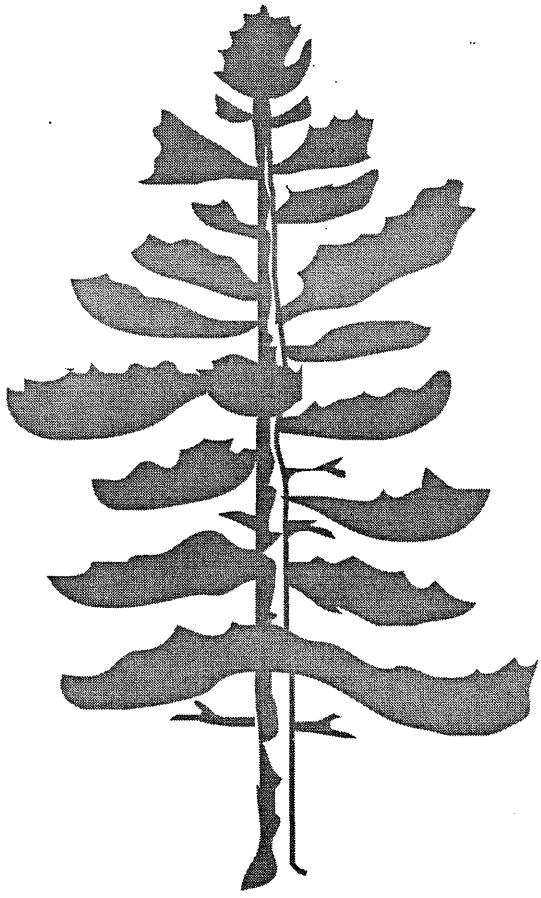
Minnesota's White Pine

Now And For The Future



A Report By The White Pine Regeneration Strategies Work Group

December 19, 1996

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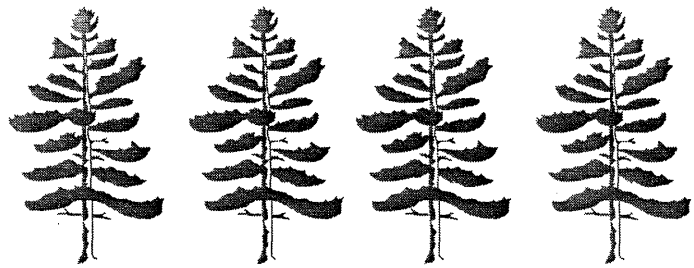

Now And For The Future

A Report
To The
Minnesota Department of Natural Resources
Minnesota Forest Resources Council

By The
White Pine Regeneration Strategies Work Group
December 19, 1996

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Part I
Introduction

White pine is a focus of attention in Minnesota's forests. It stands as a reminder not only of times gone by, but also as an indicator of the present and a promise for the future. Its contributions are many: nesting habitats for birds of prey and cavity dwellers; safe havens for some wildlife; valuable wood for a growing population; beauty; and playing a role in the forest ecosystem that we may never completely understand. All these contributions are critical, and all of them must be sustained.

For myriad reasons there are not as many white pine trees in Minnesota's forests as most people would like. The reasons include substantial harvesting for lumber in the late 1800s and early 1900s; clearing of forested land for agricultural, urban, highway, utility, and other uses; the introduction of blister rust from Europe; a greatly increased deer population that often feeds on white pine; and emphasis on the management of tree species other than white pine.

In response to widespread concern about the white pine resource in Minnesota, a White Pine Regeneration Strategies Work Group was appointed in early 1996 by the Minnesota Department of Natural Resources. (See **Appendix A**:*White Pine Strategies Work Group Members.*) The specific mission of the Work Group was to prepare a report for the Minnesota Forest Resources Council containing the following information (See **Appendix B**: Mission Statement):

- The status of Minnesota's white pine resource and its historical and current occurrence.
- Existing efforts to increase the white pine resource through management strategies and practices.
- Research needed to address specific concerns about white pine where more knowledge is needed or where adequate data is lacking to conduct an analysis.
- Recommended regeneration and management strategies that would increase the role and presence of white pine.

The Work Group believes the role and presence of white pine in Minnesota should be increased significantly, both in the short term and the long term. To do so will require the combined efforts of <u>all</u> stakeholders in Minnesota. Specifically, the Work Group recommends the following goals be adopted:

1. Appropriate silvicultural systems, including long term monitoring and care, should be used to ensure retention and regeneration of white pine on suitable sites throughout its pre-European settlement range in Minnesota.

2. The number of white pine trees and the number of acres of young white pine trees should be doubled within the next seven years. The number of acres in white pine cover type should be doubled within the next 50 years.

3. Over the long term, management activities should increase the acreage and spatial dispersion of older white pine stands. They should also create an age distribution of white pine stands that is more balanced than the current distribution.

4. Harvesting activities should be planned and conducted within the context of silvicultural systems designed to increase the growth and/or regeneration of white pine.

5. Critical research in the areas of deer predation, regeneration systems, genetic improvement, and blister rust management should be conducted and reported as quickly as possible.

6. Educational materials and programs that explain and promote white pine management should be developed and distributed to resource managers and private landowners.

7. Site level ecological classification systems should be completed because of their usefulness in identifying suitable white pine sites.

8. Best Management Practices (BMP)-type audits should be used to evaluate the success of specific regeneration activities. Forest Inventory Analysis data should be used to evaluate the accomplishment of goals related to the abundance, age distribution, and spatial dispersion of white pine.

9. Budgeting and funding decisions should support activities that help accomplish the goals stated above.

The means for accomplishing these goals are contained in the recommendations listed in the following section. The recommendations were developed by the Work Group with input from members of the White Pine Review/Advisory Group. They were included using a consensus approach; only if all members of the Work Group agreed were they included.

Recommendations are grouped in five categories: Planning/Budgeting, Management/Regeneration, Education/Training, Research, and Inventory/Classification. For each recommendation, a brief explanation of why the recommendation was made is provided. While varying in scope, the Work Group believes each of the recommended actions will have a positive impact on the white pine resource in Minnesota.

The basis for all the recommendations is information about the history, status, ecology, pests, and management of white pine the Work Group gathered through a series of meetings and field trips, including a meeting with members of the White Pine Review/Advisory Group. (See **Appendix C** & **Appendix G:** *White Pine Review/Advisory Group Members & Concerns of White Pine Review/Advisory Group*) The relevant information resulting from these meetings is summarized in Part II of the report.

Part I

Recommendations
Planning/Budgeting

Sites where white pine occurred prior to European settlement are now owned by private individuals and companies, counties, state and federal agencies, and tribal governments. Because of differences in site characteristics, management opportunities for white pine are much better on some classes of land ownership than on others. Planning and funding decisions should recognize the differing opportunities for white pine management within and among ownerships, and target the opportunities and activities which are likely to have the most success. The recommendations in this section provide basic guidelines regarding planning and budgeting decisions that will be necessary to significantly increase the presence and role of white pine in Minnesota.

1. Recommendation:

   Set a regeneration goal so that the acreage of white pine stocked with 25 or more trees per acre under 5 inches (dbh) will be doubled from 149,000 acres to 298,000 acres over the next seven years through a combination of fostering natural regeneration and planting. In both natural regeneration and planting systems, there should be appropriate measures to promote growth and protection from pathogens and wildlife browsing for the early critical years.

   Explanation/Rationale:

   The 1990 Minnesota Forest Inventory and Analysis (FIA) shows that there are 149,000 acres that have 25 or more white pine trees less than 5 inches dbh. A seven year period would enable forest land management agencies to expand their white pine regeneration capabilities; this period of time would also coincide with the publication of the second 5-year statewide forest reinventory report that could be used to track progress towards the goal.

2. Recommendation:

   Through the budgeting process, public funding should:
   1: Target silviculture efforts that favor the survival and development of existing white pine regeneration;
   2: Target silvicultural methods that favor establishment of natural regeneration;
   3: Target planting, especially in areas with little or no existing white pine.

   Explanation/Rationale:

   The survival of much of the existing white pine regeneration is dependent on release efforts. This would be one of the most effective means to increase white pine in Minnesota. It is also important to modify harvesting techniques and to utilize site preparation to encourage natural white pine regeneration. Planting efforts will be needed in most cases to increase the acreage of white pine.

3. Recommendation:

Each DNR forestry area, state park, major wildlife management unit, and county land department within the range of white pine should set targets to increase the presence of white pine on lands under their administration through a process that incorporates goals set forth in this report.

Explanation/Rationale:

Goals established through a planning process based on stand level data are more achievable than arbitrary goals established without the expertise and input from local resource managers and key stakeholder groups. Given the training to identify suitable sites for white pine management and the resources to implement their plans, resource managers would be more effective in attaining the goals.

4. Recommendation:

The Department of Natural Resources (DNR) should develop a state-funded incentives program to encourage the establishment and long-term management of white pine on non-industrial private forest (NIPF) lands. This state-funded incentive program should be developed in coordination with the Forest Stewardship Program, and be implemented through Forest Stewardship Plans and Stewardship Incentives Program practices.

Explanation/Rationale:

Private individuals own about 40% of the land occupied by the white pine type in Minnesota and about 50% of the land in areas where white pine occurred prior to European settlement. With such large ownerships, private individuals can play a significant role in regenerating and managing white pine. An incentive program will encourage these landowners to make the extra effort necessary to grow white pine.

5. Recommendation:

Forest land management organizations should plan harvest schedules or other disturbance regimes and time the establishment of new areas of white pine cover type so that age classes of the white pine resource are distributed more evenly.

Explanation/Rationale:

An even distribution of stand ages within each landscape region of the state would help ensure that stands of various ages would always be present, thus benefitting the maintenance of biodiversity and help to insure a steady flow of white pine timber in the future.

6. Recommendation:

Funding should be made available to county land management organizations actively encouraging the establishment and long-term management of white pine on county-administered lands.

Explanation/Rationale:

County-administered lands represent approximately 18% of the sites containing white pine at the time of the public land survey. As such, they represent a significant opportunity for increasing the role and presence of white pine in Minnesota. Those counties that demonstrate a commitment to establishing and managing white pine (e.g. development and use of white pine management guidelines) should be recognized and receive priority in the allocation of funds made available through white pine budget initiatives.

7. Recommendation:

An advocate for white-pine regeneration should be a participant at DNR goal setting processes designed to set the deer population goal in areas where increased regeneration is desirable.

Explanation/Rationale:

Deer management in Minnesota is predicated on a system of "population goals" and antlerless permits are adjusted on an annual basis to maintain deer density near these goals. Some sort of "round table" process will be used within the next year to revise these goals. Typically, participants are invited to attend these meetings to review the consequences of changes to deer density, "reflect" their concerns and attempt to reach consensus on whether to change population goals. These meetings will represent the primary opportunity for all stakeholders to discuss how deer numbers should be managed. As importantly, the goals set at these meetings will form the basis for subsequent management.

Recommendations
Management/Regeneration

The ecology of white pine is different from most other conifers in Minnesota. To successfully regenerate and manage it, activities not normally used for other species will be necessary (e.g., under planting, protection from deer browse, pruning). In addition to increasing the number of white pine trees, there is also the need to increase spatial dispersion, increase the number of old trees and stands, and smooth out the age distribution. Accomplishing these goals will require significant regeneration efforts, modified silvicultural systems, long term care, and some harvesting limitations, as described in the following recommendations.

1. Recommendation:

   Harvests of white pine in the pine cover types on state-administered lands should be restricted to thinnings, selective harvests, or shelterwood harvests. When harvesting white pine in other forest cover types, the best seed producing white pine will be retained and treatments carried out so as to increase white pine regeneration. These restrictions shall govern planning and timber sale design by managers on state-administered lands until new inventory indicates that the number of white pine trees has doubled from 25.9 to 51.8 million trees on all ownerships. An exception to these restrictions would allow harvest if a tree poses a hazard to the public or has been severely damaged by natural causes.

   Explanation/Rationale:

   Thinnings and selective harvest enables the capture of mortality before it occurs (e.g. extensive blister rust) and allows the remaining trees to grow bigger, faster. Shelterwood harvests are a proven silvicultural system that fosters regeneration of white pine. Leaving good seed producing trees in other types would provide a seed source for expanding the presence of white pine.

2. Recommendation:

   Forest land management organizations should be encouraged to reserve the better white pine trees that occur as scattered individuals or in small groups for their seed producing, aesthetic, wildlife, and ecological benefits.

   Explanation/Rationale:

   One of the factors contributing to the decline of white pine in Minnesota is the absence of seed producing trees for natural regeneration. Reserving groups of mature trees may preserve genetic characteristics that will allow white pine to continue adapting to changes in climate, predation pressure and diseases. These trees have value as a source of seed if steps are taken to encourage natural regeneration around them. They also have value for aesthetics, ecological, and wildlife purposes even if they are dead or dying since they can serve as excellent nesting, roosting, and snag trees.

3. Recommendation:

All white pine on state-administered timber lands should be managed under the DNR's Extended Rotation Forest (ERF) Guideline so as to increase the acreage and distribution of older white pine stands and trees on the landscape.

Explanation/Rationale:

The total acreage of older white pine existing on public lands today is much less than what existed prior to European settlement. Managing all white pine on state-administered timber lands to attain ERF final harvest ages of 150-180 years would help to restore the ecological values associated with older white pine trees and stands while providing a long-term seed source for establishing white pine regeneration.

4. Recommendation:

White pine should be planted in smaller groups as well as on larger acreages within its range where white pine was once abundant but is now rare or non-existent.

Explanation/Rationale:

White pine was historically and is today more commonly found as a component of other forest types rather than as a pure white pine forest type. In order to re-establish its former role, it is important to establish a presence on favorable sites throughout its range, whether as larger stands or as more scattered individuals and groups. Planting of small groups of white pine on appropriate sites can be incorporated into reforestation programs for other species so that white pine is established as a component of the new stand.

5. Recommendation:

Managers should enhance natural seeding opportunities through treatments that create proper microsites for seedling establishment near white pine seed trees when natural and man-made disturbances occur. Treatments in the vicinity of seed trees could include mechanical scarification, prescribed burns, or leaving or enhancing the presence of coarse woody debris in advanced stages of decay on the forest floor.

Explanation/Rationale:

Natural seeding can be effective aesthetically and economically. Harvesting, windthrow, wildfire, and insect outbreaks can create openings around seed-bearing white pine trees where regeneration could be attempted or facilitated with minimal effort (e.g. use of scarification). Recognition of these opportunities and efforts to take advantage of these should result in substantial increases in white pine regeneration.

6. Recommendation:

The DNR should create a forum for resource managers that manage areas reserved from harvest for the purpose of identifying and discussing management techniques, including intensive management practices, to assist in the establishment, regeneration and maintenance of white pine in reserved areas.

Explanation/Rationale:

Managers of reserved areas (e.g.: parks, Scientific and Natural Areas, designated old-growth stands) need a set of techniques that they can use to maintain or increase the amount of white pine when that is identified as a management objective. Reserved areas often have as an overarching management goal the use and maintenance of natural processes; traditional silvicultural practices are often not used because they alter natural processes. On the other hand, the processes and disturbances that created the white pine stands that exist today may not function the way they did before settlement, or they may be unavailable as management tools. Management techniques that use or mimic natural processes and can be practically applied in the field are required.

7. Recommendation:

DNR tree nurseries should expand the procurement of white pine seed native to Minnesota in collaboration with other forest land management agencies and work with private nurseries to grow more white pine adapted to Minnesota's conditions.

Explanation/Rationale:

Native seed sources should be used to ensure adequate survival and growth of planted seedlings adapted to Minnesota conditions. In order to expand the amount of white pine planting stock, more aggressive seed collection and procurement strategies need to be in place to capture good seed crops in the different seed zones. At some point, seed orchards should provide a large amount of the white pine seed needed.

8. Recommendation:

The DNR should protect (maintain) selected stands of white pine greater than 20 acres in size in various age classes on state-administered lands to provide for future old growth. Limited harvesting for sanitation and maintenance may be allowed in some of the selected stands to help perpetuate the life of the stand and promote regeneration. Resource managers on federal and county-administered lands are encouraged to also follow this recommendation.

Explanation/Rationale:

The ecological values associated with old growth are more likely to be found in stands greater than 20 acres. This will ensure that old-growth stands will occur in the future.

9. Recommendation:

The DNR should protect (maintain) older white pine stands greater than 20 acres in size so that approximately 25 percent of the acreage of these older and larger stands exceeds 120 years of age on state administered lands. Fifty percent of the acreage of these stands older than 120 years should be maintained as old growth. Resource managers on federal and county-administered lands are encouraged to also follow this recommendation.

Explanation/Rationale:

The total acreage of this age and stand size on public lands today is probably less than 5 percent of what existed in Minnesota prior to European settlement. A significant amount of what remains should be maintained for scientific research, aesthetic, and recreational purposes.

10. Recommendation:

The Commissioner of Natural Resources, in cooperation with stakeholders should create a pilot project to identify blocks of state lands in management units of the Outdoor Recreation Act (e.g. state forest, state park) where deer density would be reduced for the short term (5-7 years) to allow white pine regeneration to out-grow the reach of the deer.

Explanation/Rationale:

It is well accepted that deer browse white pine during the winter and can retard or prevent successful regeneration. It is not clear however, whether regeneration can be stimulated by simply reducing local deer numbers. There are at least 3 advantages to using this approach. First, fewer hunters would be impacted if only specific blocks are targeted rather than entire Deer Management Areas. Second, the proposal is short term and affects deer numbers only during a specific "window" when the primary goal would be to increase white pine regeneration. Third, the blocks represent an opportunity to test whether sufficient cooperation from hunters can be secured to reduce deer number effectively and whether reduced deer numbers measurably affects regeneration.

11. Recommendation:

Resource managers should increase the use of prescribed surface fires to regenerate white pine on reserved and commercial forest land.

Explanation/Rationale:

It is known that historically white pine was established in pure and mixed stands by surface fires and crown fires. With fire suppression, shade-tolerant trees and shrubs are increasing throughout the white pine's range. Mature white pine stands especially need surface fires, or "underburning", to establish new cohorts of pines. The known benefits of using fire include reducing brush in the forest understory, reducing the duff layer to expose a mineral seed bed, and reducing the fire hazard, and other unknown benefits may also exist.

12. Recommendation:

The Minnesota Conservation Corps (MCC) should be utilized as a partner in conducting management activities that will promote the presence of white pine. For the next few years, a significant portion of the MCC's time should be devoted to projects directly related to increasing the presence of white pine on the landscape.

Explanation/Rationale:

The MCC provides an existing workforce that would be readily available to land managers for conducting projects beneficial to white pine. Examples of projects might include: pruning to reduce blister rust infection; planting; release of seedlings and saplings from competition; and bud-capping young trees to protect them from deer.

Recommendations
Education/Training

Much is known about regenerating and managing white pine, but not all of it is readily available to land owners and resource managers. The recommendations in this section are aimed at increasing the dissemination of useful information to private individuals, forest land managers, and others directly responsible for or interested in white pine management in the state.

1. Recommendation:

   A "Silvicultural Guide" should be developed to recommend the care and management of white pine.

   Guidelines should address the variety of landowners and land classifications in Minnesota (e.g. parks; natural areas; private, county, state, and federal ownerships). The following must be included in this guide:

   - Focus and emphasis should be placed on the importance of care and management practices of white pine after regeneration and establishment. Follow-up practices ensuring the establishment of seedlings by release from competing vegetation should be suggested.
   - Emphasis must be placed on the range of difficulty of establishing white pine from one type of site to another; information must be given on what prescriptions are necessary on each site.
   - Additional management options, site analysis considerations, and cultural practices should be included.

   Explanation/Rationale:

   "State-of-the-art" recommendations on white pine regeneration and management should be available to all landowners in the State of Minnesota. The range of ease/difficulty with the regeneration and management of white pine from one type of site to another should be addressed and information provided on appropriate prescriptions for each type of site.

   It is essential that public and private individuals and agencies recognize the need for timber stand improvement (TSI) practices after regeneration and establishment. These TSI techniques might include, but are not limited to pathological pruning and release work.

   Walk-away forestry will not suffice for the regeneration and establishment of white pine in Minnesota.

2. Recommendation:

Develop a continuing education program for foresters that explains and demonstrates management techniques that can increase the presence of white pine. This program needs to teach how to take advantage of, and enhance natural regeneration opportunities as well as incorporate artificial processes (e.g. site preparation work, prescribed burns, planting). A similar program should also be available to all forest landowner groups and timber harvesters. These programs should consider the development of areas that demonstrate regeneration and management techniques.

Explanation/Rationale:

There is a good deal of skepticism about managing white pine and uncertainty about how to do it. Education needs to be directed toward hands-on learning and the building of networks among managers so they can communicate with one another about problems and successes.

3. Recommendation:

Educational materials should be developed for non-industrial private forest landowners that describe white pine ecology, values, and silviculture, and that encourage landowners to regenerate and manage white pine on appropriate sites. These materials should reveal the numerous opportunities and scientific data available to make white pine regeneration a success. These materials should emphasize that the success will depend on commitment and follow-up treatments. There should be active promotion for white pine management in "stewardship plans" on appropriate sites.

Explanation/Rationale:

Existing literature stresses white pine problems rather than balancing the values of white pine with management considerations. Significant gains can be made if people are provided with a "recipe for success." No such educational materials are currently available.

4. Recommendations:

The DNR should prepare a brief key that can be used by resource managers to identify potential sites for white pine management that currently lack a white pine component.

Explanation/Rationale:

A key that describes common plant associations of white pine along with soil moisture and nutrient characteristics required by white pine would serve as a useful tool to resource managers in identifying sites suitable for white pine management.

5. Recommendation:

Establish an "Adopt Young White Pines" program that provides education, training, and recognition to any individual, family, or organized group that adopts a young white pine site managed by participating public forest land management agencies and that agrees to apply cultural practices that will protect young pine from pest problems during their early critical years.

Explanation/Rationale:

White pine are most vulnerable to damage from blister rust, deer browsing, and tip weevil when they are young. Pruning the lower branches and bud capping until the seedling is above browse height are two practices that would increase their potential for survival. This could be accomplished through the dedicated care of an individual or organization that has indicated a commitment by enrolling in a program such as Adopt Young White Pines.

Recommendations
Research

Although much is known about white pine, there are some critical gaps in the knowledge base. Major areas needing additional research include deer predation, blister rust management, white pine genetics, natural regeneration techniques, old growth systems, and the costs and benefits of growing white pine. The following recommendations identify research which should be conducted to assist white pine management efforts.

1. Recommendation:

   Research should be funded to address the following questions concerning white-tailed deer:

   1. Determine the extent of deer browsing that will kill or retard seedling growth enough that it will lose its competitive edge.
   2. Determine whether there is a threshold in patch/plantation size and/or seedling densities at which deer browsing will not prevent sufficient stocking levels to occur.
   3. Determine whether there are specific "habitat types" in which white pine is less likely to be browsed.
   4. Determine deer palatability as it relates to seed source and type of planting stock.

   Explanation/Rationale:

   It is well documented that deer browse white pine seedlings, but it is not clear how severe this browsing must be to kill an individual tree. It is well-known that many animals produce so many young that predators are overwhelmed, and sufficient numbers of young survive to be recruited to an adult population. A likely parallel may be applied to white pine seedlings covering the landscape in fairly large patches. This begs the question: Can larger areas or high densities of seedlings be planted to "overwhelm" browsing by deer?

   Deer browse white pine primarily in winter on their winter range. Assuming a classification scheme is identified for determining where white pine should be planted, is it possible to identify specific "habitat types" that represent winter habitat or yarding areas of deer, thus areas of potential high browsing of white pine?

2. Recommendation:

   Research efforts should be funded to refine management and harvesting practices that improves the cost effectiveness of regeneration, and expansion of white pine from individual trees, clusters or stands.

Explanation/Rationale:

Additional information is needed to develop reliable practices for regenerating clumps or small stands of white pine. Information is also needed on how to promote regeneration around isolated trees and how to expand clumps or small stands beyond their current size.

3. Recommendation:

Research should be funded to address the following concerns with blister rust in the State of Minnesota.

- Investigate methods of predicting site specific blister rust impacts: Where will severe impacts be likely and, therefore, where will management of white pine be difficult.
- Develop management tools and techniques that can be utilized in Minnesota to reduce the impact of blister rust.

Explanation/Rationale:

Almost the entire northern 1/3 of Minnesota is within the two highest hazard zones for blister rust. However, field observation indicates that the levels of blister rust varies within that large area. If managers can predict where rust incidence will be great, or vice versa, successful regeneration efforts should be more likely.

White pine was originally distributed widely in the area now considered high hazard. Its re-establishment in those areas is desired. Therefore, management techniques that can be used to successfully regenerate white pine and reduce the impact of blister rust are highly desirable.

4. Recommendation:

Funding should be provided to develop genetic improvement in growth rates and blister rust resistance in white pine.

Explanation/Rationale:

Fast growing seedlings have several advantages. In an understory situation they may be able to compensate somewhat for the loss of growth normally associated with partial shade. They are likely to grow beyond deer browse and rust problems sooner. Grown in the right conditions, trees will become larger faster. Resistance to blister rust is polygenic (controlled by multiple genes) and several generations of breeding are necessary to fix resistance at a practical level. Polygenic resistance normally does not give complete protection (immunity), but the resistance is more permanent from generation to generation and should be more difficult for new races of blister rust to overcome.

5. Recommendation:

Research should be funded to study the regeneration processes that occur in old growth stands (as defined by the Minnesota Department of Natural Resources) where white pine is an important component.

Explanation/Rationale:

Old-growth stands are recognized as laboratories where the natural processes that have regenerated white pine for thousands of years can still be reconstructed. Most of what we know about natural processes in white pine stands has come from, and will continue to come from the few remnant stands in the state. Thus, knowledge about regeneration depends upon information obtained from these stands. The old-growth system and reserved lands in the Boundary Waters Canoe Area Wilderness, Scientific and Natural Areas, Research Natural Areas, state parks, or wherever old-growth stands occur can serve as these laboratories.

6. Recommendation:

An economic analysis should be conducted to gauge the potential benefit of intensively managing white pine under three situations: white pine stands, white pine as a component of other forest types, and where white pine is currently not present. The analysis should take into account different risk factors (e.g.blister rust hazard zones) and include costs associated with the long term care required to grow white pine.

Explanation/Rationale:

Such an analysis will make it easier to justify the benefits of the intensive management and investment costs of white pine. Foresters, legislators, and the general public need to see that investment in white pine can be justified in economic terms as well as ecological terms.

Recommendations
Inventory/Monitoring

Good decisions about the regeneration and management of white pine on specific sites requires useful information about the site. Site classification systems provide such information more accurately than simply using the existing cover type. This section recommends that site classification systems be developed for Minnesota because of their potential value in selecting appropriate sites on which to regenerate and manage white pine. It also recommends that monitoring systems be developed to measure the effectiveness of white pine management activities, and changes in the overall status of the white pine resource.

1. Recommendation:

   Forest land management organizations should develop ecological classification systems that have utility for managing white pine at the field level and that address plant community dynamics.

   Explanation/Rationale:

   Thoughtful forest management requires information on the ecological potential of a site; cover types are not enough. An ecological classification system that places sites in an ecological context and offers potential successional pathways will be of great utility. As a tool for land managers, it will:

   - Identify potential sites for white pine management that are currently without a white pine component.
   - Determine degree of difficulty in establishing white pine and the type of silvicultural system most likely to succeed.
   - Help identify pest problems related to a specific site.
   - Look beyond present cover type and recognize ecological potential of a site to support cover types in addition to the present cover type.
   - Provide common site interpretive language for resource managers of various resource specialties.
   - Serve as a tool in future forest inventories to help predict future forest cover type trends and potential site opportunities to meet future management objectives.

2. Recommendation:

   The Department of Natural Resources should develop a comprehensive monitoring program to evaluate the effectiveness of managing for white pine at the stand level. The program should be designed to select relevant sites through a stratified random sampling process. It should also include field audits similar to those used in the Best Management Practices to Protect Water Quality program.

Explanation/Rationale:

Follow-up monitoring and evaluation are essential to the success of establishing white pine regeneration and management for white pine. Monitoring the tending needs beyond initial regeneration surveys is essential to protecting and enhancing previous investments and ensuring success. Silvicultural recommendations for white pine management prepared by the White Pine Regeneration Strategies Work Group could be used in the evaluation in the absence of specific guidelines. Including stakeholders in the field audits would build creditability to the process. A "walk away" mentality after initial establishment must be discouraged.

3. Recommendation:

The Annual Forest Inventory System (AFIS) should be used to the extent possible in assessing the condition of the white pine resource and monitoring progress towards goals.

Explanation/Rationale:

The Forest Inventory Analysis (FIA) is managed by the U.S. Forest Service's research stations to periodically inventory the state's forests. The DNR cooperates in conducting FIA in Minnesota and has been working with the U.S. Forest Service on a pilot project, the Annual Forest Inventory System (AFIS), to provide more frequent updates on the condition of the state's forests. AFIS has been designed to provide a complete statewide reinventory every 4 years along with a continuously updated data base kept current through annual field sampling, use of satellite imagery, and computer modeling.

Part II - Historic and Current Status

Public Perspectives 1990-96

In 1992, over 600 people participated in a symposium in Duluth, Minnesota to address the history, ecology, policy, and management of the eastern white pine. The Symposium brought together people with an interest in this native tree species, including foresters, wildlife managers, special interest groups, forest industry, recreationists, and preservationists.

The excitement and impetus for making a difference in the future presence, viability, and health of that tree species was high. Presentations from natural resource specialists and professionals explored the role of white pine: in ecosystems; as spiritual, recreational, and economic values; in forest management; and in the ecology of forests as a whole.

The message that came from that gathering was clearly spoken and summarized in the words of Alan C. Jones, Forest Health Specialist, Minnesota Department of Natural Resources: *If we are to work toward the goal of increasing white pine in Minnesota, there is a critical need for everyone to work together. Establishing and culturing white pine will require a commitment and a long term investment. Without some vision of the commitment and investment paying off monetarily, ecologically, aesthetically, or spiritually, there will be very few who will make the commitment and investment necessary to bring white pine back.* The symposium ended with a call for a white pine management and restoration initiative.

Regrettably, the commitment waned. In 1994, the subject of white pine and its presence in Minnesota's forests was again brought to the forefront of thought through the publishing of the Generic Environmental Impact Statement on Timber Harvesting in Minnesota. The study returned concerns about the white pine resource to the table.

The GEIS document stated in Chapter 5, "Implications:" *The main problem with the pine communities, in addition to fire suppression, is a failure to restore the pine acreage after early exploitation and land clearing. Limited success in regenerating white pine over the past several decades has contributed to the failure in restoring the white pine acreage to historic levels. This failure in regenerating a large acreage is due in part to the impact of white pine blister rust, expansion of the deer herd, reduced incidence of fire, and difficulty in controlling competing vegetation.*

The continued growing interest in white pine was reflected by the introduction of legislation in the 1995 session of the Minnesota Legislature ("Restore the White Pine Act" HF 1897 SF 1757). The proposed act called for a moratorium on the harvesting of white pine. The proposal to implement a moratorium was prompted by a perception that Minnesota was losing its white pine resource.

The Society of American Foresters (SAF) produced a statement opposing the moratorium. The SAF suggested a moratorium would harm white pine by not allowing removal of infected trees; not allowing thinning of white pine forests which encourages natural reseeding and vigor of surviving trees; and restricting other management activities that will benefit the replanting, survival, and/or growth of white pine.

Both conservationists and forest resource managers agreed that the demise of white pine was exacerbated by the lack of developing regeneration techniques and lack of effort to "follow through" with regeneration strategies. They also agreed that the impediments to perpetuating white pine (ie. competition from brush, blister rust, tip weevil, and deer browsing) were unreasonably "scaring" resource managers away from accepting the challenge of managing eastern white pine.

Early in 1996, a White Pine Regeneration Strategies Work Group composed of forest land managers, ecologists, silviculturists, and scientists was appointed by Minnesota State Forester Gerald A. Rose. The Work Group was established to make recommendations about and to help lay the foundation for a white pine management initiative. Formation of the group was endorsed by the Minnesota Forest Resources Council, which was appointed by Governor Arne Carlson as authorized by the Minnesota Sustainable Forest Resources Act of 1995. (See **Appendix A:** *Members-White Pine Strategies Work Group.)*

Pre-European Settlement

Evidence from fossil pollen indicates that white pine entered Minnesota from the east around 7,000 years before present. Further movement westward was slowed for several thousand years because of the warm, dry climate of that period. The species reached maximum abundance about 4,000 years ago. Since then, a slowly cooling climate has caused white pine to slowly decline in abundance. It reached the region of Itasca State Park around 2,700 years ago. The cooler climate of recent millennia has allowed hardwoods, such as sugar maple, to invade white pine forests along the southern and southwestern edges of it range.

This cooling has also allowed boreal tree species to move in from the north, in effect "squeezing" white pine from both directions. Such rate of change is so slow, however, that no one—in the passage of their lifetime—would notice any marked change in the natural range of white pine.

White pine was perpetuated for thousands of years by a natural disturbance regime. This regime consisted of:
• A fire cycle of 150 to 300 years and intervening light surface fires every 20 to 40 years. The variation in the intervals between successive fires was more important than the mean interval. Stands of all ages are equally likely to burn, therefore, some stands may burn twice in one decade, while others do not burn for several hundred years.

White pine is killed by crown fires, but individual trees survive in refuges such as rock outcrops, lakeshores, and river bottoms where fires are not very intense. Under the natural disturbance regime, white pine reproduces under a canopy of aspen, paper birch, oak, or red maple. All of these other species become established in a burned area and grow faster than white pine after a major disturbance. White pine slowly invades these stands, with surviving trees in refuges serving as a seed source. These surviving trees were exceptionally widespread over most of Minnesota and the Lake States in general.

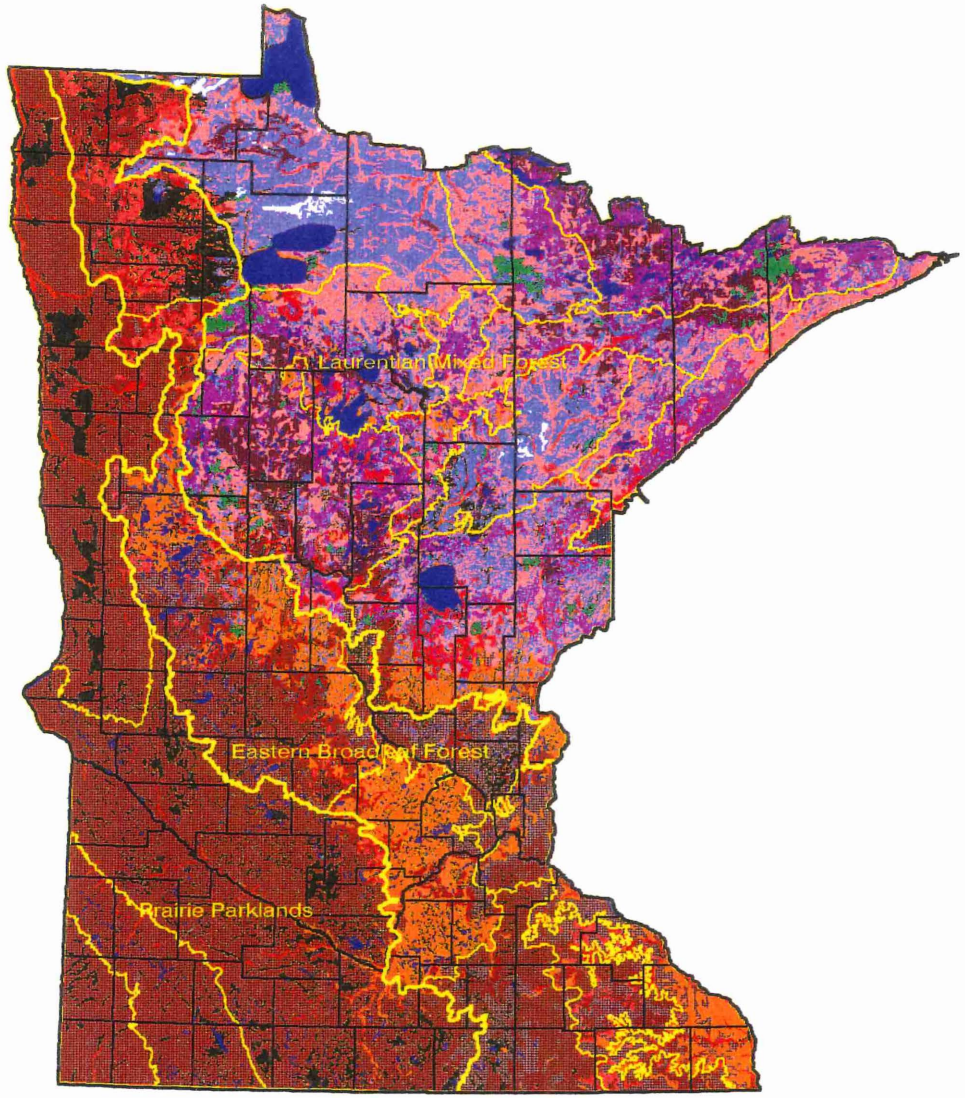
• Widely scattered seed sources and gradual invasion of post-fire stands over a 20 to 40-year period in the natural regime allowed white pine to be a successful species in pre-settlement times. Its life-history characteristics of a long life span, ability of mature trees to survive some fires, and moderate shade tolerance were well-suited to this strategy.

Succession from shade-tolerant hardwoods back to white pine depended on an unusual event, such as intense fire followed by a catastrophic windfall, which may only occur every 1,000 to 2,000 years at a given location. White pine could potentially be maintained indefinitely at one site by surface fires at 20- to 40-year intervals. These surface fires do not kill adult white pine, but do kill invading hardwoods or shade-tolerant conifers such as balsam fir. Such a disturbance regime is very hard to maintain for long time periods, since the severity of a fire is controlled by weather.

Based on pollen records, public land survey records, and other vegetation maps, it is apparent that concentrations of white pine moved about the landscape. Its wide amplitude of environmental tolerances allowed it to maintain a presence in stands over a large geographic area, with greater concentrations in those stands where infrequent combinations of events favored white pine over other tree species.

Somewhat reliable information on the historical presence of white pine in Minnesota has been gathered from the original public land surveyors' notes that provide one view of its presence around 1850. In addition, a map is available (see following page, *The Original Vegetation of Minnesota,* an adaptation of Frances Marschner map of 1930) that shows "pre-settlement" vegetation. Both provide a "snapshot" view of the presence of white pine.

The Original Vegetation of Minnesota



- Prairie
- Wet Prairie
- Brush Prairie
- Aspen-Oak
- Oak Openings & Barrens
- Big Woods/Hardwoods (QU/AC/TI/CA)
- River Bottom Forest
- Aspen/Birch (Hardwood trending)
- Mixed Hardwood & Pine
- White Pine
- Mixed Red and White Pine
- Jack Pine Barrens and Openings
- Pine Flats (TS/PI/AB/PNw,POt)
- Aspen/Birch (Conifer trending)
- Conifer Bogs and Swamps
- Open Muskeg
- Lakes

Scale: 0 — 50 mi — 100 mi

Source: USFS (NCFES) 1974 adaption from original data compiled during the 1930's.
Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Ecosystem Health Unit

12/4/1996

ECO, ECS Provinces

ECO, ECS, Subsections, 1995

Minnesota
Department of Natural Resources

Logging Era History

The slow natural loss of white pine that occurred over the past several thousand years was greatly accelerated in magnitude of one to two orders in rate of change in the recent past 100 years by the logging and burning activities of the late 1800 and early 1900s.

History journals are painted with colorful images of the great heyday of logging. Of all woods, the straightest, the most desirable, the best for building homes, churches and barns—was white pine. Its wood was beautiful—light in weight, soft, and straight grained. Its abundance, cheapness, and varied usefulness made possible the settlement and development of the State of Minnesota and the westward movement of civilization. In fact, before 1855-1890, the term "lumbering" as used in Michigan, Wisconsin, and Minnesota applied almost exclusively to work in white pine (*History of the Lumber and Forest Industry of the Northwest,* G.W. Hotchkiss). For five decades, white pine dominated the lumber industry in Minnesota.

According to Agnes C. Larson, *"White Pine Industry,"* white pine was found in every county in Minnesota east of the Mississippi River from Minneapolis to Canada. While Itasca, St. Louis, Mille Lacs, Kanabec, Pine, Aitkin, Beltrami, Cass, and Carlton counties had especially good stands, "Carlton county was its favored abode." Minnesota was also endowed with a river system that provided the highways for carrying the forest resource to markets, including the Red River of the North, the St. Louis, the Cloquet, the Mississippi, and its tributary the St. Croix.

The mill considered to be the largest, most modern and complete lumber plant in the world did its work in the white pine stands of Minnesota. From 1910 to 1929, the Virginia & Rainy Lake Company cut 1,991,566,030 board feet of logs within an area in northern St. Louis County alone, comprising Townships 64N through 70N and Ranges 16W through 23W.

The company's headquarters and mills were located in Virginia and consisted of two large sawmills, a lath mill, and a planing mill. The sawmills had a combined 24-hour daily capacity of 875,000 board feet. It is interesting to note that although white pine was the focus of the V & RL Company, about 25 to 30 percent of the timber cut was Norway pine, poplar, birch, and cedar. It was the policy of the company throughout its operations to cut small trees that might not have been utilized in operations that possessed better quality stands of white pine. The V & RL was located in a transitional climate zone; logging less desirable trees species was necessary to supplement white pine production. The mill was complex in its operations to facilitate its need to process these variety of tree species.

When the timber stands were depleted and the mill closed in October 1929, the people of northeastern Minnesota and the entire Great Lakes region witnessed the last of the huge white pine sawmills. The extensive harvesting that had taken place left much of Minnesota cluttered with brush and stumps. Planting was not a consideration because land clearing for settlement and farming was the focus.

Fires set to rid the land of slash did not always respect the boundaries intended by those who set them. Throughout three decades spanning the turn of the century, forest fires headlined the newspapers with news of their destruction: 418 dead in the great Hinckley Fire of 1894; mass destruction in Chisholm in 1908 and in Baudette and Spooner in 1910; 438 dead in the Cloquet-Moose Lake fire of 1918.

In a state as large as Minnesota, it took approximately 80 years of timbering and settlement to finally "subdue" the vast forest lands. Eventually, every one-mile section of land felt the axe, the saw, and the effects of fire. The extensive harvesting, followed by the policies of land clearing and development, brought a major reduction in the white pine forest type.

The prophetic words of Agnes Larson, *White Pine Industry,* (1949), are worthy of repeating:
"One thought emerges above all others . . . . We have seen that pine forests played a major role in the development of the Upper Mississippi Valley; the lumber industry they supported provided materials, men, capital, and institutions that contributed richly to the growth of the nation and particularly to the region where the industry flourished. The industry is

gone because the pine forests are gone, and Minnesota and the region are poorer as a result. To be sure, we still have much of the material and human wealth that were stored up in the decades of activity in forest and lumber mill. But as the houses and barns decay, so too will the other products of the lumber age disappear.

"The lesson this situation should bring home to us is the need of restoring the forest industry. Our forests should be nurtured so as to serve the generations to come as they did the generations that are past. To this end the people of Minnesota must shape their plans. Only thoughtful planning and careful management over a long period of time can again make productive the forest lands of the white pine region."

Post-Logging Era History

Settlement, land clearing, and agriculture had profound effects on the land from the very beginnings of European colonization. The shadows of that past are visible in Minnesota's forest landscape today—aspen, birch, maple, and basswood setting their roots where once white pine had a notable presence on the land.

Changed land use policies coupled with the debilitating effects of pathogens, insects, and deer browsing further complicated the management and regeneration of white pine. Post-logging slash fires and the harvest of individual trees that survived the original logging episodes led to the near elimination of the formerly widespread white pine trees that were in refuges and relatively safe from disturbance. Natural succession of post-fire aspen and birch forests back to white pine is now difficult.

Early fire protection laws required the burning of slash at harvested sites to discourage chances for catastrophic fires later on. In the process, the slash fires eliminated seed sources for natural regeneration. And, even until relatively recent times, much of the white pine harvests were accomplished in the winter which minimized opportunities to scarify the soil—a process that helps produce good seed bed conditions for seeds to germinate, become established, and grow.

Suppression of surface fires in those few stands remaining after logging allowed shade-tolerant conifers and hardwoods to invade and replace white pine. Without fire or logging, most upland forests containing pines will eventually convert to a balsam-spruce-birch complex. The age class mosaic that resulted from pre-settlement fires will gradually become homogenized, and fuels will likely be abundant across the landscape, creating potential for large wild fires. Insect destruction and wind throw may also contribute to the build up of fuel that may lead to catastrophic wild fires, and serve as potential disturbance factors.

Increased white-tailed deer populations in the northern part of the state also contributed to the lack of regeneration that has occurred for the past 80 years. Timber harvest at the turn of the century and subsequent wild fires opened up the forest and created ideal habitat for deer. The northern forests had previously been home to moose and caribou; white-tailed deer were relatively uncommon. At that time, most deer inhabited the wooded river valleys in the prairie and the transitional areas where prairies were replaced by forests.

Development of young aspen/birch stands on cutover pine sites in the late 1800s and early 1900s created ideal habitat for deer. In Itasca State Park, population estimates in the late 1930s exceeded 70 deer/sq. mile on some sections based on a Civilian Conservation Corps census. Deer browsing from the mid-1920s through 1945 eliminated nearly all white and red pine seedlings. (Ross, B.A., J.R. Bray, and W.M. Marshall. 1970. *Effect of long-term deer exclusion on a Pinus resinosa forest in north-central Minnesota.* Ecology 51:1088-1093). The current situation in Itasca State Park is that deer browsing appears to be a major factor limiting regeneration of white and red pine.

Although research studies have not documented the level at which browsing results in death of trees, browsing slows the height growth of white pine. Regardless of the extent of the browsing, it reduces the height and diameter growth of the tree, causing it to lose its competitive edge. A number of forest land managers also regard the deer browsing as one of the major causes for the lack of white pine being able to establish itself.

Both a fungus and an insect that occur in Minnesota have also discouraged efforts to regenerate white pine. Blister rust is a fungus that was first found in Minnesota in 1916 at Taylor Falls. It is an exotic pathogen native to Asia but came to the United States via Europe. The fungus will kill white pine. The tip weevil is a small beetle native to North America where it has developed a reputation as one of the most significant insect pests of white pine. While it is not a tree killer, the weevil reduces the economic and aesthetic values of white pine by causing crooked, multi-stemmed and/or knotted branches and trunks. Both pests have discouraged most land managers and foresters from attempting to extensively regenerate white pine.

It is important to note that the history of this kingly tree is also tainted with fiction. Historians and ecologists have attempted to dispel the myth that pure white pine forests once covered vast acreages of the Lake States region. While there were well-known pockets of white and red pine mix (the "pineries") in Michigan, Wisconsin, and Minnesota, most of the white pine occurred in small groups, or as scattered individuals in mixture with other species, including northern hardwoods.

Changes in the Abundance of White Pine in Minnesota

Public Land Survey

The best and only information that can be used to document white pine abundance prior to large-scale logging is found in the Public Land Survey (PLS) records. Government surveyors identified trees throughout Minnesota that were found along their survey routes. At section corners (a section is one square mile) and midway through section lines trees were blazed, diameters measured, and distance from the survey point determined. Of all these measurements, the simple presence at a survey point—up to four trees per section corner, and two trees midway along a section line—provide a measure of white pine's relative abundance in the pre-logging forest.

Scientists have written about the errors in this information and the biases of the government surveyors. Taking all of this into account, the White Pine Strategies Work Group feels that the presence of white pine at section corners and along lines was a reasonable sampling of the number of white pine trees relative to all other species during the 1850-1905 survey period. The survey was systematically carried out on a statewide grid and the surveyors, by and large, used all available tree species because they were instructed to pick tree species nearest to the survey point.

It is an assumption that the surveyors could nearly always identify white pine because of their training and interest in white pine for its great commercial value. However, in the Mille Lacs Uplands, an ecological Subsection (See accompanying map: *Upper Three levels of ECS for Minnesota*), it was determined the surveyors used the term "pine" to refer to white pine. This is the most significant error in the survey; this was corrected by adding "pine" to the numbers of "white pine" in the Mille Lacs Uplands Subsection (See accompanying table *Changes in Abundance of White Pine in Minnesota*).

In the four ecological Subsections located south of the Mille Lacs Uplands, it is possible that white pine abundance is slightly underestimated by the PLS due to the early logging documented in Agnes Larson's book, *"History of the White Pine Industry in Minnesota"* (1949 University of Minnesota Press).

Locations of white pine and pine "witness trees" blazed by the early land surveyors is concentrated in 10 of Minnesota's 24 Subsections (See accompanying map: *Pre-settlement PLS Bearing Tree Locations).* Even within these Subsections, white pine appears concentrated in certain areas and sparse in others. The Tamarack Lowlands stands out from the Subsections around it in having a sparse distribution of white pine by comparison.

Forest Inventory and Analysis

The most reliable measure of present-day white pine abundance that is comparable to the PLS data is found in the U.S. Forest Service "Forest Inventory and Analysis" (FIA) data. (See detailed discussion under section *Occurrence of Minnesota's White Pine.)* The latest inventory took place in 1990 and represents a statistical sampling of the makeup in Minnesota's "timberland" or forest land. This excludes reserved forests like the Boundary Waters Canoe Area Wilderness, Voyageurs National Park, and state parks.

As in the PLS, the FIA is laid out by townships. Aerial photo mosaics of the townships are studied and surveyors are sent to the field for detailed assessments at locations picked systematically. The surveyors visit the predetermined forest stands and take measurements of trees and other features. Trees are identified in the permanent plots established at these stands. The number of white pine trees encountered by surveyors can be compared to the total number of trees encountered statewide. This represents the relative abundance of white pine today.

While the confidence levels of these data vary due to sampling limitations, they are the best available for estimating the abundance of white pine across the state. However, the White Pine Strategies Work Group wanted to understand changes on a Subsection basis. After considerable discussion, it was agreed that at the level of a Subsection, these data would be useable enough to detect major shifts in white pine abundance from the 1800s to 1990. It would be similar to comparing two photographs taken of the same place a century apart—gross changes would be evident.

Trees larger than five inches diameter at breast height (DBH) were used in the calculations of FIA data since that is roughly equal to the smallest trees used in the PLS. Another problem with FIA data is that tree data are not taken from forest reserves. As a result, the FIA estimated number of white pine in the Border Lakes Subsection is less than the actual amount.

Locations of white pine in forest inventory plots are concentrated in the same 10 Subsections as historically. Because white pine abundance is so much less today than formerly, the strong patterns of distribution apparent on the PLS map are not evident now. The Border Lakes Subsection has a gap in sampling at the locations of Voyageurs National Park and the Boundary Waters Canoe Area Wilderness. Finally, when FIA data are summarized in areas as small as ecological subsections, the uncertainty (or error) in the white pine count increases.

Qualitative Comparison

To compare the two data sources,the Subsections beginning with those experiencing the greatest decrease in the abundance of white pine were listed (See accompanying table *Changes in Abundance of White Pine in Minnesota).* For example, in the Glacial Lake Superior Plain, white pine once numbered 24.1 percent of all the witness trees, based on the PLS sample of the forest then. Now it is estimated at 2.8 percent of all trees using FIA data. This represents an order of magnitude change that we call an "obvious decline." (See accompanying map *Changes in Abundance of White Pine in Minnesota.* This map is based on Subsections.) This magnitude of change would remain even if the FIA data were 100 percent in error. Five Subsections showed this magnitude of change—from numbers above 10 percent to numbers below three percent. Recall that "white pine" and "pine"were combined to arrive at former abundance in the Mille Lacs Uplands.

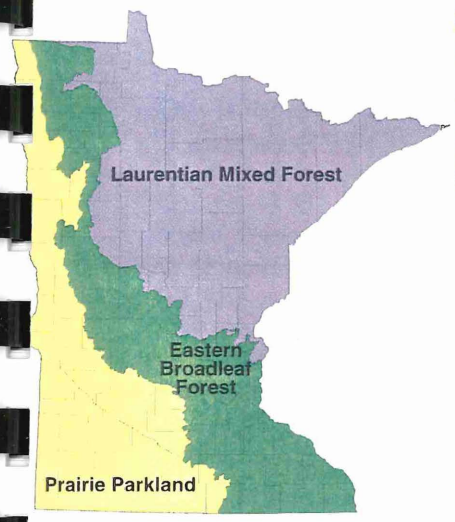
In the other Subsections where white pine may have decreased in abundance, its decline was simply noted. Nine Subsections showed a decline from the 1800s to the present, although when the change is smaller (e.g. in the Agassiz Lowland Subsection) the decline may be so small as to be negligible, given the uncertainty of the data. Five Subsections showed increases in white pine, although given possible errors in the FIA data and uncertainty about harvest prior to the PLS, these areas are best considered unchanged regarding white pine abundance. The white pine located in the five remaining Subsections was and remains too rare for detection by either survey method.

Opportunity Subsections

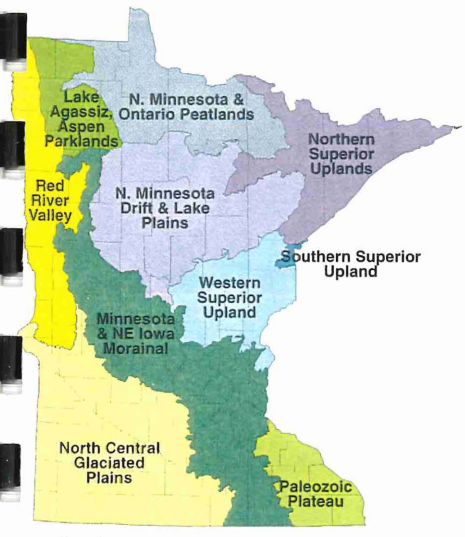
The five Subsections experiencing obvious declines in white pine abundance represent many opportunities for restoration on many sites. White pine was once abundant in these Subsections because of climate, soil, topography, and recurring wildfires, and has persisted here for 5,000 years. Historically, conditions were right for white pine. Today, a changing climate, higher deer numbers, white pine blister rust, and fire suppression have altered those conditions, presenting challenges for white pine management.

Other Subsections where white pine showed a decline present additional opportunities to increase white pine's role, abundance, and distribution in Minnesota forests.

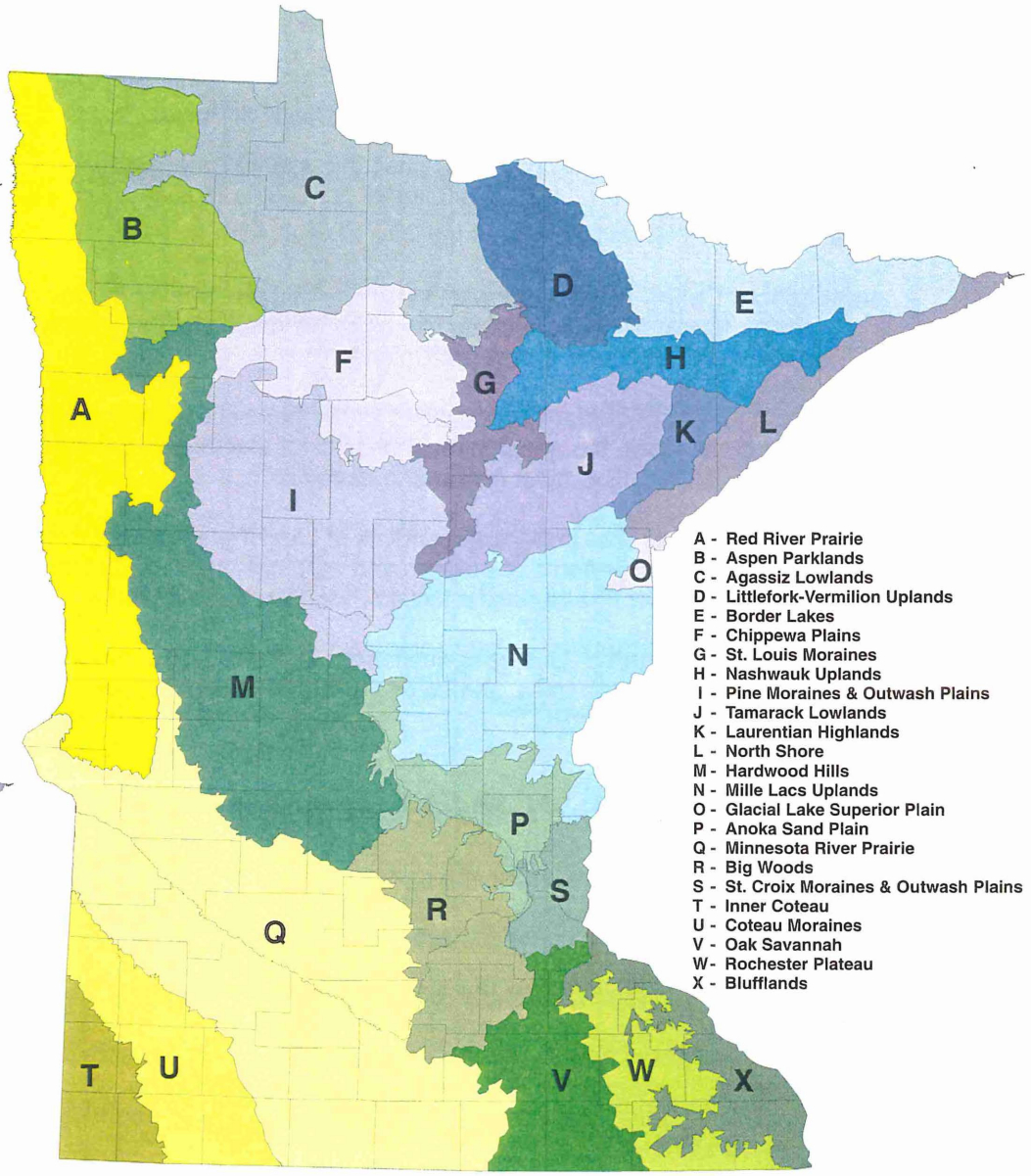
Upper Three Levels of ECS for Minnesota



1) Province



2) Section



3) Subsection

A - Red River Prairie
B - Aspen Parklands
C - Agassiz Lowlands
D - Littlefork-Vermilion Uplands
E - Border Lakes
F - Chippewa Plains
G - St. Louis Moraines
H - Nashwauk Uplands
I - Pine Moraines & Outwash Plains
J - Tamarack Lowlands
K - Laurentian Highlands
L - North Shore
M - Hardwood Hills
N - Mille Lacs Uplands
O - Glacial Lake Superior Plain
P - Anoka Sand Plain
Q - Minnesota River Prairie
R - Big Woods
S - St. Croix Moraines & Outwash Plains
T - Inner Coteau
U - Coteau Moraines
V - Oak Savannah
W - Rochester Plateau
X - Blufflands

Compiled by:
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January, 1996

Minnesota
DEPARTMENT OF NATURAL RESOURCES

What is an Ecological Classification System (ECS)?

The ECS is part of a nationwide mapping initiative developed to improve our ability to manage all natural resources on a sustainable basis.

- Definition: Ecological Classification System is a method to identify, describe, and map units of land with different capabilities to support natural resources. This is done by integrating climatic, geologic, hydrologic, topographic, soil and vegetation data.

- In Minnesota, the classification and mapping is divided into six levels of detail. These levels are:

Province: Largest units representing the major climate zones in North America, each covering several states. Minnesota has three provinces. Example: Eastern Broadleaf Forest.

Section: Divisions within provinces that often cross state lines. Sections are defined by the origin of glacial deposits, regional elevation, distribution of plants and regional climate. Minnesota has 10 sections. Example: Red River Valley.

Subsection: County-sized areas within sections that are defined by glacial land-forming processes, bedrock formations, local climate, topographic relief, and the distribution of plants. Minnesota has 24 subsections. Example: Mille Lacs Uplands.

Land Type Association: Landscapes within subsections, characterized by glacial formations, bedrock types, topographic roughness, lake and stream patterns, depth to ground water table and soil material. Example: Alexandria Moraine.

Land Type: The individual elements of Land Type Associations, defined by recurring patterns of uplands and wetlands, soil types, plant communities, and fire history. Example: Fire-dependant Xeric Pine-Hardwood Association.

Community: Unique combinations of plants and soils within Land Types, defined by characteristic trees, shrubs and forbs; elevation and soil moisture. Example: Sugar Maple-Basswood Forest.

What can an Ecological Classification System do?

- Define the units of Minnesota's landscape using a consistent methodology.

- Provide a common means for communication among a variety of resource managers and with the public.

- Provide a framework to organize natural resource information.

- Improve predictions about how vegetation will change over time in response to various influences.

- Improve our understanding of the interrelationships between plant communities, wildlife habitat, timber production, and water quality.

What are the end products?

- Maps and descriptions of ecological units for provinces through land types.

- Field keys and descriptions to determine which communities are present on a parcel of land.

- Applications for management for provinces through communities.

- Mapping of province, section, and subsection boundaries is complete throughout Minnesota, as shown by the maps on the reverse. The development of other levels is under way.

CHANGES IN ABUNDANCE OF WHITE PINES IN MINNESOTA

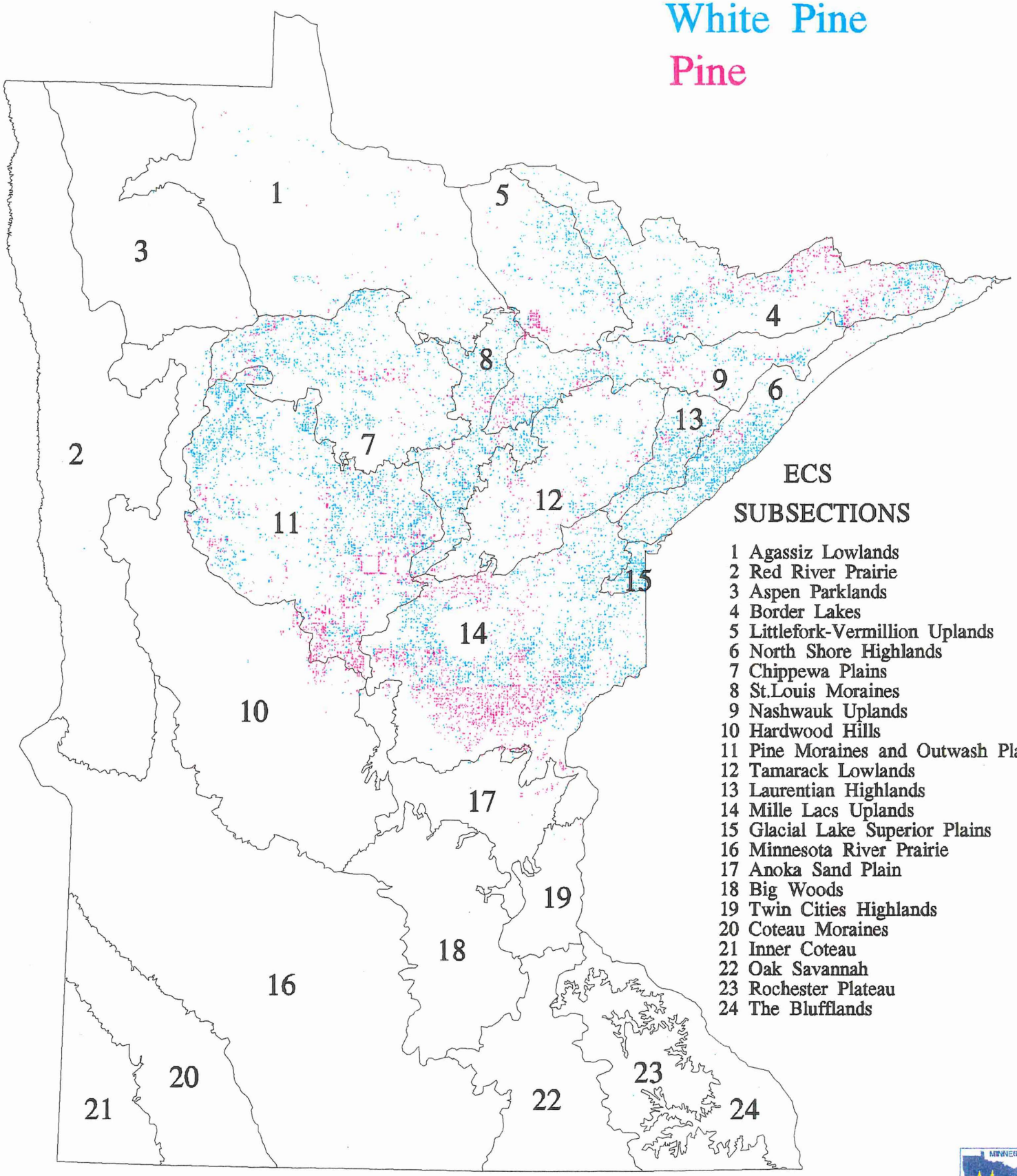
This table was prepared for the White Pine Restoration and Regeneration Strategies Work Group by members Lee Frelich, Klaus Puettmann, Kim Chapman and Craig Locey. A charge of this group is to document changes in the abundance of white pine in Minnesota, and to recommend ways to increase white pine. The relative change in white pine abundance is shown for ecological subsections, with an "obvious decrease" defined as from above 10% to below 3%. A map accompanies this table.

Ecoregion Subsections	1800's Public Land Survey		1990 Forest Inventory & Assessment	Notes
	% White Pine Bearing Trees	% Pine Bearing Trees	% White Pine > 5" dbh	
Glacial Lake Superior Plain (O)	24.1	0.4	2.8	Obvious Decrease
Laurentian Highlands (K)	13.4	1.1	2.1	Obvious Decrease
North Shore (L)	10.9	0.7	0.7	Obvious Decrease
Mille Lacs Uplands (N)	6.0	4.9	0.9	Obvious Decrease "White pine is 10.9% because "Pine" was likely "White Pine." Pine already cut in south?
St. Louis Moraines (G)	10.3	1.4	1.1	Obvious Decrease
Pine Moraines & Outwash Plains (I)	8.2	3.7	1.6	Decrease
Chippewa Plains (F)	6.6	1.3	1.4	Decrease
Nashwauk Uplands (H)	5.2	2.4	1.3	Decrease
Tamarack Lowlands (J)	3.2	1.4	0.6	Decrease
Littlefork-Vermilion Uplands (D)	3.3	1.3	1.4	Decrease
Border Lakes (E)	5.2	3.3	4.3	Decrease; the BWCA and Voyageurs are not included in FIA data, therefore, the decline may be less.

Ecoregion Subsections	1800's Public Land Survey		1990 Forest Inventory & Assessment	Notes
	% White Pine Bearing Trees	% Pine Bearing Trees	% White Pine > 5" dbh	
Agassiz Lowlands (C)	0.5	0.2	0.2	Decrease
Aspen Parklands (B)	0.1	0	0	Decrease
Hardwood Hills (M)	0.2	0.4	0.1	Decrease
St. Croix Moraines & Outwash Plains (Twin Cities Highlands) (S)	0	0.1	0.3	Increase? Pine already cut?
Blufflands (X)	0	0	0.4	Increase? Pine already cut?
Anoka Sand Plain (P)	0.2	0.9	0.8	Increase? Pine already cut?
Rochester Plateau (W)	0	0	0.7	Increase? Pine already cut?
Red River Prairie (A)	0.1	0	0.9	Increase
Minnesota River Prairie (Q)	0	0	0	Absent
Big Woods (R)	0	0	0	Absent
Inner Coteau (T)	0	0	0	Absent
Coteau Moraines (U)	0	0	0	Absent
Oak Savannah (V)	0	0	0	Absent

The most reliable information on the change of the abundance in white pine is found in the Public Land Survey (1850-1905) (PLS) and the U.S. Forest Service's "Forest Inventory and Assessment" (FIA) survey (1990). Despite minor biases and inconsistencies in these surveys, they provide an accurate snap-shot of white pine abundance historically and presently. Both methods provide a count of white pines relative to all other trees. There are roughly the same number of locations where white pine was counted in both the PLS and FIA studies.

Pre-Settlement PLS Bearing Tree Locations



ECS SUBSECTIONS

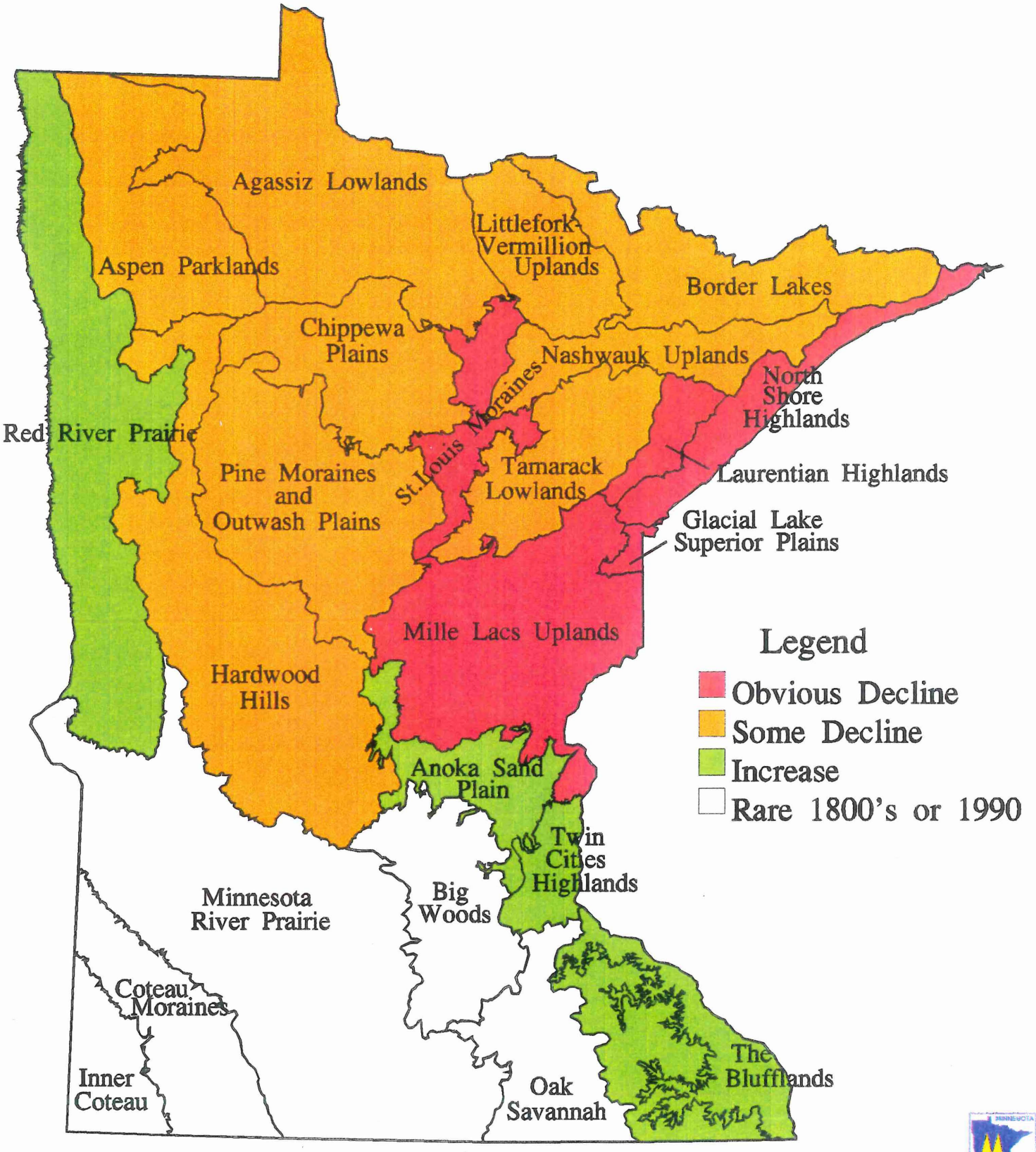
1 Agassiz Lowlands
2 Red River Prairie
3 Aspen Parklands
4 Border Lakes
5 Littlefork-Vermillion Uplands
6 North Shore Highlands
7 Chippewa Plains
8 St.Louis Moraines
9 Nashwauk Uplands
10 Hardwood Hills
11 Pine Moraines and Outwash Plains
12 Tamarack Lowlands
13 Laurentian Highlands
14 Mille Lacs Uplands
15 Glacial Lake Superior Plains
16 Minnesota River Prairie
17 Anoka Sand Plain
18 Big Woods
19 Twin Cities Highlands
20 Coteau Moraines
21 Inner Coteau
22 Oak Savannah
23 Rochester Plateau
24 The Blufflands

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

September 25, 1996

Changes in Abundance of White Pines in Minnesota

Comparing 1800's Public Land Survey to 1990 Forest Inventory Assessment



September 25, 1996

Occurrence of Minnesota's White Pine

Information from notes recorded during the Public Land Survey (PLS) of Minnesota (1850-1905) indicates that white pine, as a percent of all trees used as witness trees to the corners established by the surveyors, was a common occurrence. Using the 1990 Forest Inventory and Analysis (FIA) of Minnesota's timberlands, the current percent of white pine trees, relative to all trees sampled, is significantly less than the percent of white pine trees in the PLS. From Francis Marschner's 1930 map, *The Original Vegetation of Minnesota*, which is based on information from the PLS, the area of forest communities with white pine prior to European settlement was more than 4,000,000 acres. Much of this was not pure white pine, but found as a component of several forest communities.

Today, that acreage is much less. Determining just how much less white pine exists in Minnesota today is somewhat problematic. Public land management organizations and industrial forest landowners each have their own forest inventories. And most of the thousands of non-industrial private forest landowners have very little inventory information.

The most comprehensive inventory of Minnesota's forests is the U.S. Forest Service's periodic Forest Inventory and Analysis (FIA). There have been five FIA inventories conducted in Minnesota: 1936, 1953, 1962, 1977, and 1990. The most reliable and most comparable inventories are the ones conducted in 1977 and 1990 due to the tripling of sampled field plots compared to previous FIAs. Conducted by the U.S.D.A. Forest Service North Central Forest Experiment Station, the DNR has cooperated beginning with the 1977 FIA, so that Minnesota's forest inventories are conducted at triple the intensity of most states.

Data gathered by FIA are estimates of Minnesota's forests and their characteristics based on a statistically sound sampling procedure that relies on interpretation of aerial photography as well as on-the-ground field work. The reliability of estimates associated with large areas (e.g. the entire State of Minnesota) or for large cover types (e.g. aspen, with 5,055,000 acres in the 1990 FIA) are high because these estimates are based on a larger number of sample plots than a smaller area (e.g. a county) or smaller cover types.

FIA provides several views of the white pine resource in Minnesota: number of acres of white pine type; number of trees; and volume expressed as cubic feet of wood.

Acres of White Pine

The FIA publications have reported a significant decline in the number of acres of the white pine cover type in Minnesota since 1936.

Year	Acres of White Pine Type
1936	224,000[1]
1953	125,000[1]
1962	132,000[2]
1977	68,300[3]
1990	63,700[3]

[1]Table 14, Resource Bulletin NC-1, *A Third Look at Minnesota's Timber*, 1966
[2]Table 1, Resource Bulletin NC-53, *Minnesota Forest Statistics*, 1977
[3]Table 27, Resource Bulletin NC-158, *Minnesota Forest Statistics*, 1990 Revised

The 1977 and 1990 figures understate the actual amount of white pine acreage in Minnesota. In the 1977 inventory, 6,100 acres that were included in the 1962 FIA were reclassified as productive reserve forest due to expansion of wilderness areas. Since FIA inventories have not included productive reserve areas (such as the Boundary Waters Canoe Area Wilderness), the 6,100 acres were not included in the 1977 and 1990 FIA data. To provide more accurate information, future FIA inventories will include productive reserve areas..

While the area of white pine type from 1990 FIA is fairly accurate at the statewide level, its reliability by ownership category is not as great. Sampling errors increase as the number of sample plots decline upon which an estimate is based. For example, the 1990 FIA indicates that there are 5,700 acres of white pine type on state-administered lands. The DNR's own stand-based inventory, however, indicates that the white pine type on its timberlands was 11,769 acres at the time. Thus, the 1990 FIA should be viewed as a relative estimate of the current ownership of the white pine type as follows:

Ownership	Acres
National forests	15,300
Other federal	900
State	5,700
County and municipal	4,700
Indian	1,900
Forest industry	6,000
Individual	24,100
Corporate	5,100
Total	**63,700**

As another comparison, the Minnesota Forest Resources Partnership reported from a survey (See detailed discussion under section *Existing Efforts to Increase White Pine*) a total of 82,647 acres of white pine cover type. The difference between this figure and the FIA total can be explained by differing definitions of cover type and the fact that stand based inventories like the DNR's may provide a more accurate picture of smaller cover types due to more intensive sampling.

Since white pine is often an important component of other forest types, the number of acres of other forest types in which white pine occurs give a sense of its distribution across the landscape. The 1990 FIA indicates that there is 1,008,900 acres of timberland with at least one white pine per acre as shown in the following table, *"Total Acres by Type With White Pine Trees."*

Average stand age has increased from 73 to 80 from 1977 to 1990. Current white pine stand age distribution is illustrated in the following figure, *Area of Timberland in White Pine Type by Stand-Age Class, Minnesota 1990.*

Numbers of White Pine

Total numbers of white pine trees have declined within the last inventory period, from 32,257,000 in 1977, to 29,585,000 in 1990. However, except for trees in the 15-19 inch size classes, the size of those trees is on a trend upward as trees grow into larger size classes.

	Diameter class - inches at breast height (in thousand trees)											
	1.0-2.9	3,0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0 20.9	21.0-28.9	29.0+
1977	8,834	8,528	4,691	2,318	2,661	1,282	1,161	1,066	755	315	602	44
1990	9,066	5,273	4,629	2,904	2,206	1,615	1,200	753	579	494	747	119

TOTAL ACRES by TYPE with WHITE PINE TREES 8/22/96

For Minnesota Statewide, all Ownerships

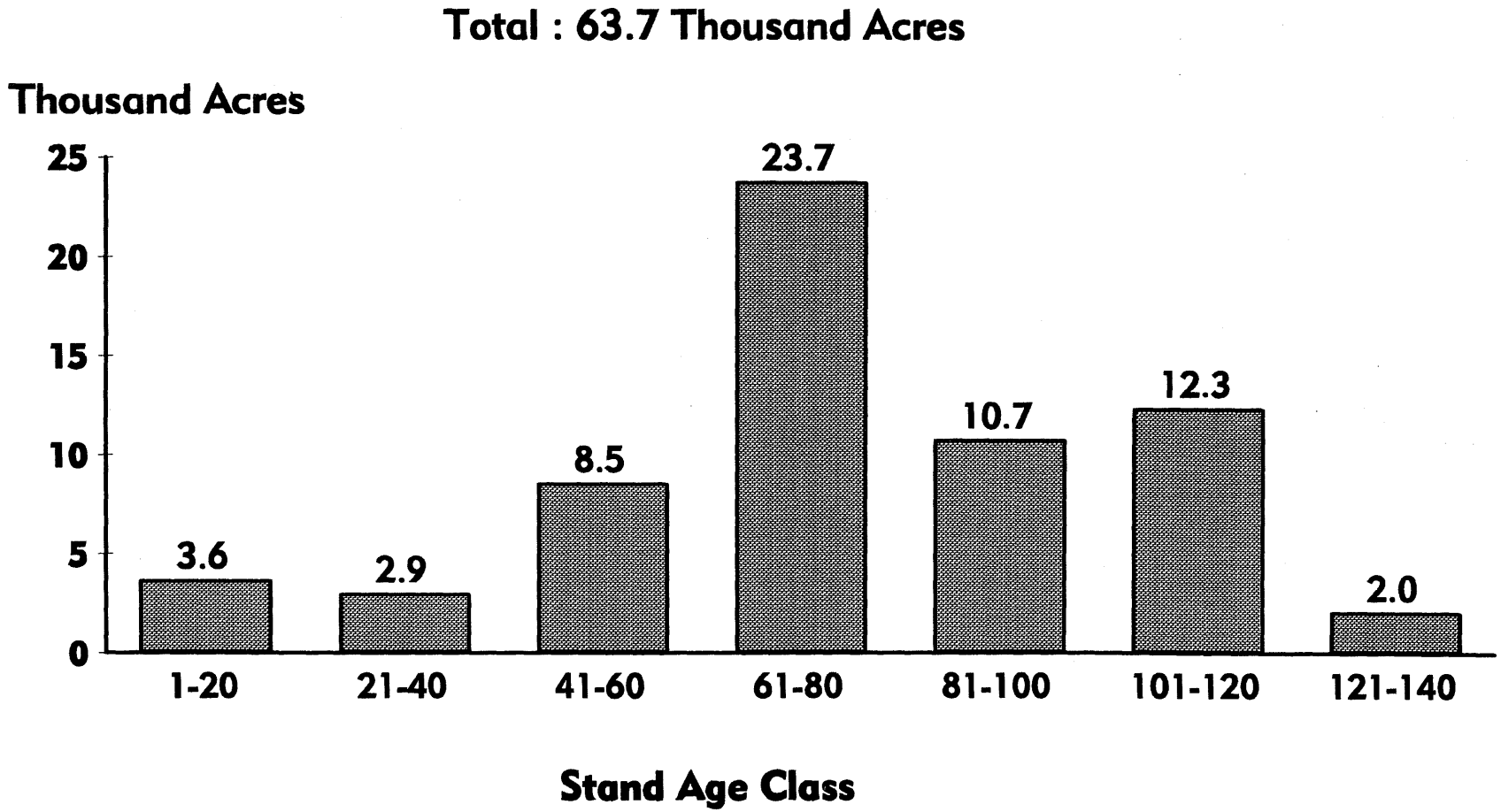
Based on 1990 FIA (Eastwide Database)

	Ownerships								Total
Cover Type	Forest Industry	Indian	Nat F.	Other Federal	Other Private	Private Indiv.	State	county	acres
Jack Pine	2100	1100	16000	1000	0	6000	6200	13600	46000
Red Pine	7300	10500	41100	3500	3800	12100	10900	16100	105300
White Pine	6000	1900	15300	900	9900	18800	5700	4700	63200
Scotch Pine	0	0	0	0	0	700	0	0	700
Balsam Fir	7600	1200	50600	1300	8600	9100	17700	13900	110000
Black Spruce	3600	0	13600	0	3300	5400	8500	7600	42000
White Cedar	1400	1100	6500	1100	0	4200	3800	7200	25300
Tamarack	0	0	0	0	7500	9300	5300	3600	25700
White Spruce	1500	0	5600	0	0	3900	1900	0	12900
Oak	0	1900	0	0	7600	13400	4100	3600	30600
Lowl.Hdwds	2500	0	1900	0	3900	8400	2300	3800	22800
North.Hdwds	4100	6500	22400	2100	23500	21000	14200	15900	109700
Aspen	12100	9700	63200	4000	35400	80000	44300	68800	317500
Birch	2300	2500	18700	1100	12600	20000	6600	28600	92400
Balsam Poplar	0	0	1400	0	1300	0	0	2100	4800
Total	50500	36400	256300	15000	117400	212300	131500	189500	1008900

Note: The white pine type : 63,200 acres consistent with USDA FS Resource Bull.NC-141, 1992.

Revised table #7 (USDA FS Resource Bull.NC-158, 1995) shows 63,700 acres of white pine type.

Area of Timberland in White Pine Type by Stand Age Class, Minnesota 1990 FIA



Source : Table #36 of MN Forest Statistics, 1990 (Revised). USDA FS Reso.Bull NC-158

Volume of White Pine

The net volume of white pine growing stock (trees 5.0 inches DBH and over, from one foot above the ground to a minimum 4.0 inch top diameter outside the bark of the central stem) has increased since 1962.

Year	Volume (million cubic feet)
1962	192
1977	208
1990	264

This information also suggests a trend toward larger trees. Average net annual growth between 1977 and 1990 from the 1990 FIA was 8,838 thousand cubic feet or 111,873 cords from all timberland ownerships. Average annual removals of growing stock in the same inventory period were 5,231 thousand cubic feet or 66,215 cords from all ownerships.

Today's Ownership of Pre-settlement White Pine Forests

While the 1990 FIA provides a good basis for assessing management of existing white pine, looking at the future opportunities for white pine management by ownership is another matter. The White Pine Regeneration Strategies Work Group compared the area of pre-European settlement forest communities with white pine from an adaptation of Marschner's map, *The Original Vegetation of Minnesota's Pre-settlement Pine Areas* to a map of the 1983 Minnesota Land Management Information Center's *Public Land Ownership Class*. The result is a map that displays the current ownership of these pre-settlement pine areas, *Pre-settlement Forest Communities with White Pine by Land Ownership with ECS Subsections*. Three zones[4] were identified in Minnesota, based on change in the relative abundance of white pine between the PLS and the 1990 FIA.

In the Obvious Decline Zone, generally the north shore of Lake Superior extending fairly well south through east central Minnesota, ownership of sites having pre-European settlement forest communities with white pine is now:

Ownership	%	Acres
Non-public (private)	63	1,041,481
County	19	308,907
State	12	205,627
Federal	6	101,299
Total	**100%**	**1,658,507**

In the Moderate Decline Zone, generally the rest of northern Minnesota, the ownership of these sites is now:

Ownership	%	Acres
Non-public (private)	39	953,860
County	18	432,377
State	14	301,665
Federal	17	416,877
BWCAW/Nat'l parks	14	339,839
Total	**100%**	**2,444,618**

In the Increase Zone, generally the sand plains just north of the Twin Cities and extending south along the Mississippi River counties, the ownership of the sites was not calculated because the information was considered too unreliable.

It should be noted that white pine still occurs on some of the acreage above. It is from that occurrence that much of the increase of white pine could be encouraged. Any monies that come about from a white pine initiative

should consider the management opportunities for white pine in proportion to the acreages above.

[4]The three zones were determined by comparing the percentage of white pine trees used as bearing trees in the Public Land Survey (PLS) of the late 1800s with the percentage of white pine trees in the 1990 Forest Inventory Analysis (FIA). Only trees greater than five inches diameter breast height were used in this analysis. The three zones are defined as follows:

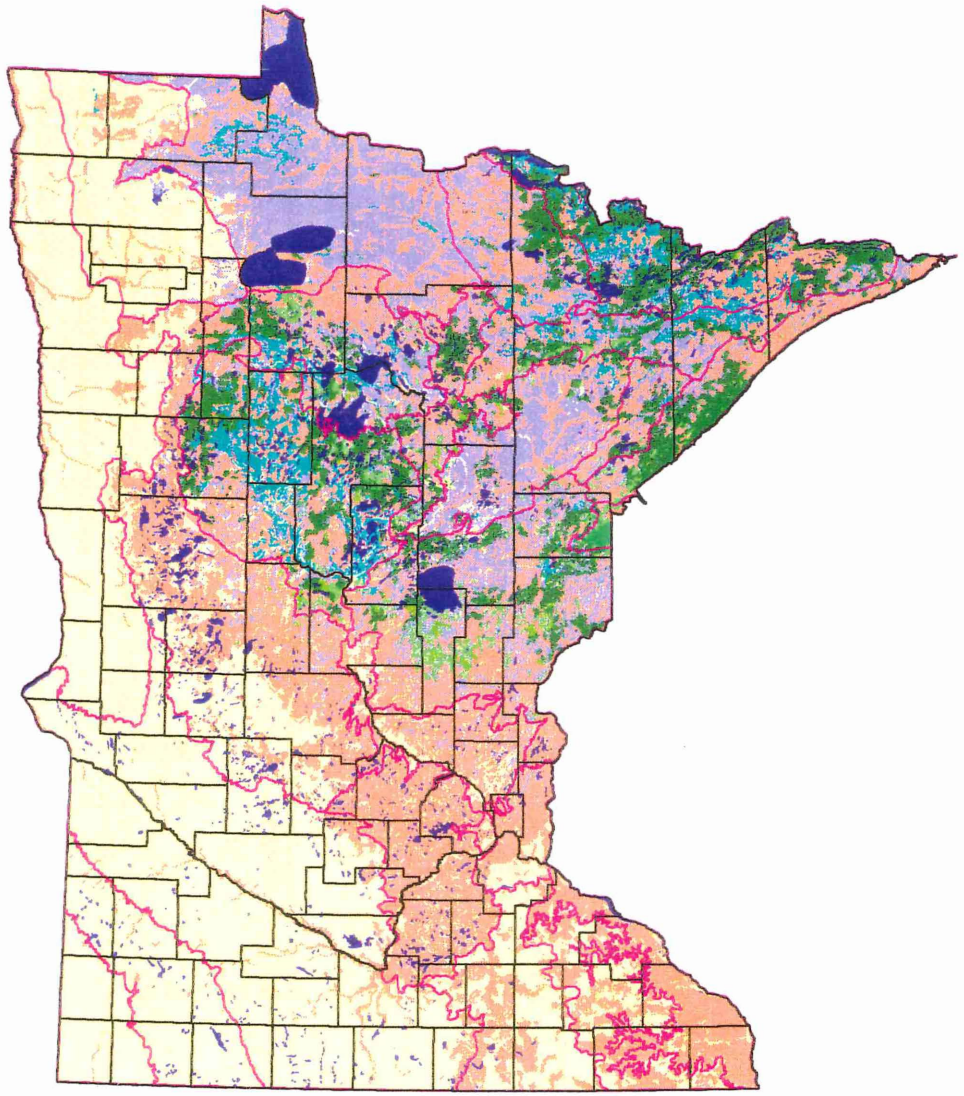
Obvious Decline Zone: More than 10 percent of bearing trees were white pine; less than 3 percent of FIA trees were white pine.

Moderate Decline Zone: Less than 10 percent of bearing trees were white pine; comparatively fewer white pine trees at the time of the FIA.

Increase Zone: Amount of white pine is greater in the 1990 FIA compared to the PLS. However, it is possible that most of the white pine was cut before the time of the PLS, so a true increase may be questionable.

The Original Vegetation of Minnesota

Pre-settlement Pine Areas



- Prairie
- Hardwoods
- Wetlands
- Mixed Hardwood & Pine
- White Pine
- Mixed Red and White Pine
- Jack Pine Barrens and Openings
- Pine Flats (TS/PI/AB/PNw,POt)
- Lakes

Scale: 0 — 50 mi — 100 mi

Source: MN-DNR adapation from USFS Marshner Map (1974).

Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Ecosystem Health Unit

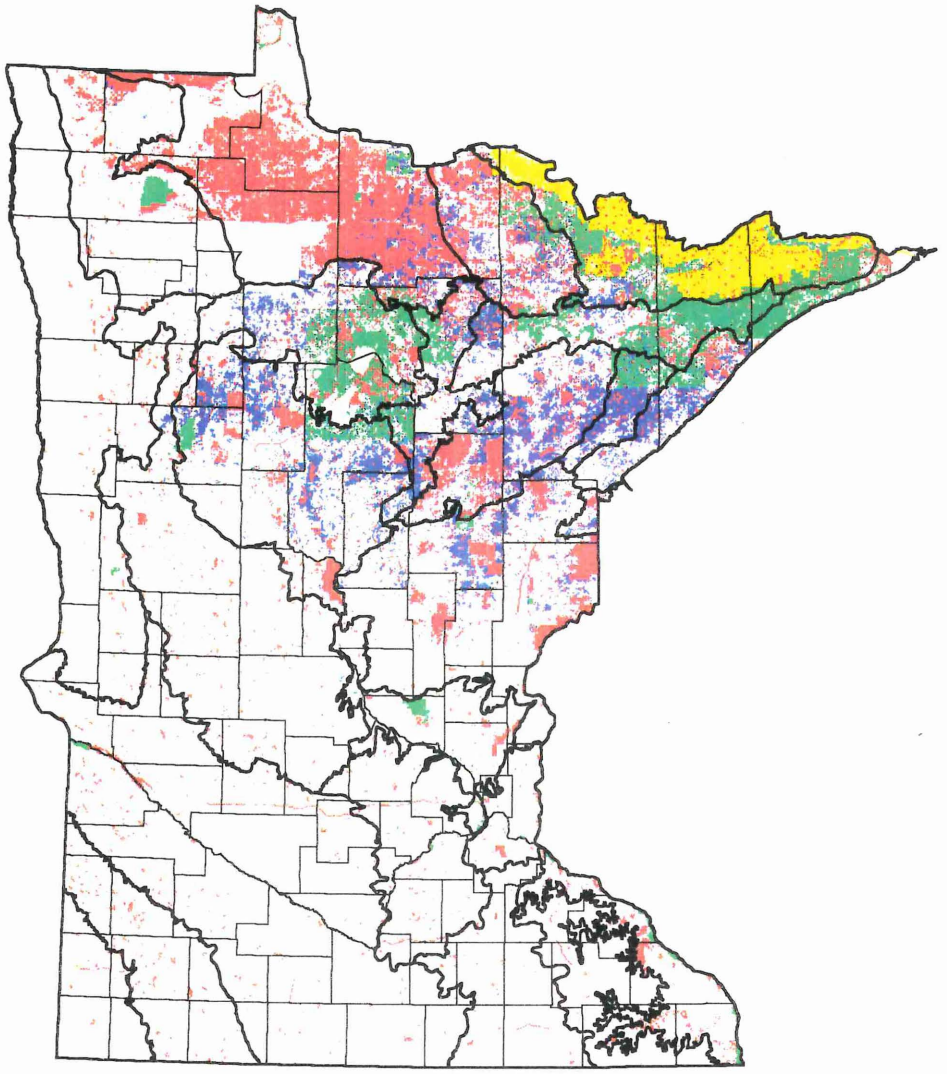
12/4/1996

ECO, ECS, Subsections, 1995

Minnesota
DEPARTMENT OF NATURAL RESOURCES

Public Land Ownership Class

1983



- Non-public Lands
- State of Minnesota
- Minnesota Counties
- Federal
- Federal (BWCA + NPS)

Scale: 0 — 50 mi — 100 mi

Source: Data compiled by LMIC.
Classification model Minnesota DNR - Forestry.
Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Ecosystem Health Unit

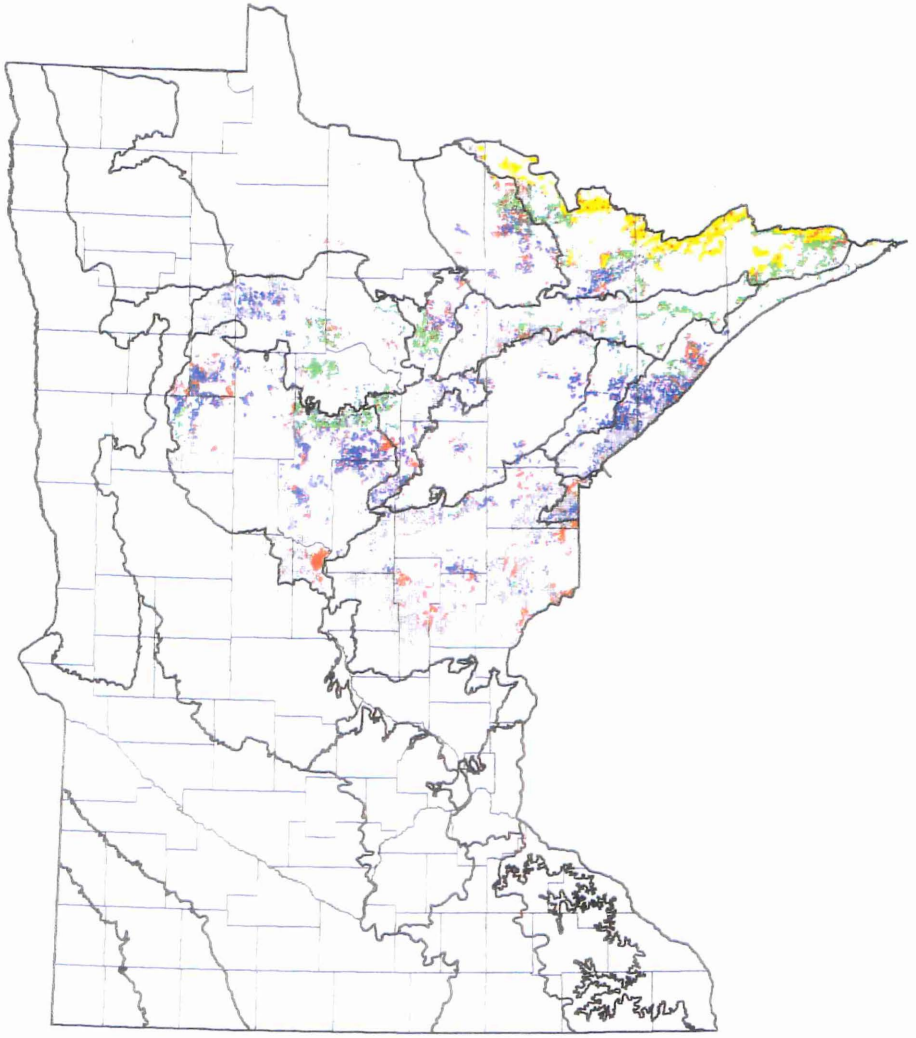
11/4/1996

ECO, ECS, Subsections, 1995

Minnesota Department of Natural Resources

Pre-settlement Forest Communities With White Pine

By Land Ownership With ECS Subsections



- Non-white pine Land
- Non-public Lands
- State of Minnesota
- Minnesota Counties
- Federal
- Federal (BWCA & NPS)

Scale:
0 50 mi 100 mi

DNR Model from Marshner (1974) Vegetation Map includes mixed hdw/pine, w. pine, pine flats, and mixed red/white pine.
Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Ecosystem Health Unit

11/15/1996

ECO, ECS, Subsections, 1995

Minnesota
DEPARTMENT OF NATURAL RESOURCES

Existing Efforts to Increase White Pine

- Minnesota Forest Resource Partnership Survey -

The Minnesota Forest Resource Partnership (MFRP) is a consortium of forest landowners, forest land managers, and practitioners. The MFRP has its basis in state law—the Minnesota Sustainable Forest Resources Act. Its purpose is to serve as a forum for discussing operational issues and problem-solving related to forest resource management and planning concerns. Representation on the Partnership comes from private forest landowners, county land management departments, forest industry, U.S. Forest Service, Department of Natural Resources (DNR), and timber harvesters.

In 1996, the MFRP conducted a survey of the status of white pine and white pine regeneration efforts. The survey included responses from two federal forests, the Minnesota DNR, 14 Minnesota counties, and Minnesota forest industries. (See **Appendix F**: *Minnesota Forest Resource Partnership White Pine Survey.*)

Respondents reported that they manage 52,000 acres where white pine is the dominant cover type. Additionally, there are 28,700 acres of non-industrial private forest lands, and 1,900 acres of Indian tribal lands of white pine cover type according to the 1990 Minnesota Forest Inventory and Analysis (FIA), making a total of more than 82,000 acres of white pine cover type in Minnesota today. FIA data show that white pine is significantly present on 491,000 acres. Overall, there are 1,008,900 acres of timber land in Minnesota with at least one white pine per acre.

All respondents indicated their interest in white pine, its importance in the forest, and its ecological and economic roles. All felt that the white pine resource should be increased.

All respondents indicated that regeneration efforts are needed to increase white pine, but feel challenged by the difficulty in regenerating the species. However, the majority of respondents are attempting to "do something;" a few are experimenting with trying to develop natural regeneration by scarifying sites in and around existing seed trees. Most respondents are working at developing programs for planting seedlings, mainly in the understory of shelterwoods.

Although there continues to be concern about blister rust and tip weevil, many respondents mentioned the greater difficulty of protecting seedlings from deer browse and from being "choked out" by competitive shrubs (e.g. Rubus spp., and forbs).

In summary, efforts can be described as "cautious" but "serious." It would appear that increasing the presence of white pine is now more than just a "good idea;" many landowners and managers have committed to initiatives to prove what will work and what won't work. The result will certainly be an increase in focus on this species and ultimately more white pine through regeneration efforts.

White Pine Survey - Minnesota Forest Resources Partnership

8/96

White Pine Cover Type Acres

Source	Age Class (years) 100+	50-99	20-49	0-19	Total acres	Planting Program: M trees per year	acres per year
Chippewa N.F.	1,723	2,486	124	1,017	5,350	80	112
Superior N.F.	7,957	9,539	314	5,494	23,304	300	600
DNR	5,106	4,913	1,437	2,441	13,897	346	367
Aitkin County	135				135		
Becker					0		
Beltrami	62	241	14	52	369		
Carlton	88				88		
Cass	80	106	58	40	284		
Clearwater	30	628	11	4	673		
Cook					0		
Crow Wing	19				19	0.6	1
Hubbard	8	29	15	2	54		
Itasca	40	114	7	24	185	15	20
Koochiching	159				159		
Lake	55	55	66		176	5.5	80
Pine					0		
St. Louis	285	4,251	151	49	4,736	20	25
Bandin	43				43		
Rajala	1,275		210	1,090	2,575	200	200
Subtotal	17,065	22,362	2,407	10,213	52,047	967	1,405
Plus from 1990 MN FIA :							
Farmer & NIPF					28,700		
Indian					1,900		
				Total :	82,647 acres		

Part III
Ecology, Genetics, Pest Concerns, and Silviculture

The following discussion provides a summary of what is currently known about the ecology of eastern white pine, including detailed discussion about white pine's major pest problems in Minnesota: white pine weevil, blister rust and white-tailed deer. Silvicultural recommendations are provided at the end of this chapter. It should be noted that substantial research on white pine continues. A brief summary of research efforts in Minnesota is contained in **Appendix E:** *Ongoing research.*

The material in this section is based on research findings reported in a number of scientific publications. In order to make this material easily readable, citations were intentionally kept to a minimum. If supporting documentation is needed for any of this material, please contact one of co-chairs of the White Pine Regeneration Strategies Work Group.

A summary of the most important points include:

• White pine grows on many different soils in Minnesota. It can be found as a minor component growing with other tree species, as a co-dominant in some stands, or in some locations as pure white pine stands.

• White pine is a species that is benefited by disturbance. Historically, fire played a major role in creating suitable seedbeds. Today, scarification can also be used where the seedbed conditions are in need of disturbance.

• White pine seedlings cannot compete with excessive growth of brush in the understory. Historically, frequent low intensity fires probably limited brush on many sites. Today, prescribed fire can still be used for this purpose as can other methods of vegetation control.

• Young white pine can survive and grow moderately well in some shade. But dense shade will eventually kill seedlings and young trees.

• The optimal conditions for natural white pine regeneration are:

- a seedbed of moist mineral soil with little or no duff cover
- relative freedom from competition by shrubs and understory trees
- a live overhead seed source
- considerable opening in the overhead canopy

• For production of viable seed, it is necessary to have adequate numbers of scattered trees and clumps that are in close enough association to ensure good cross pollination. Further, these trees should not be closely related so as to avoid inbreeding.

• Planting seedlings is an option for white pine regeneration.

• If white pine can survive and become a member of the forest canopy, they can grow to a large size and an old age.

• Much of the genetics work associated with white pine has been tied to finding resistance to blister rust and relatively little effort has been expended on understanding the basic population genetics of the species.

• White pine seedlings grow slowly during the first five years of their life. Selecting seedlings for fast growth rates has not been done and could prove beneficial. Fast growing seedlings may be able to compensate somewhat for the loss of growth normally associated with partial shade. Also, they would be likely to grow beyond deer browse and blister rust problems sooner.

• Blister rust can kill trees. It is most lethal on young trees. In many areas, especially in northern Minnesota, blis-

ter rust must be considered in how stands are managed. However, it is important to point out that blister rust does not preclude the growing of white pine anywhere in the state. Cool, moist conditions in the late summer and fall are very conducive to blister rust. Therefore, blister rust incidence will be more prevalent wherever these conditions predominate. In Minnesota this includes much of the northern 1/3 of the state, especially areas along Lake Superior and other major lakes.

• Management practices that can significantly reduce the incidence of blister rust are available. One should not rely solely on planting stock that claims blister rust resistance. Currently, there is no evidence that indicates that significant blister rust resistance has been developed in eastern white pine.

• The white pine weevil is a small beetle that is native to North America where it has developed a reputation as the most important insect pest of white pine. This insect is not a tree killer, rather it deforms white pine by killing the leader (very top) of young pines. Management practices that will reduce the impact of white pine weevil do exist; therefore, the presence of this insect does not have to be a serious impediment to growing high quality white pine.

• Deer can become a serious problem for seedlings and sapling sized trees because they often feed on the buds of small trees, inhibiting growth and, if repeatedly fed on, death. A productive approach may be to regenerate white pine on areas not used by deer as winter range. An alternative may be to overwhelm deer by regenerating white pine in such large numbers or over a large enough area that the proportion of stems browsed becomes minor. More direct approaches to browse prevention have been developed and are successful. One approach involves the use of "bud caps" (paper caps stapled around the terminal bud of the seedling).

The Ecology of White Pine

Detailed information on the text presented in this section can be found in *Pine Forests in Itasca State Park*, by John R. Tester and Mary Jo Kenyon. Additional information for this section was taken from the articles, *Ecological characteristics of white pine*, by Forest Stearns and *The relationship of natural disturbances to white pine stand development*, by Lee Frelich, at the 1992 White Pine Symposium in Duluth.

Soil Properties

One of the reasons white pine was a common species in northern Minnesota is that it grows well under a wide range of soil and moisture conditions. Though in most cases it is most successful on well drained sandy or sandy loam soils, it does very well on finer textured soils such as silt loams. However, on these finer textured soils, competition from hardwood species can prevent its establishment and limit its early growth. White pine rarely occurs on very dry, nutrient poor soils and it does not do well on heavy clay soils or poorly drained bottom lands.

White pine can readily use moderate to high levels of soil nutrients, but low levels do not seem to severely limit its growth. The best and most rapid growth potential for white pine is on sites relatively rich in nutrients, though again, competition with hardwood trees can be intense on these sites.

Topography

Prior to the 1850s, the best developed white pine stands in northern Minnesota occurred on moist sites along lake margins and lower slopes. These sites were excellent for white pine growth. In addition, these areas had a history of less intense fires than drier, upland forests. The fire cycle and intensity were very important in determining where and how much white pine occurred on the Minnesota landscape (see **Fire History**).

Today, the role of topography has undoubtedly changed due to fire suppression and because of the introduction of blister rust. Fire suppression has allowed white pine to encroach on the drier, more fire prone forests historically dominated by jack pine. At the same time, fire suppression has reduced white pine's ability to compete on the moister sites since hardwoods, which would be killed by frequent low intensity fires, compete heavily with young white pine. Blister rust, introduced into Minnesota during this century, is often most intense along lakes and on lower slopes and therefore, white pine has a more difficult time surviving and thriving in these areas.

Fire History

The natural disturbance regime that perpetuated white pine forests at various levels for thousands of years in Minnesota, consisted of severe crown fires at 150-300 year intervals, with occasional surface fires in the intervening years. White pine are killed by crown fires, but individual trees survived in refuges along lakes or on rock outcrops to provide a seed source for new white pine trees. The occasional surface fires were not hot enough to kill larger white pine but did kill the more susceptible hardwoods and conifers such as balsam fir. The hardwoods and fir would have out competed young white pine in most cases if they had not been controlled by the frequent low intensity fires. Fires also served another purpose, preparing a good seed bed for white pine. While it does not require disturbances for successful regeneration, white pine should definitely be considered a species that is benefited by disturbance.

Tolerance to Shade and the Ability to Compete

White pine is usually classed as intermediate in shade tolerance. This means that it can survive and grow moderately well in some shade. But, dense shade will eventually kill seedlings and young trees. The tolerance to partial shade enables white pine to become established under existing forest canopies that are not extremely dense. Aspen and paper birch canopies, for example, allow sufficient light for young white pine survival. Young seedlings develop and survive in as little as 20 percent full sunlight. However, after establishment, the seedlings become less shade tolerant and more light is required for adequate growth to occur. Maximum height growth will occur in as little as 45 percent full sunlight, but maximum wood production requires full sunlight. Because of the changing light requirements of white pine as it ages, competition from other vegetation can become a serious problem, especially for older regeneration (trees 5-15 years old).

Associated Cover Types

Prior to European settlement in Minnesota, white pine was most commonly found as a mixed component growing with other tree species across the landscape of northern Minnesota. Another common way it was found growing was as a co-dominant with red pine. Few stands were heavily dominated by white pine alone. The species was mixed with red pine in most stands, but was also mixed with white cedar along the North Shore, with northern hardwoods, with birch and aspen, with oak , and with jack pine and the boreal conifers such as balsam fir and white spruce.

Seedbed Requirements and Site Preparation

Seedbed conditions necessary for germination and early survival of white pine differ depending upon whether the seedbed is partially shaded or under full sun. Some shade is needed to successfully establish seedlings on drier, sandy sites, but not on wetter, clay-sand sites. Moist mineral soil, polytichum moss, rotten wood and moderately burned ground surfaces provide a good seedbed for white pine. Thick humus or needle layers are not good seedbeds.

Because white pine seedlings can germinate and survive on both disturbed and undisturbed litter layers, disturbance is not always necessary for seedbed preparation. However, in many cases some type of disturbance is very beneficial. Historically, fire played a major role in creating suitable seedbeds. Today, in addition to fire, scarification can be used on sites where the seedbed conditions are in need of disturbance.

White pine seedlings cannot compete with excessive brush in the understory. Historically, frequent low intensity fires probably limited brush on many sites. Today, prescribed fire can still be used for this purpose as can other methods of vegetation control.

Seed Production and Dispersal

White pine seed production is irregular and infrequent. Good cone crops occur every 3 to 5 years. This irregularity, coupled with the low viability of seed stored in the soil can compromise natural regeneration. If seedbed preparation does not coincide with a good seed year, successful regeneration is unlikely. Most seed is dispersed within the month following cone maturity, which occurs in August and September. Seed is dispersed as far as 200 feet within a white pine stand and more than 700 feet in the open.

Seed production usually begins when white pines are 20 to 30 years-old. Widely spaced dominant trees with full crowns produce the most seeds per cone. Furthermore, intermediate density stands produce far more viable seeds per acre in a good seed year than high or low density stands. However, individual white pine trees that are separated by 200 ft or more will produce almost no viable seeds because of inadequate pollination. Clumps of isolated white pine may produce seed with high levels of inbreeding. Therefore, for production of viable seed, it is necessary to have adequate numbers of scattered trees and clumps which are in close enough association to ensure good cross pollination. Further, these trees should not be closely related to avoid inbreeding.

White pine does have two insect species, the white pine cone beetle and the white pine cone borer, that feed on developing cones. In some years, these insects can kill the entire cone crop and cause regeneration failures.

Germination and Early Growth

To germinate, white pine seed normally requires stratification for about 60 days at a low temperature. Since seed fall occurs in late August and September, germination often does not occur until the following spring. Direct seeding of white pine is often done in the early spring with seed that has already been stratified. By seeding in the spring versus the fall, loss of seeds to rodents and birds is less likely.

White pine seedlings less than 30-days-old are susceptible to serious heat injury or death on exposed sandy soils because the soil surface can reach and maintain lethal temperatures for prolonged periods of time. The presence of abundant surface soil moisture has a large influence on soil surface temperatures on sandy soils. So, by selecting sites with soils that have a high water-retaining capacity or sites with a shallow water table (within four feet of the surface), lethal temperatures can be avoided and the success of seeding can be enhanced. However, damping-off (a fungal diseases that kills new seedlings) is a frequent cause of mortality on sites with high humidity. Seeding in autumn or early spring or giving special pre-treatment to stimulate early germination will also help

to reduce the threat of heat injury to young seedlings.

Seeding can be enhanced by the silvicultural method of shelterwood cutting. This method, when used properly, ensures that an adequate source of seed and partial shade are available during the initial stages of establishment and provides full sunlight later when it is needed for seedling growth and survival.

Deer can become a serious problem for seedlings and sapling sized trees because they often feed on the twigs and remove or damage the buds on small trees. Deer are discussed in more detail later in this report. Blister rust, which is also discussed in more detail, can also kill young trees.

Planting Seedlings

Planting seedlings is an option for white pine regeneration if no natural seed source is available. White pine is sufficiently tolerant of the understory environment to be well-suited to underplanting and shelterwood management (see the discussion on silviculture).

It is recommended that underplanting should not be attempted in young and vigorous hardwood stands unless a program for controlling competing vegetation is planned. The Rajala Lumber Company of Deer River has very high success in planting white pine seedlings under a thinned overstory. In many cases, hand or chemical release from competing understory vegetation becomes necessary.

Long-term Growth and Survival

White pine grows slowly in the seedling stage and is susceptible at this time to being out competed by other tree species, shrubs and herbs. Open-grown white pine trees are about 5 inches high when 3 years-old; 12 inches high when 5 years-old; and 4.5 feet high after 8 to 10 years. However, if the tree survives to the sapling stage, its ability to compete is greatly improved because its annual growth rate increases considerably. Between 10-20 years, the average annual height growth is 16 inches and between 20-30 years it is 20 inches.

If white pine can survive and become a member of the forest canopy it can grow to a large size and an old age. Commonly, individual white pine can survive to about 200 years of age, though this varies by the quality of the site it is growing on. The maximum age can exceed 450 years, but this is unusual. Blister rust has become one agent that can reduce the lifespan of many older trees. Though infections in the upper parts of these old trees may not kill the entire tree quickly, it can begin a gradual decline process that often starts with the death of the top of the tree.

The Genetics of White Pine

General

Information on eastern white pine genetics dates back over 50 years, but relatively little is known compared to other major conifers. Much of the genetics work has been tied to finding resistance to blister rust and relatively little effort has been expended on understanding the basic population genetics of the species.

Range-wide provenance tests that were conducted showed that slightly southern seed sources grow better at most locations. However, plantings in the northern Lake State should still use sources from cool climates (mean January temperatures less than 7 degrees Celsius, which includes all of Minnesota).

A significant amount of genetic variation exists within stands relative to variation among stands. Some work has been done on interspecific crosses. Overall, hybrids have never been tested on a large scale. Several researchers have advocated the use of interspecific hybridization (crossing eastern white pine with another white pine species such as western white pine) in an effort to develop genetic resistance to blister rust in eastern white pine. However, there appears to be little support in Minnesota to follow this approach.

Silvicultural Systems

Management activities must address three interrelated genetic principles: a) Practice positive silvicultural selection and discourage all types of high-grading because of the negative effects on gene pools; b) Minimize inbreeding by retaining sufficient numbers of healthy, vigorous parent trees for abundant pollen and ovule production, at sufficient densities to ensure abundant cross fertilization; c) Maintain genetic diversity, which is required for continued adaptation and evolution in constantly changing environmental conditions.

Increasing Growth Rates

As mentioned earlier, little work has been done on selecting white pine for fast juvenile growth rates. Fast growing seedlings would have several advantages. First, in an understory situation they may be able to compensate somewhat for the loss of growth normally associated with partial shade. Second, they would be likely to grow beyond deer browse and blister rust problems sooner. The selection for height growth would need to be done on a family basis rather than an individual tree basis and if clonal methods were employed, greater gains should be possible.

Resistance to Blister Rust

A great deal of work has been conducted on finding and developing rust resistant eastern white pine trees. However, to date there is no truly rust resistant planting stock for Minnesota. The following statements summarize what is known about blister rust resistance in eastern white pine:

- Complete immunity to the rust does not exist.
- Provenance resistance of eastern white pine does not exist.
- There is no major gene for resistance.
- Family selection is effective for improving rust resistance while picking uninfected trees in the wild is not.
- Resistance to blister rust of an individual tree increases with age.
- Resistance to blister rust is polygenic (controlled by multiple genes), and several generations of breeding would be necessary to fix resistance at a practical level. Polygenic resistance normally does not give complete protection (immunity), but the resistance is more permanent from generation to generation and should be more difficult to overcome by new races of blister rust.

Resistance to White Pine Weevil

Much less work has been done on genetic resistance to white pine weevil than on blister rust resistance. Direct selection of trees and races resistant to weevil has so far been unsuccessful. Management practices described in the following section on white pine weevil provide a much more efficient method of controlling the impacts of this insect than would searching for genetic resistance.

Clonal Propagation

Young eastern white pine are relatively easy to clone using vegetative propagation, either rooting or grafting. Rooting ability of trees stays about the same up to about 10 years of age, but drops off rapidly after that. The success rate for rooting individual trees ranges from 0-100 percent. This is genetically controlled so that some trees are very easy to root while others are very difficult.

Research Needs

Far better information is needed about genetic variability of the white pine species. In addition, what benefits could be gained by developing young trees with rapid growth rates needs to be investigated. It seems likely that faster growing trees could be more useful in some situations than trees resistant to blister rust. Fast growth also would be much easier to obtain through a selection and breeding program than would rust resistance. However, work on developing genetic resistance to blister rust should continue. Research needs to concentrate on breeding and selection through several generations to fix resistance at an acceptable level.

White Pine Blister Rust

White pine blister rust is caused by the fungus *Cronartium ribicola,* which was introduced into Minnesota around 1916 in the Taylor Falls area. By 1930, rust infections on white pine were evident throughout much of east central Minnesota. The fungus apparently originated in Asia but was introduced into North America via Europe around the turn of the century.

Disease Cycle: The life cycle of this fungus is rather complicated to complete since it requires two different host plants. One host is white pine, the other is a small shrubby plant called gooseberry (other names include currant and Ribes). During the summer months the fungus can be found growing on infected gooseberry leaves. By late summer and fall the fungus growing on the gooseberry leaves begins to produce spores that can infect white pine. These spores are moved by wind currents. To successfully infect a white pine tree, a viable spore must land on a white pine needle. Spores floating in the wind are quite easily killed by sunlight, heat or lack of moisture. Further, once on a needle, conditions must be conducive to the spores survival for a period long enough for infection to occur.

Successful infection requires that moisture be present on needles for about 48 hours and that the temperature be less than 68 degrees during that time. If everything is in place, infection takes place and the fungus grows slowly through the needle and over a period of years, into the branch and down the branch to the main stem. Once in the main stem, the fungus eventually girdles the tree, killing the portion of the tree above the girdle. The entire process can take a number of years to occur since the fungus grows slowly, about 1 inch each year. It is important to note that after infection occurs, a recognizable blister rust canker may not develop for 3 to 5 years.

Another spore stage is produced by the fungus growing on white pine in the early spring. This spore stage cannot reinfect other pine. Rather, it infects the leaves of gooseberry plants. This completes the cycle.

Understanding the disease cycle for blister rust provides some management insights. These include:
• Cool, moist conditions in the late summer and fall are very conducive to blister rust. Therefore, blister rust incidence will be more prevalent wherever these conditions predominate. In Minnesota this includes much of the northern 1/3 of the state, especially areas along Lake Superior. Further, local spots that collect cool air and moisture will also encourage blister rust. This includes bases of slopes and small openings in forest canopies.

• Based on climactic and elevation information and how they influence the incidence of blister rust, a hazard zone map was developed for Minnesota (see following page *White Pine Blister Rust Hazard Zones Overlaid with ECS Subsections*). This map breaks the state into four zones:

Zone 1: Low incidence on most sites. White pine blister rust can be largely ignored.

Zone 2: Moderate incidence, spores can spread 50-75 feet. In most cases, blister rust will not be a problem though losses to blister rust can occur in localized areas that are conducive to rust, such as at the bases of slopes, in small valleys and in small forest openings.

Zone 3: High incidence, spores can spread 600-900 feet. Blister rust can be quite prevalent, especially at the bases of slopes, in small valleys and in small forest openings.

Zone 4: Very High incidence, spores may spread up to five miles. It is important that every management precaution be taken in these areas. It is important to point out that being classed as zone 4 DOES NOT preclude the growing of white pine. It simply means that blister rust will be present and must be considered in how stands are managed in an area.

• Infection of pine can only occur through needles. Further, research has found that the vast majority (90+ %) of rust infections occur in the lower parts of trees. The reason for this is that moisture and temperature conditions are more conducive for infection near the ground. Therefore, pruning to remove needle bearing branches in the lower portions of young trees has been shown to reduce the incidence of blister rust by as much as one-third that of unpruned trees.

• The spore stage produced on gooseberry plants is required to get new infections on white pine. Spores from one infected white pine cannot directly infect another white pine. Therefore, as a general rule, the more abundant gooseberry is and the closer it occurs to white pine, the more likely is infection of the pine. However, in high hazard zones, conditions are so conducive to survival of the spores that gooseberry plants can be long distances (as far as five miles) from any white pine and still result in infections.

• The idea that gooseberry must be closely associated with white pine led to a large program in the 1950's and early 60's based on eradicating gooseberry plants in white pine areas. The program was abandoned by most states and deemed by many a failure. However, recent studies conducted in Maine indicate that local eradication of gooseberry plants may be beneficial in the more moderate hazard zones where the spores cannot move long distances.

Impact

Trees less than 25 feet tall are commonly killed by blister rust infections. Taller trees however, may only have individual branches or their top portions killed. If the top of a large pine dies, the tree itself can remain alive for many years. Top-killed white pine are a common sight in northern Minnesota.

A number of different surveys for blister rust have been conducted in Minnesota since the introduction of blister rust. The results from these surveys vary widely, from 5 % of trees infected in one study to 82 % in another study. This variability is not unusual and is one reason why blister rust can be difficult to plan and manage for. Big differences in the incidence of blister rust can occur based on where trees are growing, the age of the white pine, and the weather conditions that have prevailed in the area during the past few years.

Management Suggestions

1) Site selection is very important, especially as you move into zones 3 and 4. In zones 2, 3 and 4, avoid the base of slopes, the base of V-shaped valleys and small openings in the forest canopy.

2) Understory planting can reduce infection to 1/9th of that found in open fields. The presence of an overstory reduces dew formation on the needles of young pines and thereby reduces the levels of infection. A high canopy of species such as birch or aspen is highly preferred. In zones 3 and 4, planting under existing forest canopies is highly recommended.

2) The local removal of gooseberry plants can be effective, especially in zones 2 and 3. However, the removal of gooseberry plants from an area can be difficult to accomplish. In hazard zone 4, spores can move such long distances that removal of gooseberries may not reduce the local abundance of spores.

3) Pruning of young trees has been shown to reduce infection rates by 1/3. Pruning should be started at an early age. In addition, early removal of infected branches can be effective if the branch is removed before the fungus has grown to within 4 inches of the main stem.

4) In zones 3 and 4, some mortality from blister rust will occur. Therefore, the number of white pine planted in any given area should be significantly greater than in zones 1 and 2.

5) Do not solely rely on planting stock that claims blister rust resistance. Currently, there is no evidence that indicates that significant blister rust resistance has been developed in eastern white pine.

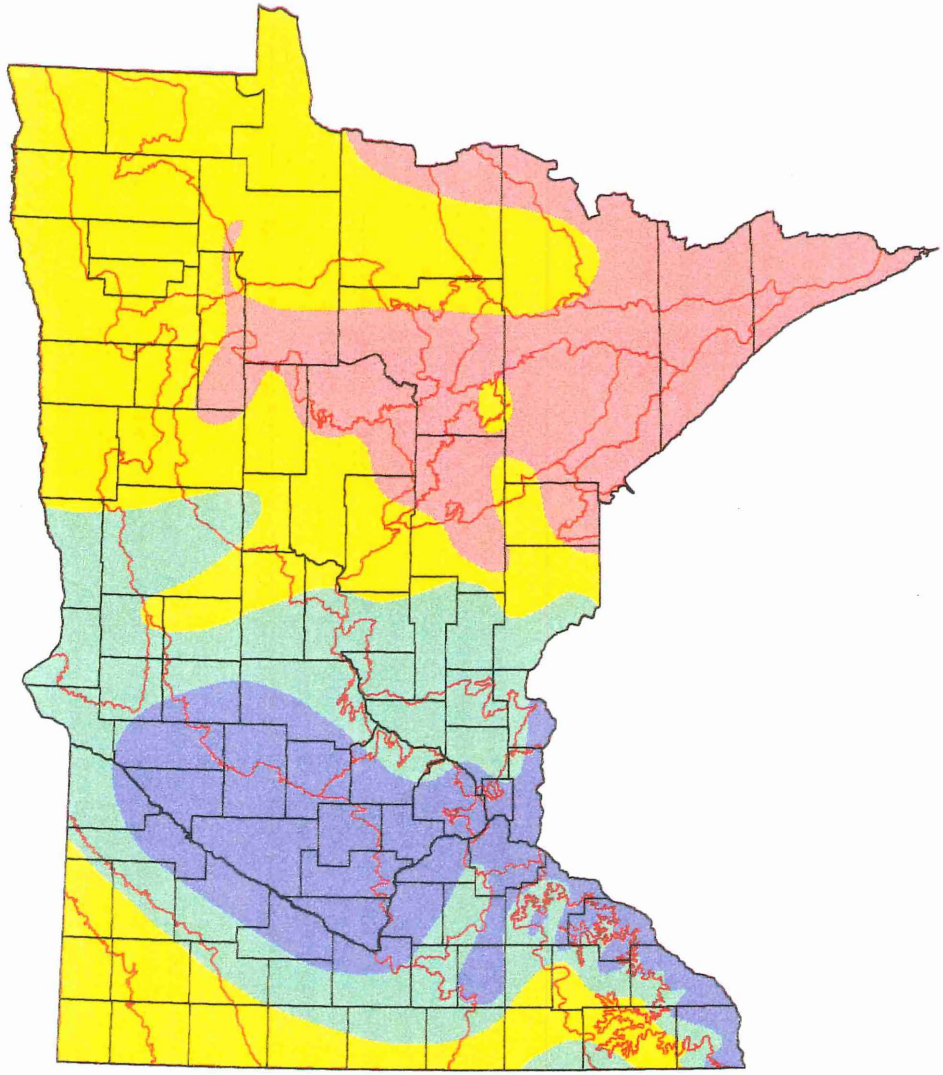
Research Needs

A more refined hazard zone map would be very beneficial in targeting where significant blister rust problems are more likely to occur. The original map was developed using a limited number of weather stations. Additional information is available that could result in a more refined map.

In addition to the development of a new hazard zone map, a greater understanding of the site specific characteristics that indicate where blister rust will be at higher or lower intensity is needed. This would probably be based upon landscape and stand characteristics.

Management practices targeted at reducing the impacts from blister rust need to be further investigated under conditions present in Minnesota. This is especially true in the highest hazard zones in northern Minnesota.

White Pine Blister Rust Hazard Zones
Overlaid With ECS Subsections



- Low Hazard (1)
- Moderate Hazard (2)
- High Hazard (3)
- Very High Hazard (4)

Scale: 0 — 50 mi — 100 mi

Source: WPBR Zones, Van Arsdel, USDA Misc. Pub. 1221, 1972.
ECS Subsections, 1995, ECS Working Group, MN-DNR.
Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Ecosystem Health Unit

12/11/1996

ECO, ECS, Subsections, 1995

Minnesota Department of Natural Resources

White Pine Weevil

Impact

The white pine weevil is a small beetle that is native to North America where it has developed a reputation as the most important insect pest of white pine. Interestingly, this insect is not a tree killer. Rather, it creates problems by killing the leader (very top) of young pines. When a young tree loses its leader, side branches turn upward and try to gain dominance over other side branches. If one branch wins, the tree again has a main leader, though often the main stem has a large crook in it. In some cases, two or three branches may take over and the tree becomes multi-stemmed.

Trees can be attacked several different times and the result can be a tree with a twisted, deformed main stem. In addition, attacked trees often have large branches which form big knots. Much of the degrade associated with sawed white pine boards is in the form of large branch knots. Thus, from a wood products standpoint, the value of wood from these trees can be greatly reduced. Other values can also be reduced. If, for aesthetic purposes, a tall straight white pine is desired, weevil attacks make this more difficult to attain.

It is important to point out that the presence of white pine weevil does not have to be a serious impediment to growing high quality white pine. Much depends upon how individual trees respond to the loss of their leader. Specifically, it is important how quickly the side branches turn upward. Trees growing in very dense stands with a great deal of side shade have their branches turn upward quickly with a single branch often taking over as the new top. In most of these cases the crook in the main stem is minimal. However, if the tree is growing without much side competition, the branches are not forced up. Rather they make a more gradual turn upward. Thus the crook in the main stem becomes much larger and the branches that are fighting for dominance become bigger. Therefore, the negative impacts resulting from white pine weevil attacks can be significantly reduced by growing young white pine in dense stands.

In Minnesota, white pine weevil is more prevalent in the northern half of the state. It is less of a problem in other parts of the state, especially in the southeastern portion.

Biology

The white pine weevil has been one of the most intensely studied forest insects in North America and therefore, much is known about it.

Female weevils lay their eggs in the early spring. Egg laying occurs only in leaders which were formed the previous summer. Female weevils are selective in choosing which leaders they prefer for egg laying. They select leaders based upon their diameter, the bigger the better. The reason for this is that the immature stages of the weevils, called larvae, feed on plant tissue inside the leaders. Bigger leaders simply contain more food than smaller leaders. If there is not enough food for the developing larvae they either starve or cannibalize one another. The end result of all of this is that the white pine weevil prefers to attack young trees, 5-25 feet tall, that are growing in full sunlight. These trees tend to be growing vigorously and, therefore, they have large diameter leaders. In contrast, trees growing in shade grow slower and tend to have leaders that are of smaller diameter.

Larvae develop during spring and early summer, and by mid-summer they have caused enough damage inside the leader to kill it. About this time, the larvae turn into pupae and then into adult weevils. The adults cut holes through the bark of the now dead leader some time in August or September and emerge. The winter is spent as an adult in the needle layer, generally under the same tree they emerged from. The following spring they disperse by flying and finding new trees to attack.

Control

There are several ways that the impact from white pine weevil can be reduced. These include:
Grow young stands at high density —High stand density forces rapid height growth, yet reduces diameter growth. Therefore, young trees do not develop large diameter leaders that are conducive to weevil survival. Further, high stand density forces trees that are attacked to straighten quickly. These trees recover well from attacks resulting in minimal reduction in wood quality.

Grow young stands in partial shade —Shade reduces growth of young white pine and, therefore, reduces the incidence of weevil attacks. However, this growth loss can itself be a serious detriment. The general recommendation is to grow young white pine in partial shade that allows in enough light for adequate growth and yet discourages weevil attacks. Growing young white pine as an understory tree has been a widely used recommendation in the past.

Insecticide Application —Early spring and fall insecticide applications have been shown to be effective in controlling white pine weevil populations. In the spring, treatments can be targeted to the terminal or leader of trees where the adults congregate. In the fall, application must be made throughout the crown of the trees since the adults do not congregate on leaders at this time of year. Generally, white pine weevil populations do not recover quickly following area wide treatment. Therefore, annual treatments would not be necessary. Insecticide treatment programs are currently not widely used, basically because of the concerns with insecticide applications in forested ecosystems.

Pruning —Pruning branches is not necessarily a control measure but rather a way of reducing the impact following weevil attacks. If the goal is production of high quality wood products, pruning is very important. As mentioned earlier, weevil attacks often result in the formation of large branches that lead to big knots in sawed boards. Early pruning of attacked trees can remove branches that would become the eventual knots.

White-Tailed Deer

Timber harvest at the turn of the century and subsequent wild fires opened up the forest and created ideal habitat for deer. Deer populations expanded into this new habitat and their numbers gradually increased until the mid-1960s. In the late 1960s, a series of severe winters caused deer numbers to drop sharply and, in 1971, the deer season was closed to allow deer populations to recover. Deer numbers increased again in the 1970s and 1980s; harvests reached record levels by the early 1990s. The winter of 1995-96 was characterized by deep snow and cold temperatures. By some measures, it was the most severe winter since the 1930s. Deer numbers declined by as much as 50 percent in some areas and it may be three to four years before deer numbers recover to 1995 levels.

It is well documented that white-tailed deer browse on white pine seedlings and saplings during the winter. Most often, the deer remove the terminal bud and annual growth on one or more lateral branches. In severe cases, deer may browse all of the annual growth from the tree. Regardless of the extent of the browsing, it reduces the height and diameter growth of the tree.

There are extreme examples of the effects of deer browsing, such as in Itasca State Park in the late 1930s and early 1940s where deer density may have been as high as 75 deer per square mile, and browsing prevented the regeneration of any hardwood or softwood species. In extreme situations such as this, where deer are highly concentrated and have over-browsed their range, it is clear that deer will prevent the regeneration of white pine. It isn't clear, however, how important intermediate levels of deer browsing are to successful regeneration.

Even assuming a level of deer browsing can be identified that is detrimental to white pine regeneration, it may be difficult to measurably reduce browsing pressure by reducing deer numbers. Deer tend to concentrate on winter ranges and if white pine is available, even a fairly low number of deer may browse a significant proportion of the trees. A more productive approach may be to regenerate white pine on areas not used by deer as winter range. An alternative approach may be to overwhelm deer by regenerating white pine in such large numbers or over a large enough area that the proportion of stems browsed becomes minor.

More direct approaches to browse prevention have been developed and are successful. One approach involves the use of "bud caps" made from paper cut to approximately 4" x 6", folded over the terminal bud, and secured in place with two or three staples. While these bud caps are effective, they must be replaced every fall until the terminal bud is out of reach of the deer.

Research into the use of deer repellents during the winter is under way and may result in alternatives to bud caps.

White Pine
Silvicultural Recommendations

General Considerations

White pine is a long-lived, disturbance-oriented species. In natural regimes these attributes affiliate white pine regeneration with fire and wind. White pine is moderately shade tolerant which enables it to become established in understories. White pine's ability to become established in understories reduces the impact of two pests: white pine tip weevil and blister rust.

White pine reaches the western edge of its natural range in Minnesota. Any plant on the edge of its natural range is going to encounter a higher percentage of its life span under some level of stress, compared to one growing in optimum conditions of its range. This contributes to periods of inconsistent regeneration and responses to management efforts. Silvicultural systems developed in other areas of the eastern white pine range may need adjustments to be as effective in Minnesota white pine ecosystems.

White pine rarely occurs in pure stands, but frequently occurs in mixture with other species. According to the 1990 forest inventory, 27 percent of the white pine volume occurs in stands where white pine makes up a plurality of the stand, while 73 percent of the volume occurs in other forest cover types. There are, of course, many sites where white pine once grew but is no longer present. In order to increase the presence and role of white pine, silvicultural systems must be adapted to each of these generalized situations:

- no white pine present
- white pine present as a minor species
- white pine present as a major species

White pine grows, or can grow, on a broad range of sites in Minnesota. This broad range of sites causes the character of stands containing white pine to vary from one part of the state to another. Ecological classification systems are new tools that can help sort out some of this variability and provide a means to recognize potential management options. These tools need to be developed down to the site level to be of full value to resource managers as they develop regeneration and management prescriptions.

Ecological classification systems will help synthesize and identify site characteristics that are important to growing white pine. These characteristics include soils, macro and micro climate, existing vegetation, potential competing vegetation, potential pest problems such as blister rust, and others. Using this information and landowner's goals, resource managers can help identify management objectives and appropriate silvicultural systems for each site to foster the desired future species mixes.

In the case of white pine, success will be measured against the desired outcome (or management objective). In places where there is currently no white pine, the objective may simply be establishment of a few trees or groups of trees. Where a few white pine already exist, the objective might be to increase their number so they represent a plurality in the stand. Where white pine is already a plurality, the objective might be to maintain, and perhaps expand the stand.

There is no one "best " solution or prescription to increase white pine in Minnesota. Instead, there are multiple options for accomplishing this, driven by the site's ecological potential, stage of successional development, and the landowner's goals. The significant change in the analysis process is the determination of the site's ecological potential as compared to the traditional analysis of the present cover type. Identifying ecological potential should improve resource managers' success ratio and the ability to synthesize management recommendations at the landscape level.

White Pine Management Site Priority Considerations

- Identify ECS Subsections of the state where white pine was significant in the past and shows promise of response to management efforts.

- Within ECS Subsections, the following considerations at the site level seem a logical priority to consider:
    1. Sites where white pine reproduction already exists and can be enhanced through management.
    2. Sites where natural regeneration can be established through management.
    3. Sites where white pine regeneration will have to be established through planting.

Silvicultural Systems

Silvicultural systems are designed to prepare the site for regeneration of the next stand in addition to the harvest of products. The desired future species, or mix of species should be defined in the management unit (or stand) objective before harvest begins. Silvicultural systems describe how the harvest should be accomplished to prepare the site for regeneration.

Potential pest problems such as blister rust and tip weevil must be taken into account when developing a specific prescription for a silvicultural system to minimize pest problems.

Considering white pine biology, site selection priorities, and stand characteristics, the following silvicultural systems or combinations of them are viable considerations for white pine in Minnesota. On going and future Minnesota white pine research results will contribute to the refinement of these systems to conditions that exist in Minnesota. Since there are many combinations and variations of these systems, based on the conditions described earlier, the following systems will be described in general terms and would be more specific on a site-by-site basis.

—*White pine shelterwood method*

The shelterwood system is flexible and provides time to evaluate results and make adjustments. While a shelterwood system offers significant flexibility, monitoring and follow up are imperative to ensure success. The follow- up period may extend 15 to 20 years beyond the initial harvest. The following steps describe a typical stand where there is sufficient white pine in the overstory to accomplish a shelterwood harvest and ensure natural regeneration.

1. At maturity, the stand canopy would be thinned to approximately 50 percent crown closure, allowing up to 50 percent of full sunlight to reach the forest floor. Suppressed and less desirable species would be removed in this harvest, leaving the more vigorous, desirable, seed-producing trees to provide a seed source and sufficient shade for germination and establishment of the next generation of seedlings.

2. After the first cut, the site should be left for at least two years to determine how intense sprout competition from other species will be and to allow slash to deteriorate. If the competition needs control, time the control with a good seed year and scarify as close to 80 percent of the site as possible. Since white pine is a disturbance-oriented species, and seeds germinate and establish themselves best on sites where the organic layer is lightly mixed with mineral soil, scarification is of the utmost importance. Prescribed fire is another site preparation alternative to scarification if conditions permit the use of fire.

3. Regeneration is considered successful when about 75 percent of the area is stocked with approximately 1,000 stems/acre. This reproduction may be a mixture of white pine and other desirable species associated with the particular type of site (or ecological unit).

4. Monitoring over a period of years should be done to determine if release will be necessary. After seedlings have become established, a second harvest cut may be initiated. This cut is intended to increase light and keep the seedlings growing vigorously. The second cut typically reduces the canopy closure to 20 percent, providing up to 80 percent of full sunlight. This also leaves enough seed-producing trees for insurance, should a failure occur.

5. Typically the final removal of the overstory and release of the new stand may be done over a period of years. Seldom is the regeneration uniform enough that a forest manager will want to release all of the stand at once.

**The system works well for the Menominee Tribal Enterprises in central Wisconsin.*

These recommendations have been generalized; research and experience will fine-tune these recommendations for site conditions existing in Minnesota.

—White pine seed tree method

When there are only a few scattered trees or clumps of white pine, then the seed tree method offers an opportunity to increase white pine through natural regeneration. Typically, these few white pine may be embedded in another cover type such as aspen or birch. In high blister rust hazard zones, a partial cut of the aspen/birch in the vicinity of the seed trees is recommended to serve the same purpose as a shelterwood. When the aspen or birch is harvested, the better seed producing white pine would be left. Within seed dispersal distance, seed bed preparation by scarification or prescribed fire, when appropriate, is imperative. The seed trees may be retained for an extended period of time if desirable. This system is ideally suited to increasing the white pine component in stands containing only scattered white pine. The seed tree system differs from the shelterwood system only in that fewer seed trees are present and the intermediate harvest to increase light is not needed.

—White pine planting and seeding

On sites where there are few or no white pine present, and the ecological interpretation indicates it was once part of the system, planting is the most effective option. Planting white pine in the understory of another cover type can be successfully accomplished. Broadcast seeding for white pine can also be done, but successful germination and survival of the seedlings is less assured.

The initial investment may be greater than natural regeneration because of the additional costs of site preparation, seedlings, planting, and control of competing vegetation. Like the other systems, monitoring over a period of years is imperative to successful establishment.

Planting may also be considered with shelterwood and seed tree systems to increase stocking if needed.

A) Planting under an existing overstory involves the following steps:

1. Thin the existing stand to a maximum of 70 percent crown closure, permitting at least 30 percent of full sunlight to reach the forest floor.
2. Prepare the site to expose mineral soil and control competing vegetation prior to planting.
3. If the object is to have white pine make up a plurality of the next stand, plant upwards of 1,000 seedlings per acre as uniformly spaced as possible. If the objective is to have white pine be a mixed component in the future stand, fewer seedlings per acre are needed. Planting small canopy gaps, particularly in high hazard blister rust areas, should be approached with caution. Dew often persists in these openings increasing the risk of blister rust infections on the newly planted seedlings.
4. Monitor over a period of years to determine if further release will be necessary.
5. Protect seedlings from browsing until they are five feet tall; prune lower branches of saplings to reduce the incidence of blister rust.

B) Planting in fields and openings can also be successful and will likely result in greater tree vigor. However, tree quality is often compromised by tip weevil damage, and the incidence of blister rust will likely increase.

Artificial seeding on sites that have been scarified is another technique that may be used when planting is too difficult. Like natural seeding, successful germination and survival are dependent on good seed bed conditions, and seed that has been stratified. If seeding is considered, it should be done in the fall to mimic natural conditions of seed dispersal.

It should be noted that the above recommendations are general in nature, but have been successfully implemented by both public and private landowners throughout Minnesota. Continuing research on white pine in Minnesota, documented field experience, and future research proposals, if approved, will be used to compile a comprehensive white pine silvicultural guide for Minnesota.

Appendix A

White Pine Strategies Work Group Members

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Craig is a silviculture adviser to seven state forestry organizations in the upper Midwest/Lake States and is well versed in ecological concepts, having served with the Wisconsin DNR for 23 years. While in Wisconsin he was instrumental in developing Wisconsin's forest habitat classification system. He also served on the program committee for the 1992 White Pine Symposium in Duluth.

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Appendix B

Mission of Strategies Work Group

The White Pine Regeneration Strategies Work Group was appointed by the Minnesota Department of Natural Resources to prepare a report to the Minnesota Forest Resources Council and the Department of Natural Resources by December 1996. That report was to address:

- The status of Minnesota's white pine resources and its historical and current occurrence;
- Existing efforts to increase white pine through management strategies and practices;
- Research needs to address specific concerns about white pine where knowledge is needed or data is lacking to conduct analysis;
- Recommended regeneration and management strategies that will increase the role and presence of white pine in appropriate units of ecological classification systems.

Appendix C
White Pine Review/Advisory Group

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Appendix D

Activities of the White Pine Strategies Work Group

The Work Group met a total of 10 times, holding its first meeting April 29; its last December 2. Protocol for each meeting followed review of the previous meeting's summaries; presentations on specific areas of white pine history, management, biology, and/or ecology; discussion; and setting the agenda for the forthcoming meeting. In between these meetings, four subcommittees of the main Work Group held their own meetings.

Two meetings were conducted in conjunction with field trips intended to study on-the-ground, white pine management. The first field trip (Aug. 28) was to the Rajala Companies' Wolf Lake Camp north of Grand Rapids. The Work Group toured regeneration sites and other management activities. The other field trip (Sept. 17) was to the Menominee Indian Reservation in Wis., to study the tribe's natural resource activities as they relate to white pine and the Menominee's 140-year history of forest management.

A review/advisory group was also formed in April 1996 to review the progress of the Work Group and to provide input. Members of the advisory group were mailed summaries of the Work Group's meetings as they progressed. A meeting was held October 23, 1996 to update the advisory group on the activities of the Work Group and to answer questions. (See **Appendix G** —*Concerns of Review/Advisory Group).* Approximately 15 members of the advisory group attended the day-long meeting held in Hinckley, Minn.

Appendix E

Ongoing Research

Ongoing research at the Department of Forest Resources, University of Minnesota, on the ecology and silviculture of white pine. Note: This list of ongoing research is not all inclusive as it does not reflect research taking place in other public and private organizations.

1. Studies of distribution, abundance, growth, and survival of white pine (and other woody species) in the understory of mature and old growth white pine stands. Studies focus on the effect of light, nitrogen supply, and soil depth, and use mapped plots in the Superior National Forest and other plots in the Cloquet Forestry Center. PI: Machado, Reich.

2. Investigating growth and survival of white pine and six other species on trenched/untrenched plots across a low light gradient in northern Wisconsin. PI: Walter, Machado, Reich

3. Studies of the stand dynamics and overstory/understory relations on the same mapped plots (focusing on long-term dynamics) as well as on white pine mapped plots at Boot Lake and on a burned island in Seagull Lake (BWCAW) PI: Frelich, Reich

4. Studies of the mature tree growth, understory composition, and regeneration of white and red pine in mature and old growth white and red pine stands along a gradient from the Arrowhead region to the southwest edge of the range (near Detroit Lakes). Investigating how these variables change along climate and associated vegetation type and fragmentation gradients. PI: Ahola, Reich

5. Studies of pattern of tree and total plant species diversity as a function of forest type, stand age, and disturbance history (wildfire vs. logging) in the northeast part of Minnesota. PI: Reich

6. Studies of the distribution and abundance of white pine (and other species) trees in the late 19th century, based on bearing tree data from the Public Land Survey, in relation to soil, topography, geology, hydrology. Also included are studies of changes from pre-settlement and current vegetation in burned vs. logged areas. PI: Friedman, Reich

7. Studies on the role of local seed sources of white pine on regeneration in clearcuts dominated by aspen/birch. PI: Dovciak, Reich, Frelich

8. Studies on the interactive effects of browsing and competition on growth of white pine seedlings. PI: Saunders, Puettmann

9. Studies on the effect of surrounding vegetation on the frequency of browsing of white pine seedlings. PI: Saunders, Puettmann

10. Studies on the effects of canopy and understory competition on growth of white pine seedlings under different cover types. The effect of light and water and nutrient competition is also quantified. PI: Smidt, Puettmann

11. Studies on the effect of overstory removal on growth of release white pine. PI Smidt, Puettmann

12. White pine competition and resources use in monoculture and mixed species stands. PI: Puettmann, Reich

13. Selection and breeding for blister rust resistance and increased growth rates. PI: Stine, Klevorn

14. Use of plant hormones to induce flower production in young white pine trees. PI: Stine, Pijut

Appendix F

Minnesota Forest Resource Partnership
White Pine Survey

The Minnesota Forest Resource Partners (MFRP) survey were asked to respond to a survey commenting on the extent and conditions of white pine type and what is being done in white pine management and regeneration.

Surveys are not complete, nor do they provide complete data. Yet, some interesting and valuable information is available. Some observations area:

1. White pine doesn't seem to be found nearly as often in stands (based on cover type acres) as it is a significant species in other cover types. This seems to confirm data in the 1990 Forest Survey.

2. On an acreage basis, white pine is far more prevalent in the older age/large diameter classes than in the intermediate or younger/smaller classes. This again confirms 1990 data. But what is notable is that the survey is not reporting much in the 40-60 year-old and 5-15 inch diameter classes. An interesting question is how much of it might be hidden as a secondary species growing in the understory or as a component within other cover types. The answer is certainly going to have relevance to the question of managing for white pine.

3. A number of responses mentioned that as a dominant cover type, white pine is now a rather small percent of pre-settlement acreage. However, they report large acreages of other cover types with white pine as a significant component. The 1990 Minnesota Forest Survey showed a total of 1,008,900 acres where white pine is present and 491,000 acres where it is significant in other cover types. This raises two important management issues:

a) Pre-European settlement forest might have been more mixed than previously thought, especially if it is acknowledged that there once was a higher percent of hardwood forest and that white pine favored these sites, but would not likely have dominated over the long term.
b) The degree to which natural successional phenomenon is happening without the natural occurrence of fire.

4. Responses indicate that there are a variety (range) of approaches to managing white pine both in terms of growth considerations and harvesting. White pine management is not approached from a pure rotation-age prescription. Instead, concerns run from keeping it healthy, and using white pine as a seed source to considerations of thinning. Responses often indicated that worries of blister rust are strong. Generally, it could be characterized that white pine management is very cautious.

5. All respondents show a definite interest in white pine regeneration and are doing some of it. Yet, there is a very broad range of perspectives on how to manage for, how much, and for how long. The descriptions given show that what literature is "out there" is certainly being followed (e.g. shelterwood/understory systems, site preparation, dealing with competitive vegetation, micro-climate concerns, browsing concerns, and always the great concern for resistance to the dreaded blister rust). Notably, no one mentioned the compounding problem of slow growth in years 1-5.

6. All respondents showed a commitment to regeneration and plan to do an increasing amount. Concerns that surfaced include:
a) The complexities of regeneration/management
b) Funding versus costs
c) Availability of rust-resistant stock
d) Blister rust hazard zones
e. Ongoing research on blister rust
f) Opportunities/systems for natural regeneration

7. A non-industrial private forest (NIPF) landowner raised the question of markets for pole timber and pulp-

wood, incentives, restrictions on cutting because of media scare of overcut. Big uestions remain regarding NIPF lands.
a) How much do they have?
b) What kind of shape is the land in?
c) What are their attitudes/interests?
d) How to reach them/with what message?

8. Most land management agencies have an active program to maintain and increase the presence of white pine regeneration—naturally and through planting. In total, the respondents reported that approximately 860,000 seedlings are planted per year on over 1,200 acres. Other examples of these programs are reflected in comments such as:
• The Chippewa National Forest stated: "The average annual growth (4,933 MBF)is more than five times the volume lost to mortality (422 MBF) and harvest (416 MBF) per year. The total white pine volume has increased from 42 million board feet (MMBF) in 1947 to 185 MMBF in 1996."

• The Superior National Forest stated: "Doing nothing is not a good option. If no management action is taken to promote regeneration of new white pine trees, white pine will continue to decline."

• The Minnesota Department of Natural Resources (DNR) management guidelines state: "Management of white pine should be aimed at maintaining the current white pine cover type as well as increasing its presence on appropriate sites within its range."

• Aitkin County Land Department states it has: "planted 5,000-10,000 trees per year for the last several years. With some additional funding sources, the county would be willing to expand its white pine program despite the cost relative to the risk which has limited its white pine program to date."

• Cass County Land Department stated it is: "in the process of initiating a stratified re-inventory of its white pine resource to obtain comprehensive and reliable information on the status of its white pine resource and the extent to which it is naturally regenerating."

• Clearwater County stated: "September of 1992 was predicted to be a god seed year for white pine in our area. Three weeks prior to seed fall the county scarified the soil beneath 25 acres of white pine cover type. The project was viewed as a success in establishing new white pine seedlings on the forest floor. During the spring of 1995, Clearwater County planted a mix of 10 percent white pine on all new Norway pine plantations. This is going to be done in 1996, and future years."

• Itasca County states: "In appropriate low quality hardwood stands, thinning is done to open sites for underplanting of white pine. Sites are commonly mechanically or chemically treated, and hand-planted to high quality bare-root or container stock. Seedlings are checked annually for blister rust infections and are bud capped to reduce predation by deer and hare. Approximately 15,000 seedlings over 20 acres are targeted annually."

• Koochiching County Forestry states it is: "actively managing stands having a white pine component by following a 2-stage shelterwood system."

• Tom Martinson, Lake County Land Commissioner states: "White pine is our favorite tree and, as Aldo Leopold said, 'I love all pines but I'm in love with white pine.' Our county is planning to try more underplanting and we are also thinking of exposing mineral soil in areas where there are scattered white pines."

• St. Louis County Land Department states: "We recognize the importance of managing white pine for its biological, social, and longer-term economic values, and we have committed the Department to expending its time and resources in order to expand and intensify all aspects of white pine management. This commitment includes having already established a white pine clonal seed orchard (not a small cost item)."

• Jack Rajala of the Rajala Companies states: "Just 'managing' our 'old' white pine is not enough—nor is reducing our harvest the answer (harvest levels have been reduced 75 percent in the past five years). Restoring white pine is really a matter of regeneration and there is solid enthusiasm among both public and private sectors for white pine regeneration."

Some Possible Conclusions:

1. There are more acres than last FIA.

2. Other than St. Louis County, imbalance exists in the 20-50 year age class.

3. Acknowledgement of a history of decline in the late 19th and first half of 20th century.

3. Decline is generally credited to:
a) Heavy early logging
b) Absence of old/natural regeneration regimes (fire, etc.)
c) Society's land ethic of late 19th and early 20th centuries to eliminate forest
d) Lack of management/difficulty of management
e) New impediments to regeneration:
    1. Competitive vegetation
    2. Blister rust
    3. Tip weevil
    4. Browsing

5. Most are replicating natural regeneration (e.g. Menominee style).
    - pre-harvest/post harvest site work
    - shelterwood

6. Some are planting with a growing emphasis on underplanting.

7. All show enthusiasm but have concerns about:
a) Difficulties
b) Costs

8. Most are retaining trees depending on:
a) Health and vigor
b) Seed trees
c) Aesthetics
d) Thinning or final cut

9. All acknowledge that the future depends on regeneration, follow up, and care.

10. Likely, there are 300-500M acres of "significant in other cover types," like white pine always was, so we have more than 15 percent of original.

11. For many managers enthusiasm is tempered with caution because of the perception that technologies for regenerating white pine at a commercial level are experimental.

Appendix G

Concerns of the White Pine Review/Advisory Group

In April 1996, the Minnesota Department of Natural Resources formed a White Pine Review/Advisory Group of individuals who had expressed an interest in reviewing progress of the White Pine Regeneration Strategies Work Group and providing input on the work of that group at key points as it developed its report.

Meeting summaries of the Work Group were sent to members of the Review/Advisory Group after those summaries were approved by the Work Group. On October 23, 1996, four members of the Work Group met with approximately 20 people, most of them members of the Review/Advisory Group, to address their questions and concerns. Copies of draft recommendations made by individual members of the Work Group were sent in late November to the Review/Advisory Group for members' comments.

Following are some of the questions, suggestions, and concerns raised by the Review/Advisory Group at the October 23 meeting, and the Work Group's responses.

Concern: The Work Group's policy recommendations need to address the various landowner categories; they shouldn't be so general that they cannot be applied.
Response: The Work Group has tried to do that. For instance, it looked at the pre-European settlement forest communities with white pine and compared those locations to current ownership patterns as a basis for suggested funding for programs. The Work Group has also proposed recommendations that apply to specific ownerships, such as state land and non-industrial private forest lands.

Concern: Pilot projects should be considered to address specific problems such as deer browsing on young white pine.
Response: There could be opportunities for applied research projects that would address some specific problems on individual sites. The greater challenge will be to implement a project for a long enough time period and at a large enough scale on the landscape to make a difference. The Work Group also developed recommendations related to deer browsing.

Concern: Information from past research studies and current management activities that demonstrate what works or doesn't work should be assembled so that information is more readily available and used in developing guidelines.
Response: The Work Group has recommendations related to guidelines for white pine management that should address this suggestion.

Concern: Monitoring and information transfer is something that the Work Group should address.
Response: There are recommendations to address this suggestion.

Concern: What are the effects of continued cutting of white pine? It should not be harvested if it can't be regenerated economically.
Response: The effects from harvesting white pine need to be considered in a holistic manner that recognizes that preservation of individuals can be at the expense of the species if it isn't regenerated. Over much of Minnesota, white pine is a species that relies greatly upon disturbances to establish good regeneration. Growing conditions for white pine have changed since the early logging era. Deer have expanded their range and blister rust is now a significant problem. Our society has contributed to white pine's current situation in Minnesota, and it has the

capability to help improve the situation. Harvesting within white pine stands and harvesting around trees that serve as seed sources is one of the more economical means to regenerate white pine by opening up the canopy, disturbing the soil, and providing access to accomplish regeneration activities. Revenue generated from the harvesting also helps cover regeneration costs. The Work Group recognizes that continued harvesting of white pine should only occur when there is a commitment to maintain and increase its presence on the landscape.

Concern: What level of white pine harvest is sustainable? The Work Group needs to look at the past and present harvesting rates to present the whole picture of what is happening.
Response: The sustainable harvest level is dependent upon what the management objectives are for any given area. For instance, if most larger white pine were to be reserved for any reason, the harvest levels would be extremely low. If the objectives were based on increasing the amount of white pine acreage by a significant amount, the long-term sustainable harvest could be set much higher. This determination of management objectives should be accomplished through a landscape-based planning process that involves stakeholders and other interests, so that whatever is agreed upon is more apt to be implementable. After determining the management objective, harvest levels can be set either as a function of the amount of area or volume that should be harvested periodically to meet the management objectives.

On a statewide basis, if the sustainable harvest level were set equal to the average net annual growth between 1977 and 1990 (from the 1990 Forest Inventory and Analysis), it would be 8,838 thousand cubic feet, or 111,873 cords from all timberland ownerships. Average annual removals of growing stock in the same inventory period were 5,231 thousand cubic feet or 66,215 cords from all timberlands, resulting in an increase in average diameter and total volume of white pine. But, while more board feet exist, there has been a decline in the number of white pine trees and acres of the white pine type. Concerns over harvest rates have been reflected in the Work Group's recommendations in a number of areas.

Concern: What are the impacts from harvests on the residual gene pool of white pine?
Response: This is hard to quantify and depends a great deal on the harvest and regeneration system used. Within stands, harvesting up to 50 percent of the trees and leaving the rest to produce seed for regenerating the site will have minimal or no impact on the gene pool. Harvesting a larger percentage of the trees prior to regeneration may reduce the frequency of some genes. A benefit of thinning a stand prior to regeneration is reducing the probability of inbreeding among closely related individuals. In small, isolated groups of trees, harvesting may eliminate some genes, although it is likely such groups already contain closely related individuals with a limited gene pool. In such circumstances, seeds or seedlings from other sources could be used to enrich the gene pool and reduce problems with inbreeding. Nearly all the recommendations relating to harvesting, regenerating, and preserving trees have gene pool conservation as an underlying principle.

Concern: White pine should not be extirpated from a site.
Response: The Work Group agrees! That principle is reflected in a number of recommendations.

Concern: The current age class distribution of white pine is out of balance. There should be recommendations to even it out by Subsections (a unit of the Minnesota Ecological Classification System) if possible.
Response: Much of the gap in the intermediate age classes (20 to 80 years) is a result of large scale fires, early slash disposal laws to prevent catastrophic wildfires, and a reliance on harvesting during the winter when soil scarification of seed beds was minimal. It will take a considerable period of time to even out the age class acreages. There is no direct correlation between current harvest levels and long-term sustained harvest levels because there are so many options for moving towards a fully regulated age class structure (i.e. even distribution of age classes). Normally, transitions from the present structure to a target age class structure require several rotations. Quite often, smaller geographic areas have greater disparities between age classes that require longer time periods to achieve fully regulated age class structures. However, it is something that should be strived for through a landscape based planning process. Recommendations are developed to address this concern.

Concern: Can't white pine be regenerated without cutting white pine?
Response: In many cases—yes, particularly where the area surrounding a white pine seed source lends itself to treatment for natural seeding or planting. But again, white pine is a species that relies greatly upon disturbances to maintain itself on the site. In the absence of disturbance, it will often succeed to more shade tolerant species as the older pine die.

Concern: There should be a public comment period for state and county timber sales—at least for white pine.
Response: The DNR encourages public involvement in the setting of timber management goals in area timber management plans. Once those goals have been set for the plan period (usually five years), it can be very costly and time consuming to review each individual harvest proposal. It would be far more effective for people interested in forest management to be involved at the front end to influence management goals in the planning process.

Concern: The Work Group should describe levels needed, and locations for white pine restoration.
Response: The Work Group has looked at locations where the greatest declines in the white pine resource have occurred since the Public Land Survey. It is located primarily along the north shore of Lake Superior and extends fairly well south through east central Minnesota. Ownership of sites having pre-European settlement forest communities with white pine in this area of most "obvious decline" is now 63 percent private, 19 percent county, 12 percent state, and 6 percent federal lands. Recommendations regarding reforestation goals have taken this kind of information into account.

Concern: The DNR should play a major role in assisting other landowners in growing white pine.
Response: The DNR has, and will continue to play a major role through providing seedlings from its tree nurseries, giving advice and technical assistance through the Forest Stewardship Program, providing monies through grant agreements to county lands, and through the development of training and educational programs. The Minnesota Forest Resources Council is the appropriate forum for coordinating landscape based planning and, with the Minnesota Forest Resources Partnership, coordination of management activities between ownerships.

Concern: Is anyone working on Ribes eradication?
Response: The State of Maine has a program. In the Lake States, the eradication of Ribes to break the blister rust cycle was shown not to be that effective because of the huge reservoir of this alternate host for blister rust. It is also arguable, from a scientific viewpoint, whether it is appropriate to try extirpating several species of native gooseberries.

Concern: At what geographic scale should age class goals be set?
Response: This is a topic that the Minnesota Forest Resources Council should address. Each forest resource issue may need to have its own scale in order to address the issue most effectively. It is also dependent upon available information and its statistical reliability to adequately address the issue, let alone monitoring progress towards goals. In the case of white pine, the sampling errors for area of the white pine cover type (with 63,700 acres statewide) in the 1990 statewide forest inventory for each of the four survey units were: aspen-birch 7.57 percent; northern pine 7.66 percent; central hardwoods 21.47 percent; and prairie unit 59.69 percent. In the case of the aspen cover type (with 5,055,000 acres), the sampling errors are much smaller; therefore, aspen age class issues could be addressed at much smaller scales. In other words, one size may not fit all.

Concern: Will there be an opportunity to review the work group's recommendations?
Response: To the extent possible, copies of proposed recommendations from the individual work group members will be made available for comment, recognizing that the time for review will be short in order for the Work Group to finalize its work on schedule.

- END -