3,300		
	165		1,400	1,400	1,400		4,600		
	175		3,000	3,000	1,700				
	185		1,700	1,700	1,700		1800		
	195		2,000	2,000	2,000				
Total		89,200	227,940	202,711	158,178	39,900	106,700		

Table 2.2. Age class by forest type for FIA timberland, reserved and unproductive forest acres, statewide 1990 and projected (continued).

		Timberland				Reserved		Unproductive	
			2040 - 3 Scenarios						
Forest Type	Age	1990*	Base**	Medium**	High**	1990*	2040**	1990*	2040**
Oak-hickory	5	29,000	111,392	129,973	139,096	2,200		800	
	15	19,100	146,988	172,228	211,271				
	25	26,400	130,295	165,269	216,426			1,000	
	35	15,500	76,648	84,517	73,396			200	
	45	95,300	47,770	39.361	68,028	1,700			
	55	183,400	46,664	44,713	50,466		4,177	600	1,887
	65	226,400	22,878	22,878	22,878	4,100		1,900	
	75	154,100	38,117	37,366	38,568	700		1,100	1,348
	85	142,200	33,280	31,349	26,215			3,100	269
	95	99,600	94,749	77,648	71,794		3,505	1,200	
	105	65,700	155,354	129,380	101,235	800	1,078	600	809
	115	15,900	139,493	110,977	109,588		5,527	1,200	2,774
	125	46,900	106,258	85,822	69,233		2,291	1,700	1,100
	135	1,000	67,319	60,430	42,443		943		4,302
	145	3,500	77,408	63,876	63,115				1,618
	155		38,072	31,241	25,405		1,078		809
	165		14,184	12,214	10,507				1,618
	175		23,330	23,330	14,398				2,292
	185								
	195								
Total		1,124,700	1,370,199	1,322,361	1,354,062	9,500	18,599	13,400	18,826
Elm-ash-cottonwood	5	100,400	119,376	183,755	224,734	7,700		6,200	
	15	103,500	117,176	172,423	238,803			3,100	
	25	51,700	113,674	151,428	247,846				
	35	61,700	46,461	63,026	82,743			1,100	
	45	91,700	23,065	17,695	41,354	4,500			
	55	129,000	122,915	120,596	115,123	6,100	13,638	1,800	6,608
	65	197,900	119,525	111,335	115,589	3,400	5,600	4,200	3,100
	75	126,800	61,568	53,788	57,842	4,200	2,643	3,700	
	85	80,100	72,174	56,589	47,153	1,900		1,800	1,100
	95	67,800	129,506	117,825	101,709	7,300	14,143	4,200	
	105	47,900	181,485	142,723	122,672	4,100	14,935		1,800
	115	12,500	192,327	145,963	102,297	1,800	24,064		5,400
	125	18,600	155,766	134,812	86,769		3,600	1,100	4,013
	135	4,100	86,049	77,418	39,137	1,800	3,600	2,600	2,009
	145	14,600	72,998	60,405	31,973		7,300	3,300	14,200
	155		47,443	35,191	20,213		4,100		
	165		16,502	14,600	7,200		1,800		
	175		22,750	18,944	11,259				1,100
	185		9,306	8,551	7,351				2,600
	195		33,949	27,777	21,700				3,300
Total		1,108,300	1,744,015	1,714,844	1,721,467	42,800	95,423	33,100	35,230

Table 2.2. Age class by forest type for FIA timberland, reserved and unproductive forest acres, statewide 1990 and projected (continued).

Forest Type	Age	Timberland				Reserved		Unproductive	
			2040 - 3 Scenarios						
		1990*	Base**	Medium**	High**	1990*	2040**	1990*	2040**
Maple-basswood	5	79,900	70,242	129,219	231,154				
	15	107,500	85,284	110,531	185,145	1,600			
	25	76,600	68,052	112,632	131,983				
	35	63,000	49,359	50,696	54,944				
	45	137,300	50,828	43,639	47,323				
	55	254,500	71,383	61,097	68,181	7,100	1,022		2,100
	65	261,100	70,844	70,844	71,675	4,500	2,157		
	75	171,300	48,637	42,753	39,993				
	85	142,300	42,342	37,166	38,666	2,800	943		
	95	70,900	105,085	81,550	55,028		4,091		
	105	59,100	169,911	128,042	65,530		11,217		
	115	9,100	230,621	162,862	90,827	1,000	8,513		
	125	21,100	139,832	109,208	52,513		2,300		
	135	3,400	114,355	100,435	54,745		3,148		
	145	7,000	52,191	45,254	19,948				
	155		46,975	41,967	24,176				
	165		11,409	10,578	5,424				
	175		17,389	14,605	8,493				
	185		6,930	6,930	3,697				
	195		8,573	8,573	5,792		1,400		
Total		1,464,100	1,460,242	1,368,581	1,255,237	17,000	34,791		2,100
Aspen	5	753,400	946,143	1,020,427	1,464,253	9,000		4,600	
	15	587,200	901,143	952,862	1,145,248	15,800		3,300	
	25	415,700	850,932	859,931	1,081,590	24,600		1,100	
	35	461,900	1,122,492	1,259,639	1,287,461	12,000		6,000	
	45	761,900	528,134	540,371	21,959	42,400		3,200	
	55	957,700	173,682	169,831	160,506	128,700	8,292	6,900	8,771
	65	791,200	132,292	131,416	125,949	166,800	8,600	1,800	5,674
	75	295,600	76,727	76,727	71,725	17,700	19,578		1,100
	85	110,000	62,580	64,080	59,835	2,300	12,348	1,000	6,000
	95	40,900	99,917	96,031	84,717	900	38,373	2,400	3,200
	105	8,800	157,772	151,793	102,979	1,900	125,995		6,900
	115	3,400	111,537	107,087	80,060		144,782		1,800
	125	4,600	39,043	35,412	23,812		22,813		
	135		20,040	15,514	7,714		4,000		1,000
	145	1,000	5,900	5,000	2,200		2,700		2,400
	155		4,000	4,000	4,000		1,900		
	165		3,106	3,106	3,204		500		
	175		1,100	1,100	1,100		1,800		
	185		900	900	900		1,800		
	195		1,300	1,300	1,300				
Total		5,193,600	5,238,745	5,496,527	5,730,278	422,100	393,481	30,300	36,845

Table 2.2. Age class by forest type for FIA timberland, reserved and unproductive forest acres, statewide 1990 and projected (continued).

		Timberland				Reserved		Unproductive	
			2040 - 3 Scenarios						
Forest Type	Age	1990*	Base**	Medium**	High**	1990*	2040**	1990*	2040**
Paper birch	5	41,600	40,176	44,327	50,422	1,800			
	15	22,400	61,530	94,334	98,475	1,800		1,100	
	25	23,200	65,209	106,694	174,260	3,600			
	35	22,600	25,973	53,793	70,648			1,100	
	45	96,700	14,702	10,585	57,160	5,300			
	55	200,000	57,068	46,200	33,902	29,300	2,500		
	65	207,400	19,708	15,257	20,977	46,100	1,348		1,483
	75	115,200	23,098	20,198	19,298	5,300	1,800		
	85	35,900	20,700	16,749	13,449		1,400		1,000
	95	27,900	34,606	28,892	14,692	1,700	7,200		
	105	12,300	89,308	71,683	29,371		23,500		4,000
	115	6,400	104,387	73,630	30,070		52,800		
	125	5,000	73,436	65,354	21,361		19,100		
	135		41,875	37,543	21,461				
	145		31,179	27,666	16,443				
	155		22,104	19,504	9,426		3,600		
	165		25,593	22,793	14,931		3,200		
	175		16,268	16,268	12,935		1,800		
	185		9,409	9,409	9,409		3,600		
	195		27,046	25,346	22,991		1,800		
Total		816,600	803,375	806,225	741,681	94,900	123,648	2,100	6,483
Balsam poplar	5	60,200	112,390	122,213	112,253				
	15	61,500	65,947	80,852	96,594	3,500		900	
	25	42,000	63,219	73,580	78,750				
	35	40,200	73,388	80,279	91,648			1,300	
	45	101,300	6,249	4,849	4,849	1,800		3,000	
	55	75,700	18,211	18,211	18,211	1,800		1,000	
	65	67,500	15,562	15,562	15,562		5,200		900
	75	31,100	9,087	9,087	9,087				
	85	6,800	8,586	8,586	8,586				1,300
	95	10,400	22,186	22,186	22,186		1,800		3,000
	105		9,472	9,472	9,472		1,800		2,100
	115		3,412	3,412	3,412		5,700	1,100	
	125		2,655	1,555	1,555				
	135	500							
	145		831	831	831				2,200
	155								
	165		1,400						
	175		1,100	1,100					1,100
	185								
	195								1,100
Total		497,200	413,695	451,755	472,996	7,100	14,500	8,400	9,500

Table 2.2. Age class by forest type for FIA timberland, reserved and unproductive forest acres, statewide 1990 and projected (continued).

		Timberland				Reserved		Unproductive	
			2040 - 3 Scenarios						
Forest Type	Age	1990*	Base**	Medium**	High**	1990*	2040**	1990*	2040**
Other or non-stocked	5	90,500				6,500		11,100	
	15	9,300						3,000	
	25	3,700				700		3,600	
	35	6,200				700		2,600	
	45	4,000				900		3,500	
	55	2,600				900		2,200	
	65	2,400						1,200	
	75	2,500						4,900	
	85	2,000				700		3,600	
	95							2,100	
	105							1,000	
	115								
	125							3,600	
	135							800	
	145							1,300	
	155								
	165								
	175								
	185								
	195								
Total		125,000				10,400		44,500	
Grand Total		14,773,400	14,879,449	14,879,449	14,879,449	1,113,100	1,140,242	828,300	837,288

* *Source*: 1990 values developed from FIA test data using FIA covertype algorithm (see Jaakko Pöyry Consulting, Inc. 1992a).
** Projected values based on GEIS covertype algorithm. Note that while this sorting algorithm identifies covertypes, some short-lived species and/or covertypes appear to continue beyond the expected age of conversion to replacement covertypes, e.g., balsam fir. Part of that can be explained by the presence of initially young stems that contribute more and more to covertype classification as the stand is grown and projected. Also, the projected stand age here is for simplicity, the initial age plus 50 years, even though through mortality, the stand might be comprised largely of younger stems. Lacking individual tree age information for all the trees on the FIA plot, it was not possible to determine a more precise age. Also, to project stands for 50 years and call them less than the above projected age would have raised questions of another kind. For clarity, stand age was lowered only upon clearcutting. Thus, some projected ages for some stands might better be termed *years since origin*.

APPENDIX 3

Bird Mitigations

Table 3.1. Mitigation strategies relevant to those bird species projected to be negatively impacted by one or more of the harvesting scenarios.

Species	Mitigation Codes*
Spruce Grouse	1,3,8
Green-backed Heron	1,5
Sharp-shinned Hawk	1,3,8
Cooper's Hawk	1,2,3,8
Northern Goshawk	1,3,8
Red-shouldered Hawk	1,2,3,5,8
Broad-winged Hawk	1,3
Merlin	1,3,8
Eastern Screech-owl	1,2,5,8
Great Horned Owl	1,2,3,8
Barred Owl	1,2,3,8,9
Great Gray Owl	1,3,8
Long-eared Owl	1,2,3,8
Boreal Owl	1,3,8,9
Northern Saw-whet Owl	1,3,8,9
Whip-poor-will	2,3,4,5
Red-headed Woodpecker	1,2,9
Red-bellied Woodpecker	1,2,9
Yellow-bellied Sapsucker	1,3,8,9
Hairy Woodpecker	1,2,3,5,7,9
Black-backed Woodpecker	1,3,8,9
Northern Flicker	4,7,9
Pileated Woodpecker	1,2,3,5,8,9
Olive-sided Flycatcher	3,7,9
Eastern Wood Pewee	1,4,5
Yellow-bellied Flycatcher	1,3,8
Acadian Flycatcher	2,5,8
Least Flycatcher	1,3,8
Eastern Phoebe	5
Great Crested Flycatcher	1,3,9
Gray Jay	1,3,8
Blue Jay	6
American Crow	(low concern)

Species	Mitigation Codes*
Common Raven	1,3
Black-capped Chickadee	1,2,3,9
Boreal Chickadee	1,3,8,9
Red-breasted Nuthatch	1,3,9
White-breasted Nuthatch	1,2,3,9
Brown Creeper	1,3,9
Golden-crowned Kinglet	1,3,8
Ruby-crowned Kinglet	1,3,8
Blue-gray Gnatcatcher	1,2,8
Eastern Bluebird	7,9
Veery	4
Swainson's Thrush	1,3,8
Hermit Thrush	1,3,8
Wood Thrush	1,3,8
Gray Catbird	4,5
Brown Thrasher	4,5
Solitary Vireo	1,3,8
Yellow-throated Vireo	1,2,3,5,8
Red-eyed Vireo	1,2,3,8
Tennessee Warbler	1,3,8
Nashville Warbler	3,4
Northern Parula	1,3,8
Yellow Warbler	4,5 (low concern)
Magnolia Warbler	4
Cape May Warbler	1,3,8
Black-throated Blue Warbler	1,3,4,8
Black-throated Green Warbler	1,3,8
Blackburnian Warbler	1,3,8
Pine Warbler	1,3,8
Bay-breasted Warbler	1,3,8
Cerulean Warbler	1,2,5,8
Black-and-white Warbler	1,2,3,4,8
American Redstart	2,3,4
Ovenbird	1,2,3,5,8
Louisiana Waterthrush	1,2,5,8
Connecticut Warbler	1,3,8
Common Yellowthroat	5 (low concern)
Hooded Warbler	1,2,5,8

Species	Mitigation Codes*
Wilson's Warbler	5
Yellow-rumped Warbler	1,3
Northern Cardinal	4
Indigo Bunting	4,5,7
Scarlet Tanager	1,2,3,8
Chipping Sparrow	7
Song Sparrow	4,5 (low concern)
Lincoln's Sparrow	3
Dark-eyed Junco	1,3
Common Grackle	4,5 (low concern)
Northern Oriole	1,2,3,5
Purple finch	1,2,3,5
Red Crossbill	1,3
White-winged Crossbill	1,3,6
Pine Siskin	1,2,3
American Goldfinch	4 (low concern)
Evening Grosbeak	1,3

***Key**
1 = ERF
2 = large patches south
3 = large patches north
4 = uneven-aged/thinning management
5 = riparian corridors
6 = mast trees
7 = clearcut with residuals
8 = connected landscape
9 = retain cavity trees

APPENDIX 4

Suggested Strategic Responses Background Materials

4.1 Introduction

The GEIS suggested strategic responses are presented in section 8 of the main report. The purpose of this appendix is to provide important background materials that together will help create a more complete backdrop for understanding the form and structure of the suggested strategic responses in section 8 of the main report.

The materials covered in this appendix are as follows:

- summary of GEIS mitigation strategies;
- companion states' forest practices experiences;
- forest practices regulations position statement (SAF);
- GEIS identified forest research deficiencies;
- alternative services delivery options;
- public policies and programs participants;
- forest resource policies and programs administration background; and
- Minnesota forest resources administrative structure illustrative example.

4.2 Mitigations Recommendations Summary

The individual study groups' recommended mitigation strategies are displayed in appendix 1. Sections 5 to 7 of the main report discuss the *integrated* recommended strategies across all key issue areas for the three timber harvesting and forest management activity levels. These integrated mitigation strategies were grouped into three general categories:

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

To help the reader better understand the scope of these integrated strategies, this section of the appendix revisits them and provides a brief descriptive summary from a different perspective. Here they are overviewed based on the *functional* role they play in terms of the following:

- guidance;
- constraints;
- objectives;
- oversight;
- education; and

- research.

4.2.1 *Guidance*-oriented Mitigation Strategies

A certain subset of the recommended mitigation strategies actually establish guides or guidelines that need to be adhered to:

- limit all harvesting activities in the southern part of Minnesota in riparian corridors 200 feet wide either side of watercourses;
- for the remainder of the state, where shoreline rules do not apply, for riparian zones 100 feet wide along lakes, wetlands, and each river and stream (> third order), limit all harvesting activities;
- construct no permanent roads in ROS classes 1 and 2 areas anywhere in Minnesota;
- limit harvesting in at least 20 percent of the state's timberlands to techniques that will generate ERF conditions;
- restrict harvesting to generate one-half to one mile wide corridors that establish corridors for connected landscapes involving old growth patches, research natural areas, and scientific natural areas;
- develop VMGs, especially in conjunction with nonpermanent roads and visually sensitive areas;
- restrict logging in and around all sensitive sites such as those for eagles rookeries, or other special species identified in sections 5 to 7; and
- develop guidelines for good harvest practices, for applications in statewide harvesting operations where the guidelines begin with and are similar to existing water quality BMPs that are directed at site-level operation and planning.

4.2.2 *Constraints*-oriented Mitigation Strategies

Select mitigation strategies can be grouped as prescriptions aimed at constraining the type of management activities to those that will mitigate significant impacts where appropriate:

- adhere to a program of site slash retention where as much slash as is physically and economically feasible should be contained as close as possible to the tree stump, except where stand hygiene (e.g., for red pine) dictates otherwise;
- utilize thinning, harvesting, and other silvicultural equipment selected to minimize stand or site disturbance and damage;
- use silvicultural techniques that maintain the integrity of riparian vegetation zones at all times;

- use harvest planning techniques that retain cavity containing trees per requirements for local bird species and other cavity dwelling animals;
- maintain desired age class distributions for each covertype statewide by employing silvicultural techniques aimed at adjusting tree species mix and age distribution to generate the desired balance;
- employed modified silvicultural systems, such as uneven-aged management, thinning or clearcutting with residuals for retention of key habitat types;
- modify times of stand entry to reduce potential for site damage, such as in poor soil moisture periods; and
- select tree species and silvicultural systems best suited to local site conditions.

4.2.3
Objectives-oriented Mitigation Strategies

A few key recommended mitigation strategies can be classified as goal setting in nature:

- optimize wood fiber utilization at all levels from the woods to the manufacturing line;
- increase the timber productivity of existing and future stands statewide, especially on NIPF owned lands;
- reduce the area of forest land and timberland converted to nonforest land uses;
- balance age class and covertype structures statewide;
- retain key habitat forest land types, such as riparian areas;
- develop and institute a statewide road and trail plan;
- adopt a statewide IPM strategy; and
- increase proportion of wintertime harvesting activities.

4.2.4
Oversight-oriented Mitigation Strategies

Certain significant impacts will not be mitigated successfully without better information and monitoring over time:

- monitor the age class and covertype structure of the state's forests;
- complete the MNDNR county biodiversity inventory;
- provide adequate resources to upscale and maintain the state's listing of known unique cultural and historical and traditional use sites; and
- develop information collection and monitoring programs as the need arises to ensure other mitigation strategies are working (such as for BMPs).

4.2.5
Education-oriented Mitigation Strategies

Effective implementation of certain recommended mitigation strategies will require that companion education type strategies (specifically noted previously or implied) also be pursued:

- develop and implement a comprehensive statewide landowners extension or continuing education program covering the mitigation strategies developed for this GEIS;
- institute a continuing education program for loggers, forest operators and foresters that can be the basis for certification and licensing programs; and
- provide publicly available educational materials to help ensure the public is objectively informed on the issues affecting resource management decisions.

4.2.6
Research-oriented Mitigation Strategies

Knowledge enhancement is a key to both successful mitigation strategy implementation and enhancing or expanding mitigation strategies as needed. A range of research strategies were either previously recommended or their need was implicitly derived. These are developed in detail in section 4.5 of this appendix.

4.3
Companion States' Forest Practices Experiences

Ellefson and Cheng (1993) identified key considerations for any state contemplating the development of a statewide forest practice law. These considerations include the following:

- regulations by governments are harsh public policy tools;
- regulatory programs are becoming more and more common;
- private landowners' careless application of forest practices has stimulated consideration for such regulations;
- the public's interest in natural environments is greatly increased;
- federal environmental laws, policies and regulations (e.g., NEPA, EPA, RPA, etc.) have nurtured states' interest in complementary regulations;
- the public sentiment is moving toward greater accountability;
- local ordinances, rules, guidelines, etc., are proliferating into a jungle of complex mishmash that collectively confound and confuse everyone, including the on-the-ground operators;

- there is a growing interest in the forest as a landscape, that tends to transcend ownership boundaries; and
- there is escalating special interest group pressure and motivation to follow special interest leadership out of group rather than subject matter loyalty.

Furthermore, any comprehensive forest practices program should recognize that for existing programs:

- there seems to be agreement that they have led to improved forest environmental quality;
- most clientele (e.g., loggers, landowners, etc.) do not see the current regulations as overburdensome; and
- landowner and operator compliance rates are high; generally in the 85 to 95 percent range;
- compliance is only slightly better where the regulatory practices are mandatory and there is a thorough companion monitoring and compliance enforcement program; and
- any regulatory program of this type can be costly to both public agencies and private concerns:
  - the 13 states listed previously expended over $30 million in 1991 (see table 4.1) and with staffing of over 400 people;
  - the range of expenditures were from a low of $83,000 for Montana's voluntary program to a high of $10+ million for California's complex mandatory program; and
  - regulation also raises costs to the forest landowner and loggers, via lost harvest, revenues, higher operating costs, and new expenses for the regulatory compliance activities.

Finally, while regulatory approaches to forest management and timber harvesting practices may be needed under certain circumstances, several alternatives to regulation exist. Therefore, both states with enacted regulatory-based forest practice acts/programs as well as those considering such an approach should consider the alternative mechanisms for implementation such as:

- voluntary BMPs (e.g., Minnesota today);
- extension education;
- technical assistance programs;
- financial assistance;
- cost sharing; and
- tax incentives.

Research by Ellefson and Cheng (1993) indicates that of these, technical assistance and regulations are most effective in protecting forest values such as water quality. Almost none of the state administrators contacted felt voluntary programs alone were effective long-term solutions.

Table 4.1. Administrative and enforcement expenditures for state forest practice regulatory programs.

	1991 (thousands $)
Alaska	
Division of Forestry	$ 224
Division of Fish and Game	500
Department of Environmental Conservation	400
California	
Department of Forestry and Fire Protection	$ 8,690
Regional Water Quality Agencies	1,200
Department of Fish and Game	1,000
State Water Resources Board	100
Tahoe Regional Planning Agency	22
Connecticut	
Division of Forestry	NA
Florida	
Regional Water Management Districts	$ 327
Idaho	
Department of Lands	$ 685
Division of Environmental Quality	140
Maine	
Maine Forest Service	$ 340
Maryland	
Chesapeake Bay Critical Areas Program	$1,294
Non-Tidal Wetlands Program	47
Erosion and Sediment Control Program	180
Waterway Access Program	596
Massachusetts	
Division of Forests and Parks	$650
Montana	
Division of Forestry	$ 83
Nevada	
Division of Forestry	$ 1,250
New Mexico	
Division of Forestry and Resources Conservation	$ 217
Oregon	
Department of Forestry	$ 3,300
Department of Environmental Quality	100
Department of Fish and Wildlife	100
Washington	
Division of Forest Practices	$ 6,600
Department of Fisheries	772
Department of Wildlife	660
Department of Ecology	687
Total	$ 30,074

Source: Ellefson and Cheng 1993 (in press).

4.4
Forest Practices Regulations Position Statement

As far as developing whatever program a state believes it should ultimately adopt, key considerations which have been effectively articulated in a recent SAF position on this topic (SAF 1989) should be taken into serious consideration:

" • The SAF neither advocates, or opposes the public regulation of private forest practices in general."

• Where states choose to regulate, "...the society advocates systems on regulation that will enhance rather than deplete forest resources and that reflect the cost of regulation in relation to benefits achieved.

• Forest practices regulation should be authorized by bodies that represent the broad public interest and the full range of forest users.

• Effective forest practices should include the interests of all citizens they are likely to affect.

• Forest-practice regulations should be based on the application of scientific knowledge, forest management principles, and their impacts on landowners' objectives.

• Forest-practice regulations should assure the productivity of forest lands and protect the environment.

• An effective regulatory system should include means to obtain and incorporate the best information about its consequences.

• Regulation of forest practices should recognize variations in forest conditions and forest-derived values within a state.

• To be adaptable, a regulatory system should separate rule-making from legislative functions.

• The regulatory system should place rule-making responsibilities in representative bodies that have direct access to the information they require.

• When several means can achieve the same regulatory goal, a landowner should have the discretion to choose the means that best suits his or her particular circumstances.

• A regulatory system should provide for sound monitoring of its impacts in different physical and social conditions.

• Forest-practice regulations should be clearly applied and enforced with respect to (1) the lands and practices to which they apply; (2) the governmental jurisdictions that exercise authority for them; and (3) the processes through which this authority is exercised and appealed.

• Forest-practice laws and rules should clearly define the land they cover, the terms used, and the standards for acceptable practices.

• If overlapping levels of governmental jurisdiction enact regulations, the precedence among jurisdictions should be clearly established.

• Enforcement must be consistent among ownerships with similar characteristics and for the same ownerships at different times.

• A regulatory system should inform those it affects.

• The authorities and responsibilities for forest-practice regulation should be as unambiguous and as uncomplicated as possible.

• The processes of rule-making and appeal should be readily accessible, responsive, and equitable for all who may wish to use them.

• Forest-practice regulations and related programs should provide incentives that both promote desired private practices and support the viability of the ownerships the regulations are intended to affect.

• A regulatory system should be designed and administered to product incentives that have the greatest net beneficial effect on the forest resources it is intended to improve. The system's capacity to do so should be evaluated in terms of (1) the physical impacts and public responses it produces and (2) the compatibility of other forest policies and programs with regulatory intent.

• Forest-practice regulation should not exceed what a government can finance and staff adequately to satisfy the preceding criteria.

• A regulatory system should provide clear information to the public about the legal and financial costs that regulation of private forest management may entail.

Forest-practice regulations are one means to sustain forest productivity and protect environmental quality. Although they may express a broad public intent to achieve this objective, they should not be assumed to do so by virtue of intent alone. The effectiveness of forest-practice regulations depends on their impact. Their impact depends on landowners' responses to them, and rarely can these responses be expected to follow directly from the regulatory intent"

4.5
GEIS Identified Forest Research Deficiencies Summary

As was noted in the main report, the GEIS has demonstrated three very important realities with regard to forest-based research in Minnesota:

- the GEIS process has been totally dependent on previously conducted forest-based research;
- the GEIS process has required a very significant amount of well-founded research in order to respond credibly, factually, and objectively to the FSD key issues; and
- while substantial and relevant research information was readily available for GEIS-related work, the GEIS process clearly identified the need for significantly enhanced research to comprehensively address all FSD key issues.

The GEIS identified forest-based research needs are summarized here by the primary GEIS technical areas:

Maintaining Productivity and the Resource Base

- to provide the scientific basis and technical support to developing some of the inventory and monitoring functions identified as needed under the FRPP and SFRP, including more timely and detailed information on nontimber aspects of forests and their development and monitoring of spatial patterns and their implications;
- to provide the scientific basis for setting and refining desired age class and covertype structure goals to meet biological diversity objectives;
- to develop improved forest growth and change models, including ingrowth, regeneration, and succession estimation that provides sensitivity to specific harvesting and ecological conditions on a wide range of sites and ownerships and under varying silvicultural practices;
- to provide improved estimates of the increased yields from various levels of investment in forest management practices;
- to develop improved models and estimates of uneven-aged stand management yields and associated harvest and management costs;
- to improve the utilization data for Minnesota tree species and harvesting practices;
- to develop cost effective regeneration techniques to establish desired species under site conditions exhibiting low levels of disturbance and under existing stands as in the case of enrichment plantings (red and white pine and northern white cedar are priority species for this effort);
- to determine the harvesting spatial patterns at a landscape level that favor timber production and simultaneously achieving biological and aesthetic goals; and
- to examine findings of global change modelling efforts as they relate to Minnesota's forests, including forest change modelling to identify implications and response strategies.

Forest Health

- to monitor forest health to keep abreast of developing problems and trends and to provide for implementation of anticipatory IPM;
- to assess the pattern and rate of spread of pests and diseases from older forests in reserved areas to surrounding timberlands; and
- to improve the understanding of forest health as it relates to wildlife habitat and biodiversity concerns.

Forest Soils

- to document nutrient removals and replenishment rates under various harvesting systems and utilization levels on a range of soil types (including slash and bark retention on site);
- to document on site physical effects (compaction, puddling, etc.) under current and prospective harvesting systems in Minnesota; and
- to identify and quantify the benefits of low impact timber harvesting techniques and technologies; and
- to assess the changes in soil and soil water nutrient content, organic matter and acidity that occurs after covertypes are changed by harvesting practices.

Water Quality and Fisheries

- to assess the effectiveness of BMPs by region in preventing changes in the flux of organic matter, nutrients and light energy to streams, wetlands and lakes;
- to determine cumulative effects of multiple harvests within a watershed with emphasis on harvested area, timing, pattern across the watershed and harvesting practices;
- to assess the effects of reestablishing riparian corridors on stream community structure and function; and
- to develop Instream Flow Incremental Methodology (IFIM) for improving the understanding of water quality impacts.

Biodiversity

- to determine the relationships between covertype, stand age and plant community composition in a site specific and landscape context;
- to determine the effectiveness of connected landscapes concepts for natural dispersal and movement of plant and animal species and to develop cost effective approaches to their implementation;
- to assess harvesting effects on plant community species composition including herbaceous plants and tree species near the edge of their range, with emphasis on the direct physical effects and indirect effects from changing the environment;
- to quantify harvesting effects on endangered, threatened, and special concern species, with emphasis on the habitat factors that lead to change with manipulation, including consideration of population genetics and gene flow; and
- to improve the understanding of the relationship between rotation length, harvesting methods and conifer component of mixed species stands, especially for aspen stands.

Wildlife

- to improve the understanding and models of habitat requirements by species;

- to improve the understanding of species displacement and recovery under various harvesting practices;
- to improve the knowledge of relationships between covertype, stand age, site quality and animal population levels over short and long time periods;
- to improve the understanding of habitat fragmentation impacts on wildlife population levels in both northern and southern Minnesota forests; and
- to determine the effect of harvesting methods on quantity, quality and distribution of coarse woody debris and the role coarse woody debris plays in animal habitats.

Recreation and Aesthetics

- to refine and validate models of recreation and aesthetic value for predicting sensitivity of forested sites and landscapes to harvesting;
- to develop indices of the statewide and regional recreation and aesthetic value and attributes of Minnesota's forest lands for monitoring impacts and changes over time;
- to improve landscape and regional level models of the impact of forest structure and harvesting on recreation activity levels over short and long time periods; and
- to improve estimates of harvesting and road development impacts on the more primitive areas and associated recreational opportunities.

Historical and Cultural Resources

- to develop improved predictive models for site location on timberlands statewide; and
- to develop guidelines for harvesting and management on sensitive sites and landscapes, perhaps by region.

Economics and Management Issues

- to identify and quantify the interaction between the level of timber harvesting and the implications for the tourism and travel/outdoor recreation industry;
- to develop an improved recreation-tourism component for the IMPLAN model for analysis of harvesting impacts and changes on regional economies;
- to improve cost estimates for the mitigations specified in the technical papers and identify who would ultimately pay for these mitigations;
- to identify potentially complementary forest-based industries for Minnesota; and
- to identify appropriate types and levels of incentives to encourage private forest management in light of public and private benefits of such land use.

Harvesting and Silviculture

- to identify and evaluate low impact harvesting techniques and technologies applicable to Minnesota;
- to assess retention of conifers and other minor components of aspen stands with respect to harvesting practices and rotation age; and
- to develop and test silvicultural guidelines for uneven-aged management of forest stands, including those of mixed species composition, for a range of short- and long-term management objectives.

Wood Utilization and Recycling

- to improve technologies for increasing efficiency of wood use;
- to develop new process technology to enhance the suitability of recycled fiber in existing mills;
- to develop technical information for use of a wider array of species in existing and emerging wood and fiber products;
- to determine relationships between silvicultural practices, wood quality, and wood products characteristics; and
- to assess life cycle environmental impacts of alternative raw materials with emphasis on wood-based products

Policy and Administration

- to monitor the extent and administrative effectiveness of implementation of GEIS related recommendations;
- to assess GEIS related public, agency, and clientele understanding of issues, process, and progress; and
- to identify and evaluate refinements to GEIS programmatic approaches as suggested by progress in implementation of study recommendations.

Particularly important in this research is to increase the detail and resolution of models that can provide the prediction and assessment of impacts and the determination of the effectiveness of mitigations.

4.6 Alternative Services Delivery Options

The GEIS study outlines three broad policy directions creating programs for the following:

- forest resources practices program (FRPP);
- sustainable forest resources program (SFRP); and
- forest resources research program (FRRP).

Mechanisms for helping deliver these programs to the public were also briefly addressed in the main document. The purpose of this section is to provide a more comprehensive overview of delivery mechanisms available to the state that need to be considered in terms of the overall administrative and organizational structure recommendations discussed in the GEIS study.

In the book, *Reinventing Government* (Osborne and Gaebler 1992), the authors listed 36 specific, different ways that government can "intervene in the market" for the social good. Although not all 36 will ultimately be applicable to how government might mitigate timber harvesting and forest management impacts in Minnesota, they do represent a wide range of options worthy of consideration for helping deliver the three programs identified above. Table 4.2 presents a summary of these 36 alternative categorized as follows:

- rulemaking;
- monetary incentives;
- action steps;
- information exchange;
- organizational structuring; and
- program incentives.

Table 4.2 also provides a subjective assessment of each alternative in terms of which program(s) (FRPP, SFRP, and/or FRRP) it may apply to and to what degree it may be successful in advancing one or more of the programs in Minnesota.

4.6.1 Rulemaking

The Minnesota government is empowered to legislate, regulate, deregulate, license, and tax. The recommended mitigation strategies and strategic program directions for this GEIS study will, in many cases, require new laws, regulations, licensing programs and taxation policies. Collectively, this group of rulemaking options will be critical for successful development and implementation of the three strategic programs. For example:

- Creating legal rules and sanctions will be the first step in establishing all three strategic programs and their organizational structures as well as their spans of responsibility and authority.
- Regulations (not deregulations) will be a key component of the FRPP and, to a lesser extent, of the SFRP. Regulatory actions are not likely to affect the FRRP.
- The only program to be significantly affected by licensing is the FRPP. This is especially the case for the required licensing and COP components of the FRPP.

Table 4.2. Alternative service delivery options.

Alternative*	Utility for Minnesota's Strategic Programs		
	FRPP	SFRP	FRRP
Rulemaking			
1. creating legal rules and sanctions	1**	1	1
2. regulation or deregulation	1	2	3
3. licensing	1	3	3
4. tax policy	2	2	2
Monetary Incentives			
1. grants	3	3	1
2. subsidies	1	3	3
3. loans	1	3	3
4. loan guarantees	1	3	3
5. rewards, awards and bounties	2	2	2
6. vouchers	3	3	3
7. impact fees	1	1	1
8. seed money	1	3	2
9. equity investments	1	3	2
10. *quid pro quo*'s	2	2	3
Action Steps			
1. monitoring and investigating	1	1	1
2. contracting	1	2	2
3. franchising	1	1	2
4. catalyzing nongovernment efforts	1	1	1
5. convening nongovernment leaders	1	1	1
6. jawboning	3	3	3
7. sale, exchange, use of property	3	2	2
8. restructuring the market	2	2	3
Information Exchange			
1. technical assistance	1	1	1
2. information	2	2	1
3. referral	2	2	3
Organizational Structuring			
1. public-private partnerships	1	1	1
2. public-public partnerships	1	1	1
3. quasi-public or private corporations	3	3	3
4. public enterprise	2	2	2
5. volunteers	2	2	2
6. voluntary associations	2	2	2

Alternative*	Utility for Minnesota's Strategic Programs		
	FRPP	SFRP	FRRP
Program Incentives			
1. procurement	3	3	3
2. insurance	3	3	3
3. coproduction or self-help	3	3	3
4. demand management	2	2	3
5. changing public investment policy	2	2	2

*List from Osborne and Gaebler 1992.
**1=good, 2=low, 3=unknown or not applicable.

- Tax policy legislation or regulation will have potential to impact adequate funding for all three strategic programs. Recall that one of the goals for all three programs is to move them toward self-funding. Tax policies can be crucial in achieving this goal. For example, tax credits for aiding the FRRP would channel revenue toward that program. Use taxes can create funds for administering the FRPP. Revenue sharing tax policies among the state, counties and federal land owning agencies may be needed to effectively advance the SFRP.

4.6.2 Monetary Incentive

The range of monetary incentives noted in table 4.2 will play a variety of roles relative to the recommended three strategic programs. Some examples of how these incentives can help successfully advance the three recommended strategic programs are noted here:

1. Grants will play a critical role in assuring funding for the FRRP, however, their role in the FRPP and SFRP will likely be minimal to nonexistent.
2. Subsidies may be used as incentives for compliance with FRPP regulations, but their use for the FRRP and SFRP seem quite limited.
3. Loans and loan guarantees could become quite helpful in stimulating the introduction of new equipment and technologies aimed at advancing the FRPP, but they will be of little use for the SFRP and FRRP.
4. Rewards, awards and bounties may play a meaningful role for the FRPP, but the focus should be on rewards and awards for good practice, rather than bounties for failure. Also good performances for advancing the SFRP and achieving uniquely helpful results from the FRRP can be stimulated by judicious use of rewards and awards.
5. Vouchers will not likely play a significant role in any of the three strategic programs.
6. Impact fees could play a very unique and meaningful role for all three strategic programs:

- in the form of penalties for creating adverse impacts not acceptable within the bounds of the FRPP;
- in the form of revenues from user fee for forest-related activities to help fund the financial needs of the FRPP, SFRP, and FRRP; and
- in the form of incentives to direct forest uses towards or away from activities that help or detract from efforts to mitigate potential significant impacts.

7. Seed money and equity investments may ultimately support development of technologies and equipment that will help the FRPP. Lesser potential exists here to advance the FRRP, and no real benefit can be seen for the SFRP.
8. *Quid pro quo*, where business interests pay for support services (roads, gates, etc.) for the right to pursue development or resource use could play a role in encouraging compliance with the FRPP. The *quid pro quo* could also be utilized to stimulate adherence to the statewide forest plan developed under the SFRP, such as establishing ERFs in return for certain access rights. No major role for *quid pro quo* is foreseen for the FRRP, at this time.

4.6.3 Action Steps

The action steps listed in table 4.2 will have varying degrees of impact on implementation of the three strategic programs. For example:

1. Monitoring and investigating will play a key role in all three strategic programs. The FRPP will require monitoring to identify practices compliance. Investigation of noncompliance will be necessary to determine scope and remedies. The SFRP and FRRP will likewise benefit from differing degrees of monitoring and investigation to help ensure each program is staying on track. The degree of monitoring and investigating required will be a product of development of the three programs.
2. Contracting and franchising may be the best and most economical course for the state to meet the independent and objective monitoring and investigation needs of the three strategic programs, especially for the FRPP. This approach will allow the functions to be achieved without building an expensive and cumbersome bureaucracy.
3. Catalyzing nongovernment efforts and convening nongovernment leaders will be critical components of the public participation process for each of the three strategic programs. For example, the GEIS process itself has been advanced by the citizen's Advisory Committee and the state's encouragement of statewide stakeholder participation. Similar public

stimulation and involvement will need to be secured for successful statewide implementation of the three subject programs.

4. Jawboning may have a minor role to play in the three strategic programs, but it is not likely to have any real significant impact.
5. Sale, exchange or use of property may have a role in SFRP- and FRRP-related activities, but is not likely to advance FRPP. For example, achieving ERFs may be more possible by developing a pattern of land exchange or property use exemptions. Research may be advanced by establishing research access and sites through property sales, exchange of use agreements.
6. Restructuring the market is a very delicate and controversial tool. It may have application in the FRPP and SFRP areas by helping shift demand to surplus fiber species or away from delicate areas, for example. However, the FRRP will likely need to be utilized to develop the best market restructuring concepts prior to any real move in this direction.

4.6.4 Information Exchange

Availability of the correct information is crucial for successful development and implementation of both the FRPP and SFRP. Without the proper data and knowledge, many aspects of these two strategic programs would simply fail, or not ever exist from the outset. For example:

1. Technical assistance will be required to develop the licensing and COP component of the FRPP. Technical assistance will also be needed to impart education (such as through the MES) to landowners and operators to aid in FRPP compliance. The SFRP will also be dependent on technical assistance at the county level to help ensure the statewide SFRP directions are based on sound ideas and can be pursued by all landowners. Again, the FRRP will be the key source for generation of the technical assistance program support elements.
2. Educational information was identified above as the foundation of the technical assistance program for successful implementation of the FRPP and SFRP. This same type of information will also be an important tool for explaining the three programs' needs, successes, failures and so forth. For example, quality educational information is integrally linked to the monitoring function discussed previously. General information will play a less important role.
3. The referral option will play a modest but at times needed role in pursuing the FRPP and SFRP activities. Landowners can be referred to literature, equipment, technologies, etc., that will help in compliance with the needs of the FRPP. County commissioners can be referred to studies, planning tools, support groups, etc., which will help them with their part of the SFRP and its associated statewide forest management plan.

4.6.5 Organizational Structuring

The family of organizational structuring options displayed in table 4.2 offer the state of Minnesota options for pursuing key aspects of all three strategic programs that may not be possible otherwise. For example:

1. The public-private partnerships in the UofM have much potential to generate research truly focused at the FRPP and SFRP needs over time because of the shared vested interests. New such partnerships may help create techniques for transmitting technical assistance, guiding, monitoring and investigation functions, and even provide enhanced services in the forest environment (such as recreation, or implementation of a statewide road and trial plan, etc.). In the final analysis, complete successful implementation of the FRPP, SFRP and FRRP will require very close partnerships across all key public and private organizations involved with Minnesota's forest-based resources.
2. Public-public partnerships will be essential for all three strategic programs. The state MNDNR, county land commissioners, the BLM and the USDA Forest Service must all cooperate closely in such partnerships or all three programs will likely fail.
3. Quasi-public or private corporations (nonprofit enterprises run by public or private entities) may have a role in this arena, but it must be developed. Presently the role is not envisioned to be significant.
4. Public enterprise has already played a major role historically in Minnesota. The USDA Forest Service and the National Park Service provide for recreational opportunities the private sector cannot. The MNDNR and counties also provide for forest-based public services, but on a more constrained scale. The availability of the public enterprise and its forest resource will continue to play an important role in call three strategic programs over time.
5. Volunteers and voluntary associations can play a meaningful role in all three strategic programs. Professional services (legal, forestry, etc.) volunteers can provide an economic stimulus to better develop and implement all three strategic programs. Voluntary associations can serve as a mechanism to review and advance the SFRP or help evaluate progress in the FRRP. These resources are also likely to be the key to the citizen advisory committee input needed to help guide the FRPP. In a sense, the imagination is the only limit here; the key will be to structure and channel this type of support in a constructive manner across time.

4.6.6 Program Incentives

The program incentives listed in table 4.2 are representative of a broad range of such efforts the state of Minnesota can pursue. Some will have some potential for helping advance the three strategic programs, and others will have only limited potential:

1. Procurement, insurance and coproduction or self-help programs have little potential for the strategic directions being discussed here.
2. Demand management programs can be used to help shift pressure to or away from selected forest resources. For example, heavy user fees on backpacking can reduce the demand for such an activity. High severance fees for harvesting trees over, say, 100 years of age can direct the demand for wood away from older trees and toward younger trees. Viewed in this light, demand management can impact both the FRPP and the SFRP. However, with restructuring the market discussed previously, great care must be exercised here because the *cause-and-effect* relations are very complicated. The FRRP would be a good tool to ensure research is conducted before any such major directions are pursued.
3. Changing public investment policy can encourage or discourage almost any behavior. Higher investments in quality BMPs that are a foundation of the FRPP will help generate a better quality and a more successful FRPP. Grants that encourage public-public participation will advance the SFRP. Providing investment incentives to private firms for financial support of the FRRP will enhance the quality and success of this key strategic program. In a sense, this particular tool offers good policy potential for helping advance all three strategic programs, if well thought out policy steps are taken to stimulate private investment toward the most helpful arenas.

4.6.7 Overall Observation

This appendix section has overviewed a very wide range of alternative service delivery options as they relate to the three GEIS recommended strategic program directions. This range should provide a good foundation for consideration of the types of activities required post-GEIS to help take the strategic program recommendations and turn them into reality. The key here will be to tailor specific service delivery options to the three strategic programs within the foundation of the GEIS recommended administrative and organizational structure.

4.7
Public Policy and Program Participants

The purpose of this appendix section is to illustrate the truly broad sweeping nature of the current groups of participants involved in Minnesota's forest-based public policies and programs. The intent is not to ensure that every single participant is listed, but is to provide a comprehensive illustration. The structure, policies and programs, and current planning and coordination efforts for Minnesota's land managing organizations are discussed in section 4 of the main GEIS document. A more detailed presentation on those matters is contained in the GEIS background paper on Public Forestry Organizations and Policies (Jaakko Pöyry Consulting, Inc. 1992k). As noted in section 4 of the main GEIS document, Minnesota has a comprehensive and complex hierarchy of mechanisms that create the framework for resource management. These mechanisms are encompassed by:

- policies;
- planning;
- coordination;
- programs; and
- public participation.

The aforementioned hierarchy involves the governor's office, select legislative committees, and several agencies, departments, boards and citizen advisory committees at the state level. The counties involve their commissioners, land departments, special committees and citizen oversight and action groups. Through the USDA Forest Service, several other entities are brought into the process:

- USDA Forest Service, Washington office;
- USDA Forest Service, regional office;
- USDA Forest Service Forest Products Laboratory;
- Superior and Chippewa national forests;
- NRRI;
- UofM, College of Natural Resources;
- UofM, MAES;
- UofM, MES;
- public participation groups; and
- the state and federal legal systems.

Numerous other groups also are involved or participate in the resource management process:

- NIPF landowners;
- Native Americans and the BIA;
- forest products industry firms;
- U.S. BLM;
- U.S. Fish and Wildlife Service;

- U.S. EPA;
- U.S. Corps of Engineers;
- MACLC;
- Timber Producers Association;
- Minnesota Association of Soil and Water Conservation Districts (SWCD);
- Minnesota Forest Coordinating Committee;
- Minnesota Resort Association;
- RIM Coalition;
- LCMR;
- Minnesota Forestry Association;
- Minnesota Forest Industries, Inc.;
- Minnesota Public Interest Research Group (MPIRG);
- The Audubon Society;
- Izaak Walton League;
- The Wilderness Society;
- The Sierra Club;
- SAF;
- Minnesota deer hunters, fishing and recreation associations; and
- numerous other technical specialty groups and interested members of the public at large.

4.8
Forest Resource Policies and Programs Administration Background

The GEIS study has examined a very wide range of complex and interdependent natural conditions and forces that collectively have shaped Minnesota's forest resource base. Similarly, this study has also explored the rather complicated political and policy arena that currently provides the administrative and organizational structure that is directed at managing and protecting this forest resource base. Similar to most states, Minnesota's forest resource base policies and programs are spread across a broad range of governmental units, both within and across various governments.

Within such a complicated and interactive environment, effective coordination of all key policies and programs will be essential for meeting often conflicting and always demanding and desirable social objectives. The main body of the GEIS report has, furthermore, described the likely significant impacts of timber harvesting and forest management activities in Minnesota, as well as a family of recommended mitigation strategies.

Subsequently, the GEIS study recommended three statewide strategic programs to allow for the implementation of the recommended mitigations:

- FRPP;
- SFRP; and
- FRRP.

The purpose of this appendix section is to provide some helpful background information that is relevant to the formulation of the overall administrative and organizational structure recommended in the main GEIS report for effective implementation of the three suggested strategic programs.

4.8.1
Alternative Administrative Mechanisms

A recent study (Kilgore and Ellefson 1992), which evaluated administrative mechanisms used by all 50 state governments to deal with forest resource policies and programs, provides some very appropriate food for thought on alternative administrative mechanisms. Governments use a variety of methods for effective administration and coordination of major policies and programs:

- information interagency communications links;
- memorandums of agreement among and between government agencies;
- programs and the processes required to generate and implement multiple resource-oriented statewide strategic plans;
- formal administrative mechanisms assigned responsibilities for programs and broad policies' development (e.g., boards and commissions); and
- reorganization of agencies aimed at stimulating more integrated planning and management.

4.8.2
Perspectives for Forest Resource Issues

Specific administrative structures designed especially for forest resource issues and affairs demand a unique perspective because of the following (Kilgore and Ellefson 1992):

- forest resource issues and affairs are broad in scope and of extensive interest to numerous public agencies—and as such, are extremely difficult to package effectively;
- multiple units and layers of government will be involved in covering forest resource issues and affairs;
- these issues and affairs often lack the presence of one voice within and across governments, which in turn leads directly to ongoing advocacy conflicts;
- the conflicting and contradictory missions of various government units often generate policies that are in conflict with and are contradictory to each other;
- policy development for forest resources is often inefficient due to poor coordination across the wide range of involved government units;
- these issues and affairs often lack quality input from multiple interests, which in turn, makes them too narrow and less useful;
- unified government agencies' postures on forest resource issues and affairs are often lacking, which negatively affects others positive views on such matters; and

- multiple government units often generate very narrowly focused plans that are neither strategic nor comprehensive, which detracts a great deal from the focused attention they need.

Forest resource programs are often organized by the separate natural resource categories that constitute them. As such, they very often then exist within separate units of government. This generates an environment of highly individualistic behavior, with no real requirements to coordinate across the integrated nature of the multiple resource complex.

However, state governments are becoming more and more aware of the importance of better administrative mechanisms that both allow for and stimulate the need to address the involved problems and issues in an integrated manner.

4.8.3 Frequency and Types of Forest Resource Programs

The types of programs that are involved in statewide forest resource matters cover a broad range of subject matters, as is illustrated by table 4.3. The most predominant programs involve NIPF assistance, wildfire suppression and insect disease and control. Interestingly, only five states offer continuing education programs, which seems to go against the grain of offering meaningful long-term NIPF assistance programs.

Success of each state's family of forest resource programs is varied. Often this success is tied to the effectiveness of statewide administrative structures to stimulate or allow for widespread coordination. In most states such coordination is common, but the methods vary from informal task forces for information sharing and formal forestry coordination mechanisms (most states) to use of state planning or finance agencies, the governor's office or simply organizational consolidation (only a handful of states) (Kilgore and Ellefson 1992).

Table 4.3. Programs administered by state forestry organizations, by type and frequency of program, 1989.

Program Type	Percentage of States	Proportion
Nonindustrial Private Forestry Assistance	48	96
Wildfire Suppression	46	92
Insect and Disease Control	45	90
Forest Planning	44	88
Urban Forestry	44	88
Reforestation Programs	43	86
Timber Sale Programs	43	86
Tree Nursery Programs	41	82
Prescribed Burning	39	78
Forest Resource Assessment	36	72
Forest Watershed Management	23	46
Forest Land Acquisition	20	40
Forest Road Development	20	40
Forest Tax Law Administration	19	38
Environmental Education	18	36
Private Forest Regulation	17	34
Forest Recreation Development and Administration	13	26
Environmental Review	12	24
Forestry Research	12	24
Forest Wildlife Management	7	14
Resource Information Systems	7	14
Professional Continuing Education	5	10

Source: Kilgore and Ellefson (1992).

4.8.4
Administrative Mechanisms Overview

Formal administrative mechanisms for forest resource policies and programs are relatively common in state governments. Table 4.4 illustrates that over 60 percent of the states have a forestry board, commission, council, committee or similar mechanism authorized to deal with such policies and programs. Furthermore, 80 percent of these states with formal mechanisms established them through state law (Kilgore and Ellefson 1992).

The membership of these formal administrative mechanisms ranges from 5 to 30 persons, but the average is 11. The majority has 10 members or less. Table 4.5 illustrates that public forestry managers and forest industry representatives are the most often represented groups on such mechanisms. At the bottom of the list are the state planning agencies.

Table 4.4. Formal mechanisms used by state governments to coordinate forest policies and programs, 1989.

State	Coordinating Mechanism
Alabama	Alabama Forestry Planning Committee
Arkansas	Arkansas Forestry Commission Board of Forestry
Florida	Florida Forestry Council
Georgia	Georgia Forestry Commission
Idaho	Forest Practices Act Advisory Committee
Illinois	Forestry Council
Indiana	State Forestry Planning Committee
Kentucky	(name not assigned)
Louisiana	Louisiana Forestry Commission
Maine	Citizen's Forest Advisory Council
Massachusetts	Massachusetts State Forestry Committee
Michigan	Michigan Council on Forest Product Industrial Development
Minnesota	Minnesota Forestry Coordinating Committee
Mississippi	Mississippi Forestry Commission
Missouri	Missouri Forest Resources Planning Committee
Montana	Land Board
Nevada	Board of Forestry
North Carolina	North Carolina Forestry Advisory Council
North Dakota	Forestry Planning Committee
Ohio	Forestry Advisory Council
Oregon	State Board of Forestry
Rhode Island	State Forestry Planning Committee
South Carolina	South Carolina Forestry Commission
Tennessee	Tennessee Forestry Commission
Utah	Board of State Lands and Forestry
Vermont	Forest Resources Advisory Council
Virginia	Forestry Board
Washington	Board of Natural Resources
West Virginia	Forest Management Review Commission
Wisconsin	Natural Resources Board

Source: Kilgore and Ellefson (1992).

Table 4.5. Representation on formal forestry coordinating mechanisms of state governments, by frequency and average number per mechanism, 1989.

Affiliation	Represented		Composite Index of Representation
	Percent of Time*	Average Number	
Public forest managers	52	3.68	1.00
Forest industry	58	2.72	0.82
Citizen members	39	3.41	0.69
Academic and research personnel	42	1.84	0.40
Fish and wildlife managers	45	1.35	0.32
Local elected officials	10	5.33	0.28
Agricultural agencies	35	1.36	0.25
Legislators	10	4.66	0.24
Landowner associations	26	1.37	0.19
Environmental groups	29	1.11	0.17
Trade associations	19	1.50	0.15
Soil and water districts	26	1.12	0.15
Forest land management agencies	13	2.00	0.14
Private forest owners	6	2.00	0.06
Sporting groups	10	1.00	0.05
State conservation agencies	6	1.50	0.05
Livestock industry	6	1.50	0.05
Pollution control agencies	6	1.00	0.03
Society of American Foresters	6	1.00	0.03
Departments of education	6	1.00	0.03
Office of the governor	6	1.00	0.03
Forestry consultants	6	1.00	0.03
State planning agencies	3	1.00	0.02

Source: Kilgore and Ellefson (1992).
* Percent of mechanisms having the noted representation assigned to them.

Of the 31 states with formal forestry administrative mechanisms, only two use the process of public elections for selecting membership on boards or commissions. The other 29 rely on the use of the appointment process, primarily involving executive branch of government through the governor's office. The terms of appointment range from two to nine years, with the typical term being four years.

The responsibilities of these mechanisms cover a broad range of topics. Table 4.6 shows that the most predominant are for:

- policy and program development;
- program oversight and evaluation; and
- long-range and strategic planning.

For the 31 formal state mechanisms, the following displays the entity type to which they are held accountable:

- director or head of the state's lead forestry agency or natural resources department—12 states;
- the governor's office—nine states;
- the state legislature—seven states; and
- the governor's office shared with the state legislature—three states.

Table 4.6. Primary functions of formal forestry coordinating mechanisms of state governments, 1989.

Function	Number of States	Proportion (percent)
Policy and program development	18	58
Program oversight and evaluation	17	55
Long-range and strategic planning	16	48
Program evaluation	10	31
Regulation of private forestry	4	14
Information sharing	3	10
Fiscal and budget development	2	7
State forester appointment	1	3

Source: Kilgore and Ellefson (1992).

4.8.5
Major Formal Administrative Mechanisms Form and Function

Generally speaking there are four basic categories of formal administrative mechanisms:

- forestry boards;
- forestry commissions;
- forestry councils; and
- forestry committees.

The data in table 4.7 summarizes several key factors associated with the formation and ongoing functioning of these formal type forestry type mechanisms (Kilgore and Ellefson 1992).

Table 4.7. Major formal coordinating mechanisms for state forestry programs and policies, by selected characteristics, 1989.

Characteristic	Board	Commission	Council	Committee
Number of states using	8	7	7	9
Average size	7.75	9.43	13.6	14.11
Method of selection	A/E	A	A	A
Means of creation	L	L	L	L/Ia
Predominant accountability	G	L	C	C
Primary functions	Pd	Pd	Pl	Pl,D
Relative effectiveness	2nd	1st	2nd	3rd
Influence on ownerships	2nd	1st	4th	3rd

Key: A=appointed, E=elected, L=legislature, Ia=informal agreements, G=governor, C=department head, Pd=policy development, Pl=long-range and/or strategic planning, and D=discussion of forestry issues.
Source: Kilgore and Ellefson (1992).

Forestry Boards
There are eight states that use this form of a formal administrative mechanism for forestry issues and affairs. Interestingly, six are located in the western or southwestern United States. Membership averages eight individuals per board. Two of these boards are open to popular election processes, while the other six are subject to the appointment process.

All eight of the boards were created by legislative action. Four boards report to the governor, one to the state legislature, one to the lead forestry department, and two to no particular entity. Interestingly, these later two are judged to be rather ineffective in providing coordination and administrative leadership. Note also that the low effectiveness ranking of these two "floating" boards lowered the overall effectiveness of the board data reported in table 4.7.

Forestry Commissions
A total of seven states, all in the southern and southeastern United States, have established forestry commissions. The average membership is between nine and ten individuals per commission. All members of these commissions are appointed, with average terms of just over six years.

Similar to forestry boards, all of the commissions were created by legislative action. One commission reports to no particular entity, two report jointly to the governor and the legislature, and four directly to the legislature.

Forestry Councils
Seven states, all in the eastern United States, have established forestry councils. Their membership roles tend to be significantly larger than either boards or commissions, averaging over 13 persons per council.

Their range is quite broad too, covering a spread of from five to 25 members. The typical method of membership is through appointment with an average length of service of about four years.

All state forestry councils were created by legislative action. However, unlike for the boards and commissions which were primarily created in response to some particular major forestry issue, only two councils were created with a similar impetus. Most councils report to the lead state forestry or natural resource agency head.

Forestry Committees
Formal forestry committees are found in nine states. The average membership is 14 individuals, with a range of eight to 30. All committee members in every state are appointed, and few have designated terms. Only two of the committees were established by legislative action.

None of the committees report either to the governor or the legislature. Nearly all report in an advisory capacity to the department head for the lead natural resources or forestry agency. Unlike boards, commissions or councils, committees rarely deal with policy and program matters. They serve primarily as a forum or a vehicle for stimulating coordination of forestry matters of mutual interest.

4.8.6 General Observations

The types of administrative structures available to states to coordinate and implement statewide forest policies and programs are varied and diverse. No one approach has been proven to be the absolute best in meeting all of the various demands of society. At the same time, those states that have made definitive moves toward establishing formal mechanisms to deal with today's myriad of conflicting forest-based issues and affairs have helped create a growing body of practical knowledge from which all interested parties can gain. Some of the keys to success appear to encompass the following:

- legislative creation of a forestry board or commission has distinct advantages over other alternatives;
- membership size should be kept moderate, ranging from 8 to 12 members;
- members should be appointed rather than elected;
- terms vary from 2 to 9 years, with 4 to 6 being common;
- staggered terms are predominant;
- effectiveness is directly tied to accountability;

- typical accountability assignments are either to the state legislature or the governor's office;
- authority to develop and both implement and administer administrative rules will also be crucial for success; and
- longer-term, every interested state will need to be involved in research on the best methodology to pursue in terms of formal forest resources administrative structures due to its highly undeveloped current nature.

4.9 Minnesota Forest Resources Administrative Structure Illustrative Example

One of the key recommendations of the GEIS study displayed in section 8 of the main report is to create a Minnesota Board of Forest Resources. The purpose of this appendix section is to *provide an example to illustrate more clearly the general concept* of a board of forest resources. The general attributes of such a body as envisioned by the study team are as follows:

Charter. The Minnesota Board of Forest Resources will need to be created by legislative action. This will ensure its legal standing and provide the assurance of stability and durability. The enacting legislation will need to address many details related to the full charge of responsibilities, authorities and accountabilities. Many of these matters have been addressed in this section and others have been addressed in appendix 4.

Membership. The Minnesota Board of Forest Resources members should be appointed by the executive branch of the state government, subject to confirmation by the state legislature. Membership terms should be at least four and not more than six years. The terms should be staggered to ensure protection against a one-time change. The membership total should be kept small, in the 8 to 10 range. Every effort should be made to secure balanced representation for all major landowner groups, however, aside from the major landowners (the state, the USDA Forest Service, forest industries, the counties, and the NIPF), no board member should represent a particular interest group or constituency or have any financial interests in any of the state's forest lands.

Appointments to the board need to be based on each individual's professional qualifications, education, experience, knowledge, and interest in forest resource-related issues and subject matters. Care should be taken to avoid appointments based on other criteria. Credibility with the public at large and the state's major landowners will be absolutely essential for the board to be successful. Therefore, individuals appointed to this board should be well- respected *states-people* who have a broad and visionary outlook on how the state's forest resources should be managed and protected.

Leadership. The governor should be charged with nominating a board chairman and vice chairman. Their appointments would be subject to legislative approval.

The board chair would be accountable to the governor's office.

Public Input. The quality and social acceptability of the board's actions will frequently depend on the availability and type of public input. Random or disorganized input can be quite disruptive and counter productive. Consequently, the GEIS study team also recommends the creation of a formal Citizens' Advisory Committee to the Minnesota Board of Forest Resources. This citizens' group would function similarly to the GEIS Citizens' Advisory Committee. The formal rules for its establishment and operation should be left to the purview of the board.

Administrative and Staffing Issues. Aside from the board membership itself, additional staffing support will obviously be required. However, with care and creativity, the net impact on the limited budgetary resources of the state of Minnesota can be minimized. An example of this can be found in the California situation where nearly $10 million are spent solely on administration and enforcement of state forest practices regulatory programs, but only $400,000 is earmarked for the board's annual operating budget. The direct staffing assigned to support the California board consists of a full- time assistant executive officer, a program analyst, a management services technician, required clerical support, and a few student interns.

The key is to utilize existing state resources as much as is practically possible. In the final analysis, this will likely require some form of reorganization of the myriad of state entities that have involvement with the state's forest resources in one way or another. One option here is to have the state forester, who is an employee of the MNDNR, serve as the formal technical advisor to the board. This step will help funnel resources of the MNDNR Division of Forestry toward activities that directly support the board's needs. The most important factor to keep in mind here is that the state must set a goal to minimize staffing and costs without undercutting the board's ability to meet its responsibilities.

Funding Considerations. Funding for the board's operations should be provided as much as possible from revenues derived from uses of the forest resources the board is charged to look after. In other words, just like for the FRPP, SFRP, and FRRP, the board should end up being self-funded as much as is practically possible. One of the keys here will be the need for stability, durability, consistency, and independence. Dramatic swings in funding levels or the budgetary process itself would be extremely damaging to the board's ability to have a long-term (strategic) focus.

Figure 4.1 illustrates graphically the Minnesota Board of Forest Resources example presented here, where:

- the board consists of nine members, each appointed for six-year terms, staggered for three appointments every two years;
- the vice chairman is to be appointed for a two-year term and then automatically elevated to the position of board chairman for a four-year term;
- two members of the board will serve on one each of the FRPP, SFRP and FRRP subcommittees with at least a two-year stagger per member, and where the senior member is the subcommittee chairman;
- the ninth board member shall serve as the co-chairman of the citizen's advisory committee with a citizen co-chairman chosen at large for a two-year period by the board chairman;
- the citizen co-chairman of the citizen's advisory committee shall serve as a nonvoting advisor to the board;
- the citizen's advisory committee members will be appointed by the board chairman to represent the broad interests of the state, where the membership shall be 8 to 10, and no member shall serve a term of more than four consecutive years at any one time;
- the board shall employ a managing director of the FRPP who shall be responsible for administering this program and shall sit as a voting member of the FRPP committee and as a nonvoting advisor to the board itself;
- the board chairman shall appoint three additional members to the FRPP committee who shall each serve six-year staggered terms;
- the state forester shall be responsible for administering the SFRP and sit as a voting member on the SFRP committee and as a nonvoting advisor to the board;
- the board chairman shall appoint three additional members to the SFRP committee who shall each serve six-year staggered terms;
- the director of the MAES at the UofM shall be responsible for administering the FRRP and sit as a voting member on the FRRP committee and as a nonvoting advisor to the board;
- the board chairman shall appoint three additional members to the FRRP committee who shall each serve six-year staggered terms;
- the board shall be supported in its day-to-day operations by an assistant executive officer, a program analyst, a management services technician, required clerical support, and a few student interns; and
- the three program committees will also require selected personnel support, which will need to be defined by the board.

More specifics could be offered in *this example*, however, the basics have been outlined in enough detail to illustrate the types of indepth considerations that will be necessary in order to fully establish a comprehensive, working organizational structure. In the final analysis, the state legislature and the governor's office will be responsible for all of the hard decisions that will be needed to set in motion the GEIS recommendations. As was noted in the main report, these decisions will need to be acted on expediently in order to maintain the positive momentum already provided by the GEIS study itself.

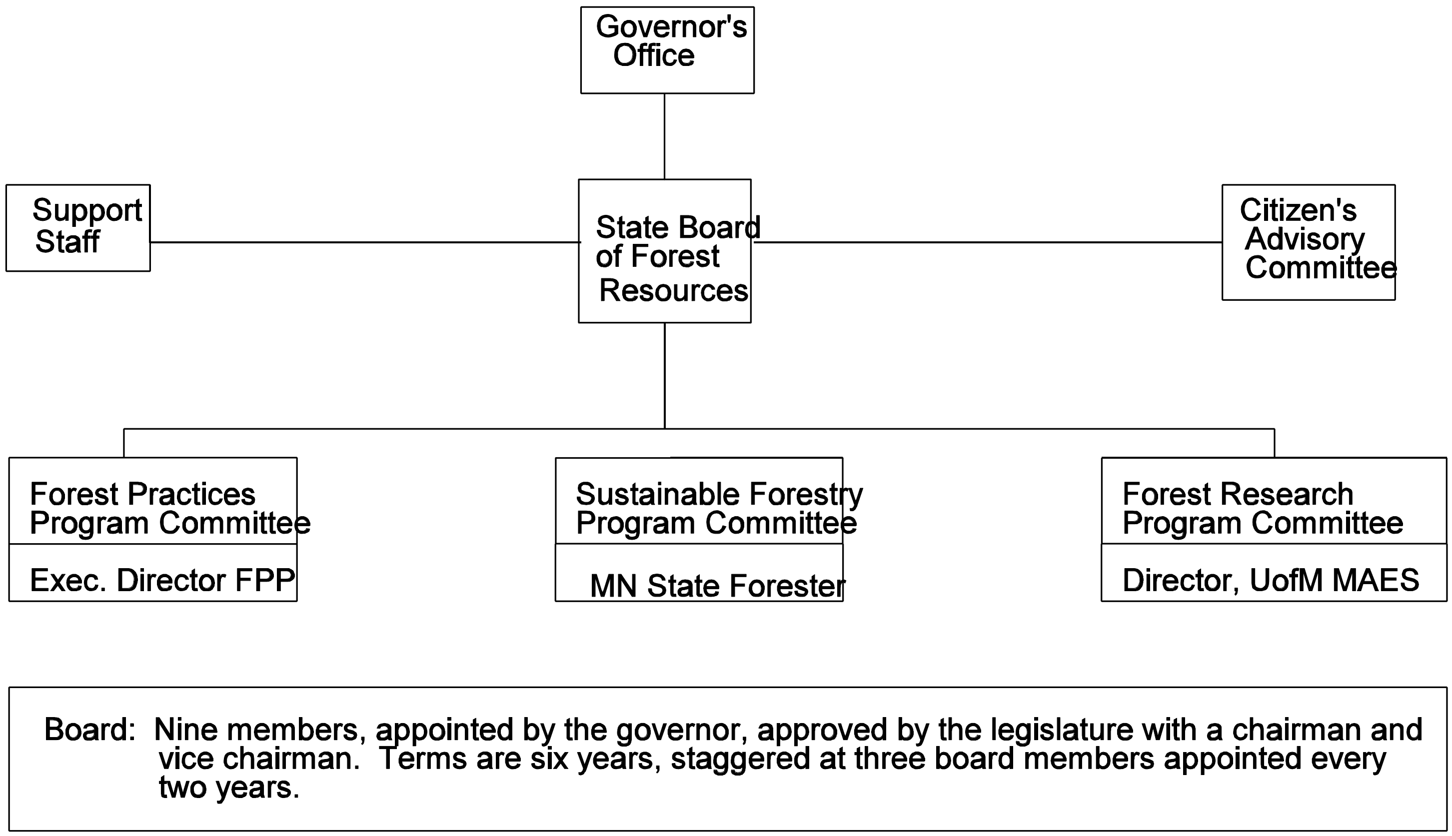

Figure 4.1. Minnesota Board of Forest Resources, illustrative example.